Energy's Next Frontiers

How technology is radically reshaping supply, demand, and the energy of geopolitics

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Dr. Stanislaw was one of the three founders of Cambridge Energy Research Associates in 1983 and served as managing director for all non-US activity until 1997, when he was named president and chief executive officer. He is an adjunct professor in the Nicholas School of the Environment and Earth Sciences at Duke University, where he is a Member of the Board of Advisors for the Nicholas Institute for Environmental Policy Solutions. Dr. Stanislaw was a Research Fellow of Clare Hall and lecturer in Economics at Cambridge University, where he was also a member of the Energy Research Group in the university's Cavendish Laboratory. He was a senior economist at the Organization of Economic Cooperation and Development's International Energy Agency in Paris.

Dr. Stanislaw is co-author of *The Commanding Heights: The Battle for the World Economy.* Now in the second edition, the book has been translated into 13 languages and made into a six-hour documentary on PBS. He is also the author or co-author of numerous reports and published papers on the geopolitics and economics of future energy supply and demand, including *Energy in Flux: The 21st Century's Greatest Challenge*, and *Clean Over Green: Striking a New Energy Balance as We Build a Bridge to a Low-Carbon Future,* and he is featured in the public television documentary, *Oil ShockWave*.

Dr. Stanislaw received a BA, cum laude, from Harvard College, a PhD in Economics from the University of Edinburgh, and was awarded an MA from the University of Cambridge. He is one of only several people to have been awarded an Honorary Doctorate and Professorship from Gubkin Russian State University of Oil and Gas in Moscow.

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Through the looking glass (full steam ahead, but…)

TO understand how radically the energy industry is changing, consider this: The United States has become the No. 1 producer of natural gas in the world. This is due to combining horizontal drilling and hydraulic fracturing technologies, a combination that has been in widespread use for just four years—and that has allowed gas from shale formations to go from accounting for just 2 percent of America's natural gas production in 2001 to over 30 percent[1] today. As a result, natural gas prices have been falling in the United States for years. Given appropriate policy and smart investments, North America could eventually achieve the goal of energy independence—with enough domestic supplies to meet American needs—though crude oil prices would still be at the mercy of world markets. The fundamental question Americans now face is: Can they capitalize on this extraordinary opportunity?

Or, think about this: In 2008, with oil at $137 a barrel, there was a frenzy of fear over peak oil supply. Yet today, when we talk about peak oil, we do so in reference to demand. At some point within the next two decades, global oil consumption could even crest. In the United States, net petroleum imports reached their peak of domestic consumption—60 percent—in 2005, and have been falling ever since. Imports are now down to 46 percent. Soaring output from the Bakken shale fields, coupled with increased deepwater output primarily from the Gulf of Mexico, has pushed up US domestic production by 12 percent since 2008.[2] This is the first increase in a quarter-century and has confounded predictions that domestic output was set on an inexorable downtrend.

It is a rare blessing for a country to be confronted with an abundance of energy. Pessimism has reigned for the better part of 150 years. In 1865, the British economist William Stanley Jevons published *The Coal Question*, a study that spread panic about the depletion of coal reserves. At the 1956 meeting of the American Petroleum Institute, M. King Hubbert, a Shell geoscientist, coined the concept of "peak oil" and, in 1974, he forecast that global oil supplies would peak in 1995. The Department of Energy's 2005 *Hirsch Report* contemplated the imminent, "abrupt," and dangerous peaking of world oil and gas supplies.

Yet, while humanity has consumed a total of one trillion barrels of oil since the early 19th century, today, thanks to an onslaught of technology-enabled discoveries, another four trillion barrels are thought to be accessible. In consequence, reserves-to-production ratios for many major oil producers are climbing as far out as 2040, and oil and other liquid fuels will remain the world's largest energy source, meeting one-third of demand. Meanwhile, many people now believe that both the United States and Europe likely experienced peak demand for gasoline in 2007.[3]

Information technology is energy technology

What is driving this energy revolution? Technology.

Cutting-edge technology—hardware and, especially, software—is unlocking geological potential in places and ways hardly imaginable even a few years ago. Energy companies now rank among the most important—and sophisticated—technology companies in the world. Information technology companies are pioneers on every front of the energy revolution, by:

- Driving innovations in exploration
- Cutting energy consumption in buildings through software-driven construction and energy management
- Allowing utilities to more smartly source and manage their energy output
- Empowering individuals to understand how to reduce their energy use; this underscores the "Power of One"—how each and every one of us can become players in the energy game
- Enabling the design and testing of energy systems, from solar arrays and wind turbines to nuclear plants

The breakthroughs have been stunning, and often elegant in their simplicity. Among the least appreciated technologies are those that empower companies and individuals to understand and manage—and thus significantly reduce—their energy consumption. Last year, venture capitalists invested $275 million—up 75 percent from 2010—in start-ups that make software and other technologies to manage energy use.[4]

Equally impressive is the evolution of renewable and alternative energy technologies. The renewable energy market is expected to reach as high as $800 billion by 2015 and to generate 17 percent of the world's electricity by 2030. In parts of the world, the cost of solar energy is reaching grid parity. Nuclear, despite the Fukushima disaster, is growing at a pace not seen in decades, especially in Asia—21 reactors provide 31percent of South Korea's electricity, while 26 reactors are under construction in China.[5]

And energy storage is perhaps the biggest game-changer: Apple, to take one example, is said to be working on a hydrogen-based laptop battery that could last for months. Once the energy storage puzzle is cracked, renewables and alternatives should have even greater currency.

