The Outlook for Energy: A View to 2040

2015

ExxonMobil

Energy lives here™

Energy

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in diverse resources

60

and human progress

The Outlook for Energy is our long-term global view of energy demand and supply. Its findings help guide our long-term investments, and we share *The Outlook* to help promote better understanding of the issues shaping the world's energy future. Updated each year, this edition covers the period to 2040.


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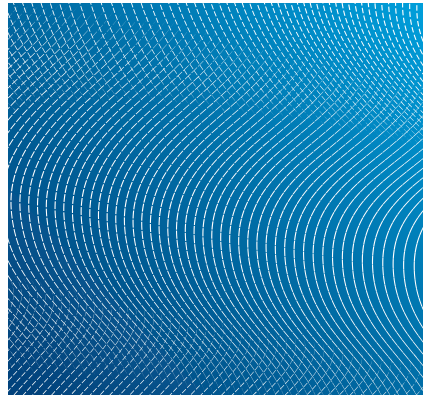
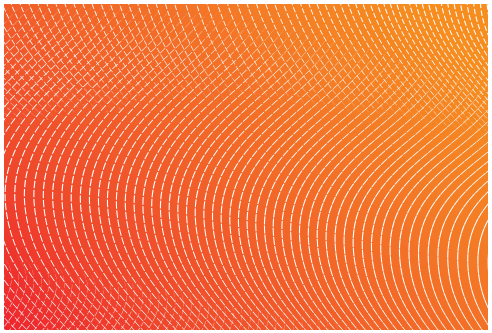
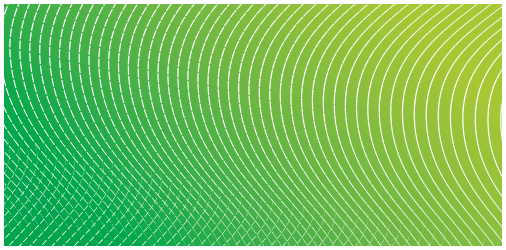






Why energy?

A house. A car. Lights at night and heat in the winter. A refrigerator to keep food fresh and a stove for cooking. A better education and a good job. Modern health care. Wireless communications. Technology and innovation. The freedom to focus one's daily activities on something more than mere subsistence.

These are among the many benefits of modern energy.

During the past century, growth in the availability and use of modern fuels — including electricity — has radically enhanced the lives of billions. But the progress enabled by modern energy has not reached everyone.

Some nations have prospered more than others, in part reflecting the pace of transitioning to modern energy coupled with modern technologies. As recently as 1990, developed economies (as defined by membership in the Organisation for Economic Co-operation and Development or OECD) consumed more than 50 percent of the world's energy, despite having only 20 percent of its population. Even today, some 80 years after Franklin Delano Roosevelt declared, "Electricity is no longer a luxury," one out of every five people in the world still has no access to electricity. Even more lack modern cooking fuels.

However, as *The Outlook* shows, the coming decades are poised for a dramatic new chapter in the story of human progress. Economic growth in China, India and other non-OECD countries will enable some 3 billion people to rise into the ranks of the middle class — the largest collective increase in living standards in history. This means new demand for food, for travel, for electricity, for housing, schools and hospitals, and for businesses meeting countless needs. It means better lives for billions.

Will non-OECD countries follow the same path the OECD did during the previous century? In many ways, no. New technologies are reshaping not only our economies and our societies, but also how people use energy. While demand is rising, supplies are shifting to lower-carbon fuels. Efficiency is curbing growth in both energy demand and emissions. The net effect of these changes is best seen in OECD nations, where economies are expanding while energy demand and emissions are already starting to fall.

The benefits of modern technology and energy are self-evident, especially to those who are only now beginning to gain access. To help enable billions to reach the middle class and living standards to rise, the question remains — as always — how to expand the benefits of modern technology and energy while protecting the environment. Answers to that question will continue to be found through practical choices backed by human ingenuity. The good news is that practical options to meet people's needs for reliable, affordable energy continue to expand.

So why energy?

Because energy is vital in our everyday lives.

Modern energy for modern living

Gains in living standards over the past two centuries have been enabled in large part by a transition to modern energy sources.

One element driving this transition is the "energy density" of various energy types. Fuels high in energy content use less space and are often the easiest to transport for various uses. This helps explain why gasoline is prevalent as a transportation fuel and why people in high-rise buildings do not rely on wood for heating and cooking.

To help compare energy content, we've converted some sources of energy used today to one of mankind's earliest forms of energy: wood logs used as fuel for fire.

5 logs
(3.5 inch diameter, 16 inch length)
=
1 gallon gasoline
=
13,000 AA batteries

21 logs

Daily OECD* energy demand per person

(Non-OECD demand is only 6 logs per person)

=

4 logs
Household use

+

3 logs
Personal transportation

+

Comfort and security

Fire was the first form of light and heat, providing safety, comfort and security after dark.

Kerosene and other petroleum products became widely used for their low cost and versatility versus solid fuels.

Lighting for cities is provided by one of the most convenient energy types — electricity.

Then — Now

Personal mobility

It used to take 25 days to travel 2,000 miles by stagecoach.

By the 1860s, the trip could be made in 2 weeks by steam locomotive.

The same distance can now be traveled by a gasoline-powered car in just 3 days.

Then — Now

*The Organisation for Economic Co-operation and Development

Energy fit for modern purposes

When selecting a type of energy for a particular need, many factors are considered including practicality, convenience and cost. Energy content is often "lost" in burning a log or charging a battery, and logs of wood can't easily power a car nonstop for 300 miles. Gasoline has advantages on the road, but doesn't compete well with batteries for powering a smartphone.

Technology and energy work together to provide practical solutions. This is what makes modern living standards possible and why we use a diversity of fuels.

3 logs
Commercial buildings

+

3 logs
Commercial transportation

+

8 logs
Industrial use

Productive workspaces

Before the late 19th century, office buildings generally did not exceed five stories because of construction costs and the lack of elevators.

Steel frame construction, elevators, electric lighting and air conditioning enabled taller buildings, which maximized real estate.

Modern insulation, lighting and temperature control have greatly improved commercial building energy-efficiency.

Then — Now

Travel and trade

With the use of wind power in 1620, the Mayflower took 66 days to cross the Atlantic.

The invention of steam-powered ships allowed the same trip to be made in two weeks.

Modern aircraft and jet fuel make flights across the Atlantic faster, taking less than 8 hours.

Then — Now

Modern manufacturing

Prior to the Industrial Revolution, factory locations were near fast-flowing streams to use water power.

The invention of the steam engine helped accelerate the Industrial Revolution and the demand for coal.

Modern manufacturing equipment now requires energy dense fuels like natural gas and electricity.

Then — Now

Energy

in tomorrow's global landscape

What will the world look like in 2040?

Forecasting long-term energy trends begins with a simple fact: people need energy. Over the next few decades, population and income growth — and an unprecedented expansion of the global middle class — are expected to create new demands for energy. We see global energy consumption rising by about 35 percent from 2010 to 2040.

But as *The Outlook* shows, the world's energy future is not just about growth.

It also is about using energy far more efficiently — in everything from vehicles to buildings to industries; without efficiency gains we estimate global energy demand would grow not by 35 percent, but by 140 percent. The future will also be marked by a shift to lower-carbon fuels, a plateau in CO_2 emissions and technologies that open up new energy options, such as unconventional oil and natural gas in North America.

Different regions, different trends

Energy demand trends from 2010 to 2040 are expected to vary significantly around the world, **as countries move along very different trajectories in terms of key demand drivers including population, demographics, economic growth and income levels.**

In general, we can trace future energy trends by focusing on three groups:

- **China and India** together are expected to account for half the growth in global energy demand because these two developing economies will lead the world in terms of population size and the pace of growth in standards of living.

- A group of 10 **Key Growth** countries is expected to represent an increasingly significant share of the global energy market due to their rising populations and living standards. This geographically diverse group comprises Brazil and Mexico in the Americas; South Africa and Nigeria in Africa; Egypt and Turkey in North Africa/Mediterranean; Saudi Arabia and Iran in the Middle East; as well as Thailand and Indonesia in Asia.

- At the same time, the OECD represents the developed economies. Of the 34 member countries in the OECD, we include two (Mexico and Turkey) in our Key Growth category because their energy and economic growth more closely mirror that of the developing economies. Therefore, we will use the **OECD32** to signify the remaining developed economies that continue to show income growth but have relatively modest changes in energy demand.

"When dozens of countries and billions of people move up the development ladder, as they are doing today, it has a direct impact on wealth creation and broader human progress in all countries and regions of the world."

— United Nations Development Programme

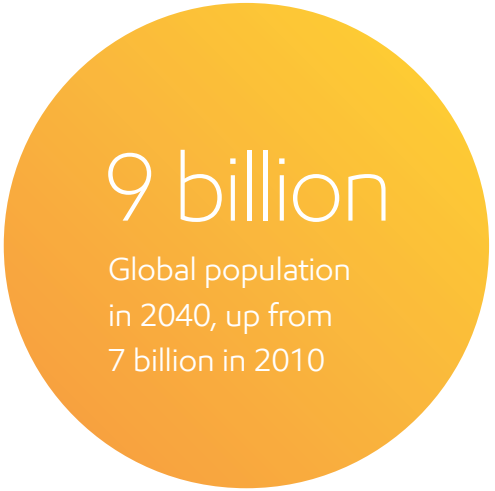
Changing population and demographics

The global population is projected to rise to 9 billion in 2040, compared to about 7 billion in 2010. About 40 percent of this increase is expected to come from India and the 10 Key Growth countries. OECD32 nations are likely to see only modest population growth, as should China.

China's population is expected to plateau around 2030, at 1.4 billion, enabling India to become the world's most populous country, with an anticipated 1.6 billion people by 2040.

Economic growth is tied closely to demographics, in particular the number of working-age citizens (ages 15–64) as a percent of total population. As this share increases, there is more opportunity for economic growth, both in the aggregate sense and, more importantly, on a per capita basis. Good examples of this dynamic include post-World War II Japan and China since the 1980s.

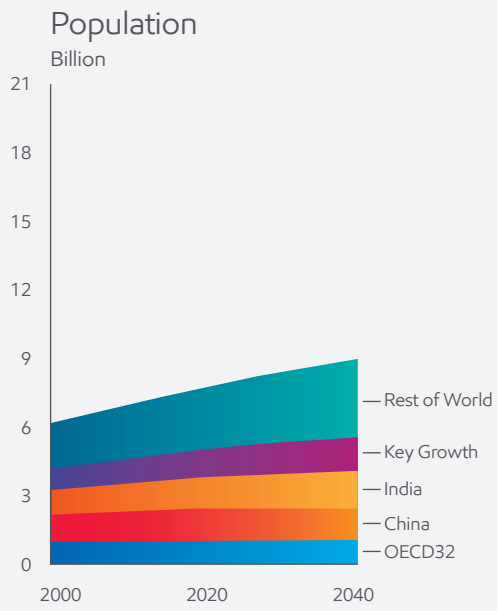
Over *The Outlook* period, there are likely to be important changes in both population and demographics in many countries due to changes in fertility rates and life expectancy. These changes will have a significant impact on economic growth.

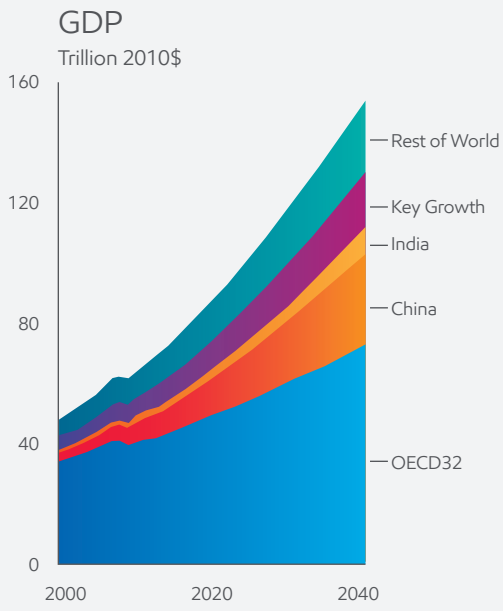


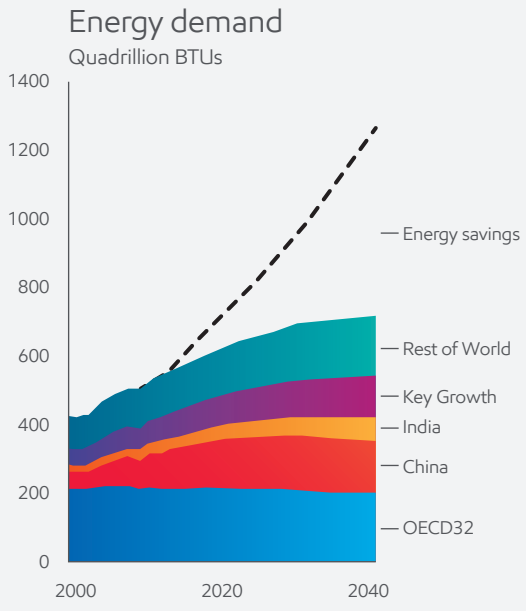
- **The OECD32 should see its working-age group shrink** as a share of the total population, leading to gradually declining economic growth rates.

- **China's working-age group already is peaking,** and the percent of people over 65 in China is projected to rise from 8 percent in 2010 to over 20 percent in 2040. As its population ages, China's economic growth should moderate, although its GDP still is expected to expand by about 400 percent over *The Outlook* period.

- **Most of the rest of the world — including India and the Key Growth countries — is expected to see large increases in working-age populations both in absolute numbers and as shares of the total.** This represents both an opportunity and a challenge, because in order to fully benefit from this "demographic dividend," these countries must have in place other key ingredients for economic growth — such as education, capital, technology and rule of law.







Source: United Nations and ExxonMobil

Income and rising GDP

As the world population increases by an estimated 30 percent from 2010 to 2040, we see global GDP rising by about 140 percent. While all countries are likely to experience economic growth, some are expected to see very rapid expansion. The fastest growth is seen in China, India and the Key Growth economies.

A closer look at these trends reveals that what really drives a country's energy demand is not just the size of its economy or its population, but rather the interaction of the two — the income level of its citizens.

A simple measure of personal income is GDP per capita. **By 2040, per capita GDP in China is expected to be four times higher than it is in 2010. It is likely going to be three times higher in India, and 1-2 times higher in Key Growth economies**. It's worth emphasizing that these changes are not just about GDP statistics; they mean higher standards of living for billions of people.

Measured in absolute dollars of GDP per capita, many developing economies' income levels should still be quite low compared with the OECD32 even by 2040. Nevertheless, this projected rise in income will result in a fast-growing middle class (see page 12) in many developing countries, significantly boosting energy demand.

Demand rising in China, India and Key Growth countries

The Brookings Institution estimates 2.8 billion people will join the middle class between 2010 and 2030, and almost all of them will live in developing countries. China, India and Key Growth countries combined represent more than 80 percent of projected middle-class growth.

Likewise, we project that essentially all the growth in global energy demand through 2040 will come from developing countries, where energy consumption is seen increasing by nearly 70 percent. Of the projected growth in global energy demand, China, India and the Key Growth countries will account for 30, 20 and 30 percent, respectively.

This is not to suggest that nothing is happening in developed economies. **In fact, what's happening in the OECD32 is unprecedented: economies are still expanding, but energy consumption is not.**

"The growth of the global middle class constitutes a tectonic shift: for the first time, a majority of the world's population will not be impoverished, and the middle classes will be the most important social and economic sector in the vast majority of countries around the world."

— U.S. National Intelligence Council

Energy demand in the OECD32 is projected to decline by about 7 percent over *The Outlook* period, even though its collective GDP is seen rising by about 80 percent. This achievement is due to improved efficiency across all sectors. Developing countries are also expected to see significant efficiency gains, but these should be outpaced by economic growth.

It is important to note that improved efficiency is one factor behind an overall slowdown in global energy demand growth. While global demand for energy is projected to rise by about 35 percent from 2010 to 2040, that is less than half the growth rate seen during the previous 30-year period from 1980 to 2010. **In addition, we estimate that three quarters of this increased energy demand will occur in the first half of *The Outlook* period (2010 to 2025).**

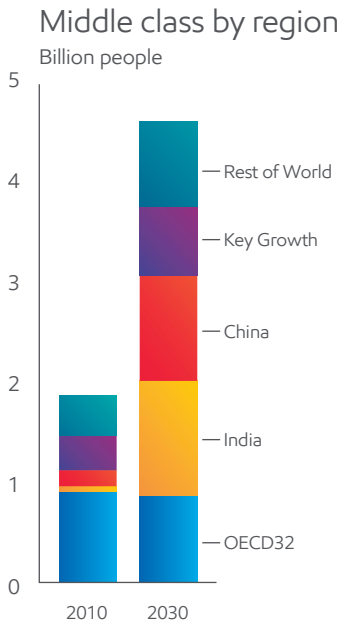
The expanding global middle class

Among the many observers who foresee a dramatic expansion of the world's middle class, **The Brookings Institution has recently estimated that the number of people who earn enough to be considered "middle class" will reach 4.7 billion by 2030, up from 1.9 billion in 2010.**

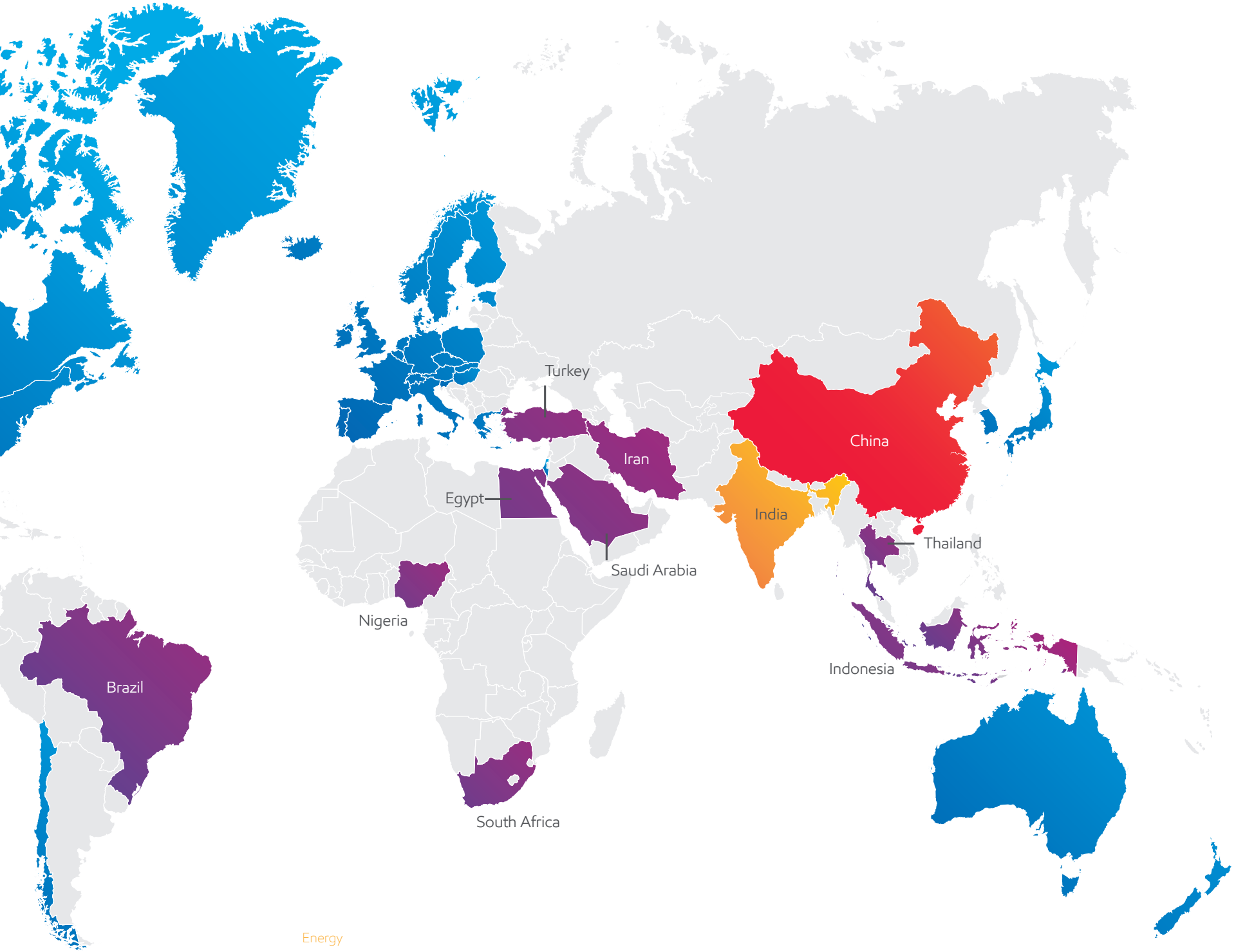
There are different ways to define middle class. In general, when people enter the middle class, they are earning enough to have discretionary spending power beyond daily necessities. Crossing this threshold puts them in reach of durable consumer goods such as electric appliances and cars. Many can readily afford services ranging from dining out to travel, modern medicine to higher education. They can improve their living conditions through the use of temperature-controlled rooms and less densely populated homes.

