GE Oil & Gas

Digital Future
of oil & gas & energy

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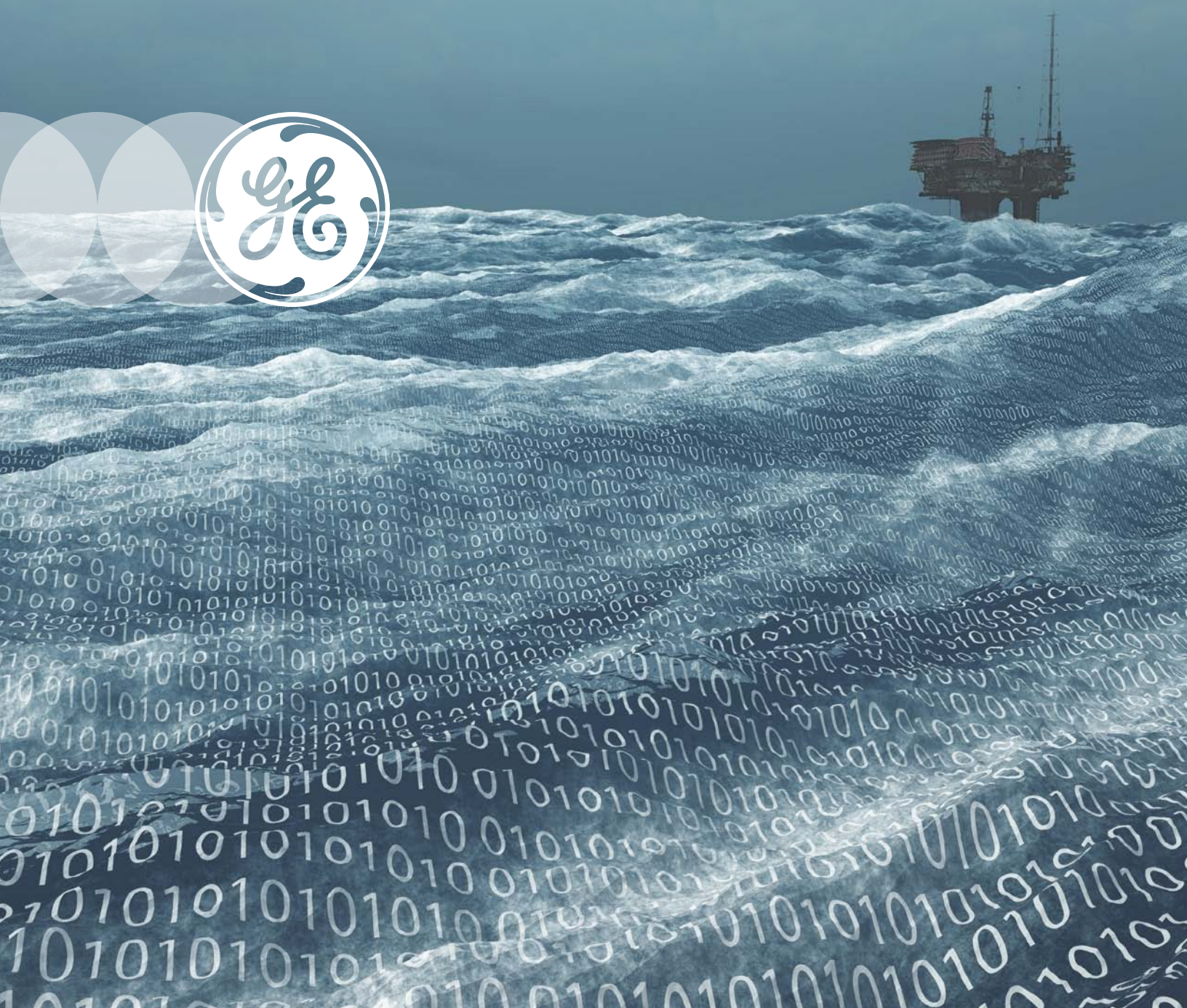


Contents

Executive summary

The oil and gas industry is facing a new frontier. The sharp fall in international oil prices is putting intense pressure on margins, leading operators to reassess their capacity and investors to reassess their strategies. The interplay of economic, technological and geopolitical forces has created an environment of increased uncertainty and volatility.

Lower oil prices have reduced the revenue accruing to oil-producing countries, limiting the resources available for investment in the energy sector. Some countries have cut energy subsidies to the population, a move that improves the sustainability of public finances—but that will also change the demand response once prices recover.

Coping with lower prices and revenues in a way that does not jeopardize future performance is the most immediate challenge for the oil and gas industry, but it is not the only one. The industry has to also contend with a more complex asset mix, which brings a wider range of technical, logistical and operational challenges. Workforces and infrastructure are aging—exacerbating the risk that the industry might suffer lower productivity when it needs more. The industry also faces increased scrutiny and concerns over health, safety and environmental impact. Last but not least, a structurally more volatile and uncertain environment requires a higher degree of flexibility and adaptability.

These multiple challenges mean that industry operators are under pressure to find ways to reduce downtime and lower operational costs, to improve operational efficiency and equipment reliability, to increase safety, to build a stronger pipeline of talent and avoid or at least mitigate the impact of the retirement of more experienced workers, and to optimize their capital expenditure (capex) strategy in a more uncertain and volatile environment with increased funding pressures.

The answer, we believe, lies in realizing the digital future of the oil and gas industry. Industrial Internet solutions—combining sensors and cloud-based, big-data analytics—enable a shift to optimized performance and maintenance, which can substantially reduce unplanned downtime, yielding major cost savings and profitability. New digital solutions go beyond asset optimization; increased visibility over entire networks of industrial assets leads to system optimization and better prioritization of capital and human resources, which reduces operating and maintenance costs. The Industrial Internet's digital solutions provide a bridge between information technology and operations technology, extending efficiency improvements across enterprises. Asset optimization and improved operations management can yield important increases in efficiency and productivity. Moreover, a deeper understanding of assets will lead to a stronger capex strategy that optimizes the trade-off between the life of the assets and their performance. Industrial Internet solutions can also capture the knowledge and experience of an aging workforce, preserving it and transmitting it to incoming generations, avoiding the risk of lost expertise and productivity.

Industrial Internet solutions for the oil and gas industry are already being deployed. The coming years will see a rapid acceleration in the pace at which new solutions are deployed and scaled, largely thanks to Predix™, the newly created operating system for the Industrial Internet. Predix will not only enable the secure and efficient adoption of Industrial Internet solutions but, by attracting the efforts of third-party developers, it will also foster the birth of an industrial-app economy that will act as an accelerator.

This new level of digital capability will help the oil and gas industry navigate current and future challenges, and leverage the opportunities offered by the growing need for energy to fuel the global economy in the decades ahead.

The remainder of this paper is organized as follows:

- Section 1 assesses the macroeconomic and demographic trends that will shape energy demand in the years ahead;
- Section 2 discusses how the supply of oil, gas and other fuels will likely evolve to meet demand;
- Section 3 analyzes the main challenges currently facing the oil and gas industry;
- Section 4 illustrates how the Industrial Internet revolution can help to successfully surmount these challenges; and
- Section 5 concludes.

