A REPORT OF THE CSIS
ENERGY AND NATIONAL
SECURITY PROGRAM

The Geopolitics of Energy

EMERGING TRENDS, CHANGING LANDSCAPES, UNCERTAIN TIMES

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About the Geopolitics of Energy Series

In November 2000, CSIS published The Geopolitics of Energy into the 21st Century. The report was the culmination of a two-year effort conducted under the auspices of the Strategic Energy Initiative (SEI), designed to identify and examine significant geopolitical shifts that could affect future global energy security, supply, and demand. The effort was cochaired by Senator Sam Nunn and Dr. James Schlesinger. The initiative was undertaken on the premise that the relatively benign global energy situation that had persisted for the previous 15 years was masking emerging changes in both markets and international realignments and consequently allowing policymakers and the public at large to become complacent about making hard choices with respect to energy, foreign and national security policy, the economy, and the environment.

The time horizon for the SEI report was the first two decades of the twenty-first century, and many of its conclusions, in hindsight, look remarkably prophetic and remain critically relevant almost a decade later, although events of the past several years also point to some clear omissions. Central to our (and a variety of other) forecasts at the time, the SEI projected that energy demand over the time period would be met in essentially the same ways as it was at the turn of the century, but in increasingly larger quantities.

The report concluded that fossil fuels would continue to provide the overwhelming majority (in excess of 85 percent) of global energy needs for the next several years; that the Persian Gulf would remain the key marginal supplier of oil to the world (cautioning that massive investment would be needed to realize needed increases in future production); that the anticipated growth in energy use would both tax the delivery system and raise a new series of geopolitical issues that could lead to new political alignments; that production from the Caspian would be important at the margin, but not a pivotal source of global supply; that Asian demand would increasingly look to the Persian Gulf for energy; that Europe's overreliance on Russian natural gas would become a "worrisome" dependency; and that U.S. oil imports would continue to grow.

Three broad conclusions were drawn from the SEI analysis: namely, that as the world's only superpower, the United States had accepted special responsibilities for preserving worldwide energy supply and global trade routes; that ensuring adequate and reliable energy supplies would require enormous investments that needed to be made "immediately"; and that decisionmakers in this century would face the special challenge of balancing the objectives of sustained economic growth with concerns about the environment.

Missing from the analysis, however, was the recognition of how sharply China's energy demand would grow; how dramatically prices would change over a relatively short time period; the emergence of unconventional shale gas as a potential game changer; and how quickly climate change, carbon constraints, and renewable fuels initiatives would move to center stage.

Nonetheless, the SEI emphasized the concerns surrounding the political fragility in key energy-producing countries and regions, predicted an increase in resource competition, and articulated how weakened U.S. alliance relationships with Europe, the Persian Gulf, and Asia coupled with a resurgence of conflict and power politics could adversely affect global energy security and promote geopolitical realignment.

At the time of its publication, portions of the SEI assessment were characterized as unduly pessimistic. Events of the past decade suggest that they were anything but.

In this update of the Geopolitics of Energy, our intent is not to reassess the accuracy or shortcomings of our previous report or to develop a new bottom-up projection of supply/demand forecasts from now to 2035. Rather, this iteration of the topic is designed to provide a high-level overview of the relevant drivers that will dictate future trends in energy consumption, supply sources, geopolitical relationships, foreign policy, and environmental choices. For greater detail on the topical areas identified in this report, readers are urged to explore the CSIS Energy and National Security Program Web site (http://csis.org/program/energy-and-national-security) for relevant reports, analyses, commentary, and public events addressing these topics. Additionally, the following country reports are currently available as part of the CSIS Geopolitics of Energy Series:

Geopolitics and Energy in Iraq:
Where Politics Rules • Robert E. Ebel (August 2010)

Geopolitics of the Iranian Nuclear Energy Program:
But Oil and Gas Still Matter • Robert E. Ebel (March 2010)

Energy and Geopolitics in China:
Mixing Oil and Politics • Robert E. Ebel (November 2009)

The Geopolitics of Russian Energy:
Looking Back, Looking Forward • Robert E. Ebel (July 2009)

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Foreword

James R. Schlesinger

It is timely again to examine the geopolitics of energy, which commendably CSIS has periodically done. The need for such a review has recently been highlighted by the Deepwater Horizon disaster in the Gulf of Mexico, which, in addition to the lamentable loss of life and sizeable economic and environmental damage, unavoidably will put a crimp in the domestic production of oil—and consequently further increase our relative dependence on imports.

Oil remains our critical fuel. Reflecting our import dependence, the geopolitics of oil is particularly subject to rapid, almost kaleidoscopic change over time. Thirty-five years ago, following the Arab oil embargo, the United States was primarily concerned about the reliability of supply from the Middle East. Consequently, it sought to increase reliance on Western Hemisphere supplies—sources like Venezuela. Yet, Venezuelan production has been falling and that nation has become increasingly hostile toward the United States and erratic in its policies. In contrast, and perhaps ironically, since the embargo Saudi Arabia has proved to be a bulwark in overall oil supply. Moreover, it has generally been responsive to the needs and policies of consumer nations. Yet Saudi Arabia could prove to be a diminishing bulwark; for, as Saudi Aramco's CEO has pointed out, internal consumption, which is subsidized, is growing rapidly and may in the decades ahead expand at the expense of oil for export.

In recent years, the overall composition of oil demand has been shifting, notably toward the rising Asian powers, particularly China. As a consequence, as demand shifts, the role of the United States in shaping oil markets will diminish. Also importantly for the United States and worldwide, the relative growth of transportation demand is making the demand curve for liquid fuels increasingly inelastic.

On the supply side, the International Energy Agency—previously optimistic—now suggests that the production of conventional oil likely will reach a plateau sometime this decade. The combination of rising demand and supply constraints means continued price volatility. Non-OPEC supplies appear to be approaching a peak—which implies greater dependence on OPEC and the Persian Gulf going forward. The magnitude of the overall challenge of supplying the projected demand for liquid fuels is suggested by figure 5 on page 6. Given the anticipated decline curves, it would require something on the order of developing the equivalent of five Saudi Arabias to satisfy both replacement and projected growth over the next quarter century.

Electric power is continuously offered as a political solution to our oil dependency, yet due to infrastructure needs, capital stock turnover, and technology challenges, electric power cannot readily solve our dependence on oil for transportation—at least not anytime soon. If additional electric power production is called for, it can, in principle, readily be increased by either coal-fired or nuclear plants. Coal, however, reflecting its relatively high emissions of greenhouse gases, is now under a cloud, at least in Western nations. And while nuclear power faces less political opposition than it has in the past, the capacity to put additional reactors on line remains limited. Unconventional shale gas development provides great hope, but as with all fuels, also faces challenges. Despite the hope and fanfare, renewables start from a relatively low base—and do not present a panacea.

Consequently we would do well to bear in mind what a number of studies, including recent reports by both the National Petroleum Council and the U.S. Chamber of Commerce (the latter of which was chaired by the president's National Security Advisor) have concluded: namely, that this nation will require increased production of *all* forms of energy.

The conclusion is quite simple: the geopolitics of energy will continue both to fascinate and to provide a source of worry. This report by CSIS's Energy and National Security Program provides a brief but most welcome guide to what lies ahead in these uncertain times.

James R. Schlesinger became the nation's first secretary of energy in 1977, having been charged the previous year with drafting a plan for the establishment of a U.S. Department of Energy and a blueprint for the nation's energy policy. Previously, Dr. Schlesinger had served as secretary of defense and, prior to that, as director of central intelligence. He also served as chairman of the Atomic Energy Commission. Dr. Schlesinger currently serves as chairman of the MITRE Corporation and is a CSIS counselor and trustee.

Executive Summary

Even before the onset of the credit crunch and the global economic meltdown, energy markets and global landscapes were already in the midst of significant change. Oil demand growth earlier in the decade (2002–2007) had eroded existing spare capacity, creating persistently tight markets in which any geopolitical or weather-related supply interruption often resulted in exaggerated spikes in commodity prices. This picture was further complicated by infrastructure and capability limitations, heightened geopolitical and investment risk, volatile costs and prices, and a growing concern about the environmental implications of fossil fuel use. At the same time, the emergence of new global players with increasingly larger energy and geopolitical footprints posed new threats to the ability of the United States to influence and shape the global energy system in the future. In short, a growing consensus had emerged that the world was on an increasingly unsustainable path with respect to energy and that the time had come to fundamentally reform the system and develop new technologies, policies, and strategies to simultaneously address the economic, environmental, and foreign policy/security challenges related to the ways in which nations produce, transport, and consume energy.

In late 2008, the global economy experienced one of the most serious economic recessions and financial crises in history. Energy prices collapsed from all-time highs (oil prices fell by more than $100 per barrel before stabilizing and beginning to reverse that trend). Financial markets and global trade retracted, and the world's major economies coordinated efforts to inject near-term government stimulus expenditures to forestall greater economic damage.

One of the most obvious effects of the economic crisis was the dramatic decline in global energy consumption, although that decline was, at best, uneven, with most of the reduction resulting from lower (or negative) economic growth in the developed world. And while growth rates in countries that do not belong to the Organization for Economic Cooperation and Development (OECD) have been substantially reduced from earlier (pre-recession) forecasts, pockets of sustained growth, most noticeably in Asia and the Middle East, continue. At the same time, the combination of the credit crunch and the economic downturn has had a significant impact on both the direction and outlay for research efforts, efficiency improvements, and the timing of new production projects—all of which carry consequences for future supply availability when economies begin to recover.

Consequently, in many ways the mid- to longer-term global outlook for energy hinges on the shape and pace of economic recovery in the near term; the lasting effects of the crisis and subsequent reform of financial markets; the ability of governments to scale back stimulus spending, restore fiscal balance, and regain economic strength; the outlook for long-term economic growth in the post-crisis environment; the success of policies aimed at restructuring markets and promoting efficiency improvements; and the development and scalable deployment of alternative fuels.

Adding further complexity to the challenge, policymakers around the world are pressing to adopt more aggressive policies to reduce the environmental impact of energy production, delivery, and use in an effort to slow and reverse the growth in greenhouse gas (GHG) emissions. Many of these policies will fundamentally alter the economic and regulatory environment for investment decisions and fuel choices. The momentum from "bottom-up" policies at the state and local levels has pushed national policies. Similarly, national policies have driven expectations for globally coordinated climate agreements and programs—the ultimate goal for effective action to reduce carbon dioxide emissions. Many of these policies, however, have only recently been put in place, and at this writing it remains unclear how many and which of them will persist if global action to reduce emissions does not materialize and subsidies are withdrawn.

Geopolitical trends continue to have a significant impact on energy production, prices, and trade. Higher energy prices resulted in a resurgence of resource nationalism and the tendency to exert greater state control over indigenous energy resources. They also, in some notable cases, allowed producers to use energy resource leverage to further foreign policy and political agendas. Although sovereign nations have always exerted control over indigenous resources, the revision of legal and regulatory structures has created an atmosphere of investment uncertainty and reduced access for non-state players, except in the case of the most expensive and technically challenging of projects. The catastrophic explosion and loss of the Deepwater Horizon drill rig and consequent oil spill in the Gulf of Mexico is the most recent testament to some of the difficulties confronting this cutting-edge challenge, and that event will likely spur a new era of offshore/deepwater regulation in order to minimize the prospect of future spills and promote improved methods of addressing well intervention and enhanced (oil spill) containment and capture capabilities. The success of those efforts will largely determine—at least in the case of the United States—whether future exploration and production efforts in the Outer Continental Shelf will be impeded or sustained.

