Energy Markets and Global Politics

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Crude oil prices exceeded $70 per barrel in the summer of 2006. U.S. average gasoline prices exceeded $3 per gallon during the peak driving season and were extremely volatile. Wars, violence and threats were undermining stability globally and in oil and gas producing countries and regions in particular. Oil demand has soared while spare production capacity has all but disappeared, leaving the market more volatile. Infrastructure throughout the world has been stretched to its limits. New refinery capacity in the U.S. and elsewhere has been limited due to commercial considerations and environmental concerns.

Are these economic and geopolitical events temporary, or is a shift occurring in the structure of energy markets, leading to higher future energy prices? If energy prices remain high, will this lead to sufficient investment to ameliorate or reverse the increases? How are countries responding to the perceived threats to their energy security? Are upstream pressures solely to blame for today's volatile markets, or are downstream problems contributing? What is happening in important producing and consuming countries? Are developments in the transportation sector adding to today's pressures or providing comfort for the future?

How are policy makers responding to all these events? Is the energy sector in a crisis that warrants dramatic action? Has the response been too complacent? A group of energy experts were asked to

address these and other questions at the Aspen Institute's Forum on Global Energy, Economy and Security in July 2006, and this report summarizes their discussions.

The Outlook for Energy

The Forum first looked at long term projections of energy demand and supply, primarily for oil but also for other resources. Since unconventional oil is becoming an important element in future supply projections, the discussions also focused in some detail on Canadian oil sands. The projections raised important energy security questions for policy makers, and the experts took a hard look at these questions from the U.S. perspective.

A baseline energy outlook to 2030, based on energy demand by countries and end-use sectors, was provided by a major oil company as a basis for discussion. Total energy growth was linked to economic drivers such as the growth in GDP and population. Population is expected to increase by one third, growing from about 6 billion people in 2000 to 8 billion in 2030. The non-OECD or developing regions grow at a rate more than double that of the OECD. The most significant increases will occur in Latin America, Africa and particularly Asia Pacific (the non-OECD countries of that region, including China, India, and others). World GDP growth will be robust and will more than double over the 30-year time period, with an annual growth rate of 2.7%. Despite strong growth in the OECD, the fastest growth will be in Asia-Pacific, led by China, India, Indonesia, and Malaysia. By 2030, the GDP of the Asia Pacific region will approach that of Europe.

This rapid economic growth will be a key driver of energy demand, and the world will need about 60 percent more energy in 2030 than in 2000. In the OECD countries, technology and efficiency gains will keep demand growth relatively small. But non-OECD demand, driven especially by the annual growth of 3.2 percent in the Asia-Pacific region, will move past the OECD countries. In addition the overall declining trend in energy intensity, the amount of energy

used per unit of GDP, will continue everywhere, but the trend will accelerate in developing countries.

The fastest growing area of energy demand through 2030 is fuel for electric power generation, growing annually at 2 percent. Not far behind are transportation and chemical demand, both growing at 1.7 percent per year. Natural gas and coal will experience the highest growth rates — 1.8 percent per year — due to their use in electric power generation. Oil demand growth will follow at 1.4 percent per year. At the projected growth rates, oil and gas combined will represent about 60 percent of overall energy use, about today's share.

Oil will continue to have the largest share among all fuels due to its use in the transport sector. In the OECD countries, oil demand is likely to peak by 2020 due to increases in the fuel economy of personal vehicles, including the growth of hybrid and diesel vehicles. In North America, fuel demand for light duty vehicles in 2030 will be about the same as in 2000, primarily due to 30 percent of the fleet moving towards technologies such as hybrids and diesels, while in Europe this demand should be less than it was in 2000. In developing countries oil demand will continue to increase through 2030, led by the transport sector, and by 2030 will exceed that in the OECD countries. Vehicle numbers are expected to quadruple in the Asia-Pacific region, but due to improved fuel economy, including the increasing use of hybrids and diesel vehicles, fuel demand will "only" triple.

Since oil demand is so highly correlated with transportation, a question arises concerning the impact of alternative transportation fuels such as ethanol. The projection assumed a relatively small penetration of ethanol by 2030, and especially cellulosic ethanol because of scale, cost and bio-engineering issues. To get to commercial scale is still an immense challenge. This projection met with much skepticism in the discussions, and several participants argued that all forms of ethanol would penetrate the market for transportation fuels much sooner and in larger volumes.

How will oil supplies be developed to meet the growing need? An estimate of conventional oil resources indicated that the world con-

tained about 3.2 trillion barrels, which is similar to the estimates made by the U.S. Geological Survey, with non-conventional resources such as oil sands increasing that total to over 4 trillion barrels. To provide some context to these numbers, from the beginning of its history through 2004, the energy industry produced about 1 trillion barrels, leaving more than 2 trillion of conventional resources still to be produced. The Middle East and the Russia/Caspian regions have the largest remaining resources, and only North America has produced over 50 percent of its estimated reserves. In the Middle East, the largest growth in production in the long term is projected to come from Iran and Iraq. It is likely that their production will decline in the short term; however, changes in the security situation or the regime and terms of access are likely at some point, and therefore production is expected to increase. Coupled with smaller projected increases elsewhere, these estimates led to the conclusion that we are not near peak oil production, and participants in the Forum did not seriously challenge this conclusion.

Today OPEC contributes about 30 million barrels per day (mmbpd) to world liquid energy supplies (oil, condensate, oil sands, natural gas liquids, gas-to-liquids, coal-to-liquids, and bio-fuels). By 2030, OPEC's output is expected to grow to 47 mmbpd, assuming that investments in development are made in a timely manner. The discussion focused on whether the Middle East can meet this challenge from a technical and political perspective. If OPEC only produces 35 or 40 mmbpd rather than the 47 mmbpd suggested by this projection, still an increase of 17 to 33%, does this imply much higher energy prices? Another question about the projections focused on access. Today about 75 to 90 percent of available deposits are closed to international oil companies (IOCs). Will this change over the time period to allow IOCs greater access? What if it doesn't? If not, will the financial and technical resources for development be available? There were no clear answers to these difficult questions; and they highlighted the difficulty of long-term projections.

In assessing non-conventional liquids production, synthetics such as gas-to-liquids and coal-to-liquids will play a small part, according to this projection, providing perhaps 1 mmbpd by 2030. Oil sands

could have a larger impact, but the oil price must remain high enough to promote the development of this resource (see below).

World natural gas demand is projected to grow at 1.8 percent annually through 2030. North American demand will grow at 0.5 percent annually, European demand at about 1.5 percent, and Asia Pacific's at an average of 3.6 percent annually, driven primarily by the use of gas in electric power generation. By 2030, Asia Pacific's daily natural gas needs will be on a par with North America at 90 billion cubic feet per day.

Imports of natural gas become increasingly important by 2030 to North America, Europe and Asia Pacific. With North American production declining, LNG imports are expected to increase to about 25 percent of supply by 2030. European gas imports will increase to about 85 percent of supply, with LNG making up a significant portion of these imports. Imports will remain at about one third of Asia-Pacific supply through 2030 with LNG comprising most of the imports or about 30 percent overall, but volumes will increase substantially with the overall growth in demand.

