BRIEFING PAPER

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Petroleum Reserves in Question

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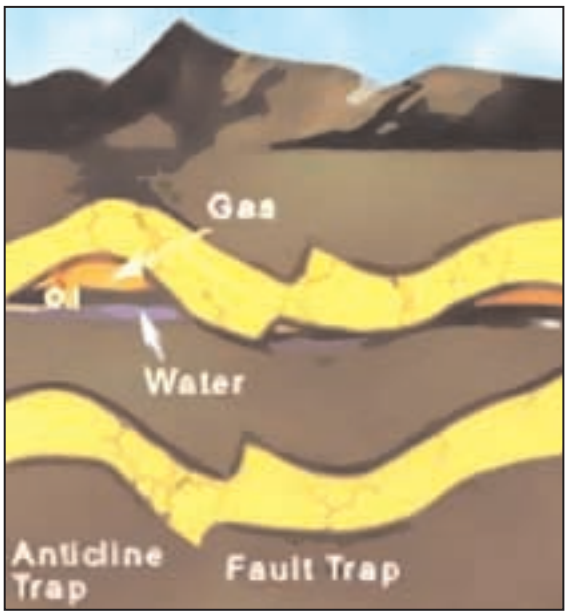

Summary

• Petroleum reserves cannot be measured directly.

• Estimates of reserves, and future production, combine information and assumptions about economics, feasible technology and geology.

• To use reserves estimates sensibly it is necessary to have some understanding of how they are generated and to have confidence in the integrity of the estimating process.

• Until a flexible, consistent and comprehensive system is widely adopted, great care needs to be exercised in interpreting numbers which purport to describe reserves of oil and gas.

Outline

Petroleum reserves cannot be measured, but estimates of reserves are important to different people for different purposes:

- To oil and gas companies whose market value is influenced by estimates of their reserves;
- To governments with large revenues from oil and gas production;
- To business and policy makers in economies which have significant oil or gas imports or exports - most countries are in this position.

Estimates of future production combine information and assumptions about economics, feasible technology and geology. To use reserve estimates sensibly in planning, policy and analysis it is necessary to have some understanding of how they are generated and to have confidence in the integrity of the estimating process. Strict conditions are applied by enterprises reporting 'proven' reserves for financial purposes in the US, but these exclude information about firms' potential other sources of production. Some governments explain the basis of their national reserves estimates but probably half to three-quarters of the world's oil is in countries where the oil sector is a state monopoly and whose governments do not feel the need to explain the basis of their reserves estimates. Professional estimates of world-wide petroleum resources exclude economic information. The UN Framework Classification for Energy and Mineral Resources (UNFC) offers a clear identification of the different effects of economics, project feasibility and geology. A Group of Experts working under the UN Economic Commission for Europe has recently proposed a detailed method for applying the Framework to Petroleum. The proposals have been discussed with OPEC member countries and with the members of the UN Economic and Social Commission for West Asia. The UN Economic and Social Council in July 2004 recommended that the method be applied in all regions. This paper compares the essential idea of the UNFC proposal with the various existing methods of generating reserves estimates at enterprise, national and global levels.

What are petroleum reserves?

Petroleum (or any other natural resource) reserves cannot be measured directly. They are estimates of future production under certain conditions which may or may not be well specified, but which include economic assumptions, knowledge of the feasibility of projects to extract the resources, and geological information. Judgement is involved and different estimates for the same field are legitimately possible.[1]

Who generates the numbers?

Oil and gas companies (including state companies) develop internal information about their petroleum resources and prospects. This information is derived from the results of exploration activities, including regional geological studies, seismic survey, drilling, sampling and pressure testing, reservoir modelling, combined with feasibility and design studies for resource development and commercial evaluation of the economics of production. The Society of Petroleum Engineers and World Petroleum Congress (SPE/WPC) have developed a set of professional guidelines for estimating reserves from this information. The UNFC proposals build on these and propose further segregation of the information flow to increase the possibility of verification of individual elements in the factors contributing to the estimates.