Other factors—such as the changing role of geopolitical alliances in forming energy deals; issues of (poor) governance and political stability; threats to facilities, infrastructure, and transit areas; environmental degradation; poverty alleviation; and energy equity issues—have emerged as elements of the changing geopolitical landscape affecting energy production, delivery, and use. As a result of these factors and volatile prices, governments are increasingly concerned about their immediate and long-term energy security.

These changing dynamics call into question the relevance and effectiveness of existing institutions, many of which are the product of a post–World War II international financial and economic order that was conceived in an environment decidedly different from today's. For instance, the existence and magnitude of recent sovereign wealth funds have allowed strategic resource holders and burgeoning economic powers to self-finance new investments both at home and abroad without the involvement or structures of traditional international lending institutions. Similarly, the emergence and aspirations of growing economic powers like China, India, and Brazil, coupled with dissatisfaction with how financial and other markets operated in the run-up to the economic meltdown, are challenging traditional notions of free trade and globalization.

Problems of the "commons"—challenges shared across boundaries, like poverty (some 1.5 billion people still live without electricity), disease, drought, climatic disasters, terrorism, cyberwarfare—are becoming increasingly persistent and more difficult to contend with. They can emerge and spread at alarming rates and, in many cases, challenge the ability of sovereign states to adapt, contain, and eradicate. To the extent that the scope and severity of these challenges undermines rule of law in particular areas, large-scale migration can disrupt neighboring nations with a kind of destabilizing domino effect. In summary, the world energy system is facing a time of great uncertainty. Many new investments must be made in the coming years. How and where those investments are made, what policies drive them, and what energy trends ultimately materialize as a result are still very much undetermined. This report explores the emerging energy trends and major decision points that will be important for understanding the geopolitics of energy going forward.

As discussed in greater detail below, the coming decades are expected to exhibit greater complexity in terms of policy choices and implications, increased competition, technological innovation, and marked changes in efficiency improvements and fuel choices. A transformation is already under way, and managing the transition may be society's greatest challenge over the coming decades.

“We can’t solve problems by using the same kind of thinking we used when we created them.”

—*Albert Einstein*

The changing energy landscape is inherently complex. It includes multiple players in various parts of the world, a variety of fuels and supply choices (each with benefits and challenges), differing consumption patterns, large sectors of the economy, and a range of policy choices and investments that go far beyond energy portfolios. There are a number of ways to describe this changing landscape, but for ease of understanding, this report seeks to group and organize these factors into five major trends:

- shifting demand dynamics;
- the changing resource base, supply choices, and delivery requirements for petroleum;
- investment, price volatility, and alternative fuels;
- key players and evolving rules; and
- climate change and efforts to impose carbon constraints on a fossil fuel-dependent world

The five sections that follow discuss the main drivers and possible variability within each of these trends.

SHIFTING DEMAND DYNAMICS

Even when adjusting for the impact of the economic downturn, as a consequence of continued population and GDP growth and improved living standards for large portions of the world's population, most forecasts—including those published by the U.S. Energy Information Administration (EIA), the International Energy Agency (IEA), and the Organization of the Petroleum Exporting Countries (OPEC)—project that global energy demand will increase by more than 45 percent between today and 2035, with

"Even when adjusting for the impact of the economic downturn, most forecasts—including those published by the EIA, IEA, and OPEC—project that global energy demand will increase by more than 45 percent between today and 2035, with the overwhelming majority of new growth coming from the developing economies."

the overwhelming majority of the new growth coming from the developing economies (nations not members of the Organization for Economic Cooperation and Development, or the OECD) and nearly half of that from China and India alone (see the fact box "Interpreting Forecasts," page 4). In fact, energy demand from the developing economies has already officially overtaken energy demand requirements in the developed world (see figure 1).[1] This changing dynamic poses considerable challenges for transparency, data reliability, and quality, an uncertainty that can affect both investments and policy choices for the future. Notwithstanding this increase in demand, however, over this 25-year period, largely as a function of available technologies, price, infrastructure, and scale, the energy fuel mix of 2035 is expected to be only marginally different from today's, with fossil fuels still comprising the lion's share (more than 80 percent) of energy supplies, although alternative and renewable fuels penetration rates will continue to increase (see figure 2).

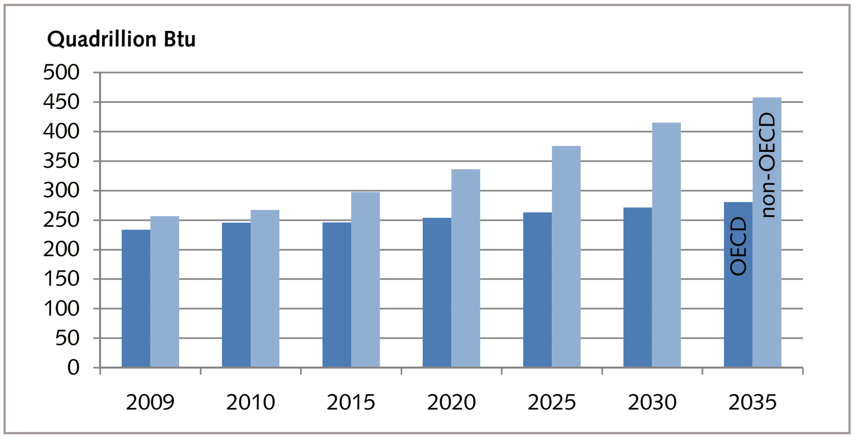


Figure 1: Energy Consumption in the OECD and non-OECD Countries, 2009–2035

Source of data: Energy Information Administration, *International Energy Outlook* 2010 (hereafter *IEO 2010*) (Washington, D.C.: EIA).

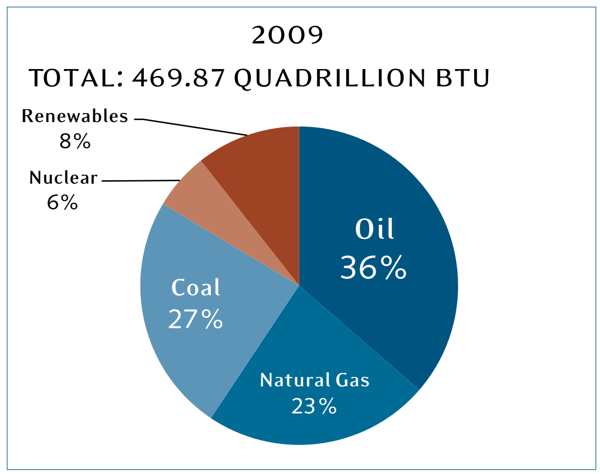
"Slower economic growth, though temporarily forestalling the need for incremental energy supplies and reducing greenhouse gas (GHG) emissions, does little to alter the basic trend lines and carries adverse consequences of its own."

This global energy makeup, as expressed in percentage terms, is remarkably consistent even within disparate regions of the world, although the relative regional predominance of coal and oil appears to be a function of the scale and choice of transportation options available to individual societies and countries.

In the case of the world's developing and emerging economies, energy demand growth is projected to be particularly dramatic. Forecasts developed by the EIA project energy consumption in the non-OECD countries—including China and India and also substantial portions of the Middle East—to increase by some 78 percent between 2009 and 2035, accounting for three-fourths of the total increase in projected global demand. Consequently, their demand growth also accounts for the majority of the growth in energy-related carbon dioxide (CO_2) emissions over that period. These non-OECD nations currently derive almost 90 percent of their energy needs from fossil fuels, with coal providing the largest share (see figure 3).

Figure 2: Global Primary Energy Consumption by Fuel, 2009 and 2035

Source of data: EIA, *IEO 2010.*



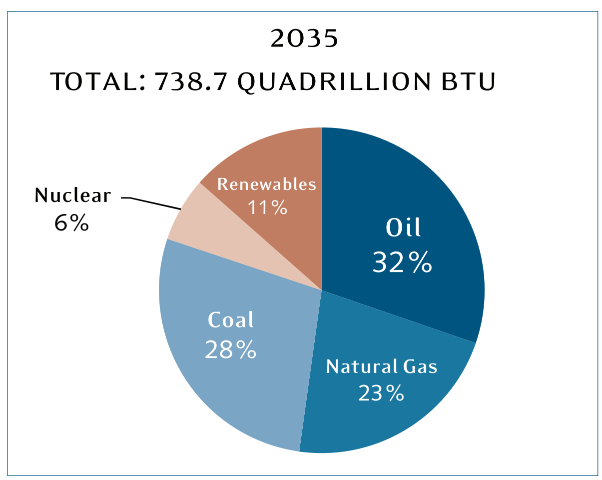
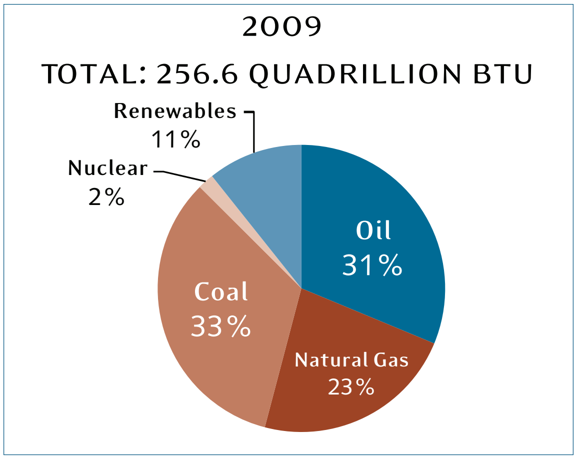
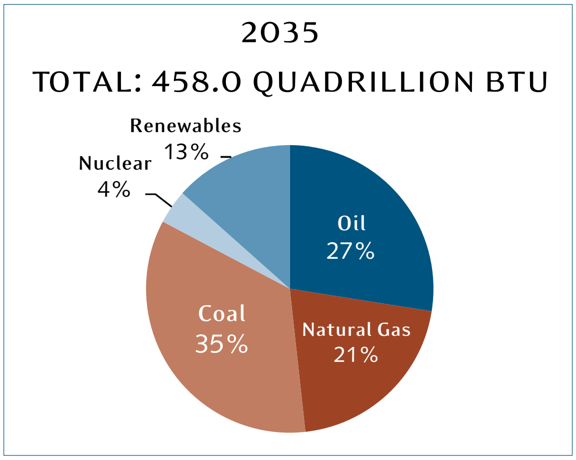


Figure 3: Energy Demand (by fuel type) in the Developing World, 2009 and 2035

Source of data: EIA, *IEO 2010*.





Although sustained high energy prices may ultimately moderate the growth of energy use in Asia (and elsewhere), the pace and level of the region's energy consumption will likely place serious strains on global energy markets and consequently raise significant concerns for both capital flows and emissions growth.

Of the total energy consumed worldwide, approximately 40 percent serves power generation needs and another 30 percent goes to meet transportation requirements. Half the world's oil—half of a market of 86 million barrels a day (mmb/d)—is dedicated to fueling transportation needs. In the absence of a comparably efficient and scalable liquid fuel or changes to the internal combustion engine and transport fleet, this demand has become increasingly inelastic, especially in the United States, the world's largest oil consumer, although recent demand declines attributed to persistent high fuel prices have been impressive. Without improved efficiency and fuel capability changes in the power and transportation sectors, energy demand cannot materially be reduced—except through increasingly higher prices. And though the expanded use of alternative transportation fuels and technologies—such as ethanol, biofuels, compressed natural gas (CNG), electric vehicles, and batteries—is welcome as supplemental transportation choices, their ability to displace or replace liquid fuels at scale is at least several decades away.

"Today's energy resources are geographically, geologically, technologically, environmentally, and financially more challenging to bring to market."