1. A growing need for energy

Oil prices have fallen sharply. From a level of about $100 per barrel in mid 2014, the benchmark WTI crude oil price fell to about $50 per barrel at the end of 2014. The price held broadly above $45 per barrel through most of 2015, but then experienced another sudden drop to around $30 per barrel in January 2016.

A number of factors have contributed to this sharp and protracted decline. Investments and advances in production technology have significantly boosted U.S. supply over the past few years; OPEC production has remained elevated; geopolitical factors have contributed to stronger supply prospects; and the growth slowdown in China and other emerging markets has raised concerns on the demand outlook. Financial investment flows might also have magnified price movements.

Industry operators have come under pressure, as margins have been squeezed and investment strategies put in doubt. Oil-exporting countries in turn face the challenge of adapting their public finances to the significant loss in oil revenues. On the other hand, lower energy costs have provided a windfall for consumers and governments in oil-importing countries—a beneficial impact to the world economy that should countervail, at the global level, the adverse effect on oil companies and oil exporters.

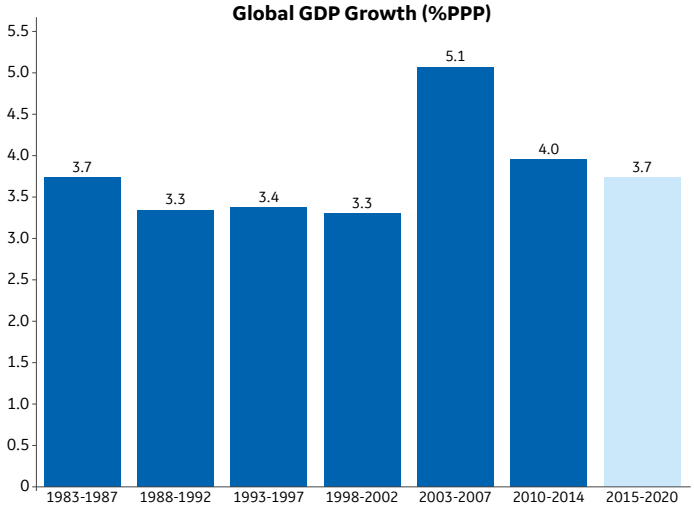
Given the number of complex factors at play, it is difficult to predict how oil prices will evolve in the near term. The heightened uncertainty is one of the major challenges that the oil and gas industry has to face. However, an analysis of macroeconomic factors suggests that, over the medium and long term, demand conditions should prove supportive.

In this section we provide a brief assessment of macro trends and how they will shape future demand for oil and gas and other energy sources from global, region-specific and sector-specific perspectives.

a. Macro background

China's economy, a major consumer and importer of oil, has slowed. Oil prices are substantially below their mid-2014 levels, and other commodity prices have also declined significantly. A marked pessimism characterizes the public debate on global growth prospects—and colors the discussion on the outlook for the global energy market.

However, this pessimistic lens does not show the whole picture. Since the world economy started recovering from the Great Financial Crisis in 2010, global growth averaged an estimated 3.8 percent per year.[1] This pace compares favorably with the 3.4 percent average of 1982-2002, and was only surpassed by the credit-fueled and unsustainable pre-crisis pace of 2002-2007.

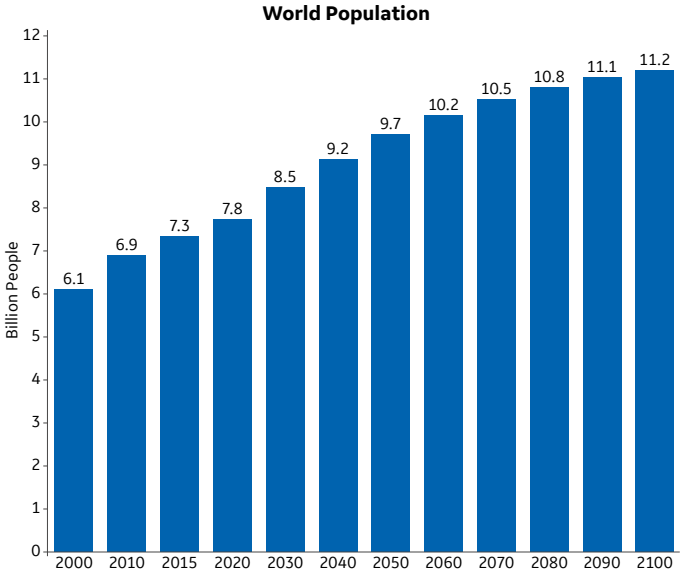


Growth slowed down to a little more than 3 percent in 2015, but is projected to recover to 4 percent by the end of the decade[2]. There is a significant degree of uncertainty, and much will depend on the performance of the two largest economies—and largest energy consumers—the United States and China. The U.S. recovery has proved resilient so far, and the labor market is close to full employment. China's economy has been losing momentum, with gross domestic product (GDP) growth slowing to about 7 percent from 10 percent of 2010-2011. However, this lower rate of growth now applies to a much larger economy—the additional GDP created every year in dollar terms is even higher than in the past. Moreover, this slowdown is a necessary part of China's rebalancing, which makes its growth more sustainable—though less energy intensive.

[1] International Monetary Fund October 2015
[2] International Monetary Fund, http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx

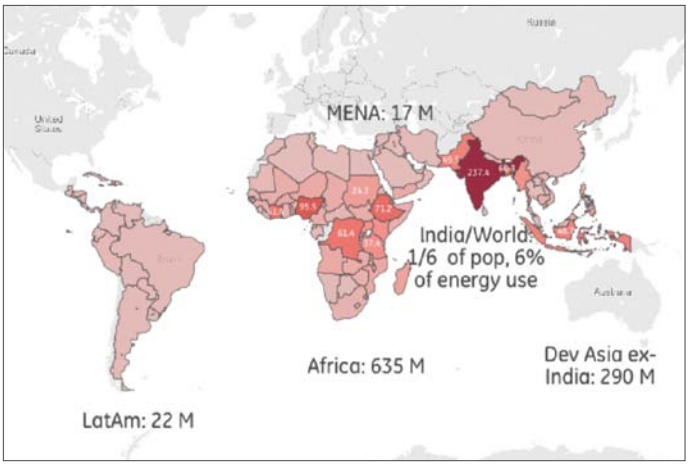
b. Energy demand

At this projected pace of growth, consistent with historical norms, the world will need a lot more energy. By 2020, the global economy will be one-fifth larger than today[3], in real terms, and the global population will have increased by about one billion people. By the latter part of the century, the world population is projected to reach 11 billion people, a 50 percent increase from the current 7.3 billion.



