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The E&P Challenge: Achieving the Four Trillion Barrel Vision

Society of Petroleum
Engineers Dinner
Meeting



Abdallah S. Jum'ah
President and Chief Executive Officer, Saudi Aramco

DHAHRAN, December 18, 2006 -- Thank you, Jamal, for that introduction, and let me thank the Society of Petroleum Engineers for the opportunity to address this distinguished group of friends, colleagues and fellow petroleum professionals. SPE as a worldwide organization has an important role to play in preparing upstream experts to meet the energy challenges we face, but when it comes to SPE's Saudi Arabia Section, there is probably no other chapter that can contribute as much to satisfying the petroleum needs of an energy-hungry world.

Without a doubt, oil and gas are indispensable to our modern way of life, to the health of the global economy, and to helping countless communities around the world realize their aspirations for a brighter future. With very few exceptions, the planet's six-plus billion inhabitants rely upon petroleum and products derived from it for their transportation; to grow and distribute their food; to preserve their health and cure their diseases; and to produce thousands upon thousands of essential consumer items. Look around this hall, and you will find very few things that have not been produced using petroleum at some stage in their manufacture.

By 2025, our planet will be home to some eight billion people, and whatever else may change in the next twenty years, I believe that Saudi Aramco will continue to be their best and brightest hope for a stable, reliable and affordable supply of petroleum.

However, meeting that challenge won't be easy. According to the International Energy Agency's latest estimates, global demand for oil will increase from 85 million barrels per day at present to more than 116 million bpd by 2030. In other words, for every three barrels produced in the world today, our industry will have to add a fourth in less than a quarter-century—even as existing reservoirs are depleted and more production is drawn from increasingly more challenging fields.

Most of that demand growth will come from the developing world, largely as a result of increased levels of automobile ownership in those countries. For example, some 70 percent of the world's cars are currently found in countries

that account for less than 20 percent of the world's population, and while the United States has 655 vehicles per 1,000 inhabitants, India and China have only 10 or 20 vehicles per thousand people. So there is massive pent-up oil demand growth potential in these nations—potential that will be unleashed in the years and decades to come.

That shift is mirrored on the supply side of the equation, as OECD production steadily declines and developing nations contribute an ever larger proportion of global petroleum supplies. The Middle East will continue to be the dominant region for production, although supplies from the former Soviet Union, West Africa and Latin America are all set for growth in the coming decades.

But because oil is so important to so many people and demand growth is set for steady expansion, there have been increasing concerns voiced about the long-term adequacy of oil resources. Over the last several years, no less than thirty books have been devoted to the "peak oil" theory, the imminent exhaustion of oil, and the world's inability to grow future petroleum supplies. The peak oil proponents routinely used the rise in oil prices over the last several years as evidence for their arguments about scarcity, but with the recent pullback in prices and the moderating call on oil from Saudi Aramco and other major producers, many now acknowledge there is actually an oversupply of petroleum in the market. In fact, what seems to be in short supply these days are vocal peak oil theorists!

But while fears over the long-term prospects for oil as a fuel source have receded to some degree, what remains is our industry's very real need to expand oil supplies in order to meet increasing demand. To tackle that challenge, we need to press ahead in three major areas: hydrocarbon resources, petroleum technology, and human resources.

Much of the speculation about future petroleum supplies has focused on the size of the total resource base, the proportion of resources that can be recovered, and how far supplies can be grown. Of course, reserves are essential; we simply wouldn't be in business without them. But while there is nothing we can do about putting more oil in the ground, we do have a great deal of untapped potential when it comes to finding more oil and getting more of it out of the ground. Harnessing that potential is the topic I'd like to address tonight.