Although there is always a chance that energy demand will not achieve these projected levels of growth, due to reduced rates of future economic growth, improved efficiency, or lower rates of energy intensity, the overall outlook nonetheless remains daunting. Slower economic growth, though temporarily forestalling the need for incremental energy supplies and reducing greenhouse gas (GHG) emissions, does little to alter the basic trend lines and carries adverse consequences of its own.

THE CHANGING RESOURCE BASE, SUPPLY CHOICES, AND DELIVERY REQUIREMENTS FOR PETROLEUM

Despite the doomsday predictions of the past decade, the world's endowment of energy resources —both conventional and unconventional—is enormous. These resources, however, are becoming increasingly difficult to access, produce, convert, and deliver to where they are needed in a cost-effective, secure, and environmentally benign manner. Today's energy resources are geographically, geologically, technologically, environmentally, and financially

Interpreting Forecasts

Energy trend analysis requires heavy dependence on historical data, energy forecasts, and models. Like all models, energy forecasts have their strengths and shortcomings. They are enormously useful for trying to understand the implications of current trends in a given set of future scenarios, but they are necessarily limited by inputs, assumptions, and the inability to take into account the universe of probable, possible, and unforeseen future changes, including those from advanced technology, discontinuities from "Black Swan" events, new policies, or enhanced economic, security, or environmental concerns.

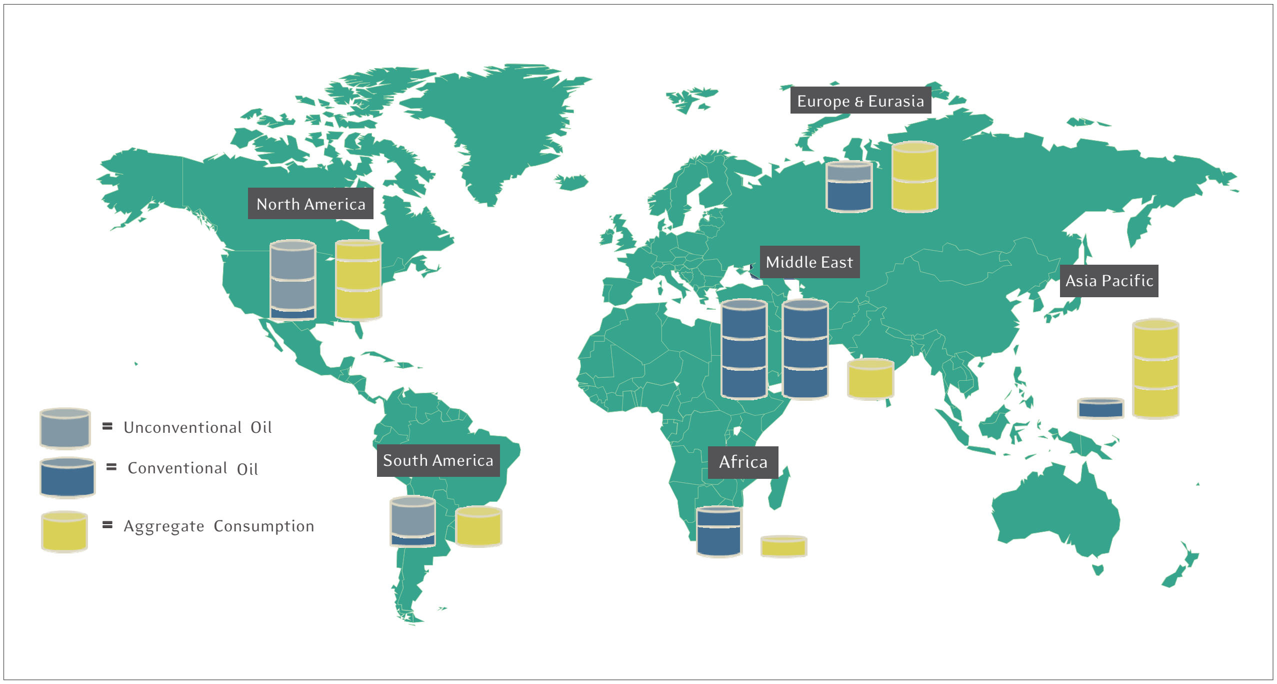
The reasons for largely static forecasts with respect to fuel preferences and consumer usage reflect the historical experience that the enormous size and scope of the global market and the long lead times necessary to develop both new conventional supplies and alternative energy forms at scale, as well as turn over capital stock, make it difficult to produce a significant difference in worldwide totals within a 20-year time horizon. Consequently, absent an economic, foreign policy, or environmental crisis or a major technological breakthrough, the demand for fossil fuels (oil, natural gas, and coal) is expected to continue to dominate the global energy mix for at least the next several decades.

Herein is one of the major shortcomings of 25-year forecasts. Given the substantial lead time needed to (1) turn over the vehicle fleet (estimated to exceed two decades if using 2009 sales data), (2) bring new technology to market at scale (roughly 16 years), (3) move from prospect identification and contract discussions to large-scale resource production in many regions, or (4) develop the infrastructure necessary to support alternative methods for delivering energy supplies, the effects of likely—but not yet enacted—policies in the 2010 timeframe are not expected to result in major changes with respect to supply/demand balances before 2025. Government policies and new regulation or incentives may be able to accelerate deployment and marginally alter demand curves, but they are unlikely to make significant impacts in the space of a decade or two.

As a consequence, static forecasts tend to be the norm, inaccurate though they may be in terms of estimating a precise data point projection. In large-scale markets, fuel substitution is an extremely cumbersome and slow process. The end result is that (absent major shifts in technology or policy or both) although forecasts may be inherently inaccurate, they are more often than not directionally correct and more apt to be off by 5 percent rather than by 50 percent.

Figure 4: Global Oil Reserves and Aggregate Consumption by Region, 2009–2030

Sources of data: EIA, *IEO 2009*, table A2; BP, *BP Statistical Review of World Energy 2009*.



more challenging to bring to market. Much of the remaining conventional oil and natural gas resources are located in the Middle East, Africa, and Eurasia. While the Western Hemisphere is rich in unconventional fuels such oil sands, oil shale, unconventional gas, and extra-heavy oil deposits (see figure 4)—a benefit from a security perspective—their extraction and refining present considerable environmental challenges, particularly in an age of carbon constraints.

The adequacy and security of the delivery infrastructure required to transport larger volumes of oil and gas over increasingly long distances and through already crowded and potentially vulnerable transit or choke points and multiple transit nations is also a growing concern. Though indigenous and locally produced alternative energy forms provide a welcome supplement to conventional energy resources, they are as yet unable to serve as replacements at scale, and they require significant new infrastructure and investments as well as lead times of their own.

The implications of persistently uncertain and frequently changing energy supply/demand balances also pose challenges for suppliers and consumers alike and are especially evident in today's oil markets. The EIA's 2010 *International Energy Outlook* reference case forecasts global liquids demand at 110.6 mmb/d in 2035. The IEA's 2009 *World Energy Outlook* projected a similar figure at 105.2 mmb/d in 2030. Less than five years ago, consensus projections for 2030 oil demand exceeded 120 mmb/d.

Even though both updated forecasts of future liquids demand reflect reduced assessments of global consumption, each still substantially exceeds current supply levels by more than 25 percent, and requires more than 20 mmb/d of additional supply above current levels. Given projected rates of oil field decline on the order of 4 to 7 percent per year, meeting even more modest 2030 oil needs will still require the addition (in gross capacity) of 60 mmb/d to 90 mmb/d of new production—a level comparable to current output (see figure 5).

Achieving this level of production will require sizable contributions from both OPEC and non-OPEC sources. Yet there is more than anecdotal evidence to suggest that non-OPEC output may be

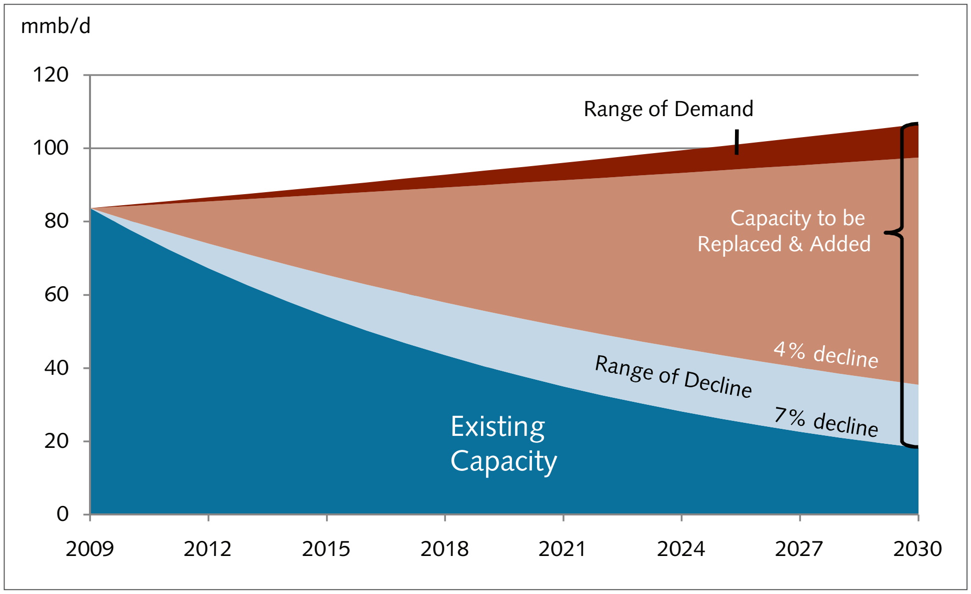


Figure 5: Global Liquids Supply and Replacement Needs, 2009–2030

Source of data: EIA.

reaching a plateau somewhere in the middle to the end of the next decade. In the near to middle term, increases in non-OPEC volumes can plausibly emerge from Canada (oil sands development), the United States' offshore, Brazil, Russia, and the Caspian Sea region, but not in quantities significant enough to match the expected growth in global demand.

Consequently, if demand continues to increase along the lines of international consensus forecasts, meeting the target will require a substantial increase in OPEC volumes. And while there is a high level of confidence that global energy reserves, when measured in terms of molecules in the ground (conventional, unconventional, and the ability to convert solids and gasses to liquid fuels) are adequate to meet these targets, the strain on resources, supporting infrastructure, and political governance (who and what policies will control resource development) cannot and should not be underestimated.

In forecasting future OPEC output, considerable attention must be paid to the pace and success of expansion efforts in Saudi Arabia and Angola, and to the restoration of output losses in Venezuela and Nigeria. For a variety of reasons—political upheaval, war, nationalization, and sanctions—the production capabilities of Iraq, Iran, and Libya have been largely neglected for decades. Consequently, the combined productive capacity of these countries today is 5 mmb/d less than it was about 30 years ago, although it should be noted that Iraq's projected production profile—assuming contractual obligations will all be met—could substantially improve that country's oil output and export levels.

Over the past 30 years, energy efficiency gains coupled with the growth in oil production from non-OPEC sources has significantly contributed to the marked erosion in OPEC market share. But that trend is changing. Despite the emergence of a wider variety of producer nations in the 1980s and 1990s—including new production from Latin America, the Caspian Sea region, Australia, and West Africa, along with unconventional oil from Venezuela and Canada, plus the sharp rebound in Russian oil production—future growth, if it occurs at all, is likely to come disproportionately from the resource-rich Middle East.

