Unpacking Uncertainty: Investment Issues in the Petroleum Sector

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A Report commissioned by the IEF

By
PFC Energy

Please note that more recent outlooks are available from both IEA and OPEC but, due to time constraints, were not included in the projections made by PFC Energy in this report.

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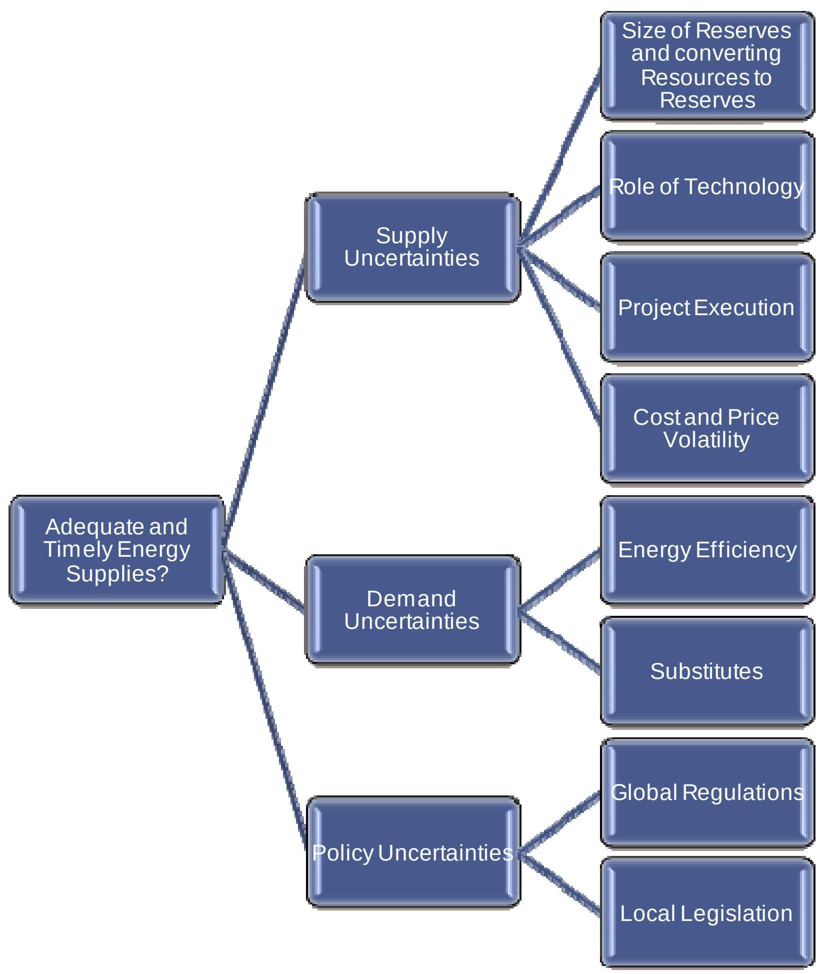
Unpacking Uncertainties Holding Back Investment in the Petroleum Sector

The Secretariat of the International Energy Forum (IEF) commissioned PFC Energy to complete a preliminary assessment of uncertainties impacting investment in the petroleum sector. PFC Energy has sought to disaggregate, or "unpack," these uncertainties in order to allow for a clearer and more thorough examination of the various issues. In particular, PFC Energy has sought to identify specific areas where active collaboration among ministers from both producing and consuming countries could potentially make a positive impact in resolving some of the uncertainties currently impacting investment decisions and actions by market participants. This paper represents only the initial assessment of the state of the industry; PFC Energy looks forward to the possibility of working further with the IEF Secretariat to more fully investigate those areas deemed most fruitful by the member countries of the International Energy Forum.

Executive Summary, Conclusions and Recommendations

Beginning from a quick review of projections for global oil supply and demand trends, it is readily apparent that there exists a high degree of uncertainty within the industry. The International Energy Agency, for example, sees total oil demand reaching 111 mmb/d in 2030, while OPEC's projection sees demand reaching a slightly higher 113 mmb/d. However, OPEC's base case was issued in 2008 before the on-set of the steepest part of the economic crisis, and the IEA's own projections, while reflecting the economic crisis, are likely to be further revised downward, as their short- and medium-term oil market projections have in the intervening months. But how this demand is met is also subject to uncertainty, with OPEC projecting stronger growth in non-OPEC supplies (reaching 53.9 mmb/d in 2030 compared to an IEA forecast of 50.9 mmb/d). In sharp contrast, PFC Energy projects a high probability of constraints within the global upstream sector impacting



the availability of future oil reserves, resulting in a supply constrained world. In PFC Energy's scenario, global crude oil output is likely to be constrained just below 100 mmb/d, resulting in demand constrained and possibly falling after the 2025 time frame.

The purpose of the PFC Energy scenario as well as the fuller discussion of this report is not to cast doubt on the conclusions reached by the IEA, OPEC or other public and private long-term projections. But rather the juxtaposition of the various scenarios allows for closer examination of the various key uncertainties surrounding investment decisions in the global oil and gas industry. The fundamental question surrounds the conditions that would allow for timely investments to be made in order to ensure plentiful supplies of hydrocarbon-based energy supplies for future economic development. For common to all three projections is an assessment that the resources exist, but the question as to whether or not these can be turned into tomorrow's reserves remains an open one.

Uncertainty of Supply

Much of the public discourse in recent years has centered on the size of available resources. To be certain questions remain on the size of reserves, and while these generally surround reserves reported by OPEC countries, the lack of a generally agreed upon international standard for reserves has led to some misunderstanding (and mis-reporting) of IOC claimed proven reserves. But the discussion regarding the size of the reserves base is meaningless outside the context of investments necessary to maintain and increase global crude oil production. Indeed, the trends in decline rates among non-OPEC producing countries is a key uncertainty for future markets, particularly whether or not sufficient investments can be made to either stem the decline, or to increase total recovery from oil fields.

While much of this will be dependent upon the application of new technologies, several aspects of the industry raise questions as to whether or not technology alone can play a role as a proverbial silver bullet. Indeed, while technological gains could be realized both in terms of slowing decline rates and boosting recovery rates—as well as improving the success rates in exploration efforts—traditionally the industry has placed the greatest emphasis on technologies where the most direct impact has been on reducing costs. While cost-reduction by itself also improves project economics, and hence appetite for investment, both the relatively slow adaptation of new technologies, as well as the lack of spending of the industry in research and development are seen as major impediments to rapid deployment of "game-changing" technologies.

The tremendous price volatility seen over the past several years has also had the effect of complicating investment decisions. Often blamed on the increasing participation of financial market participants in crude markets, financial market regulators, including especially the US CFTC are now examining new regulations for commodities exchanges (as well as other financial instruments) intended to lower volatility. Nonetheless, analysis of daily volatility around the monthly average does not suggest the deepening commodities markets have appreciably increased volatility, by themselves (though significant periods of aberrant pricing behavior still continue, themselves a continuing focus of regulation efforts). Rather, the most significant periods of volatility coincide with periods of demand or economic uncertainty—a disturbing finding given the current economic outlook. While long-dated contract months—which have also benefitted from growing liquidity as commodity markets deepened with financial inflows—have shown increasing stability, front-month prices are likely to see continued volatility until the global economy is firmly on an economy recovery. While this may greatly complicate investment decisions, those deeper far-forward contract do offer the promise of allowing at least some firms to hedge future exposures, and ensure adequate revenues for short-term development or M&A projects.

But finally for the upstream sector there remains the crunch of time. On the one hand, geological realities place a premium on timely and efficient project development and execution. As decline rates in maturing areas increase, the need for new projects to come on stream to offset these declines rises. But also on the personnel side, persistent under-investment throughout the 1990s undervalued skilled professionals in the upstream sector, leading to an acute personnel shortage. The average age of employees in the sector is just under 50, and half of today's workforce is expected to retire within ten years. Although some universities continue to generate petro-technical graduates at high rates, globally, attracting enough trained personnel into the industry will be a major challenge, greatly complicating the efforts of the industry to make the necessary investments to see oil production steadily increase.

Uncertainty of Demand

The current economic crisis has brought to the fore the issue of uncertainty of demand, an issue previously raised repeatedly by major resource holders, but largely ignored by consuming countries before 2008. And indeed, the initial focus of the impact of the economic slowdown was a continued focus on the impact on upstream investment. But it is also clear that the economy contraction has not only "re-set" the global demand base at a much lower level, but has also called into question the likely future demand trajectories once the recovery takes hold.

Combining both impacts on demand and supply, and even after making what would seem to be realistic if not conservative assumptions for economic growth and energy consumption, PFC Energy's projections could lead to a situation that shows demand outstripping supply by as early as 2025. The real uncertainty facing the industry, however, is that investments needed to ensure higher levels of conventional and unconventional fossil fuels, as well as the reasonable development and utilization of alternative energy sources requires substantial lead times. However, in the near-term, as demand uncertainties pre-dominate, the natural inclination may very well be to delay such investments, thereby raising requirements necessary in coming year.

Indeed, despite the economic uncertainties, two policies are likely to be continued that would suggest demand trajectories could be on an even lower track: development of biofuels alternatives to oil-based transportation fuels, and policies aimed at the mitigation of the emission of greenhouse gases (GHG). Although conventional wisdom may hold that such policies would be placed aside as governments around the world focus their efforts on safeguarding the economy, the growing public awareness of global warming—and rising demands for governments to take action—will keep these issues on the forefront of policy-makers' agendas even before a recovery takes firm hold. Indeed, many governments have taken the step of introducing elements into stimulus spending aimed at boosting alternative energies to "green" the economy and improve industrial footing in a future of carbon emission restrictions and/or higher energy prices.

But whether or not policies surrounding promotion of biofuels, limiting GHG emissions, or other environmental and industry regulations occurs on a global or a local basis is another key demand uncertainty. Indeed, while the entire globalization project is in many ways under threat in the current economic crisis, and the traditional leader on global issues—the United States—finds its soft power weakened and attention internally focused while no other country appears set to take the reins, the issues of common concerns will still be addressed. But the failure to adopt international frameworks to address global issues—such as that sought at the COP 15 in Copenhagen this December—will result in more disruptive, and possibly counter-production regional or country-level policy stances. To the extent the issues are local (e.g., combating urban pollution), local regulations will necessarily be required. But even here adaptation of best practices—taking into account local environmental, political and economic conditions—can both reduce uncertainties for industry and potentially increase the effectiveness of mooted regulatory changes.

These regulatory changes are also expected to have substantial impacts on the development of trends in gas supply and demand. Indeed, the recent breakthroughs in unconventional gas developments have the potential to be a "game-changer," quickly transforming one plentiful resource into reserves. While further development of technologies for some plays is likely to be necessary, the potential of carbon-constraints in the future is seen as a dramatic fillip for gas demand. Indeed, gas is seen by many as the environmental fuel, not only for its lower carbon footprint that coal or oil in power generation, but also its ability to serve as the marginal supplier to supplement other alternative sources, such as wind, solar and wave power.

But a key issue regards the uncertainties brought about by strategy homogeneity. Currently several player have sought to take advantage of counter-cyclical LNG markets to secure intermittent but affordable energy supplies. However, a move by all these countries at once serves to increase costs, not only for LNG supplies, but also for the construction of necessary facilities. Such disruptions have also been seen in the nuclear field, both for fuel and facilities. Establishment of international frameworks to both develop agreed-upon energy and environmental standards, as well as coordinating strategies to achieving these goals is essential not only for the realization of the policy goals, but also to reduce unnecessary additional costs.

Policy Recommendations

For several of the uncertainties facing the industry, there are no clear cut policy prescriptions. Economic conditions and geopolitical strategies and alignments are largely beyond the mandate of energy ministers and the International Energy Forum. However, several steps can be taken to ensure the best possible outcomes, regardless of changes in the wider environment:

1. **Stability of the investment climate.** While both the level and volatility of prices will to a large measure remain outside the direct control of energy policy makers—and the outcome of the current economic crisis will have a significant impact on additional signals for investment given to the industry—stability of the investment climate, especially within the major resource holders, will be essential to maximizing investment under prevailing conditions. It should be noted, however, that this does not mean either open access to investment in all areas, nor homogeneity in investment and fiscal terms on offer. Rather, investment regimes must offer predictability for firms operating in the oil sector—whether IOCs, independents, domestic or foreign NOCs—and stability over time. As such, investment regimes should reflect local economic and political considerations, as well as specific conditions of the geological, infrastructure and other risks associated with the development of oil and gas reserves in that particular market. Ironically, PFC Energy would caution a move toward harmonization of upstream terms that does not take into account the specific needs of the various stakeholders—and in particular, the resource-holding state—will lead to longer-term instability of production, and raise uncertainties over future supplies.

2. **Promotion of research and development in key technologies.** In many regards, the oil and gas industry is a very high-tech industry. But in comparison with many other industries, both adaptation of new technologies as well as spending on basic R&D significantly lags. However, the industry organization is not one that lends itself easily to the open collaborative networks that most easily foster technological innovation. This opens a clear role for governments to sponsor the basic R&D necessary to promote commercialization of new processes to increase supplies—especially in areas such as increasing discovery success rates and improving recovery that are traditionally downplayed by industry—or more efficiently use demand—including developments of alternative energy sources, such as second generation biofuels and improved battery technologies. While the latter technologies seemingly benefit consuming countries at the expense of producing countries, it should be noted that producing countries also rank among the fastest growing consumers of oil products globally. Furthermore, improvements in energy efficiency will also lower the costs required for development of the most expensive marginal supplies required should demand growth outpace the ability of the oil industry to meet demand from today's existing reserves. Some technological improvements—such as the carbon capture and sequestration—while seemingly promoting only competitors to oil and gas (in this

case coal), actually also have beneficial impacts in lowering the carbon footprint of oil and gas production as well.

3. **Encouraging skills acquisition.** A key issue facing the oil and gas industry as noted above is the rapid ageing of the workforce and the impending retirement of especially its skilled workforce. This comes as a result of undervaluing of the requisite skills throughout the 1990s, when investment in the global upstream was at low levels. Unfortunately, the current economic crisis threatens to send the same discouraging signals to a new generation of potential workers, just ahead of the period when the industry will need them the most. For both producing and consuming countries, the consequences of failing to attract enough new skilled entrants into the industry are dire. Accelerating decline rates will put a premium on being able to rapidly and effectively execute increasingly complex projects—as will the innovations necessary to convert current resources into reserves. But the ageing of the existing workforce requires a rapid increase in the uptake of new personnel in order to accelerate the transfer of skills and experience from the current workforce to the next. In many ways, the NOCs are better positioned to meet these needs than the IOCs, given the priority placed in several countries on job-creation within these firms, even as IOCs lay-off some of their workforces. However, all countries can and should implement policies designed to encourage students to take necessary petro-technical courses, and to support university programs in geological sciences and engineering. Whether ultimately employed by IOCs, NOCs, independents at home or abroad, all countries will ultimately depend on the oil and gas industry having a sufficient and sufficiently skilled workforce.

4. **Maximizing transparency of energy policies.** Security of demand has become a real concern, not only for OPEC state maintain increasing levels of surplus capacity, but even for IOCs and independents unsure of future investments in the oil industry. It is understandable when consuming countries introduce policies aimed at increasing conservation efforts and energy efficiency, especially when viewed in economic and environmental terms. And almost by definition, the boldest plans to restructure economies to be more energy efficient will require herculean efforts or not-yet-developed technologies to realize the most ambitious gains. Anything easier would not require substantial government intervention. But in setting out such policies, it should also be made clear to the extent possible, which gains are likely to be made from existing technologies, which still require commercial development, and when policy reviews will take place. Bearing in mind the long lead times necessary to execute upstream oil and gas developments (with these times increasing with the complexity of new resources), last-minute realizations that new technologies will not be available cannot easily be made up through new investments in oil and gas projects. Certainly some of this unofficial review takes place within boardrooms of various oil and gas companies, but government policies still influence these calculations, along with those of the investment community often necessary to provide capital. Open reviews of both progress-to-date as well as existing challenges to meeting future goals—and revisions of those goals where appropriate—will help to reduce uncertainties of demand, while still not prejudicing the freedom of consuming countries to pursue ambitious programs to change demand patterns. (Similarly, periodic publication and review of medium-term development plans from major resource holding countries could similarly assuage the security fears behind many of the consuming countries' policies, particularly those premised on security of supply fears.)

5. **Coordination of energy and environmental policies.** Especially regarding policies impacting global issues—and in particular global warming—international coordination will be essential. But coordination needs to move beyond a broad agreement on goals, but also coordination of policies intended to realize these targets as well. In many instances such coordination will be required rather than simply desired to meet goals, but in all cases, coordination of strategies will ensure both complementarity of approaches as well as ensuring a minimum of unintended disruptions and associated costs. Even with more local problems such as urban pollution, adoption of best practices can not only increase efficiency, but also raise predictability in investment decisions as well. This is particularly acute in assessing the relative

costs and benefits of differing strategies to meet proposed environmental goals, as a rush from one energy source to a differing one, not only alters the relative costs among a variety of fuels, but raises costs across the fuel sector, mitigating some of the proposed advantages of the strategy. Such costs of strategy homogeneity perhaps cannot be altogether mitigated, but certainly limited with more open and international coordination of goals, and also strategies to achieve them.