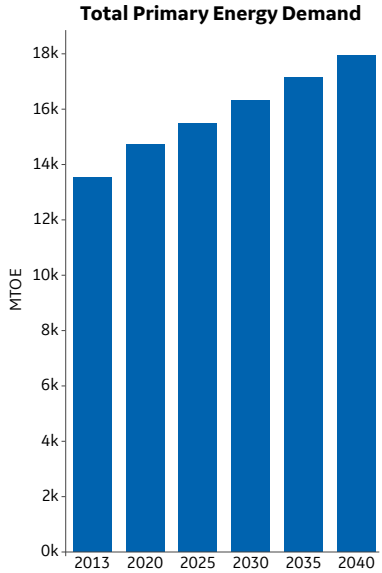
Source: United Nations Populations Projections

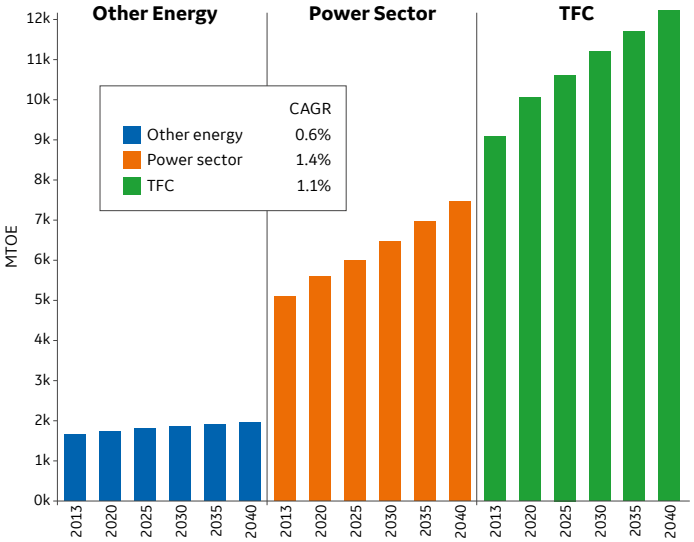
These additional billions of people will need access to electricity and to clean cooking fuel. Already today, approximately 1.2 billion people around the world have no access to electricity—that is one person in six.



Source: IEA

In line with these economic and demographic forecasts, the International Energy Agency projects that total energy demand will rise by one-third through 2040, from about 13.6k million tonnes of oil equivalent (MTOE) to nearly 18k MTOE, corresponding to a 1 percent compound annual growth rate over the period. An additional 1.2k MTOE will be needed in just the next five years. The power sector will be the main driver of demand growth, followed by total final consumption (TFC).





Source: IEA

The increase in energy demand will be front-loaded, rising at about 1.5 percent per year at the beginning, and slowing to below 1 percent towards the end of the forecast horizon.

[3] International Monetary Fund, http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx

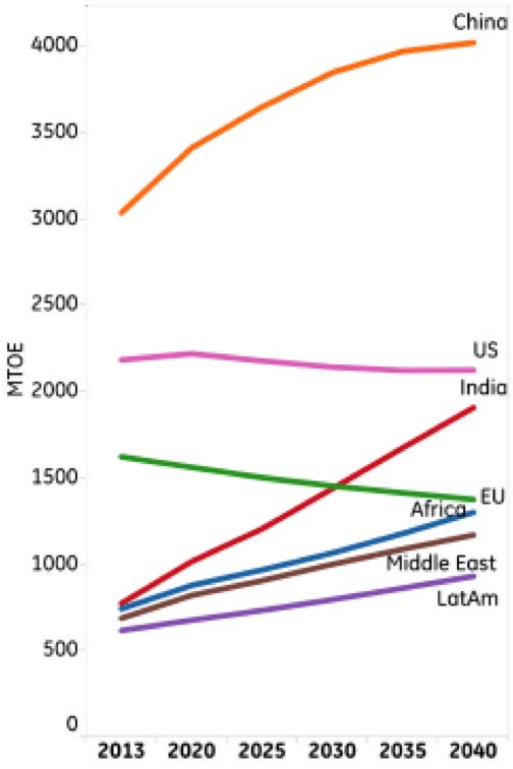
c. Regional opportunities

The geographical distribution of energy consumption will also be shaped by the macro factors discussed above. Both population growth and economic convergence will shift the center of energy growth toward emerging markets; China and India will be the main sources of energy demand, though with different dynamics.

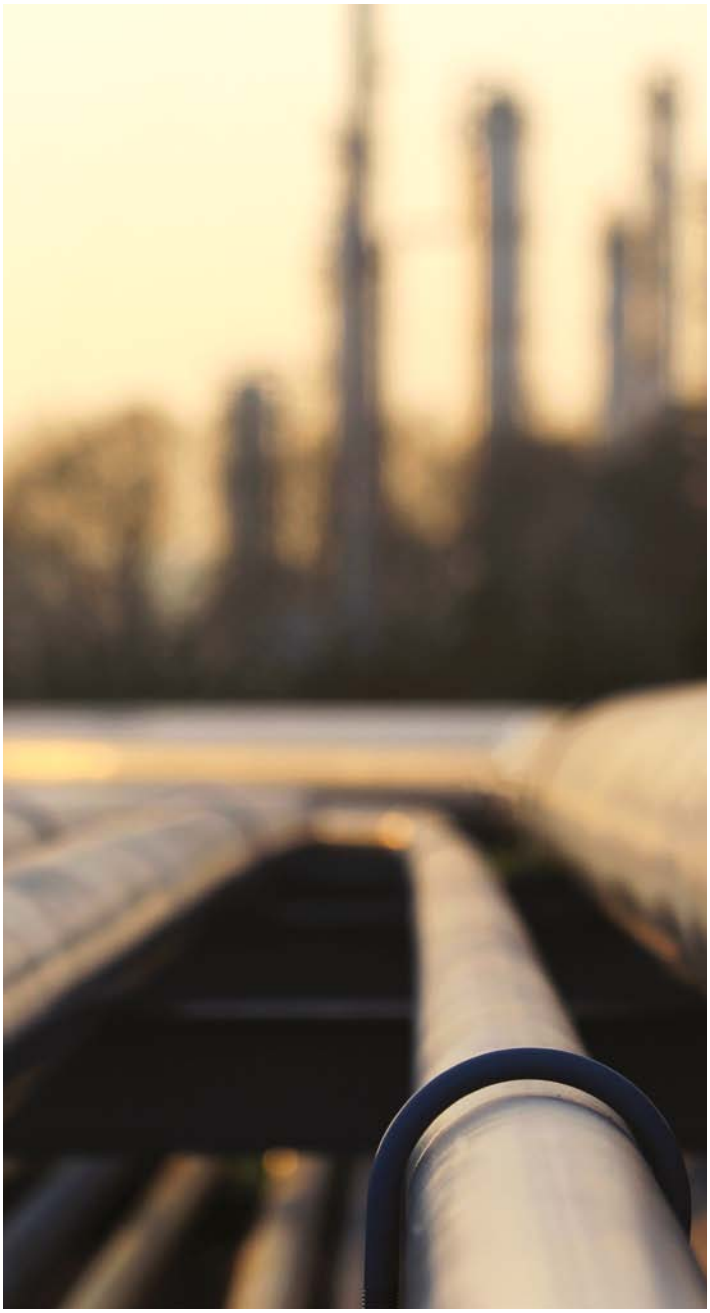
China is already—and will remain—the largest consumer of energy; it is set to become the largest consumer of oil by 2030, surpassing the United States. However, as its economy rebalances toward domestic consumption and services, it will become less energy intensive, and the pace of Chinese energy demand growth will slow. In India, on the other hand, the process of industrialization is about to accelerate, driving a much steeper increase in energy demand. Its oil consumption will increase nearly threefold by 2040. Africa, the Middle East and Latin America will also see significant increases in demand.