Therein lies at least part of the dilemma. Volatile markets and prices (not just oil markets but other energy markets as well) have become somewhat of a defining feature of the changing landscape. In times of surplus or lagging energy demand, investments in efficiency, alternatives, and more expensive conventional and unconventional fossil

"The experience of the past several years has left considerable uncertainty over the long-term price path for many important energy commodities, making investment decisions even more difficult."

fuels tend to be reduced or postponed. Given the leads and lags in bringing new investment and production increments on line, in the absence of surplus capacity, the unabated resumption of demand growth has historically resulted in upward price movements. Conversely, when supplies are tight, other dimensions of the market take on new significance. Spare capacity, commercial stock levels, strategic stock policies and practices, domestic fuel subsidies, fuel switching, political instability, investment decisions, and the role of nontraditional investors all are more carefully scrutinized when markets are tight. Tight markets magnify the impact of problems because of reduced cushions and an increased awareness of vulnerability. Market actors also behave differently when faced with tight rather than surplus conditions. And, as we have witnessed over the past decade, tight markets exacerbate the role of investor activity on the margins and can result in greater price volatility when disruptions occur.

INVESTMENT, PRICE VOLATILITY, AND ALTERNATIVE FUEL CHOICES

Persistent demand and tight supplies, along with escalating equipment and materials costs, as evidenced in 2007–2008, caused energy prices to rise across the board. In the five-year period between 2003 and 2008, oil prices rose by more than $100 per barrel and doubled in just one year alone. In the subsequent year (July 2008–July 2009), prices declined by more than 50 percent, only to rise again as optimism about the anticipated economic recovery was translated into commodity investment decisions and more bullish outlooks (see figure 6). Much of the world's economy was built on cheap energy. In the United States, homes, vehicles, transportation habits, and heating and cooling preferences were all geared toward a world in which energy was relatively inexpensive. The experience of the past several years has left considerable uncertainty over the long-term price path for many important energy commodities, making investment decisions even more difficult.

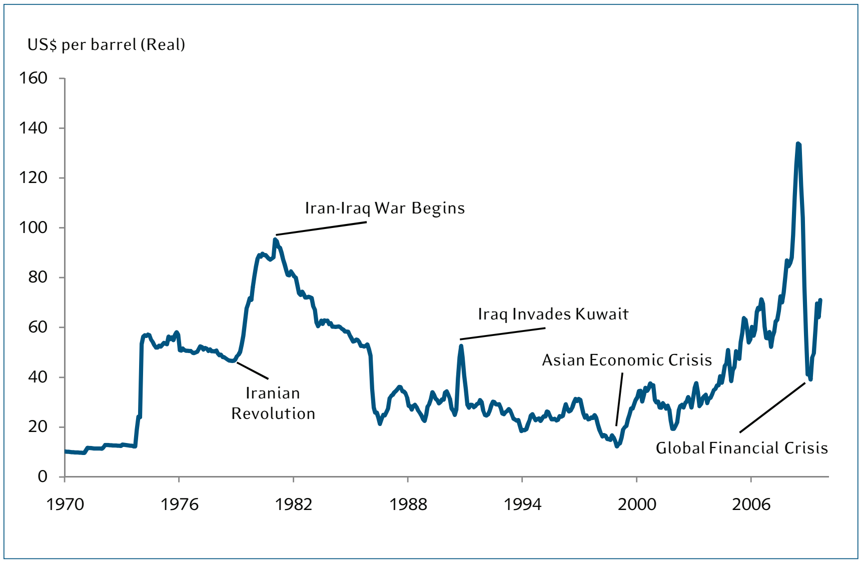


Figure 6: World Oil Prices, 1970–2009

Source of data: EIA, *Annual Oil Market Chronology*, various editions.

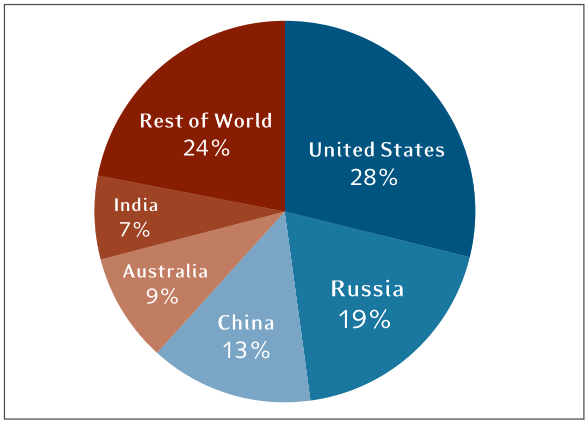
"This makes it all the more important for policymakers to find ways to ensure the robustness and adequacy of the current energy system, even while seeking a transition to low-carbon alternatives."

The IEA estimates that industry and governments will need to invest some $26 trillion between now and 2030 to meet the forecasted energy demand. This figure does not take into consideration the investment necessary to shift the global energy system from its current state to a lower-carbon alternative. The inability to access lowest-cost reserves, combined with new demand for materials and labor, has substantially increased project development costs. New capacity, regardless of its relation to specific fuel choices—conventional oil and natural gas, coal, nuclear power, pipeline and transmission facilities, as well as supporting infrastructure for a new generation of renewable energy forms—requires sustained investment over a long period of time.

Investment decisions about particular fuels are subject to a wide variety of considerations, including the cost of fuel, projected long-term supply, the investment framework, material costs, the regulatory environment, reliability, sectoral demand outlook, other resources (e.g., water availability), and environmental impacts. The sum of these considerations yields a fuel hierarchy where decisions are made based on the relative importance of these factors. During times of high prices and perceived resource constraints, abundant and cheap fuels are the most attractive. When environmental opposition to more carbon-intensive fuels or environmentally invasive extraction or production practices is predominant, more expensive and cleaner fuels are held at a premium. During the last several years, these factors determining the fuel hierarchy have been at play in different parts of the world, affecting investment decisions along the way.

Figure 7: Top Holders of Coal Reserves, 2009

Source of data: BP, *BP Statistical Review of World Energy 2010*.



Coal

Coal is a relatively inexpensive and widely available fuel for power generation and other uses in many parts of the world. Since 2000, demand growth for coal has outpaced that for any other fuel. Most of that growth has been in non-OECD countries. As a result, global coal production is expected to increase by more than 50 percent by 2035, and almost all of this increased production is projected to come from non-OECD countries, the majority from China. Currently, the top five reserve holders in the world (see figure 7) control about three-quarters of global coal reserves. In fact, with more than 270 billion short tons of coal within its borders, the United States is frequently described as the Saudi Arabia of coal. Consequently, because coal accounts for fully half of U.S. electric power needs, coal is viewed as a major contributor to U.S. energy security.

The continued use of coal for power generation is considered critical for continued economic growth in a variety of other economies, especially China and India (see figure 8). China accounts for 40 percent of global coal demand, and its share is expected to more than double by 2035, according to the EIA's *International Energy Outlook* 2010. With China's efforts to boost domestic coal production and limit exports, it is expected to move from being a net exporter to a net importer of coal in the coming decades. However, because burning coal is a primary source of CO_2 emissions (about 42 percent of global energy-related CO_2 emissions come from coal), meeting international goals for GHG emissions reductions will necessarily require developed and developing countries alike to find ways to mitigate the emissions associated with coal production and use. This challenge is primarily technological but also carries investment, infrastructure, and societal considerations (e.g., mining accidents, environmental and water degradation, climate concerns). It requires the substitution and replacement of present-generation plants with more efficient facilities, the development and implementation of carbon capture and sequestration (CCS) on an enormous scale, and the extensive adoption of lower-emission and renewable fuels.

Replacing current coal use at scale will not be easy. It will require massive investment in both new technology and new delivery infrastructure over the course of several decades. Coal also accounts for a significant share of energy use in developing and emerging economies—those frequently least able to take advantage of cutting-edge technology breakthroughs and economic transformations. Moreover, preserving the role of coal in power generation by capturing and sequestering the CO_2 that is emitted will require additional investment in, and greater consumption of, coal due to the energy penalty incurred during the gas separation process. To date, many countries have instituted policies to give other, less emissions-intensive fuels a competitive edge over coal. However, these policies have not yet proven adequate to the task of encouraging a widespread switch away from coal, though many, including large-scale substitution with natural gas, have the potential to do so if sustained over the long term.

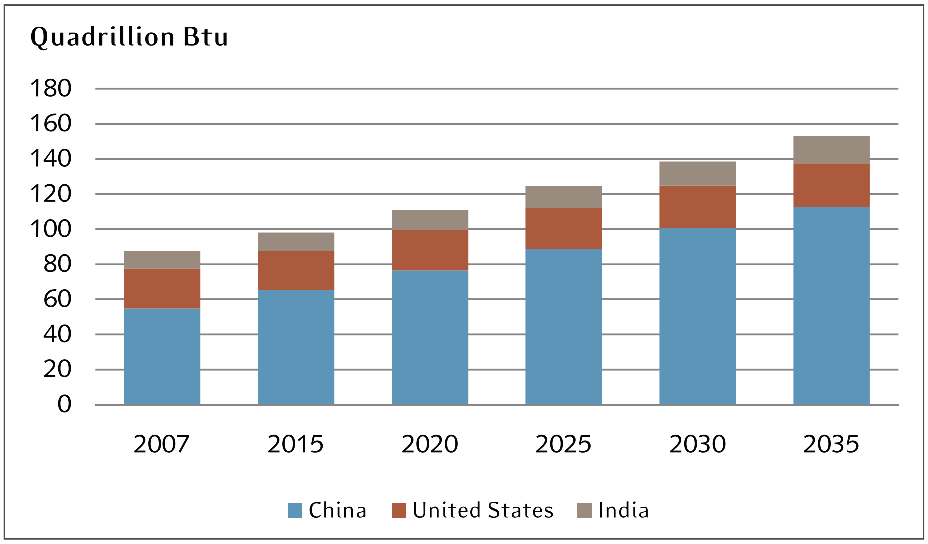


Figure 8:
Coal Consumption in China, the United States, and India, 2009–2035

Source of data: EIA, *IEO 2010*, table A7.

Renewables

Renewable energy sources have seen considerable growth in many parts of the world, as environmental concerns and requirements drive investors to cleaner energy options and security-minded policymakers seek greater diversity in their fuel mix. Recent substantial increases in wind and solar energy projects are a welcome development. Yet the total of all renewables—including wind, solar, geothermal, biomass, and hydroelectric power—accounts for less than 10 percent of global energy usage today and, owing to scale, is expected to reach only 11 percent by 2035.[2] Non-hydro renewables still represent less than 5 percent of the global energy mix.[3]

The combination of concerns over climate change, increasing demand for energy, and energy security is driving investment in clean energy technology ventures. According to research conducted by New Energy Finance, global investment in renewable energy and energy efficiency grew to $155 billion in 2008, four and a half times the level of investment in 2004.[4] Wind and solar power were the largest recipients of financing, with biofuels third. Though the United States and the European Union continue to attract the lion's share of financing, investment is increasingly shifting to developing markets like China, India, and Brazil. Research and development spending has also increased, from $12.4 billion to $16.9 billion between 2005 and 2007. Investment is still very much driven by policy (taxes, subsidies, and regulations), but in a lower-demand future, the loss of government subsidies (due to financial and spending/lending constraints) and the absence of effective demand-pull mechanisms could pose significant threats to the sustained success of these advances. In addition, we are already beginning to witness the competition between lower-emission fuels, like natural gas, and efficiency against "green" choices.

Both the EIA and IEA map out business-as-usual reference case scenarios that project conventional fossil fuels meeting the overwhelming majority of global energy demand for decades to come. Even assuming a more optimistic increase in the deployment of renewable energy, given the current global energy system's sheer size and capital turnover rate, fossil fuels will continue to play a significant role. This makes it all the more important for policymakers to find ways to ensure the robustness and adequacy of the current energy system, even while seeking a transition to low-carbon alternatives.