Middle class consumers also are concerned not just about the quantity of products and services they buy, but also the quality. Increasing earning power enables them to enter the world of financing, which offers opportunities to smooth out their spending over time. This is particularly helpful in purchasing homes and cars, which represent a large portion of personal energy needs.

All of these improvements depend on energy. In addition, the rise of a middle class is not just about income. It is typically accompanied by other society-wide changes that also drive increased energy use, such as improved infrastructure, electrification and urbanization.



Source: The Brookings Institution


Turkey
Iran
Egypt
Saudi Arabia
China
India
Thailand
Nigeria
Indonesia
Brazil
South Africa

Energy

and evolving consumer demand

Energy is vital to virtually every aspect of modern life. Around the clock, around the globe, people rely on energy to get to work, prepare meals, pursue business endeavors, communicate with friends and much more. Behind the scenes, even more energy is used to expand and modernize cities, manufacture products people rely upon every day and generate electricity for thousands of uses.

Energy comes in many forms — from gasoline to natural gas to electricity — each with properties well-suited for particular applications.

Our outlook for energy demand projects how much and what forms of energy are likely to be needed in countries around the world for transportation, residential/commercial use, industrial processes and electricity generation.

Transportation energy shifting towards developing nations

Rising prosperity will drive increased fuel demand for transportation through 2040. An expanding global middle class means millions of people will buy a car for the first time. Still, essentially all the growth in energy for transportation will come from commercial activity — from air travel to shipments by ship, train, or truck of raw materials, building supplies, food products, appliances, and countless other consumer goods.

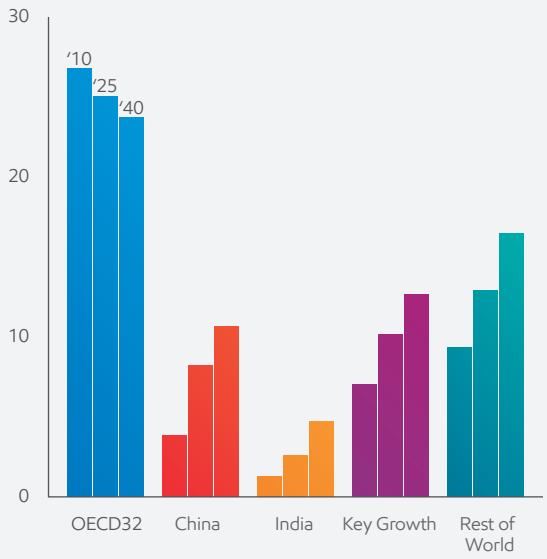
Global energy demand for transportation is projected to rise by 40 percent from 2010 to 2040. However, these energy needs will vary significantly by country.

From 2010 to 2040, transportation energy needs in OECD32 countries are projected to fall about 10 percent, while in the rest of the world these needs are expected to double. China and India will together account for about half of the global increase.

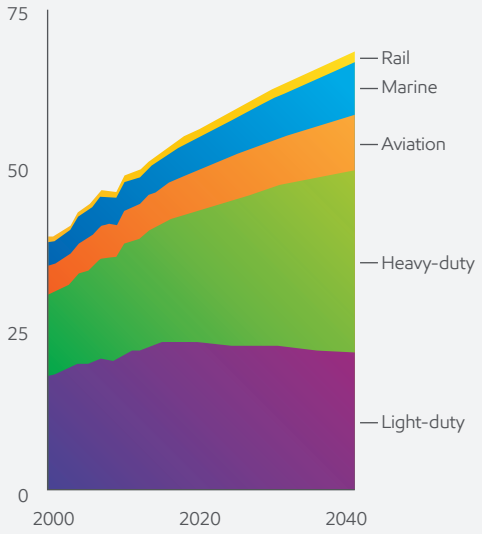
Driving the growth in energy for transportation — in every region — is commercial transportation: heavy-duty vehicles, marine, aviation and rail. As global GDP increases about 140 percent from 2010 to 2040, energy needs in these four subsectors are likely to grow about 70 percent. As a result, the amount of fuel required to support a unit of economic output is projected to decline 30 percent from 2010 to 2040, or more than three times faster than the rate of improvement from 1980 to 2010.

Remarkably, **energy demand for cars and other personal vehicles is expected to rise only slightly from 2010 to 2040,** as fuel economy improvements in passenger cars over time essentially offset a steep rise in the number of cars in the world.

Transportation fuel demand by region



Transportation fuel demand by sector

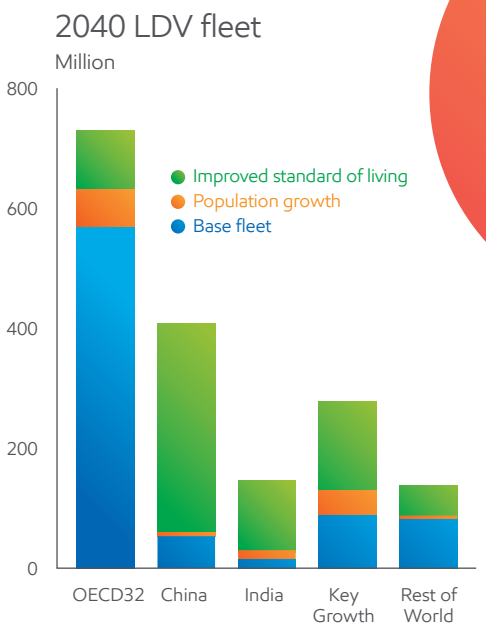


Twice as many cars, little change to fuel demand

Owning a car is one indication of prosperity. The coming expansion of the world's middle class — and other factors like population growth — are expected to result in a significant increase in the use of light-duty vehicles.

The number of light-duty vehicles in the world is expected to more than double, from approximately 825 million in 2010 to about 1.7 billion in 2040. That's an increase of more than 100 percent — nearly four times the number of cars in the U.S. in 2010. Yet because cars themselves will become far more fuel-efficient, we expect global energy demand for light-duty vehicles to be little changed even as demand shifts regionally away from the OECD.

Light-duty is the only major transportation subsector in which energy demand is not expected to increase significantly through 2040. **We see global light-duty demand peaking around 2020, at about 23 million oil-equivalent barrels per day (MBDOE).**



50%

of new car buyers in China have never owned a car before

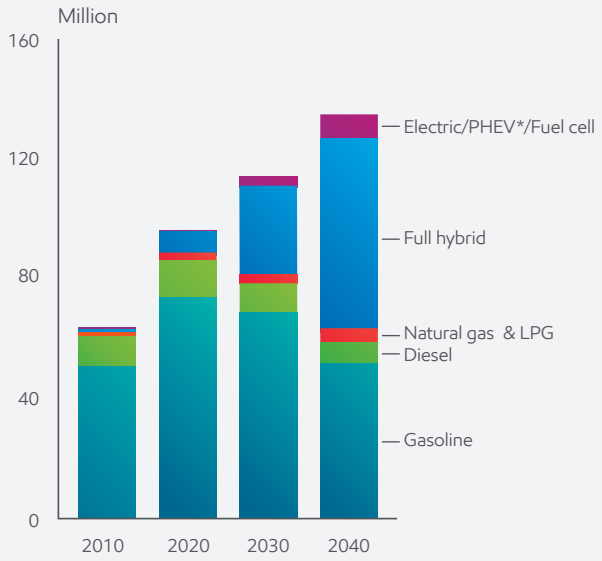
More income brings more cars on the road

While population plays a role in the size of a country's fleet, a more influential factor is income. About 85 percent of the growth in the global fleet through 2040 will likely come from countries outside the OECD32, where per capita income is likely to be more than two and a half times the 2010 level. **China alone is expected to account for about 40 percent of the global fleet increase.** Other developing nations with strong fleet growth include India, Brazil, Mexico and Indonesia.

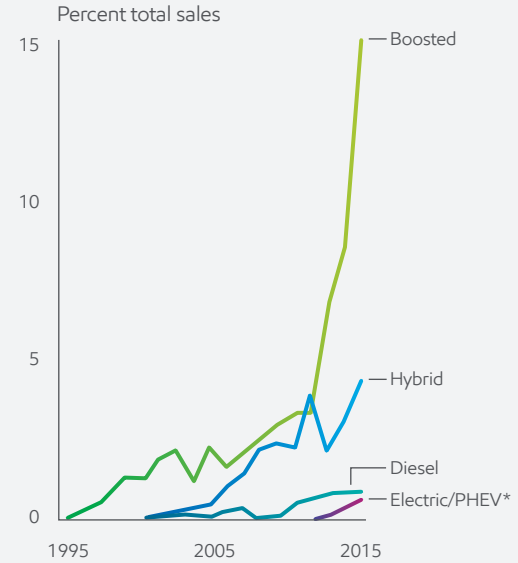
By 2040, China's light-duty vehicle fleet is expected to be about 400 million — 40 percent bigger than the U.S. fleet — which is remarkable considering that in 2010 it was only 60 million. The main reasons are rising incomes and an expanding middle class. Whereas 10 years ago, only the wealthiest Chinese were active in buying personal vehicles, cars now are being purchased much more broadly across all segments of the country's population.

However, even by 2040 China will likely have only about 30 cars for every 100 people, compared to about 80 cars per 100 people in the U.S. and about 40 per 100 in South Korea. We believe that even as income levels rise, per capita vehicle growth in China and many other developing countries will not follow the pattern seen in many OECD nations. Instead, we expect China and others, including India, to develop more along the lines of South Korea, where vehicle growth per capita to 2040 is limited to an extent by relatively high population density and government policies that seek to encourage public transportation.

Annual new LDV sales by type



U.S. new LDVs



*Plug-in hybrid electric vehicles

Source: U.S. EPA (2013) and ExxonMobil

Hybrids and the gains in fuel efficiency

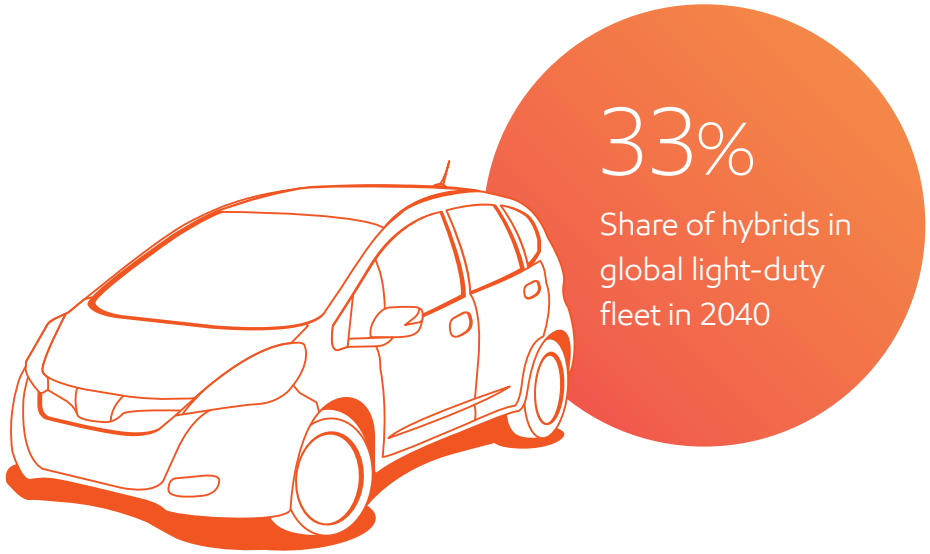
We project that the fuel economy of the average vehicle on the world's roads will be 45 miles per gallon in 2040, compared to about 25 mpg in 2010.

Contributing significantly to fuel savings through 2040 will be improvements to the fuel economy of conventional gasoline and diesel vehicles, which today are already benefitting from advances such as boosted — turbocharged — technologies and improved transmission systems. In the U.S., the country with the largest light-duty fleet, these boosted vehicles are entering the new-car market far more rapidly than hybrids because of their cost/benefit advantages today.

Hybrid vehicles are projected to grow from 1 percent of new-car sales in 2010 to close to 50 percent of sales by 2040, making up about one-third of the global fleet at that time. This is significant because hybrid cars can provide about a 30 percent fuel economy benefit compared to conventional gasoline cars and are expected to become cost-competitive by 2025.

Plug-in hybrid and full electric cars will likely continue to make modest gains, but penetration remains very low due to their high cost and functional constraints compared to alternatives. Even though battery costs are likely to fall in coming decades, electric vehicles will continue to face significant challenges as other alternatives also improve; we see electric vehicles accounting for only about 5 percent of the global fleet in 2040.

We project that energy needs for light-duty vehicles will increase by only about 10 percent from 2010 to 2025, after which demand will likely decline about 5 percent to 2040. This flattening of demand will be a significant accomplishment, especially considering that the global vehicle fleet is projected to double during that time period. Still, we expect ongoing technology advances will help enable automakers to deliver vehicles that satisfy both the functional and economic needs of consumers while also achieving significant fuel economy improvements, stimulated in part by government mandates.

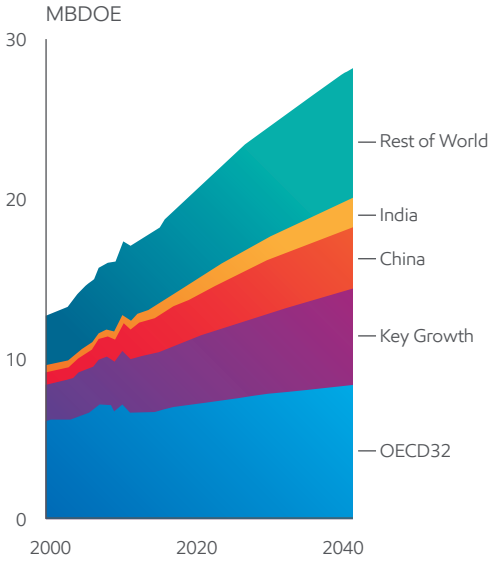


The rise of heavy-duty vehicles

The production and movement of goods remains a cornerstone of the world's economies. Even in the Internet age, items bought on a website need to be transported to the customer, mostly by commercial trucks. Rising economic activity around the world will continue to increase fuel demand for trucks and other heavy-duty vehicles.

Around 2025, heavy-duty vehicles are likely to surpass light-duty vehicles as the largest energy-consuming segment of the transportation sector. Total energy demand for heavy-duty vehicles is expected to rise by about 65 percent from 2010 to 2040, as economic expansion and the associated increased movement of goods more than outweighs significant improvements in fuel economy.

Heavy-duty transportation demand by region



How retail activity influences heavy-duty vehicle trends

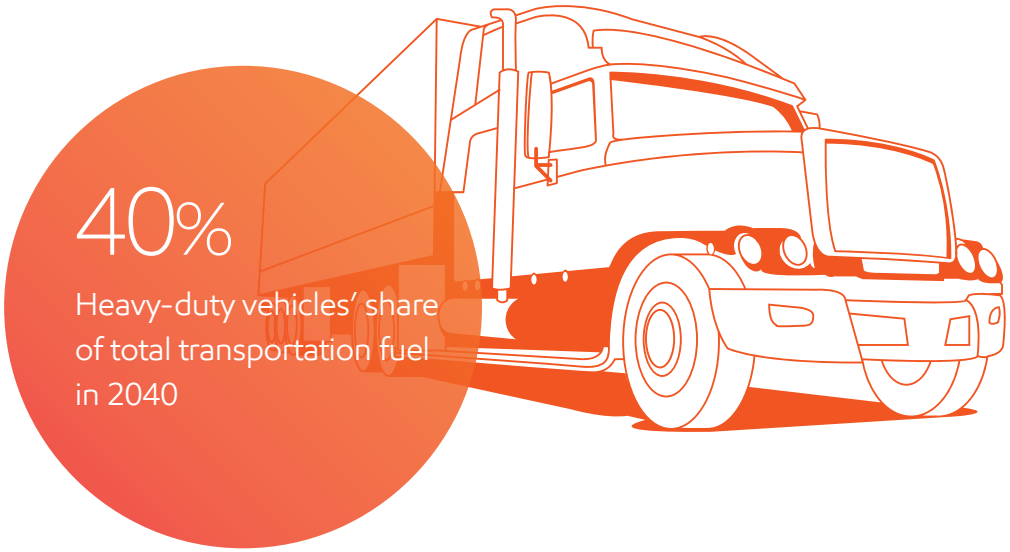
In the U.S. alone, Walmart has 158 distribution centers, each of which supports 90 to 100 stores. It has a fleet of 6,500 tractors, 55,000 trailers and more than 7,000 drivers. Each driver averages around 100,000 miles annually.

To reduce fuel costs and emissions, the company is making expanded use of more efficient driving techniques, improved processes and systems, and advanced tractor-trailer technologies such as electrification, lightweighting, improved aerodynamics and fuel-efficient tires. It also is experimenting with prototypes that include hybrid assist, wheel-end hybrid assist, full propulsion hybrid and natural gas (LNG and CNG).

Source: Walmart.com, November 2014

Because commercial transportation is so closely tied to economic growth, demand for energy for heavy-duty vehicles will rise much faster in developing economies, but many mature markets also will see higher demand as their economies continue to expand. The largest demand center today is the U.S. However, by 2040, China is expected to be the largest, as its heavy-duty transportation fuel demand rises by 130 percent. India is seen moving into third place as its heavy-duty transportation fuel demand growth outpaces even China, more than tripling over *The Outlook* period. Together, China and India likely will account for about 30 percent of the global growth in demand for energy for heavy-duty vehicles, while the U.S. and Europe combine to account for only about 10 percent.

Demand in the Key Growth countries is expected to increase by about 85 percent, or about 3 MBDOE. Combined with China and India, they will account for about 55 percent of total heavy-duty demand growth.



Growing heavy-duty demand for diesel and natural gas

Today, about three-fourths of heavy-duty transportation energy requirements are met by diesel fuel. Diesel is the most favored fuel for heavy-duty vehicles due to its widespread availability and the robust ability of diesel engine technology to handle heavy loads. Diesel's share is likely to increase marginally through 2040, as it accounts for about 80 percent of the growth in heavy-duty transportation fuel demand. The vast majority of this demand increase will support rapidly growing non-OECD economies.

In some regions, natural gas is emerging as an alternative fuel in the heavy-duty transportation sector. This trend is being driven by potential economic benefits to truck operators where natural gas is readily available as a competitive alternative to liquid fuels. While the initial cost of natural gas trucks — equipped for either compressed natural gas (CNG) or liquefied natural gas (LNG) — can be tens of thousands of dollars higher than conventional diesel trucks, in some markets, prices of natural gas relative to diesel over time may provide significant cost savings on fuel. In addition, natural gas can provide benefits in reducing emissions.