Or take exploration: Our ability to process and analyze massive amounts of three-dimensional data about the ocean floor has allowed the energy industry to discover vast new fossil fuel deposits. Technological innovations in drilling then allow producers to access these deposits, many of them located in remote, once-forbidding places—beneath the Arctic icecap, for instance, or at extraordinary depths.

Great Game 2.0

The economic, environmental, and geopolitical consequences of this technological transformation are breathtaking. Perhaps no change is more important than the introduction into the energy game of dozens of new players. The energy of geopolitics will not likely ever be the same.

Today, alongside traditional powers like Saudi Arabia and the United Arab Emirates, Brazil is becoming an energy superpower and Canada is reinforcing its position as one, as is Russia. Also joining the ranks of growing energy producers are countries like the Philippines, Argentina, Angola, and Suriname (all thanks to deepwater drilling), and Poland (shale gas). In Israel, massive recent gas discoveries are upending the energy and political calculus—a fact that would most likely have stunned former Prime Minister Golda Meir. "Let me tell you something that we Israelis have against Moses," she famously joked in 1956. "He took us 40 years through the desert in order to bring us to the one spot in the Middle East that has no oil." The Department of Energy estimates that there are 32 countries worldwide with meaningful reserves of shale gas.

The global energy map has been redrawn and expanded by technology—which is the real driving force in "Great Game 2.0."

The geopolitical consequences are nowhere greater, perhaps, than in the United States. For decades, the United States has been the world's oil glutton, consuming about a quarter of global energy supplies, despite having just 5 percent of the population. Until recently, the United States had grown increasingly reliant on energy imports, a dependency that shaped its economy and its foreign policy. Since 2008, however, US domestic oil output has climbed 12 percent, largely on the back of the Bakken and other shale discoveries, as well as on the rapid expansion of deepwater drilling. With its production projected to climb for years to come, the United States should soon lose its ranking as the world's top oil importer—a dubious honor that is expected to go to the European Union by 2015 and China by 2020. (China already has overtaken the United States as the biggest importer of oil from the Middle East.)[6]

If, five years ago, you had asked "Which country in which region of the world can be totally energy self-sufficient?" no one would have guessed the United States. Yet now, the revelation of North America's massive shale gas and oil reserves, combined with the technological innovations that unlock their potential, is helping bring into focus the tantalizing prospect of energy independence for the United States. Just a few years ago, the fossil-fuel-rich corridor that ran from Saudi Arabia, through the Caspian, over Siberia, and into Canada—the Saudi-Caspian-Siberia-Canada (SCSC) corridor—was seen as the world's energy backbone. Six years ago, the corridor stopped in Canada. But now, that energy rainbow extends to the United States where, potentially, Americans will be able to tap into the pot of gold at the end of that rainbow. But the fairytale will only come true if the United States seizes the opportunity through appropriate policy, investments in infrastructure, and intelligent energy management.

Energy technology is also bringing its transformative power to other parts of the world, principally by decoupling energy from its traditional sources. Renewable energy sources like wind and solar exist across the globe. The incredible diaspora of shale gas and oil resources, and the reserves unlocked by deepwater exploration, expand the energy map even further. This "localization" of energy could be a major force in—for instance—lifting Africa out of poverty by helping bring reliable energy supplies to remote areas. It will help enable the continued boom in urbanization, since energy consumption and high energy costs are one of the brakes on economic development. And by being locally embedded, energy technologies will help keep communities globally connected—rather than dependent.

Since the notion of the "Great Game" was coined in the 19th century, it has referred to the often-violent scramble among nations for control of territories harboring energy reserves. This old-style game is still very relevant. This is evident in the growing geopolitical tensions over access to the Arctic's mammoth energy reserves; in China's pursuit of control over fossil fuel deposits in Central Asia, Africa, the Middle East, and South America; and in the strong entry of India into the global resources game.

But today it has become equally, if not more, important to control the technology assets—the hardware and the software. Thus, the game has changed.

Energy Inc. and the Power of One

The new technologies have not only empowered dozens of countries, but they also have made corporations and individuals participants in the energy game.

Google is perhaps the highest-profile example of this: Its data centers continuously drew almost 260 million watts—about a quarter of the output of an average nuclear power plant—to run Google searches, YouTube views, Gmail messaging, and display ads. Yet, it has pioneered technologies that allow its data centers to use only 50 percent of the energy that most other data centers consume. To help meet its energy needs, meanwhile, Google has built a $915 million portfolio of clean energy investments on a simple investment philosophy.[7]

That is, the future will be powered by multiple clean energy technologies, and the key is to find the ones that will ignite a revolution and scale to meet the world's energy needs.

Already, Google has a zero carbon footprint—and its goal is to go negative.

Meanwhile, smart meters, the Internet, and advanced software are allowing individuals to fine-tune their energy consumption. This underscores the Power of One—the ability of every person to proactively manage their energy consumption and their carbon footprint. This generational change is a function of heightened awareness of the impact of energy consumption on household expenses, on foreign policy, and on the environment. The consumption of energy is no longer just an economic act—this is becoming a conscious act and an act of conscience. This will likely intensify in the coming years.

For both companies and individuals, technology has unleashed the potential creation of a virtuous energy cycle: By understanding and managing energy use, individuals save money, companies increase profits, and both lessen the environmental impact. Everyone wins.