European energy demand, on the contrary, is projected to decline, driven by a combination of slower economic growth, demographic changes, and faster improvements in energy efficiency. Energy demand in the United States is expected to stabilize close to current levels.

TPED Growth



Source: IEA, World Energy Outlook 2015



The geographic distribution of energy consumption will have important implications for the mix of energy sources. Strong economic growth across emerging economies will create a large and rapidly growing middle class, aspiring to a lifestyle and consumption levels similar to those currently enjoyed in developed economies. This will include substantially stronger energy consumption, and a fast rise in car ownership and gasoline consumption.

2. Meeting rising energy needs

Meeting this sustained increase in energy demand will require a holistic approach across energy sources, including fossil fuels. Today, oil accounts for 30 percent of total energy demand; oil, gas and coal together account for nearly 80 percent. Fossil fuels have maintained the lion's share of global energy supply throughout the last 30 years. By 2040, fossil fuels will still account for three-quarters of energy demand, with the share of oil declining only marginally to 26 percent, according to the IEA's central scenario. Natural gas should experience rapid growth, arriving to match the share of coal in global supply by 2040—today the share of natural gas is one-third lower than that of coal.

There are different views, and a significant margin of uncertainty, on how the shares of different fuels will evolve. The IEA's central forecasts envision a marginal increase in the share of nuclear energy and a five-point increase in the share of renewables. Technological advances in one area could skew the balance somewhat in favor of a specific energy source. It is difficult to envision, however, that the large and growing energy needs of the global economy could be met over the forecast horizon without persistent reliance on a substantial contribution from oil and other fossil fuels. This is even more so in the near term, when any major technological changes would have less time to exert an impact.

a. Oil

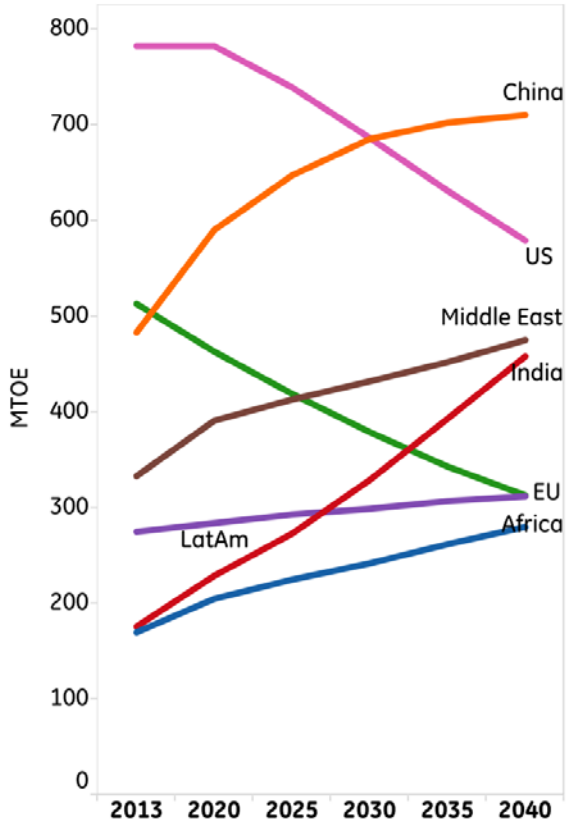
The oil market is going through an especially complex rebalancing process. Oil prices have declined sharply from around $100 per barrel in mid-2014 to under $40 per barrel at the end of 2015. Technological, strategic, geopolitical and economic factors have all played roles: the rise in tight U.S. oil supply, OPEC's failure to agree on supply cuts, the prospect of additional supply from Iran, and concerns on the economic slowdown in China and other emerging markets.

There is significant uncertainty on how these factors will evolve and interact in the coming months and years. Some trends, however, are emerging. First of all, the price decline seems to have been largely driven by a supply increase that outpaced demand, even as oil demand continued to grow. Current low prices are now curbing production and investment. The U.S. rig count, which had tripled between 2009 and 2011, has fallen by about 50 percent from its peak. The reduction in drilling activity was initially partially offset by an increase in productivity, as production became concentrated in the higher-yielding rigs. More recently, however, productivity is re-stabilizing, which should contribute to the ongoing reduction in tight oil supply.

Key oil demand indicators have remained robust, with vehicle miles travelled in the United States growing at the strongest pace in a decade, and a rebound in vehicle sales in China. Demand conditions also appear resilient in the European Union (where vehicle sales grew at about 3 percent in 2015, double the 2014 pace), Japan and India—which, together with the United States and China, account for nearly 60 percent of global oil demand.

These trends should support sustained growth in global oil demand. For example, the IEA's central scenario sees oil demand increasing from 90.6 million barrels per day (Mbd) in 2014 to 103.5 Mbd in 2040—a 15 percent increase. The rise in demand would be front-loaded, rising on average by 900 thousand barrels per day over the next five years—led by China, India and the Middle East—while demand should continue to decline in most OECD countries, leveling off thereafter.

Global Oil Demand by Region



Source: IEA, World Energy Outlook 2015

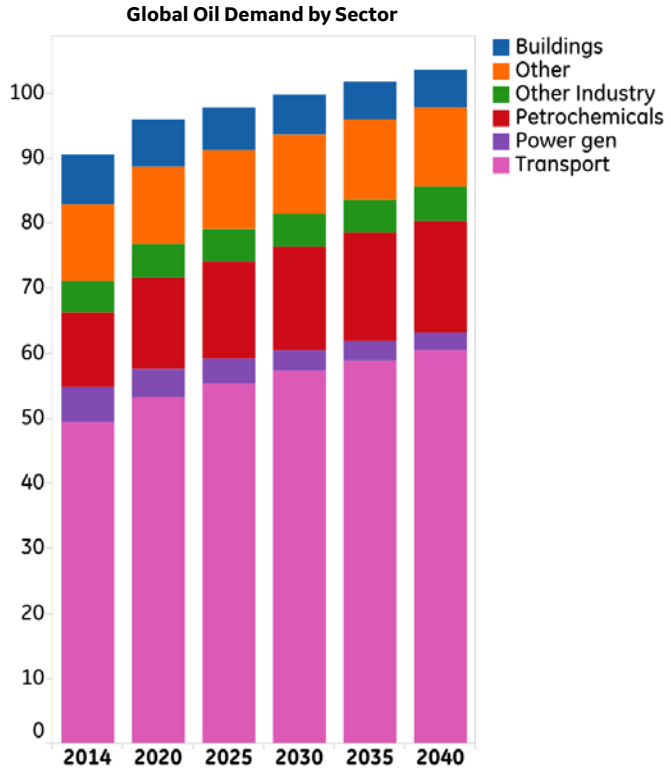
Oil demand is also rapidly picking up pace in Africa. At the moment, per capita oil consumption in Africa is still much below the world average, owing to lower levels of industrialization and vehicle use, so that fast consumption growth does not yet translate into a substantial addition to global demand in absolute terms. Looking

towards the longer-term, however, Africa's economic development will undoubtedly bring a powerful boost to oil consumption—especially given Africa's extremely buoyant demographic prospects.