Government agencies may also develop information about national resources, using information from companies operating in their country, independent geological studies, studies by government geological and planning agencies, and outside consultants. The US Geological Survey (USGS) offers a periodic review of world petroleum reserves, based on available public data (including data bought from commercial consultants), evaluated by groups of their own and industry experts.

National regulatory authorities, such as Norwegian, UK, Canadian and other governments, where petroleum resources are not exclusively in state hands, place additional constraints on the procedure for estimating 'proven' reserves by private-sector enterprises in their countries, and publish national reserves and resource estimates whose basis is clearly explained.

The US Securities and Exchange Commission (SEC) strictly defines the information which may be used to report 'proven' reserves by enterprises (private- or public-sector) whose securities are traded on US exchanges: it does not specify rules for estimating other categories of reserves or resources.

Some 80 per cent of the worlds 'proven' oil resources are in countries where information about reserves, mainly from state monopoly companies, need not necessarily comply with such procedures. National government estimates of these countries' reserves are publicly stated (in the case of OPEC members to the OPEC secretariat), and are collected by the commercial press, such as the *Oil and Gas Journal* and *World Oil*, and in the *BP Statistical Review*. From time to time some of the state companies in these countries volunteer information about the basis of their reserves estimates, as Saudi Aramco has done in 2004.

The continued existence of this mixture of approaches and the absence of a clear and consistent internationally applied metric or standard create confusion and lead to misunderstanding, leaving open the potential for those wishing to take an advantage of the confusion of estimates to advance their own agendas or influence policy. If the UNFC proposals were to be generally adopted, the governments and

public of countries with state monopolies, as well as the international financial and trading community, would be better able to understand their own as well as the global reserves situation.

Oil (or gas) 'in place'

Modern computing power and education in statistical method have transformed the treatment of probabilistic information in the evaluation of petroleum prospects. The gains are most obvious in analysing geological information. Technical conditions for the presence of petroleum sources are well known. Data can be interpreted probabilistically estimating for each prospect the likelihood of each necessary condition being met, and therefore of all conditions being met. This estimating process applies not only to the volume of oil or gas resources initially in place (and to the probability of the existence of undiscovered resources, for example), but to reservoir characteristics (delineation of the reservoir, rock porosity and permeability, pressure, chemical composition of the oil or gas etc.) of discovered resources. These characteristics need to be known before any development plan can be formulated which could compete for investment funds. More data and better analysis can improve the accuracy (narrow the range) of the estimate so that the estimate of petroleum-in-place may change when money is spent to obtain more or better information, but the precise *ex ante* properties of a reservoir are what they are and cannot be changed. (Some production techniques, such as 'fracting' or chemical treatments, do change the physical potential of the reservoir).

Reserves definitions

Reserves definitions are labels for the processes used in arriving at estimates of hydrocarbons that can be recovered under certain economic and technical conditions. Estimates of 'proven' reserves assume current economics and technology. Estimates of other categories of reserves may use expectations about future economics and technology. Unlike the estimates of oil or gas in place, which are estimates of physical measurements, estimates of oil or gas reserves are therefore really *predictions of production in the foreseeable future,* combined with the record of past production, if any.

These reserves estimates involve input on:

- *Economics* (information about current costs, prices and taxes, for *'proven' reserves;* assumptions or predictions about future costs, prices, taxes, for other categories);
- *Feasibility* (the feasible development schemes, which assume development technologies available and environmental impact constraints); and
- *Geology* (the petroleum initially-in-place estimates and reservoir characteristics).

Some petroleum known to be in place may never be produced ('recovered') because of technical difficulty or high cost. The percentage of oil-in-place which is recovered (the 'recovery factor') may vary between fields and may improve in the future with improvements in technology.

While *oil in place* could in principle be defined exactly with perfect technical knowledge of the physical situation, estimates of *reserves* are therefore a mixture of three factors: hard physical measurements (the sum of past production), information about current economics and technology (for 'proven' reserves estimates) and forecasts which depend on future technology and commercial conditions that cannot be discovered accurately by spending more money or doing more analysis today.