A recent report by Deloitte—the reSources 2012 study—found consumer resourcefulness has become entrenched among American consumers. Eighty-three percent of consumers took steps to reduce their electric bills over the past year, up from 68 percent in the 2011 reSources study. And, consumers are demanding that companies offer more environmentally considerate solutions. US businesses, on average, are targeting reductions in energy consumption of 23-24 percent over a 3-4 year period across electricity, natural gas, and transportation fleet. This year's survey indicates that companies are increasingly recognizing energy management as a necessary strategic discipline and a key to competitiveness. The 2011 and 2012 studies suggest there are three categories where businesses will fall as it relates to their energy management practices—Pioneers, Engagers, and Reactors.

Danger ahead—A license to operate?

The breakneck pace of the energy technology revolution likely masked inherent risks, however—especially in terms of the environment and the public reaction.

The expansion of hydraulic fracturing and the accelerated production of the Canadian oil sands coincided with the global economic crisis that began in 2008. This initially blunted reaction to the potential dangers of new energy technologies, since the general public was absorbed by its core economic concerns and thus inclined to think more about the savings that came from less-expensive energy than about environmental concerns. In parallel, the campaign for a global climate treaty effectively collapsed after Copenhagen in 2009, upending the momentum to curb carbon emissions. In other words, in the competition between desire (for cheaper energy) and fear (of the eco-consequences of fossil fuels), desire was at the forefront.

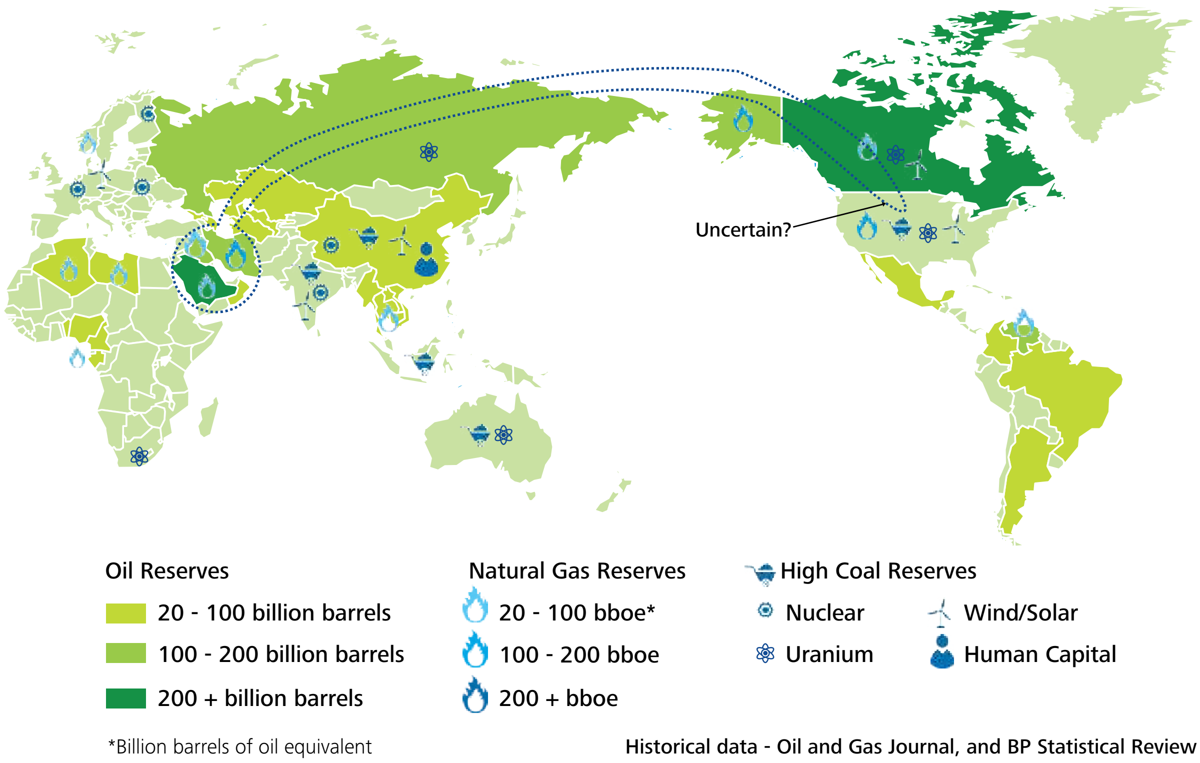
But environmental concerns are again front-and-center. The past three years have seen a series of energy-linked environmental challenges that have reawakened public concerns: the Gulf of Mexico oil spill, the Fukushima nuclear incident, the controversy of hydraulic fracturing, and more.

Another example is the 1,700-mile Keystone XL pipeline (which would transport 700,000 barrels per day of Canadian oil sands crude to US Gulf Coast refineries), which has stirred a storm of controversy in Washington after concerns were raised about carbon emissions from oil sands production. The grassroots movement against hydraulic fracturing, meanwhile, has gained steam due to concerns about the potential contamination of ground water, risks to air quality, and the possible migration of gases and hydraulic fracturing chemicals to the surface. In January 2012, over 40,000 New Yorkers weighed in during the public comment period on the state's deliberations to allow hydraulic fracturing.

The concerns of the ecological crowd are receiving attention, with some reports showing that groundwater tends to contain higher concentrations of methane near hydraulic fracturing wells. Also, hydraulic fracturing has been linked to earthquakes—not yet proven but sowing distrust. In November 2011, an earthquake measuring 5.6 rattled Oklahoma and was felt as far away as Illinois. Until two years ago, Oklahoma typically had about 50 earthquakes a year, but in 2010, 1,047 quakes shook the state. Both the US Army and the US Geological Survey have concluded that the practice of injecting water into deep rock formations causes earthquakes. The unsettled nature of these concerns means that companies still have not secured a free-and-clear "license to operate" from the public.