About 45 percent of the projected growth in natural gas as a fuel for heavy-duty vehicles is seen coming from China and India. China is making increased use of its stranded gas resources through small liquefaction operations (trucked LNG), and India also is promoting increased use of gas. By 2040, natural gas is expected to account for about 15 percent of the heavy-duty transportation sector in both China and India.

The U.S. is expected to account for about 15 percent of the global growth in natural gas use for heavy-duty vehicles. Today, use of natural gas as a transportation fuel in the U.S. is very modest, but we expect it to reach about 10 percent of the U.S. heavy-duty sector by 2040. Most of this demand, at least initially, would come from CNG — for fleet vehicles like buses and both medium-duty and heavy-duty trucks.

Aviation, marine and rail — the fastest-growing subsectors

The energy used to move freight and people by aircraft, marine vessels and trains accounts for more than 20 percent of transportation fuel demand today. By 2040, we expect that share will be approaching 30 percent, as energy demand for aviation, marine and rail grows by an average of about 75 percent. To put the growing importance of these three sectors in perspective, consider that in 2010 their combined demand was only about half the demand of the world's light-duty vehicle fleet. However, by 2040, energy demand from aviation, marine and rail is expected to reach about 90 percent of light-duty vehicle demand.

Most of the energy demand growth in these three sectors is expected to be met by oil, representing a projected combined increase of about 7 MBDOE. However, in the marine and rail sectors, we anticipate natural gas will meet about one-fifth of the growth in demand and reach about a 10 percent share by 2040.

Liquid fuel savings in transportation

Energy efficiency is sometimes called "the hidden fuel," and for good reason. Greater use of hybrid vehicles and other fuel-saving advances in the transportation sector are expected to save a tremendous amount of oil and other liquid fuels in coming decades. We estimate that improved transportation efficiencies will help curb global liquids (petroleum products and biofuels) demand growth in 2040 by about 35 MBDOE. In addition, another 5 MBDOE will be saved as consumers — especially in the commercial road and marine sectors — switch to other fuel sources such as natural gas. This combined 40 MBDOE in avoided liquids demand represents a significant amount of fuel. It is a little less than half the approximately 89 MBDOE of total liquids used in the world in 2010.

It also represents a significant reduction in the investments that would otherwise be required to meet the world's demand for liquid fuels. To put this in perspective, data from the International Energy Agency (IEA) implies that about $13 trillion (in 2013 dollars) of upstream investment will be needed over the period 2014 through 2040 to develop new oil supplies just to offset the decline of existing fields.

The biggest contributions to savings will come from personal and commercial road vehicles, which each account for about 40 percent of the 40 MBDOE expected to be saved in 2040.

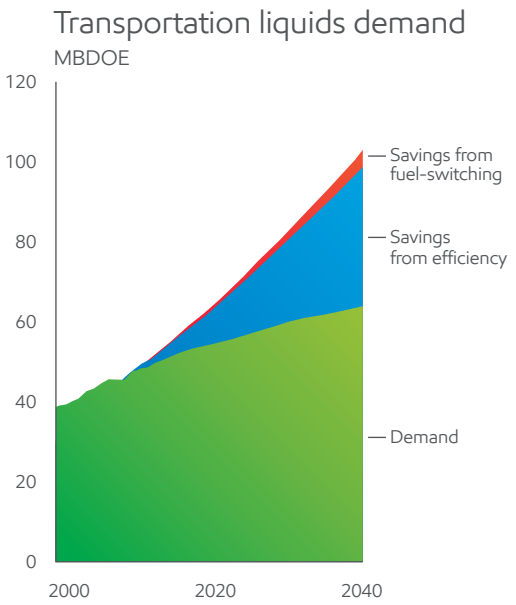
We expect that fuel demand for light-duty vehicles will change little through 2040, even though the global fleet is projected to double. Government mandates — such as Corporate Average Fuel Economy (CAFE) standards in the U.S. — will promote energy-efficiency technologies in OECD countries, and these technologies will reach other nations as they become economic.

Heavy-duty vehicle efficiencies will come from improved technology and logistics. As with light-duty vehicles, technological improvements will be introduced in the OECD and then migrate to the rest of the world.

U.S. jet engine efficiency improvements have averaged 2.5 percent per year since the 1980s. Going forward, we expect to see enhanced engine technologies such as geared turbofans, logistical improvements such as right-sizing of planes, and continued retrofits such as winglets. These are expected to contribute to aviation fuel savings of about 4 MBDOE in 2040.

In marine transport, the global recession and a recent excess in vessel capacity led the industry to adopt "slow-steaming" — operating ships well below their design speeds — resulting in significant fuel savings. We expect ships built in the latter half of *The Outlook* will be designed to operate at slower speeds.

Without transportation efficiencies and fuel-switching, we estimate that global demand for oil and other liquids fuels could have risen by as much as 75 percent from 2010 to 2040, instead of 30 percent as currently projected.



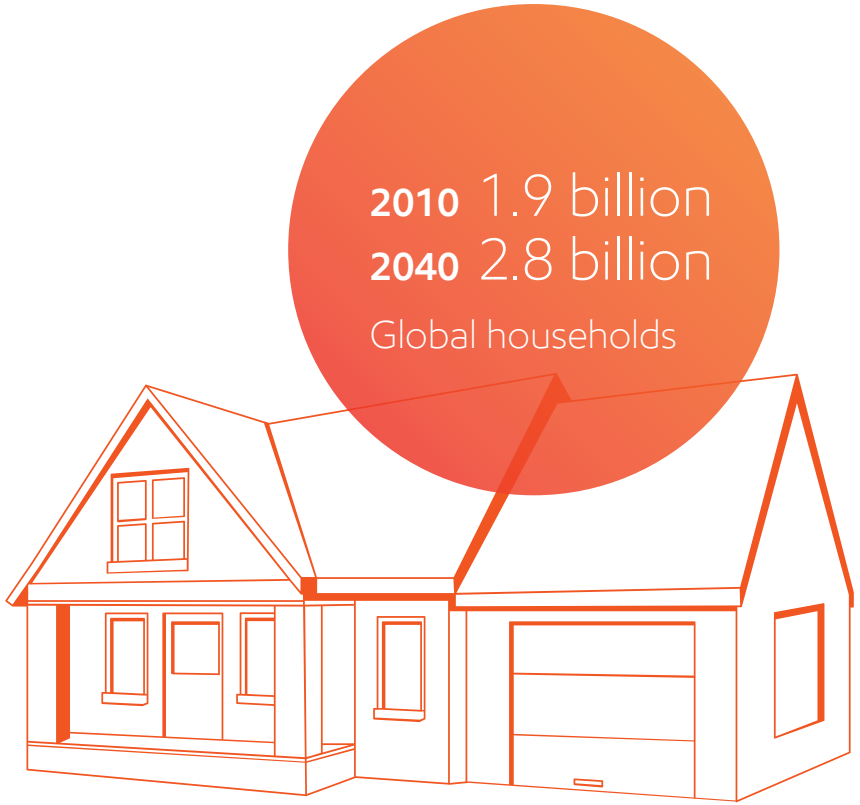
Residential and commercial growth

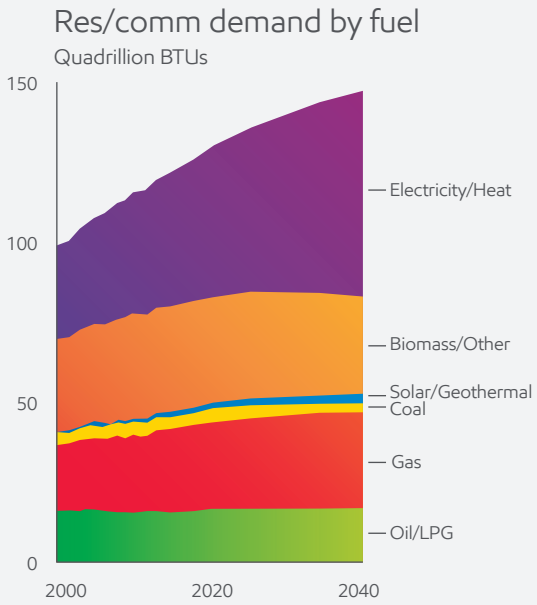
Homes and buildings are a significant source of demand for energy, especially electricity. The residential/commercial sector accounts for only about 15 percent of global primary energy consumption, but about 50 percent of electricity demand. **Residential/commercial energy demand, including electricity, is projected to rise by more than 25 percent from 2010 to 2040.**

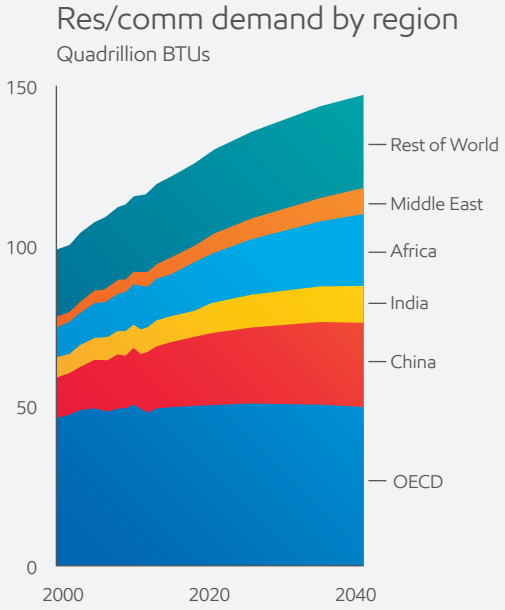
Energy demand for commercial buildings — which includes offices, stores and medical facilities — is seen rising by about 45 percent. But the largest volume growth is expected in the residential subsector.

Over *The Outlook* period, the number of households in the world is expected to rise by nearly 50 percent, to 2.8 billion. This increase is due to population growth, rising living standards and the movement of people from rural to urban areas. Asia's urbanization rate will likely rise from almost 45 to 60 percent through 2040, and Africa's from about 40 to almost 55 percent.

Urbanization increases residential energy demand, in part because when populations move from rural to urban settings there tend to be fewer people per household and therefore fewer shared energy services. For example, through 2040 the number of households in China is expected to grow even though its population remains fairly stable.







A more efficient household

While energy demand in the residential sector is projected to grow by more than 20 percent over *The Outlook* period, that growth would have been far higher — closer to 50 percent — were it not for projected gains in residential energy efficiency and the increasing share of developing country households.

Efficiency gains are expected to lead to a 20 percent improvement in average per-household energy use from 2010 to 2040. These savings would be the combined result of improved building codes, more efficient household appliances and residents in developing countries switching to more efficient energy sources. Improved household efficiency is the reason North America and Europe are projected to see net declines in residential energy demand through 2040.

In the United States, new homes are about 30 percent larger than those built before 2000 but consume the same amount of energy.

— U.S. Energy Information Administration

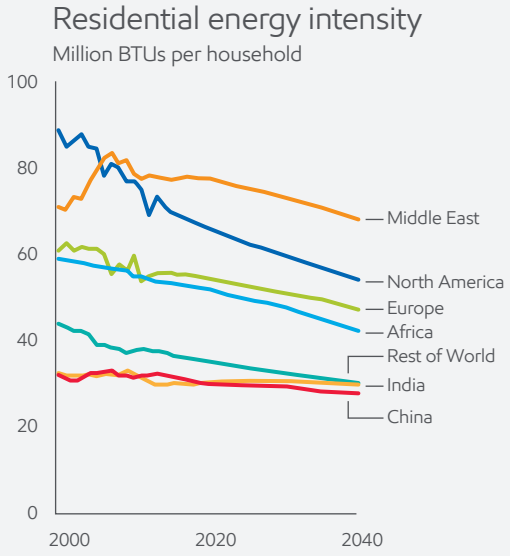
Developing countries' shift to modern fuels

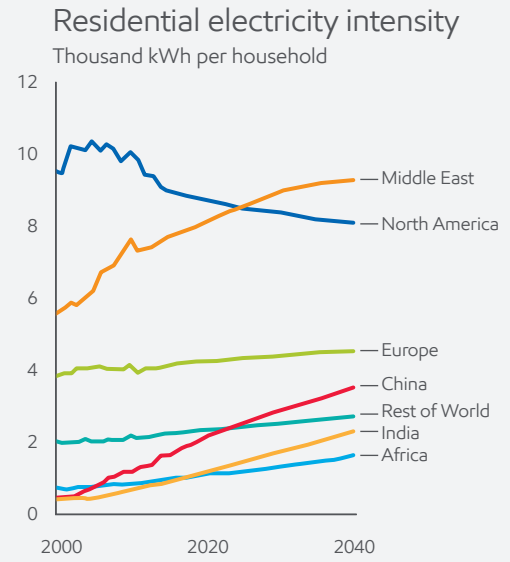
The types of energy used in homes differ significantly by region. North American homes use primarily electricity and natural gas. Other countries are in varying stages of transition to these modern fuels. By 2040, China's residential fuel profile is likely to be similar to North America's today. India's should look more like China's today, and Africa's should become more like India's is today.

But one trend is the same in all regions — **households will see a shift toward cleaner fuels and an increasing use of electricity rather than primary fuels.**

We expect residential demand for electricity to almost double through 2040, and electricity's share of residential energy use to rise from 20 percent to more than 30 percent. In all regions, rising demand for electricity in the home will be driven in part by increased use of appliances and electronics. In China in 1990, virtually no urban households had air conditioners or water heaters. Today, almost every urban home has a water heater, and there are 1.3 air conditioners for every household.

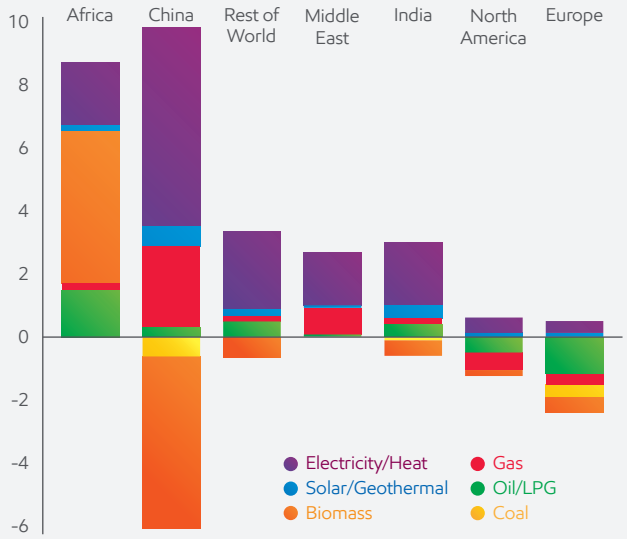
But in the non-OECD, another factor is expected to play a big role: rising incomes are enabling residents to use electricity and modern technologies for heating and cooking in place of traditional biomass.





2010 to 2040 residential demand change

Quadrillion BTUs



China's growing residential sector is expected to make a pronounced shift away from traditional biomass fuels like wood and charcoal (projected to decline by more than 5 quadrillion BTUs) in favor of cleaner, modern fuels like electricity and natural gas (which rise by more than 9 quads). In Africa, however, all forms of residential energy are forecast to grow through 2040, including biomass fuels.

55% **2010** | 30% **2040**

Amount of Asia Pacific's residential energy demand met by traditional fuels like charcoal, wood and dung

Improving fuels and human health

The use of biomass fuels — such as charcoal, wood and dung — accounted for nearly 40 percent of global residential energy demand in 2010. By 2040, we expect that share to have dropped to 30 percent. Most of the shift will come in the Asia Pacific region, where biomass is seen dropping from 55 percent of residential demand in 2010 to under 30 percent in 2040. The most dramatic change is likely to be seen in China, where residential use of biomass fuels is projected to drop by almost 75 percent, but electricity and natural gas are seen rising by over 300 percent.

Modern fuels such as electricity, natural gas and liquefied petroleum gas (LPG) are up to five times more efficient than wood and dung when used for cooking and heating. They also are better for human health; the World Health Organization estimates that about 4 million people die prematurely each year from illnesses attributable to indoor pollution from soot and other harmful particulates emitted by solid fuels.

In many developing regions, solid fuels are being replaced by LPG, a category of liquid fuels that includes propane. Residential LPG demand is projected to grow by 200 percent in Africa and 75 percent in Asia Pacific. Globally, we see LPG demand growing by 55 percent , the highest growth rate of any oil-based residential fuel over *The Outlook* period. **LPGs are expected to make up over 80 percent of residential oil demand in 2040.**

Natural gas demand is projected to grow by 20 percent in the residential sector, and by 2040 should continue to account for 20 percent of that market. Use of thermal solar and geothermal is expected to more than triple by 2040, when we expect they will account for 2 percent of residential energy demand.

Industrial energy demand

If energy is the lifeblood of economic development, industry is the backbone. Almost half of the world's energy is dedicated to industrial activity. Industry accounts for 30 percent of primary energy usage and 50 percent of electricity demand. Industry is invisible to many, but people rely on industrial products every hour of every day.

The Industrial sector includes:

- Agriculture that provides the food for the world's 7 billion people (and counting).
- Steel, cement, asphalt and other materials used to construct homes, schools, shopping malls, roadways, bridges, pipelines and airports.
- Plastics, glass, textiles, aluminum and electronics that are the building blocks for myriad furnishings, apparel, appliances and gadgets used in homes, offices and hospitals.
- Manufacturing of the planes, trains, automobiles and other vehicles that move people and goods around the globe.
- Extracting and processing of the oil, gas and coal needed to fuel the global economy.

As the world's middle class expands, so does demand for modern conveniences such as refrigerators, washing machines, cars, cell phones and computers. All these require energy to manufacture. **Total industrial energy demand is projected to rise by about 40 percent through 2040.** The two largest subsectors — heavy industry and chemicals — together are expected to account for about 85 percent of this growth.

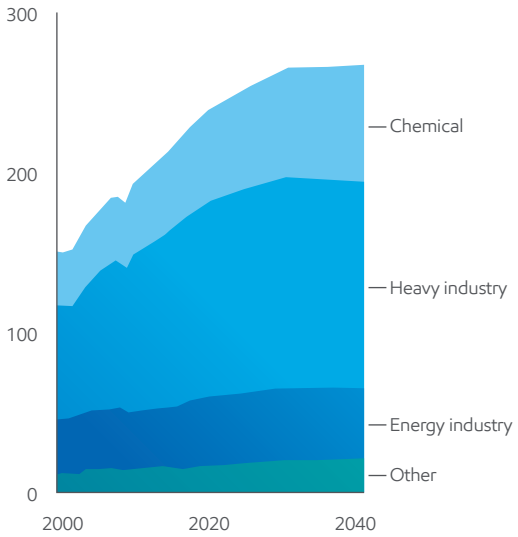
Shifting industrial demand growth

Industrial activity tends to migrate over time toward areas with ready access to affordable labor, raw materials, energy and capital, as well as growing demand for goods. Since 1990, China has dominated industrial growth as its demand for steel, cement and manufactured products grew rapidly along with its urban population and economy. **Over the next 25 years, however, we expect industrial energy demand growth to shift toward the rest of the developing world as China's economy matures.**

India, Brazil and Saudi Arabia are expected to lead this growth, but many other countries also will see their industrial energy demand rise to support a growing middle class and its urban communities. From 2010 to 2040, India and the Key Growth countries' combined share of industrial energy demand is expected to rise from 20 percent to about 30 percent, higher than China's or the OECD32's.

Industrial demand by sector

Quadrillion BTUs



40%

Less industrial energy use per dollar of GDP in 2040 than in 2010

China's economy will continue to expand, but with a greater proportion of services and technologically advanced light manufacturing, and less heavy industry. Consequently, China's industrial energy demand is forecast to peak during *The Outlook* and, by 2040, decline to a level only modestly higher than in 2013.

