BALANCING EXPLORATION AND PRODUCTION TECHNOLOGY NEEDS

Ladies and gentlemen, good afternoon. Thank you very much for the opportunity to be here and to speak at this Peter Ellis Jones Memorial Conference. The perspective that I bring is that of a technology supplier to the oil and gas industry—I will leave the real geopolitical context to people far more qualified than I.

I'd like to begin by taking a look at a little history.

The extraordinary adventure of oil and gas exploration and production over the last 150 years has been characterized by unprecedented globalization. Oil and gas have dominated the world's energy mix through their ability to provide affordable, efficient and readily transportable sources of energy. And as sources closest to the first markets

depleted, the low cost and flexibility of liquid hydrocarbons ensured that the quest for new supplies stretched the frontiers of both geography and technology.

The resulting energy has powered world economic growth over the same period. The geographical diversification and continuing technology development that lowered cost and increased production allowed us to guarantee continued supplies to the consumer markets where it was most needed. For us as an industry the words economic growth, energy, globalization and technology are synonymous, and in almost any phrase that links them, changing their order rarely changes their relationship.

As many have noted, as good an illustration as any of the global dependence on our industry was the decision made by Winston Churchill as First Lord of the Admiralty in 1913 when he was faced with the choice to switch the primary fuel supply of the Royal Navy from coal to oil. At the time, Britain had access to vast coal reserves both at home and abroad but the benefits of oil were apparent—smaller ships, fewer sailors, greater autonomy and better performance.

"On no one quality, on no one process, on no one country, on no one route and on no one field must we be dependent. Safety and certainty in oil lie in variety and in variety alone". Words just as valid today for the fast developing economies of China and India, as they were for the British in the years preceding the First World War. The result of Churchill's decision was of course to promote British interests through the support of Shell and BP and I would contend that this is not so very different from the today's developing economies approach of wanting to lock in relationships with the world's major resource holders or the interdependence between producers and consumers in developing and marketing gas resources in the Eastern Hemisphere.

As soon as diversification in the search for oil supplies away from sources close to the largest market in North America began, the question of security of supply, and in particular the question of consumer access to reserves in countries with the capacity to produce, has been the cause of massive changes in the way the exploration and production business has been conducted. Often as not, politics rather than economics have been the driving force. The post WW1 distribution of the Middle East; the competition for the attention of King Ibn Saud during and after WW2; the realization by the OPEC producers of their power in the 1960s and 1970s with their subsequent adoption of control over their own reserves; and the post-Soviet struggle for influence in the Caspian and Central Asia are all examples of how consumer fears of lack of supply and producer desires to control the destinies of their own natural resources have caused huge shifts in our industry.

These shifts have also had a dramatic effect on the development of technology. Of course changing economics were also responsible, but the changes of ownership in the 1960s and 1970s encouraged the development of the offshore technologies that allowed the

development of the North Sea, and of Cantarell in Mexico, while adaptation of exploration and production technology to Arctic conditions enabled the development of Alaska. To a certain extent it can therefore be said that the type of reserves available governed the direction taken by the development of technology.

At the same time, the national oil companies who had not traditionally been large investors in E&P technology became increasingly competent in technology application and development. This was partly driven by a lack of availability of technology from their previous partners after the wave of nationalizations, and partly due to their reserves-specific technology requirements. Their concern is more the long-term management and custodianship of their resources, rather than any rapid change in production that the market may demand.

Meanwhile, the post-1973 era saw an increased role in technology development for the service companies as the demands made on them by their customers led to an increasing range and greater complexity in their products and services. This trend accelerated in the late 1980s as oil companies cut discretionary spending and the resulting shift in a lot of the industry's R&D investment to the service companies has endured to this day.

By now I'm sure that you are asking yourselves what is the point of this history lesson? Well, I am simply describing this situation because in my mind a number of factors have converged to cause another major shift in the relationship between producers and consumers of oil and gas. This new shift is having, and will continue to have, a dramatic effect on the role of the exploration and production industry and the technology that it develops.