These are the early days of the high-tech energy era. Our knowledge of the potential and the consequences of new technologies is in its infancy. The full cast of players in Great Game 2.0—states, technology companies, energy producers—is only now emerging onto the stage. How all of these forces interact and play out in the coming years could well determine not just where we get our energy from and how much it costs, but also the shape of domestic and global development. The Great Game 2.0 may well decide which countries and companies emerge as enduring powers in the 21st century—which ones, in other words, will reach the pot of gold at the end of the energy rainbow.

Figure 1. The Saudi-Caspian-Siberia-Canada corridor: How deeply and quickly will the "pot of gold" be realized in the United States



Source: The JAStainislaw Group LLC

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Framing the Great Game 2.0: Safety, security, and stability

THE past few years have seen several crises that absorbed analysts and seemed to augur significant changes in the energy industry—natural disasters like the Japanese earthquakes that shook up the nuclear calculus, political upheavals in North Africa and the Middle East that looked ominous for oil (think Iran and Libya), and man-made environmental accidents like the Gulf of Mexico oil spill. All were grave in their own way. But none ultimately have been of truly significant consequence for global energy supplies.

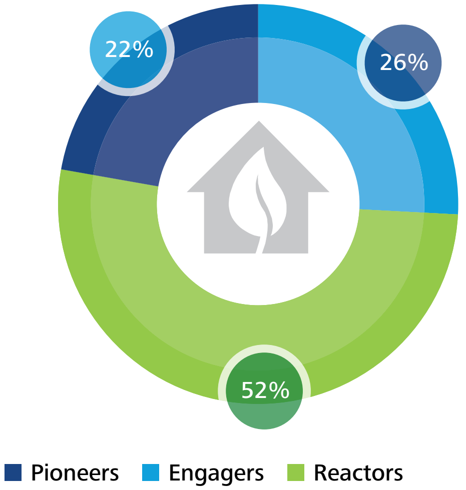
The reason for this is that deeper, more profound, longer-term trends are powering the energy equation. By far, the most significant one is this: Energy is a central force in global economics and politics. It is at the heart of the major global issues—economics, poverty reduction, climate change, clean water, and so many more. As a result, governments are pursuing an energy triptych—security, safety, and stability. This pursuit is at the heart of the Great Game 2.0.

In the Great Game 2.0, "security of supply" trumps. Unpack security of supply and you discover several essential components beyond the physical access to resources, including the technology needed to tap those resources, the human talent to invent and manage that technology, and the ability to securely transport energy through vulnerable channels, from the Strait of Hormuz and the Gulf of Malaca. Absent security of supply, national sovereignty is potentially at risk.

The other two "s" words in the energy triptych are safety and stability. Real security of supply will demand that energy can be accessed with minimal environmental impact and risk to human safety. And it also will depend on the long-term stability of a country's legal and regulatory framework, which allows companies and consumers to invest for the long haul.

The scale of investments being made in new energy technologies is unprecedented—and nowhere more so than in China. Beijing is investing $1.7 trillion in "strategic sectors," a major portion of it targeted to clean energy and clean energy technology. Specifically, Beijing says the package—equivalent to Italy's GDP and four times China's 2008 fiscal stimulus—will focus on "alternative energy, biotechnology, new-generation information

Figure 2. Organizations are increasingly sophisticated at managing energy at multiple levels within their enterprise and across the supply chain.



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Pioneers, Engagers, or Reactors are descriptors for the spectrum of businesses engaged in some level of energy management.

The Deloitte reSources 2012 study identified three distinct types of companies engaged in some level of energy management:

- **Pioneers:** 26 percent of respondents—embracing the challenges of energy management; developed and implementing strategy
- **Engagers:** 52 percent of respondents—believe must change or lose to the competition; new to the challenge, reported difficulty in developing and executing programs effectively
- **Reactors:** 22 percent of respondents—no comprehensive strategy; isolated, tactical, project initiatives

technology, high-end equipment manufacturing, advanced materials, alternative-fuel cars and energy-saving and environmentally friendly technologies."[8] China has become proficient in the design of nuclear reactors, solar, wind, and other energy technologies. While the Chinese are ramping up their own R&D, they have been especially skilled at adopting and adapting technologies and reengineering them to lower their costs.

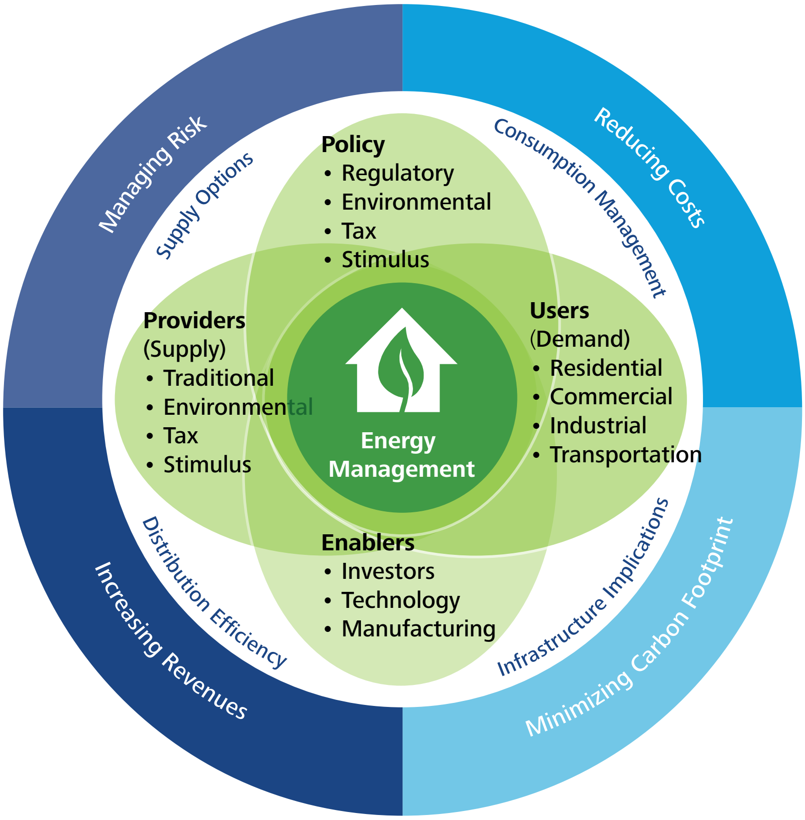
The countries that leap ahead in this energy technology game should be better positioned to protect their sovereignty and to benefit from sustainable development. But they also will be able to multiply their gains by being the beneficiaries of a "virtuous cycle of innovation" in much the same way that the initial discovery of fossil fuels and, a century later, the technology behind the Internet redefined the economic landscape.