The bulk of oil consumption is in the transport sector, which accounts for 55 percent of global oil demand. With rising living standards in China, India and other emerging markets, the transport sector is projected to add over 10 Mbd to global oil demand, increasing its share to about 60 percent—even as more stringent fuel-economy standards come into place.

To get a sense of the potential increase in demand, consider that the United States has 82 cars per 100 inhabitants; China has only 7 cars per 100 inhabitants, and India only 4. Even without assuming that China and India will fill the gap with the United States, the pent-up demand for road transportation that will be unleashed by continued economic growth is apparent.

After road transport, aviation will remain a substantial source of rising oil consumption within the transport sector, especially in passenger travel. Passenger air travel has increased at an annual rate of nearly 5 percent over the past decade and a half, double the pace of average per capita income growth over the same period, and revenue-passenger kilometers are now double the 1998 level. Asia, and China in particular, are set to drive further substantial growth in passenger air traffic.



Source: IEA, World Energy Outlook 2015

Oil consumption in industry is also set to keep growing, notably in the petrochemical sector, but also as fuel for off-road vehicles in mining and construction—a range of uses for which there is currently no viable alternative to oil.

A complex set of factors will continue to shape oil demand in the coming decades. The decline in the oil intensity of global growth has been driven by various elements, including emission controls and fuel efficiency standards. These in turn have been shaped by both economic and environmental considerations. The trend towards greater efficiency is expected to continue; China is slated to adopt fuel economy standards for passenger vehicles; a number of countries have reduced subsidies for fuels and other oil derivatives, taking advantage of lower price levels but also responding to the need to reduce pressure on public budgets. Future trends in oil prices and other economic variables could affect some of these decisions, and therefore influence the pace of growth of overall oil demand.

Underlying this, however, the main driving force remains the sustained growth of the global economy, and notably the rise in per capita incomes in emerging markets, where large and growing populations see their living standards gradually rise towards advanced countries' levels.

b. Natural gas

Natural gas production and consumption have increased strongly over the past years, driven by major advances in hydraulic fracturing technologies that have opened up the exploitation of large reserves of shale gas. This "shale gas boom" is set to continue in the decades ahead.

Natural gas offers a number of advantages: it is clean relative to other fossil fuels; it is cheap—though with very important regional variations—and it is the ideal complement to renewable sources like wind and solar: supply of wind and solar energy is very volatile, contingent on atmospheric conditions and with limited storing possibilities. Gas can act as a complement, stepping in to meet demand at times of low output from renewables.

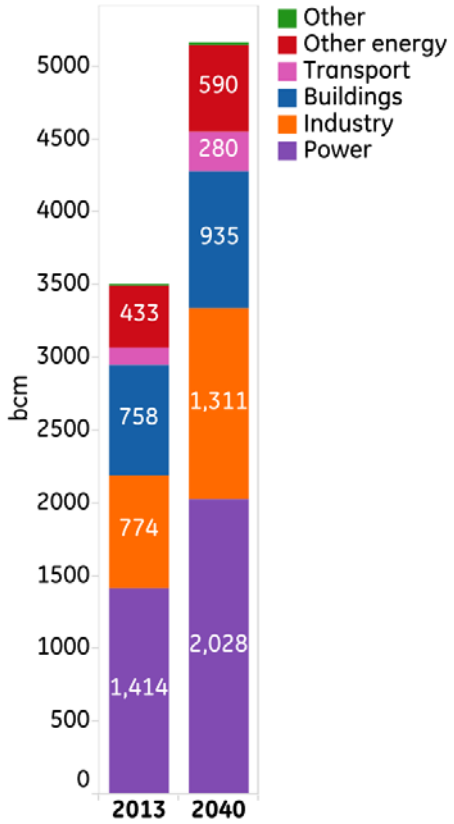
The IEA expects natural gas demand to increase by about 1,600 billion cubic meters (bcm), to 5,160 bcm by 2040—representing a 1.4 percent compounded annual growth rate.

The main driver of rising natural gas demand will be power generation, which should account for about 40 percent of the additional consumption, increasing by about 160 bcm to 590 bcm by 2040. In the OECD, over the next 10 years, natural gas could overtake coal as the single largest source of power generation. In the United States, which enjoys the lowest prices, natural gas is also playing a greater role in industry, notably petrochemicals—whereas industrial use will continue to decline in Europe, where prices remain

significantly higher. The buildings sector will add about 170 bcm to gas demand over the period. The increase in demand in this sector will be held back by more stringent energy efficiency standards in advanced economies, as well as the fact that the most rapid growth in the building sector will take place in warmer countries, with less need of gas-generated heating.[4] Gas demand will also increase in the transport sector, although this will continue to account for only a small share of overall consumption.

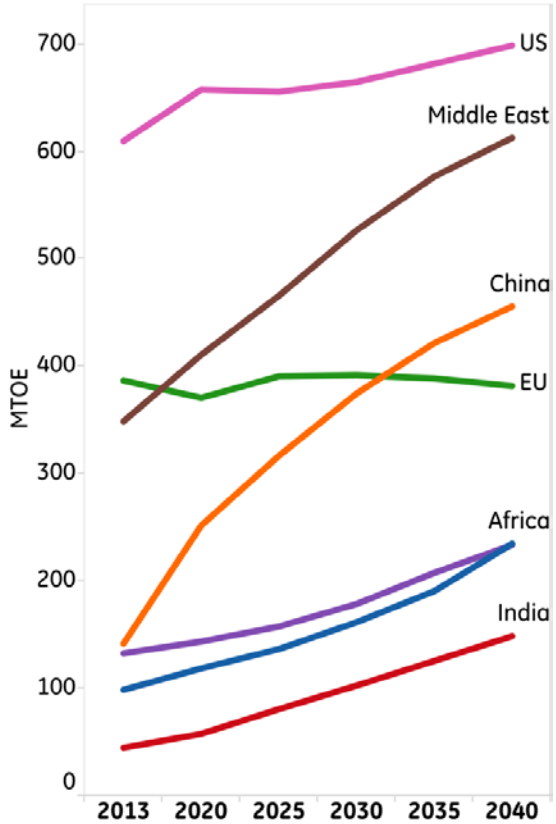
From a geographical perspective, demand for natural gas will rise at a fast pace around most of the globe, with the notable exception of Europe. The fastest and most substantial increases in natural gas consumption are expected in China and the Middle East.[5]

Global Natural Gas Demand



Source: IEA, World Energy Outlook 2015

Global Natural Gas Demand by Region



Source: IEA, World Energy Outlook 2015

[4] About 60 percent of gas consumption in the building sector is attributable to heating Source: IEA, World Energy Outlook 2015
[5] IEA, 2015 World Energy Outlook

3. Challenges to the industry

The analysis developed in the previous section makes it clear that the world will need more energy in the decades ahead, to keep lifting a growing number of people out of poverty and to improve living standards. This rising energy demand will need to be satisfied with continuous improvements in energy efficiency and emission controls, to guarantee both economic and environmental sustainability.