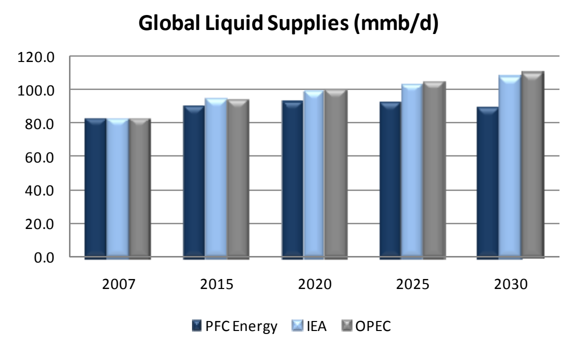
Part 1. Long-Term Supply and Demand Projections

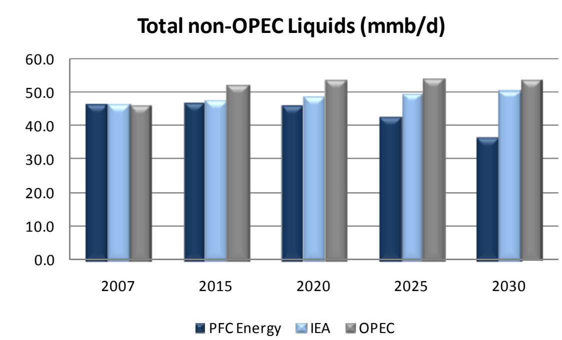
A. Comparison of IEA, OPEC and PFC Energy Long Term Outlooks

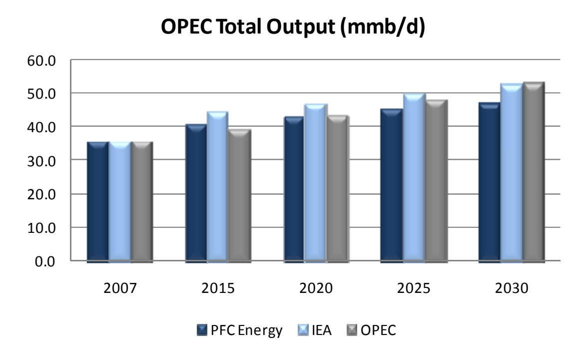
A comparison of PFC Energy's own oil supply-demand forecasts with the International Energy Agency's (IEA) 2008 World Energy Outlook and the Organization of Petroleum Exporting Countries' (OPEC) 2008 World Oil Outlook offers an insight into the key uncertainties that will impact the energy markets, and therefore the most crucial areas for producer-consumer cooperation over the next 20 years. Despite differences in the three projections, the comparison reveals a consistent set of trends that are expected to influence balances and the key factors that policy makers will need to focus on in order to adjust to the emerging energy environment and address potential dislocations.

6. Long-term Supply Forecasts

The divergences in supply forecasts among the three studies are stark and significant. The IEA and OPEC forecasts both see total liquids production rising from 83.2 mmb/d in 2007 to 108.6 mmb/d (IEA) or 110.8 mmb/d (OPEC) by 2030. In contrast, PFC Energy sees liquids output at 89.8 mmb/d in 2030, after peaking between 2020-2025 around 95.0 mmb/d.







The sharply lower PFC Energy forecast is based on a view of declining non-OPEC supplies not reflected in the assessments completed by OPEC and the IEA. Indeed, these two forecasts see non-OPEC supplies (conventional and unconventional crude oil and NGLs/condensates, but excluding biofuels) growing from 46.0 mmb/d in 2007 to 50.9 mmb/d (IEA) and 57.4 mmb/d (OPEC) in 2030. PFC Energy's reference forecast foresees a decline in non-OPEC supplies over this period to 36.3 mmb/d. In turn, these estimates largely differ in the assessments of conventional crude production. OPEC forecasts a higher estimate for conventional non-OPEC crude oil and NGL supply at the projected 2020 peak of 48.7 mmb/d, compared to the IEA's 43.2 mmb/d. PFC Energy sees conventional non-OPEC liquids declining throughout the forecast period. In contrast, however, all three studies for unconventional liquids supply in 2025 are around 6.5 mmb/d, compared to 1.5 mmb/d in 2007. Most of this supply is Albertan oil sands, with limited volumes of GTL and CTL fuels. Clearly though, these are capital intensive projects that will require sustained high prices (or technology improvements to lower costs) and certain demand and favorable investment regimes to be realized.

Turning to OPEC output, estimated at 31.0 mmb/d in 2007, production is forecast to increase in order to meet growing global demand. However, owing to a conservative assessment of OPEC reserves underlying PFC Energy's assessment, this projection shows significantly lower crude oil production in 2030 (32.5 mmb/d) than either the IEA (39.7 mmb/d) or OPEC (43.6 mmb/d). Indeed, while the IEA and OPEC see the Organization's crude output steadily growing, PFC Energy's forecast sees output declining beyond the 2020-25 timeframe. Despite this divergence on crude production, all three studies forecast that OPEC NGLs/condensates will show substantial increases as a by-product of growing natural gas production. This is estimated to grow from 4.7 mmb/d in 2007 to as much as 11.5 mmb/d in the IEA's 2025 forecast (OPEC and PFC Energy project lower output, at 8.9 mmb/d and 8.1 mmb/d, respectively).

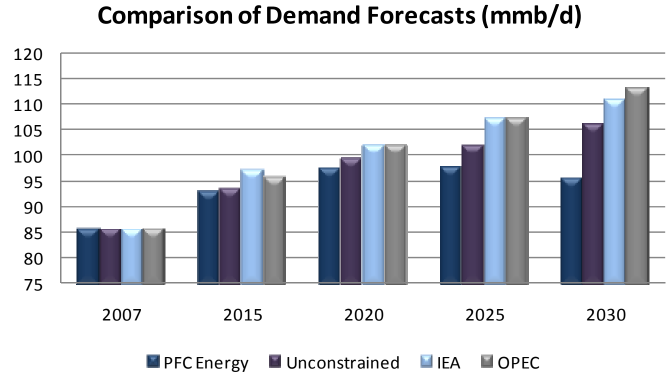
The supply outlooks in all three studies are based on relative similar views of remaining proven reserves—those that are known to exist and are economically and technically recoverable at current price expectations. Proven reserves are estimated by various organizations at 1.1-1.3 trillion barrels, with OPEC member countries' share around 75% of the total (including the substantial revisions made by OPEC in the early 1980s discussed further in following sections of this report). However, trends in developing future reserves—both in terms of additions to current reserves as well as decline rates impacting current production levels—highlight particular uncertainties implicit in all three forecasts.

New reserve additions are forecast to come from both new discoveries as well as improved recovery factors, improving the ultimate production from currently producing fields. Unfortunately the new discoveries component of reserve additions has been disappointing over the last 20 years, falling well below actual volumes produced despite occasional periods of significant new discoveries. PFC Energy and the IEA remain less optimistic about the extent of new discoveries going forward. OPEC, however, attributes this recent poor performance to the tendency for exploration results to be reported conservatively due to limited data and regulations governing reserve reporting. More importantly, the low price environment that prevailed for much of this period tended to skew assessments of recoverable reserves under prevailing conditions. Consequently, OPEC anticipates improved exploration success going forward as prices have strengthened. Although too short a period to draw firm conclusions regarding this dynamic, PFC Energy would caution that recent crude price rises have been accompanied by sky-rocketing costs across the service sector value chain, making the flat price impact on recoverability an ambiguous one. Indeed, non-OPEC supplies fell in 2007 and 2008, despite oil prices reaching record levels over these years.

Further additions to proven reserves are expected from improved recovery factors. Indeed, this element could prove to be the most important in expanding the reserve base: With the global average recovery factor estimated around 35%, the IEA calculates that an increase of only one percentage point in the recovery factor would add 80 billion barrels to proven oil reserves. Improvements will likely come as secondary and tertiary techniques are improved and as these techniques migrate to more producing countries. In addition to adding barrel to global proven reserves, improvements in the recovery rate is perhaps the single most important factor in maintaining output in existing fields and postponing or reducing the onset of field depletion. In PFC Energy's view, the fact that so much of the world's production is probably on irreversible decline is the key factor in restraining global output growth. (Both PFC Energy and the IEA forecast similar future decline rates (at about 6-7% per year. OPEC's estimate of decline rates are unspecified, but the Organization assumes these are lower "than previously thought.")

Although there exist several divergences in views, both in terms of currently existing conditions and future developments, deliverability is likely to emerge as a key issue facing the global oil upstream sector. Decisions made by resource holding states, national and international oil companies, and other actors impacting the global petroleum investment climate will be critical in shaping the actual future capacity of global oil production.

7. Long-term Demand Forecasts



Global demand estimates in the three studies are fairly close through 2015 at around 94.0-97.0 mmb/d. By 2025, however, divergences begin to emerge: PFC Energy shows demand of 110.6 mmb/d while the IEA has about 106.2 mmb/d (after adjusting the organization's forecast to add back biofuels) and OPEC's estimate is 107.7 mmb/d (OPEC's forecast, it should be noted, was first published in July 2008, before the onset of the deepest part of the financial crisis and sharp economic downturn). In addition to differing assessments of the impact of the current economic crisis on the development of future demand trajectories, PFC Energy's lower demand forecast also reflects projected supply constraints discussed above. (To better illustrate the difference stemming from projections of economic, technology and efficiency gains alone, the "unconstrained" case shown in the graph above uses PFC Energy's assumptions on future demand needs, but based on the higher output levels assumed in the IEA outlook). All three studies share a common view with regards to regional trends: OECD growth will be anemic at best between 2007 and 2030 (and is forecast to fall by 2.6 mmb/d in the IEA study); while non-OECD countries—and in particular the economies of China, India and the Middle East states—are expected to provide the strongest base for further oil consumption.

Despite the divergence in overall consumption levels, there exists broad consensus among the forecasts regarding the drivers of future oil demand: oil remaining the dominant transportation fuel; an uncertain future role for oil products in the industrial sector, and continuing decline in oil's role in power generation.

Sectorally, all of the studies concur that oil's dominance of the transportation sector will continue, as will the centrality of transportation use to overall demand growth (transportation is projected to provide 70-80% of incremental demand growth). Indeed, all three forecasts assume that oil's dominance in transportation will not be seriously challenged even over the long-term. The IEA sees only marginal increases of biofuels and electric cars, broadly in line with PFC Energy's view that alternative supplies will help meet incremental demand while not challenging the central role of oil in the sector. OPEC's forecast discusses these alternatives only as sensitivities to the base case. This assumption reflects the view that despite substantial investment in technologies that most promisingly challenge oil's role in transportation in the near term—especially commercialization of improved battery technologies or next-generation biofuels—these technologies appear insufficiently developed to play a central role in reference case scenarios. Furthermore, emerging markets are likely to provide the greatest source of demand growth, given the anticipated rise in vehicle population and transportation infrastructure in these countries. However, it should be noted that a commercial breakthrough in alternative transportation technologies could allow emerging markets to leap-frog into new modes of transportation, reducing the oil-intensity of the sector even as transportation demand grows. This represents the key long-term downside risk to transportation demand projections.

Following transportation, industrial uses of petroleum products will account for an important segment of demand growth. However, this is expected to come primarily from industrializing economies, while oil use in the OECD industrial sector is expected to contract. In part, this reflects the shrinking share of industry to OECD GDP, but also a judgment reflecting competitive feedstock prices being offered in the Middle East on the prospects for the OECD petrochemical industry (perhaps the most energy intensive).

Residential and commercial oil use in the OECD is already well-developed, and should see declines as efficiencies increase, natural gas displaces oil, and populations decline. However, population growth, urbanization, and per capita income gains in developing countries will result in increased oil use in these sectors. In large measure, increased oil consumption will reduce traditional fuel use. This substitution in some cases will somewhat unexpectedly reduce the environmental impact of increases energy consumption.

Electricity is forecast to show continued strong growth, paralleling the rising global importance of the commercial sector and of those industries that tend to make more intensive use of electric power. However, all three studies see flat to negative growth for oil use in power generation. The industry will continue to favor coal and natural gas and perhaps place greater emphasis on nuclear over the next two decades, although unforeseen disruptions in non-oil energy supplies or extreme weather could result in a temporary rise in oil demand. PFC Energy notes that, in the medium term, oil use in the power sector will likely grow in the Middle East if natural gas developments continue to lag demand, especially in Saudi Arabia, Iran and Kuwait.

Despite these general agreements on the drivers of future oil demand, uncertainties over the future economic climate and future oil supplies account for divergent demand forecasts. OPEC's demand forecast of 113 mmb/d by 2030 is the highest of the three studies, but as noted above was also released before the sharp economic downturn. While the IEA's study was released after the beginning phase of the economic downturn, not only is the contraction expected in 2009 lower than PFC Energy's forecast, but also the IEA assumed a much swifter recovery than in the PFC Energy forecast.

B. Impact of the Economic Crisis

The past year's problems in world financial markets have set the stage for an extended period of extremely slow growth in the major world economies. Most ominously for both short-term oil markets as well as longer-term energy planning, as the slowdown deepened, it had become clear that not only would industrialized economies be particularly hard hit, but also that most of the emerging markets that have anchored global oil and gas demand growth over the last several years are also facing extended periods of slower growth. The implications are wide-spread, with differing effects on both short-term and long-term industry implications:

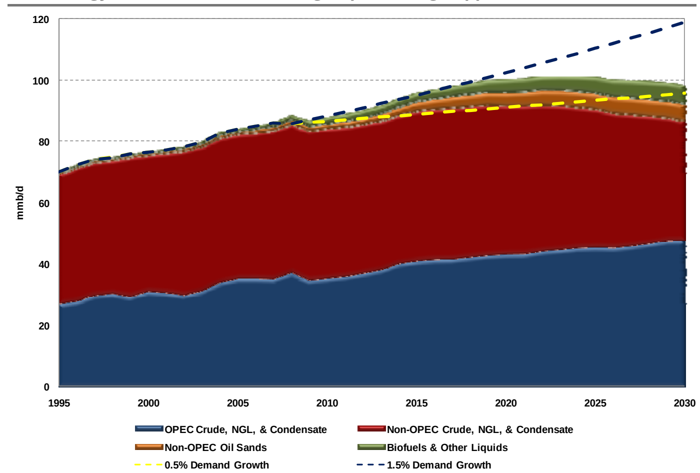
- slower growth in energy demand, supplies and prices than would have been expected even just months before the on-set of the deepest part of the crisis;
- lower investment in the development of conventional and unconventional hydrocarbon resources;
- slower development of alternative energies, including biofuels and non-combustible renewables;
- possible reductions in public and private funding for energy-related R&D; and
- possible reduction in the emphasis on conservation and on improving energy efficiency by households and industry.

Although the resultant lower oil prices, as well as lower consumer preferences for costlier renewable fuels could see a reduction in both spending on conservation and alternative energy efforts, this is not a clear-cut conclusion. In fact, environmental concerns—ranging from concerns over the emissions of greenhouse gases to local air quality issues—have played a leading role along with concerns over future energy security in placing conservation and alternative energy issues at the top of the energy policy agenda. Indeed, many of the stimulus plans already discussed or passed to deal with sagging global demand have had at least an element included that looks at improving energy efficiency and "greening" of the economy. Nonetheless, a short-term focus on reviving the economy, particularly if key countries see a further worsening of conditions, could result in a short-term suppression of both policy-maker and key constituent focus on issues of alternative energies and efficiency.

But these factors will also have an impact of the supply side of the ledger as well. PFC Energy expects an eventual flattening of conventional oil production and eventual decline (depicted in the chart to the right). PFC Energy's assessment of future decline rates is more moderate than the 9% per year recently forecast by the IEA (and we foresee only a minimal impact on investments to forestall declines stemming from the very low oil prices in the first quarter of 2009), but it is still rapid enough to produce a world energy picture that differs vastly from previous long-range energy assessments. This is not a world of "peak oil" where global hydrocarbon potential is exhausted, but rather of peak production, where the petroleum industry's ability to continue to increase—or even maintain—production of conventional oil (and eventually gas) is constrained. Exploitation of unconventional oil will provide additional liquids, but in all probability only at increasingly higher costs, and it will depend on significant investments to develop appropriate technologies to convert today's resources into tomorrow's reserves.

Potential, Not Inevitability of a Supply Crunch

PFC Energy sees constraints leading to plateauing supplies



The exact timing of both the plateau and onset of irreversible decline will be influenced by the factors that determine long-term changes in supply and demand. Nevertheless, the challenge is coming, and this emerging world of limited conventional production will require major adjustments on the part of both consumers and producers. Some of these adjustments are already underway, and others will certainly follow. But whether they will be sufficient to balance long-term supply depends on how quickly producer and consumer governments appreciate the gravity of the challenge and the need for immediate and concerted policy initiatives, including efforts to enhance recovery rates and encourage innovation.