Since the energy outlook included non-conventional fuels, the discussion focused in more detail on the promising Canadian oil sands region, with known resources of 1.7 trillion barrels of bitumen in place. Not all of these resources can be developed using today's technology and economics; there are about 174 billion barrels of proved reserves in Alberta. This compares with proved reserves of about 264 billion barrels in Saudi Arabia, the largest conventional reserve holding. In 2005, Canada produced about 2.5 mmbpd, of which about 964 thousand were from oil sands.

Today's high oil price environment encourages the pursuit of oil sands investments and production. Estimates provided of the cost of supplying oil from the Alberta oil sands were in the $30-$35 per barrel range. With high energy prices Canada could produce about 3.5 mmbpd by 2020, with a potential to produce more than 5 mmbpd. But the region is experiencing serious cost escalations due to increased cost for the energy needed to produce oil sands. Oil sands

either are mined and then processed using large quantities of energy to produce the oil, or produced under ground (in situ), again using large quantities of energy to produce steam that helps turn the heavy bitumen into flowing oil. Both methods also require large amounts of water. Based on projections using the latest, higher estimates of the cost of production, it is more likely that Alberta's oil sands region will produce 2.6 mmbpd by 2015 and 3.2 mmbpd by 2020.

Natural Gas

Discussion of the global natural gas market centered on the turbulence in various regional markets, including Europe, Russia, Central Asia, Japan and the U.S. The growing importance of the trade in liquefied natural gas (LNG) for the U.S. was discussed in the context of the global trade and whether increasing U.S. reliance on LNG added to the volatility of natural gas markets or will affect national energy security concerns.

World energy usage has shifted toward gas, a trend that will continue. By some estimates, world use of natural gas will more than double by 2030. While there is abundant natural gas in the world, demand centers are far from where the resources are located. Russia, Iran and Qatar are the leading supply centers, while most of the demand comes from the developed regions of North America, Europe and parts of Asia Pacific.

Natural gas markets can be distinguished between those supplied by pipelines and those supplied by LNG. While there are similarities due to capital intensity and the need for long-term agreements, many analysts think about these markets differently. Russia's gas markets depend upon pipelines and not LNG. Asia Pacific relies primarily on LNG supplies. The U.S. depends upon both. The ensuing discussion will look at the gas trade from these different perspectives: pipeline, LNG and mixed markets.

Pipeline Markets: With the largest natural gas resources and proved reserves, Russia leads the world in production and exports, all

delivered via pipelines. It was not always thus, since earlier in the 20th century Russia (and other parts of the Soviet Union) relied primarily on coal and then oil. In the 1950s, Russia moved to gasify its economy, developing long distance pipelines to move natural gas from its sources in Siberia to the demand centers of Moscow and St. Petersburg, and eventually to Europe. As Russia relied more and more on natural gas for electric power generation, industrial use and residential heating, it developed an enormously wasteful pattern of use. Today Russia, Ukraine and Belarus are the most natural gas intensive countries in the world on a GDP basis, with an intensity about 10 times that of the U.S. This legacy continues, since all three governments maintain low domestic prices to subsidize internal uses.

Russia, however, is approaching a crisis, since its production is not keeping up with its potential demand. While Gazprom, the state-controlled gas giant, is meeting current demand by buying gas in Central Asia, their current investment strategy is not providing the necessary investments in the Russian upstream and in infrastructure development. This will affect regional strategic considerations, the future of the gas trade between regions, and Europe's energy security.

Another important element of Gazprom's strategy is its potential gas sales to China. To date, Gazprom has been relying on its West Siberian gas deposits as sources for pipeline gas for China, which is not in China's best interest since it would be competing with Europe for these supplies. Gazprom also seeks to undercut the development of the East Siberian Kovykta field by BP by refusing to agree to a development and export strategy unless it is given an opportunity to join the project. As a result, East Siberian pipeline gas for China has not entered into current negotiations between Russia and China. This is likely to change in the future as Gazprom secures control over East Siberian natural gas development. Pipeline gas from Russia to China, however, as well as to Japan and Korea, will have to compete with LNG. Unless the upstream development and pipeline transmission costs remain competitive, Russia may not become a player in the Asia-Pacific gas markets.

LNG Markets: Discussions of LNG focused largely on the Asia

Pacific market. In general, world gas markets served by pipelines still dominate; however, by 2020 LNG will comprise 40 percent of the total world natural gas trade, up from 20 percent today. Supply will not be the problem, especially in the Asia Pacific market. According to most recent analyses, there is an abundant supply available, with 35 million additional tons committed to the Asia Pacific trade coming primarily from Qatar, Russia (Sakhalin Island), Indonesia, and Australia. Moreover, another 60 million tons of LNG could come on line within ten years, primarily from Australia, Iran, Russia, and Indonesia. Still more potential supplies can be available from East Timor, Vietnam, Myanmar, and Russian production in the Barents Sea.

Future problems will come from the ability to develop infrastructure for the growing demand. The required investments will be high and will take time to put in place. Higher financing and material costs are being offset by the "scale effect" — lower per unit costs as the size of facilities increases. For example, the size of economic liquefaction trains has grown from 2 million tons per year to 9 million tons per year. The size of vessels to transport LNG has grown from 130,000 deadweight tons (dwt) to 240,000 dwt. Improvements in technology and operations have also led to reductions in the cost of supplying LNG.

Prices of competing fuels such as coal and LPG will be looked at carefully in setting LNG prices. Contract flexibility will be important as a way of sharing risks and rents. Destination clauses are disappearing, and this is a sign of increasing flexibility in the market. Finally, vertical integration may be a way to enhance security of supply and demand.

In China's dynamic economy, demand for LNG is expected to be robust, but it will depend upon the availability of infrastructure, LNG prices, ability to pay for the gas, and demand from the power and industrial sectors.

Despite a downward reduction in the U.S. demand growth forecast, overall the expectation is for a robust global demand increase and a big potential for the LNG trade. This growth, however, is fraught with problems and issues. Among the economic issues is the

fundamental question of demand security, that is, whether LNG will be affordable in many countries. In some countries, such as China, LNG will have to compete against coal. Moreover, the high cost of distribution in urban areas will have an impact on the affordability of gas. Financial challenges will have to be overcome, especially the high initial capital costs of putting together the entire value chain of an LNG project. In some countries, especially the U.S., siting and regulatory barriers will have to be faced. Environmental regulations in many countries will play an important role in the siting process.

For now, demand for natural gas will be robust. Putting together a deal with the required demand may be difficult, but not impossible. As already noted, in Northeast Asia pipeline gas may become competitive with LNG as pipeline gas volumes grow to levels making it more economical and competitive. The bottom line appears to be that deals are possible given some flexibility on the part of both buyers and sellers. A key question is whether LNG prices will stay coupled to oil prices or whether they will decouple. If they do decouple, then it is possible that LNG prices could fall significantly in the future due to supply exceeding demand, jeopardizing LNG deals.