Greater productivity and efficiency can only be achieved through innovation. Fortunately, the oil and gas industry has a rich history of innovation. Advances in production technology have led to unlocking reserves previously thought to be beyond reach. Just over the past few years, hydraulic fracturing has nearly doubled U.S. oil production from about 5 Mbd in 2008 to about 9 Mbd in 2014[6]. Efficiency gains in unconventional drilling and completions have allowed many U.S. producers to systematically lower break-even costs and continue production in the face of the substantial oil price decline. Breakthroughs in technology have also allowed the industry to pursue more challenging reserves such as those in ultra-deep water.

These same technological advances, however, are at the root of one of the most pressing current challenges, namely low oil prices. The rise in U.S. oil production has contributed to the glut in supply that has many analysts and forecasters expecting that oil prices will remain below $50 per barrel throughout 2016.

To meet the goals of greater productivity and enhanced sustainability in an environment characterized by a high degree of uncertainty and volatility, the oil and gas industry will need to surmount a number of challenges:

- **The most immediate challenge is that of coping with low oil prices without jeopardizing future performance.** This is especially daunting as it comes after an extended period of very high prices, during which the industry had adjusted to a much more forgiving financial environment. The cost of projects ballooned over the past 10 years, imposing a substantial cost burden on oil and gas companies. Oil producing countries have also taken advantage of booming oil export receipts to expand public spending, so that most of them would require oil prices closer to $100 per barrel to balance their budgets. For governments, the adjustment will require greater discipline on public expenditures as well as efforts to diversify their economies. For oil and gas companies, the adjustment will require targeted investments to greatly increase efficiency and productivity. These efforts could be best pursued though partnership, an essential feature of the new wave of digital innovations.
- **The second challenge is posed by the increasing technical complexity of the asset mix that oil and gas companies are developing and operating.** This has evolved to include far more complex facilities—e.g. unconventional fields, liquefied natural gas (LNG) and floating liquefied natural gas (FLNG)—that demand higher levels of engineering and operations expertise. LNG and FLNG add to an already very diverse asset mix. Upstream fields have different resource types, different reservoir characteristics, different operating environments, and were developed at different time periods over the last 100 years. As a result, every field is unique and presents distinct technical and operational challenges. Even the midstream and downstream industries, which generally enjoy more homogenous conditions than upstream industries, have a great equipment diversity with specific operational challenges—the result of costly capex investments made at different points in time.
- **The third challenge is posed by the aging and turnover of the industry's workforce,** and the attendant difficulty in securing technical talent and preserving accumulated experience and knowledge. The demographics of the industry's workforce have, for some time, pointed to an impending generational change; this has been a hot topic of debate in the industry over the past decade. The turnover has now arrived, and low oil prices are accelerating retirements and departures by experienced workers. By some estimates, as much as 50 percent of the workforce will have retired by 2025, taking decades of domain knowledge and experience with them. The industry does not have a comparable pipeline of younger workers to fill the gap, and the current financial pressures are curbing hiring and making the industry appear as a less obvious prospect to new entrants into the labor force. Securing a stronger influx of qualified human capital is a priority; but so is preserving the accumulated knowledge and experience embodied in the outgoing workforce to transmit it to newer generations.

[6] According to data from the U.S. Energy Information Administration, see https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPUS2&f=A

- **Fourth, the industry's concerns around health, safety and the environment, as well as the regulatory environment added pressure to the operations.** From practices around emissions to water reinjection to transportation, health, safety and environmental concerns, all present the industry with challenges of significant complexity and cost, which are set to be a permanent feature of the operating environment. The industry has a strong commitment and focus on health and safety of its operations and its workers. There is also strong interest across the industry in identifying new technologies and techniques that will improve the impact it has on the environment.
- **Last but not least, the oil and gas sector needs to cope with a global environment characterized by much higher uncertainty and volatility.** These are generated by a number of different forces. Technological innovation can suddenly change operating conditions, costs, prices, and the relative competitiveness of different fuel sources—as well as opening up new operating environments. Cyclical fluctuations in the global economy can profoundly affect demand at global and regional levels. Regulatory changes can affect the mix of demand and supply, the relative price of inputs and products, and impose new costs and technical restrictions. Geopolitical events can also cause swings in supply and prices, and affect risk appetite in financial markets and in the oil and gas industry itself. Trends in geopolitics, economics, and technology suggest that this heightened volatility and uncertainty are here to stay. The industry will need to achieve a greater degree of flexibility and adaptability in order to cope.

4. Digital revolution

As the industry begins to cope with these new realities, and goes in search of the next big opportunities to drive productivity and efficiency, there is a digital revolution on the rise that could prove to hold a set of answers to these challenges when industry needs them most. There can be little doubt that the industry needs to shift from a mindset of increasing production to one of maximizing productivity—lowering operating costs while maintaining operating flexibility.

The Industrial Internet holds the key to unlocking the productivity that operators need to flourish amid growing volatility. In fact, the productivity that the world's economies realized during the computerization era of the 1990s, and the disruption that occurred from the rise of the consumer internet in the 2000s, will be dwarfed as we enter the age of the Industrial Internet—no longer a dream, it is here today, and investments in Industrial Internet technologies are accelerating at a staggering pace. Fueled by a proliferation of low-cost sensors, we are seeing enormous volumes of data come online. In fact, by 2020, we project to see the GE installed base generating one exabyte (one billion gigabytes) of data every day. The investments and advancements made in cloud computing technology are now allowing us to efficiently collect, store, and analyze this data at speeds and costs to which we have never before had access.

The Future of Work

In 2014, GE examined three disruptive forces of innovation that together drive the *Future of Work*—a technological revolution that focuses on speed and collaboration, accelerates innovation and change, and redefines economies of scale. Those three mutually reinforcing trends are:

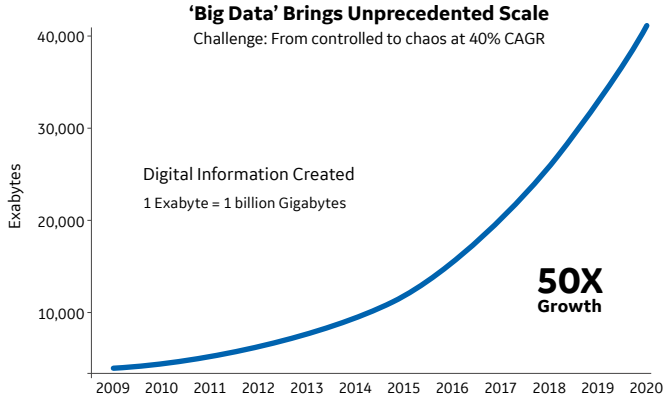
- The **Industrial Internet** merges big data and cloud-based analytics with industrial machinery, resulting in greater efficiency and increased operating performance.
- **Advanced manufacturing** weaves together design, product engineering, manufacturing, supply chain, distribution, and servicing into one cohesive intelligent system, delivering greater speed and flexibility at lower costs.
- The **Global Brain,** through digital communication, integrates the collective intelligence of human beings around the world, resulting in crowdsourcing, open collaboration, and a much faster pace of innovation.