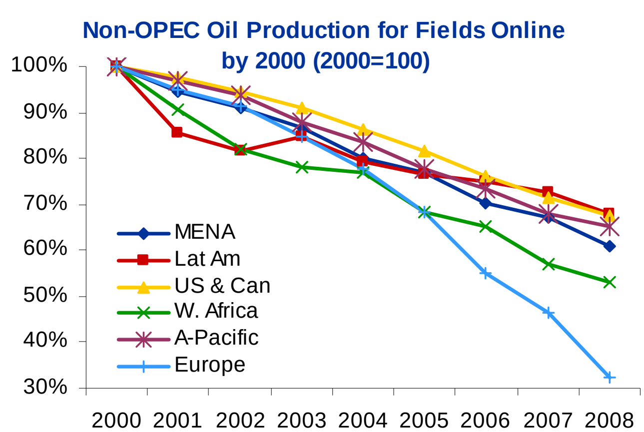
Part 2. Supply Uncertainties: From Resources to Reserves

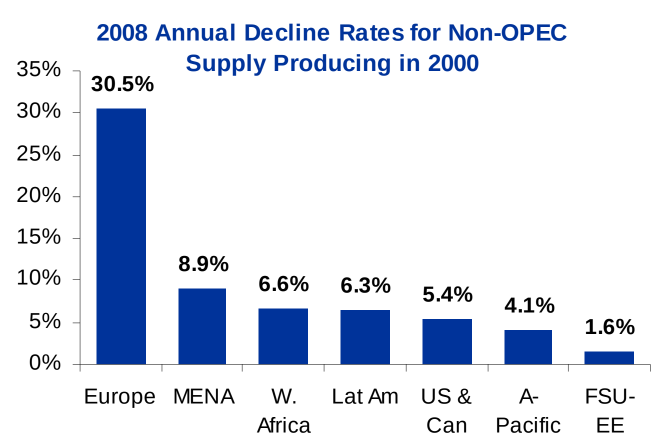
A. Size of Resources and Decline Rates

Prior to the oil price drop in the second half of 2008, PFC Energy had proposed that a global ceiling for liquids production capacity of about 100 million b/d (including conventional oil, gas liquids, unconventional heavy oil, biofuels). This estimate compares well with numbers proposed by Shell and more recently TOTAL (which postulates a 95 million b/d ceiling). The impact of the current low oil price period (depending on how long it lasts) could negatively impact the forecasted production ceiling. Cutbacks on E&P spending ranging from 10% to 40% would have the impact of steepening the base decline rate, delaying new source projects and reducing exploration activity. Should this period of low E&P investment last two years or longer, the result could be that the global production capacity ceiling would be lowered as future new volumes would find it more difficult to replace base production and provide new net volumes to global supplies. Accordingly, one of the critical uncertainties is forecasting base decline rates in current non-OPEC oil production.

Decline rates in non-OPEC and non-FSU supply have risen steadily in recent years, despite high oil prices: fields that were online in 2000 have been declining at an average global rate of 6.2% a year in the period from 2000 to 2008. Even that number aggregates lower decline rates in 2000-2003 with rising decline rates thereafter. By 2008, fields in non-OPEC countries and outside the FSU that were in production in 2000 were declining at a global average rate of 9.4% a year (6.58% including the FSU).

Thus not only were higher oil prices unable to arrest the drop in production, but the decline rates actually accelerated in recent years. The cumulative impact is that base oil production outside OPEC and the FSU (for fields online before 2000) had declined by 40% between 2000 and 2008. New supply served primarily if not exclusively to offset drops in base production. Most of this offset came from production rises in the FSU—and even then, as decline rates kept rising, new source was unable to offset declines leading to negative production growth.





Decline rates vary from region to region, but the trend is consistent:

- Europe shows the largest decline rates in the non-OPEC world, primarily as the result of the maturity of North Sea oil production. By 2008, the decline rate for fields producing oil in 2000 was over 30%, double the decline rate in 2007. In fact, base production from these older fields in 2008 was just 32% of what it was in 2000 – a loss of approximately 3.5 million b/d.

- Non-OPEC Middle East and North Africa (MENA) follows with decline rates for older fields in 2008 being 9%. By 2008, non-OPEC MENA fields were producing 40% less than in 2000 reflecting across the board declines in Egypt, Syria, Oman, Tunisia, Yemen and Bahrain.

- In non-OPEC West Africa decline rates were 6.6% in 2008 with drops coming from Gabon, Congo and Cameroon. In total, the region's mature fields produced 47% less in 2008 than in 2000.

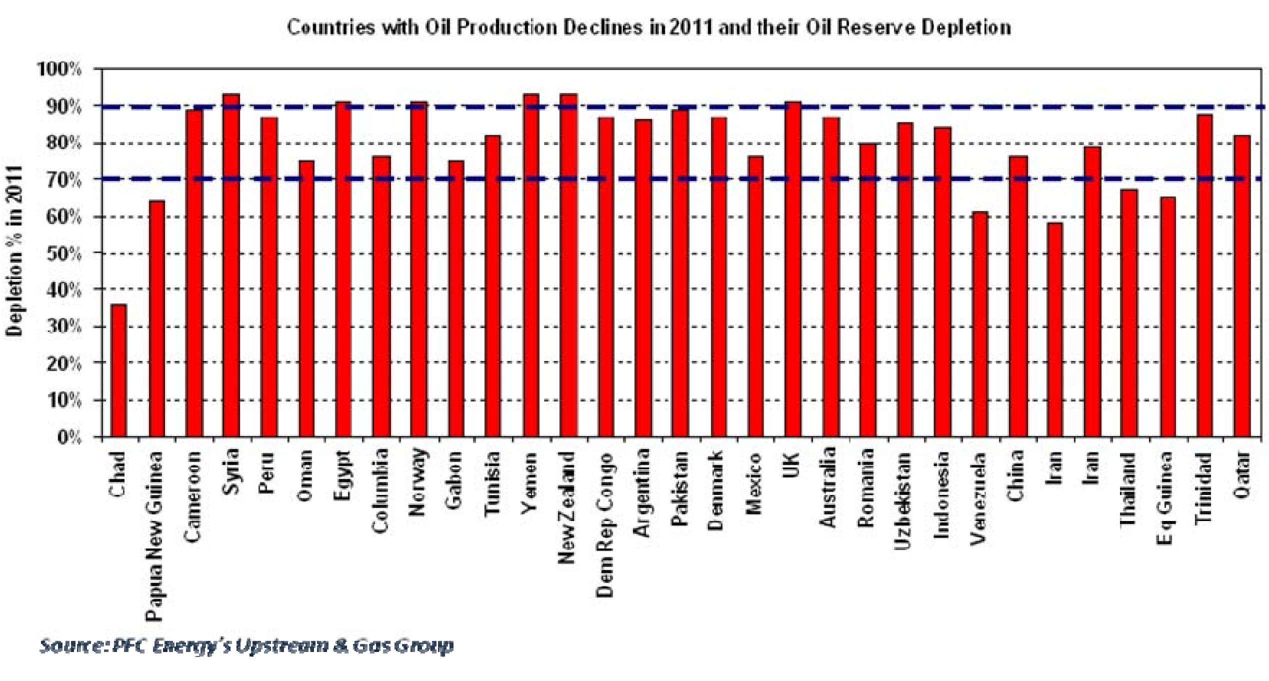
- In Latin America the decline rate for older fields was 6.3% with Mexico accounting for the majority of that (due to the steep declines at Cantarell), although declines in Argentina are also contributing to the total. In sum, the region's pre-2000 fields produced 32% less in 2008 than in 2000.

- In the United States and Canada, the average decline rate for fields producing in 2000 was 5.4%. The two countries' mature fields produced 33% less in 2008 than in 2000.

- In the Asia-Pacific region, declines in 2008 were 4.1% with drops coming from Indonesia, Australia, Vietnam, and Brunei. In total, the region's old fields produced 35% less in 2008 than in 2000.

- In the FSU and Eastern Europe, declines for older fields were lower, with the region producing more in 2008 than in 2000 as the industry recovered from the collapse in Russian oil production following the disintegration of the Soviet Union. These lower declines rates reflect in part the fact that Russian oil production refocused on producing more from existing fields or from sections of fields previously undeveloped

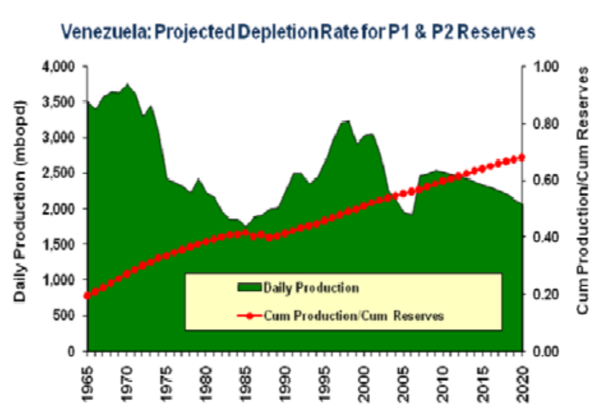
The inability to arrest decline rates over the last few years demonstrates that higher oil prices, whatever



Source: PFC Energy's Upstream & Gas Group the positive economic impact on new projects or to the attractiveness of reworking older projects, were insufficient to reverse the trend. In fact, decline rates seem to be uncorrelated with oil prices or technology at least on an aggregate level. If low oil prices lead to a period of extended low E&P investment and therefore accelerated decline rates in mature basins such as the North Sea, the "knock-on" impact on future global supply capacity will be profound.

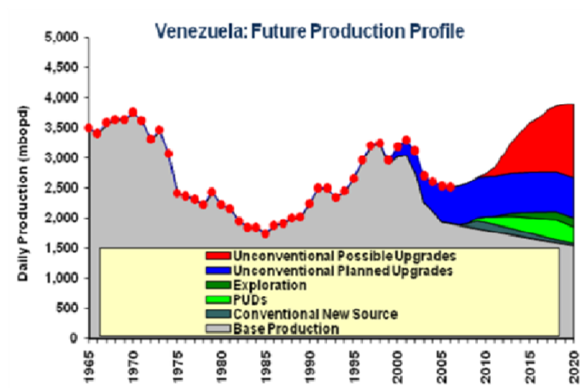
The questions of the size of the underlying resource base and decline rates, however, are meaningless except in the larger context of future development of these reserves. At some point in the next decade, conventional reserves will become scarcer, but when and how exactly this point is reached is still uncertain. On the supply side, government policies will clearly play an important role: in producing states, the extent to which national oil companies are provided with the financial resources and operational autonomy to develop the requisite technical and commercial skills to drive investment programs (or are allowed to bring in appropriate partners from abroad) will be critical to ensuring the most efficient development of the resource base. Already today, approximately 75% of the world's production comes from mature fields that are 30 years old or more. Production in these basins has either been in plateau or is now in decline. This means that the application of new technologies to existing operations is essential to extending the life-cycle of these fields. Of the 31 countries modeled in the chart above, 25 will have depleted more than 70% of their reserves by 2011 (in the case of seven of these countries, the depletion figure is more than 90% of their conventional reserves). As conventional reserves continue to be depleted, the importance of technology will grow, not only in order to prolong the plateau and flatten out the decline of conventional reserves, but also to develop potential resources.

Indeed, in addition to government policy and the oil price, technological advancements stand out as having the greatest impact on the development of hydrocarbon resources (and their discovery) in the future. Both are critical to the commercial viability of investments, particularly in unconventional resources. The inclusion of oil sands as reserves within the SEC guidelines, for example, reflects not only a higher oil price environment, but also the industry's ability to develop these reserves, thereby adding significantly to the world's recoverable reserves base. With an estimated 180 billion barrels of recoverable oil sands reserves, this would place Canada as a pre-eminent resource holder in the world, second only to Saudi Arabia. Indeed, PFC Energy sees prospects for Canada's total oil production to climb above 5 mmb/d by 2030, almost double today's output.



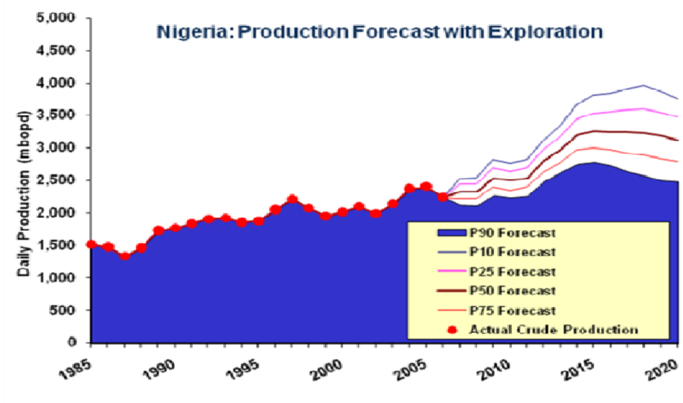
Source: PFC Energy's Global Liquids Supply Forecast

By the same token, Venezuela's future production profile will be driven by the significant unconventional heavy oil projects (bitumen) that will be brought on stream over the next decade. Venezuela has depleted 41% of its conventional reserves, and based on PFC Energy's supply models, production of conventional oil (captured in P1 and P2 reserves denoted as proven and probable) has already peaked (see chart). However, the development of unconventional reserves—mainly heavy oil requiring enhanced recovery methods—makes it possible that



Source: PFC Energy's Global Liquids Supply Forecast

Venezuela's production levels could reach a range of 3.5 mmb/d to 4.2 mmb/d by the middle of the next decade. (Note: OPEC secondary sources of member country output as well as PFC Energy estimate current Venezuelan output at around 2.4 mmb/d and declining, while Caracas officially claims production remains above 3.0 mmb/d.)



Source: PFC Energy's Global Liquids Supply Forecast

For the world's largest resource holders, these issues are not an immediate concern, as there is still untapped potential for production increases within their conventional reserves bases. Also the use of secondary and tertiary methods of recovery is not yet widespread in a number of OPEC countries where operation and production costs remain fairly low relative to more mature basins elsewhere. However, this situation will change over time. Even those countries with the biggest hydrocarbon assets will begin to enter a period of production plateau, or in some cases decline, towards the end of the next decade. For example, Nigeria—with reserves of over 36 billion barrels (P1 & P2)—currently produces around 2 mmb/d, and could add a further 1.2 mmb/d of production from new reserves discovered in water depths exceeding 1,000 feet. With approximately 51% of Nigeria's reserve base depleted, PFC Energy estimates that production will peak sometime around 2016, at no more than 3.3 mmb/d. The levels of decline thereafter will average between 1-3% per year

B. Technology

In the long-term, therefore, it will be the application of appropriate technologies that will be necessary to affect the ultimate rates of decline and recovery worldwide, as well as the peak and sustainable levels of oil and gas output. This will represent a shift in the drivers for innovation from the recent past, when it was the pressure of low oil prices and the need to maximize existing resources that provided the strong impetus for developing new technology in the industry.

Broadly speaking, technological advances have been applied to four general areas in the oil and gas production chain:

- **Cost-Efficiency.** During periods of low oil prices, and therefore low margins, IOCs have been particularly adept at boosting their bottom line by reducing costs. Technologies aimed at speeding up the rate of penetration (ROP) by using higher-tech and longer-lasting drill bits have resulted in readily measured cost savings. The use of smart well completions (eliminating the need for costly recompletion rigs) and real time operations (RTO) technology has allowed for more precise resource targeting and faster decision-making. RTO has also reduced failures in production equipment (pumps, compressors) and required less staff. Other examples of cost-efficiency technologies include rod pump technologies for longer lasting pumping time, and down-hole (rather than surface) separation.

- **Production Cycle-Time.** The poor success rate in new discoveries and the complex nature of new reserves has induced the development of technologies aimed at streamlining exploration efforts. The use of 3D and 4D seismic surveys has greatly enhanced the evaluation and precision of resource identification and quantification, even though the private sector has been fairly slow to take up new technologies and make their use widespread: 4D seismic technology has been around for nearly 30 years, but only recently has it started to make inroads within the industry as a valuable reservoir management tool, and it has still on only captured 3% of the market so far.

- **Higher Recovery & Production.** This has been evident on a number of levels:
    - The use of horizontal wells from the 1970s onwards enhanced well productivity, reduced water and gas coning and improved well economics. Horizontal drilling has been useful in multiple reservoir structures, and has improved extraction rates in Canada's heavy oil fields where thin oil zones make vertical drilling less effective.
    - The application of secondary extraction methods in many mature basins. Water re-injection, gas lifts, gas re-injection and electrical submersible pumps (ESPs) are all in use to maintain reservoir pressure and enhance recovery rates. In Saudi Arabia, water injection is integral to the new 1.2 mmb/d Khurais development, where 2 mmb/d of water will be injected to pump out the oil, in addition to maintain production at older fields in the country.
    - Tertiary oil recovery, also known as enhanced oil recovery (EOR), to reduce the viscosity of crude oil, therefore making it flow easier. Steam injection and CO_2 flooding are both common methods typically allowing a further 5-15% of the reservoir's oil to be recovered. The downside of these methods is the high cost of implementation, meaning that high oil prices are required, or more specifically targeted fiscal terms for that purpose. In the longer term, these secondary and tertiary methods of extracting resources will become a more integral part of the industry in a growing number of basins around the world.

- **Environment.** The application of technologies to minimize pollution and environmental risk has gained significant traction over the past decade. While traditionally the industry had looked at pollution control, the focus has also now shifted toward prevention. In addition to environmental benefits, some of these initiatives, such as the reduction of venting and gas flaring, have also provided a means to enhance production rates (in the case of flaring by providing CO2 for re-injection).

Technology - improvement	% Improvement by 2020
Exploration well success rate	7
Development well success rate	6
Ultimate Recovery per well	11
Drilling cost reduction	22
Completion cost reduction	16
Initial Production rate	9
Infrastructure cost reduction	14
Fixed Operating cost reduction	12

Source: PFC Energy's Upstream & Gas Group

Given the importance of technological advancements to extending life-cycles of fields and to developing new reserves, two aspects of the industry's approach to new technology adds uncertainty to the availability of new technologies to turn today's resources into tomorrow's reserves. The first is the focus of the industry on those areas impacting costs first, and enhancing discovery success rates or overall recovery factors second. PFC Energy estimates that by 2020, the greatest improvements in the application of technology in the upstream sector will lower the costs of drilling primarily, with completions, operating costs, and infrastructure also seeing benefits. Certainly the overall improvement on project economics these benefits will bring about will enhance the outlook for further investment in the upstream oil and gas sector, but the lower focus on the technologies that will ultimately be needed to maintain plateau production in mature areas—or discover new reserve to replace depleted fields—will still see far lesser improvements owing to a lower traditional priority in these areas. By 2020, PFC Energy forecasts that ultimate recovery rates will see the greatest improvement (with new technologies likely to represent an 11% improvement above today's state-of-the-art, while technologies impacting exploration well success rates are likely to improve only 7%.