The UNFC proposes that each known accumulation of oil be ranked or coded on each of these three factors, with the most favourable ranking scoring 1, so that an estimate ranking E1.F1.G1. has the highest probability (the UNFC proposes 90 per cent) of being realized. This corresponds roughly to the traditional definition of 'proven' reserves used by SPE/WPC and others.

The UNFC proposes to use the term *'reserves'* for petroleum coded in EFG categories 111,112, and 113. The variation in the geological ranking (the third digit) corresponds roughly to the traditional distinction (also used by SPE/WPC), between *'Proven', 'Probable' and 'Possible'* reserves, also known as '1P, 2P, and 3P'. 2P ('Probable') includes 1P; and 3P ('Possible') includes 1P and 2P. In probabilistic terms there should be a 10 per cent chance of exceeding the 3P estimate, a 50 per cent chance of exceeding the 2P estimate, and a 90 per cent chance of exceeding the 1P ('proven') estimate, so that these three categories can also be described as *'low', 'best', and 'high'* estimates respectively.[2]

In the UNFC system the economic and feasibility code is assumed to be favourable (1) for all categories of geological estimates of the accumulations in reserves. In traditional and SPE/WPC systems it may implicitly be so, but there is scope for judgement and it is less easy to identify situations where the geologic ranking is high but the feasibility of economics is doubtful. The UNFC recommendation is to use their explicit system to code feasibility and economic rankings rather than to subsume them in the language of 'possible, probable and proven'.

All other categories of hydrocarbons in the UNFC system would not be part of *reserves* and would be defined as *contingent or prospective resources*. *Contingent resources* would be discovered oil, which failed to score 1 on either the economics or feasibility code. The subcategory would indicate what contingency would lift the estimate into the class of reserves: for example, an accumulation of geology that is well-defined, scoring G1, might require a dramatic improvement in price or new technology to lift it from F3 or E3 into F1 or F2. An example might be the billions of barrels of bitumen trapped in carbonate rocks under the Athabasca tar sands. These are known

to exist from the hundreds of wells penetrating the formation, but there is no known method for their recovery.

An additional category (334) is proposed for *prospective* resources, i.e. exploration prospects for which no project feasibility or economics can be defined. An example of this category is clathrate hydrates of methane in deep ocean-bottom sediments. The ratio of contingent resources to reserves in any petroleum province or country varies.

To illustrate by a rough translation, in the UK (using UK Department of Energy Classifications) at year-end 2002 the 2P reserves ('proven' plus probable, best estimate, UNFC code 111 and 112) of oil remaining to be produced was estimated at 7.2 billion barrels. A further 3.2 billion barrels of possible reserves (UNFC code 113) had been identified, making a 3P reserves, high estimate, of 10.4 billion. Between 0.6 and 3.7 billion barrels of potential additional oil were thought to exist in discoveries which were not currently technically or economically producible and for which there were no current development plans (UNFC code 334).

The subdivisions of feasibility and economics proposed in the UNFC can be reconciled to the feasibility project and economic categories used in the Norwegian Petroleum Directorate. Subdivisions of category E1, F1, G1 ('proven' reserves) could be related to conditions required by the SEC.

The subdivisions proposed for petroleum in Table 4 of the UNFC are detailed in Table 1.

Table 1 – Subdivision proposed for petroleum in Table 4 of the UNFC

E1 Economic
E1.1 Normal Economic
E1.2 Exceptional Economic
E2 Potentially economic
E2.1 Marginal Economic
E2.2 Sub-Marginal Economic
E3 Intrinsically Economic
E3.1 Non-sales
E3.2 Undetermined
E3.3 Unrecoverable
F1 Justified Development and/or Production Project
F1.1 Project in Production
F1.2 Committed Development Project
F1.3 Uncommitted Development Project
F2 Contingent development project
F2.1 Under Justification
F2.2 Unclarified or On hold
F2.3 Not Viable
F3 Project Undefined
G1 Reasonably Assured Geological Conditions
G2 Estimated Geological Conditions
G3 Inferred Geological Conditions
G4 Potential Geological Conditions

Changes in reserves estimates

The UNFC system, like the SPE/WPC and traditional systems, is designed to make very clear the degree of uncertainty about the geology underlying the estimates of reserves. The estimate of reservoir volumes and characteristics can change the development options for the reservoir and the commerciality of the options.