Nuclear Energy

Based on efforts to promote the use of environmentally "cleaner" (i.e., emissions-free or low-emission) fuels, a similar case can be made for the expansion of nuclear energy use on a global scale. Nuclear reactors are a proven and reliable source of clean energy, accounting for a majority of the emissions-free electricity that is produced around the world today. Though reactors presently account for 6 percent of current global energy consumption, the construction of nuclear facilities is expected to grow substantially under certain carbon-constrained projections—not only to replace facilities that are due to be decommissioned in the next few decades, but

> "Given the massive scale of the global energy system, replacing the current fuel mix at scale is simply not realistic for the next several decades."

also to meet incremental increases in demand for electricity.

In recent years, the notion of a nuclear "renaissance" has become fashionable as countries around the world have sought to meet burgeoning energy demand with stable, base-load, and low-carbon sources of energy. According to the World Nuclear Association, global nuclear capacity was 372 gigawatts in 2009. Most of the world's 436 commercial reactors are currently located in OECD nations, but significant growth in new nuclear capacity is expected, primarily in the developing world. At the time of this writing, 54 new reactors were under construction in 15 countries—though some of those projects have been delayed or halted. Much of this construction is concentrated in the Asia-Pacific region, where China, in particular, has large growth potential.

Challenges to the nuclear renaissance are not insignificant, however. First, cost continues to be a major concern, limiting the availability of financing for a first wave of new reactors. In the United States in particular, new plants continue to be viewed as a risky economic proposition for two primary reasons: (1) the experience of the 1970s and 1980s, during which delays and soaring costs plagued nuclear construction, and (2) an as yet unproven, new licensing process. The management and disposal of long-lived, high-level nuclear waste also remains a serious issue, particularly as plans to construct a long-term waste repository at Yucca Mountain have been abandoned. Another issue, of greater concern for the international expansion of nuclear energy, is the potential for the proliferation of nuclear weapons.

Most policymakers agree that an expansion of nuclear energy is a critical component for achieving an array of fuels and technologies that will help meet future energy demand and reduce CO_2 emissions. The introduction of small modular reactors and advanced technologies may prove effective in meeting this additional demand, but the outstanding risks and uncertainties associated with the back end of the fuel cycle are likely to continue to pose challenges to the pace and scale at which nuclear energy can be added to both the U.S. and the global energy mix.

Natural Gas

Future prospects for natural gas, the "cleanest" of the conventional hydrocarbons, are at once both optimistic and cautionary. As with the case for coal, as a consequence of recent success in exploiting the unconventional gas sources (tight sands gas, coal-bed methane, and shale gas), the United States is in an enviable position of being both resource-rich and having existing infrastructure available to produce, convert (where necessary), and transport this resource to market. Gas has a wide variety of uses—from power generation and home heating, to fertilizer and petrochemical feed uses, and potentially for transportation to partially displace fuels derived from petroleum.

As a consequence of higher gas prices, technology improvements in horizontal drilling and hydraulic fracturing, and access to gas-rich shale formations like the Barnett, Haynesville, Fayetteville, Woodford, and Marcellus basins, U.S. natural gas production is expected to continue to increase—at least for the next several years (see figures 9 and 10). That is the good news. But, as with other fuel

"Energy demand projections require the development and use of **all** energy forms and an aggressive and consistent commitment to efficiency and technology improvements."

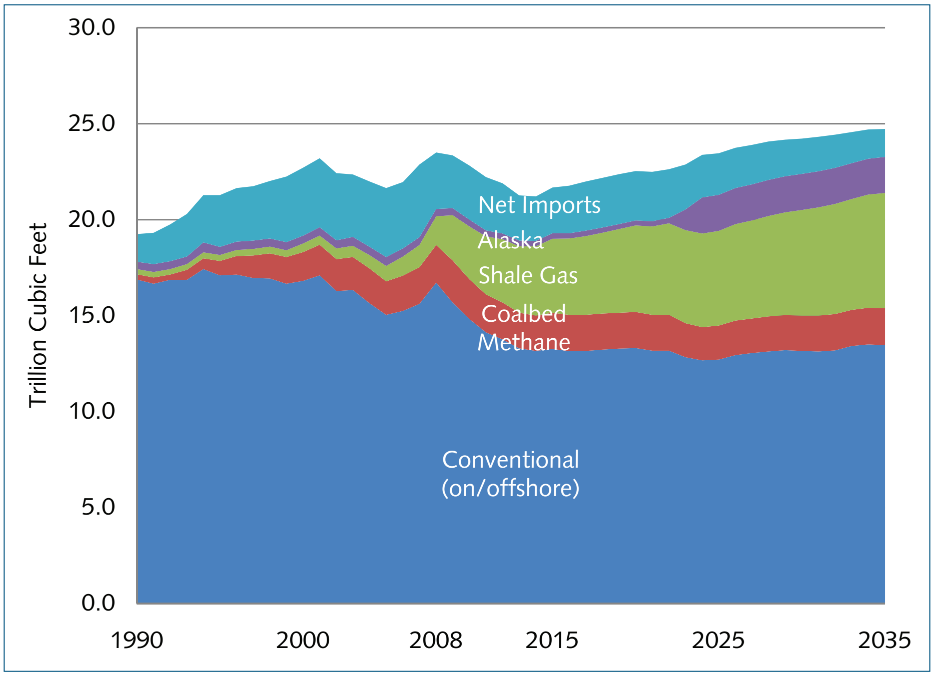


Figure 9:
U.S. Natural Gas Supply, 1990–2035

Source of data: EIA, *Annual Energy Review 2010*, figures 3 and 73.

choices, the exploitation of the shale gas resource is not without challenges and trade-offs. Concern over hydraulic fracturing and groundwater resources, infrastructure development, the "industrialization" of rural communities and/ or proximity to densely populated areas, the components of the hydraulic fracking fluids, and the large volumes of water required for the process (in terms of both production enhancement and disposal) all pose hurdles. Further, to the extent that natural gas becomes the "preferred" fuel for both power generation and, in some cases, transport, inevitable declines in production (early production decline rates exceed 60 percent in some formations) require continued drilling to maintain supply output. Failure to achieve target production requirements could result in increased import reliance similar to what we have experienced with oil. Today, Canada is the United States' primary source of imported natural gas, most of which is delivered by pipeline to the lower 48 states. A small portion of imported gas (less than 2 percent of consumption in 2009) arrives at U.S. ports as liquefied natural gas (LNG), which then needs to be regasified in coastal facilities.

On a worldwide basis, liquefied natural gas markets are currently regional, with regasification facilities tied to specific liquefaction or production projects. However, as global demand increases (a likely prospect in a carbon-constrained world), the competition for LNG is expected to increase—with European, Asian, and American consumers eventually competing against one another for cargoes. On the plus side, production profiles for existing and scheduled LNG projects over the next several years suggest that ample supplies will be available to meet projected demand, thereby simultaneously limiting price volatility and reducing GHG emissions. Further, the

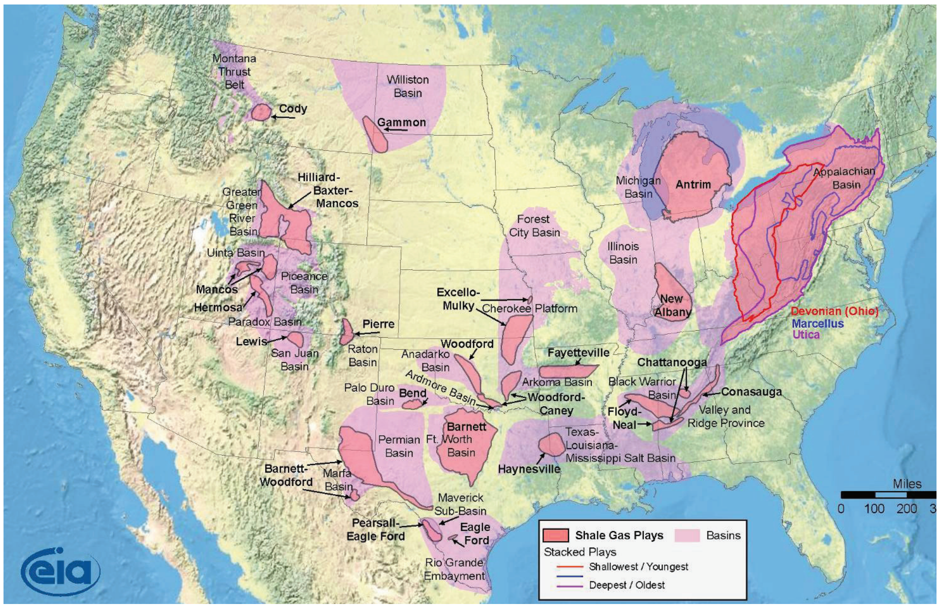


Figure 10:
U.S. Shale Gas
Resources, 2010

Source: EIA, based on data from various published studies; updated March 10, 2010, http://www.eia.doe.gov/oil_gas/rpd/shale_gas.pdf.

combination of increased LNG volumes, assuming the construction of regasification facilities, storage, and pipeline interconnections, coupled with international success in accessing the shale reserves (unconventional shale formations are also found in China, Australia, Eastern Europe, and Latin America), and improvements in renewables and efficiency can simultaneously improve nations' energy security and climate prospects. To the extent that the near-term availability of gas supplies (LNG, pipeline deliveries, indigenous conventional and unconventional production, etc.) produce a global surplus, opportunities for transforming the pricing structure of global gas markets (delinking from oil) also improve.

Energy demand projections require the development and use of *all* energy forms and an aggressive and consistent commitment to efficiency and technology improvements. All are welcome components of a diversified and sustainable energy strategy. But all also have distinctive and considerable challenges—including technology breakthroughs, substantial new capital investment and infrastructure development, a conducive regulatory environment, and the need for compatibility with existing fuels and infrastructure during the transition process.

Further, given the massive scale of the global energy system and the long lead times necessary to commercialize new technology, upgrade existing hardware, alter consumer behavior, and so on, replacement at scale (as a substitute for current fuels) is simply not realistic for the next several decades. This should not, however, block aggressive progress toward making the transition. Rather, it requires policies and strategies that ensure that the conventional energy system remains robust even as we collectively make that transformation.

> "We are entering a new era where the rules of the past—rules largely written by a handful of developed economies—can no longer be assumed to be the unchallenged, guiding principles."

KEY PLAYERS AND EVOLVING RULES

The changing energy landscape is also uniquely characterized by a new set of emerging players with new agendas and leverage, new classes of investors, and new alliances. International politics and the political environment in which companies operate are undergoing a fundamental change driven by the new priorities and interests of these emerging players. As demand from developing countries grows and incremental supply from all countries becomes increasingly important for meeting demand even as significant reserves still lie in a handful of regions, the actions of these countries, relationships among countries, and relationships among countries and companies all become more important. These decisions are driven by a number of factors but can be broken into several general categories: internal interests and drivers, geopolitical dynamics, and geoeconomics.