Exacerbating this lack of focus on the primary technologies needed to improve future production capacities is the fundamental lack of relative funding for R&D in the oil and gas industry, particularly in comparison with other industries. Three core areas will need to be addressed to reverse this picture: funding levels; the overall atmosphere of innovation and adoption; and the personnel squeeze faced by the industry that has extended to the R&D sector.

R&D spending suffers from a lack of breadth and a perceived lack of absolute value. Major R&D funding in the oil and gas industry is heavily concentrated among the super-majors, majors, some NOCs and the service industry: since the early 1990s, a large proportion of R&D activity has shifted to the service companies, who now control large portfolios of patents (company information suggests that, in 2007, Schlumberger's annual R&D spending ($720 million) eclipsed that of ExxonMobil ($650 million)). And as a whole, the oil and gas industry spends far less than other major industrial sectors. In the last comprehensive study of R&D spending for all of industry, published by the United Kingdom's Department of Trade & Industry in 2005, the highest ranked energy company in terms of absolute expenditure ranked 100 overall, and the oil and gas sector as a whole lagged in both absolute spending and R&D investment as a percentage of sales. Thus, viewed on an aggregate basis, there appears to be a lack of investment in this area, especially on longer-term pure research, something that points to potential shortfalls in the industry's future ability to respond to issues of growing concern to both producers and consumers alike.

Exacerbating the low levels of total R&D spending within the industry are obstacles to optimal innovation and a conservative approach to reservoir management that sees an overall slow adoption of new technologies. Radical breakthroughs in the oil and gas industry are relatively rare, and this pattern is compounded by the unwillingness of IOCs and NOCs alike to sharing of discoveries rapidly.

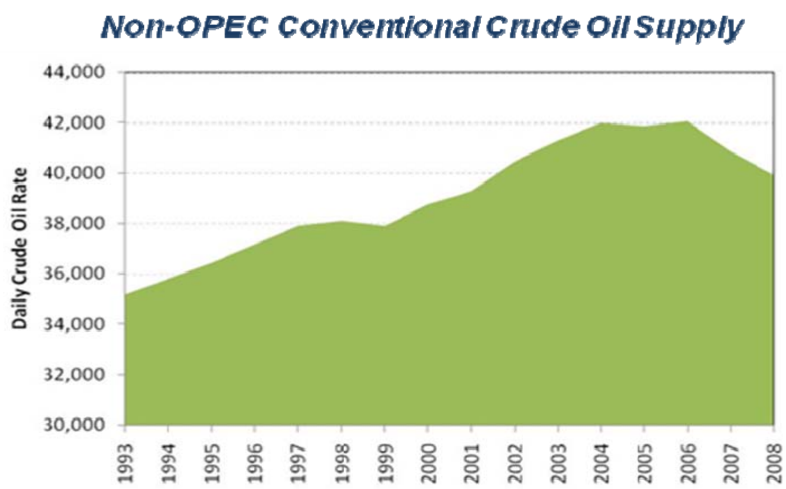
There are some indications that the pace of innovation in the oil and gas industries is picking up. Over the last 20 years, the global E&P business (in which the majority of oil and gas R&D is spent) has more than doubled the number of patents obtained, although early sharing of technological discoveries are still not in the commercial interest of IOCs and NOCs. Among service companies, where there is an interest in growing the market for new technology, the performance has been much better: since 2000 they have secured six times as many patents as the major oil companies.

Nevertheless, the majority of R&D being carried out by IOCs and NOCs is focused on addressing near-term issues, and the objectives are related to improvements rather than breakthroughs. This incremental, one-step-ahead-of-the-competition philosophy further compounds the issue of technology focus discussed above. To make matters worse, the historical relationship between operators and service companies has generally not been collaborative, except where specific technological alliances have been established. Instead, many contract awards come down to simply the lowest price, which greatly reduces the likelihood of a radical new technology being adopted; perhaps a somewhat un-surprising result given the nature of the oil and gas industry, whose appetite for risk seems to be more than satisfied by the geological uncertainties associated with exploration. What results is a Catch-22 situation where operators demand evidence that the technology is "proven" through testimonials, which makes securing candidates for pilot testing very challenging.

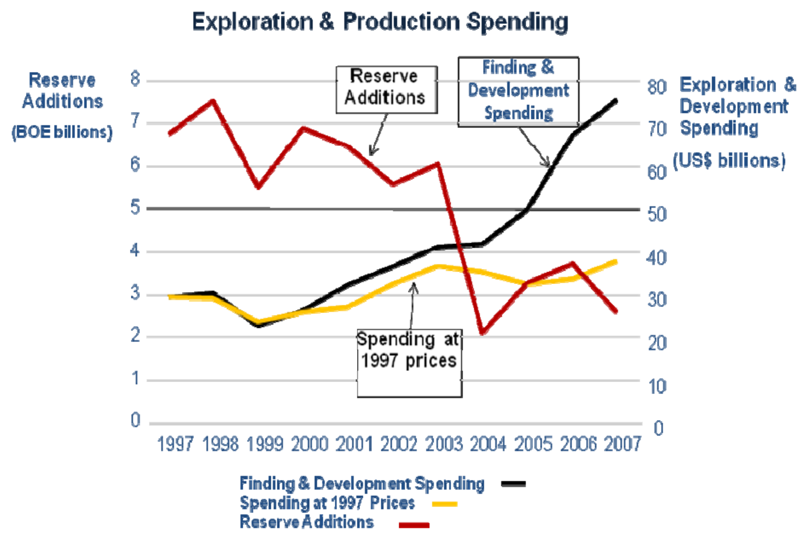
C. Cost and Price Volatility

These technologies will become increasingly important over time as balances become tighter and exploration and recovery pressures become more acute. PFC Energy maintains that the high price environment experienced since 2002 diverted much needed attention away from maintaining and extending the life-cycle of existing operations, to the pursuit of new projects, especially with entrance of new players to the sector seeking to capture high returns. While sourcing new production is a priority for the industry, particularly for publicly-traded companies whose business models are built on booking reserves, the steep output decline from existing basins in the meantime has been alarming. The use of EOR methods have been successful in extending the plateau phase of mature fields, but once in decline, these fields' depletion rates accelerate upward of 15% per year, from a previous average of 8-9% per year. With production at most of the world's oil fields peaking within three years of initial operations (with few exceptions like Ghawar and Kashagan), the length of the plateau period becomes a critical factor in global balance, making the difference between whether new developments add incremental volumes to global supplies, or simply offset losses elsewhere.

Viewed from a private sector perspective, while spending on exploration and development has almost tripled since 1997, reserves additions have dropped by nearly 60% over the same time frame. The non-OPEC crude supply chart above shows a clear plateau and consequential drop in non-OPEC supplies since 2003, a period when expenditure budgets were increased. This suggests that either less operational expenditure was dedicated to extending the life-cycle of ongoing concerns; or, even with the additional funds allocated to secondary and tertiary methods of recovery, the technologies available have not produced appreciable results given the maturity of the reserves.



Source: PFC Energy's Upstream & Gas Group



Source: PFC Energy's Upstream & Gas Group

If the former is true, capital expenditure on finding and developing new sources has not produced positive results either. While CAPEX has more than tripled in the past ten years, approximately 40-50% of the increased spending is attributable to higher contractor pricing. The net effect being that expenditure in real terms has not increased much from 1997 levels. The current price drop pressured by demand-driven factors could exacerbate these problems in the medium-term, particularly if costs in the service sector are slower to adjust. The potentially bearish supply picture, however, has not changed and with difficult projects (heavy oil, deep offshore) now under threat, markets have focused on the prospects for a spike in prices once the global economy recovers, giving some stability to long-dated crude contracts, even as volatility in the front-month prices increases with the changing tenor of current economic news. Heavily leveraged service sector firms seeking finance for completion of drilling rigs and other equipment are now under intense scrutiny as perceptions of slowing demand amid rising capacity in several areas of the service sector value chain ease constraints. While the industry's largest players have not yet significantly revised their CAPEX plans, reigning back on operational costs will be a distinct likelihood in the medium-term.

Most NOCs have also been adversely affected by the sky-rocketing costs, though for many of the stateowned oil companies, the most significant burden has come from state demands for higher revenues to support increased social and infrastructure spending, and to offset imported inflation. Thus squeezed both from the industry and the state, even some of the NOCs in the largest resource-holding states felt acute pressures amid record-high oil prices. International headlines focused on the changing terms and operating conditions for IOCs in major resource-holding areas, but similar pressure have also been applied to the domestic NOCs. States pursued four major policy objectives through changes in investment terms:

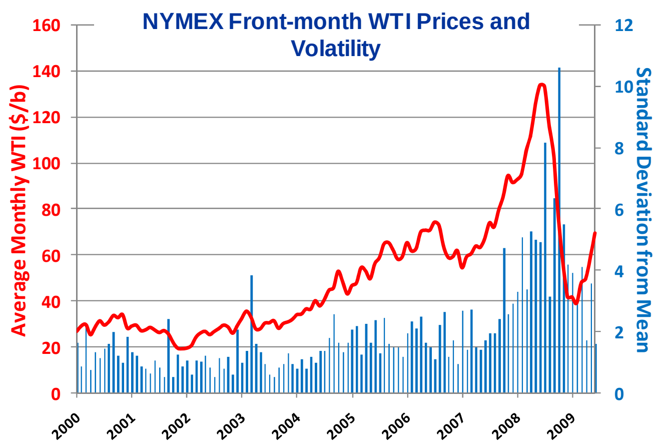
- Increased control over the oil and gas sector;
- Extraction of greater revenue from projects;
- Imposition of broader foreign direct investment requirements (in the non-oil sector);
- Indigenous capacity building in the oil/gas service sector and especially in the area of technology.

The precipitating causes were not always the same, and in addition to the financial and inflationary pressures noted above, both periods of rapid price increases and declines have historically led states to adjust upstream terms. In the case of lowering prices, the revenue needs of the state are obvious, and outweigh the longer-term considerations of maintaining a stable investment environment. But similarly during rising prices, the rationale of allowing oil companies—whether international or national—to retain an increasing revenues is questioned, particularly when either the apparent need for re-investment or the returns on that investment is not immediately obvious. In periods of declining production, as well, governments have often turned to address their revenue needs—by increasing the state take in the oil sector—over the medium-term needs of the industry (and ironically, also of the state's medium-term revenue source). And on the reverse, major new production increases or discoveries often leads to a strategic re-evaluation of the state's view of the oils sector, and in particular of its assessment of the right mix of foreign and domestic companies operating there.

Impacting both the state's actions toward upstream investment conditions, as well as the oil industry's independent assessment of commercial viability of future projects has been the extreme changes in oil prices witnessed over the past several years. Much of the recent blame and criticism of volatility in prices has been laid at the feet of financial speculation—and the US commodities exchange regulator CFTC is currently investigation the possibility of new rules governing position limits to reduce this volatility—there are other structural factors at play to suggest that increased volatility is not simply a feature of the increasing role of financial markets, but likely a persistent feature of oil markets over at least the medium-term.

Certainly increased open interest in the NYMEX and IPE financial exchanges beginning around 2004 has allowed for faster and more significant price moves, as the amount of money and traders involved in the exchange has dramatically increased. (It should also be noted, however, that this development has also added significant liquidity as well to the forward contract months, lending some stability to long-dated contracts, and even allowing hedging to cover the future production costs of otherwise too risky projects or mergers and acquisitions.) But the inflow of financial funds did not establish the environment of favorable returns, but rather the fundamentals of a sustained period of under-development of the upstream sector during much of the 1990s coupled with a booming global economy and rising oil demand attracted financial funds into energy markets. To be certain, assessments of the ultimate durability of these trends ultimately proved destructive, and short-term trading-strategies focusing on asset relationships such as the dollar-oil linkage raised oil prices to levels that caused un-due stress on physical markets and refining operations crimped by slowing demand ahead of and during the current economic crisis. The resulting collapse in oil demand—and the seemingly continual re-evaluation by the market of the short- and medium-term oil story has led to unprecedented levels of price volatility.

But viewing pricing patterns in the larger context of the entire decade, the inflow of financial money alone does not explain the dramatic rise in front-month price volatility. Though the daily price fluctuation around the monthly average does rise somewhat beginning in 2004 (see chart), the highest spikes in this standard deviation is associated with downturns in the oil price trajectory. During market rallies, there is a generally well shared consensus view of a healthy market followed an agreed-upon narrative of rising demand and eventually constricted supply. The result is a clear price path upward, though some selling occurs from participants sharing differing views of the short-term prospects. During a price fall, however, the fundamentals of this narrative are challenged, leaving the market without a clear expectation of either the short- or medium-term price direction. With no clear trajectory, market volatility increases until a new consensus price level is established, and order restored.



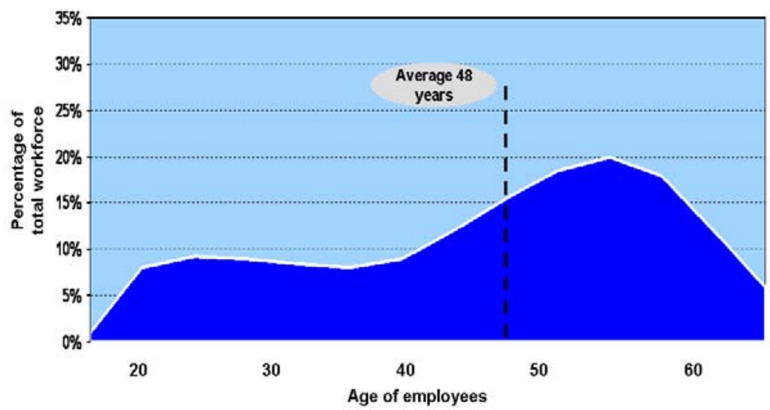
Theoretically, limiting the number of participants in the market would force considerations to be more firmly centered on those factors impacting the supply-demand fundamentals of the market (though also including geopolitical risks surrounding key markets), with less interference from considerations of financial trading strategies un-related to the particulars of the oil industry (e.g., oil as an inflation hedge). It is unlikely, however, that even new US regulations would successfully eliminate these risks without introducing other risks associated with substantially decreased liquidity (including rising volatility as market participants find it more difficult to lay off risk in financial exchanges). But even if successful in reducing the volatility brought about the financial participants, this would not eliminate the volatility brought about through the normal re-adjustment of market expectations. And given the uncertain economic environment—and the prospects that the deep structural issues at the center of the current crisis are unlikely to be firmly resolved in the short-term—oil market fundamentals will likely be continually re-assessed over the next 3-5 years, ensuring continued high volatility in front-month oil prices over this period, complicating oil companies' investment decisions.

D. Human Resources and Project Execution

The global oil and gas industry has been engaged in a "war for talent" for some time. Attracting and retaining qualified staff has become increasingly difficult, and will be exacerbated by an expected wave of retirements in the coming years. While some metrics would suggest this is primarily an issue for the OECD—there are more petroleum engineers graduating each year from Beijing universities than the whole of the United States—the global nature of the industry and the competition for talent means all companies are facing a shortage of talent, and especially of experienced talent. Failure to attract train and retain talent within the industry will ultimately affect and even undermine efforts in other areas to improve innovation and operations.

Difficulties in recruiting and retaining qualified skilled personnel in oil and gas companies are not new, and indeed structural underinvestment throughout the 1990s led to an industry-wide undervaluation of talent, the effects of which are being witnessed now. Especially between 2004-2008, strongly rising crude prices, a large increase in planned capital expenditures, changing industry demographics and geographical concentration of new projects all led demand for personnel to rise extraordinarily fast, placing acute pressures on this longer-term issue. The fall off in demand and prices has slowed demand for new skilled personnel, while firms will be slower than usual to let go of trained staff, the larger risk is one of a further signal of disinterest in new job entrants. For many students outside of some key producing countries, the oil industry is viewed as both unstable and unpopular, making company signals of disinterest even more destructive.

The talent challenge is nothing new for an industry like oil and gas, which is subject to wild market fluctuations. A recent survey by the Society of Petroleum Engineers showed that nearly 90% of senior human resources executives at 22 top international oil and gas companies consider that their industry faces a major talent void, and they call the problem one of the top five business issues facing their companies. Two reasons are generally identified as the main causes of the skill shortage: the ageing existing workforce and a lack of interested qualified young engineers. However little has been done to address this key issue, while the troubling trends which led the HR crisis to develop as it has in recent years will only be reinforced in the current bust.



The average age of professionals in the industry is one of the highest of any industry, with many people retiring in the next few years. The average oil company employee is nearly 50 years old; in the next decade more than half of the industry's employee base will retire, leaving behind a massive void of skilled workers. The industry shed a huge number of jobs over the last few decades. In the United States alone, around 1.1 million jobs disappeared in the field. This was largely the result of a wave of mergers and acquisitions during the early 1980s, which resulted in major job layoffs. The industry was also heavily under-invested during the 1990s, which also affected skills demand. Most of the layoff victims left the business for good, while the industry's boom-bust reputation scared away potential recruits. The result: a "lost generation" of oil workers whose absence has been felt well into the 21st century.

Student enrollment in petro-technical courses has been on the decline for many years. Although enrollment has picked up somewhat in the last 2-3 years, the level is still well below that of the early 1980s. Throughout the 1980s and 90s, in response to softening oil prices, the industry laid off hundreds of thousands of skilled workers, many of whom abandoned the business altogether in search of more stable jobs. Accordingly, recruitment of new employees plummeted, and fewer university students entered petroleum engineering programs. Fewer than 1,000 students obtained university degrees in petroleum engineering and geo-sciences in 2006, which represents more than a 90% decrease since 1982. Students continue to perceive the oil and gas industry as a pollution-prone business, wracked by cycles of boom and bust. In addition, young engineers that did join the industry often hit a “grey ceiling” soon after joining. As the average age is relatively high, young engineers are less likely to be given responsibility for running projects. With a relatively large pool of more experienced workers, managers are less motivated to hand out responsibilities to younger people. In engineering and science firms, on the other hand, young engineers have been known to run projects in their 20s and managing divisions in their 30s, while not much responsibility is gained in the oil industry until age 40.