But these estimates of 'recoverable' reserves involve more than scientific uncertainties. A key problem in structuring information about reserves is that relatively objective estimates of reservoir characteristics must be combined with subjective forecasts of project feasibility and commerciality. Some of these uncertain factors, for example technology and cost, may be at least partly under the control of the companies, depending on their ability to maintain investor confidence for their risky development. Others, such as tax, may be under the control of governments; others, such as the climate of policy for environmental and social impacts of development, are in the wider realm of public opinion. Oil and gas prices in the future will be the result of a complex sequence of unpredictable events. These are uncertainties of a different order from the scientific uncertainties. Subjective probabilities may be assigned to them. Scenarios may be developed and chosen for testing the sensitivity of a development plan and illustrating the risks to the company, investors, government, or the environment. Understanding how these uncertainties are treated in any reserves estimate is necessary to make sensible use of them.

Reserves of enterprises

Since reserves estimates are estimates of future production, they are an important indicator of a private-sector upstream company's future level of activity. Within a company, the management knows, or should have the capacity to know, the estimates of its various categories of reserves and the contingencies involved.

Companies may use corporate planning assumptions to limit the range of the commercial uncertainties, which are considered, and exhaustive internal debate may limit the range of technical development options. A company's internal information structure of future production estimates is not suitable for communication outside the company for many reasons:

- It would be dynamic, complex and difficult to interpret without full knowledge of all the company's practices and parameters – in other words without being inside the company;
- It would prejudice the company in competitive bids and negotiations if this information were available to its competitors and counter-parties in negotiation.

However, companies in the private sector are accountable to investors, creditors, regulators, and in a loose way to public opinion. For this purpose attention is usually given to 'proven' reserves, where the estimates are most constrained by relatively objective and verifiable conditions.

'Proven' reserves

Estimates of its 'proven' reserves are an important predictor of a company's future capacity to produce petroleum and therefore pay shareholders and debt-holders. Conventionally, under most regulatory and accounting regimes, reserves estimates may be booked as 'proven' only if they are economic under current prices and taxes, development is feasible with current technology, and the volumes of oil to be recovered can be estimated with a high degree of certainty.

Proving or 'booking' of reserves can also affect whether a company charges exploration costs to current revenues, the 'full cost' method (for example before a field is 'proven') or, over the life of the field, the 'successful efforts' method (generally acceptable once a field has been 'booked'). Differences arise as to whether the 'best estimate' (roughly 2P, 50 per cent probability, UNFC code 111 and 112) should be used or the low estimate based on '1P' (90 per cent probability, UNFC code 111).

Where '1P' estimates of different accumulations are added together for company reports or national estimates, the probability of the aggregate number is not necessarily 90 per cent: it depends on whether the uncertainties are independent and whether the distribution of the probabilities of the individual components are of the same form.

For the purposes of internal planning and decision-making companies would normally use the best estimate (2P: 'proven and probable'), although the range of uncertainty would normally be taken into account. The UK, Norway, Canada and Australia allow companies to account this 'best estimate' (UNFC code 111 and 112) as 'proven' reserves.[3]

The US Securities and Exchange Commission (SEC)

Under the SEC rules companies may claim as 'proven' reserves only those which meet more stringent criteria, roughly corresponding to P1 reserves (UNFC code 111) (90 per cent geologic probability), but with additional specific constraints. These constraints, broadly speaking, exclude accumulations not 'proven' by drilling, estimates of additional recovery due to secondary recovery mechanisms (such as gas or water injection) unless their efficacy has been demonstrated, and (a separate issue) liquids recovered from mining methods.[4] The SEC has recently granted a waiver in respect of certain deepwater offshore US reserves where it would be prohibitively expensive to prove the oil-water interface by drilling.