Mixed markets — pipeline and LNG: The U.S. market for natural gas presents its own difficulties. The integrated North American market that relies primarily on pipeline gas no longer is adequate to supply all the natural gas needs of the U.S. and Canada. Increasingly alternatives are being sought, with pipeline gas from Alaska and LNG imports expected to meet future demand increases. The Northeast and Gulf Coast of the U.S. are the areas with the largest demand, while the Gulf Coast has the highest level of LNG receipt capacity today. Applications for future LNG terminals are targeting both areas. Many of the proposed receiving terminals already moving along the regulatory approval process have been slowed or put on hold due to high project cost or difficulties in attracting supply and capacity holders.

Today, most of the LNG coming into the five existing U.S. LNG terminals originates in Trinidad and Tobago, with Algeria, Egypt, Malaysia, Nigeria, Qatar, and Oman the other suppliers. While

much of the trade is under long-term contracts, spot cargoes do make it to the U.S. In order to attract these spot cargoes, U.S. natural gas prices will have to remain strong. In the last couple of years U.S. natural gas prices have exceeded those of the Asia-Pacific rim, the destination for most spot cargoes. Despite these premium prices, U.S. LNG terminal utilization rates in these years have been averaging only 35-40 percent.

In deciding whether and where to site a new receiving terminal in the U.S., the issues include security — both accidents and terrorism; regulatory; environmental; and public opinion relating to all of these. The economic issues include investment return, contract terms, availability of downstream infrastructure, and supply timing.

A developer must take into account the length of time necessary to develop the entire supply chain as well as the cost to do so. As an example, a five-million-ton, single-train liquefaction facility capable of processing about 630,000 mcf/day would take about six years to develop. This includes the time to develop the field producing the gas (six years), building the liquefaction facility (four years), building the ships to transport the LNG (three years), and building the regasification facility (three and one half years). The overall cost would be about $3.2 to $4.5 billion, composed of the following elements: upstream: $0.8-1.0 billion; liquefaction: $1.0-1.3 billion; shipping: $0.8-1.2 billion; and regasification: $0.6-1.0 billion.

Overall, global LNG supplies are expected to remain tight through 2009 or 2010. U.S. natural gas prices will have to remain strong to attract investments. Assuming demand continues as projected, the U.S. is likely to put into service 6-10 receiving terminals over the next 7-10 years. Public opinion and policy will dictate the location of these new terminals.

Natural Gas vs Oil: Differences between natural gas and oil are important to the future of natural gas trade. Most importantly, natural gas increasingly is being used as a fuel in electric power generation where alternatives are available, while oil is being used more and more for transportation purposes.

Another distinction between oil and gas is their different investment profiles. The need to develop natural gas production, transportation and consumption markets together often distinguishes the natural gas trade from oil, since once an oil upstream play is developed, there usually are many transportation and consumption markets. While natural gas markets are evolving and becoming more flexible, today's investors still need the comfort of a package that strings together all the elements of supply, transportation and demand.

National and Regional Strategic Considerations

Many of the above themes have national and regional strategic considerations, and the Forum experts considered several specific countries and regions. The impact on energy security in Europe due to disruptions in natural gas flows from Russia and the adequacy of future natural gas supplies from Russia were explored. China's economic growth and future energy demand were considered, both as they affect China's energy security and for their impact on regional and world energy markets. The political situation in Iran and its potential impact on world politics and energy markets and the continuing supply potential of Saudi Arabia were also discussed.

Saudi Arabia: Saudi Arabia is the largest oil producer and exporter. It also holds the largest oil reserves. Future production from Saudi Arabia can make the difference between adequately supplied or constrained markets. In response to concerns about the stability of the Saudi regime in the midst of strife throughout much of the Middle East, it was noted that the regime has been stable for more than 70 years and is likely to be able to make the investments necessary to meet future oil demand.

The Saudi oil industry sees its future inextricably bound together with China and its rapidly growing economy. Long-term agreements with China are very valuable, and this is one of Saudi Aramco's approaches to handling future risk. All agreements with the Chinese have been done on a commercial basis. The Saudis understand India's and China's efforts to diversify their sources of

supply, which is not viewed by the Saudis as an attempt to undermine or damage U.S. foreign policy. As a result, the Saudis increasingly are looking to Asia-Pacific markets for their future and less towards the West. Saudi Aramco, the Saudi National Oil Company, handles all of Saudi Arabia's oil production, but Saudi Aramco relies on international oil companies for many services. Saudi Aramco's relationship with IOCs is strong, since the Saudis appreciate the ability of IOCs to handle a variety of risks, including geological, financial and political, and like the IOCs, they would prefer to let the market operate without much government interference.

Saudi Arabia's long-term strategy is building trust between consuming and producing nations, both in the West and in the East (Asia-Pacific). Saudi Aramco's goal is to invest in many countries, build more downstream capacity to process its crude oil and at the same time enhance trust.

European Union: The 25 nations making up the European Union today are dependent on imports for about 50 percent of their gas supply, a figure that will exceed 75 percent by 2030. About 12-13 percent of current supply is in the form of LNG, about half of which is delivered to Spain and a quarter to France.

Of the half of European Union gas that is imported, most comes in the form of piped gas, with 42 percent of the imports from Russia, 10 percent from Algeria, and 3 percent from Iran, Turkmenistan and Libya combined. (The rest comes from Norway, not a member of the EU.) For ten countries, pipeline gas from Russia is their only source for imports, and for some, Russia is the only source of gas.

Europe faces asymmetrical policies. The exporting countries are increasing state control and are establishing export monopolies. Russia, for example, recently codified its longstanding practice of exporting gas only through Gazprom, its state controlled gas company. Simultaneously, many European countries are liberalizing gas markets and increasingly are privatizing their gas companies. The question is whether liberalized gas markets are compatible with supplies from export monopolies. If monopolies control upstream and

transport markets, can privatized companies successfully invest in these markets in order to diversify their supply sources? If so, on what terms, and do these terms enhance or diminish energy security? If downstream markets are liberalized and open to investment, can the export monopolies acquire some portion of the assets in these markets and use this vertical integration to foreclose competition? What is the role for transit countries, such as Ukraine, that import much of their gas from the exporting country?

Energy security is at the top of Europe's collective agenda; however, with little agreement among EU members to give leadership to the European Commission on energy issues, the outcome is likely to be piecemeal solutions that do not answer these fundamental questions. As noted above and discussed more fully below, an extremely important question for Europe is whether Russia will have enough gas to meet future European demand.

Russia: With about one quarter of the world's total gas resources, Russia has increased its production about ten percent since 2001 but has recently leveled off. About one third of the production goes for exports, but about two thirds of the revenue comes from these exports. Most of Gazprom's profits come from exports, since its domestic sales barely cover its costs.

While Gazprom is the dominant producer in Russia, accounting for about 85 percent of production, the role of independent producers and oil companies is important for Russia's domestic supply, freeing up Gazprom's gas for exports. Moreover, Gazprom's production increase of 6.8 percent from 2001 to 2005 lagged the 34 percent increase by the other producers over the same period.