The digital future of oil and gas

Today, breakthroughs in oil and gas digital technologies are part of this broader, far-reaching transformation in global industry: the rise of the Industrial Internet. Enabled by the convergence of powerful, advanced computing, analytics, low-cost sensing, and new levels of connectivity, it holds the promise of delivering economic value to all industries by driving productivity and efficiency across operations.

The exponential increase in digital information has provided industries around the world with a plethora of data, together with the ability to capture, store and analyze it to obtain clear and actionable insights. In fact, the following three observations help us conclude that the Industrial Internet will in fact have profound impact on industry as a whole.

1. The last several years have seen a sharp reduction in the cost of sensors, and in the cost of collecting, storing and processing data, thanks to cloud-based technologies. The instrumentation of existing infrastructure has therefore become more cost-effective, and data-driven insights can be obtained at lower cost.

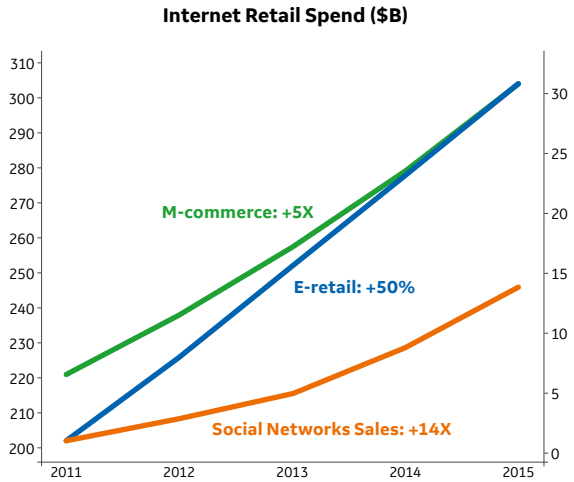


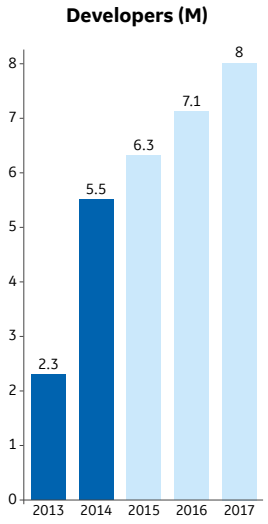
Source: IDC's Digital Universal Study, April 2014

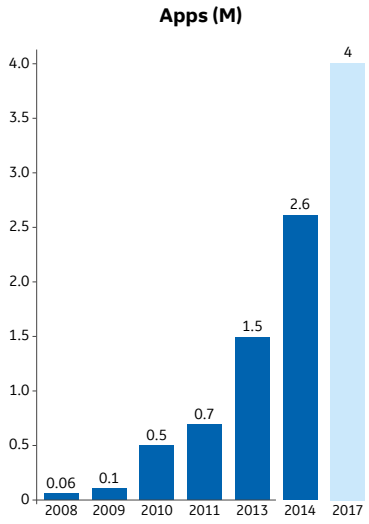
2. A first generation of Industrial Internet solutions has already demonstrated the ability to deliver substantial efficiency gains with important economic impact. We have estimated that the industrial solutions already delivered and deployed by GE across a number of industries are yielding an average 20 percent performance improvement for our customers.[7] Efficiency improvements of this magnitude, whether delivered via cost savings or greater uptime and output, make a massive difference to competitiveness and profitability.

[7] Annunziata, Marco (2015). *The time for industry.* Retrieved from, http://gereports.cdnist.com/wp-content/uploads/2015/09/29153350/Annunziata_Moment-for-industry_Final1.pdf

3. We are now seeing the birth of an "industrial-apps economy." In the consumer space, apps have played a major role in accelerating the growth and geographical spread of new solutions, leading to an exponential rise in revenues. GE has now developed Predix, the operating system for the Industrial Internet. This cloud-based, secure and industrial-strength platform will be open to third parties to develop apps for industrial use. We have estimated that, by 2020, more than 100,000 software developers will be building apps on Predix, and generating some $225 billion in economic value. The industrial-app economy will generate a rapidly growing number of Industrial Internet apps, accelerating the pace at which efficiency gains can be delivered.







Source: VisionMobile, OECD

How will digital deliver value?

Industrial Internet solutions deliver benefits to the oil and gas industry in the following three tiers of value:

1. **Asset performance management:** minimize cost, increase reliability, and optimize performance for an individual piece of equipment
2. **Operations optimization:** system-wide improvements (e.g. across a production facility, LNG plant, offshore vessel, or oil field), and optimized life cycle management with increased production, reduced operating costs, and reduced risk
3. **Enterprise optimization:** connection of demand and supply operations to optimize portfolio of cash-generating assets

Asset Performance Management

One of the clearest and greatest benefits of Industrial Internet solutions is substantially reduced equipment downtime, through preventive, condition-based maintenance. Advances in predictive analytics can now indicate when a piece of equipment is likely to experience a specific failure, so that maintenance can be performed ahead of time. This prevents the failure and resulting downtime, and allows time to efficiently adapt operations in cases where the asset needs to be taken off-line for maintenance.

Condition-based maintenance can deliver substantial cost savings in the oil and gas industry. Consider for example:

- It costs between $10 and $16 million to surface a blowout preventer for maintenance. Predictive maintenance could save drilling companies millions in unplanned downtime and repairs.
- An average, mid-size LNG facility is currently losing about $150 million every year due to unplanned downtime.
- Each week that a subsea well is out of commission, translates into over $3 million in lost revenue for the well's operator, based on industry averages.

These are just selected examples of sizable savings that can be achieved through Industrial Internet solutions enabling preventive maintenance and reducing unplanned downtime.