The SEC further allows companies to distinguish between *'developed proven reserves'* (roughly category F111 in the UNFC code) which essentially are reserves already being produced, and '*undeveloped proven reserves'* which in UNFC terms would be coded 111 but for which the investment in production had not yet taken place. (These might be coded 1(1.2) 1 by the UNFC. The SPE/WPC definitions provide for this distinction:

> 'Developed proven' reserves are those where the production and transportation systems are in place or there is a 'reasonable expectation' that they will be installed. The agency may require, as the SEC does, that 'reasonable expectations' be substantiated by the existence of sales contracts (for example for natural gas) or significant commitments to development expenditure (in the case of oil to be sold on the open market or through the producers' downstream facilities).
>
> 'Undeveloped proven' reserves are those where the geological evidence is similar to that of 'proven' reserves, but production and transportation systems are not in place at the location of the reserves (but there is a reasonable expectation that they will be developed).

The SEC also requires that the economic viability of the reserves should be calculated at the oil or gas price on the closing date of the year under reporting (normally 31 December). Expected price movements in contracts which are indexed to future world price movements are not allowed. Other accounting systems allow some degree of averaging.

ExxonMobil, for example, in the explanatory notes to their reserves data in their filing on Form 10K with the New York Securities and Exchange Commission describe their process (but not its content) and its integration within company management procedures. They point out that long-term development decisions are taken with a view of long term prices rather than the year-end price, and indicate what proportion of their reserves is affected by the difference between their internal (unstated) long-term price and the SEC required year-end price.

A few companies, including Norsk Hydro and Pemex, detail their reserves bookings (on the SEC definition of 'proven', on a field-by-field basis). Pemex, the Mexican state oil company, has bonds quoted in New York and accordingly publishes SEC-defined 'proven' reserves. The key internal estimates (the 2P or 'best estimate') and 3P (high estimate) are not however published.

What is 'reasonable' commercially may be subjective. It is arguable that evidence of a company's commitment to development expenditure may be sufficient evidence, even if sales contracts are not yet in place. It is perfectly possible for different companies to have different views of the probability of volumes and timing of sales, as evidently occurred in the case of the different SEC filings by the partners in the Ormen Lange gas field in Norway.

'Proven' reserves in financial analysis

For financial analysts, 'proven' reserves (UNFC code 111) are an indicator of future production potential and therefore of income. The success of a company's exploration and development programme, its ability to generate future production, is measured by the rate at which it adds to its estimates of 'proven' reserves (which are estimates of future production with current prices and technology). The ratio of undeveloped to developed reserves is an indicator of the company's capacity to bring forward new development projects: a falling ratio would indicate the company was running out of projects. The ratio of reserves additions to production from existing reserves (the 'replacement ratio') is treated as a headline number, though the spasmodic nature of the opening of new acreage for exploration, the discovery process, technical innovation, and changes in prices and costs mean that single-year results could be equally misleading. The company's '10K filings' with the SEC, which are public, allow further analysis: whether reserves additions are due to new discoveries, extensions of previous 'proven' reserves, purchases of reserves or revision to reserves in currently 'proven' reservoirs because of improved recovery technology, with some information about the years in which this has taken place.

A separate SEC issue is that it requires companies to report an estimate of the present value of their 'proven' oil reserves, with estimated production profiles, a 10 per cent discount rate, and the prices, taxes and costs prevailing at the close of business of 31 December of the year for which the company reports results. Few analysts would conduct commercial analyses under such assumptions, given the volatility of oil prices. Although these Net Present Value (NPV) calculations by definition must fluctuate with year-end oil prices, reserves volumes need not do so. ExxonMobil's 10K filing states that, when revising its reserves numbers 'in general, the corporation does not view temporarily low oil prices as a triggering event for conducting the impairment tests [of reserves numbers]'. It would be possible, however, for a company to take advantage of a high year-end price to increase reserves estimates, with the risk of a revision if prices were to fall the following year.