To move beyond the vicious cycle of laying off workers each time the price of oil drops or paying exorbitant sums to poach existing talent, companies are starting to recognize the need to refine their HR strategies to focus on the underlying structural problems. Being a capital-intensive industry, the boards of most companies focus on investment planning, marketing strategies and other key issues. Human resource planning is often relegated to lower echelons in the hierarchy. This needs to change.

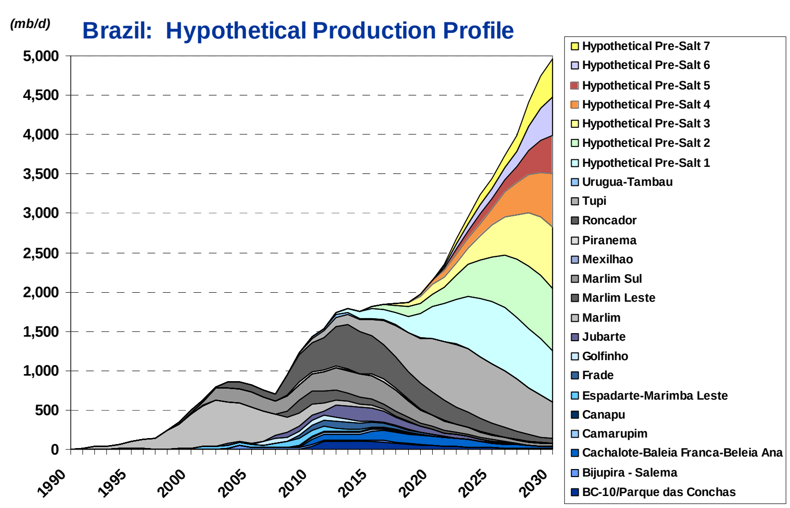
With a clear internal strategy in place, companies can then focus on replenishing the workforce. Both Shell and ExxonMobil have recently invested in global training centers to provide hands-on experience to thousands of recruits. With the ability to train nearly 10,000 students annually, the two companies hope their training facilities will attract bright young scientists and engineers to the field. BP is following suit, partnering with the Massachusetts Institute of Technology (MIT) to build a career development program for new employees. Companies across the world are partnering with local high schools, universities and technical institutes to strengthen ties to the future labor pool. However, a coherent long-term HR strategy seems far off for most companies, especially as their focus shifts to declining revenues.

Recently announced retrenchment programs by large IOCs and service companies suggest the industry will revert to its old practices and ignore structural HR issues until they reach boiling point again. Houston-based oil major ConocoPhillips began laying off more than 1,000 employees. Schlumberger Ltd., the world's largest oilfield-services company by revenue and market value, is laying off about 5,000 employees world-wide, about 6% of its work force, while Halliburton Co. is cutting an unspecified number of jobs.

E. The Press of Time

The uncertainties facing the global upstream sector appear all the more daunting as well, given the pressures of time. The accelerating decline rates in several of the key non-OECD producing areas places additional pressures on the industry to bring additional new resources on-stream in a fairly rapid manner, in order to simply maintain, let alone raise production levels. This in turn will require advancements in new technologies to both lower costs as well as increase the reserves base to be developed more quickly, while also placing an emphasis on stability in the investment climate and the availability of an adequate trained workforce.

To illustrate the challenges, the case of Brazil's future reserve production is illustrative. While this is certainly not the only oil play that could increase production over the medium- to long-term, the possibilities of the sub-salt discoveries dramatically adding to Brazil's production of conventional oil reserves can serve as a microcosm of the issues affecting the industry as a whole.



In the chart to the left, PFC Energy models expected production from Brazil, with the blue and gray bands representing existing and new projects from existing and soon-to-be-completed projects. Tupi, the first expected development from the pre-salt play is the final light gray band, while the other colored bands represent hypothetical fields of a similar size to Tupi. In order to raise Brazilian production to 5.0 mmb/d by 2030, discovery of seven more fields of a similar size to Tupi would need to be discovered, with an additional new project coming on-stream every 2-3 years. This rapid execution schedule is necessary to offset the declines foreseen in Brazil's existing production levels, and it should be noted that a rise in Brazil's output alone even to this 5.0 mmb/d level would be insufficient to offset the expected decline in non-OPEC base production over this period.

But even these limited goals would require discovery and development of 70 billion barrels of reserves beyond the original Tupi find (and discoveries since Tupi have already unearthed 14-21 billion barrels of this total). And the execution schedule necessary to continue to steady boost production levels up to the 5.0 mmb/d will require a herculean effort placing a strict premium both on the investment climate in Brazil (to allow either Petrobras or other firms to make the necessary investments), as well as to ensure that the industry has enough trained staff capable of overseeing several simultaneous development projects in a technologically challenging frontier area such as the pre-salt. Delays in the development of technological advancement, changes in the price or investment climate, or a shortage of qualified staff could all lead to project delays, which even if limited to only a year or two per project, would result in a significantly lowered ultimate output potential from any given resource play.

Part 3: Demand Uncertainties

A. Future Levels and Trajectory of Oil and Gas Demand

1. Energy Efficiency

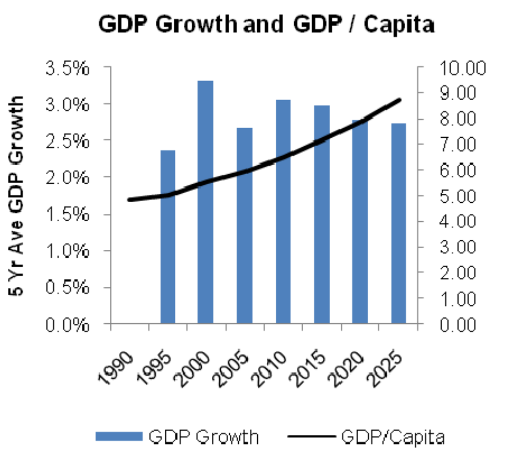
Uncertainties over the pace and timing of the global economic recovery have clouded forecasts for global economic growth in the medium term. Nevertheless, while the immediate term remains uncertain, but likely to witness slow growth as the global economic system searches for a means to resolve the persistent imbalances in trade and consumption patterns that have been the salient feature of the economic systems for over a decade, PFC Energy sees fairly steady economic expansion beyond 2015, resulting in gradual but important increases in real GDP per capita. By contrast, energy per unit GDP (the most common measure of energy intensity) is expected to edge downward, primarily as a result of continued dramatic improvements in energy efficiency in some emerging markets, although other larger or more mature markets (e.g., the OECD and China) also demonstrate modest gains. Over the past several decades world energy use per unit of GDP has declined, but at a modest pace, largely because countries that are relatively energy intensive (usually the emerging markets) have consistently grown more rapidly than counties that are less energy intensive (usually industrial countries), and have therefore become bigger as a relative proportion of the global economy.

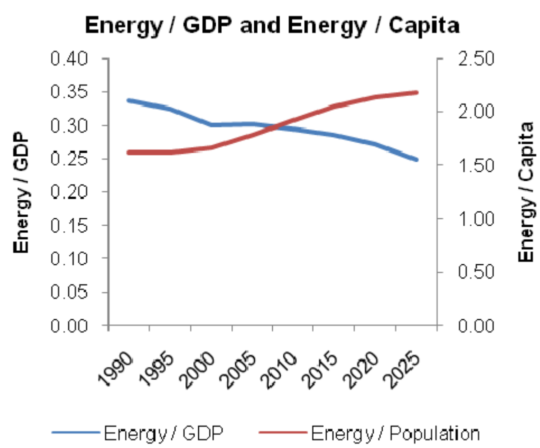
Whether this pattern is altered depends on a number of factors. One is shifts in the mix of economic activity, and energy use as a country develops. Industrialized economies have tended to develop relatively low energy intensive services and light industries like consumer electronics that gradually displace relatively high energy intensive heavy industries, such as steel making. However, many emerging markets have yet to fully industrialize, and are therefore not at a stage where the shift from heavy industries to services/light industries takes place. One of the major uncertainties arising out of the current financial and economic turmoil is how these traditional development patterns may change if for example the world trading system evolves into a collection of internally reliant countries and trading blocs, rather than the more or less open trading system that we have enjoyed in recent years. Such various development scenarios have impacts both on the level of expected global GDP, and especially for energy demand growth, the spread of improvements in energy efficiency.

Another important factor that will affect the ratio of energy demand to real GDP is changes in energy use by sector. Least developed countries traditional consume large amount of energy for residential use in relation to the size of their economies. But as economies develop, residential use grows more slowly than industrial or commercial consumption, and thus overall energy intensity tends to decline, often quite rapidly. This pattern can be offset, however, if the use of energy for transportation increases, for example. Again, government policies are critical to determining these trends. Direct conservation and investments or changes in operating practices designed to reduce the amount of energy consumed by various sectors can have a significant impact on lowering energy intensity figures.

As a consequence of last year's run up in prices, many governments are showing renewed interest in energy efficiency and conservation. But how much will be accomplished in an economic environment that in the future will show relatively low rates of investment (and quite possibly relatively low prices) for some years to come is unclear. A year ago, the stage seemed to be set for a surge in investment for energy efficiency and changes in operating procedures that quite likely would have meant substantial reductions in energy use per unit of real GDP. Now, investment spending is on hold and changes in energy demand are largely a function of changes in economic activity. Some governments are talking about encouraging investments in energy efficiency (and in fuel substitution) as a way to stimulate economic activity, but given the amount of energy equipment that is currently in use and the amount of money most governments have at their disposal, there are major questions as to how much can actually be accomplished, especially in the absence of high prices or a willingness to try to change consumer attitudes toward energy use. Consumer country policies to promote conservation are not expected to fully disappear, particularly with the shift in public thinking in several countries over the last five years on the significance of global warming. But while PFC Energy expects that concerns over the emissions of greenhouse gases and other local pollutants will keep demand policies on the agenda of economic and political decision-makers' agenda, the economic uncertainties likely to dominate for the next several years will mean that these policies are now taken in the context of economic priorities stressing first and foremost the health of the business climate.

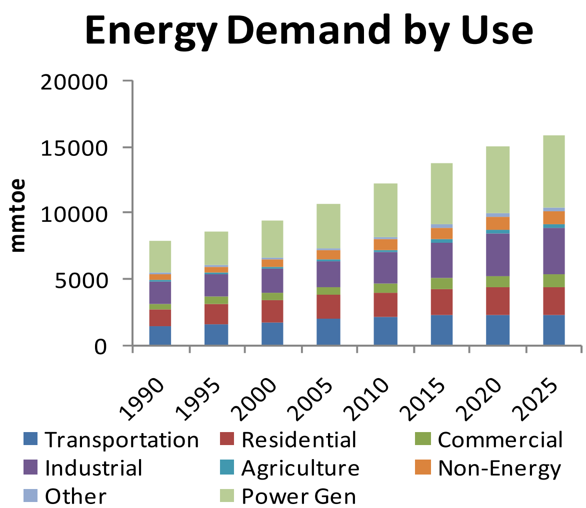
Despite these uncertainties, total energy and global energy consumption per capita is expected to rise significantly in the period to 2025, even if global energy efficiency improves and the path to industrialization for emerging markets is not as energy intensive as those followed by the OECD states.

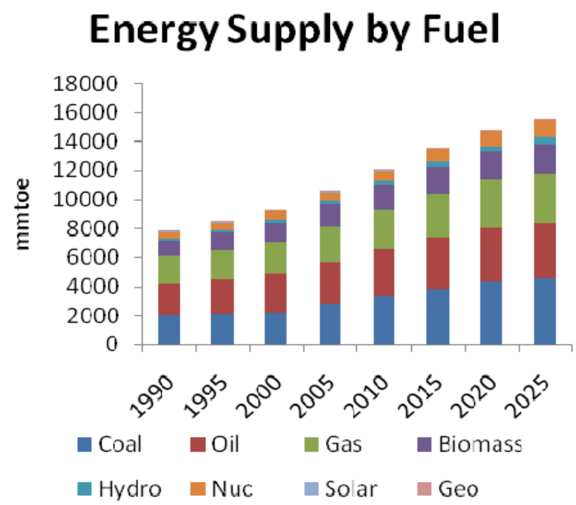




World energy demand is projected to continue to increase across the board, with electricity/power generation and industrial uses expected to contribute the lion's share of total growth. However, commercial use and non-energy uses (primarily petrochemicals) are both expected to be important at the margin. Growth in transportation energy is tempered by the assumption that most developed countries and many emerging markets (especially China and the countries of Southeast Asia) will make major efforts to constrain the growth or improve the efficiency of this particular end use. However, given the dominance of oil in the transportation sector, even modest growth in this sector will place increasing strains on the global petroleum upstream sector to meet incremental demand.

Natural gas is increasing its share of the total energy balance. It is often cheaper than oil, and more efficient than coal. Its advantages to emerging economies that may soon be forced to contend with issues of carbon constraints are well known, and most of these countries have pinned their development hopes on gas, increasing demand for the fuel. As a result, the fuel is being used more deeply (gas generation increases are higher than other fuels in many countries) and broadly (new uses for countries to include petrochemicals, water heaters, transportation etc) in the economy. This trend is driven by several factors, including a dramatic expansion in global electrification. Relatively cheap capital and O&M cost for gas-fired generation, the small carbon footprint compared to coal-fired units, and the ability to load follow are all critical for emerging economies seeking to maintain secure around the clock power generation. Load following is also important when matching intermittent generation from wind and solar to ensure steady electrical output.





Reflecting overall trends in primary energy demand, the outlook for world oil demand and supply poses some fundamental challenges. Even after making what would seem to be realistic if not conservative assumptions for economic growth and energy consumption, and combining those with what may be heroic assumptions for the development and utilization of alternative sources of supply, the result is a forecast for oil that shows demand outstripping supply by as early as 2025. Certainly the "re-setting" of global demand lower by the economic crisis, as well as PFC Energy's view that the trajectory of future demand growth will be lower than before the crisis, unchecked the possibility of a re-emergent long-term supply crunch remains.

Total oil demand and supply will necessarily "balance" by definition. Left unchecked, this balancing will take place through higher prices and lower economic growth. Unfortunately, leaving the balancing act to market forces alone will also result in a fundamentally uneven distribution of its effects—with the impacts hitting hardest among the poorest consumers—further undermining global welfare. Technology and government policies can also provide other means of balancing, but both measure generally require long lead times to have substantial impacts and to lower associated costs. Therefore, proactive measures are needed now to either improve the prospects for total oil supply or greatly increase the efficiency of its consumption, in order to avoid the impacts of supply constraints over the long-term.

Furthermore, a world characterized by tightening supplies of energy could easily become a world in which different countries choose to employ non-economic instruments to secure a disproportionate share of scarce energy resources. PFC Energy's baseline projections do not assume that countries refrain from using non-economic instruments, but they do assume that any competition that does occur will not be sufficient to disrupt materially either economic growth or the development of energy resources that would likely occur in the absence of such non-economic interventions. However, should measures not be taken to address a potential severe tightening in global oil or gas supplies, the potential for such political solutions would further increase, as well as the likelihood for a negative impact on global welfare.

2. Substitution

When considering the trends and dynamics that shape PFC Energy's forecast, many important elements fall outside the direct field of the oil and gas industry—or indeed, of the portfolios of the world's energy ministries. However, the greater application of technologies to improve efficiencies is one area where a clear role for both the industry and energy ministries can be discerned.

a. Biofuels Development

One factor that could impact the oil demand growth picture is biofuels production. Output of this energy source has seen rapid increases in recent years, as high oil prices and government mandates/subsidies have spurred construction of ethanol and bio-diesel facilities. The IEA estimates that global biofuels output has increased from 0.9 mmb/d in 2006 to an estimated 1.4 mmb/d in 2008. How much more of a market share biofuels take in the future will depend on a number of factors, including the extent of government support, determination of the real emissions gains and progress towards the successful development of second generation biofuels.

Government support has been key to the establishment of the conventional biofuels industry. This backing has been forthcoming largely for reasons of supply security concerns or climate change and, perhaps most importantly, strong support from the agricultural sector. The aid has taken the form of both usage mandates and outright subsidies. The United States has led the way, with the passage in December 2007 of the Energy Independence and Security Act that requires 36 billion gallons (2.35 mmb/d) of renewable fuels by 2022 compared to an estimated blend rate of 630 mb/d in 2008. This law also mandated that, beginning in 2016, all of the increases in biofuels come from non-corn feedstocks with greenhouse gas reduction characteristics of at least 50% (as determined by EPA). A number of other countries and organizations have also established targets, including the EU, China, Canada, Australia, Thailand and Japan.

Despite remaining generally supportive of biofuels, some governments have begun to re-evaluate their proactive policies, driven by uncertainty over greenhouse gas (GHG) emissions from these fuels, possible inflationary effects on prices of the main feedstock commodities (like corn and palm oil) and uncertainty over the long-term sustainability of biofuels as an alternative energy source given rising food requirements as populations grow.