Let me begin by first looking at hydrocarbon resources from the perspective of new petroleum technologies. In fact, I think that viewing high-potential hydrocarbon resource opportunities around the world as "technology targets" is a very useful approach, and yields four major, distinct areas of activities or strategies for the future. These are:

- First, expanding the size of the oil-in-place pie by finding new oil fields;
- Second, increasing ultimate recovery from both the existing and yet-to-be discovered fields;
- Third, giving special attention to areas which are hard to explore and produce, thereby reducing costs and making uneconomic plays feasible, and finally;
- Exploiting the potential of unconventional oil resources.

Let me first take aim at technology target number one, finding new fields in

order to expand the amount of oil-in-place. Estimates of the Earth's total endowment of conventional oil resources vary between six and eight trillion barrels, though historically the industry has been fairly conservative in estimating both this total endowment and ultimate proven reserves. For example, global remaining proven reserves in 1960 were estimated at roughly 670 billion barrels. Today, even after nearly a half-century of steadily increasing production, those total proven reserves have almost doubled to roughly 1.3 trillion barrels. The reserve revisions in most fields have also been upwards—and often significantly so—since they were first discovered.

Technology has played a critical role in this trend, and a wide range of advances in seismic technology have dramatically improved the success rate in exploratory drilling and allowed us to more effectively develop and drain oil fields. Other enhanced exploration techniques and technologies have also played a role in putting the industry ahead of the curve in the crucial search for new oil and gas reserves.

In light of this historical trend, and the promise of new technological developments both incremental and revolutionary in nature, at last summer's OPEC Seminar I challenged explorationists around the world to find no less than eight trillion barrels of oil-in-place—the higher end of the current range of estimates. That should allow us to add roughly a trillion barrels of total proven oil reserves in the form of new discoveries: a massive target to which technological enhancements could be applied in order to achieve even higher recoveries. I would like to renew that challenge tonight through the SPE, and to urge exploration specialists and technology developers to draw upon their skills, knowledge and experience to meet that challenge.

The second technology target brings our petroleum engineering specialists into the picture, together with their geologist and geophysicist colleagues, in order to enhance oil recovery through advances in drilling, completion, production, reservoir engineering, numerical simulation, better and more highly integrated reservoir description, and enhanced oil recovery techniques. Different fields present widely varying development, production and recovery challenges, of course, but through the application of new technologies and better reservoir management techniques, recovery rates in general have been rising steadily, going from a global average of just over 20 percent in 1980 to about 35 percent now. However, that still leaves some 65 percent of these precious God-given resources in the ground.

Ladies and gentlemen, this offers us a massive opportunity. Just think: increasing recovery by just one percent could add about 80 billion barrels of oil to global reserves—equivalent to nearly a quarter-century's worth of Saudi Aramco's current production. Once again, I look at past trends in recovery rates and the ingenuity of scientists, engineers and professionals like you, and I see no reason why we can't increase the global average recovery rate to 50 percent in the next several decades. Frankly, I'm still not happy about leaving that other 50 percent to Mother Earth, but even hitting the halfway mark will allow us to add another trillion barrels to the world's reserves base. I must add however that as Saudi Aramco, our target for recovery will be aimed at much higher recovery rates, in the range of 70 percent, and that is the grand challenge you will be engaged in for decades to come. There is no more efficient way to grow future reserves than to go after the resources we already know exist, and by

identifying, developing and implementing technologies which will minimize the amount of these already discovered resources left behind.

Our third technology target comprises hard to explore areas, the reduction of E&P costs, and making previously uneconomic petroleum prospects economically feasible. Today, the industry's search for new reserves is shifting to much more challenging oil provinces, and in particular, to deep sea areas, Arctic regions, heavy oil, and difficult-to-produce reservoirs.

It is largely technological advances that have made the economic development of such challenging oil and gas plays possible. When it comes to offshore areas, the use of state-of-the-art offshore platforms, sub-seafloor completions and advances in multiphase pumping can make the economic development of ultra-deep sea oil deposits possible. Similarly, special steels and new offshore platform designs are being used to meet challenges associated with developing Arctic oil deposits and enhancing the reliability of supply from these fields.