Take wind and solar energy, for example: As these sources approach grid parity, they have helped accelerate the pursuit of energy storage. And energy storage is likely a game-changer in every realm, from extending the battery life on mobile phones and laptops, to powering cars, to decentralizing energy production.

Demand is supply: The stealth revolution in energy efficiency technologies

COMPANIES have business strategies, risk strategies, strategies for growing markets, and for managing human resources, and so forth. But most companies do not yet have an energy strategy—let alone broader sustainability strategies to manage the use of water, land, and other resources. This is especially striking because—thanks to the advent of technology that revolutionizes how we manage energy consumption—every company is an energy company. The headlines at the intersection of energy and technology have been dominated by solar, wind, biogas, tidal energy, and other renewable sources for most of the past decade. But two other, less-remarked-upon advancements probably matter more. One is

Figure 3. Energy is an asset that should be strategically managed to create economic value for business enterprises



Source: Deloitte Consulting LLP

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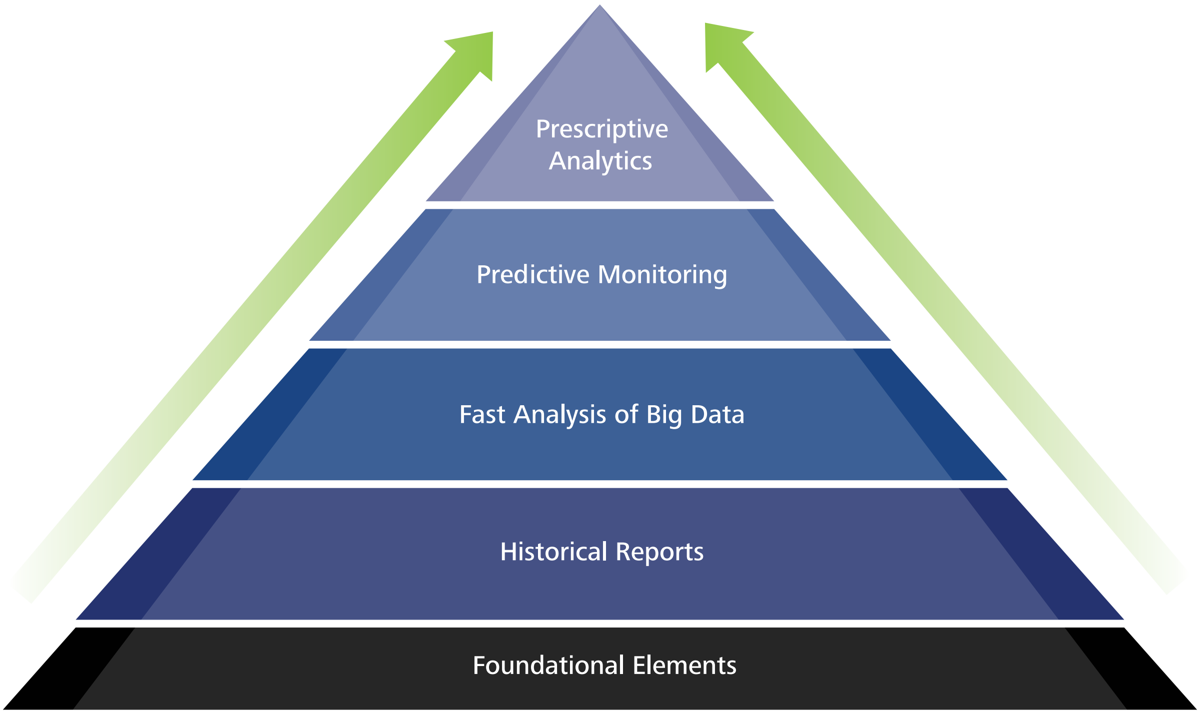
Figure 4. Real analytics for energy: The path to "big data"



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taking place in the management of energy use, where improvements in efficiency could have a greater impact on the global energy picture than any other development. And the other is in the oil and gas industries, where new technology has brought massive new reserves into play.

The marriage of technology and energy is perhaps nowhere more important than in upgrading electricity infrastructure—and in particular the long-awaited "smart grid." The gains in efficiency will likely be astounding once the grid is built out.