Gazprom's market capitalization ranks it third on the Financial Times Global 500 index (behind ExxonMobil and GE and ahead of Citigroup and Microsoft). The Russian Duma recently passed a law designating gas a "strategic material" and Gazprom or its affiliates as the sole gas exporter. Many within Russia view Gazprom as a national champion. Nevertheless, there is a question about Russia's and Gazprom's willingness to invest in future supplies. The issue is not

one of money or resources. Rather, decisions are being made on political instead of commercial grounds. Among other goals, Gazprom wants to prevent direct control of resources by Western companies.

Another question is whether Russia has the technical ability to develop some of its more challenging deposits, such as Shtokman, a huge natural gas deposit located far off-shore in the Barents Sea. There is a strong possibility that Russia will have to turn to Western companies for their technical capabilities in some of its more difficult projects. But it is also clear that Russia is seeking cooperation from Western companies on its own terms.

Russia has pursued a practice that is unique among G-8 countries, in which government officials also are involved as officers or on the board of state-owned companies. For example, Gazprom's Chairman, Dmitry Medvedev, is also Russia's First Deputy Prime Minister and until recently was the Kremlin's Chief of Staff. Other senior Gazprom officials are close associates of President Putin from their days in St. Petersburg. To ensure they do not lose their assets, those put in positions of commercial power under Putin, in Gazprom and other state-owned enterprises, will be prepared to use every resource at their disposal to ensure the election of his chosen successor in 2008.

Gazprom is making a concerted effort to penetrate foreign upstream and downstream markets. In Central Asia it has been playing a dual role of economic and political actor, making supply deals in Turkmenistan, Kazakhstan and Uzbekistan, entering into long-term contracts for the Central Asia gas system, and locking up all existing transmission alternatives from these three countries. Its political activities can be viewed as working on behalf of the Kremlin in an attempt for Russia to re-assert its hegemony over the region. Gazprom decided that presently it is cheaper to buy gas from Turkmenistan than to develop its Yamal fields and recently acquiesced in Turkmenistan's demands for higher prices at its border — increasing the price from $65 to $100 per thousand cubic meters (mcm). As the price of gas from Turkmenistan and other Central

Asian countries increases, Yamal development will become more attractive. In the downstream, Gazprom has been focusing on Europe and has been making deals with companies in Belgium, Denmark, Netherlands, Hungary, Italy, and the United Kingdom among others. It also has been looking further afield with deals in Algeria, Libya, India, Venezuela, and Vietnam.

The key question is whether Gazprom's actions are market oriented, or it is playing politics, or some combination. After being urged by Western critics, Gazprom is raising its export prices to all customers with prices increases from $45 mcm to as high as $240 mcm — the amount charged to most Western European buyers. The problem is with the unevenness of the price increases (sometimes jumping five or six times the original price), with some increases looking more political than economic. Its actions vis-à-vis Ukraine and Georgia appeared more political, since both countries recently experienced political revolutions distancing them from Russia, while its actions with Belarus and Armenia appeared to smack of political favoritism.

A future Russian gas crisis may occur due to recent Gazprom investment patterns. Rather than investing in the upstream to develop new gas fields, Gazprom has been putting its money into pipelines and downstream investments. A serious question is whether Russia and Gazprom have a solid strategy to satisfy growing gas demand. An analysis of Gazprom's future gas supply shows a potential shortfall from expected demand of about 100 billion cubic meters (bcm) by 2010. There is a huge investment gap that is not being filled. Today's gas fields are mature and in rapid decline. As already noted, production has been stagnant over the last several years. Investment in new gas production has been small — merely maintaining its presence in the fields so as not to lose its licenses.

Domestic gas demand continues to grow at a rate of 1.5-2.0 percent per year. Independent gas producers are slowing their output due to hostile market pressure from Gazprom. Future supplies from Turkmenistan, while under contract for the short-term, are not reliable for the long-term. Development of the Yamal gas fields appears

delayed for 10 or more years. Meanwhile, many new export projects are being pursued, adding to growing demand. Where, then, will future supplies come from?

If Gazprom cannot meet demand from its own supplies, the consequences are troubling. It could mean more hostile takeovers of independent gas producers, further eroding competitive pressures. Domestic consumers may see dramatic supply reductions as gas is exported to meet international contractual obligations. Russia may have to rely on unstable gas supply arrangements from Central Asia. International consumers should be on notice of these troubling trends.

Russian gas production is not a resource issue, but an investment and political issue. Gazprom has emerged in some instances as a national champion, in others instances as an energy bully, and in still others as a strong market capitalist. When dealing with Gazprom, it will be necessary to understand all three of its roles.

China: China is confronting serious issues regarding energy security and is seeking to embark on a new strategy for energy development and use. It seeks to avoid copying Western consumption models by using less fossil fuel, but it recognizes that this strategy will be hard to implement.

China is both an energy producer and consumer; however, in recent years its energy consumption has exceeded its domestic production, particularly in oil and gas. Its challenge is how to achieve sufficient energy supplies at reasonable costs in a world of increasing demand and increasingly scarce supplies.

With China a net importer of oil since 1993 and now the second largest consumer of oil after the U.S., securing oil supplies for its rapidly growing economy has become a top priority. China will pursue a dual strategy of continuing to develop domestic supplies while it seeks additional supplies overseas. One Chinese analyst indicated that, like the U.S., "China wants to have diversified channels in case of disruptions." This "going abroad policy" will mean competition for supplies with IOCs and other companies seeking secure sources

of supplies. Rather than competing, China would prefer close cooperation with producers. China's pursuit of new overseas investment will take place bilaterally as well as multilaterally, where possible.

China is implementing its search for diversification through a strategy of buying assets in many different countries. Its three state-controlled oil companies, China National Petroleum Company (PetroChina), China Petroleum and Chemical Corporation (Sinopec), and China National Offshore Oil Corporation (CNOOC), have bought assets in Africa, South America, and Central Asia. Chinese companies also are working with the Saudis in looking for natural gas in Saudi Arabia, while providing investment opportunities for Saudi Aramco in China's refinery sector. For example, Saudi Aramco and Sinopec along with ExxonMobil are developing a grass roots refinery in Fujian province in China.

While the Middle East is still the largest source of imported crude oil and Saudi Arabia the largest supplier, Africa now supplies between one quarter and one third of China's imports. In Africa, Chinese companies are actively working in Angola, Nigeria, Sudan, Algeria, Niger, Chad, and Gabon. In the Americas, Chinese companies are active in Ecuador, Columbia, and, most recently, in Venezuela. In Central Asia, Kazakhstan has been the focus, and a new oil pipeline is now exporting Kazkh oil to western China. Chinese companies also have been working together with India's Oil and Natural Gas Company (ONGC) and striking deals in Syria and Columbia. Thus, despite the political firestorm in the U.S. that blocked CNOOC's attempt to buy Unocal, China views its "going abroad policy" as essential for its future economic growth and its energy security.