The most notable example of this biofuels policy re-evaluation is the recent EU debate over re-adjustments of the Unions biofuel targets for 2010 and 2020. The EU has long had a 5.75% energy-based target for transportation fuels by 2010 that some members were unlikely to meet. A longer-term target of 10% was also established in the same legislation. In the fall of last year, however, the European Parliaments' Industry Committee, reacting to ongoing doubts about biofuels, recommended that 5% of transportation fuels be from renewable sources by 2015 (not 2010) and that at least one-fifth be from "new alternatives that do not compete with food production." This would include electricity from renewable sources and not just non-food biofuels. The 10% target for 2020 was maintained, but at least 40% should be from second generation renewables (again not just bio fuels), and the target would have to be reviewed in 2014. Greater greenhouse gas reductions were also required for all biofuels.

The finalized legislation in December 2008 did not adopt many of these recommendations, however. The 10% target for 2020 was retained, and no limits were placed on biofuels within the target, though it could be met with non-biofuel renewable energy as well. Advanced non-food-based biofuels and electric cars were incentivized by allowing them to be double-credited towards member countries' targets. A greenhouse gas reduction requirement of 35% was also declared, but this fell short of the Industrial Committee's recommendation. The legislation did not deal with the carbon emission effects of indirect land-use change, instead requiring the Commission to devise a means of reliably measuring the effect by 2010. In addition, it was agreed that the 2014 review would not alter the 10% target, and the Industrial Committee's lower target for 2015 was not adopted. This episode and legislative reviews in other countries illustrate ongoing efforts to study and properly address the unexpected consequences of biofuels use. Overall prospects for these fuels depend upon the results of this research and the implications for their long-term sustainability and production economics.

A second major question that will impact the long-term usage of biofuels relates to emissions. The environmental benefit of biofuels is still a contentious issue, despite a plethora of studies. Much of this uncertainty is due to the varying origins and feedstocks of biofuels. Ethanol produced from sugar cane (as in Brazil) has been shown to have the greatest reduction in GHG emissions of GHG (in a "well-to-wheels" comparison with oil based fuels) since fossil fuel needs are low in the fermentation process and nearly all of the material left over, the sugarcane plant stocks, is used to provide process heat and power. On the other hand, corn-based ethanol (as in the United States) is a more energy intensive process and the comparison to oil-based fuels is not nearly as favorable. The IEA cites studies that calculate a 40% to 60% reduction in GHG emissions from sugar-cane-based ethanol, and 10% to 30% for corn-based ethanol, compared to gasoline on an emission per kilometer traveled basis.

If the emissions story was solely one of comparing oil-based fuels to biofuels, the superiority of the latter would essentially be beyond dispute; however, these analyses have until recently never taken account of the vast land use changes that would be necessary to grow ever larger quantities of biofuels feedstock. The necessary clearing of trees and brush, and that moving of soil, all cause carbon/CO2 to be released into the atmosphere. In addition, as the OPEC 2008 Energy Outlook pointed out, the conversion of land to produce biofuels in one country can lead to the conversion of grass lands or forest lands in another country to replace that crop. Land use change is clearly an important issue, but the methodological difficulties in measuring these impacts are significant. It will likely be several years before any consensus on this issue is reached and this in PFC Energy's view is a major issue in slowing the biofuels bandwagon, especially in Europe.

The impact of biofuels development on global food supplies will be a critical determinant of how much production expands. In this regard, progress towards the development of second-generation biofuels is important. Commodity markets have stabilized since the summer of 2008, suggesting that the role of biofuels in raising food prices appears to have been exaggerated somewhat. Nevertheless, it still remains an important consideration, particularly in the United States, where about 25-30% of the corn crop is used for ethanol production. PFC Energy believes that biofuels do contribute to increasing food prices, but like all economic relationships, the precise influence of rising biofuels production is difficult to quantify.

The food prices issues will lessen in importance if second-generation biofuels—which use crops that can grow on marginal land or are produced from non-food cellulosic biomass such as switch grass that is converted to fuels using enzyme based bio-chemical conversion—prove technically and commercially viable. However, there is no consensus when this will occur. Governments and private enterprises are spending a great deal of money to prove up these technologies beyond the current small-scale demonstration plants. The US Department of Energy alone is spending nearly $400 million to support six demonstration plants that are supposed to establish cellulosic ethanol as cost competitive with gasoline by 2012. But with the technology still in its formative stages and costs largely unknown (although they are likely to be much higher than for conventional biofuel plants), it is unclear when these second-generation fuels will be market ready. This is recognized in both US and EU legislation, which have escape clauses allowing for postponement of fuel targets if advanced biofuels are not technically or commercially available.

There is one bright spot for biofuels supply. Even if the introduction of cellulosic technology is delayed, production of conventional types could grow with less impact on prices if yields (output per acre planted) continue to increase over time. In the United States, corn yield per acre has increased by 30% since the early 1990s, and productivity gains have been seen globally as well. Growth of the biofuels industry has motivated additional research activity that should ensure that these yield gains continue and possibly accelerate, helping crop production meet mandated requirements in future years without placing undue stress on availability of cropland needed for food production.

Unfortunately, as more land is devoted to biofuel crops another challenge arises: the availability of water.

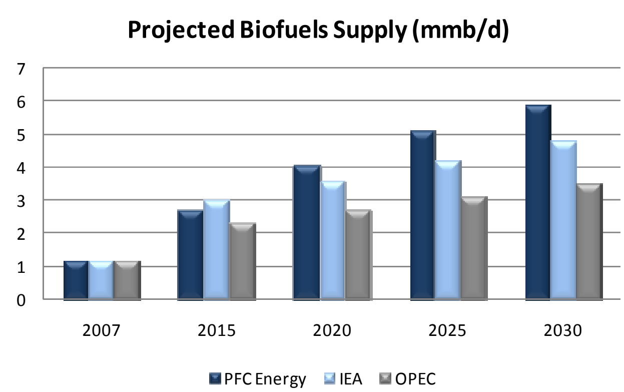
This is clearly a critical issue as demand for water to grow food and animal feed will continue to increase. The biofuels industry is seeking to address potential water shortage problems by using second-generation feedstocks which will not require significant irrigation and by enhancing the water efficiency of their production processes (primarily an issue for ethanol). If second-generation feedstocks live up to their potential, biofuels should be able to continue to expand without severely impacting water supplies, but the performance of these new feedstocks will not be clear for several years.

Establishment of the technical and commercial viability (albeit with some government subsidies) of second-generation biofuels will likely offer the first real significant alternative to oil in the transportation sector. Even though there is certainly a land and water issue, PFC Energy believes advanced biofuels will still play a growing role. Rising oil prices will be one incentive, as will a desire in some consumer states to reduce the reliance on OPEC. With the considerable ongoing activity in biofuel research, the future of this technology should be known within the next half decade.

A major factor that could alter this forecast is if energy efficiency gains moderate demand growth for oil and non-oil based transport fuels, or even reduce it. The United States (home to about 50% of global gasoline consumption and 20% of global diesel consumption) could see actual declines in transport fuel use as the Energy Independence and Security Act is implemented. This Act calls for a 40% increase in fuel economy standards by 2020, and there are efforts to front end load this gain so most of the increase is instituted by 2015. The Obama Administration has started formulating the guidelines that are to be in place by 2011.

There are many obstacles to these efficiency gains being quickly realized, the most important being the precarious health of the US auto industry and the willingness of consumers to purchase smaller vehicles. Assuming these issues are ultimately overcome through tax and subsidy policies, and if the United States shifts to a lower economic growth rate as the country exits from its financial crisis, the demand for transport fuels—including biofuels—may be less than expected. In many quarters, increasing energy efficiency is being seen as the only sure route to cutting GHG emissions while allowing economies to expand.

As a result, PFC Energy expects biofuels to remain a key but relatively limited long-term component of the global liquids supply, playing an important role in both boosting energy production and providing some contribution toward reducing GHG emissions. Considering the uncertainty surrounding critical aspects of the industry such as second-generation biofuels and indirect land-use change, the degree to which these fuel sources will meet their desired potential remains unclear.



That biofuels production will increase is a near certainty. From global production levels of just over 1.0 mmb/d, the IEA and OPEC see total biofuels output in 2030 reaching 4.8 mmb/d and 3.5 mmb/d, respectively. The OPEC forecast reflects both uncertainties regarding the ultimate commerciality of second-generation biofuels, as well as likely growing concerns over both the food competition and land use concerns. In contrast, PFC Energy forecasts even stronger growth in biofuels, reaching 5.9 mmb/d by 2030. This forecast does assume an eventual breakthrough in second generation biofuels, as well as a judgment that development of these biofuels can also positively impact difficult politics of land management in several emerging markets (e.g., India), giving a further fillip to the wide-spread adoption of next generation fuels, once commercial breakthroughs are made. Of course, the supply constraints foreseen by PFC Energy for oil production also gives a strong incentive to biofuels production in our base case projections. Significantly, this uncertainty over future production levels—about 2.5 mmb/d from OPEC's projection to that of PFC Energy—also reflects the relatively youth of this segment of the industry, with this discrepancy representing 2.5 times total 2007 biofuels output.

b. "Clean Coal" and Substitution for Oil

Coal is among the world's most abundant energy resources, and for many countries, the most affordable. However, both the potential impact on global climate change and the increased local pollution and resultant health problems associated with increased use could potentially limit the expansion of coal-derived energy in the future (and thereby increase demand for natural gas, in particular). Efforts to develop clean coal have been in the works for almost three decades. This problem is primarily viewed as a challenge to the power generation industry, particularly in countries with abundant coal resources and voracious electricity demand, such as China, India and the United States.

There are now a wide range of carbon sequestration and carbon capture and storage (CCS) alternatives under development, but most are still at the stage of research and prototype testing. Bringing these technologies to commercial application through testing and scale-up will be a major undertaking. Successful completion of this process would make possible a major step up in the long-term utilization, not only of coal, but of other fossil fuels as well. In particular, this could greatly improve the production of previously discussed unconventional sources of energy, many of which currently carry a large carbon footprint associated with production.

Improvement of clean coal technologies also opens the potential for other applications of this resource, particularly in petrochemical applications. This transfer would further reduce the demands placed on the global oil and gas industry. With present technologies, even theoretical efforts to assess minimal requirements for oil and gas in most countries usually run into constraints in two areas: transportation and non-energy use. In theory at least, the easiest substitution into this latter category might well be coal, but substantial investment in R&D would be required to commercialize potential breakthroughs, including bringing traditional technologies up to the modern standards for petrochemical products.

c. Transportation Applications

Improved efficiency of engines for transportation uses would reduce the pace of demand growth for oil in this sector, aside from the biofuels discussed above. Efforts to more widely broaden the types of fuels that could be harnessed in the transportation sector, however, would require electrification of the fleet, either through hybrids or electric vehicles. At this point the basic technologies—the mechanical systems that will drive the hybrids and electrics—are largely in place; what is required is the development of batteries that combine high output and long life at reasonable cost for original and replacement equipment. The other requirement is an early resolution of the issues surrounding the growth in production of electricity and, in particular, whether this power will be generated primarily from coal and gas as at present, or from nuclear and other alternatives.

d. Fuel Cell and Battery Technologies

Fuel cells are proven, effective sources of power in large stationary and mobile applications—office buildings, apartment houses, buses and trucks. But, thus far, they have not been successfully applied in smaller stationary uses—single family homes or in personal transportation vehicles such as cars and pick-up trucks. Successful downsizing of fuel cells would provide an alternative clean source of fuel for transport that could offer helpful competition for electricity and advanced batteries, as well as oil-based fuels.

In addition to transportation uses, other mass uses of cost-effective and practical battery technologies would be needed as costs of solar, wind and other non-hydrocarbon renewables come down and utilization becomes more widespread. The proliferation of such sources brings a growing need for cost effective storage to allow the electricity that is generated to be available for use during periods of darkness or when the wind is calm.. The issue here is that, despite years of research, advanced batteries remain limited in effectiveness and prohibitively high in cost, at least for most applications. Nevertheless, such batteries would likely find ready application in almost all countries and as such would seem to be a particularly promising area for multinational research and development.

e. Nuclear Technologies

Even for countries that have accepted the safety of nuclear power for high volume generation of electricity, the lack of alternatives for safe long-term storage, reprocessing or disposal remain barriers to it use as a major source of electricity. And as with clean coal technologies, failure to meet these needs will also result in greater demands placed on the oil and gas industry to supply alternative fuels for electricity generation.

B. Environmental Regulation and Climate Issues

The global economic crisis has certainly impacted the prospects for global oil and energy demand, both in the short-term as a result of the steep economic contraction, but likely on the future trajectory of demand growth as well. But an equally important impact will be on the sustainability and pace of globalization. While globalization has generally been seen as both a natural and irreversible development, neither case is true. Rather, globalization has come about largely because of a concerted political effort, in the post-World War II period lead first and foremost by the United States. But already by the beginning of the Doha Round of trade negotiations under the WTO, it was apparent the appetite for further efforts at globalization was waning. The industrialized countries that had traditionally led the path toward deeper economic integration this time called for equal measures to be made by emerging markets, before offering policies aimed at further trade liberalization. Even more damaging for continued globalization efforts, the United States was both increasingly less interested in providing global leadership, and other countries were increasingly less likely to turn to Washington as an example. This was a result both of persistent economic imbalances, expensive and disruptive foreign policies, as well as a perceived failure of the advocated reforms, particularly in the financial crisis that began with problems in the US sub-prime mortgage market. Certainly the United States remains a global super-power by any definition, but the soft power of moral suasion has been eroded, and the need for an internal focus to confront the deepening recession has sapped even the Obama Administration's willingness or ability to oversee global responses to issues impacting all.

But this means neither that globalization is necessarily at an end, nor that there will be responses to issues of common concern. Rather, it underscores that globalization is a political process, and one that will need the engagement of policy-makers to either consolidate gains already made, or to further advance the agenda. And while globalization in the past has been synonymous with de-regulation, a period of re-regulation is certainly underway, though this process can take place at either a global, regional or local level. The impending re-regulation of financial markets will have indirect impacts on demand for oil and gas, as it impacts the expected pace of future economic growth. But of more direct concern to energy markets are efforts to combat the issue of global warming through regulation of GHG emissions. As noted above, changes in political perceptions among the polities in several key consuming countries will likely keep the global warming issue on the public policy agenda, even with the immediate priority necessarily on safeguarding the economy. A key uncertainty, however, is whether a truly global approach to advancing the global warming agenda will be adopted, or if instead efforts will be made primarily at a regional or state level. The outcome will affect not only the efficacy of such efforts, but also the costs and potential dislocations to patterns of demand resulting from new regulations.

1. Global regulation

The Obama Administration's decision to push for limits on emissions of GHG would appear to settle the question of whether the United States will now be more active in its efforts to address climate change. The Congress must still agree but even if it accepts the Administration's decision to opt for a cap and trade system, there will still be a large number of uncertainties for the oil and gas industry both in the U.S. and in the rest of the world.

Starting in the U.S. one set of uncertainties concerns the implementation of the cap and trade system, the limits on emissions, how these limits will be set, how they will be adjusted, the industries that will be covered, how emissions will be monitored and how allowable emissions—the right to emit set amounts of GHG—will be allocated and traded. Another set of uncertainties concerns the effectiveness of the cap and trade system as it is likely to be implemented in limiting emissions over time. An initially ineffective system would likely lead to even more government interventions, whereas an effective system will almost certainly lead to less demand for fossil fuels.

Two considerations make both sets of uncertainties particularly problematic for the energy industry. One is the fact that the only real test of a cap and trade system in the US has been in limiting emissions of SOX and NOX in power generation, already a highly regulated industry, with a limited number of companies and facilities that must be monitored. Given this history, the cap and trade system for limiting GHG could conceivably start with power generation. But since the sources of large volumes of GHG are much more numerous than the sources of SOX or NOX, the question is how such a system might be "build out" to encompass these other sources. Other countries have of course attempted such "build outs" but the American effort, like other aspects of American energy policy, will likely have a disproportionate influence on the policies adopted by the rest of the world.

Sorting out the likely specifics of the American program is where the second consideration comes in. The US executive branch and Congress have a long history of tailoring systems such as this to advance other political priorities including minimizing the impact on the public, aiding smaller businesses and even protecting endangered industries like car manufacturers or coal mining in states where those are economically important. In this case these political objectives are probably not consistent with achieving the types of reductions in GHG that are envisioned. The risk therefore is that oil and gas companies may be forced to take on a disproportionate share of the costs of reducing GHG either directly if it proves to be difficult to pass on the costs of reducing GHG in manufacturing and quite possibly in the use of its products or indirectly, if these costs can be passed on and the result is reductions in demand.

Internationally there are other uncertainties that should be of major concern to the industry. One is how the systems in different countries will be aligned—if in fact they are aligned—and how these different systems will affect demand for oil and gas country by country and worldwide. For years analysts have speculated on the likelihood that efforts to limit and reduce GHG would eventually lead to restrictions on imports from countries adopting more moderate policies than those that are importing. Now that possibility seems to be much closer with indications that U.S. is already considering such penalties, with likely serious consequences for example for tar sands development in Canada.

The UN Climate Change Conference (COP 15) to be held in Copenhagen in December 2009 will serve as an important point in the determination of whether a global or local framework will be ultimately adopted. Agreement by participants on a widely-accepted framework not only for overall reductions in GHG emissions, but also the means by which to carry out these reductions will go a significant way toward mitigating the potential dislocations from mis-alignment of various countries' strategies. Failure to agree on such a framework will raise the prospects of individual countries acting alone, and enacting policies impacting trade flows based on emissions policies of the originating countries. Though this is by no means a foregone conclusion, a successful conclusion to COP 15—to include agreement on both the ends and the means—would be a substantial accomplishment in reducing the likely impacts of policy conflicts.