In the OECD32, industrial energy demand is expected to grow slightly by 2025, as the U.S. and Canada see an upturn in manufacturing and chemicals due to growth in production of unconventional oil and natural gas.

Improving industrial energy intensity

Producing more value with less energy makes sense — economically and environmentally — and is a priority for manufacturing companies and countries alike. In an age of global trade, successful companies are continually improving technology, processes and logistics to optimize energy usage and gain a competitive edge. Examples include the installation of energy-efficient technologies (such as variable speed motors and advanced process controls) and the adoption of process changes aimed at optimizing heat and energy utilization. Some nations also set efficiency standards and other targets intended to meet environmental and energy security objectives.

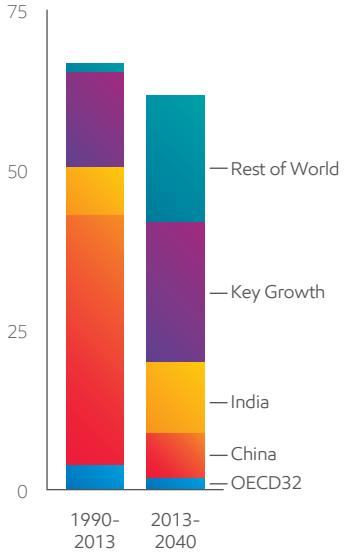
Industrial energy intensity is a measure of the amount of energy needed to create a unit of value, as measured by GDP. Improvements in energy intensity reflect both efficiency gains and structural shifts like the one China's economy is expected to undergo.

Industrial energy intensity in the OECD32 improved at about 2 percent per year from 1995 to 2010, a rate that is expected to continue through 2040. China's energy intensity improved at twice the rate of the OECD32 through 2010, albeit from a much higher base. By 2040, China's industrial energy intensity is expected to reach the level seen in the OECD32 in 1995. The rest of the world is expected to improve at a rate similar to the OECD32.

By 2040, average industrial energy intensity worldwide is projected to improve by 40 percent compared to 2010. The average amount of industrial energy demand per unit of economic output worldwide in 2040 is expected to be similar to the level of the U.S. in 2005.

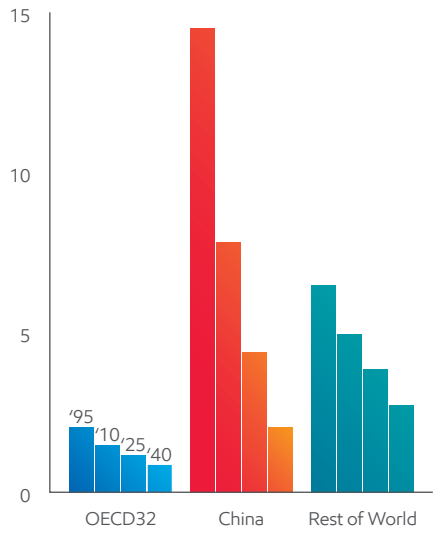
Industrial demand growth

Quadrillion BTUs



Industrial energy intensity

Thousand BTUs per dollar of GDP



Heavy industry fuel mix evolves

The largest industrial subsector, heavy industry, gets more than 35 percent of its energy from coal, followed by electricity and natural gas. In the future, **we expect electricity and natural gas to increasingly become the fuels of choice for manufacturing.**

We project electricity use in heavy industry to more than double, and natural gas to nearly double. As a result, the combined shares of natural gas and electricity in global heavy industry are expected to climb from about 40 percent to about 60 percent by 2040. Meanwhile, coal demand is expected to peak and then decline.

By 2040, use of coal in heavy industry is expected to fall below 2010 levels, mostly because of changes in China, the world's largest user of coal.

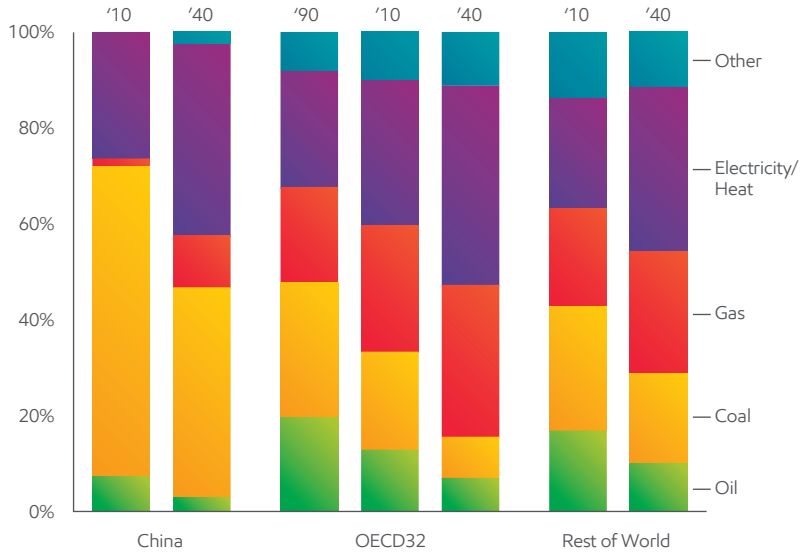
China's rapid industrial growth over the last two decades was fueled primarily by coal. In 2010, coal accounted for about two-thirds of the country's heavy industry fuel. Through 2040, we expect China's fuel mix to "lighten up," with higher shares of electricity and natural gas displacing coal and oil. These changes are anticipated to come in response to clean air policies for heavy industry — such as steel and cement — and as a natural result of the country's shift toward lighter industry.

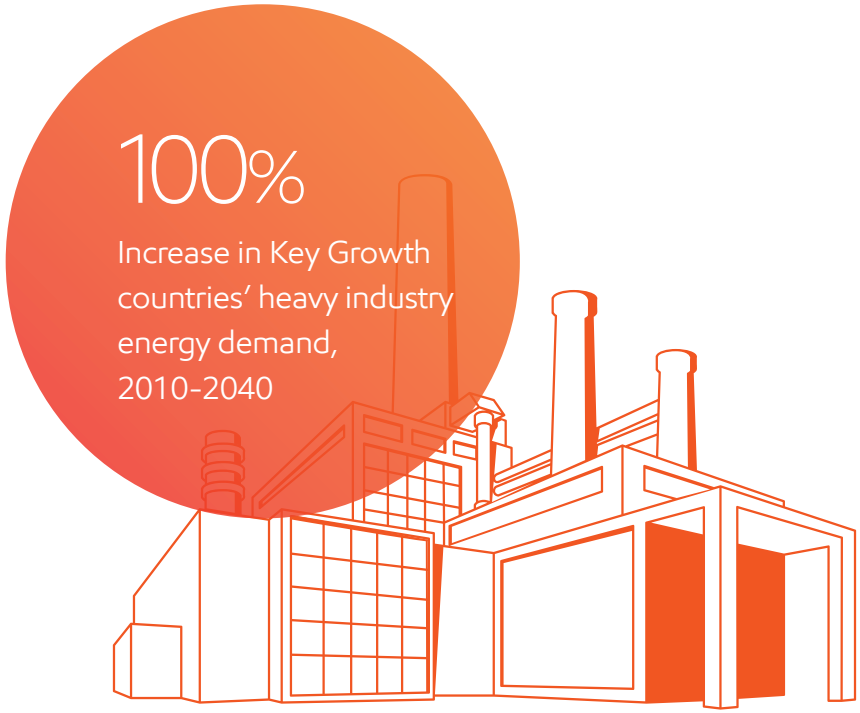
These trends are not unique to China. OECD32 manufacturing has been shifting away from coal and oil for several decades, and that trend is expected to continue. In 1990, coal and oil made up nearly half of OECD32 heavy industry fuel; by 2010, their share had dropped to one-third and by 2040, it is expected to decline to just 15 percent.

Other nations are expected to follow a similar path. With the availability of technologies like energy-efficient variable speed motors, the growth in gas production in many regions, and a global emphasis on clean air and emissions reduction, **we expect the rest of the world to increasingly turn to electricity and natural gas to fuel their industrial growth.** Interestingly, the industrial fuel mix in the rest of the world in 2010 was remarkably similar to where the OECD32 was in 1990. By 2040, we expect the mix of industrial fuels used in the rest of the world to resemble that of the OECD32 in 2010, although each country's fuel mix will vary based upon its unique combination of industrial activities and the relative availability and cost of its energy sources.

Heavy industry and manufacturing fuel mix transition

Fuel share percent





A steady rise in chemical energy demand

While global energy demand from heavy industry is projected to flatten after 2030, **demand from the chemical sector is seen rising throughout *The Outlook* period, increasing by about two-thirds from 2010 to 2040.** Three-quarters of this growth is expected to come from China, India and the Key Growth countries, which by 2040 are expected to have a combined 50 percent share of global chemical energy demand.

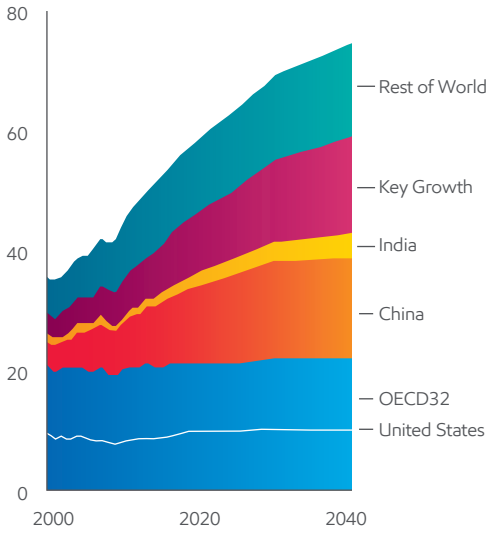
More than 95 percent of manufactured goods involve plastics and other chemicals. For example, plastics make up 50 percent of the volume of today's new cars. As economies grow and living standards rise, so will demand for plastics and other chemical products.

"The amount of energy required to produce a tonne of steel has been reduced by 50% in the past 30 years."

— World Steel Association, *World Steel in Figures 2014*

Chemical demand by region

Quadrillion BTUs



Chemicals and the middle class

In many parts of the world, people can remember when their parents or grandparents bought their first home, car, television, air conditioner or computer. In developing countries, rising incomes and an expanding middle class are enabling many more families to experience these transformative events for the first time.

While it's obvious that items like cars and computers need energy to keep them running, less obvious is the fact that they are all manufactured using plastics and other chemicals made from petroleum products.

Now more than ever, chemicals are the building blocks of modern life. A new car in the 1950s was made mostly from materials like steel and glass, but today's new cars are often about 50 percent plastic by volume, because advanced plastics and synthetic fibers cost less, perform better and save fuel. When you consider that by 2040 the world is expected to have almost 900 million more cars than it did in 2010, you get a glimpse of one reason why plastics and chemicals are such a large and growing source of global energy demand.

Chemicals also play a key role in fields integral to human progress, including agriculture, pharmaceuticals, medical equipment, surgical supplies, as well as efficient manufacturing and packaging of a wide array of consumer goods.

Including both fuel and feedstock, the production of chemicals today accounts for about 10 percent of global natural gas demand and about 15 percent of global oil demand, including about 45 percent of natural gas liquids (NGL). Oil and NGL shares are expected to continue to grow, as energy demand from the chemical sector rises at more than 1.5 times the rate of overall energy demand.

In terms of understanding energy demand trends in the chemical sector, it is important to note that improved efficiency has less impact on chemicals than other end-use sectors. This is because about 60 percent of the energy content used in petrochemical plants is not used as fuel, but as feedstock as hydrocarbon molecules like ethane are transformed into plastics and other products.

The amount of energy used by the chemical industry today, including fuel and feedstocks, is equal to the energy used by cars and other light-duty vehicles.

One key difference, however, is that energy demand from the light-duty vehicle sector is expected to be little changed through 2040 because of improved fuel efficiency, while energy demand from the chemicals sector is expected to rise by more than 65 percent.

Shift to ethane feedstock

Chemicals are made from a variety of feedstocks. Steam cracking, the largest petrochemical process used for converting raw materials into the building blocks for plastics, can shift production to accommodate whichever feedstocks are most affordable and available. Today, the No. 1 steam cracker feedstock continues to be naphtha, a refinery product, which accounts for over half of feedstock demand. Ethane and other NGLs are second, at about 30 percent.

Demand for NGL feedstock is expected to rise by about 125 percent through 2040, and naphtha feedstock by about 70 percent.

We foresee NGLs surpassing naphtha as the top liquid type used in the chemical sector during the middle of *The Outlook* period, before ultimately leveling off to about equal share with naphtha.

Ethane's rising profile is largely an offshoot of growing natural gas production, particularly in North America and the Middle East, both of which are expected to expand supplies of NGLs. These regions are expected to utilize their feedstock and energy advantages to make plastics for export to developing economies where demand is strong.

This rising demand in developing economies will drive expanded global trade in chemicals. Ten years ago, the volume of chemicals traded between regions equaled about 5 percent of global production capacity. Today, it has grown to about 10 percent, and we expect that volume to double by 2025.

At the same time, chemical manufacturers — especially those with limited access to NGLs — continue to seek alternate economic feedstock options. For example, China is pursuing opportunities to leverage its abundant coal resources for use as a chemical feedstock. Research also continues into the possibility of economic use of biofuels as a chemical feedstock.

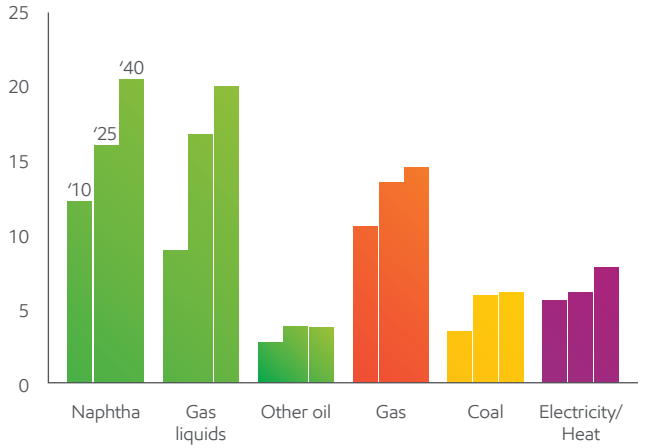
Chemicals and the environment

The chemicals industry is not only essential for enabling human progress, but also for reducing the environmental impact of that progress. Compared to traditional materials like steel and paper, products like strong-but-lightweight plastics and packaging perform better while also reducing cost, energy use and emissions.

As the American Chemistry Council notes, more than 95 percent of manufactured goods are directly touched by the business of chemistry. As people and economies advance through 2040, and the ranks of middle-class consumers continues to rise, innovations in chemistry will remain essential to improving quality of life.

Chemical demand by fuel type

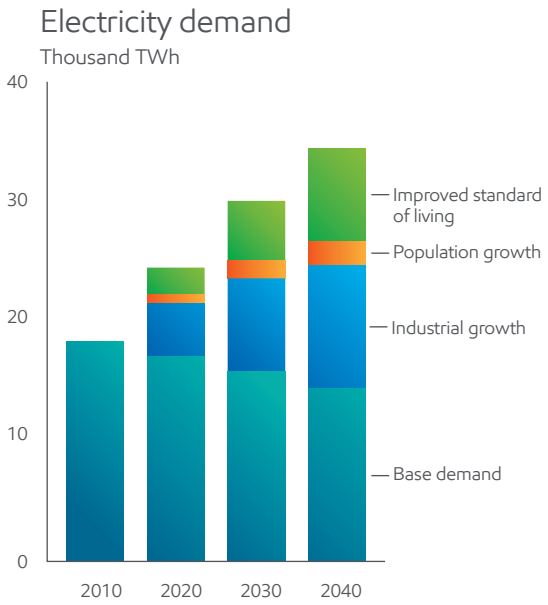
Quadrillion BTUs



Growing demand for electricity

Rising demand for electricity — the "invisible" energy that powers everything from home appliances to global e-commerce and banking networks to advanced robotic manufacturing — remains the single largest influence on global energy consumption.

From 2010 to 2040, global electricity demand is projected to increase by about 85 percent as living standards rise, economies expand and the electrification of society continues. The demand for fuel to produce that electricity is projected to rise by only about 50 percent, however, due to changes in the mix of fuels used to produce electricity, as well as improved efficiency in power generation and transmission.

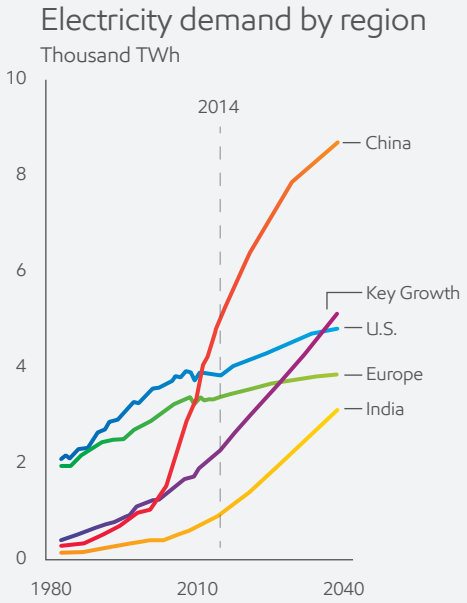


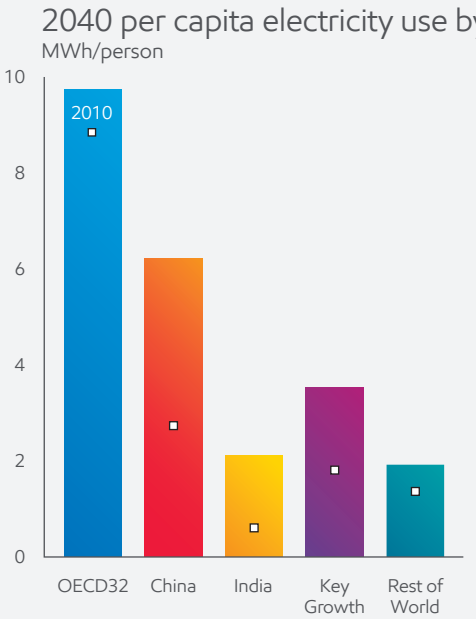
Drivers of electricity demand

About half of the projected global growth in electricity demand through 2040 is from the industrial sector. In addition to the increased need for manufactured goods that accompanies economic growth and a rising middle class, industry is expected to derive a greater share of its energy from electricity as advanced manufacturing, automation and control technologies continue to transform the sector.

Strong growth also will be seen in the residential/commercial sector, as rising living standards reflect greater electricity consumption by individuals through the wider use of products like air conditioning, water heaters, appliances, computers and smart devices.

Smartphones are a good example of how societal changes can impact electricity usage across sectors. The electricity to charge smartphones shows up predominantly in the residential/commercial sector. Electricity used to manufacture smartphones and other consumer goods is in the industrial sector, along with the electricity to operate the data centers and networks that provide the content accessed by smartphones.





Electricity demand growing fastest in China and non-OECD

The vast majority (about 85 percent) of growth in global electricity demand through 2040 is expected to come from the non-OECD nations, where the middle class is expanding most rapidly.

China already surpassed the U.S. as the world's largest electricity consumer, and its demand is projected to grow by more than 140 percent from 2010 to 2040. By 2040, one-quarter of the world's electricity demand will come from China. India and other Key Growth countries also are expected to see steep increases in electricity demand.

Per capita electricity use in China is projected to more than double through 2040 in conjunction with rising income levels. By 2040, per capita electricity use in China is expected to be about the same as Europe, though only about 65 percent of the OECD32 level.

The expansion of electricity access

Some of the growth in electricity demand through 2040 will come from people in developing economies gaining access to electricity for the first time.

The IEA estimates that by 2030 an additional 1.7 billion people will have gained access to electricity, and the number of people who lack electricity will have dropped from 1.3 billion to just under 1 billion, or about 10 percent of the population. This progress would result not only from rising incomes and a growing middle class, but also the expected shift of populations to urban areas with broader access to electricity. Rural electrification in some developing countries is expected to bypass large national grids in favor of distributed generation.