China's acquisitions will not diminish global energy supplies. Even if the assets were removed from the market and used only to supply China, this activity merely displaces what the Chinese otherwise would have bought on the open market. The Chinese companies often work in countries where U.S. companies cannot, such as Iran and Sudan, posing potential foreign policy problems for the U.S. Although these challenges are significant, there may be a silver

lining in that global energy supplies actually may be enlarged, since only the Chinese and relatively few other companies are willing to work in these politically troubled regions.

China is also focusing on energy efficiency, and its energy strategy recognizes that saving energy is the equivalent of developing new sources of supply. Although its goal is to improve its energy efficiency by 30 percent over the next two decades, and many think that China is a leader in efficiency, it is lagging in its implementation and is seeking ideas and assistance from the U.S. and others. There used to be a dialogue between the U.S. and China on energy efficiency, and China would be interested in renewing it and broadening its focus. From China's perspective these bilateral dialogues are more robust than multilateral dialogues, which do not appear to lead to concrete results.

Iran: The Forum's discussion of Iran focused primarily on U.S.-Iran political relations and was based on a presentation that was pessimistic about the current situation but optimistic about the future. In the past, relations between the two countries were based on misperceptions and misunderstandings, leading to a complete lack of trust. Discussion became ideological with each side becoming obsessed with the other. The relationship was mismanaged by both sides. The result was hatred and the development of mutual enmity.

The U.S. views theocracy as an unacceptable model of government. The U.S. also is troubled by Iran's eastward orientation to Russia and China. These disagreements have not been verbalized, but exist and undermine the relationship. Today, the U.S. focus with Iran is on terrorism and its nuclear ambitions. There are no territorial issues between the U.S. and Iran, nor is there real economic rivalry. On the other hand, the Iranian government used its policies towards the U.S. to their advantage to suppress democratic movements and keep the U.S. out of the country. Iran now says that the U.S. forced it into its nuclear policy. Although the nuclear issue is very dangerous and can lead to war, it does make each side think seriously of the other. Direct negotiations on this issue would be a breakthrough but, according to Iran, can occur only if there are no preconditions.

The Forum concluded that Iran and the U.S. should not miss the opportunity to negotiate. Iran is not strong enough to fight the U.S. Iran also should suspend enrichment, but suspension is negotiable and does not need to be a precondition to talks, as demanded by the U.S. It should be put on the table and, if there is success at the negotiating table, suspension could occur.

The U.S. really has no better option. War is not an acceptable option, and striking Iran's nuclear sites would not be conclusive since not all sites are known. In addition, an incentive package offered to encourage Iran to suspend their nuclear enrichment program has to be large enough so that the Iranian people will force the Iranian government to accept it. Right now neither the incentive package nor the stick is large enough.

In a more optimistic vein, one participant cited the adage that "Nations have no permanent enemies; they have permanent interests," leading to the expectation that eventually the U.S. and Iran will be friends. A recommendation was made that to move Iran towards democracy, the U.S. should enter into diplomatic relations with Iran.

Refineries and Refined Products

The Forum discussions of the downstream oil sector focused on the adequacy of refining capacity and whether recent high oil prices could be attributable to refinery problems or refined product markets. The experts considered whether recent high refinery margins will lead to additional refining capacity or whether these high margins are temporary and only will produce more profits but little, if any, additional capacity. Moreover, recent natural events have placed stress on refining and other infrastructure in the U.S. Will these stresses be reduced and corrected any time soon?

The group considered the link between crude oil prices and petroleum prices and the extent to which they influence each other. As a predicate to this analysis, there was a brief discussion of influences on crude oil prices. These included: the action of foreign gov-

ernments; the heterogeneous nature of crude oil (variations from light to heavy and sweet to sour); current and prospective actions on global warming; changing environmental specifications that require reformulated gasoline and oxygenates; differences in outlook between consumers and producers; rules of competition; resistance to siting new infrastructure; capital requirements; and, in the U.S., shifts from MTBE to ethanol.

The experts then considered an unconventional explanation of high crude oil prices. The general belief is that crude prices set product prices and actions that affect the crude oil market lead to changes in product prices. The innovative explanation presented at Aspen posits that these "crude-centric" explanations are wrong. Rather, for the last two to three years crude oil prices have followed and not determined product prices. Policies that limit the ability of the market to adequately supply the product market either lead to shortages or to increasing prices. As product prices increase, crude prices follow. Thus, the acts of automakers, governments and independent refiners will have more impact on product prices and hence crude prices than the actions of oil producers, whether NOCs or IOCs.

As evidence of this unconventional thesis, the discussions noted that even though OPEC increased production over the last two to three years and inventories filled to capacity, crude prices continued their steep climb. Even though inventories were brimming with crude oil and product prices kept rising, refiners were not operating at capacity. There was a mismatch between the kinds of crude oil available to the market and the ability of refiners to refine the crude oil into useable products.

Most importantly, environmental rules set by the EPA in the U.S. to produce cleaner fuels also contributed to refining capacity shortages and erected non-tariff barriers that prevented some foreign producers from participating in U.S. markets. The EPA placed most of the cost burden for cleaner fuels on the oil industry through standards eliminating sulfur and reducing other harmful chemicals such as benzene. These costs translated into a few cents per gallon. But the spin-off effects were more detrimental. Refiners had to choose

between spending on new capacity or meeting environmental regulations in existing refineries. They chose the latter. Moreover, the EPA regulations meant that imported fuels had to meet strict quality standards or they could not be imported, reducing supplies and putting upward pressure on product prices. Automakers also contributed to rising product prices, according to this explanation, by producing automobiles that used more fuel while resisting efforts to tighten fuel economy standards.

This unconventional explanation points to lack of coordination among government agencies (primarily the EPA), the auto industry and the oil industry as the prime reason that product prices are so high. Governments forced the oil industry to produce cleaner fuels and, in Europe, encouraged the shift to diesel. Automakers complied with requirements for clean engines while continuing to design and sell large and popular models loaded with everything consumers wanted, which usually did not include fuel economy. Oil refiners invested to produce clean fuels but not to expand capacity. The result: increasing demand collided with static supply; naturally, prices rose.

OPEC action to influence oil prices changed in recent years. From 1999 to mid-2004 OPEC was restraining production in order to limit inventories and place upward pressure on crude oil prices. By 2005 OPEC altered its strategy and increased production, which led to increased inventories. But OPEC also noted at that time that there was a growing shortage of effective refining capacity to meet the strong growth in product demand. Mid-2004 marks the beginning of a period of refinery constraint that is responsible for continuing high prices.

As prices for gasoline and distillates increased, refiners sought to produce more of these products. One way to do this with existing capacity is to use lighter crude oils that produce the highest percentage of gasoline and distillates. Another way is to invest in conversion capacity so that most crude oils could be used to produce the lighter products. Absent new conversion capacity, refiners turned to the lighter crude oils and bid their price up. This bidding process pulls crude prices up to the value of the products produced from the oil

because supplies of the most desirable crude oils are limited. Spot prices for these crude oils rose to the value of the products derived from them. Simple arbitrage between crude and product assured that WTI prices reached $70 per barrel when the products derived from it were worth $70 per barrel. Eventually, new investment in upgrading conversion capacity will allow refiners to use lower quality crude oils to produce more light products, alleviating the upward pressure on product prices. The question remains whether sufficient new refining capacity will be built soon enough to meet current and future demand for light products.