Contingent reserves

Definitions of reserves which are anchored to existing technology and economics do not allow for technical progress and changing economic circumstances. All the definitions of 'reserves' clearly understate the future potential production from known oil discoveries:

- Where full technical appraisal is not complete;
- Where further technology development may be necessary to achieve a feasible plan, and;
- Where or when, even with those conditions met, sales are at present uncertain or commercial conditions are not at present adequate.

Improvements in the scientific information, project design or commercial conditions would convert 'contingent resources' into 'reserves'. New discoveries would transfer estimates from 'prospective' to contingent resources or to reserves. Enterprises develop internal estimates of 'probable' and 'possible' reserves and contingent resources in order to plan how to convert them into reserves. If these estimates were coded in the UNFC scheme under the codes below 111, 112 and 113 (which are 'reserves'), it would be relatively easy to identify the real most important relevant contingency: pre-economics, feasibility, or geology. Some of this information could be aggregated into national estimates, as in Norway and the UK.

National reserves estimates

Governments and, in democratic countries, the political public, are interested, like enterprises, in the possibilities of production beyond those which are estimated in the 'proven' reserves or UNFC category 111. In countries where the industry is in the private sector these data are not normally available from information published by the companies. The SPE/WPC do not recommend, and the SEC does not recognize, the publication of 'probable' or 'possible' reserves estimates or estimates of contingent resources by private-sector companies. The internal information which would generate these numbers is used within companies in determining their forward programme, and may be disclosed confidentially to other companies in the course of negotiations for mergers, acquisitions, and assets sales or purchases.

In the US, UK, Canada and Norway and some other countries government agencies play an aggregating role in reviewing the states' own geoscience data together with internal data from private-sector companies (and state companies in Norway) to produce national numbers for contingent resources and to estimate the range of potential undiscovered resources. These agencies have access to some of the companies' 'internal' geologic data (because these companies are usually operating under state or federal leases and have reporting obligations). The agencies also have access to a great deal of engineering information, since, for the same reason, companies must file and often get approval for development plans for projects which will deplete the country's natural resources. Some resource conservation and petroleum regulatory agencies, for example, require that after a specified confidentiality period, cores, well logs and other data be submitted to and made publicly available at government-managed facilities where other explorers may have access to the information. The analyses published by these government agencies are quite detailed, and are designed to give a

democratic accounting of the petroleum resources of the country concerned. In a general sense, such information also assists external assessment of the country's economic resources. [5]

Decisions by individual countries may have a significant international impact. The Alberta Energy and Utilities Board in 2002 determined that 175 billion barrels of oil were recoverable with existing technology and economics from the Albertan oil sands. These had previously been excluded by definition. This change was accepted by the *Oil and Gas Journal* for its published annual review of world oil reserves, and in turn by the Energy Information Administration of the US Department of Energy. The *BP Statistical Review,* which reports estimates from various sources, has not in the past recognized these as reserves. However, in its 2004 *Review*, it chose to recognize some 11 billion barrels, specifically those reserves that are under active development in the three mining operations and the few projects employing *in situ* steam techniques. OPEC member countries report 'reserves' to the OPEC secretariat, which does not prescribe the basis on which the submissions should be made. Several OPEC member countries made increases of around 300 billion barrels in the 1980s, with less explanation than in the case of Alberta The aggregations of 'reserves' in these published sources combine 'proven' reserves, as in the case of Mexico, with 'best estimates' in the case of the UK, and unexplained numbers in the case of most OPEC countries.