"Access to electricity is particularly crucial to human development as electricity is, in practice, indispensable for certain basic activities, such as lighting, refrigeration and the running of household appliances, and cannot easily be replaced by other forms of energy."

— International Energy Agency

A shift in the power generation sector

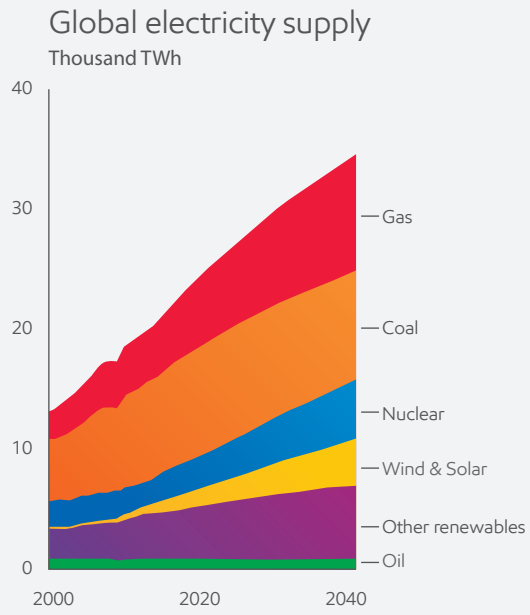
Coal is expected to remain an important source of electricity generation, but its share of delivered electricity is expected to drop from 40 percent to about 25 percent over *The Outlook* period as most nations turn to cleaner, less-carbon-intense fuels to improve air quality and curb greenhouse gas (GHG) emissions. The biggest gains are likely to come from natural gas and nuclear power, as well as renewable generation like wind and solar.

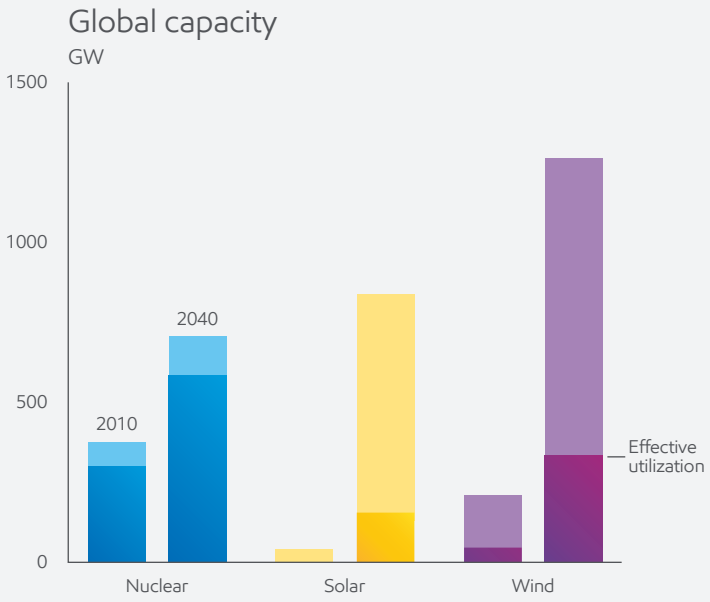
Natural gas is expected to supply 135 percent more electricity in 2040 than in 2010, and overtake coal as the largest source of electricity.

Nuclear capacity is expected to increase by about 90 percent, with growth led by China and India.

Solar capacity is expected to grow by more than 20 times from 2010 to 2040. More than half of today's installed solar capacity is non-utility-scale distributed, i.e., rooftop solar for residential and commercial applications. We expect distributed solar will retain a relatively high share of the solar market, expanding to regions that lack well-developed grids.

Wind capacity is expected to expand by almost five times — the vast majority as onshore wind.





Although wind and solar each are expected to exceed global nuclear capacity by 2040, installed capacity does not tell the whole story about how much electricity will actually be generated. Because nuclear is a "baseload" technology, its capacity will generate electricity about 80 to 85 percent of the time. Wind and solar, however, have much lower effective capacity utilization levels because they are intermittent sources. As a result, even by 2040, wind and solar each will meet far less electricity demand than nuclear power.

As penetration of intermittent renewables like wind and solar increases, extra steps must be taken to ensure a reliable flow of electricity to consumers. These steps create additional, often overlooked, costs. For example, additional generating capacity, such as natural gas-fired plants, must be made available to back up wind and solar during the times when the sun is not shining and the wind is not blowing.

By 2040, natural gas, nuclear and renewables are expected to deliver more than 70 percent of the world's electricity.

"... Even though the share of renewables is rising, we will continue to need almost as many gas-fired and coal-fired power stations as before. ... When there is no wind, or it is cloudy, conventional power stations need to jump in and cover the bulk of energy consumption."

— Germany, Federal Ministry of Economics and Technology (2013) from *Energy reforms on path to success*

Regional approaches to power generation

About two-thirds of the growth in fuel demand for power generation is expected to occur before 2025. By that time, improvements to efficiency will begin to significantly slow global demand growth. This shift, most noticeable as a decrease in power generation fuel demand in the OECD32, is expected to come from improved technologies and the shift away from older, coal-fired generators to newer, more efficient natural gas-based units and renewables.

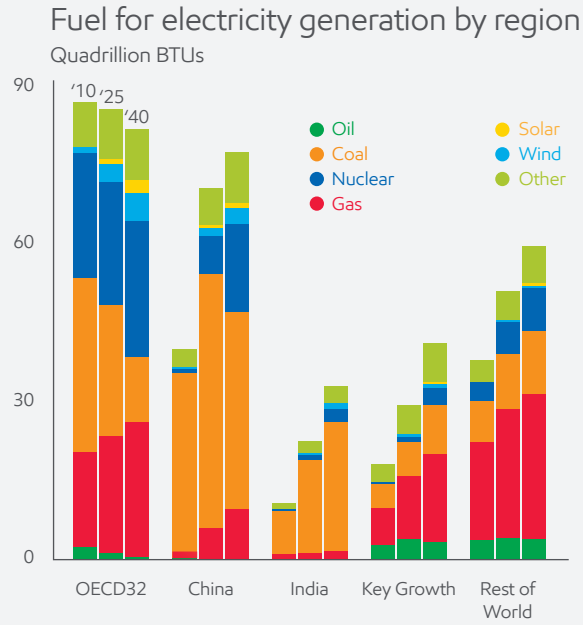
We foresee different regional trends through 2040, because the choice of fuels used for power generation is largely dependent on local availability, cost and government policies.

Today, coal accounts for almost 40 percent of the fuel used for power generation in the OECD32, but we expect it to drop to 15 percent by 2040. Natural gas, nuclear and renewables will grow as these nations continue to enact policies to reduce greenhouse gas (GHG) emissions and lead in the utilization of renewable fuels, including wind and solar.

Coal's share of China's power generation fuel mix is expected to decrease from about 85 percent in 2010 to less than 50 percent in 2040, while nuclear, natural gas and renewables are all expected to grow in share. The rapid expansion of China's nuclear power serves economic, environmental and supply security needs.

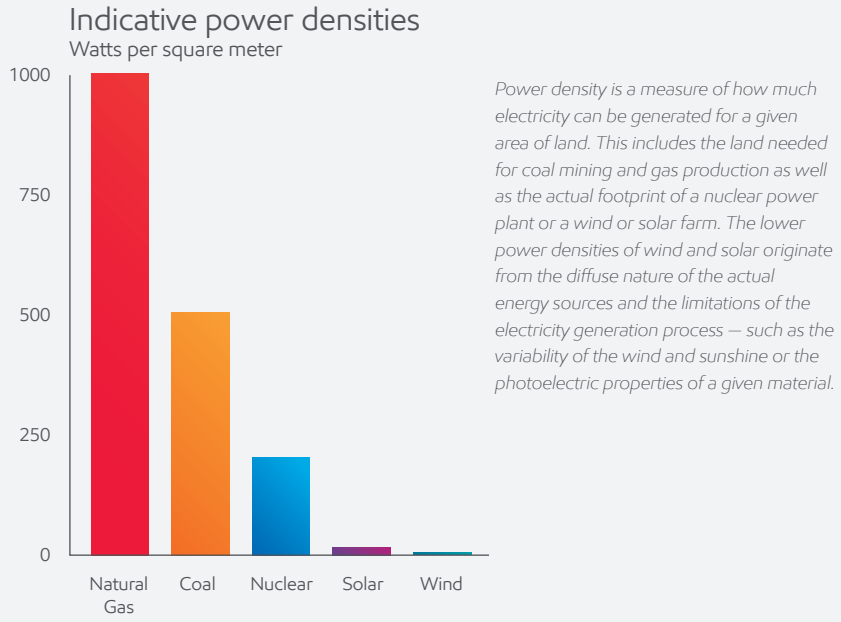
In India, however, coal is expected to continue to be the main fuel for power generation, nearly tripling over *The Outlook* period. Nuclear power in India also is expected to see significant growth, rising about nine times by 2040.

Key Growth countries are expected to meet rising electricity demand with a diverse mix of energy sources, with the largest increase being from natural gas; several of these countries have access to significant domestic gas resources. In addition, many Key Growth countries are expected to add nuclear power capacity including several nations that will be developing nuclear power for the first time.



When considering options for reducing CO_2 emissions associated with power generated from natural gas and coal, carbon capture and storage (CCS) often is discussed. New gas-fired power plants are likely to generate about 50 percent fewer CO_2 emissions than new coal-fired plants, resulting in a lower CCS cost. CCS technology, however, continues to face substantial economic and practical hurdles, which we expect will limit significant deployment over *The Outlook* period.

The shift away from coal and toward natural gas, nuclear and renewables in power generation is expected to be an important contributor to the projected slowdown in global energy-related CO_2 emissions over *The Outlook* period.



Power density is a measure of how much electricity can be generated for a given area of land. This includes the land needed for coal mining and gas production as well as the actual footprint of a nuclear power plant or a wind or solar farm. The lower power densities of wind and solar originate from the diffuse nature of the actual energy sources and the limitations of the electricity generation process — such as the variability of the wind and sunshine or the photoelectric properties of a given material.

Source: V. Smil (2010) *Power Density Primer* and ExxonMobil

Global CO_2 emissions seen peaking around 2030

Managing climate change risks by pursuing reductions of GHG emissions is a goal shared by many nations. While every country faces a unique set of priorities and resource constraints, we expect that most every nation, regardless of circumstance, will seek solutions that help curb emissions without harming the prospects of greater prosperity for its own citizens.

Toward this objective, two of the most effective solutions are improving energy efficiency across the economy (also referred to as reducing energy intensity) and reducing the CO_2 content across the energy mix. Through 2040, each will play a powerful role in slowing emissions growth, and ultimately reversing what had been a decades-long rise in global CO_2 emissions. In fact, we expect **global energy-related CO_2 emissions will rise by about 25 percent from 2010 to 2030 and then decline approximately 5 percent to 2040.**

In absolute terms, global CO_2 emissions are expected to be about 6 billion tonnes higher in 2040 than they were in 2010. While that increase is significant, it is only about half the level of emissions growth seen from 1980 to 2010. This is all the more remarkable considering the growth in economic output from 2010 to 2040 will be about 150 percent more than the prior 30-year period.

The role of policy

Some of this projected slowdown in emissions will be driven by market forces; for example, the shift from coal to natural gas in North America will be aided by unconventional production technologies that have made gas both more abundant and more affordable in that region. Some will result from changing consumer preferences; for example, individuals installing solar panels on their homes to reduce their personal carbon footprints. And surely some of the projected progress on emissions through 2040 will come as a result of government policies designed to reduce emissions.

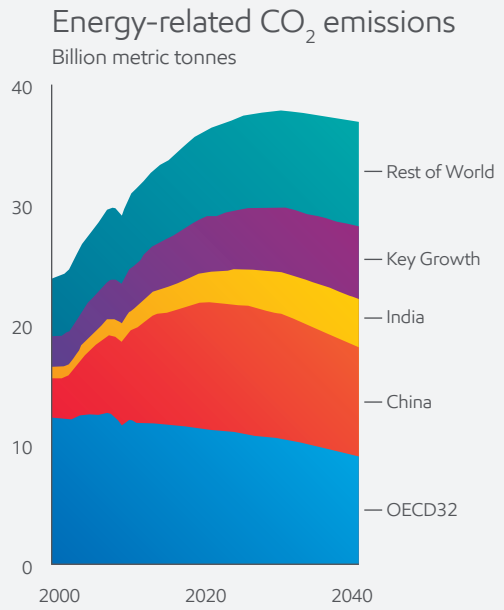
Many aspects of climate policies remain uncertain. But for the purposes of *The Outlook*, we continue to assume that governments will enact policies that impose rising costs on energy-related CO_2 emissions. OECD nations are likely to lead the way in adopting more stringent policies, with other nations gradually following, led by China. **Across OECD nations, we assume the implied cost of CO_2 emissions will reach about $80 per tonne in 2040.**

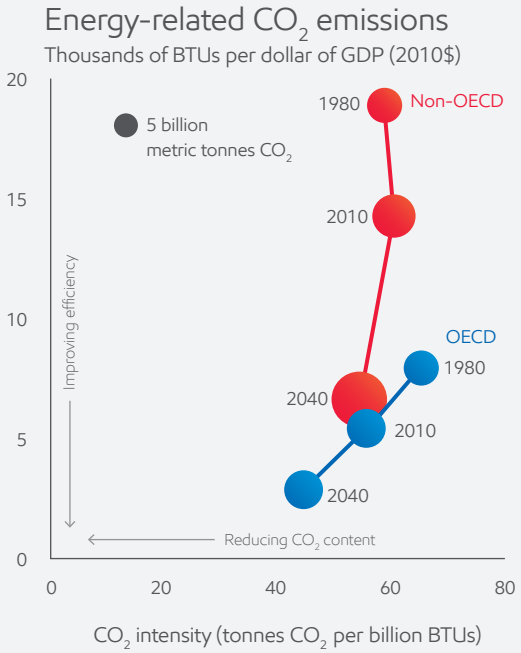
We assume that rising energy costs associated with climate policies will, over time, lead to greater adoption of energy-saving technologies and practices.

Most OECD countries see emissions decline

Progress on curbing energy-related CO_2 emissions through 2040 will be led by OECD nations, as energy demand trends lower and a shift to lower-carbon fuels proceeds. Emissions already are declining in most OECD countries. **From 2010 to 2040, we expect that OECD emissions will fall by more than 20 percent.**

By 2040, CO_2 emissions in the OECD are projected to be about 10 percent below 1980 levels, even though these countries will have about 40 percent more people and economies close to 275 percent larger than in 1980. By comparison, CO_2 emissions in non-OECD countries are expected to be more than 250 percent higher in 2040 versus 1980, as the population in these countries will have doubled, and economic output will be about 1,000 percent greater.





Non-OECD emissions to rise, then flatten

Non-OECD CO_2 emissions surpassed the OECD's in 2004, and over the period from 2010 to 2040, emissions are expected to rise by about 50 percent.

This growth will occur despite significant gains in efficiency and reductions in carbon intensity through 2040, as rapid economic growth and improved living standards for billions of people will more than offset these emissions savings.

However, even in these developing nations, emissions are projected to flatten after 2030. This outcome reflects in large part an expected drop in China's emissions post-2025 as further diversification of its energy mix, including reduced dependence on coal, and a tempering of industrial growth combine to produce a peak in China's CO_2 emissions around 2025.

By 2040, non-OECD countries will account for about 75 percent of the world's energy-related CO_2 emissions, up from 40 percent in 1980. But even so, on a per capita basis, emissions in non-OECD nations will be only about half the level of those in the OECD.

"Although it would be nice to believe there's no trade-off between sustainability and development, such a trade-off undeniably exists."

— Charles Kenny, senior fellow, Center for Global Development

Energy

in diverse resources

Advances in technology and significant investments continue to expand the availability of energy supplies to meet growing demand. As energy needs continue to evolve around the world, practical supply alternatives must continue to meet a range of consumer requirements in terms of convenience, performance and affordability while also managing environmental impacts.

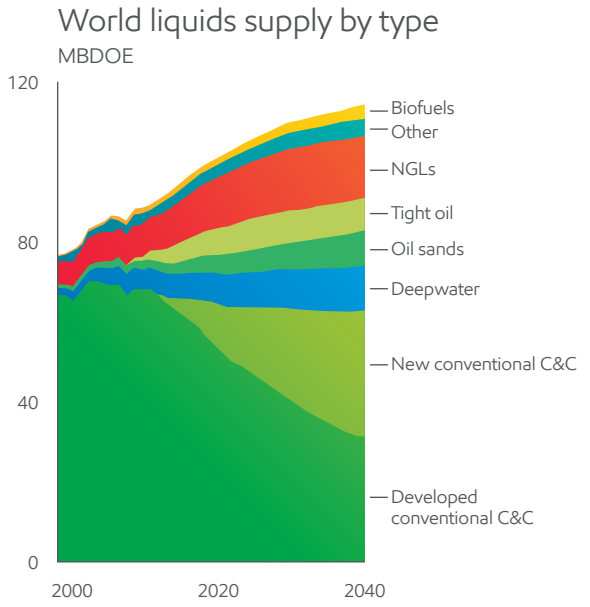
Among the most significant advances are those related to development of unconventional oil and natural gas resources, while nuclear and modern renewable energy supplies are becoming more prominent in many countries.

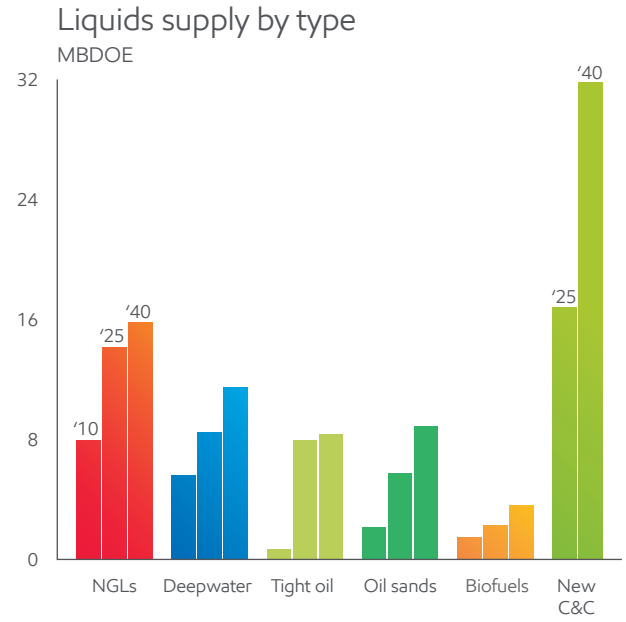
Unlocking new supplies of tight oil and NGLs

Since the modern oil industry began more than 150 years ago, global oil supply has expanded to serve rising demand for transportation fuels and other petroleum liquids. That will remain true through 2040. We expect global liquid supplies will rise from 89 MBD in 2010 to 115 MBD in 2040, an increase of almost 30 percent.

Through 2040, an increasing share of liquids will come not from the conventional oil deposits that have been the mainstay for generations, but from other sources such as those unlocked by relatively recent advances in technology.

New development of conventional deposits is expected to rise significantly, but not quite enough to offset declines in developed ones. **By 2040, sources other than conventional crude and condensate (C&C) will account for about 45 percent of global liquids production, compared to under 25 percent in 2010.** As a result, global liquids supplies will diversify, both by source and by region.





What are NGLs?

Natural Gas Liquids (NGLs) are an important and growing part of the world's liquid supply. But what are they, and why are they important?

NGLs are liquid fuels, but they are chiefly produced in association with natural gas. NGLs are components of natural gas that are separated from the gaseous state into liquid form during natural gas processing. Ethane, propane, butane, isobutane and pentane are all NGLs. NGLs are different from field condensates, which are obtained from field gas separators upstream of a gas processing plant.