In response, the discussions turned to a consideration of today's refining sector and the outlook for future capacity. Refinery margins — the difference between the cost of a barrel of crude oil plus processing costs, and the sales price at the refinery gate of the products derived from that barrel of crude — were very high at the time of the Forum. Traditionally refinery margins have been in the $2-4 per barrel range. In the past couple of years they have exceeded $10. Importantly, not all refineries operate on the same margins. Today the more sophisticated refineries with deep conversion capacity are doing the best.

To explore the distinction among refiners, the discussion focused on margins produced with different types of crude oil. For refiners using light crude oils, the prices they receive for light products (gasoline, distillates, jet fuel) are relatively inelastic in the short-term, since the factors that change demand take time to affect the demand structure. But prices for heavier products such as residual fuel oil are quite elastic, since they have to compete with other fuels such as coal and natural gas. Residual fuel oil is used for powering the boilers in tankers, as fuel for electric power plants, and as fuel for industrial and commercial establishments. Coal and natural gas are good substitutes in these uses. Consequently, light product prices will adjust until the point where the refinery margin for residual fuel oil in the least sophisticated refinery reaches zero.

The other equilibrium focuses on the differences between light crude oil and heavy crude oils. Heavy crudes are more viscous and

often require some form of heat for the oil to flow. It takes more sophisticated refining processes to produce more light products from heavy crudes. The equilibrium point is reached when the least sophisticated refinery (hydroskimming) will use either light crude oil or heavy crude since the price differential produces the same refinery margin and the same value. In this situation, the more sophisticated refineries (cracking or coking) will do extremely well since they produce more light products from heavy crude oil and their margins will increase significantly. The light-heavy crude oil differential averaged about $5.00 per barrel at the U.S. Gulf Coast through most of the late 1990s and then started to increase from 2000 onward towards $10.00 per barrel. From 2004 to 2006 this differential widened to levels exceeding $15.00 per barrel. A refiner with cracking or coking conversion capacity could take advantage of the huge discount available for heavy crude oil and high product prices to reap large profits. Moreover, even between refiners with cracking and coking capacity, the refinery margin differential increases substantially for the coking refiner as the price of crude oil increases and consequently, the light-heavy differential increases.

Refining profitability tends to move in cycles and in the summer of 2006 seemed to be approaching a peak. This peak was the result of long-term trends in supply and demand exacerbated by the 2005 hurricanes and the switch from MTBE to ethanol. The rate of growth in demand for refined products peaked in 2004 (driven by China and the U.S.) but kept growing in 2005-2006, albeit at lower levels. The result is that refineries are utilizing all of their available capacity to meet the demand surge. In addition, the hurricanes closed about 10 percent of U.S. refining capacity, leading to a spike in margins in the fall of 2005. While these refineries have recovered and re-opened, the phase-out of MTBE led to another spike in refinery margins in the spring of 2006.

If some refiners are reaping the benefits of high crude and product prices, will new investment bring forth additional refining capacity? This depends upon a variety of factors including consumer behavior, auto company strategy, government policies, and refinery investment.

In the area of consumer behavior, the key question is whether higher gasoline prices are leading to changes in demand. In one analysis, recent evidence from the U.S. gasoline market suggested no immediate change in consumer behavior; however, past analyses indicate that consumers change their habits when gasoline prices stay high for sustained periods of time, and there is some evidence of a price response in vehicle miles traveled — the rate of growth has been declining since 2005 — and in reduced sales of larger vehicles in 2006. The share of personal deposable income going to gasoline is important, and recent evidence suggests that on average the cost of gasoline is making less of a dent in people's pocket books than in earlier years. But if prices stay high for a significant period of time, this may change and may lead to the use of more efficient vehicles, and for some families the extra cost of gasoline is significant. As indicated in the discussion of auto technology summarized below, automakers are responding to higher gasoline prices through use of technology and are seeking to improve the fuel economy of even large and powerful vehicles.

Government policy will have an impact on gasoline and other light product demand. For example, Europe increasingly is turning to diesel as tax policies favor its use. Bio-fuels (ethanol and bio-diesel) have government mandates and subsidies in the U.S. and elsewhere that can make their use economical in a high product price environment. Will these policies persist? With high margins in the U.S., investments in corn based ethanol and bio-diesel are accelerating. Estimates of penetration into the fuel mix range from as low as 4 percent by 2030, while some optimists are pushing for "30-30" — 30 percent penetration by 2030.

Lastly, what about investments in refineries? Will refiners build everything they say they will? Where will they build this capacity? To date, announcements of additional capacity appear to be keeping pace with demand growth, except for deep conversion coking capacity, which seems to be lagging. Some areas of the world seem to be building more capacity than needed, e.g. the Middle East and India, based on speculation that investment in other areas does not seem to be adequate to meet demand.. Refiners in both the Middle East

and India are looking to the markets in China and the U.S. to demand the supplies produced in these new refineries.

Motivations for adding refinery capacity differ. The "Rationalists" rely on market fundamentals in their assessments. Major and independent refiners usually fall into this category and usually are hesitant to add capacity even with sustained high refinery margins; they know these investments take a long time to build and pay out while recent margins are thought to be a short-term phenomenon. Analysis of current refinery capacity announcements shows that rationalists make up about 20-30% of announced capacity increases; however, the same analysis indicates that those falling into the rationalist camp are not adding as much capacity as demand suggests. The "Energy Securists," such as China, are investing to ensure access to refined product supply and are willing to pay a premium in order to secure future supplies. Perhaps 30-40% of announcement capacity falls into this area. The "Integrators," such as Saudi Arabia, invest to provide secured access to their crude oil and use a set of economic perspectives that rely on the economics of vertical integration. About 20-30% of announced capacity falls into this sector. Lastly, the "Speculators" may have made about 10-20% of the capacity announcements but often cannot obtain financing to proceed with their projects due to the speculative nature of their investments.

In this view, the outlook for refiners remains positive through the end of the decade. Alternatively, from the consumer perspective, the prospect for removing capacity constraint as a cause of higher product prices appears dim. The question for the long-term is whether margins for the refinery sector will crash or see a soft landing. Demand growth will be the most critical factor — will high prices choke off demand, and will high prices lead to an economic slowdown? On the supply side, the question is whether the industry will overbuild. Current announcements are in line with future demand expectations. If supply and demand projections remain closely aligned, the industry can anticipate a soft landing.