Five factors make the current situation somewhat complex. The first of these is the higher price of oil caused by a combination of increased demand, a lack of renewal of the production base in the twenty years that prices were low, and the re-appearance of the

peak oil theorists who amplify the factor of scarcity or fear. Geology and economics do not sit well together in academic arguments but in my view the availability of new resources at current prices is not in doubt. The resources may not always be where people would like them to be, nor of the quality they would like, but they are there.

The second factor that makes this period in the history of the oil and gas industry so different is the unprecedented restriction in the flow of market capital to the ownership of reserves. Estimates show that less than 25% of oil reserves are freely available to investment by international capital, and of that 25% a considerable proportion is currently held by new Russian companies. Debt and project financing are of course available but the risk mitigation factor of an international partner or consortium is less and less the case. Major resource holders are increasingly conscious of the additional value that high prices have placed on their reserves and are increasingly reluctant to share the additional rent with international partners. This places an equally unprecedented responsibility on the national oil companies to respond to the supply challenge, and on the major resource holders to provide their national champions with sufficient capital to get the job done.

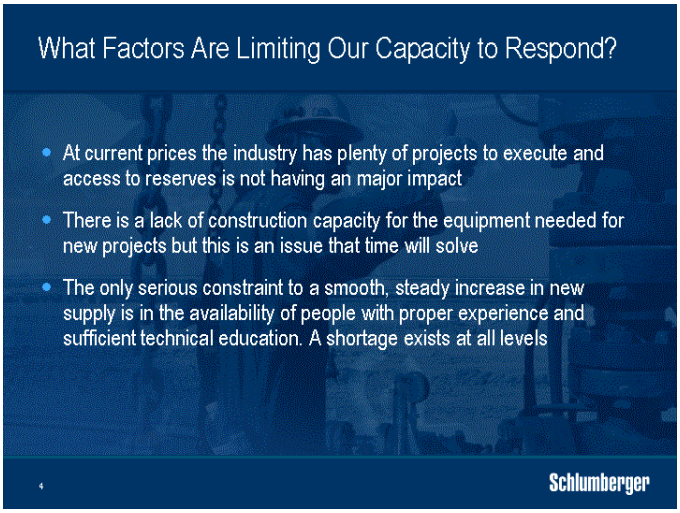
The third factor is the expansion in activity of many national oil companies beyond their geographical borders. Perhaps the same was once true of the companies we now call the IOCs. After all, Standard Oil began as a national oil company. So while this is nothing new, it is taking a slightly different form and there is a new generation of companies—that have been called the international national oil companies—out scouring the world for reserves. There are those who want to replace their domestic resources that have reached, or are reaching maturity. And there are those who are the champions of the increasing energy needs of the developing economies for whom domestic resources have become insufficient. Whatever the reason these players add a new dynamic in the search for access to reserves and this trend is sure to continue.

Fourthly, I think we would be wrong not to mention the effect of the climate change debate. We can no longer ignore the levels of CO_2 emissions in the atmosphere and the contribution made by the burning of fossil fuels makes. We should therefore be contributing to the possibilities that exist to reduce them among which carbon capture and storage is a technology that the oil and gas industry has already mastered to a large extent. We should actively promote its practice both in our industry and beyond.

Finally, and largely as a result of some of the preceding factors, the current call on the industry's physical and human resources to meet the supply challenge is unprecedented. It is not just that we have begun a new cycle of exploration and development to expand production capacity—it is also that we are trying to achieve massive developments of natural gas production capacity and refining and transportation infrastructure. In North America, activity levels unprecedented since the early 1980s are underway to develop poorer quality gas reservoirs to keep pace with gas supply depletion from the older fields. Huge investments are being made in unconventional hydrocarbon projects such as the

Canadian tar sands. Elsewhere many oil and gas projects in Africa, the Middle East and Eastern Russia have strained the industry's capacity to deliver, and have certainly limited our ability to do more in the short term.

Within this context, I would now like to turn to the strains being put on the producing organizations be they oil companies, service companies or construction companies. We need to recognize that our industry is suffering from a long period of under-investment with the result that we have only limited capacity to respond. We are not alone in this dilemma—look at the nuclear industry where failure to invest since the late 1980s led to a lack of nuclear engineering and construction capacity which will severely restrict that industry's ability to grow rapidly. The commodity boom in other raw materials such as iron ore and copper has placed similar strains on the mining industry as far as people, equipment and infrastructure are concerned.