Internal Drivers and External Actions

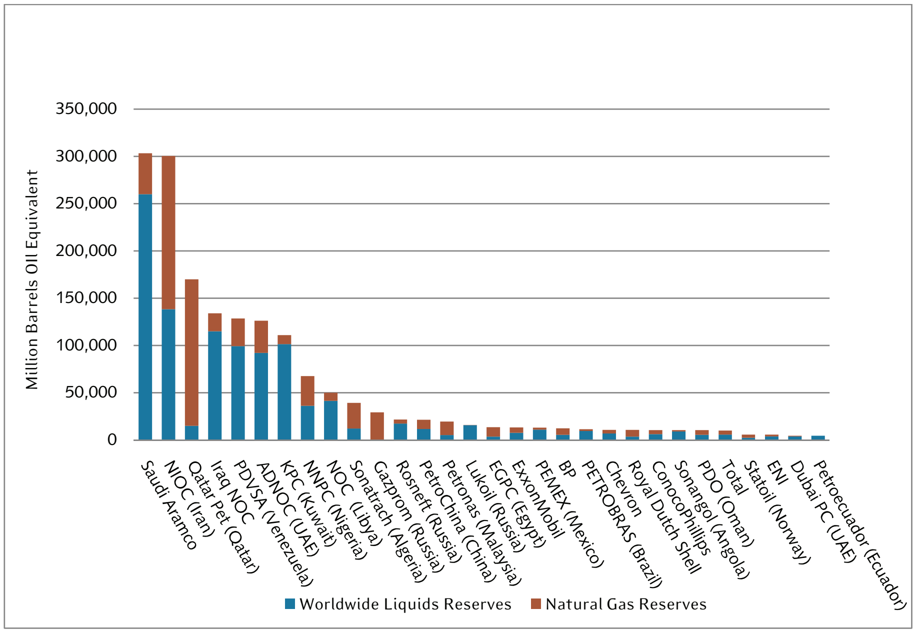
On the economic front, this new world transformation appears to be characterized by, at the very least, a recalibration and reassessment of "market-based" principles. The appeal of economic efficiency and reliance on the market, which resulted in the rapid spread of domestic market reforms and global financial, trade, and investment integration in the 1980s and 1990s, has stalled. For the oil sector, the domestic economic reforms of past decades were welcomed because they permitted foreign investment and even some limited privatization. But increasingly, nations—citing internal justifications of security, jobs, environmental concerns, economic competition, and the narrow need for securing energy supplies—in certain instances appear to be slowing or reversing reforms and, instead, pursuing more centralized, ideologically justified, interventionist economic policies, often with widespread domestic public support.

Many of the rapidly emerging economies have large populations with a widening divide between the wealthy and poorer segments of society. The longevity of political leaders in these countries rests on their ability to bring people out of poverty and maintain economic and political stability. Energy is the lifeblood of these emerging economies, and therefore a crucial element of the current leadership's political viability. The importance of energy manifests itself in a variety of policies—large-scale subsidy programs to make energy more affordable, incentives to exploit all domestically available resources, and international efforts, often spearheaded by state-owned energy companies, to develop resources abroad and ensure adequate supplies.

On the supply side, countries are reevaluating how their natural resources are developed. In recent years, fear that oil supplies could be dwindling caused some natural resource holders to exert greater control over the production and use of their reserves to either preserve them for future generations or ensure that the resultant oil revenues are used to maximize social and economic well-being. In addition, past experience with economic liberalization and opening to foreign investment have not yielded the economic and social development gains many of these

Figure 11:
World's Largest Oil and Gas Resource Holders (2007 estimates)

Source of data: PetroStrategies, Inc., http://www.petrostrategies.org/Links/Worlds_Largest_Oil_and_Gas_Companies_Sites.htm.



countries once hoped to achieve through those measures. Avoiding the "resource curse" and taking more energy-derived revenue for the state are the driving forces of resource policies in many of these countries.

The confluence of these political and economic changes holds several major implications for energy investors. First, to the extent that international oil companies (IOCs) continue to be denied access to those few select, resource-rich nations under competitive terms comparable to those offered elsewhere, their exploration and production (E&P) investment opportunities are likely to become more complicated (technologically, as in the case of ultradeep water or sub-salt activity, or politically) as well as more expensive. This shift will cause investors to continually rebalance their portfolio risk, including the addition of less attractive opportunities, with potentially longer payout periods. The portfolios of the future for international majors will likely include fewer and more limited exploration opportunities in commercially attractive areas, higher-risk positions in technically challenging frontiers, and "service"-type contracts in workover areas where national ministries seek to forestall production declines by offering more attractive terms to new and needed partners.

Coupled with the difficulty of obtaining access to proprietary reserves is the emergence of significant (including national) competitors pursuing investments in the most attractive exploration and production markets. As discussed above, the most aggressive of these new competitors are China and, to a lesser extent, India. And this raises a third challenge: how to deal with the reemergence of security-inspired, politically driven foreign investment. Countries opting to exploit their newfound leverage are in subtle and not-so-subtle ways redefining market competition. And though the implications of this strategy have not gone unnoticed, the United States and others have been slow to recognize and adjust to the dynamics of this potentially changing market.

"Because emerging economies can finance their own development or seek partnerships with one another rather than adopt the rules of existing global institutions, the effectiveness of those institutions and the global norms they seek to support could be undermined."

Shifting Geopolitical Dynamics and Outmoded Institutions

Geopolitical trends and alliances continue to have a strong impact on energy production and trade. The emergence of new regional and international commercial and strategic alliances may mark the beginning of a "new game" in the geopolitics of oil as well as other energy resources. Evidence of this new game may be found in the activities of resource-rich nations that seek to exploit the strategic commodities they possess in an effort to further their foreign policy objectives; in the rising role of national oil companies (in both producer and consumer nations, see figure 11), which now control the majority of conventional resources and account for more than half of current oil and natural gas production around the globe (and an increasing future concentration); in the emergence of new energy-consuming giants —China, India, and others in the developing world, whose growth is concentrated in the industrial sectors but who, as living standards increase, are also likely to have an increasing impact on transportation fuels growth—and in the geopolitical alignments that accompany these changes.

With the concentration of both conventional resource control and the majority of new demand growth in the emerging and developing (non-OECD) world, we are entering a new era where the rules of the past—rules largely written by a handful of developed economies—can no longer be assumed to be the unchallenged, guiding principles. Moreover, the political commitments and facilitating agreements among these developing-world governments—sometimes hidden, sometimes not—add an additional, worrisome element.

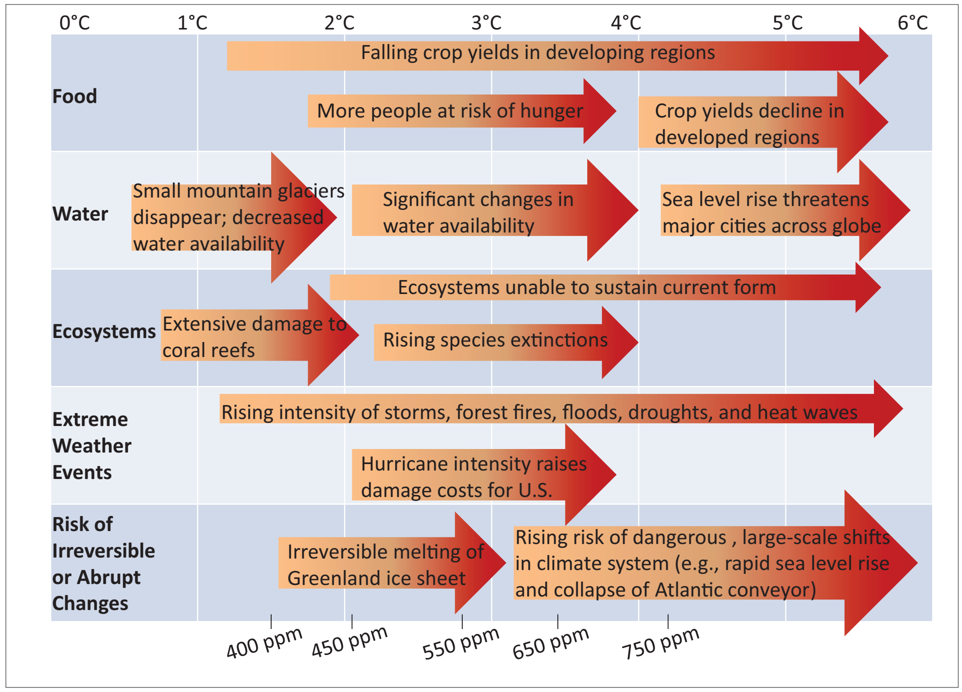
The actions taken by both governments and nongovernmental organizations (NGOs) can affect both sides of the supply/demand balance. Recent examples of political activity that has adversely affected supply include restrictions on access to resource-rich areas by national sovereigns; changing regulations (sometimes retroactively) that discourage or delay needed investments or alter the composition of fuel types and usage; and threats to security (of people and assets) and sabotage by radical organizations. Protracted sanctions against producer countries, particularly when coupled with political upheaval, war or other conflicts, and sabotage, have also had a decided dampening effect on nations' abilities to increase energy production.

Geopolitical decisions and activity by nations can also affect and be affected by demand considerations, as seen in the rise of China's and India's desires to strike bilateral alliances with producer governments to "secure" supplies in order to meet projected energy needs. Examples of political decisions that affect demand include policies affecting consumption taxes or subsidies, import levels and sources, fuels choices, and how to promote conservation and efficiency technologies.

Additionally, as the nature of the challenges transcend national boundaries and become more global in scope (e.g., climate change, disease pandemics, water and resource scarcity, terrorism),

Figure 12: Projected Climate Impacts of Rising Temperatures and Increasing CO2 Concentrations

Source: Adapted from Nicholas Stern, *Stern Review on the Economics of Climate Change,* Report to the Prime Minister and Chancellor of the Exchequer, October 30, 2006, Executive Summary (full), p. v, Figure 2, available at http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/sternreview_index.htm.



implementing effective "horizontal" solutions becomes increasingly problematic for institutions, companies, and nations that are vertically structured.

Geoeconomics

As oil prices have risen (to more than $100 a barrel in the past five years, and by more than 40 percent in the short period between January and July 2008), an enormous amount of capital wealth has been transferred from energy consumers to a small and increasingly concentrated group of energy-producing nations. A number of these nations, however, do not currently have adequate institutional safeguards to protect against rampant corruption and inadvisable uses of such revenues. The presence and size of these funds may allow oil-producing nations to self-finance development projects both at home and selectively in other nations, without either the assistance or transparency and good governance requirements of the multilateral financial institutions. Such an occurrence will likely accelerate the erosion of international standards, largely created by Western economies, and the consequent leverage of those traditionally influential nations.

To the extent that those nations invest in either the United States or the European Union, consumer dependence becomes doubly complicated—tied to both energy dependence and a fear of investment withdrawal. Because emerging economies can finance their own development or seek partnerships with one another rather than adopt the rules of existing global institutions, the effectiveness of those institutions and the global norms they seek to support could be undermined. Global receptivity to U.S. alliances or "Western"-based institutions has declined in recent years, and public opinion of the United States and, by virtue of the association, of U.S.-based companies, has taken a decidedly negative turn. As new global players emerge with new priorities and perspectives, it raises the question of whether current international institutions and relationships can continue to be effective.

As indicated above, the IEA is already making efforts to engage many new consumers like China and India, but it is unclear whether either of those countries views the "benefits" of membership as outweighing the obligations. This question of institutional effectiveness extends to organizations with broader mandates, like the World Bank, International Monetary Fund, regional development banks, treaty organizations, and trade groups. Serious consideration should be given to the questions of whether and how well these institutions are still serving their original purposes (or whether, in fact, those objectives need to be recalibrated in light of changing conditions) and how effective they will be in this changing global environment.

CLIMATE CHANGE: THE GAME CHANGER

Of all the trends identified above, government actions designed to address the effects of climate change (through decarbonization of the energy mix) and the climatic impacts of rising temperatures, changes in rainfall, glacial melting, and rising sea levels have the greatest potential to fundamentally transform the global energy system (see figure 12). The Intergovernmental Panel on Climate Change (IPCC) report has identified the use of fossil fuels as a major contributor of anthropogenic greenhouse gas emissions into the atmosphere and a key factor in global warming.[5] Policymakers are increasingly concerned that given the array of potential risks, prudence dictates that concerted action should be taken to avoid or forestall the most dangerous impacts of climate change. According to the IPCC analysis (and a range of others), to do so requires the timely stabilization and reversal of atmospheric concentrations of greenhouse gases. Because human activity has been identified as a major contributor to the growth in global GHG emissions, a prime target for action is the CO_2 emitted in the burning of fossil fuels.