In countries where state monopolies exist (apart from Mexico), there are generally no public statements of the basis of the declared estimates of reserves and no estimates of prospective undiscovered resources. In some cases, such as Saudi Aramco, the company states that SPE/WPC definitions are used in estimating reserves, but it is not clear whether these estimates would meet SEC standards. Saudi Aramco has recently published, through presentations, 'best estimates' of oil reserves and resources as follows:

Undiscovered resources

Remaining proven reserves	260 bn bbls
Probable	32 bn bbls
Possible	71 bn bbls
Contingent resources	238 bn bbls

No range of uncertainty has been published for the contingent resources.

SPE/WPC and UNFC definitions also exist for undiscovered petroleum resources (UNFC code 334). These are predictions of future discoveries, given some elements of geologic information and similar (but much less precise) sets of options for development projects and assumptions about economic conditions, as are used in predicting the range of probable production from discovered resources. The same problem exists for undiscovered resources as for discovered resources, that estimates of future production (i.e. remaining reserves) involve combining estimates of future scientific, engineering and economic conditions. In the case of undiscovered resources the range of uncertainty regarding total petroleum in place (if any) is wider than in the case of discovered resources. Companies may estimate the probabilities of future discoveries but do not usually share their specific information.

One source of difficulty in public debate is the discrepancy between national statements of 'proven' reserves and the separate estimates of recoverable resources, including undiscovered resources, made for the world by the US Geological Survey of World Petroleum Resources, and for the US by the National Petroleum Council. The USGS world survey covers the main geological prospect basins, not the whole country, and there may be some definitional issues; it was compiled by expert review of published data, and not from internal national oil company information (though Saudi Aramco have recently used USGS data in discussing their reserves). The USGS estimates the technical recoverability, but not the economics, of the reserves and resources it identifies (in other words, it looks only at the F and G dimensions of the UNFC system). One would expect its estimates to be higher than those that include economic criteria. However, this is not necessarily the case.

The USGS survey, though published in 2000, was essentially based on a survey of 1996–7 data. Comparison with the official reserves numbers reported by governments either to the OPEC secretariat or the *Oil and Gas Journal* for its 1997 annual survey shows the following examples where the official statements of 'remaining proven reserves' *exceeded* the USGS estimate of 'known oil, less past production' by the following amounts:
The Mexican number is particularly interesting, since this anomaly with the official reserves numbers has now disappeared. Pemex revisions to comply with SPE

Iran	22 billion barrels
Iraq	34 billion barrels*
Kuwait	36 billion barrels
Saudi Arabia	46 billion barrels
Mexico	26 billion Barrels

* This is included in the much quoted Iraq reserves numbers of 112 billion barrels

definitions and then with the more limiting SEC definitions led to a reduction of 36 billion barrels in the government's statement of reserves which are now reported as 'proven' reserves to the SEC and (as one would expect), significantly *lower* than the USGS number.

For comparison, the SEC 'proven' reserves of the top nine private-sector companies in the world (outside Russia) total 63 billion barrels, and the reported 'proven' reserves of the top five Russian companies total 45 billion barrels. The anomalies in the major Middle East producers' stated reserves numbers are greater than the Russian and other private-sector 'proven' reserves companies.

The UNECE Committee on Sustainable Energy has convened an Ad Hoc Group of Experts on the Supply of Fossil Fuels which will meet in November 2004. As part of a broader agenda the Group will use country case studies to illustrate the application of the UNFC to national reserves estimates and to particular types of fields and deposits. It is hoped that this work will lead to a more coherent presentation of national reserves estimates.

The global question in the longer term

Improvement in the consistency of national reserves estimates will not remove the longer term uncertainties about how much reserves may be increased by 'growth' resulting from the application of new technology to known resources, or by discoveries of new reservoirs. From time to time the US Geological Survey has published a world-wide review which includes estimates (with a probability distribution) for known reserves (including 'probable' and 'possible') and undiscovered reserves for the main geological reservoir prospects worldwide. The data available for such estimates vary in intensity and quality. The USGS used all publicly available data, which is evaluated with the help of panels of experts, to produce its estimate. It is the only large-scale, publicly available source of estimates for future possible discoveries. They are relevant to discussions of long term oil and gas supply and greenhouse gas impacts. As Figure 2 shows, the range is very wide.