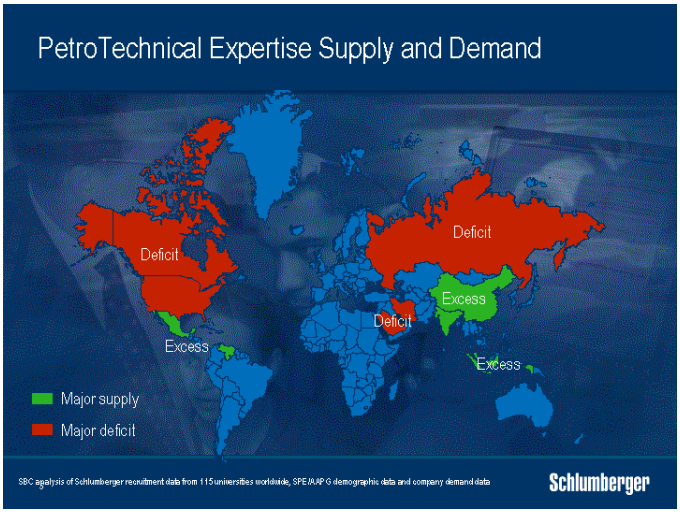


So I think that there are really three factors that limit our capacity to respond. The first is the lack of places in which to invest, which is caused to a large extent by access to reserves. This does not necessarily reduce any long-term potential as national oil companies and major resource holders certainly have the needed capital. Short term however, it does reduce flexibility. While I do not believe that this is having a major impact at the moment, it may do so in the future. At current prices I think that the industry has plenty of projects to execute and it is more the lack of equipment and people that is slowing the response. It is not access to reserves.

The second factor is the lack of construction capacity for the equipment needed for new projects. I'll be brief here, not because I don't consider it important, but because I think it's an issue that time will solve. The growing industrial might of China, India, Brazil and the Middle East will rapidly adapt their construction capacity to meet the need for rigs, platforms, tankers and refineries, just as Korea, Japan, Malaysia and Singapore did in the 1970s. It is quite extraordinary that over the last two years an industry that was

considered to be somewhat slow and distressed has taken orders for nearly 90 new drilling units for delivery between now and 2009. So if equipment is not a long-term issue, where does the real constraint lie?

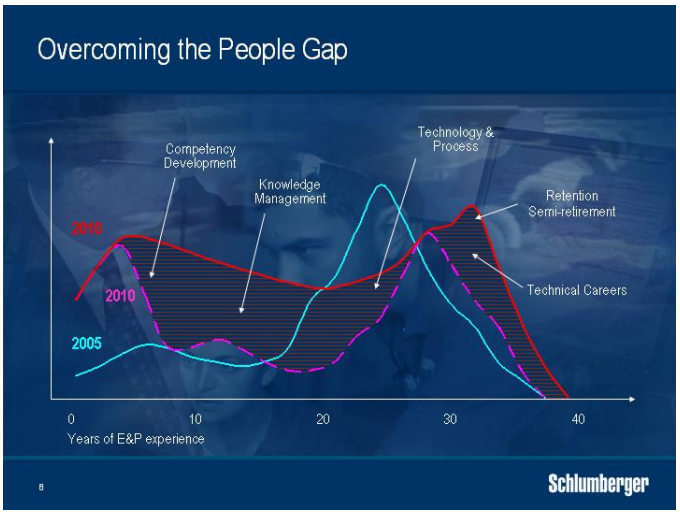
In my opinion the only serious constraint to a smooth, steady increase in new supply is in the availability of people with proper experience and sufficient technical education. Unfortunately a shortage exists at almost all levels of our industry. This is the result of the under-investment in new talent, and the discouragement of existing talent, over the last twenty years. While I am sure you all know the figures let me just quote a few. The number of jobs lost between 1993 and 2000 by the listed Western oil companies was more than 200,000. The US graduated more than 1,500 petroleum engineers in 1984 but by 2000 this had become just 260. And this must also be seen against the overall US enrollment in engineering disciplines of all types that has dropped by more than 24% over the same period. Contrast this with the extraordinary increases in students enrolling in computer and life-science disciplines over the same twenty years. Fortunately market mechanisms do work, and professors will tell you that in the current high-price environment, enrollment in earth science disciplines has already begun to increase.