Enhanced oil recovery technologies also have a role to play in many fields, particularly those where water-floods are nearing their economic limit. There are a wide variety of techniques being used in a number of pilot projects, and some hold considerable potential. Certainly a healthy oil price environment supports the application of these higher cost EOR technologies, and makes their economic use possible.

Although not all these emergent technologies are applicable to fields here in the region, they will play an increasingly important role in the industry throughout the world, and as such we have an interest in tracking their development and deployment. As members of SPE, you will also understand that technical advances in one application and discipline may be adapted for use in another, and may ultimately benefit our own upstream operations.

The industry's final technology target involves non-conventional heavy oil resources. Here again, there may not be a direct role for our region to play in their development, but such resources will have a considerable impact on the face and future of our industry as a whole, and on the global supply-demand balance. Because these are generally known, the challenge is finding production methods that can turn these resources into reserves and economic supplies. Therefore, it is useful to divide these non-conventional resources into two groups: the first consisting of extra heavy oil, tar sands and bitumen; and the second made up of oil shales.

The first group accounts for some 4.7 trillion barrels of oil in place, is already being exploited, and should make an increasingly significant contribution to global supplies. Current recovery from these resources is about a quarter of the oil in place, and here I would like to propose a stretch goal of utilizing technology to take that recovery rate to 50 percent, thus adding between one and two trillion barrels of oil to producible global resources. The technical, economic and environmental issues surrounding these non-conventional resources are daunting, but once again a range of emerging technologies hold out hope that this higher recovery challenge can and will be met in the decades to come.

The recovery of oil from oil shales is an even more complex process, and involves mining, transportation, processing and waste disposal operations which

require a lot of energy and water, and exact a heavy environmental toll. But oil shales are a massive target, with total in-place resources estimated between 2.5 and three trillion barrels. Given the considerable challenges involved in producing oil from oil shale, ultimate recoveries could vary considerably, and here again it will be innovative R&D initiatives and advanced technologies that hold the key to unlocking the potential of these extensive energy resources.

So looking at these four technology targets in total, where do we stand in terms of recoverable oil reserves? Add them all up and we have more than four and a half trillion barrels of potentially recoverable oil, or roughly 145 years of supply at today's rate of consumption. To put it another way, the world has consumed less than a fifth of its conventional and non-conventional producible potential, even excluding oil shale potential. So rather than "peak oil," I would argue that we're still only in the foothills when it comes to oil resources.

But let us not confuse confidence with complacency. Achieving these stretch targets will not be easy, and the development of the technologies required for success is far from a foregone conclusion. But I do believe that our industry, and our company, has the requisite human talent, knowledge base and skill set to bring these four technology targets within our reach. Therefore I put my faith in the people of the petroleum sector, and their ability to grow the global resource base.

And yet here, too, we face immense challenges. In the midst of one of the greatest periods of expansion in the history of the petroleum business, the industry is encountering manpower shortages brought on by market volatility, past employment practices, and the misguided perception among many young people that oil is an industry whose heyday has come and gone.

Thirty years ago, many talented young people saw petroleum engineering and related earth science disciplines as promising professions, but throughout the 1980s and '90s, the industry laid off thousands of skilled workers as a result of softening prices. Many of those people never returned to the oil business, the recruitment of new employees plummeted, and today many of the best and brightest students are opting to pursue careers in information technology and investment banking rather than earth sciences and petroleum engineering, not just globally but also here in the Kingdom.

Frankly, the global oil industry is now reaping a poor harvest from the shortsighted human resource policies of the past. According to the American Petroleum Institute, in fact, the average employee in the oil and gas industry is now nearly fifty years old. In the next decade, more than half the people currently working in our industry will retire, leaving behind a huge void not only in terms of numbers, but even more importantly in terms of job knowledge and experience.