2. Local legislation

Like climate change "local legislation" is another issue that will continue to raise uncertainties for the industry both domestically and internationally. Though the mechanics are often different, the international effects of such local legislation are similar in some respects to actions that are taken to limit GHG that end up shaping the actions of other countries. And indeed, such local legislation can take up the issue of GHG or other global issues when there is a failure at the international level. But there are differences: First, the mechanism in this case is often international NGOs acting as advisors to national governments rather formal agreements, provisions and penalties, which will tend to be the vehicles for the proliferation of actions designed to limit emissions of GHG. The second difference involves the reasonableness of the legislation and regulations that may be transmitted given the stage of development of the countries involved. Since the effects of rising levels of atmospheric GHG are world-wide in nature, it can be argued that any emissions anywhere in the world are of equal importance. But in the case of energy facilities, the consequences are local and it may not make sense for all nations to have the same standards, especially if the prohibition of a particular type of facility serves as a barrier to economic development.

Viewed from this perspective, the uncertainty begins with the question of how severe such legislation and regulations might become in the most developed or environmentally sensitive counties and proceeds to the question of how widely and quickly such legislation and regulations might spread even among countries that are neither developed nor particularly sensitive, absent the policies adopted by others. Because the issues being addressed are by nature local rather than global, formulation of an international framework under which to address these issues is not feasible. However, even accounting for the differences in local environmental, political and economic conditions, efforts to develop guidelines or best practices in terms of combating local pollution levels could serve to not only reduce industry uncertainties regarding the future regulatory framework, but potentially also allow concerned governments to improve the efficacy of their own initial efforts to address issues of local pollution and regulation.

C. Prices: Taxes and Subsidies

Market price volatility was discussed in the section on supply uncertainties (with a focus on the impact on investment uncertainty), but these market signals are obviously also distorted by taxes and subsidies. Both could be justified from either microeconomic or macroeconomic point of view (energy efficiency and energy demand conservation policy, deployment of renewables in their early stages of development, etc.).

While taxes and subsidies on energy use are found in most if not all countries, the available evidence suggests that there is more standardization across countries with respect to types of taxes than there is with respect to types of subsidies. Specifics including rates obviously differ but with the exception of some of the producers, most countries apply one or more of a limited number of taxes at various points in the value chain. In contrast the types of subsidies tend to vary widely depending on the politics and priorities of the particular countries and the structure of their energy industries including the share of domestic production in meeting their overall requirements.

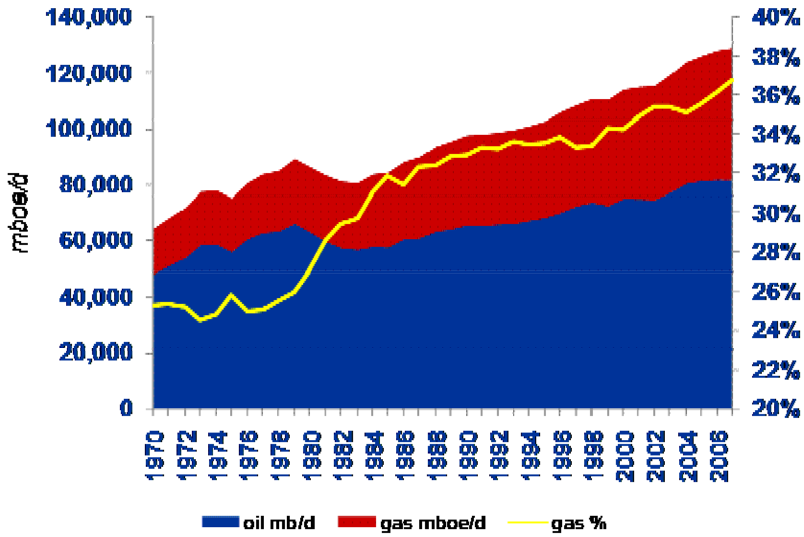
Both taxes and subsidies are important in determining prices and demand and thus trends and more importantly, the likelihood of changes in trends in each are major sources of uncertainty for the industry. In the case of taxes, the trends are generally clear in that once taxes are in place they are rarely if ever reduced, at least on a permanent basis. What is less clear, however, is whether tax rates, which have generally have been trending upward, will plateau. Or could these rates continue rising on the grounds that many governments have been convinced that more of the externalities associated with energy use should now be "captured" through higher taxes. Cap and trade systems or taxes on GHG emissions are one example but higher taxes on motor fuels to capture the negative externalities associated with air pollution, noise and even congestion are another. The risk here is that to the extent one or more consuming country governments are successful in implementing this broader justification for higher taxes, other countries will follow, much as they will in the case of restrictions on energy facilities as discussed above. (It should be noted as well, that in addition to any environmental benefits, demonstrated higher revenues offer a strong incentive for other consuming countries to adopt successful tax regimes implemented elsewhere.)

Subsidies are different in that to the extent most have been tailored to the specifics of the individual countries, changes in subsidies in one country are less likely to be copied by others. Despite this, however, all subsidies carry with them the risk of change which depending on size of the country and the volume of products consumed can still generate considerable uncertainty. In recent years more and more countries seem to have been convinced of the need to reduce or eliminate subsidies for most products and end users. Many have even reduced their subsidies (only to reinstate them at least in part, when circumstances have changed).

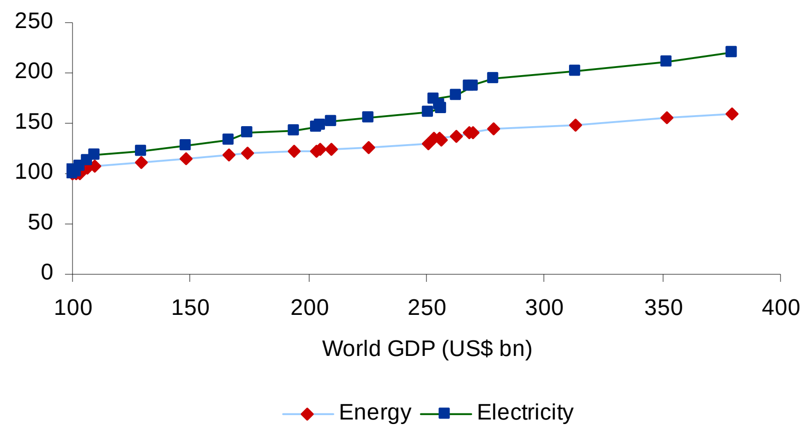
Research has shown that the uncertainties surrounding both taxes and subsidies can be narrowed through analysis of the political and economic situations and prospects in the particular countries of interest. Without such analysis however the inevitable changes will come as surprises, which history has shown can be extremely disruptive to industry planning. That said, while changes in taxes and subsidies in the emerging markets can have a significant impact both on the relative rates of growth—and especially on inter-fuel competition—in the more mature and larger markets, changes in such policies have the potential to have even greater impacts on future patterns of demand. For many of the emerging markets, patterns of economic development will still see substantial increases in demand, both as a reflection of the energy-intensity of industrialization, but also as a gradually more affluent population is better able to absorb higher energy costs. To a large extent industrialized and larger emerging market economies should therefore also be immune to the impact of changes in taxation and subsidization. But to the extent these are effectively implemented to shape consuming behavior—for example, to encourage the purchase of more efficient automobile or plant equipment—the changes brought about by taxation policy will not be offset by overall gains in energy demand brought about by transformations within the economy.

Part 4: Gas and Power Issues

Natural gas is becoming an increasingly important part of the global economy, expanding its share of the primary energy balance from approximately 25% in the 1970s to more than 37% today (see chart at right). This remarkable growth has been accomplished on the demand side with the aid of technology in the form of combined cycle turbines and natural gas fueled consumer products while on the supply side advances in LNG technology has expanded opportunities to market previously stranded gas reserves and regional price increases and technology advancements have also aided in expanding the supply source to unconventional gas reserves to include coal bed (or coal seam) methane, shale and other tight gas plays.

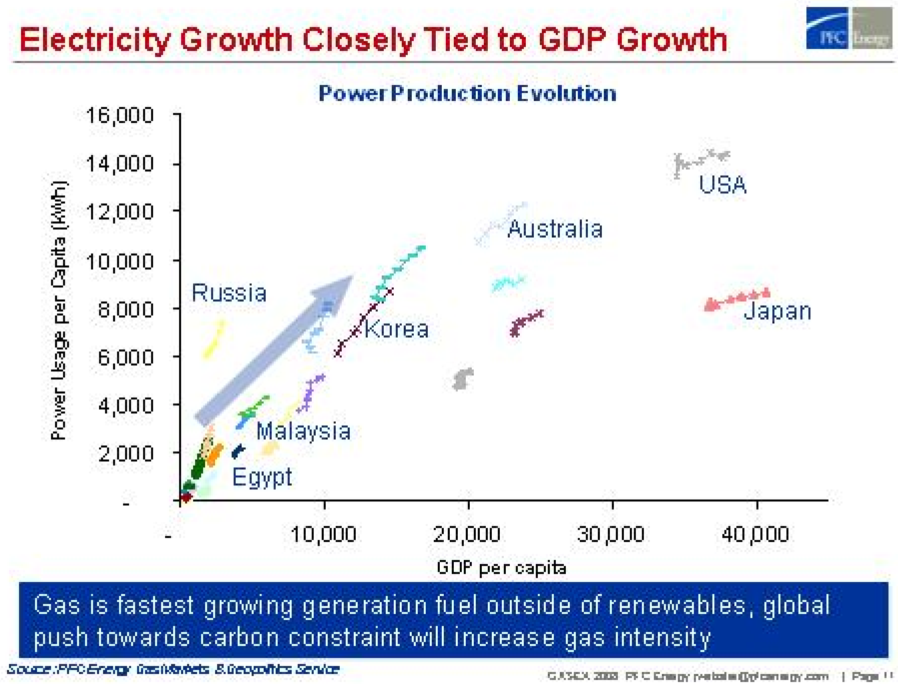


World GDP (US$ bn) v. Electricity Production and Energy Consumption (1980=100)



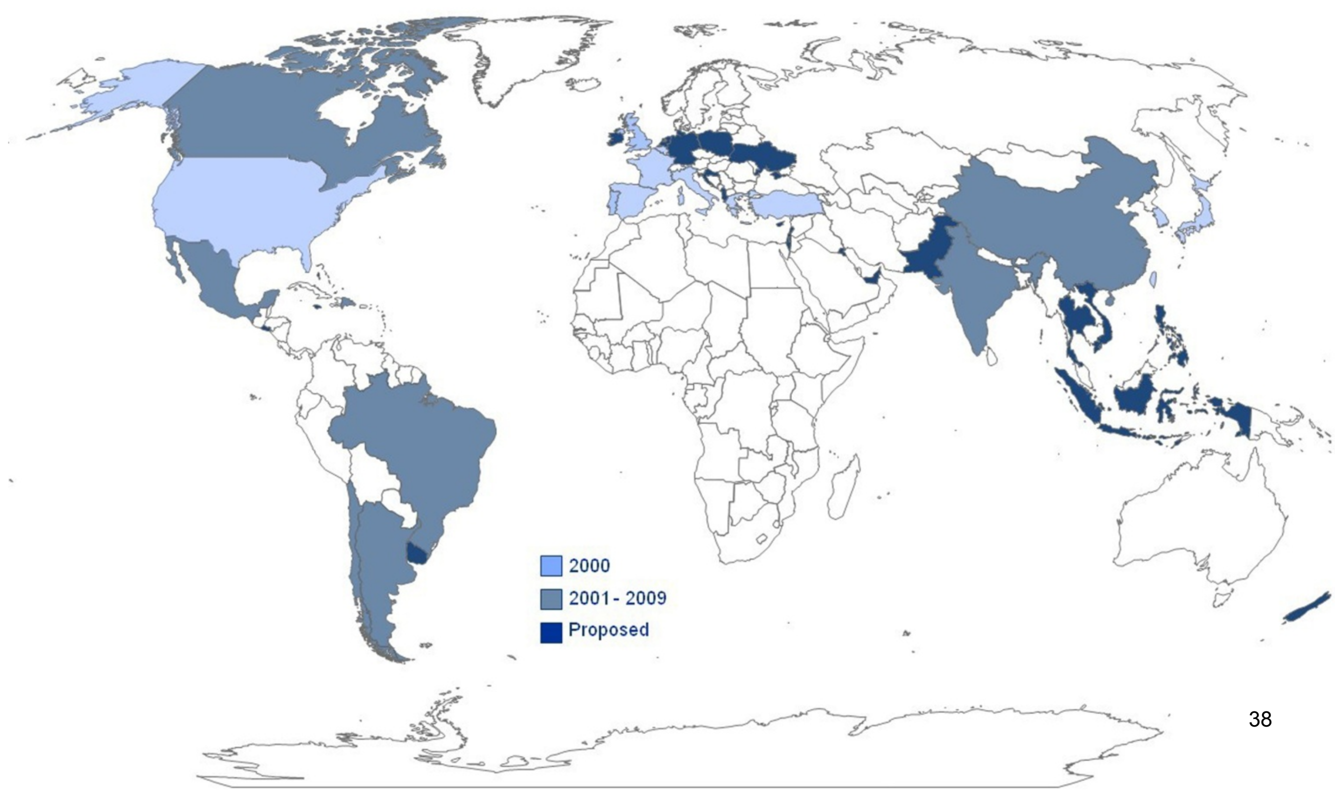
The global gas industry is still made up of regional and local players and markets, with no common global reference pricing point emerging, and the likely long term seller's market in LNG will preclude a global price from emerging, or at least not one that is not tied to an existing oil contract price. Electricity production and consumption has also seen rapid growth as electrification expands into more homes and businesses in emerging countries, while developed countries have seen an uptick in consumption on a per capita basis with the increased demand for electricity from consumer products. This has caused electricity growth to meet or outpace total energy growth nearly every year since 1980. Coal-fired generation has provided the largest portion of this electricity output for decades globally with about 40% of total supply, with some countries, such as China, at shares as high as 80% of its total electricity production.

The growth of electricity usage will continue, and even accelerate as global oil production reaches its maximum level and countries are forced to look at alternatives to rising oil and oil product consumption. While there are uncertainties and constraints to expanding the breadth and depth of electricity usage, it is natural to view it, along with conservation and demand side resources, as a potential pressure release valve to expanding energy demands amid flat oil production.



A. Strategy Homogeneity

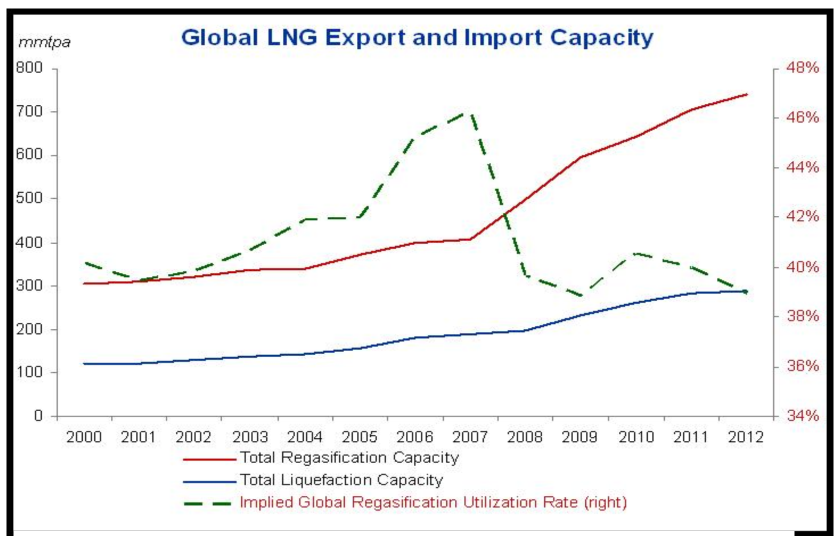
Between 2000 and 2007 gas demand globally has grown at a compound annual growth rate of 2.7% with a non-OECD countries demand outstripping OECD country demand in 2006. With the expansion of economies and a long term rising middle class in many emerging countries, particularly in Asia, sources of energy supply are being studied and contracted for to meet this growing demand. Unfortunately too many of these countries that are or will be net energy importers are adopting the same strategies to meet rising gas and power demand. This strategy homogeneity will necessary create intense competition for the resources to implement these strategies, driving up the price for those successful in adopting the strategy, while losers will be required to quickly revamp and modify the strategy, with the potential to severely

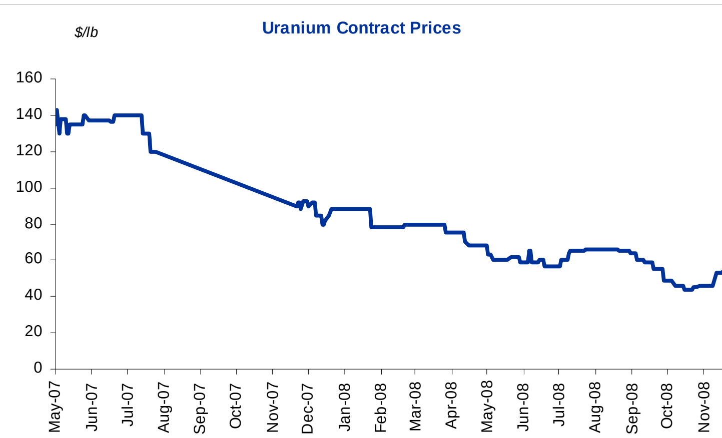


impact growth for several years as the new strategy and necessary infrastructure is brought online.