Equally fortunately this is not true everywhere. The data shown on this chart come from a recent Schlumberger Business Consulting study that surveyed the workforces of more than 30 oil and gas companies worldwide. It includes figures from AAPG membership statistics, as well from the 115 universities that supply the major part of the industry's technical professionals. The objectives of the study were to quantify the difference between the supply and demand of petrotechnical disciplines to determine those changes that are likely to impact the industry in both the short- and long-term.

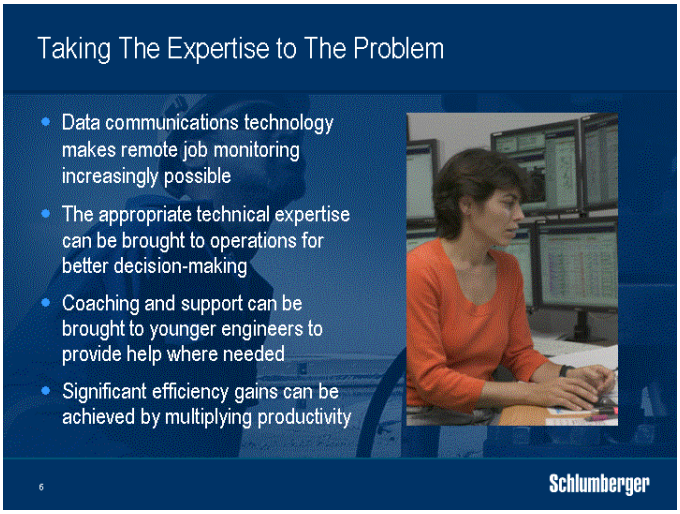
The results show that although the supply of technical professionals may well be sufficient to meet demand at a global level, major shifts in recruitment patterns will be needed and it is these shifts that present challenges for the competency development and

career models in place today. This means that as the human resources will inevitably come from diverse nationality backgrounds, attracting the best will require acceptance that career advancement be open to all, even for nationals of countries other than the oil company's original home. This is something that, in my view, all companies in the industry need to take very seriously.



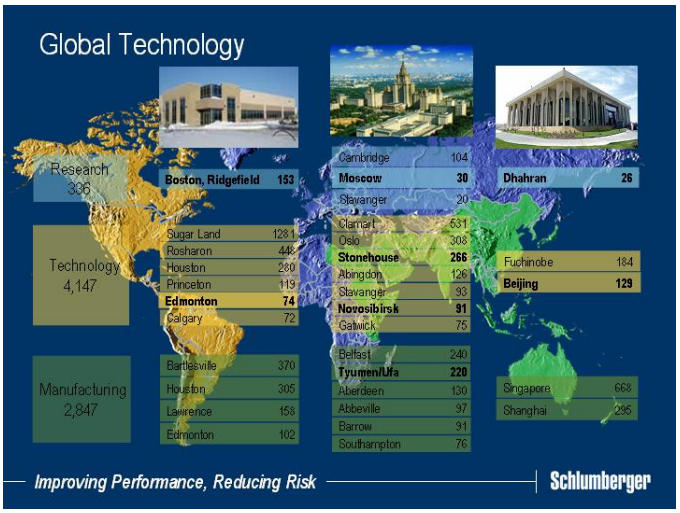
Solving this human resources challenge will not be possible without a massive cooperative effort on the part of the industry and this is perhaps best illustrated by way of an example. In this chart, the blue line shows the experience profile of a medium-sized independent oil company in 2005. The data come from the study that I was describing a moment or two ago. The dotted magenta line represents how we would expect this profile to change as a result of the massive industry recruiting efforts of today.

But these efforts are not going to be enough to yield the expertise and ability that will be needed to develop the far more challenging reservoirs of tomorrow. So just as now we must expect a certain amount of mid-career recruitment—also this is largely a zero-sum game—and we must also look at how to make our human resources more productive in terms of their ability to make independent decisions earlier. Competency development, knowledge management, technological advancement, process change as well as a focus on technical career development and better management of retiring senior employees are all part of the solution. Let me give you some examples of what can be done.