Although their chemical compositions are similar, each NGL has different applications and uses in the various energy demand sectors.

For example, ethane is primarily used in the industrial sector as feedstock for petrochemicals to produce ethylene, the largest petrochemical building block used to make products like plastic bags, PVC pipe and detergents. Propane is used in the residential sector for cooking and home heating, while pentanes are used in refining to produce gasoline and within the oil industry to enable the production of Canadian oil sands. Also, a mixture of propane and butane, commonly known as LPG, is used as a transportation fuel in some markets.

Just as technology enabled 20th century advances like offshore drilling, many of these nonconventional liquids also are the result of improved technology. The combination of horizontal drilling and hydraulic fracturing, plus enhanced seismic mapping, led to the development of North American tight oil and shale gas resources and their associated NGLs. And while offshore developments at water depths of 400 meters were considered too challenging several decades ago, frontier deepwater projects at depths of more than 3,000 meters are likely in the future.

Tight oil's significant expansion

Tight oil is the most recent example of how breakthroughs in technology can — sometimes very rapidly and unexpectedly — expand energy supplies.

In 2010, tight oil — oil contained in rock formations with very low permeability — accounted for less than 1 percent of the world's liquids supply. By 2040, however, we project that tight oil will have grown to 7 percent of global liquids supply as production rises by a factor of 15.

The majority of the growth in tight oil production through 2040 is expected to come from North America, where supply is expanding so rapidly that North America is poised to become a net liquids exporter by the end of this decade.

Production at the Bakken field in North Dakota, which was one of the first tight oil fields to be developed at large scale, has climbed from less than 100,000 barrels per day (BPD) in 2007 to more than 1 MBD currently. In Texas, rising tight oil production in the Eagle Ford Shale and Permian Basin will likely enable Texas to produce more than 3 MBD by 2020 — triple its output in 2010.

By 2015, U.S. tight oil production will likely be higher than the production of any OPEC country except for Saudi Arabia. Argentina and Russia, among others, are expected to make significant contributions to the global tight oil supply toward the later years of *The Outlook* period.

Tight oil is not the only liquid fuel expanding as a result of the unconventional production technologies developed in North America; the other is NGLs. NGLs, which include ethane, propane and butane, are produced in association with both oil and natural gas, and tend to have higher volumes in unconventional resources. **Rising natural gas production in North America and the Middle East will create a growing global supply of NGLs, which by 2040 are expected to account for nearly 15 percent of liquids supply.**

Other significant production increases are seen in the deepwater oil category, which is projected to more than double to over 10 MBD by 2040, and oil sands, which are seen more than quadrupling to almost 9 MBD. Growth in oil sands will be driven by developments in Canada and Venezuela.

"The biggest innovation in energy so far this century has been the development of shale gas and the associated resource known as 'tight oil.'"

— Daniel Yergin, vice chairman, IHS

Investments in liquid supply development

Today's world needs more than 90 million barrels of liquid supplies every day. To meet growing demand in coming decades will require, according to the IEA, an average annual investment of about $650 billion (in 2013 dollars). The IEA also estimates that approximately 75 percent of this investment will be needed just to maintain upstream oil production equivalent to today's rates, given natural rates of decline from existing fields.

We expect that in order to offset declines in existing conventional developments, new conventional developments will need to produce more than 15 MBD by 2025 and more than 30 MBD by 2040. The largest investments will be needed in the Middle East, where existing conventional supply is projected to decline by more than 25 percent, as well as in Russia, where conventional supplies are seen declining by 50 percent.

Development of nontraditional supply sources like tight oil, oil sands, deepwater and NGLs also require significant investment. Many of these resources had been prohibitively expensive to produce until certain advances in technology made them affordable, and further technological advance continue to bring down their costs.

For example, advances in pad drilling — drilling multiple wells from a common surface location — have significantly reduced drilling time and therefore tight oil development costs. The average time to drill a horizontal well in the Eagle Ford has fallen by about 50 percent in the last several years, even as average well lengths have increased. Pad drilling also reduces environmental impact by creating a smaller surface footprint.

Expansion of global liquid trade

Trade between regions plays a pivotal role in meeting the world's need for oil and other liquid fuels. Geographic trends in oil trading are shifting over time as supply, demand and technology evolve. Some nations can be both importers and exporters depending on their particular mix of liquids production and refining capacity. We expect that half of global liquids fuel demand will be met with international trade over *The Outlook*.

From now through 2040, the Middle East and Russia/Caspian are expected to remain the dominant oil exporting regions, while Asia Pacific and Europe should remain the largest importers. **But a significant shift is foreseen in North America, which is poised to emerge as a net liquids exporter due to projected strong growth in tight oil, oil sands and NGLs.**

North America shifts to net exporter

North America had been a significant oil importer for decades, but growth in unconventional oil and natural gas in the U.S., plus oil sands in Canada, are expected to enable net exports from the region by about 2020.

North American liquids production is projected to rise by more than 10 MBDOE through 2040 — an increase of more than 65 percent — while demand declines by about 1 MBDOE, mostly due to efficiency gains in light-duty transportation.

The combination of robust production growth and receding demand would eliminate North America's need to draw on global liquid balances. **This does not mean there won't be imports in North America — just that such transactions will be driven by reasons other than an overall gap between local demand and supply.**

For example, within North America, rising oil sands production will enable Canada to continue exporting its surplus heavy crude to the U.S., whose refining system generally is designed to process heavier grades of crude. Meanwhile, within the U.S., the projected steep growth in production of tight oil, which is very light, would likely create a surplus of light crude. However, a longstanding U.S. ban on crude exports currently limits the country's export options.

Asia Pacific dominates imports

In addition to North America's emergence as a liquids exporter, the other big change in the global oil market will take place on the other side of the world, in the Asia Pacific region.

Asia Pacific is already the world's largest oil-importing region. **But through 2040, Asia Pacific's net imports are projected to rise by nearly 80 percent.** Nearly all of these imports will continue to come from countries outside the region. Liquids production in the region is expected to stay relatively flat, but demand is seen rising by about 50 percent as economic growth and a rising middle class create new demand for oil for transportation and other uses.

A significant portion of this increased activity will be centered in China, where the percent of liquids demand met by imports is projected to rise to about 75 percent by the middle of *The Outlook* period, compared to about 55 percent today. One reason is a projected 20 percent decline in China's liquids production over *The Outlook* period.

Europe is expected to remain the second-largest oil importing region through 2040, with production and demand both showing moderate declines through *The Outlook* period.

Middle East and Russia/Caspian remain the largest exporters

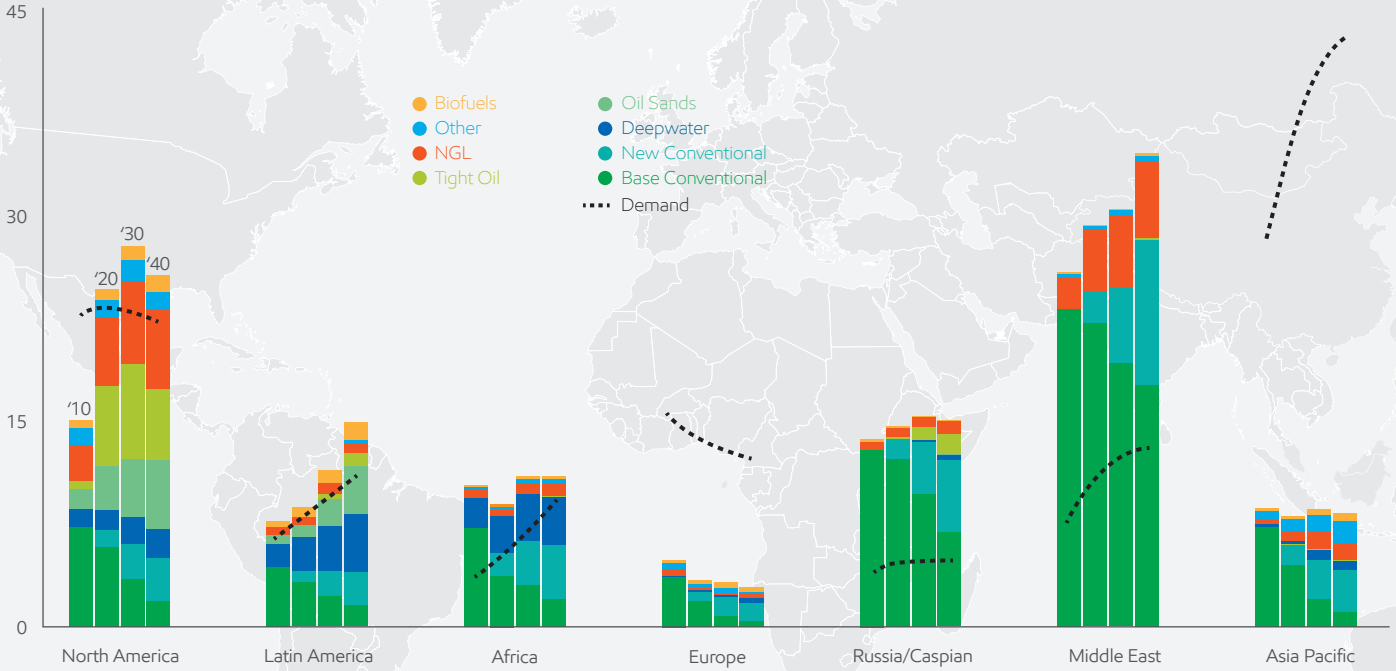
The Middle East and Russia/Caspian regions are the most prominent sources of liquids exports today. These regions are projected to continue to provide the largest share of liquids exports through 2040.

In addition, Latin America's liquids production is expected to nearly double through 2040, with growth driven by the expansion of deepwater and unconventional supplies. We expect this growth to enable a tripling of exports from Latin America, which will help balance global demand.

In Africa, liquids production is expected to benefit from deepwater and conventional developments. However, strong regional demand growth is likely to mean that Africa will not contribute as much to the international liquids trade after the middle of *The Outlook*. Liquids demand in Africa is expected to rise by nearly 160 percent due to economic growth and rising living standards. For example, in Nigeria, demand for liquid fuels for transportation is projected to more than triple over *The Outlook* period — the fastest rate of increase of any of the Key Growth countries.

Liquids production and demand by region

MBDOE

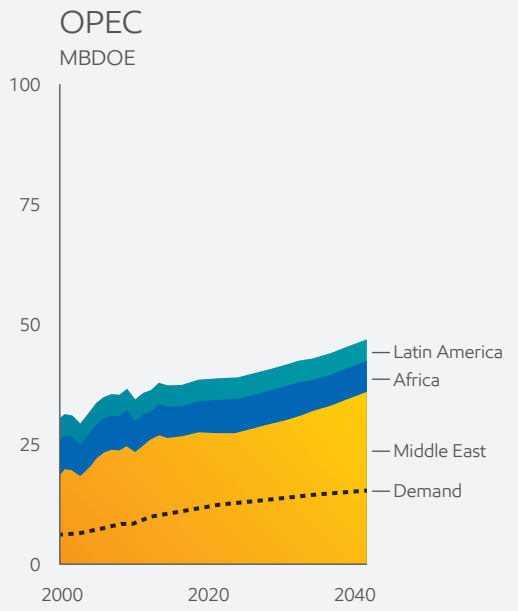


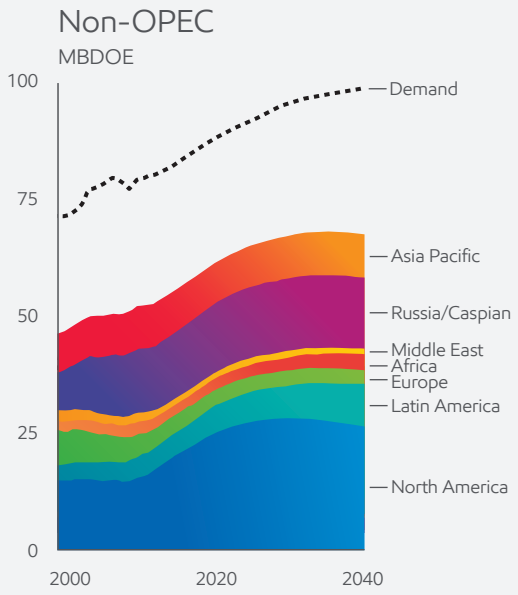
Expansion in OPEC exports

Exports from Organization of the Petroleum Exporting Countries (OPEC) member nations will remain essential to meeting global oil demand. About one-third of non-OPEC oil demand was met by OPEC imports in 2010 and that percentage is expected to remain at similar levels over *The Outlook*.

Non-OPEC liquids production is projected to rise by more than 25 percent — from less than 55 MBD in 2010 to more than 65 MBD in 2040 — mostly due to growth in Latin America and North America, especially during the first half of *The Outlook* period. However, non-OPEC demand is expected to grow toward a wider margin. As a result, we see the "call on OPEC" rising from 27 MBD in 2010 to about 33 MBD in 2040, although most of this growth occurs after 2025.

Among OPEC members, Middle East nations will continue to dominate, with their production accounting for about three quarters of total OPEC supply in 2040. In some OPEC nations — such as Saudi Arabia, Iran and Nigeria — rising domestic demand will reduce the amount of oil available for export.





Natural gas rises in prominence

The IEA has called this era "the golden age of natural gas," and for good reason. Consumers are increasingly choosing natural gas for its versatility, efficiency and availability as well as its cleaner-burning properties. **Global demand for natural gas is projected to rise by 65 percent from 2010 to 2040, the largest volume growth of any energy source.** We expect half of that increase will come from the Asia Pacific region, particularly China.

Natural gas resources are abundant and geographically diverse. Like oil, estimates of recoverable gas have grown over the last decade as the application of horizontal drilling and hydraulic fracturing technology has enabled economic extraction of unconventional gas resources that were previously considered too difficult or too costly to produce. The IEA estimates the world's remaining recoverable natural gas resources to be about 28,500 trillion cubic feet (TCF) as of year-end 2013 — more than 200 times the natural gas the world currently consumes in a year.

Global unconventional gas production nearly quadruples

Natural gas production is projected to grow in almost all regions. Through 2040, a significant portion of this growth is likely to come from unconventional natural gas, particularly the shale gas produced in North America.

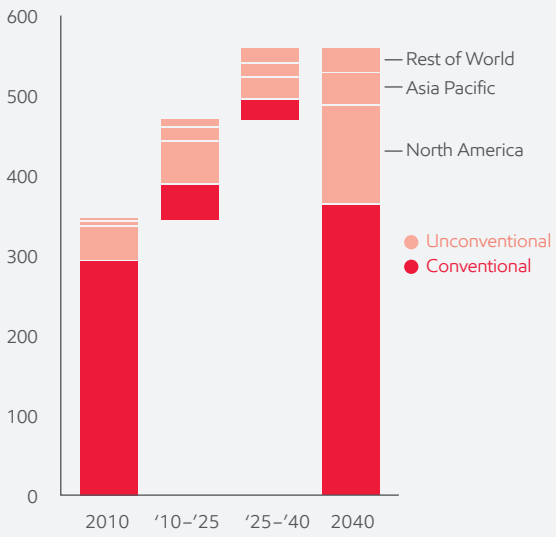
From 2010 to 2013, North American unconventional gas production (primarily in the U.S.) grew by more than 30 percent to almost 55 billion cubic feet per day (BCFD), on par with Asia Pacific's total gas production. Within a few years, North America's unconventional gas output is expected to exceed the Middle East's total gas production. Around 2020, North America is expected to surpass Russia/Caspian as the largest gas-producing region. Over *The Outlook* period, North America's natural gas production is projected to grow by about 75 percent, to around 140 BCFD, as its unconventional gas production nearly triples.

Unconventional natural gas

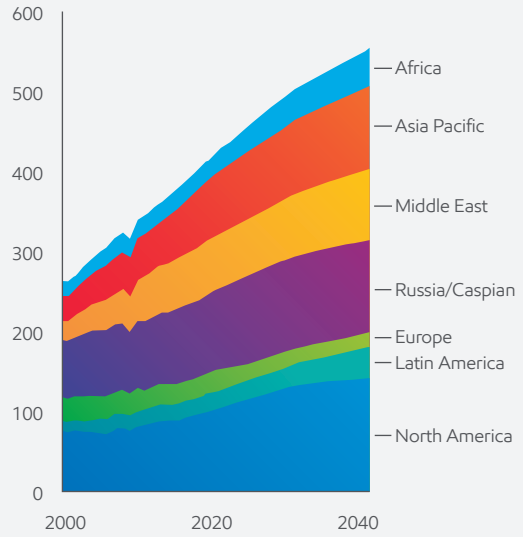
Unconventional gas generally refers to natural gas located in shale and other dense rock formations. Unconventional resources require the application of external stimulation to enable hydrocarbons to flow at economic rates. Hydraulic fracturing, which cracks underground source rock to release gas or oil embedded within it, is one such form of external stimulation that has been safely used by the oil and gas industry for more than 60 years.

The combination of hydraulic fracturing with horizontal drilling has unlocked North America's unconventional gas. Over the past decade, these technologies have enabled rapid expansion of production from North America's substantial unconventional gas resources, more than compensating for declines in conventional gas production in the region. More recently, these technologies have been successfully applied to oil as well.

Gas production by resource type



Gas production by region



Technologies to extract unconventional gas are being applied in other regions too, particularly Asia Pacific and Latin America. We forecast unconventional gas development in all regions, although the pace and scale of growth are not expected to match North America's due to differences in geology, governing policies, supporting infrastructure, market maturity and development economics. In Asia Pacific, which will see the fastest rate of growth in natural gas production of any region, unconventional gas is expected to account for 80 percent of production growth after 2025.

Globally, two-thirds of the increase in natural gas demand through 2040 is forecast to be met by unconventional gas. By 2040, unconventional supplies are expected to account for 35 percent of global gas production, up from 15 percent in 2010. Nonetheless, investments to maintain and expand conventional gas production also are critical to meeting the world's demand for natural gas. Conventional gas production should continue to account for the majority of growth in Russia/Caspian, the Middle East and Africa. Conventional production is expected to grow in all regions except North America and Europe.

"We are entering the age of much more efficient natural gas markets, with additional benefits for energy security."

— Maria van der Hoeven, executive director, IEA

Trade – a growing role in gas supply

Each region will continue to rely on a unique mix of domestic and imported supply to meet its natural gas needs through 2040. But several major trends are anticipated: **Asia Pacific will likely overtake Europe as the world's largest gas importer; North America is expected to emerge as an exporter of natural gas; and Russia/Caspian is forecast to remain a significant gas supplier.**

Expanding trade in LNG will create new connections between producers and consumers. Through 2040, LNG trade is expected to more than triple to nearly 100 BCFD. Most of this growth will serve existing demand in Europe and rapidly growing gas demand in Asia; however, Latin America and Africa also are expected to see expanded LNG imports.

Interregional pipeline exports are forecast to double, with Asia Pacific joining Europe as a significant interregional pipeline importer.

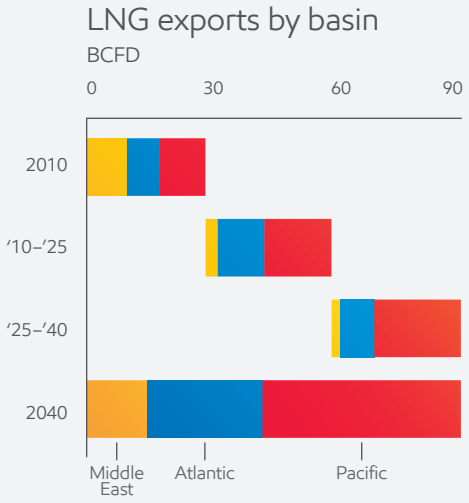
While gas trade is expected to grow, the majority of natural gas needs still will be met by local production, which is projected to supply three-quarters of global natural gas usage in 2040, compared to 85 percent in 2010.