Transportation Fuels and Technologies

In considering the impact on oil demand from new transportation fuels or new automotive technology, the experts considered which are likely to penetrate the transportation market and how quickly, and what strategies some of the major auto producers are pursuing that may make a difference. Without stronger government regulations or incentives, reducing the demand for oil in the transport sector depends on whether more fuel-efficient vehicles will be built and purchased as a result of high gasoline prices, whether biofuels will achieve significant market share, and where auto manufacturers are going in their use of technology to develop other alternatives such as gas-electric hybrids or fuel cells.

The transportation strategies developed by the auto companies include short-term options focused on improvements in the internal combustion engine and transmissions, and a variety of fuel choices including gasoline, gas-to-liquids, bio-fuels, compressed natural gas, and diesel. The mid-term strategy is to move towards hybrids that use some form of the previously mentioned fuels and electricity. A long-term strategy would move to fuel cells using hydrogen.

Enhancements to internal combustion engines: In the near term, auto makers are looking at options to improve the performance of internal combustion engines through improved variable valve timing, more sophisticated six-speed transmissions, other fuels including advanced diesel technology, and actively managing fuel use through cylinder cutoff capabilities. GM is making ethanol a major marketing push, seeing a future especially for E-85 used in flexible-fuel vehicles. (E-85 is a gasoline-ethanol blend of up to 85 percent ethanol; flex-fuel vehicles can use E-85, 100 percent gasoline, or any blend in between.) By 2008, all their large vehicles will have flex-fuel capability. Brazil currently requires all of its new vehicles to be flex-fuel, with 100 percent ethanol capability. Sweden is moving in the same direction and is mandating E-85; eventually one fourth of all of its pumps will be E-85 capable.

DaimlerChrysler is focused on improving its conventional power

trains while moving towards innovations in diesel technology. In the near term they are rapidly increasing the percentage of their vehicles that have flex-fuel capability. They see enormous oil savings potential if the U.S. moves more towards diesel — for example, if one half of today's auto fleet used diesel, fuel savings could be about 12 billion gallons or about 8.5% of auto fuel consumption. Moreover, DaimlerChrysler has developed a technology that adds urea to the exhaust as a way of reducing emissions from diesel. They will be introducing this technology in the U.S. in 2006, and it will also allow them to meet the EU diesel exhaust standards.

Hybrid technology: All auto companies are focusing on hybrid technology as a mid-term strategy. Hybrid technology uses two or more energy storage systems, e.g. gasoline and electric batteries, for propulsion. Hybrids have distinct benefits, including reduced oil consumption, since some portion of the power relies on the electric motor rather than the gasoline engine, and reduced exhaust emissions. Today, most U.S. drivers appear to prefer performance over fuel economy, although with sustained high gasoline prices, there has been some shift in consumer preference to fuel economy. Hybrids seek to achieve both, but currently come with a price premium. Auto companies are striving to reduce the price premium through increasing the volume of cars produced and understanding the unique attributes of hybrids. Not all hybrids are the same; there is a wide variation in the types of hybrids, their fuel economy, and how they perform. Today, most hybrids are marketed similarly, producing some confusion among consumers on just what kind of hybrid they are buying. Many larger or more powerful hybrids have worse fuel economy than smaller all-gasoline vehicles. If they are purchased instead of similarly large and powerful all-gasoline vehicles, however, the fuel savings can be significant. Fuel economy for hybrids, however, is excellent in city driving compared to comparable gasoline only vehicles. Their advantage declines significantly in highway driving.

Toyota's strategy is firmly focused on development of hybrids. They are not ignoring enhancements in internal combustion engines but place greater emphasis on improving hybrids, including improving their fuel efficiency. GM's hybrid strategy is to go from

large vehicles to small — buses to autos. It is starting with buses since bus hybrids have huge fuel savings. Next in line for GM are SUVs, such as the Saturn Vue. GM's Saturn Vue is a not a full hybrid like Toyota's Prius, since it does not have stand-alone electric capability. GM and DaimlerChrysler are working together and with BMW on two-mode hybrid systems with continuous variable transmissions. GM and DaimlerChrysler will adapt their joint research to their individual models.

The future direction for hybrids is to improve batteries so that hybrids could be all electric in cities. Hybrids then would move towards plug-in hybrids, where batteries are used and recharged at plug-in stations to maximize the use of the electric motor in cities — the area where hybrids have a clear advantage. Significant improvements in battery technology will be needed before plug-in hybrids are ready for commercialization.

Fuel Cell Technology: All the auto companies indicated that their long-term strategy is to move to fuel cells using hydrogen fuel. Toyota is planning an all-wire fuel cell vehicle with no direct mechanical connections, meaning that each wheel has its own motor for propulsion. This provides more flexibility. For example, the front and rear wheels could separately turn 90 degrees for ease of parking. GM sees many challenges in moving to hydrogen fuel cells, including the appropriate storage system for hydrogen. DaimlerChrysler will be demonstrating its fuel cell vehicles in the U.S. and in other markets in 2006. This is part of their strategy of moving from fossil fuels to bio-fuels to hydrogen-based systems.

In addition to the strategies of some major auto manufacturers, the group discussed an innovative concept that is now in the research stage — the ethanol-boosted turbo gasoline engine. The idea is to use smaller, turbo charged engines with direct injection of the fuel. The direct fuel injection vaporizes within the cylinder, creating an enormous cooling effect that suppresses engine knock while also producing the effect of high octane — about 150 octane. Thus the horsepower of the engine can be increased while using smaller and more efficient engines.

If the turbo charged gasoline engine used small amounts of ethanol, higher efficiency could be achieved, approaching the efficiency levels of hybrid vehicles. According to this research, ethanol use could be minimized and used only when needed at high torque. This would require much less than the 10 percent ethanol now used in many gasoline fuels. This approach would limit the need for large ethanol distribution networks since only small amounts would be needed. Ethanol could be available in pumps or containers and would require about one gallon per month refill. Research is underway with a major automobile manufacturer to determine the feasibility of this approach.

Energy Security

Energy security is at the top of the agenda for consuming and producing countries alike due to the extreme uncertainty in today's energy markets. The top agenda item of the G-8 meeting that took place in St. Petersburg, Russia in July 2006 was energy security. The EU and other nations in Europe collectively and individually are concerned about their future energy security due to disruptions in their gas supplies. China, India, Japan, the U.S. and other major consuming countries worry that energy supplies will not keep pace with demand and, with imports providing larger portions of their energy supplies, that disruptions of foreign supplies will undermine their economic growth. A re-evaluation of the collective energy security arrangements developed in response to the disruptions of the 1970s is underway. Producing countries also worry that short-term demand arrangements will be insufficient to sustain their future investments in increasingly more costly supplies. Are new mechanisms needed for both consuming and producing countries to satisfy their energy security concerns? In this discussion the Forum participants focused on potential policy alternatives in the U.S. and elsewhere to meet some of these energy security concerns.

One of today's greatest foreign policy challenges is the enormous transfer of wealth from consuming countries to producing countries due to the high level of oil imported by consuming countries. Many

of today's oil producers are hostile to the policies of the U.S. and other major consuming countries, are overly aggressive toward their neighbors, are corrupt, or are simply disruptive. In this analysis, oil is shifting the balance of power in the world as more governments take control of their oil and gas resources and use them as a tool of foreign policy.