A picture of what's possible is unfolding in South Korea, where a prototype grid is being developed in tandem with intelligently designed buildings. "Smart" buildings connect and communicate with the utility company via the smart grid, allowing customers to check the energy use of every socket and track electricity prices minute by minute. This allows them to automatically schedule the use of power-hungry appliances like dishwashers when electricity is cheapest. In fact, by modulating use, customers are not only able to consume cheaper, off-peak power, but they can sell power back to the utility that otherwise would have been lost—the meters in the prototype system run backwards. Customers with energy-producing technologies like rooftop solar arrays or wind turbines also can sell their excess energy back to the power company.

Meanwhile, the smart grid allows South Korean utilities to chart energy use by house, by neighborhood, by time of day, by season—and thus to better plan how they will supply energy in the future. In leaping ahead with its prototype grid, South Korea is aiming at its own virtuous cycle of innovation, one that not only will allow it to combine smart technology and green energy into one ecosystem, but also allow it to spawn new companies that export the system worldwide.

Innovations can be elegantly simple as well: Opower gives electric and gas companies tools to communicate with customers, like text-messaging them mid-month if their electric bill is running particularly high.

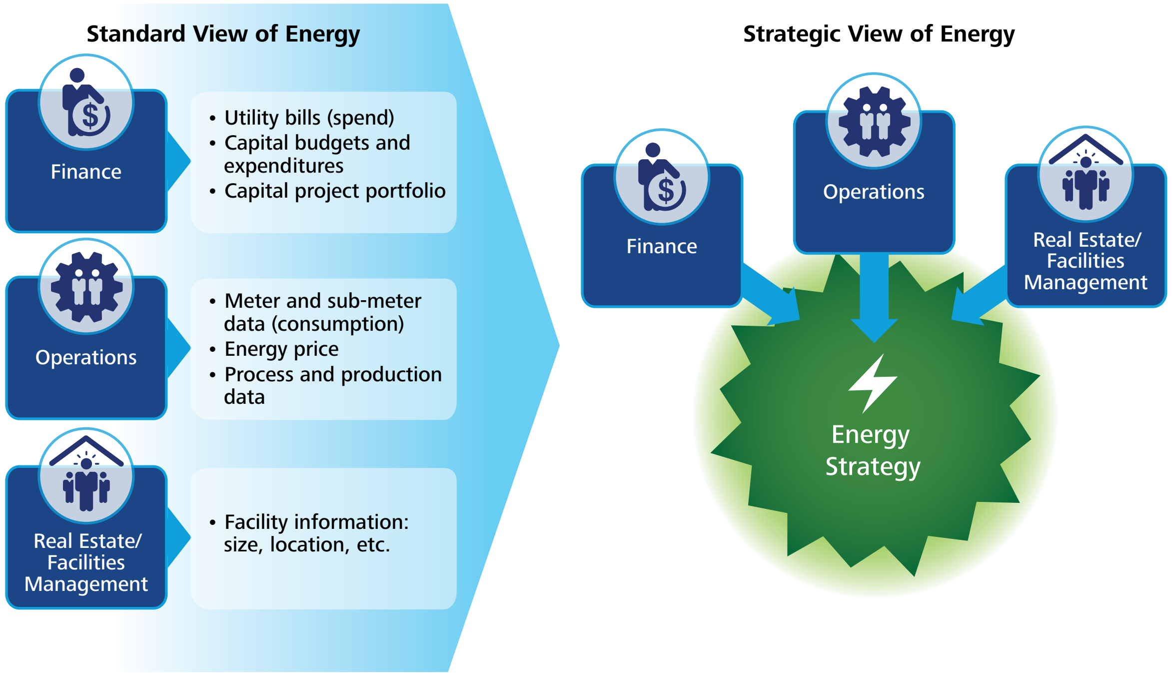
The budding "demand management" industry is already making major inroads in the corporate world. Innovators like EnerNoc, using state-of-the-art software, help companies manage energy use and automatically reduce consumption during peak periods, selling the "saved" electricity back to utilities at a profit and forestalling the need for the utilities to purchase high-priced energy on the spot market. FirstFuel Software, meanwhile, analyzes a building's electric use to produce an energy-saving plan—and it does so remotely, without a need for engineers to ever visit the building.

Almost all these energy management technologies are enabled by the availability of data. Capturing this data creates entire frontiers in energy management—much as Amazon reconfigured the supply chain and business model of consumer retail. Except, unlike Amazon, whose business model turned many brick-and-mortar players into dinosaurs, there are not necessarily "losers" in the energy management revolution—the producers, intermediaries, and consumers can all win.

How important are such innovations? Consider this: Peak electricity demand is rising faster than overall demand, so more and more power plants must be built to run for just a few hours a day. One recent study found that 21 percent of power plants run, on average, for less than an annual average of three hours per day—just to meet that peak demand.[9]

Companies generally spend a significant portion of their operating costs on energy, yet they generally have a poor understanding of their energy consumption and how to better manage it. From better management of buildings and vehicle fleets, to smarter use of technology, to tighter oversight of their entire supply chain, organizations can mobilize countless tools to transform how they use

Figure 5. Without a coordinated view of cost, consumption, operational and facility data there can be no enterprise energy management strategy.



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energy and other resources. The benefits of active energy and sustainability management are not only financial—though the bottom-line effect is the one most likely to motivate management—they also foster an ethos of sustainability throughout an organization, attract consumers who are now savvy about how "green" the products and services are that they consume, and serve to shield a company from being buffeted by energy price volatility.