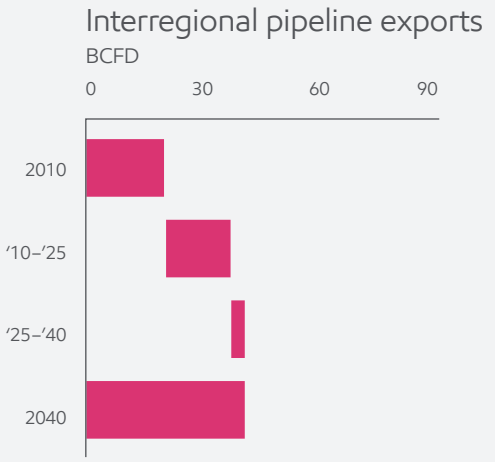
4x unconventional gas quadruples

3x LNG trade triples

2x interregional pipeline trade doubles

From 2010 to 2040





LNG helps meet surging demand in Asia Pacific

In 2010, about 30 percent of the natural gas used within the Asia Pacific region was imported. By 2040, we expect that number to surpass 50 percent. Although natural gas production in the region is expected to double over *The Outlook* period, even that robust growth will not keep pace with strong local demand, which is expected to rise by more than 100 BCFD.

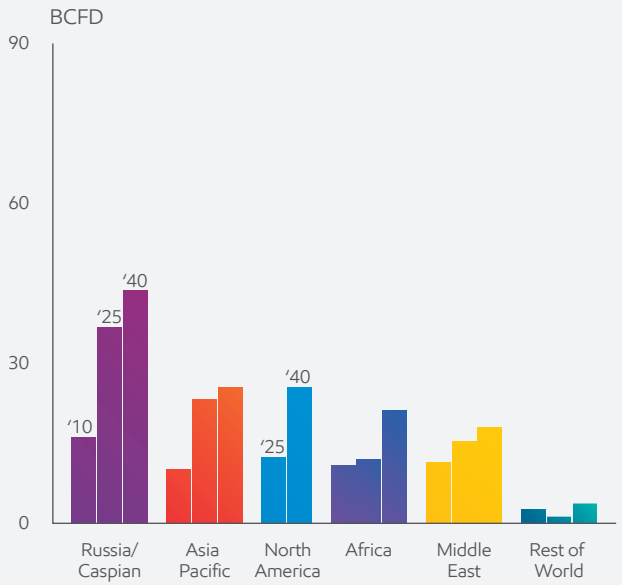
Eighty percent of the projected growth in imports in Asia Pacific is seen coming from LNG, although much of that LNG — 50 percent in 2025 and about 35 percent by 2040 — could come from within the region. The significance of LNG in Asia Pacific is not surprising considering that the region spans two continents and has many island nations.

Despite this projected growth in domestic production and imports, in 2040 Asia Pacific is forecast to remain the region with the lowest penetration of natural gas in its primary energy mix.

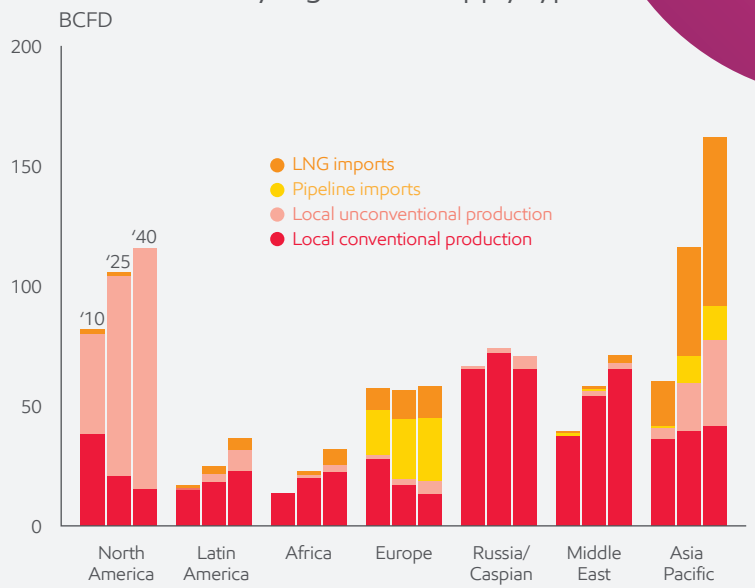
50%

By 2040, nearly 50 percent of demand for natural gas will be met by LNG imports or local production of unconventional gas

Gas export by region



Gas demand by region and supply type



North America shifts to net exporter

In North America, unconventional gas already has transformed the energy landscape, and its importance to the region will only grow in coming decades. By 2040, unconventional production is expected to meet 85 percent or more of North American gas demand. Gas demand is forecast to rise in North America through 2040 due in part to electricity generators and manufacturers taking advantage of abundant, cost-competitive unconventional gas supply.

In North America, gas demand is projected to grow by more than 40 percent from 2010 to 2040. Even so, the unconventional gas production outlook is so robust that supply is forecast to exceed local demand by a wide margin. **By 2025, we expect North America to be a significant natural gas exporter; by 2040, North America could even rival Asia Pacific's LNG exports.**

This shift, unthinkable a decade ago, is a remarkable example of the combined potential of technology and trade to enhance global energy and economic prosperity.

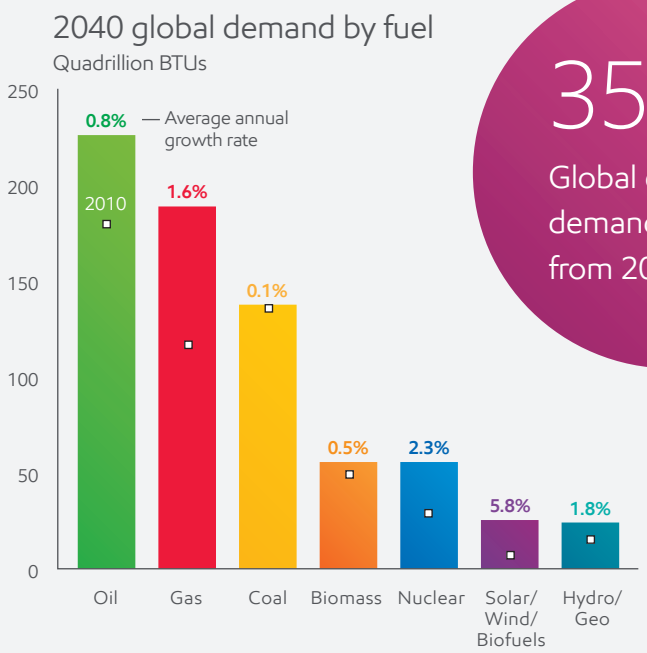
Gas grows in the Middle East, Africa and Latin America

The Middle East, Africa and Latin America all are forecast to see rising gas production through 2040, fueled by strong growth in local natural gas demand as well as export opportunities. In the Middle East, about 80 percent of current and future gas production is likely to serve domestic demand, while 20 percent will be exported.

In both Africa and Latin America, gas production is expected to nearly double through 2040. Both regions also are forecast to supplement local production with LNG imports. By 2040, LNG imports will likely meet about 20 percent of demand in Africa and 10 percent in Latin America. Interestingly, both regions are expected to play growing roles in gas exports, particularly Africa in the second half of *The Outlook* period. The fact that several regions are both importers and exporters of natural gas highlights the important role of trade in optimizing energy flows in a global marketplace.

Russia/Caspian remains largest exporter

In the Russia/Caspian region, we expect almost all the growth in gas production will be destined for the export market. Strategically located between Europe and Asia Pacific, Russia/Caspian is expected to expand exports by more than 25 BCFD from 2010 to 2040, primarily via pipeline but also via planned LNG export facilities. By 2040, interregional exports are forecast to be almost 40 percent of Russia/Caspian's gas production, up from about 20 percent in 2010. It's also estimated that about one-third of all interregional gas exports will come from this region.



35%

Global energy demand increase from 2010 to 2040

Oil

Oil is expected to remain the No. 1 energy source, with demand rising by almost 30 percent due to growth in commercial transportation and the chemicals industry's need for feedstock. Among major oil products, we expect diesel and jet fuel to grow sharply, while gasoline remains essentially flat.

Natural Gas

Natural gas is expected to see demand growth of about 65 percent, rising into second place as a wide range of consumers — particularly utilities and industrial manufacturers — choose gas for its low emissions and its versatility as a fuel and feedstock. Gas is also emerging as a fuel for transportation.

Coal

With demand for coal expected to be about the same in 2040 as in 2010, coal's share of the global energy market is seen shrinking from about 25 percent in 2010 to less than 20 percent in 2040 as China follows OECD nations in shifting toward cleaner-burning fuels. Coal remains the No. 1 fuel for power generation.

Biomass

Rising incomes and urbanization will enable a shift away from traditional biomass fuels such as wood and charcoal, particularly in Asia, where biomass' share of residential energy is projected to drop from 55 percent to 30 percent. Biomass fuels are inefficient and pose a threat to human health, particularly for women and children.

Nuclear

Nuclear energy is expected to grow more than twice as fast as overall energy demand as many nations expand nuclear capacity to address energy security and climate concerns. Growth is strongest in Asia Pacific, including China and India.

Solar/Wind/Biofuels

Solar and wind will grow briskly in the power generation sector, while biofuels expand modestly in transportation, supported by government policies to curb GHG emissions. By 2040, these renewable fuels are expected to be approaching 4 percent of global energy demand. More rapid growth is limited by several factors; in the case of solar and wind, the biggest limitations are cost and intermittency.

Hydroelectric/Geothermal

Hydropower is an important source of electricity generation in many areas. More than a dozen countries, including Norway, Brazil, Canada and several African countries, get 50 percent or more of their electricity from hydro. By 2040, hydropower is expected to account for about 15 percent of global electricity needs. Geothermal will continue to be used in geologically active areas, but growth is expected to be limited by cost.

Oil resources: then and now

Current recoverable resources are enough to meet the world's need for oil beyond the 21st century. Today, as in years past, improvements in exploration and production technologies continue to open doors to new oil and liquid resources.

When the first modern oil well was drilled in Pennsylvania in 1859, many believed the state's oil resources were isolated geological anomalies. In 1885, Pennsylvania's state geologist said oil was a "temporary and vanishing phenomenon." The discovery of the California oil fields in the early 1900s, and the Spindletop field in East Texas in 1901, although significant at the time, were expected to provide only limited supply. Resources discovered in the Middle East and elsewhere in the mid-20th century significantly increased global resource estimates, but some continued to believe these resources were ephemeral.

Geoscientist M. King Hubbert famously predicted that U.S. oil production would peak between 1965 and 1970 and then decline steadily. But U.S. output of crude and condensate continued to rise through 1985, reaching almost 9 MBD. When production began to decline after 1985, it looked to some as if Hubbert had been correct, if two decades off in his timing.

However, U.S. oil production is back on the upswing as a result of unconventional technologies that have unlocked the region's vast supply of tight oil. From 2008 to 2013, U.S. crude production grew by 50 percent — from 5 MBD to almost 7.5 MBD — and within the next few years is expected to surpass the "peak" it saw in the 1980s.

Growing recoverable resources

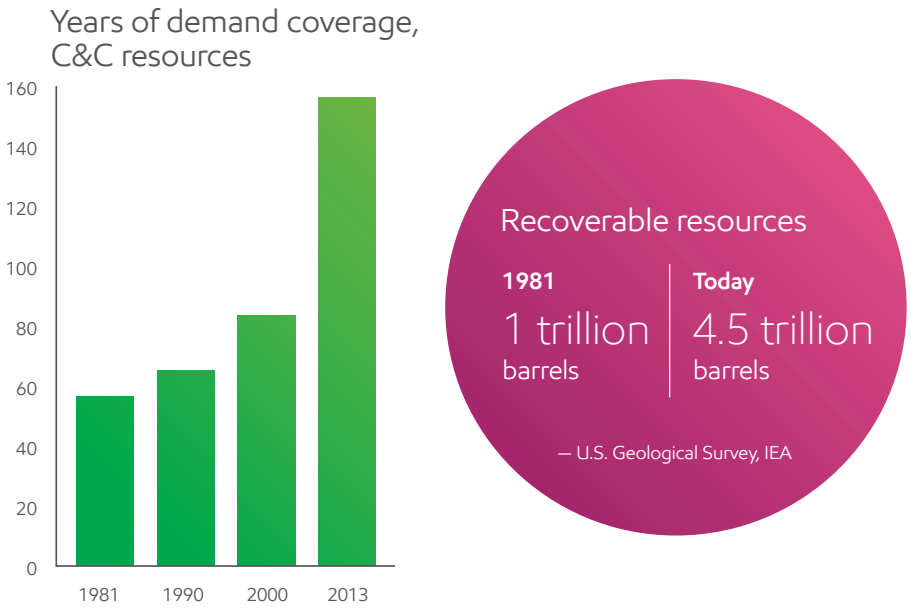
In terms of assessing mankind's ability to meet future oil demand, what matters is not how much oil is in the ground (a fixed, although unknown number), but how much of that resource is technically recoverable (a number that changes over time). The U.S. Geological Survey's estimate of total remaining global recoverable crude and condensate resources has grown from about 1 trillion barrels in the 1980s to about 4.5 trillion barrels today.

Advances in technology have enabled this growth. One example is the discovery of deepwater resources and the development of technology to produce them. Another is Canadian oil sands. Early on, recovery factors for in-situ (non-surface mined) oil sands were estimated as likely to be around 10 percent, but these estimates have more than quadrupled by application of advanced technologies.

More recently, unconventional production technologies, like hydraulic fracturing and horizontal drilling, have unlocked significant resources of oil and natural gas liquids that will help supply global markets for many decades.

Even today, only about 5 to 10 percent of unconventional — or "tight" — oil resources are considered recoverable, which would leave significant quantities available for possible future development. In addition, tight oil resources have yet to be tested and developed in significant quantities outside the U.S. As international tight oil production expands in coming years, there is the likelihood that this activity will result in upward revisions of global estimated recoverable tight oil resources.

Furthermore, there are known resources that cannot be economically produced today — and so are not included in the technically recoverable resource estimates — but may be developed in the future. For example, kerogen oil — also known as oil shale — is an abundant resource. This resource contains organic-rich matter that is the source material for petroleum. The IEA estimates 1.1 trillion barrels of potentially recoverable kerogen oil — over 30 years of additional supply. Other technologies include coal to liquids or gas to liquids, which transform coal and natural gas into liquid products — and would provide liquids fuels for centuries. And there may yet be unknown types of resources in new locations that can be developed with new technology.



Recoverable resources

1981
1 trillion
barrels

Today
4.5 trillion
barrels

— U.S. Geological Survey, IEA

Growth in the years of coverage

These human innovations continue to extend "years of coverage" — the amount of time resources would last given current demand.

In 1981, the USGS estimated there was less than 60 years' worth of recoverable crude and condensate. By year-end 2013, years-of-coverage had more than doubled, to over 150 years. This growth is even more remarkable considering that about three decades worth of C&C had been consumed during that period, and the fact that demand in 2013 was significantly higher than in 1981. In fact, had the 2013 C&C resource assessment been applied in 1981, there would have been an estimated 250 years of coverage at that year's demand.

Another important factor is energy efficiency. Better efficiency in all oil-consuming demand sectors, particularly transportation, continues to reduce the amount of oil needed to meet the needs of people and economies. Whether driven by political mandates, technological advances or consumer choices, the net effect of efficiency is to reduce demand growth. Ultimately, this extends the lifespan of the world's oil resources.

Global demand for oil and liquids already is more than 90 million barrels per day, and we expect it to rise by almost 30 percent from 2010 to 2040. As history has shown, from the early days of U.S. production to recent developments in unconventional oil and gas, technology will continue to unlock new sources of energy to meet demand. The only uncertainty is what — and where — the next technology breakthrough will be.

Energy

and human progress

The wide disparities in living conditions around the world reflect, to a large degree, ongoing but uneven penetration of radical advances in technology over the last couple of centuries. These advances, coupled with modern energy and growing trade, have transformed life for billions of people by substantially improving access to clean water, clean air, comfortable shelter, food, health care, education and transportation.

Questions about how to extend and accelerate this progress for billions more are a prominent feature of discussions around the world today. Surely answers will be found through human ingenuity and the practical choices people make to advance prosperity.

The drivers of progress

People have long labored to achieve better living conditions, yet only in recent centuries have living standards improved dramatically. Certainly, the progress since the 1700s was not planned or predicted. So what accounts for the revolutionary changes the world has seen? Looking back, we attribute this remarkable human progress to three interwoven elements: technology, energy and trade.

Technology

The first element – technology – is really a story of ingenuity, one of the great abilities that people possess to solve problems and improve life. Early technological progress showed up in the form of sailing vessels, waterwheels and windmills. However, it was in the 1700s that the modern technology age got underway, with prominent inventions including the steam engine. This advance was followed in the 1800s by internal combustion engines, which led to much greater mobility for freight and people. Of course, the 20th century was dominated by innovations in everything from manufacturing to modern medicine, as well as information systems powered by electricity.

Energy

Huge demand for these advanced technologies reflected their obvious value, which in turn prompted a rapid evolution in the second vital ingredient in enabling progress: energy. Building up reliable energy supplies to pair with emerging technologies became paramount. This evolution was unprecedented, requiring not only new types of energy but also delivery of that energy in a manner convenient for consumers. Early on, coal proved valuable in replacing wood. Not far behind was the growing prevalence of oil products to fuel emerging fleets of ships, trucks, cars and airplanes. More recently, natural gas, nuclear and renewables have gained prominence to meet growing electricity needs.

Trade

The third element essential to human progress — trade — is arguably the one that has been at work the longest. By the time Adam Smith's economic treatise, *The Wealth of Nations*, was published in 1776, entrepreneurs were beginning to flourish and the seeds of the Industrial Revolution were in place. Trade is the natural avenue by which new technologies and their benefits are propagated around the world, creating and capturing value that would not exist otherwise.

The factors driving human progress in recent history provide a guide to aid our path forward. Gains in technology, energy and trade will remain essential and should be promoted. This is vital to maximizing economic opportunities, expanding access to energy and technology, and boosting living standards the world over.

The past 15 years

The Outlook for Energy is developed annually by ExxonMobil as a foundation for our business strategies and investments. Developing accurate predictions about energy is challenging. This is particularly true today given the world's growing complexity, which reflects not only remarkable advances in technology but also increased globalization and continuing shifts in socioeconomic conditions.

In just the last 15 years, we have seen a huge surge in China's development, a global economic recession, and breakthrough technologies including those related to unconventional oil and gas. We have seen a devastating tsunami and its ripple effect on nuclear power policies. And we have seen policymakers pursue a wide range of energy and environmental initiatives. All have had significant impact on the global energy landscape.

To illustrate how *The Outlook* has held up over this period, our forecasts since the 2000 Outlook for global energy demand in the year 2010 ran fairly consistently around 500 quadrillion BTUs, averaging about 510 quads, or about 3 percent below actual 2010 results. (Note that historical results are often restated and so only in the past two years have we had the benefit of final data for 2010 as reported by the IEA.)

The biggest change related to China, which sustained remarkable economic growth far longer than we (and others) thought likely. This led to another shift related to coal – almost exclusively due to growth in China, particularly for electricity generation. The average of our oil demand estimates for 2010 since the 2000 *Outlook* was about 2 percent above actual 2010 results. Our natural gas projections showed some volatility from year to year, but actual 2010 demand ended up within 1 percent of the average of our forecasts. Our projections of 2010 demand for nuclear and renewables were fairly stable.