The up or downside (compared with the mean) on possible future discoveries and reserves growth together totals more than the cumulative production to date. The USGS set a horizon of 30 years on its estimates: clearly the pace of new discoveries will depend on access to acreage and incentives to explore, and reserves growth is likewise subject to government depletion policy (in NOC countries) and commercial conditions, so that the speed at which these uncertainties could be resolved is uncertain, though important.

Comment

Oil and gas reserves cannot be measured. Geological, engineering, and economic information, including predictions, must be combined to give estimates of how much oil and gas may be produced in the future. The recent UN Framework Classification builds on previous work by the Society of Petroleum Engineers and others to provide a flexible, consistent, and comprehensive system which makes the process of estimating transparent. Until such a system is widely adopted - especially in major oil and gas resource countries - great care needs to be exercised in interpreting numbers which purport to describe reserves of oil and gas.

Table 2: Table for Undiscovered Conventional Oil Reserves & Reserves Growth Outside the US (Source: USGS Worl Survey 2000, Table AR1)

	Billion barrels (crude oil only; excludes NGLs)			
	F95	F50	F5	Mean
Undiscovered conventional	334	607	1107	649
Reserves Growth(conventional)	192	612	1031	612
Remaining reserves				859
Cumulative production to 1.1.96				539
Total				2659

Endnotes

[1] For a discussion of US practice, see Energy Information Administration, *US Crude Oil, Natural Gas and Natural Gas Liquids Reserves 2002 Annual Report*, Appendix G.

[2] A detailed discussion of the sub-divisions and comparison between the UNFC and SPE/WPC systems is contained in the report of the Ad Hoc Group of Experts to the UNECE Committee on Sustainable Energy, ECOSOC paper ENERGY/GE.3/2003/1 of 7 April 2003.

[3] The International Financial Reporting Standards which will be used in Europe and Australia from 1 January 2005 do not provide specific rules for reserve accounting. European and Australian companies will no doubt continue to include reserve accounting in the reports which they prepare under US accounting rules.

[4] The SEC does not recognize 'proven' reserves from deposits that rely on mining techniques for their recovery. Their rule reads: 'crude oil, natural gas, and natural gas liquids, that may be recovered from oil shales, coal, gilsonite and other sources. ... Hydrocarbons 'manufactured' through extensive treatment of gilsonite, coal and oil shales are mining activities reportable under Industry Guide 7. They cannot be called 'proven' oil and gas reserves.' In the case of the Alberta oil sands, over 90 per cent of the oil in place is recovered where it is mined, the highest recovery rate anywhere, and its certainty of recovery is extremely high given the detailed

delineation drilling that must be applied for mining operations. Paradoxically, laterally contiguous bitumen in the same geologic formation, but at depths beyond mining methods, where in situ steam stimulation techniques must be employed, and where the rate and certainty of recovery is much less, is potentially less viable under current economic conditions given North American gas prices. The SEC allows companies to book oil sands as 'proven' reserves where an active project is underway. Companies active in oil sands mining, which report under the SEC, identify their mined reserves under a separate heading, noting the SEC's ruling their non-inclusion in the company's global reserves.

[5] Alberta's estimate of oil sands reserves is based on thousands of wells, tens of thousands of core samples and well logs, applying a strict set of criteria on minimum thicknesses of continuous oil sands, assumptions of horizontal continuity based on adjacent wells, and so forth. Alberta requires holders of oil sands leases to drill a set number of wells per section (160 acres) and specifies the percentage of wells from which cores are pulled and the minimum percentage cored of cored wells. These data are publicly available and government geoscientists make their assessments accordingly. Others can view the data and arrive at their own conclusions. The openness is conducive to further exploration and competition among explorers, and a deeper and more precise understanding of just how much 'resource' is there, and how much might be converted to reserves.

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