An efficiency "sea change" is taking place offshore as well—in the world of shipping. Technology is allowing designers to reinvent how ships are made and how they move, revolutionizing the industry. The B9 Energy Group in the United Kingdom is retrofitting Rolls Royce engines to run on natural gas, thereby reducing fuel consumption. But B9's real innovation is in the giant high-tech sails that provide most of a ship's propulsion. These will be able to unfurl or fold up at the push of a button, avoiding the need for the large crews that manned the rigging of large sailing ships in years gone by. Even more impressive: The DK Group in the Netherlands has tested what it calls an "air cavity system" that enables a ship to glide at low friction through the water by injecting air around the submerged part of the ship's hull, creating a carpet of bubbles under the vessel.

These innovations in shipping crystallize the notion of locally embedded technologies that are globally connected—a hallmark of the new technology-driven energy era.

The supply surprise

THE supply-side revolution in energy technology is equally impressive. Thanks to advances made possible principally by advanced software, the International Energy Agency (IEA) estimates that unconventional resources like shale gas now account for about half of the world's natural gas resources, while unconventional oil production will reach 10 million barrels a day by 2035. Conservative estimates put the world's oil reserves at four times the total consumed throughout history, while more optimistic forecasters place the multiple at 10 or even 12. The IEA estimates that $20 trillion will be spent on unconventional sources of gas and oil between now and 2035.[10]

Wildcatters near Santa Barbara, California, first found "brown shale"—an oil-rich, porous, lightweight rock—in the Orcutt oil fields in 1901. But for the next century, the various owners of Orcutt drilled 2,000 vertical wells, bypassing the shale in order to get at the liquid oil beneath. By 2004, the field was thought to be in terminal decline and was sold to Breitburn Energy Partners. Breitburn quickly determined that the brown shale, just 900 feet deep, was a vast potential resource. Applying the latest technology, Breitburn was able to nearly double Orcutt's output to 90,000 barrels a month.

What made this possible? Today, the modern day version of wildcatters are energy technology entrepreneurs—geoscientists and software engineers who drill wells on computer screens before drilling in the field. They create three-dimensional images of the underground—a kind of MRI of the earth—that reveal hidden oil deposits. Offset angle drilling then allows drillers to penetrate previously inaccessible deposits, directionally guiding drill bits at angles between 45 degrees and 80 degrees into spaces between old vertical wells where crude still remains in shale reservoirs.

Fracturing technology developed over decades, but when combined with horizontal drilling, it has come to dominate in just four years. Nearly every day, potential shale oil and gas reserves are discovered in such unlikely places as Pennsylvania (which now produces more natural gas than Texas), Poland, Israel, and Ohio—names not normally associated with the oil field. And many of these are not small fields, but what are known in the industry as "elephants" holding one billion barrels or more. So much oil is coming out of the Bakken formation in Montana/North Dakota—discovered in 1951, but "unlocked" by the new rock fracturing and horizontal drilling technology only in 2008—that it has outstripped the existing pipeline capacity to move it to refineries. Railroads such as BNSF and Canadian National have been pressed into service to move some of the crude. At latest count, Bakken is said to hold 18 billion barrels of recoverable oil.

> Just a few years ago the expectation was that the United States would be importing large volumes of natural gas and becoming heavily dependent on world markets. Now people talk about a hundred-year supply of domestic natural gas.

Just a few years ago the expectation was that the United States would be importing large volumes of natural gas and becoming heavily dependent on world markets—and spending upward of $100 billion a year for those imports. Now people talk about a hundred-year supply of domestic natural gas. The new hydraulic fracturing technologies are also producing legions of jobs.

And in many ways, this is just the beginning of the unconventional revolution. Companies are continuing to pioneer innovative exploration methods. In Long Beach, California, Signal Hill Petroleum has buried 6,000 small yellow canisters containing sophisticated equipment so sensitive it can record the vibrations of a person walking past.[11] The devices work in tandem with a fleet of hydraulic "vibroseis" trucks. By producing vibrations, the trucks create images of formations as far as three miles underground. Meanwhile, new technology based on radar and sonar techniques will drastically reduce the cost of hydraulic fracturing and increase its efficiency.

Shale gas has been dominating headlines, but its fossil twin, shale (or "tight") oil is also experiencing a technological revolution—helping raise US crude oil output by 18 percent since 2008. For years, tight oil—which is extracted from dense rock—had been a very marginal business. In 2000, production was only about 200,000 barrels per day, 3 percent of total output. Today it is about a million barrels per day. The dramatic increase in tight oil has been made possible by the same technologies—hydraulic fracturing and horizontal drilling—that enabled the explosive growth in shale gas production.[12] Thanks to new technology, the United States has become less dependent on petroleum imports from unstable countries.

The revolution is not only taking place on land, but is occurring offshore as well. Deepwater exploration has been revolutionized by the ability of powerful computers to crunch seismic data 15,000 feet below the sea floor. The result has been a boom in deepwater drilling: In 2000, there were just 20 deepwater drilling vessels. Today, there are over 200, and deepwater wells are supplying 8 percent of the world's oil—a figure expected to double by 2020.[13] Here, too, technology leaps are taking place in the field: The invention of super strong alloys, for instance, allows drill bits to go into hot, high-pressure fields deep in the earth's crust. Shell, meanwhile, is deploying the world's largest vessel—a 500-meter, all-in-one behemoth that explores, extracts, liquefies, and compresses from small gas fields.[14]

The new Great Game–A technology race

THE global energy technology race has profound implications for the economy, workers, the environment, and national security. History often turns as a result of energy innovations—beginning, of course, with fire. Each time a major new energy technology has emerged—be it steam, electricity, or oil—the balance of power among nations has shifted, while entire new industries have been spawned. The technology-driven revolution in efficiency management, unconventional fossil fuels, and clean energy could rearrange the chessboard again.