The world relies on fossil fuels for more than 80 percent of its energy needs. Reducing this dependence will require significant new investment, technology improvements, and massive-scale deployment sustained over a long period. Transitioning to a low-carbon energy future will require a complete transformation of the energy delivery system upon which the world has relied for a century, moving toward a new, more resilient, and sustainable system—but one that is largely theoretical, untested at scale, and expensive. Given the unsustainable trajectory of the current system, however, such a transition must inevitably occur; and in many ways, the transformation is already under way.

Climate change is not a new phenomenon, nor is concern over resource scarcity in the face of a growing and developing population. In fact, climatic records indicate that the earth has undergone a series of protracted periods of cooling and warming trends over millennia, and theories about the human role in causing climate change have been around for over a century. In the 1970s, scientists and sociologists expressed concerns about resource constraints, the environment, and overpopulation of the planet in reports like *The Limits to Growth*.[6] However, as populations have continued to grow (estimates for global population approach 9 billion people by 2050[7]), as greater portions of the population live in coastal areas, and as projected climatic impacts pose a severe threat to food and potable water supplies, the spread of disease, and flooding and drought, the potential for catastrophic outcomes has increased along with concerns about resource competition.

"Government actions designed to address the effects of climate change (through decarbonization of the energy mix) and the climatic impacts of rising temperatures, changes in rainfall, glacial melting, and rising sea levels have the greatest potential to fundamentally transform the global energy system."

As a consequence, both governmental policies aimed at curbing emissions growth and the direct impacts of climatic change have the potential to alter the natural environment as well as the global economic framework. To the extent that global warming produces significant changes in local and regional climate patterns (including loss of hydropower due to drought), population migration, and altered food supplies and growing seasons, what is currently viewed as a predominantly environmental concern could change into a major security challenge. The lessons drawn from the recent food and grain shortage—partly the result of climate changes in agricultural areas, increased global demand, and the conversion of certain food crops (e.g., corn) to fuels—should be instructive about the range of "unanticipated consequences"; the interrelationships between energy security, climate, and agricultural policy; and the complexities of the global system. Depending on how the current political trends play out, the future geopolitical effects of climate change could also have enormous ramifications for the geopolitics of energy.

That said, even in the aftermath of the 2009 UN Conference in Copenhagen there is little consensus regarding how society is actually prepared to address the climate change issue. There appears to be relatively broad agreement that CO_2 emissions mitigation, adaptation measures, and dedication to the long-term study

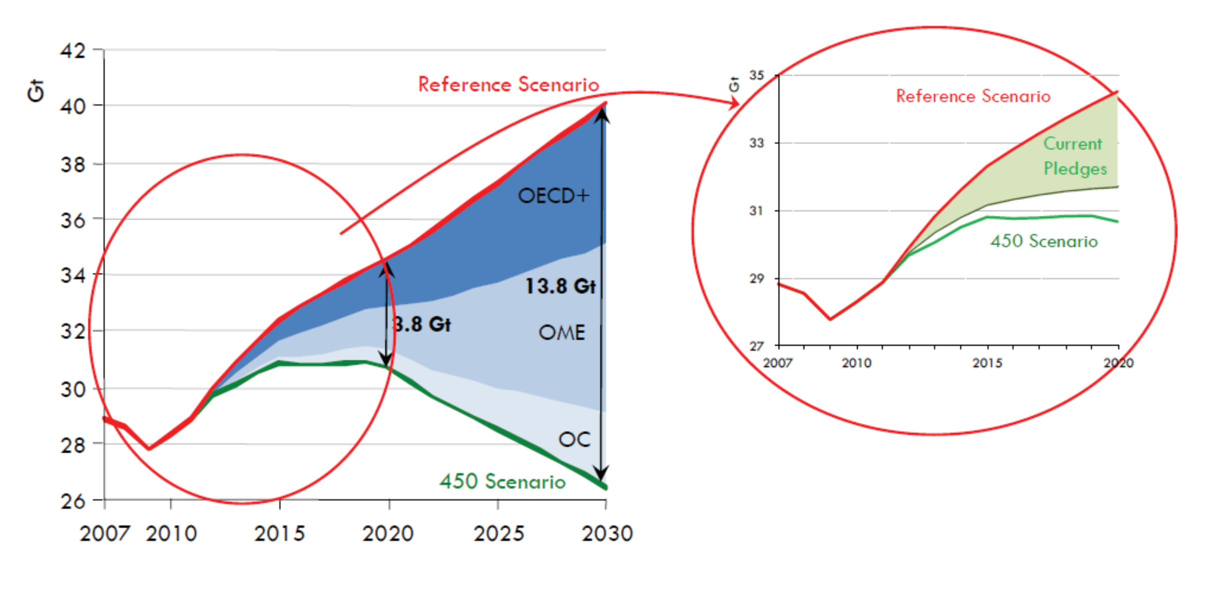


Figure 13: Emissions Pledges in the 450 Scenario

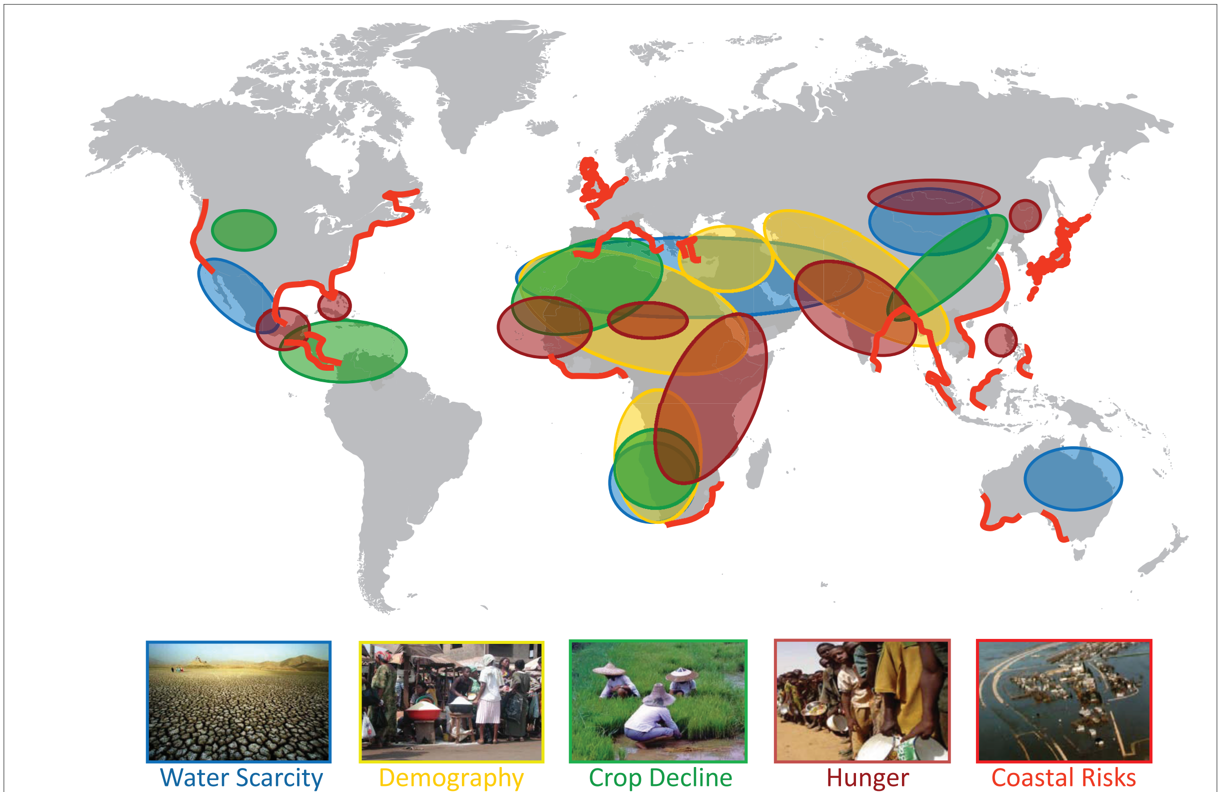
Source of data: IEA, *World Energy Outlook 2009.*

Notes:
Gt = gigatons
OECD+ = OECD and other non-OECD EU countries
OME = other major economies—Brazil, China, Middle East, Russia, South Africa
OC = other countries

“Society...must be prepared to adapt to the possibly unavoidable impacts of changing patterns of rainfall and drought, increasingly severe weather conditions, and generally hotter temperatures.”

Figure 14: Climate Change as a Threat Multiplier

Source: Created by CSIS.



of climate science are all necessary components of an effective climate policy. The IPCC’s best estimates indicate that stabilization at about 450 parts per million (ppm) CO2-equivalent in the Earth’s atmosphere—the so-called 450 scenario—will increase the chances of limiting the global average temperature increase to 2.0 to 2.4 degrees Celsius, although more recent studies suggest even higher temperature responses (see figure 13).[8] Recent analysis by the IEA and others of the emissions reduction commitments agreed to as part of the Copenhagen Accord strongly suggests that the commitments are likely to be inadequate to ensure the realization of the 450 ppm scenario, thereby requiring greater cumulative reductions or resulting in a temperature rise of more than 2 to 3 degrees Celsius. The IPCC analysis is also careful to state that stabilization at the 450 ppm level would not insulate the world from the impact of climate changes already under way (figure 14). Even as nations attempt to spur technology solutions and pursue mitigation efforts, society therefore must also be prepared to adapt to the possibly unavoidable impacts of changing patterns of rainfall and drought, increasingly severe weather conditions, and generally hotter temperatures.

Scientists still do not fully understand how the Earth’s climate and various natural systems will react to the climatic changes that are already under way. Recent evidence that the climate is changing faster than predicted (e.g., more severe ice melting, increased saturation of the Earth's carbon sinks) illustrates the importance of continued research and monitoring. The possibility of tipping points—abrupt changes in one of the Earth's major natural systems, such as ocean currents—is one main area of study for climate scientists who are worried about managing some of the less-predictable climate scenarios.

In addition to the question of how to achieve an overarching, unified, global approach to climate issues, there is currently no international agreement on a number of mechanical issues. These include the division of responsibility (major emitters, lesser contributors, for example) for reducing CO_2 emissions, the most effective mechanisms for achieving desired emissions reductions, questions of economic development and climate change mitigation, the role of government in technology development and global deployment (including financing mechanisms), and, most recently, the economic consequences of instituting aggressive climate policy in the wake of the global financial crisis and subsequent economic slowdown. Ironically, the economic downturn has slowed and in some cases decreased the growth of emissions (at least temporarily) as a consequence of reduced economic activity and fossil fuel consumption. It has also left national treasuries and economies less able to fund transformational infrastructure efforts.

There also remains the issue of global, coordinated (top down) approaches vs. more fragmented and diversified (bottom up) mechanisms. A variety of governmental agencies at the local and national levels have instituted policies to reduce CO_2 emissions through greater efficiency, promoting renewable energy, establishing emissions reduction targets, and investing in technology research and development. And while the international community is both interested and engaged in efforts to coordinate these activities to ensure that actions taken around the world are robust enough to achieve a desired environmental outcome, the lack of a legally binding agreement or effective means of reductions verification could easily reduce that process to a cataloging effort rather than one directed at effective mitigation. Notwithstanding these substantial challenges, however, government policymakers have begun to assimilate climate change considerations when crafting energy policy formulations. Nowhere has this change been more pronounced or advanced than in the European Union. Energy policy (laws, regulations, and tax structures) traditionally focused on providing low-cost energy to consumers and properly marketing domestic energy resources for exports. With the increase in demand for conventional energy resources (oil, natural gas, and coal), energy policy turned its focus to providing greater energy security (i.e., the provision of secure, reliable, and affordable energy). In the United States, energy security tends to be closely aligned with transportation fuel security and the importation of oil supplies. Here, the pillars of energy security policy have tended to emphasize diversity of supply and suppliers, increased efficiency, sustained domestic production, and the managing of global geopolitics, including protection of the sea-lanes. To the extent that renewables, or low-carbon fuel options, became part of the equation, they were included as elements of diversification, with a secondary focus on the environmental benefits. As the urgency to address climate change by reducing emissions grows, energy policy is, to varying degrees, being filtered through a "climate lens" if not explicitly being altered to prioritize emissions reductions. In the process, key economic and foreign policy/ security considerations are often overlooked or undervalued.