Filling that hole requires a new approach to developing skilled professionals, but even if the industry and academia pursue the right HR development strategies, it will take a decade or more to close the gap, especially when it comes to specialized personnel like geologists, geophysicists, petroleum engineers and senior scientists and researchers, among whom the shortages will be most severe. However, I am glad to say that at Saudi Aramco, we are in better shape than many of our industry counterparts because we have consistently followed a

long-term approach of educating, hiring, developing and retaining our people.

Without a doubt, our industry owes much of its current success to the efforts today's top petroleum professionals have made over the last many decades, and at Saudi Aramco we celebrate and honor the contributions of our seasoned upstream personnel—including many of the people in the audience tonight. However, I believe you veterans will also continue to shape the future of both our industry and our company, through the lasting positive impact that can be achieved through mentoring young, promising professionals.

When that golden day finally arrives and you retire to pursue other interests and play with the grandkids, the Company will be sorry to lose you. But to be honest, I don't want you to take all of your hard-earned experience and hard-won knowledge with you when you walk out that gate for the last time. Instead, I need you to share your knowledge and wisdom with your younger colleagues now, knowing that you will still be contributing to our success and the Kingdom's prosperity for decades to come, as those young engineers and researchers rise to become the seasoned professionals of the future. So when you come back to work tomorrow morning, don't just think about what you need to do in the next eight hours, but rather about the impact you will have on the next generation of Saudi Aramcons in your area of expertise.

And there is no avoiding the fact that the members of that next generation of skilled oil and gas professionals will bear a relatively heavier burden than those who have come before them. The operational challenges they face will be increasingly complex, the tempo of technological change will continue to increase, and there will be smaller numbers of trained and skilled personnel available to tackle these issues. Tonight I am gratified to see so many young men and women in the audience, both those already in the workforce and those still studying for their degrees, and to know that you are actively pursuing skills and gaining knowledge. I derive a great deal of comfort from my interaction and conversations with our young upstreamers, and I am confident in your ability to master the challenges that will confront our company and our industry in the decades ahead.

But just as I've encouraged our experienced people to assume a more active role as mentors, I want to challenge you to take on more personal responsibility for the development of your own talents and careers. This is a business that depends on knowledge, and knowledge is gained through experience, by learning on the job, and by keeping up to speed with emerging trends and technologies. Don't wait to be taught; if you do, the pace of change in our industry all but guarantees that you'll be left behind. Rather, try to learn by doing, be an active participant in your own development, and learn from the senior people in your organizations—they are among the most experienced and the most accomplished people in our industry, and working alongside them represents a tremendous opportunity.

Ladies and gentlemen, with each passing day mentoring, learning, dialogue and collaboration are becoming even more vital to our business. That's because knowledge itself is becoming increasingly important in sustaining our success, and sharing knowledge and experience is essential to maintaining our competitive advantage as a company and as an industry. It's also one reason I'm delighted to hear about the Communities of Practices being promoted within your

organizations, the increasing use of the E-Way concept, and the focus on technologies and techniques that not only leverage expert knowledge, but also share lessons learned from practical experience. I am also pleased that in 2007 and beyond, the SPE will be devoting even greater attention to the issue of human resource development in the upstream sector. Continuous learning is indispensable in today's fast-changing world, and efforts like these help us to systematize and spread innovative approaches to our work. That's important, because talent and knowledge are really only beneficial when they drive our actual performance, and act as a catalyst in our operations and activities.

Ladies and gentlemen, in closing, a steadily growing global population and a rise in living standards in the developing world mean demand for our petroleum will continue to expand. Supplying that demand will not be easy, and in the years and decades to come I am sure that we will be tried and tested. But I am also confident that we can and will meet those challenges, because of the work that you do and the contributions that you make to our company, our industry, and to our country. Knowing you, the range of your skills and talents, and the strength of your dedication, I have every confidence that you will be successful.

Thank you, and good evening.

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