For both nations and companies, secure, stable energy supplies will become ever more important as new sources of instability are introduced into the equation. Evidence of these are legion: from the budding “trade war” between the United States and China over solar energy, to attacks on energy grids that have raised the specter of a “cyber Pearl Harbor,” to the brake on energy development that could be placed by environmental concerns.

But instability has always been a factor in the energy game. What’s new is that technology is making greater energy resources available to a greater number of actors than ever before. This holds the promise of generating much greater energy security for countries, companies, and individuals. But which countries and companies will emerge as kings and queens, and which as pawns, is still unclear. In a recent survey by Deloitte—the reSources 2012 study—more than one-third (35 percent) of companies generate some portion of their electricity on-site from renewables, co-generation, or other methods, with another 17 percent planning to do so.

Energy security, stability, and safety would be rich enough prizes. But the job creation potential of the energy technology revolution presents a reward of enormous value to our societies. Until now, this paradigm shift has benefited China above all, thanks to its low-cost jobs and its skill in appropriating and scaling up technology developed by others.

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Nonetheless, it is not too early to discern what might separate the winners from the losers in the Great Game 2.0.

For governments, the keys to success will be:

- **Developing a visionary and stable national policy framework:** What matters above all is a robust, long-term energy vision. Stable, forward-looking legislative frameworks are critical in this regard. Absent a federal energy framework—a national energy policy—companies cannot realize the investment potential of the future. Certainty matters. For example, China’s dominance of the solar and wind industries was built in just five years on central government mandates. China is not only increasing its cleantech capacity but is also building powerful industries to export renewable and alternative energy components around the world.

- **Building national infrastructure:** In addition to legislative frameworks, governments should lead in enabling the creation of state-of-the-art energy infrastructure. Case in point: In the United States, 30 states have developed renewable energy mandates, with targets of between 15-25 percent by 2020. But it is very difficult to upgrade the electric grid. The grid, which was built on a regulatory structure that dates to the 1930s, has emerged as an ill-matched patchwork defined by decisions made at the state level. For the United States to tap the potential of wind and solar resources that may be several states away from the big load centers, this must change. Presently, no single agency, no single entity, is charged with looking at the broad national energy interest.

- **Making deep, long-term commitments to R&D:** High-octane research budgets are needed; the private sector alone cannot sustain investment and propel breakthroughs in the midst of volatile energy markets and pressure to create profits. Take the shale gas revolution, which was made possible by the federal government. Between 1978 and 2007, the Department of Energy (DOE) spent $24 billion on fossil energy research. In doing so, it helped pioneer massive hydraulic fracturing in 1976 with its Eastern Gas Shales Project. Horizontal drilling and well installation were also enabled by air-based drilling and drill bits developed by the DOE. And 3-D imaging also was a DOE innovation. All these projects were widely condemned as failures in the 1980s and 1990s when natural gas was cheap. But today they appear prescient—and have positioned the United States to have at least a shot at becoming energy independent. In fact, the federal government has been determinative in almost every energy transformation over the past century.

- **Referee the level playing field:** A legislative framework creates a level playing field, and deep commitments to R&D broaden the horizon of that field. With the rules in place and the innovation pump primed, the government's next job is to get out of the way and let the players in the energy game determine which technologies win and which lose. (Of course, the government will provide the referees in this battle, too.)

- **Enforce transparency and accountability to turn the public into an ally:** The controversies over the environmental impact of hydraulic fracturing are due, in part, to misperceptions. This is understandable given that the technologies are new and it will take time for the public and environmentalists to fully understand their impact—and in the interim, advocates are likely to dwell on the most dire evidence to advance their case. But governments can accelerate the process of public education by compelling companies to disclose full data on the effects of drilling on water supplies, geological stability, and the environment more generally. Since the technologies are still in their early days, their environmental impact will be substantially mitigated over time—as has already been the case with hydraulic fracturing in its first four years of widespread use. It is likely that the public, once able to accurately weigh the costs and benefits of hydraulic fracturing, will become more supportive of it. Facts can and should prevail over fear.

A potential safety net: The Power of One

THE most extraordinary aspect of the technology-driven energy revolution, however, is that even if governments fail to act effectively, corporations and individuals have still been empowered to make a radical difference in their own consumption—and thus to materially influence the broader energy game. The Power of One has come into its own.

The new energy-related software and hardware on the market and in development—smart meters, smart appliances, demand management programs, and so forth—liberate individual actors from being at the mercy of broader forces. Every company needs an energy and sustainability strategy to define how it manages resources. The absence of such a strategy may well limit profitability potential and jeopardize the long-term health of the business. By contrast, sustainable companies can be a boon for investors. In the two years from 2009 through 2011, the top 100 companies in *Newsweek's* 2009 "Green Rankings" outperformed the S&P 500 by 4.8 percent—returning 15.2 percent versus 10.4 percent for the S&P.[15]

The use of energy can now become a conscious act—and an act of conscience. It's not about being virtuous, it's about being profitable—and, at little to no cost, virtue is achieved. Governments should do everything possible to abet this virtuous cycle—and, if nothing else, they should make certain not to hinder it.

The "Great Game of the 21st Century" is the technology continuum driving along the development curve from 1.0 to 2.0 to 3.0—with each version coming faster than the one before. The future is one of continuous research and development, informed investment job creation, and greater energy security—without sacrificing the environment.

The emerging energy world boasts a new geography, new technology enablers for both supply and demand, and a new road map—a map which can lead to the pot of gold at the end of the energy rainbow.

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