As a strategy, the diversification of energy suppliers works well for individual consumers. But if a disproportionately large amount of global supply is concentrated geographically, it follows that substantial resources must be allocated to ensure that the region itself remains stable in order to ensure the security of supply. Climate changes that threaten to upset regional stability (e.g., water shortages or crop declines in highly populated areas like Africa or the Middle East or torrential rains and flooding in low-lying regions) thereby also pose challenges for many traditional supply areas.

In addition to public sector actions, private sector companies are increasingly inclined to take climate change into consideration when making investment decisions. Exactly how and to what extent climate change influences investment decisions still varies from company to company. Some companies have found commercial opportunities associated with the increased popularity of environmentally sustainable, or "green," products and practices. Others have taken advantage of the cost savings associated with gains in energy efficiency. In some cases, the uncertainty regarding the long-term costs associated with CO_2 emissions has frozen investment decisions altogether (this is particularly true of energy-intensive industries). According to the September 2009 report of the Carbon Disclosure Project, of the Global 500 companies that responded to its climate change survey, 84 percent consider regulations associated with climate change to offer opportunities for their businesses; while 78 percent view the regulations as a risk. Further, 78 percent also identified the physical changes from climate change as presenting risks. The report noted that climate change is being slowing integrated into the leadership structure of even the companies with arguably the most to lose from emissions targets. According to the Carbon Disclosure Project, "Despite overall below-average disclosure scores, most energy respondents have a Board member or executive body with overall responsibility for climate change (76 percent, or 42 companies) and engage stakeholders regularly on climate-related issues."[9]

Uncertainty over the future price for carbon and the direction of U.S. federal and international climate policy have stalled investment in many parts of the United States and the world. For those looking to invest in carbon-emissions-intensive or energy-related industries, the near-term and long-term prices for carbon are critically important to the financial viability of their projects. The issue of climate policy uncertainty impeding investment has been exacerbated by the recent financial crisis, which has made investing in energy projects more difficult due to the decreased access to capital and the slowdown in energy demand due to a slowing economy. Most investors view the global downturn as a near-term concern, but the longer-

“Private sector companies are increasingly inclined to take climate change into consideration when making investment decisions.”

term implications of government policies to address climate change still loom large.

There are three primary ways to reduce CO_2 emissions from energy production and use: reduce demand (through greater efficiency), capture and sequester CO_2, and transition to low-carbon fuel sources. To the extent that governments decide to impose mandatory limits on greenhouse gas emissions (through a carbon tax, cap and trade, intensity targets, etc.) they will effectively change the economics of energy by establishing a cost for greenhouse gas emissions. High-carbon fuel sources like coal, oil, and, to a lesser extent, natural gas will increase in cost, while the cost-competitiveness of low-carbon fuel options like nuclear energy and renewables will improve.

Options to decarbonize current energy production through either carbon capture and storage or increased levels of efficiency (thereby reducing the energy needed and carbon generated in existing production and use) will also become more attractive. A number of studies have explored how patterns of energy production and use will change under different cost scenarios for CO_2. In general, these studies conclude that the least-cost option for greenhouse gas mitigation is energy efficiency. After efficiency, depending on assumptions of economic viability, supply, and technology availability, other fuel options fall out in a carbon-intensive (generally low to high) hierarchy.

If the economics of energy change due to the internalization of the cost of GHG mitigation, then it follows that (over time) the geopolitical leverage of fossil-based resource holders will also change. Assuming that a global cost for carbon is established (recognizing that this is a lofty assumption), then the cost structure of energy production, trade, and use could be completely transformed. In such a world, coal would arguably be unusable without a way to capture and store the resulting CO_2, forcing major coal resource holders (the United States, China, and India, for example) to find more costly replacement fuels. Depending on the stringency of the CO_2 emissions limits and the ability of producers/refiners to eliminate or reduce emissions, petroleum could cease to be a strategic commodity of first choice (although this notion also assumes that more acceptable transportation alternatives could be developed and deployed at scale). Absent technological breakthroughs, the energy- and emissions-intensive processes associated with developing unconventional resources like oil sands, oil shale, and coal-to-liquids could also become far less attractive as fuel choices.

Under such circumstances, natural gas presents a far more interesting case, especially in the near term to middle term as a “bridge” fuel. To some extent, in a carbon-constrained economy, natural gas becomes the fuel of choice for power generation (with some limited application as a supplemental transportation fuel). Natural gas is the least polluting of the fossil fuels, producing less than half the emissions associated with the burning of coal. However, not surprisingly, as a hydrocarbon, the major natural gas reserves are largely found in the same regions of the world as the largest oil reserves. So in geopolitical terms, the concentration issue presents a similar dilemma to that of oil dependence. This picture potentially

> "Materials like uranium, dysprosium, indium, platinum, lithium and lanthanum, rhenium, and rhodium may one day replace conventional fuels as strategic commodities."

changes, however, with the continued success in exploiting the sizable unconventional gas reserves (e.g., coal-bed methane, tight gas sands, and shale gas) around the globe.

The EIA estimates that the United States' increased production of unconventional natural gas, led by the development of its sizable shale gas resources, has the potential to reduce imports of both pipeline gas and LNG. The projected growth in global LNG supplies over the next several years—coupled with efficiency gains, an increased use of renewables, and the global development of indigenous unconventional supplies—promises to reshape global gas markets, simultaneously enhancing supply security while reducing environmental effects.

Even with the development of substantial new natural gas supplies, at some point the pressure of high demand (and the need to further decarbonize gas with carbon capture and sequestration technology) would inevitably increase the price of gas and create opportunities for other low-carbon technology or decarbonization options to take hold. But while such logic might suggest that the move to cleaner technologies will ultimately solve significant geopolitical leverage concerns, such optimism should be tempered by concerns over the global availability (and concentration) of certain rare earth minerals and elements that will be used to build and run those new energy systems. Materials like uranium, dysprosium (used in control rods for nuclear reactors), indium (found in photovoltaic cells), platinum (catalysts), lithium and lanthanum (used in batteries), rhenium (used for nickel-based super alloys), and rhodium (an anticorrosive material used in high-temperature coatings) may one day replace conventional fuels as strategic commodities (with associated geopolitical consequences for suppliers and consumers).

In sum, the accumulation of these trends and concerns are driving new investment and policy decisions in the United States and at a global level. In the future, technology advancements and policies prioritizing national security, economic growth, environmental effects, and international relations considerations could substantially alter the global energy mix and promote different fuel choices over traditional forms. That possibility may also have the effect of reconfiguring the global energy landscape, creating new regional and international commercial and strategic alliances, altering the environment, and changing how the world generates, transmits, transports, and consumes its energy resources. In all cases this transformation will come with an attendant economic cost. If the climate models are anywhere near correct, however, failure to act will also have obvious economic, security, and societal consequences.

SUMMARY AND CONCLUSIONS: THE CASE FOR A NEW U.S. POLICY PARADIGM

The trends and challenges outlined above are not entirely new. Growing import reliance, increasing energy prices (albeit at lower levels), vulnerable infrastructure, diminishing access to resources, geopolitical tensions, and the environmental impact of energy production and use are all phenomena we have endured for decades. Yet until recently, no one issue or combination of issues posed a serious enough concern to warrant sustained policy attention. In the future, this may no longer be the case. The fragility of the current system and the major potential changes on the horizon could significantly alter energy dynamics in the future.

Over the past 50 years, as both a major energy producer and the world's largest consumer, the United States had played an extremely influential (almost authoritative) role in advancing the basic ground rules for global energy markets. During that time, U.S. energy policy has been faithfully diverse; often internally inconsistent; amazingly flexible in adjusting to public, market, and commercial pressures; and incomprehensible to most observers. It is likely to retain many of these unique qualities, especially as U.S. policymakers attempt to address an increasingly complex set of issues in a less unified and more diverse yet interconnected world.

The 1970s provided the last clear articulation of an attempted U.S. national energy strategy—and this was largely in response to global energy events. The 1973 Arab oil embargo (and disruptions associated with the Iranian revolution and the Iran-Iraq war) prompted the development of the Strategic Petroleum Reserve, the adoption of Corporate Average Fuel Efficiency (CAFÉ) standards, and the formation of the IEA. Domestic natural gas shortages and the prospects for declining oil supplies produced the Carter administration's decision to lift the regulation of oil and natural gas prices and to pursue energy-sector transformation, ushering in a new era in U.S. policy driven by the market but also one in which the United States as a matter of policy accepted the responsibility for protection of global energy supply routes.The adoption of Clean Air and Clean Water legislation and regulations augmented the market policy with a healthy dose of government mandates.

A preference for market economics and cheap energy has prevailed for most of the last 30 years, with oil prices (until recently) remaining relatively low while U.S. energy efficiency has increased, albeit slowly. Changing market, economic, and political conditions however will undoubtedly complicate America's policy choices in the future:

- Energy security—broadly defined in terms of vulnerability to supply disruptions and to volatile and higher prices—will be a greater concern as growing global energy demand continues to push the bounds of accessible, affordable, and environmentally benign supply.

- Market developments and policy changes, particularly in alternative fuels and with respect to climate change and carbon policy, will change the economics of fuel choices and determine investments.

- There may be less multilateral cooperation and new "rules of the road" in markets as powerful new actors decide how and where they want to conduct business.

It is against this backdrop that future U.S. and global energy, security, and environmental policies must be fashioned and that both current

"Clearly a transformation is under way, but managing the transition in a way that promotes efficiency and encourages the development and deployment of clean energy forms, while concurrently maintaining the robustness of the conventional system, is key to the success of any reset."

and future perspectives—and the transition from one to the next—must be thoughtfully considered. The purpose of this report has been to lay the groundwork for next steps. Clearly a transformation is under way, but managing the transition in a way that promotes efficiency and encourages the development and deployment of clean energy forms, while concurrently maintaining the robustness of the conventional system, is key to the success of any reset.

Over the coming months, future program events and publications of the CSIS Energy and National Security Program will highlight possible solutions and pathways forward. Single-issue advocacy, unbridled optimism, and blind reliance on technological innovations are woefully inadequate through they frequently masquerade as policy prescriptions. In addition, while risk mitigation is highly desirable, virtually all of our current energy choices carry some degree of inherent risk and trade-off. Recent mining disasters in the United States, global nuclear threats from Iran and North Korea, and the oil spill in the Gulf of Mexico serve as obvious examples, but it is well to remember that renewables have intermittency challenges and that the electric grid could be subject to cyber security threats as well as physical sabotage. Consequently, viable energy policy solutions must be robust against a variety of outcomes and events.

Endnotes

[1] Unless otherwise referenced, all projections are from the Energy Information Administration (EIA,) *International Energy Outlook 2009 and International Energy Outlook 2010* (Washington: EIA, 2009, 2010), reference case. Many of the trends, however, are confirmed by projections from the International Energy Agency (IEA), *World Energy Outlook 2009* (Paris: IEA, 2009), reference case, and from OPEC.

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