Our industry still operates very much by taking the expertise to the problem rather than bringing the problem to the expertise. Today, however, the data communications technology that exists between the field and the office has made remote job monitoring increasingly possible. Remote monitoring means that not only can the appropriate technical expertise be brought to operations for better decision-making, it also means that coaching and support can be brought to younger engineers by experienced professionals monitoring several jobs in real time and providing help where needed. These changes in working practices lead also to significant efficiency gains that alleviate strain on personnel. Our own experience has shown that remote drilling operations centers can multiply the productivity of drilling engineers two-fold or three-fold as measured by the number of wells that they can supervise simultaneously.

The degree of automation that we will finally achieve remains unknown. The heterogeneities of nature are such that producing oil and gas will never become a factory process, but we can certainly do better than we do today. We've all heard a lot over the past few years about the digital oilfield. We have heard ambitious claims for real-time reservoir management, not least from my own company, and these ambitions will undoubtedly be realized at some point in the future. Not only will this allow decisions to be made on up-to-date data, it will also allow automation of tedious and repetitive tasks to free time for more productive and timely decision-making.



Enhanced communications in our industry will also promote what we call global technology development. Early models of research put R&D centers close to corporate headquarters. But today, R&D is moving closer to producing oil and gas fields and closer to centers of academic excellence. At Schlumberger we opened a new research center at Moscow State University five years ago, we opened a research center in Dhahran close to the campus of King Fahd University of Petroleum and Minerals in March last year and we are moving our primary research center to Boston, Massachusetts. The advantages are clear. Proximity to the field allows laboratory work to be compared almost immediately with practical experience, and proximity to academia promotes technology sharing from industry to industry. Both offer significant returns in the development efficiency.

A few minutes ago I mentioned how I felt development of technology had been influenced by the needs of the reserves being developed. Today, as access to reserves becomes more limited, I contend that technology development will increasingly focus on the requirements of the different industry players, and on the types of reserves available to

them. This change, which will be both slow and non-uniform, is a change that could considerably affect the long-term future of our industry. If you look at where the remaining large unexploited bodies of oil and gas reserves lie, and if you assume that industry access is unlikely to radically change any time soon, and, if you add the geographical origin of many of the future experts in our business, you can conclude that the technology priorities of oil and gas producers in the consuming nations are diverging from those in the producing nations.

Some of this change is obvious. In North America, many developments are already concentrated on non-conventional sources of hydrocarbon such as shale-gas, coalbed methane or heavy oil. In the Middle East, geological differences are driving technology development for improved recovery factors in carbonate reservoirs as well as for dealing with larger and larger proportions of sour gas. Then there are the more local factors. Deepwater technology, for example, will undoubtedly be increasingly developed by the companies that no longer have access to more conventional reserves. Elsewhere, technology for new arctic operations will largely be restricted to Canada, Alaska and Russia.

My conclusion is that the challenges of increasing supply will mean that industry players will become more and more specialized in certain areas of hydrocarbon exploration and production technology. This specialization will inevitably give rise to new leaders in these areas. Technology development will become more local or become focused around particular types of operation. Inevitably, this will require people and research and development to become more local in character. And this in turn will spread the burden of developing the new technology necessary to sustain new supply more evenly amongst the consuming and producing nations. These are all signs that as we engage in the development of new supply, the complexity of the hydrocarbon mix is increasing, and that technology will have to move faster to keep pace.

This specialization may well have one further consequence that is a reflection of the new producer dynamic. The education of the workforce, and the development of technology in the past have remained the domain of the traditional key consuming nations—at least in the upstream sector. The demographics of the likely sources of new human capital, together with the need for the producing nations to access the technology needed to exploit their natural resources, could well shift a large part of the technology advantage to those producers. I am sure the skeptics out there are thinking “impossible”. But I would remind them that the US automobile industry did not take the Japanese seriously until it was too late.

Ladies and Gentlemen, I wish you a very successful conference, and I thank you for your attention.