Operations Optimization

The largest value-creation opportunity lies in operations optimization, specifically creating an integrated approach to optimize the hydrocarbon process. Today's typical operations landscape consists of a high degree of fragmented point solutions that each satisfies a specific operational need. For example, there may be a system that manages logging data during a drilling process, another system that manages logistics and fleet for supply chain, another for monitoring and diagnostics of artificial lift equipment, and so on. However, the real value-creation opportunity exists in connecting these silos and driving collaboration across upstream, midstream, or downstream workflows. Example benefits would include:

- **Lower operating and maintenance costs.** Improved data management and analytics deliver enhanced visibility over an entire network of operations. This can enable more efficient capital and human resource allocation and improved maintenance decisions. For example, a better understanding of the performance of different onshore wells can help optimize the deployment of crews, dispatching them to the locations where interventions can be most beneficial, while avoiding wasteful transit routes from well to well. In a similar manner, better visibility and understanding of risk factors across a pipeline network can allow operators to deploy crews and physical assets most efficiently to mitigate risks in a targeted and cost-effective manner.
- **Increased workforce productivity through shared knowledge.** As previously mentioned, the industry is at risk of losing a significant portion of its expertise to retirement over the next few years. In many instances, multi-million dollar operations are dependent upon too few individuals whose domain knowledge can be very difficult to replace. Digital knowledge capture and case management capabilities give companies the ability to retain knowledge that they would otherwise lose when these experts retire. Additionally, knowledge can be shared more effectively throughout the workforce, across different divisions, business units and locations.
- **Stronger operational performance through scaled best practices.** Digital tools can give oil and gas companies a connected view across various business units, locations and divisions. This would allow companies to identify top performing operations in order to improve operations globally. For example, a company may have one facility operating at 97 percent uptime while another facility operates at 83 percent. With a connected view of global operations, an operator can identify what practices are driving the stronger performance and then apply those practices to the lesser performing facilities.

Enterprise Optimization

The final value tier is optimization across the operator's enterprise. As equipment, processes, and operations come online, the operator is able to leverage this near real-time knowledge of the status of operations to make more informed decisions that impact the financial performance of the firm. Imagine being able to make constraint-based decisions on whether to run an offshore production hub harder to capitalize on surge in spot price. Imagine now being able to weigh the same decision across a fleet of assets constrained by safety and reliability. If an operator can use data to drive a 1% improvement in fleet reliability, the impact can be measured in millions of dollars per year.

Lessons from the past

The oil and gas industry has witnessed previous attempts at digitalization. A number of industry players had started to deploy sensors and upgrade communication infrastructure to enable remote monitoring of operational performance. Those efforts, however, have not delivered on the full potential of digital—since they have not delivered a "enterprise scale", and the ideal of a "digital oil field" has not yet become a full reality.

In our view, past attempts at oil and gas digitalization have failed to achieve their full potential for the following reasons:

- They encountered a complex set of challenges, including (i) the cost of retrofitting sensors and controls to an extensive legacy field infrastructure; (ii) the difficulty of changing business processes so as to take full advantage of the digital possibilities; (iii) the difficulty of changing the mindset of management teams and workforces to put data and analytics at the center of business strategies and day to day operations.
- Past attempts followed a silo approach rather than a comprehensive strategy. Technologies meant for enterprise IT have not been able to deliver outcomes at scale when implemented in OT environments. Operators dealing with costly obsolescence needed to rethink their approach to the digital oil field. Additionally, decisions were often decentralized to regions and operations teams with insufficient consideration for standardizing technology to scale across the enterprise. This resulted in solutions that were difficult and expensive to maintain.

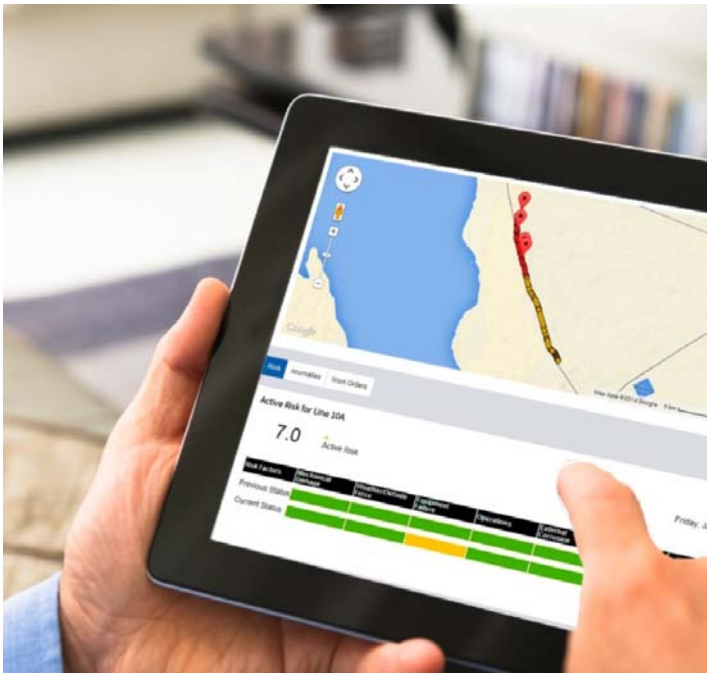
All of this created huge adoption challenges where solutions implemented in one facility could not be easily replicated in other facilities without complex integration, data management and change management. At the same time, structuring the multi-layered, complex data, and using it to form a holistic view of operations has also proven to be a challenge—one example showed that operating decisions on an offshore platform were being based on analysis of less than 1 percent of data collected with 30,000 sensors.[8]

Today, the industry has new tools and technologies to help overcome challenges like that. It now has Predix, the world's first and only cloud-based operating system built exclusively for industrial companies. As the only industrial strength operating system, Predix allows for familiar, frictionless connectivity, yet offers the security, regulation and certifications that industry demands. It also now holds the ability to effectively utilize and integrate the masses of disparate data being collected—which was lacking in previous efforts—provided by the emergence of data lakes.

This, coupled with big data and analytics, provides us with the ability to link individual technology applications and build a cross-asset integration and optimization system—a single environment to turn real-time operational data and production statistics into powerful insights that drive outcomes. Secure software platforms also provide a unified user experience, allowing operators on the ground as well as engineers, factories and supply chain leaders, to gain visibility and understanding of the system-level trade-offs of their decisions and to develop innovative services and products without the high-resource integration tasks.

The merging of digital and physical technologies marks a profound transformation of the industry. Traditional industrial assets become interconnected machines, where performance can be improved along new dimensions. Asset optimization can yield substantial efficiency gains; but the game-changer will be operations optimization, which requires a holistic approach to how wider networks of assets are managed thanks to data-driven insights and digital tools.

The new digital technologies and platforms now available are true game changers. By leveraging their potential, the oil and gas industry today has a chance to move to the forefront of the digital-industrial revolution, securing efficiency and productivity gains that have never before been within reach.



[8] *The Internet Of Things: Mapping The Value Beyond The Hype,* McKinsey Global Institute, McKinsey & Company, June 2015, www.mckinsey.com/mgi

5. Conclusions

The oil and gas industry is at a critical juncture. Coping with lower oil prices in a way that does not jeopardize future performance is the most pressing challenge, but it is not the only one. A more complex asset mix; an aging workforce; health, safety and environmental concerns; and an environment of structurally higher volatility and uncertainty are equally powerful headwinds.

At the same time, the medium and long-term demand outlook remains very favorable. The global recovery has proved resilient so far, and robust growth in emerging markets fuels the rise of a larger and energy-hungry middle-class.

The Industrial Internet revolution offers the tools to meet the industry's challenges and to exploit the opportunities ahead. A number of digital solutions can already provide substantial cost savings and improvements in operations management, asset management and investment strategies. Finally, the digital future of oil and gas is truly within reach.

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