The consequences to U.S. foreign policy in particular are serious as the U.S. sees its power and influence erode. This erosion extends beyond just energy markets and affects other countries, since it affects weapons proliferation, counterterrorism, protecting existing democracies, preventing regional or internal conflicts, resisting aggression and protecting free trade.

The Forum concluded that a business as usual approach may appear safer, but it actually will lead to a less safe, less secure future. The alternative is to take a more aggressive approach to the protection of free markets and to expanding the collective energy security system that consuming nations started building in 1973 to resolve conflicts with adversaries or with friendly nations. This should be undertaken while engaging in an immediate, long-term, multilateral strategy to reduce dramatically the importance of hydrocarbons in the global economy.

The group discussed four key challenges to the national security of the major oil and gas importing nations including the U.S. First, energy dependency by all importing nations undermines their collective ability to form coalitions to fight aggression, proliferation and monopoly. Countries are reluctant to challenge their key suppliers for fear that they will be denied supply or access or that a country will withhold supply from the world market.

Second, oil wealth enables governments to act with impunity towards their neighbors or their own people. Excess wealth can be an occasion to flout international norms with less risk of retaliation for acts of aggression. Examples include Hugo Chavez of Venezuela exporting his brand of diplomacy, much to the chagrin of U.S. policy makers; Russia's denial of third party access to its natural gas

pipeline system by EU countries and its domination of gas markets in Turkmenistan, Ukraine and Georgia to the exclusion of potential European purchasers; and the UN Security Council's inability to take prompt, effective action against the genocide in Darfur because of China's interest in Sudan's oil reserves.

Third, the free market for energy is under stress. This is occurring in a new style of competition for new exploration acreage that is challenging the interests of oil and gas importing nations. It is also occurring through the rise of NOC control of resources in a way in which governments make decisions independent of market signals.

Fourth, the trends are ominous. Future oil production will shift increasingly toward the Gulf. New consumption patterns are emerging with the growth of China and India. Power is shifting to regressive governments such as Russia, Iran, and Venezuela. Oil wealth enables governments to entrench themselves and resist economic and political reform.

A three-part response to these challenges was discussed. The first part is for consuming countries to reach out and engage other countries and regions more fully. This approach would seek more support from the developing countries of Latin America and Africa, focusing on trade, development aid and energy poverty. The collective energy system that was established in the 1970s needs to be expanded by bringing in China and India, since they have much in common with today's large energy consuming nations. There is a need to spread new technologies to make them more widely available. And, there is a need to expand the energy infrastructure to make it more robust and accessible.

A second part of the strategy for consuming nations, a supply approach, would be to use a portfolio of fuels and technologies for transportation in order to limit exposure to the instability of the Middle East — wars, growing influence of Iran, increased terrorism, proliferation of nuclear weapons of mass technology, and the possibility of future conflicts. It is not necessary to pick a single fuel or technology; rather, a range of alternatives is the best way to move for-

ward. Electricity using inexpensive feedstocks is one way to power automobiles through enhanced battery technology and plug-ins. Biofuels can use almost anything as a source. Ethanol is one of the most promising alternatives, and using cellulose from dedicated energy crops and wood and other wastes rather than starch from corn kernels offers the best and most environmentally beneficial possibility of replacing significant portions of gasoline use by 2025. To secure the collective energy future of consuming nations, waste materials should be used as much as possible coupled with electricity in hybrids.

A complementary, demand-oriented and fuel substitution approach forms the third part of the proposed response by consuming nations to the energy security challenges. It would focus on doubling end-use efficiency, which one expert argued can be done at costs of about $12 per barrel, much less than current production costs of liquids and natural gas. In the field of transportation, for example, some analysts believe it is possible to triple the efficiency of current vehicles in the U.S. using existing technology. Light-weight steel or carbon composites can be used to lighten the weight of vehicles without giving up structural strength. Moreover, ethanol can be used as a liquid that will provide a partial substitute for gasoline. The gains in countries with more efficient vehicles than the U.S. will be smaller but nevertheless important, both nationally and globally.

One major consuming country, Japan, in response to its heightened concern about energy security, has developed a new National Energy Strategy consistent with these proposals. The strategy builds on three basic objectives: 1) establishing a state of the art energy supply and demand structure that includes improving energy efficiency and diversifying energy sources; 2) strengthening resource diplomacy and energy and environmental cooperation, including improving multilateral connections with oil and gas producing countries, relationships with Asian countries, and prospective overseas projects for diversifying supply sources; and 3) enhancing emergency response measures in coordination with other energy importing countries.

Specifically in Japan's gas industry, the new strategy will focus on both upstream and downstream. In the upstream, the strategy will

seek long-term stable supply security by diversifying sources of supply, acquiring new upstream interests, owning LNG carriers, improving contract terms, and strengthening relationships with LNG exporting countries. In the downstream, Japan would promote more use of natural gas through a variety of measures including the introduction of new, high-efficiency systems and appliances, diversifying energy sources that use natural gas (cogeneration, fuel cells), and enhancing the natural gas supply infrastructure. LNG will be at the center of the strategy.

In many ways the oil and gas importing nations are at a crossroads. Part of the solution needs to be telling the public the truth on energy prices. High prices are here to stay, and consumers need to be told something they don't like to hear. The future of U.S. foreign policy depends in part upon making the range of policy choices discussed above, and in part on the decisions of other importing counties. No country can afford to go it alone, and the major consuming countries need all the help they can get from a more collective approach to energy and other security problems.

Conclusion

It appears that today's markets are heading more towards crisis unless policies change the future direction. Complacency and business as usual will not avert future crises but could lead to higher energy prices and less stable and secure markets in the future.

The question is not one of adequacy of hydrocarbon resources, since there appear to be sufficient resources assuming timely, adequate investments. The question is whether there is the ability and will to produce those resources, or to find ways to reduce demand and the need for more future supplies. It is not a question of what exists below the ground, but the adequacy of the investment environment above ground and the progress made on demand reduction that will lead to wise choices. As access to resources increasingly is taken out of the control of market forces and placed under the control of governments and government-controlled entities, the

ability to supply energy markets increasingly becomes a government decision rather than a market decision. Unfortunately, government decisions often are swayed less by what is best for the market and consumers than by what is in the best interests of individual nations or political ideologies. As politics intrude more and more into future energy decision making, the collective security of consumers and producers erodes and can fall prey to political whims and disruptive policies based on non-energy goals. Bold steps to alter course are required.

The experts in the Forum considered many issues creating today's situation and many possible solutions. The implementation of existing technology in many energy and transportation sectors is critical to avoiding complacency and confronting future crises. Research and development is critical in order to develop tomorrow's technologies. Alternative approaches to solving or avoiding energy crises emerged as a necessary part of problem solving, spreading efforts over many approaches rather than putting all eggs in one basket. Outward engagement and cooperation among major energy consumers, that is, extending the collective energy security system built decades ago, can be another part of avoiding complacency and confronting our energy future.