The map above shows countries that are small or countercyclical LNG import markets. The strategy that is now being pursued by many of these countries is to meet the gap for gas demand with LNG imports, which will feed gas-fired generation, which offers many advantages to emerging and growing economies with its relatively low capital and operating expenses, short construction times, and ability to follow fluctuating load demands an advantage that is of particular importance when an increase in intermittent renewable resources is occurring. Gas is also being looked to in many countries to provide heating demand, grow industrial capacity, and help to keep emissions low in a time of increasing concerns about carbon emissions. Longer term many of these countries are pursuing nuclear power to provide large quantities of emissions free energy. Nuclear also provides a better energy security profile as its fuel, U308 has a very high energy density, requiring fewer fuel deliveries per year than for a coal, gas, or oil-fired power plant.

Symptoms of the problems of so many countries pursuing this strategy are already creeping into the system, despite the recent economic downturn and relatively mild weather which has pushed demand down for both gas and power. Many are being lured into a false sense of security with the more than 55 mmtpa of LNG liquefaction that will be coming online in the next two years. Regasification terminals make up the smallest portion of the value chain for LNG. They are also benefitting from relatively rapid technology advancements, such as Argentina's contract to berth for several months each winter LNG ships that have the capacity to regasify LNG onboard and then send the now pipeline quality gas to markets within the country. The relatively low cost of regasification, and expansion of its capacity will drive down average global utilization of regas terminals. This trend alone is not worrying for a market that is not primarily dependent on LNG and/or has sufficient gas storage to take in the fuel when available for usage later. But for a country that in the future will largely depend on LNG, the trend is worrying and it may require paying significant premiums to gas suppliers, or offering up equity in power generation fleets as Tokyo Gas is now contemplating. The reasons for liquefaction likely not keeping pace with regasification is further explained in the next section.



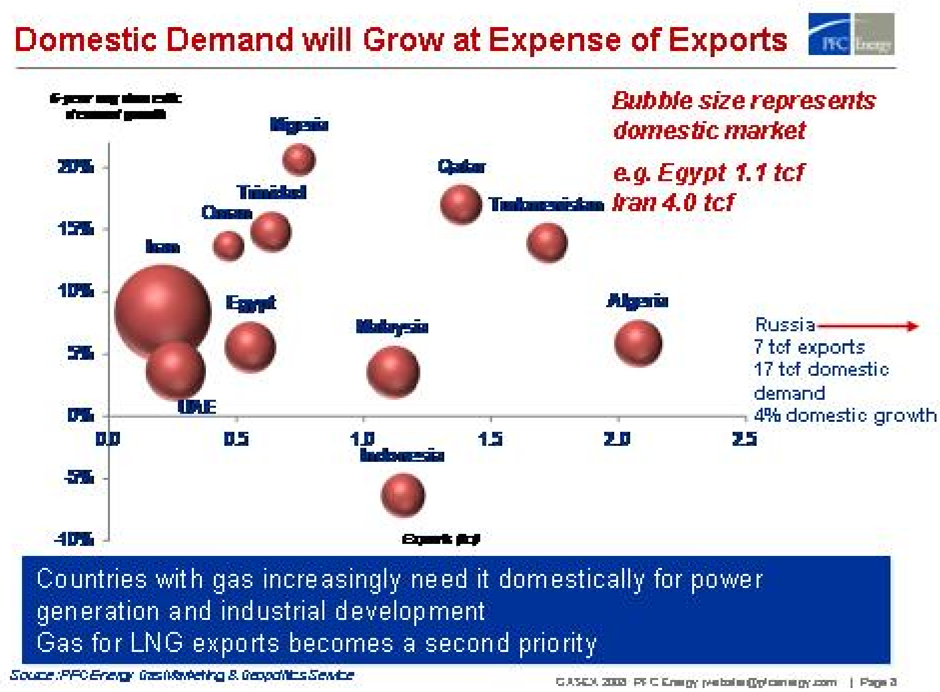


With fossil-fuels suffering from dramatic price volatility and concerns about global warming, the option to pursue a nuclear power based strategy is an attractive one for countries. This choice is fraught with uncertainties and risks, particularly as so many countries move in this direction. While fuel price risk has not historically been an issue with this power generation source, the price rose precipitously, and ahead of the oil price rise as declining output from uranium mines came up against rising nuclear power demand as reactor owners sought to maximize run times and conducted capacity upgrades. This created a bull market for the fuel that began in 2004 with the price beginning to fall in 2007 as additional mines were brought to bear. While fuel costs are relatively small compared to operations and maintenance costs, they are still a factor and could increase well past the recent highs after the 2016 period as new reactors begin to secure fuel supply. While the shortage of trained and experienced personnel was written about in the supply uncertainties section of this report, this factor is a particularly acute one for the global nuclear industry, which has not had significant demand for new nuclear facilities for several decades. While the maintenance personnel could feasibly be trained in time, considering the long lead time for building these reactors, without prior planning and focused efforts, this personnel shortage could last decades. Finally, the materials required for nuclear plants, particularly the reactor, are made in few places in the world, with currently only one company that makes the reactor's containment vessel. These constraints can cause significant delays in an already lengthy process, increasing the competition among the buyers and as in the case of LNG, pressuring those who cannot compete to quickly plot another path.

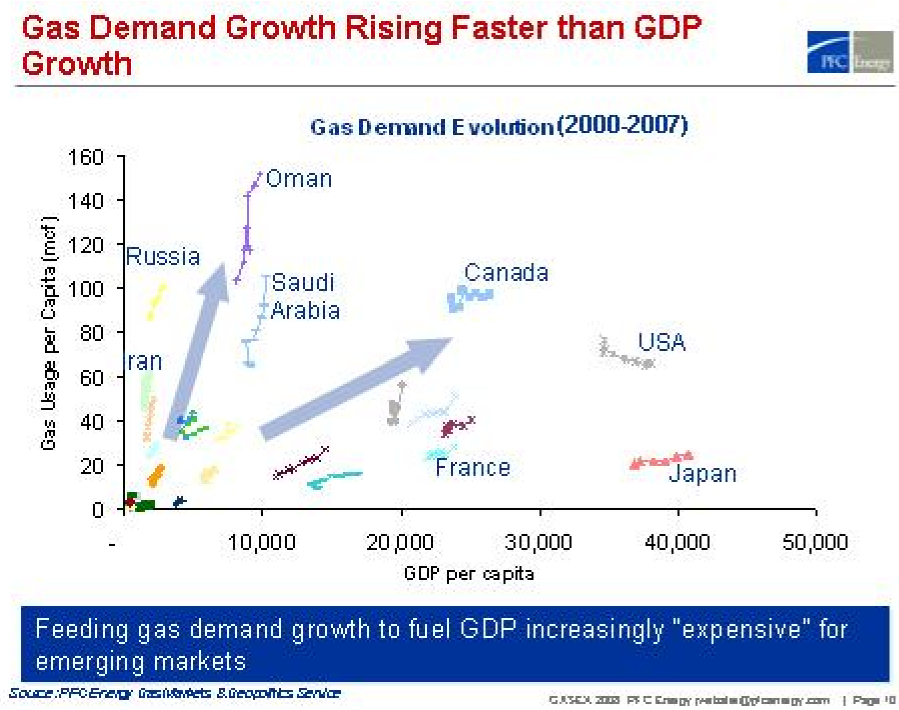
The most likely alternatives for companies or countries that may lose out on either the LNG or nuclear strategy will be to turn toward coal, which also experienced supply tightness over the last 18 months that has now loosened somewhat with the dropping oil and gas price. However, in a world of tightening carbon emission regulations, this option may not always be feasible.

B. Increasing Domestic Market Obligations

Natural gas liquefaction capacity is in the middle of the biggest expansion ever seen for LNG. This capacity now provides more than 7% of global natural gas demand, and is expected to grow nearly another 50% by 2011. But this expansion cycle may be the only one of its kind as countries that previously were moving to increase LNG exports, are now confronting rising domestic demand and are increasingly seeking to keep the gas at home as the fuel to drive their development, while using oil to bring in hard dollars. Some are also experiencing current issues with feedstock supplies (Indonesia) or may in a few years (Malaysia) and are not in a position to expand and in many cases sustain their gas exports.



Examples of this include the current moratorium in Qatar, not expected to lift for several years, if ever, and Egypt, now set to lift in 2010. While Iran is willing to export gas, current sanctions in place make this a largely unavailable option and by the time these sanctions may be lifted, domestic demand may have risen to such an extent that Iran joins the ranks of gas rich countries that nevertheless are not increasing exports.

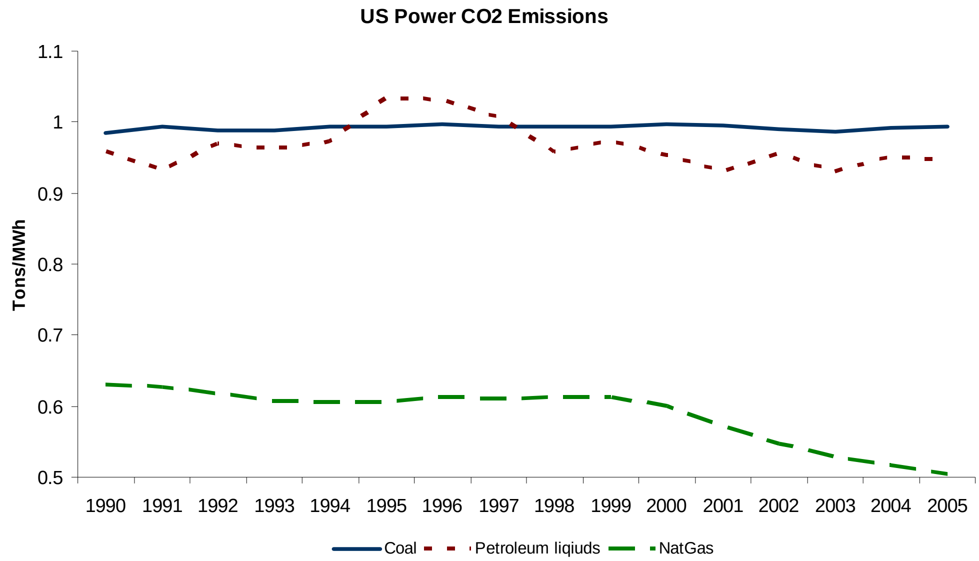


This domestic demand growth is caused by an expansion of the role of natural gas in these economies, with its use being deepened—as more gas-fired generation is brought online to fuel residential, commercial, and industrial uses—and broadened—as these economies seek new income sources from their natural gas via petrochemical plants, methanol production, desalination, etc. In some of these countries, there is also the added demand component of low, subsidized prices which serves to increase demand at a more rapid rate than would be seen in a more market-based pricing system. The chart at the right shows the gas demand evolution for several countries from 2000-2007. While nearly all countries see per capita GDP increases being accompanied by gas usage increases, those countries that either have low domestic prices, or an additional usage of natural gas (often for desalination purposes) see higher increases to gas use as GDP rises. This creates a relatively “expensive” fuel to drive GDP growth and often coincides with those countries most flush with natural gas reserves.

This long term increased retention of natural gas is analogous to the oil production peak that PFC Energy is forecasting. Natural gas supply growth will continue but there will be increased friction in the system that will limit inter-regional movement of natural gas, creating markets and regions that are gas rich, markets that by dint of long term contracts and relationships and or the willingness to pay a premium, can secure enough supply, markets that occasionally secure outside supply, and those markets where gas supply would be outstripped by demand- causing those markets to reexamine their options for meeting energy demand.

C. Carbon Regulations

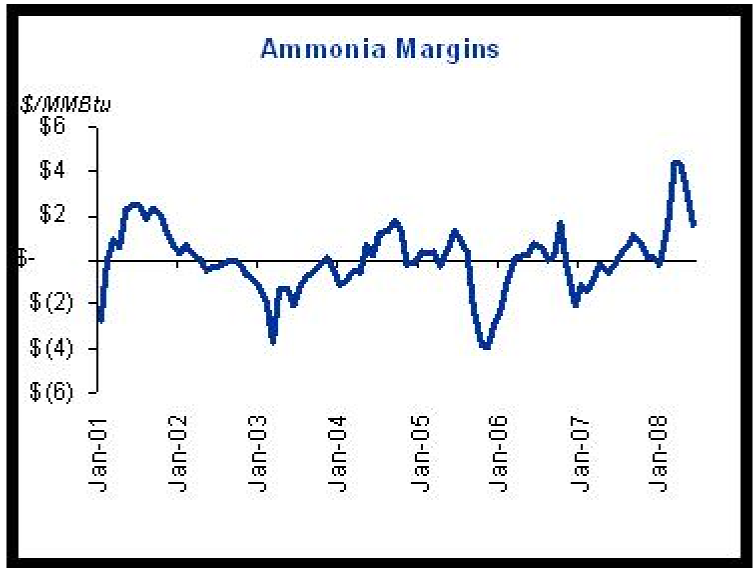
The Kyoto protocol will expire in 2012, likely to be replaced with a policy that both has more countries participating in it to include the United States, and has more stringent requirements after the largely unmet goals of the Kyoto protocol. While the depth and extent of the current financial crisis, or other factors, could delay the implementation of this sort of global carbon constraint policy, it is likely that some form will be ratified within the study period, as discussed in the section on demand uncertainties above. Additionally, countries may also avail themselves of forming carbon blocs to pool their goals and methods for carbon constraint. In all cases, a move towards a more restricted carbon policy will drive demand for natural gas and electricity, the extent to which depends on the severity of the carbon restrictions to include price signals, attendant subsidies, availability of renewable resources and other factors. The one area where gas would see a negative effect on costs would be in LNG, an issue that Australia is now tackling.



Natural gas has been frequently, and correctly, described as the bridge to a carbon constrained future. When burned for power generation, it emits approximately half the CO_2 of a similarly aged coal-fired plant. This factor, along with other advantages, has spurred increased interest in natural gas-fired generation to slow, or even decrease emissions if an older coal unit is shut down with the commencement of the new gas unit. A carbon price in a market-based electricity market that is by merit order will see coal units' spark spreads shrunk while natural gas, as the marginal fuel for most peak hours, would be able to pass on its increased costs. Carbon constraint policies often also provide incentives to increase renewable power generation sources, to include wind, solar, small hydro, wave, etc. Many of these sources rely on nature to provide the circumstances to make power generation possible, something that often occurs intermittently for most of these resources. While this can be mitigated by broadly dispersed projects to provide a location portfolio, natural gas can also be leveraged to firm up this resource by rapidly increasing and decreasing its output in response to the renewable energy output, providing a high quality power source with a very low carbon profile.

Electricity itself is completely clean at point of use, a fact which will pressure the energy source to take a greater share of the total energy supply no matter the fuel. A move in this direction would then limit the number of sources of carbon emissions, and if electricity took the place of oil for the bulk of transport fuel, this effect would be exacerbated, but would push pollution out of the cities and into the surrounding regions. As gas is the bridge to a lower carbon future, one possible end state that is being envisioned by many is a largely nuclear powered economy. Natural gas would see its demand likely move down in such a scenario, but would still have its place as nuclear power is suitable for baseload but cannot rapidly increase or decrease output easily.

D. Food into Fuel and Other Inadvertent Policy Changes



The policy ramifications of the United States tying food production into fuel production with subsidies that favored corn-based ethanol that are now making up an increasing share of transport fuel demand. The unintended consequences of this policy had the end result of dramatically increasing natural gas demand in the agriculture sector as the US reversed a long term trend of increasing imports of fertilizer, instead relying on domestically produced natural gas to make ammonia, a critical part of fertilizer. Natural gas also participates in the making of ethanol as it is was used as a feedstock and for power generation as companies switched to the more efficient, but gas-fired dry mills.

This policy change that linked food with fuel, while largely a US phenomenon, felt its effects globally, as other regions struggled to also increase food production amid Asia's boom. This policy and its aftereffects illustrate what may happen over the study period as governments defend their economy or try to increase energy security. Such policies often have effects well beyond what is written, and with natural gas often seen as the stop gap fuel, many of these unintended consequences will impact the fuel.

E. Difficult Gas Fields and Unconventional Gas Production

Natural gas has historically been a byproduct of oil production, but with gas exerting a tighter hold on the economy, companies have had to extend beyond this realm, and are now working with gas fields that are difficult to bring in. Nearly 40% of global gas reserves have high concentrations of CO_2 or H_2S, making development of such assets technically difficult, with high gas prices required to ensure a profitable enterprise. These sour gas fields are located around the world, with most volumes found in the Middle East and Central Asia. Several companies have crafted strategies around their growing expertise in producing on such difficult fields, but technical challenges remain and safety concerns remain paramount. While all of these difficult gas fields are generally more expensive to develop and produce the most difficult require a price well above historic norms to break even or additional technology breakthroughs.

One bright spot in gas supply is an increase in production from unconventional sources, to include coalbed methane, shale gas, and tight gas. The biggest players in this area have been the United States and Australia, though China has recently made progress in leveraging the gas contained in its coal reserves. Unconventional growth has made up the bulk of United States recent production growth, but the long term sustainability of the resource are still unknown, and the rapid production declines require increased drilling efforts, but also increases the resources uncertainty as the fall in production, if and when it occurs will be much more rapid than its recent rise.

Additional risks associated with unconventional gas include, in the case of coalbed methane, environmental hazards associated with dewatering the fields. And while significant advances have been made in the United States and Australia, these countries also have a long history of coal production with a significant amount of data on their coalbeds which allows for economic extraction of the gas. China conversely, while a major holder of global coal resources, is only now beginning to understand the intricacies of their tightly layered coalbeds.

Shale gas also has a rapid production decline profile, and the resource requires technical understanding about how to unlock the trapped natural gas. Adding to the uncertainty is the fact that each shale play requires different fracturing and other techniques to economically recover the gas.

Unconventional gas production will play a greater role in gas supply in the future but its total contribution is still being determined.