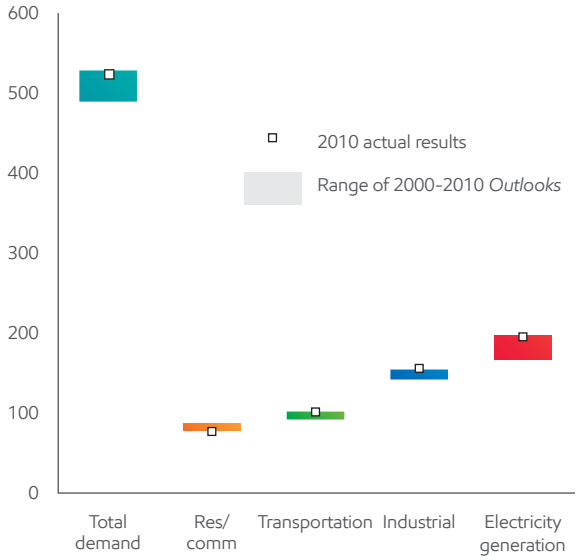
The reappraisal of our past *Outlooks* underscores the importance of keeping a close watch on underlying fundamentals, the need to effectively weigh longer-term implications of market disruptions or potential policy initiatives, and the huge value in understanding the potential of emerging technologies.

Nowhere is this last element more evident today than in the impact of unconventional oil and gas production technologies. These advances have helped to rapidly change long-held perspectives about energy scarcity by opening up abundant new supply options (see page 58, "Oil resources: then and now," for more details).

Worldwide primary energy

Range of estimates vs. actual results for 2010

Quadrillion BTUs by sector



Practical choices

Humanity's remarkable progress over the past century has been due in no small part to the expansion of modern energy. In fact, energy is so integral to better living standards that the United Nations, the World Health Organization and the World Bank all consider energy access and usage key indicators of development.

As *The Outlook* shows, people's desire for a better life — and their capacity for innovation — are expected to drive unprecedented gains in global living standards through 2040.

As many as 3 billion people are expected to rise into the middle class — meaning many will be able to enjoy lifestyle benefits such as safer and more comfortable homes, greater mobility, good jobs, better health and more time for leisure activities. This transition will be enabled — as it has in the past — by growing access to modern technology and reliable energy.

At the same time, people in nations with more advanced economies will continue to need energy to sustain their living standards and fuel economic growth. And the global population will likely rise from 7 billion to nearly 9 billion by 2040.

With more people using energy to improve their lives, we estimate that global energy demand will be 35 percent higher in 2040 than it was in 2010.

Meeting energy demand safely, reliably and affordably — while also minimizing risk and environmental impact — will require advanced technology and expanded trade and investment. It will require innovation. And it also will require smart, practical energy choices by governments, individuals and businesses.

This has always been the case. But the increasingly dynamic nature of our world poses new challenges. The pace of change in technology development, information sharing, and economic opportunities and challenges is accelerating. There are more buyers, more sellers, more choices, more competition — and more options — than ever before. In this environment, free markets and free trade are vital. They foster open, competitive playing fields that enable individuals and society to quickly adopt new technologies, pursue new business ventures, and buy and sell whatever goods they may need — including energy. This freedom expands economic opportunities for people and therefore helps create wealth and boost living standards.

Ongoing progress poses the dual challenge of meeting the world's energy needs while managing the environmental effects — including climate change — of energy use. There is no single or simple solution to this challenge. The reality is that abundant energy enables modern life, and greater access to energy is fundamental to reducing poverty and advancing standards of living for billions of people. The responsible course of action requires meeting this imperative of human progress while also enacting public policies that promote the search for meaningful solutions to the risks of climate change.

Government can facilitate development, economic growth and environmental protection through policies that promote free trade and open markets — as well as innovation, private investment and general prosperity. To aid in long-term planning and investment, policy frameworks should be transparent and predictable, with general rules that are easy to understand and applied consistently. Sound regulatory and permitting processes are also important to facilitating investment.

At the same time, energy consumers — businesses and individuals — will continue to exert tremendous influence on energy trends through their choices regarding the amount and type of energy they use. In most cases, consumers will choose whichever energy provides the most value in meeting their needs. But technology can expand and reshape those choices. One example is the tremendous growth we project in hybrid cars through 2040 as they become cost-competitive with conventional vehicles.

Other innovators, entrepreneurs and investors also will continue to play a key role, as will the energy industry itself. The IEA has estimated that meeting global energy demand will require about $66 trillion in investment through 2040. Our industry remains committed to expanding energy choices through technological innovation, responsible operations and sustained investment in energy.

Understanding the factors that drive the world's energy needs — and likely choices to meet those needs — is the mission of *The Outlook*. By sharing *The Outlook* with the public, we hope to broaden that understanding among individuals, businesses and governments. Because energy matters to everyone, and we all play a role in shaping its future.

Glossary

Billion cubic feet per day (BCFD) This is used to define volumetric rates of natural gas. One billion cubic feet per day of natural gas is enough to meet about 2 percent of the natural gas used in homes around the world. Six billion cubic feet per day of natural gas is equivalent to about 1 million oil-equivalent barrels per day.

British thermal unit (BTU) A BTU is a standard unit of energy that can be used to measure any type of energy source. The energy content of one gallon of gasoline is about 125,000 BTUs. "Quad" refers to a quadrillion BTUs.

Hydrogen fuel cell vehicle A type of light-duty vehicle where the fuel is hydrogen contained in a 10,000 psi tank. This hydrogen is passed through a fuel cell that then provides electricity to power the vehicle.

Key Growth A grouping of 10 countries expected to represent an increasingly significant share of the global energy market due to rising populations and living standards. These countries include Brazil, Egypt, Indonesia, Iran, Mexico, Nigeria, Saudi Arabia, South Africa, Thailand and Turkey.

Light-duty vehicle (LDV) A classification of road vehicles that includes cars, light trucks and sport-utility vehicles (SUV).

Liquefied natural gas (LNG) Natural gas (predominantly methane) that has been super-chilled for conversion to liquid form for ease of transport.

Liquefied petroleum gas (LPG) A classification of hydrocarbon fuel including propane, butane and other similar hydrocarbons with low molecular weight.

Million oil-equivalent barrels per day (MBDOE) This term provides a standardized unit of measure for different types of energy sources (oil, gas, coal, etc.) based on energy content relative to a typical barrel of oil. One million oil-equivalent barrels per day is enough energy to fuel about 5 percent of the light-duty vehicles on the world's roads today.

Natural Gas Liquids (NGL) A liquid fuel produced in association with natural gas. NGLs are components of natural gas that are separated from the gaseous state into liquid form during natural gas processing.

Organisation for Economic Co-operation and Development (OECD) A forum of 34 member nations that promote policies that will improve the economic and social well-being of people around the world.

OECD32 Although Mexico and Turkey are OECD member countries, their significant population, economic and energy demand growth closely resemble that of the other countries in the Key Growth group so they have been included there. As such, the OECD32 is used to denote the remaining countries of the OECD when a comparison to the Key Growth countries is made.

Plug-in Hybrid Electric Vehicle (PHEV) A type of light duty vehicle that uses an electric motor to drive the wheels. Unlike other electric vehicles, a PHEV also has a conventional internal combustion engine (ICE) that can charge its battery using petroleum fuels if needed.

Primary energy Includes energy in the form of oil, natural gas, coal, nuclear, hydro, geothermal, wind, solar and bioenergy sources (biofuels, municipal solid waste, traditional biomass). It does not include electricity or market heat, which are secondary energy types reflecting conversion/production from primary energy sources.

Secondary energy Energy types reflecting the conversion or production of energy from primary energy sources such as electricity produced using natural gas.

Watt A unit of electrical power, equal to one joule per second. A 1-gigawatt power plant can meet the electricity demand of more than 500,000 homes in the U.S. (Kilowatt (kW) = 1,000 watts; Gigawatt (GW) = 1,000,000,000 watts; Terawatt (TW) = 10^{12} watts). 300 terawatt hours is equivalent to about 1 quadrillion BTUs (Quad).

Data

Energy demand (quadrillion BTUs)						Average annual change			% change			Share of total		
Regions	1990	2000	2010	2025	2040	2010 2025	2025 2040	2010 2040	2010 2025	2025 2040	2010 2040	2010	2025	2040
World	360	418	526	662	717	1.6%	0.5%	1.0%	26%	8%	36%	100%	100%	100%
OECD	190	226	231	232	222	0.0%	-0.3%	-0.1%	0%	-4%	-4%	44%	35%	31%
Non-OECD	170	193	294	431	495	2.6%	0.9%	1.7%	46%	15%	68%	56%	65%	69%
Africa	17	22	29	43	59	2.5%	2.2%	2.4%	46%	38%	101%	6%	6%	8%
Asia Pacific	90	128	202	294	324	2.5%	0.6%	1.6%	46%	10%	61%	38%	44%	45%
China	34	47	97	153	154	3.1%	0.1%	1.5%	57%	1%	59%	18%	23%	21%
India	13	19	29	50	66	3.6%	1.9%	2.8%	71%	33%	128%	6%	8%	9%
Europe	74	78	82	77	72	-0.4%	-0.4%	-0.4%	-6%	-6%	-12%	16%	12%	10%
European Union	68	72	74	67	62	-0.6%	-0.6%	-0.6%	-9%	-8%	-16%	14%	10%	9%
Latin America	15	20	27	37	47	2.2%	1.5%	1.9%	39%	25%	74%	5%	6%	7%
Middle East	11	18	30	45	53	2.8%	1.2%	2.0%	51%	20%	81%	6%	7%	7%
North America	95	114	113	118	115	0.3%	-0.2%	0.0%	4%	-3%	1%	22%	18%	16%
United States	81	96	94	94	90	0.0%	-0.3%	-0.2%	0%	-5%	-5%	18%	14%	13%
Russia/Caspian	57	38	42	49	46	0.9%	-0.4%	0.3%	15%	-5%	9%	8%	7%	6%
Energy by type - world														
Primary	360	418	526	662	717	1.6%	0.5%	1.0%	26%	8%	36%	100%	100%	100%
Oil	137	157	178	212	228	1.2%	0.5%	0.8%	19%	7%	28%	34%	32%	32%
Gas	72	89	116	158	189	2.1%	1.2%	1.6%	37%	19%	63%	22%	24%	26%
Coal	86	93	135	164	138	1.3%	-1.1%	0.1%	22%	-16%	2%	26%	25%	19%
Nuclear	21	27	29	38	56	1.9%	2.7%	2.3%	32%	49%	97%	5%	6%	8%
Biomass/waste	36	41	49	56	56	0.9%	0.0%	0.5%	14%	1%	15%	9%	8%	8%
Hydro	7	9	12	16	20	2.3%	1.3%	1.8%	40%	21%	70%	2%	2%	3%
Other renewables	1	3	7	18	29	6.3%	3.4%	4.8%	149%	65%	311%	1%	3%	4%
End-use sectors - world														
Residential/commercial														
Total	87	98	115	135	147	1.1%	0.5%	0.8%	17%	9%	27%	100%	100%	100%
Oil	13	16	15	16	16	0.4%	-0.1%	0.2%	6%	-1%	5%	13%	12%	11%
Gas	17	21	25	29	31	1.1%	0.5%	0.8%	18%	7%	26%	21%	21%	21%
Biomass/waste	26	29	33	34	31	0.2%	-0.6%	-0.2%	2%	-9%	-7%	29%	25%	21%
Electricity	16	23	32	45	59	2.3%	1.8%	2.1%	41%	30%	84%	28%	33%	40%
Other	15	10	11	11	10	0.3%	-0.6%	-0.1%	5%	-8%	-4%	9%	8%	7%
Transportation														
Total	65	81	100	122	140	1.3%	0.9%	1.1%	22%	15%	40%	100%	100%	100%
Oil	64	79	96	113	124	1.1%	0.6%	0.9%	18%	10%	30%	95%	92%	88%
Biofuels	0	0	3	5	7	3.8%	3.0%	3.4%	75%	56%	174%	3%	4%	5%
Gas	0	0	1	4	7	9.7%	4.8%	7.2%	303%	102%	716%	1%	3%	5%
Other	1	1	1	1	2	2.1%	2.1%	2.1%	37%	36%	87%	1%	1%	1%
Industrial														
Total	139	151	193	254	269	1.8%	0.4%	1.1%	31%	6%	39%	100%	100%	100%
Oil	45	50	58	73	80	1.6%	0.6%	1.1%	27%	9%	38%	30%	29%	30%
Gas	31	37	45	60	70	2.0%	1.0%	1.5%	34%	16%	56%	23%	24%	26%
Coal	29	27	43	52	40	1.3%	-1.7%	-0.2%	22%	-23%	-6%	22%	21%	15%
Electricity	18	22	31	47	58	3.0%	1.4%	2.2%	55%	23%	90%	16%	19%	22%
Other	16	14	17	21	21	1.3%	0.1%	0.7%	21%	2%	23%	9%	8%	8%
Power generation - world														
Primary	118	144	192	258	291	2.0%	0.8%	1.4%	34%	13%	51%	100%	100%	100%
Oil	14	12	10	10	8	0.1%	-1.2%	-0.5%	2%	-16%	-15%	5%	4%	3%
Gas	24	31	46	65	81	2.4%	1.4%	1.9%	44%	23%	77%	24%	25%	28%
Coal	48	62	88	108	95	1.4%	-0.8%	0.3%	23%	-12%	9%	46%	42%	33%
Nuclear	21	27	29	38	56	1.9%	2.7%	2.3%	32%	49%	97%	15%	15%	19%
Hydro	7	9	12	16	20	2.3%	1.3%	1.8%	40%	21%	70%	6%	6%	7%
Wind	0	0	1	5	10	10.9%	4.4%	7.6%	370%	90%	792%	1%	2%	4%
Other renewables	3	4	8	14	21	4.2%	2.4%	3.3%	85%	42%	163%	4%	6%	7%
Electricity demand (terawatt hours)														
World	10135	13202	18558	27425	34746	2.6%	1.6%	2.1%	48%	27%	87%	100%	100%	100%
OECD	6656	8603	9703	10897	11883	0.8%	0.6%	0.7%	12%	9%	22%	52%	40%	34%
Non-OECD	3478	4599	8856	16528	22863	4.2%	2.2%	3.2%	87%	38%	158%	48%	60%	66%

Energy demand (quadrillion BTUs) OECD Energy by type	1990	2000	2010	2025	2040	Average annual change 2010 2025	 2025 2040	 2010 2040	% change 2010 2025	 2025 2040	 2010 2040	Share of total 2010	 2025	 2040
Primary	190	226	231	232	222	0.0%	-0.3%	-0.1%	0%	-4%	-4%	100%	100%	100%
Oil	85	98	94	88	80	-0.4%	-0.6%	-0.5%	-6%	-9%	-15%	41%	38%	36%
Gas	35	47	54	65	70	1.2%	0.5%	0.9%	20%	8%	30%	23%	28%	32%
Coal	42	43	42	31	17	-2.0%	-3.9%	-2.9%	-26%	-45%	-59%	18%	13%	8%
Nuclear	18	23	24	24	27	0.1%	0.7%	0.4%	1%	12%	13%	10%	10%	12%
Biomass/waste	6	7	9	10	9	0.7%	-0.5%	0.1%	11%	-7%	3%	4%	4%	4%
Hydro	4	5	5	5	5	0.5%	0.3%	0.4%	8%	4%	12%	2%	2%	2%
Other renewables	1	2	4	9	14	5.0%	2.9%	3.9%	107%	53%	216%	2%	4%	6%
End-use sectors														
Residential/commercial														
Total	39	46	50	50	49	0.0%	-0.1%	-0.1%	0%	-2%	-2%	100%	100%	100%
Oil	9	9	7	6	4	-1.8%	-1.9%	-1.9%	-24%	-25%	-43%	14%	11%	8%
Gas	12	16	17	17	17	0.2%	-0.3%	-0.1%	2%	-4%	-2%	34%	34%	34%
Biomass/waste	2	2	3	2	2	-0.5%	-1.4%	-1.0%	-7%	-19%	-25%	5%	5%	4%
Electricity	12	17	21	23	24	0.6%	0.5%	0.5%	9%	8%	17%	41%	45%	49%
Other	4	2	3	2	2	-0.5%	-0.2%	-0.4%	-8%	-3%	-11%	5%	5%	5%
Transportation														
Total	45	55	58	56	54	-0.3%	-0.2%	-0.3%	-4%	-3%	-8%	100%	100%	100%
Oil	44	55	56	52	48	-0.5%	-0.5%	-0.5%	-7%	-8%	-14%	96%	93%	89%
Biofuels	0	0	2	3	3	2.2%	1.8%	2.0%	38%	31%	81%	3%	5%	6%
Gas	0	0	0	1	2	13.9%	6.2%	10.0%	602%	146%	1631%	0%	2%	4%
Other	0	0	0	0	1	0.9%	2.5%	1.7%	14%	45%	65%	1%	1%	1%
Industrial														
Total	64	72	69	74	74	0.5%	-0.1%	0.2%	8%	-1%	7%	100%	100%	100%
Oil	26	29	28	28	27	0.2%	-0.3%	-0.1%	3%	-5%	-2%	40%	38%	37%
Gas	15	18	18	22	23	1.5%	0.3%	0.9%	25%	5%	31%	26%	30%	31%
Coal	10	8	7	5	3	-2.6%	-2.7%	-2.6%	-32%	-33%	-55%	10%	6%	4%
Electricity	10	12	12	14	16	1.1%	0.7%	0.9%	18%	10%	30%	17%	19%	21%
Other	3	4	4	5	5	0.8%	-0.2%	0.3%	13%	-3%	10%	6%	7%	6%
Power generation														
Primary	67	84	90	91	89	0.1%	-0.2%	-0.1%	1%	-3%	-2%	100%	100%	100%
Oil	6	5	3	2	1	-2.6%	-3.5%	-3.0%	-32%	-41%	-60%	3%	2%	1%
Gas	8	13	20	25	28	1.6%	1.0%	1.3%	26%	15%	46%	22%	27%	32%
Coal	30	35	34	26	14	-1.8%	-4.2%	-3.0%	-24%	-47%	-60%	38%	28%	15%
Nuclear	18	23	24	24	27	0.1%	0.7%	0.4%	1%	12%	13%	26%	26%	30%
Hydro	4	5	5	5	5	0.5%	0.3%	0.4%	8%	4%	12%	5%	5%	6%
Wind	0	0	1	3	6	8.5%	4.1%	6.3%	242%	82%	521%	1%	3%	6%
Other renewables	2	3	5	7	8	2.5%	1.0%	1.8%	46%	16%	70%	5%	7%	9%

Energy demand (quadrillion BTUs) Non-OECD Energy by type	1990	2000	2010	2025	2040	Average annual change 2010 2025	 2025 2040	 2010 2040	% change 2010 2025	 2025 2040	 2010 2040	Share of total 2010	 2025	 2040
Primary	170	193	294	431	495	2.6%	0.9%	1.7%	46%	15%	68%	100%	100%	100%
Oil	52	59	85	124	148	2.6%	1.2%	1.9%	47%	19%	75%	29%	29%	30%
Gas	37	42	62	93	119	2.8%	1.6%	2.2%	51%	27%	92%	21%	22%	24%
Coal	44	50	93	133	121	2.4%	-0.6%	0.9%	43%	-9%	30%	32%	31%	24%
Nuclear	3	4	5	14	29	7.1%	5.2%	6.2%	180%	115%	500%	2%	3%	6%
Biomass/waste	30	33	40	46	47	0.9%	0.2%	0.5%	15%	2%	18%	14%	11%	10%
Hydro	3	4	7	11	15	3.2%	1.7%	2.5%	61%	29%	107%	2%	3%	3%
Other renewables	0	1	3	9	15	8.0%	3.9%	5.9%	216%	78%	462%	1%	2%	3%
End-use sectors														
Residential/commercial														
Total	48	52	65	85	97	1.8%	0.9%	1.3%	30%	15%	49%	100%	100%	100%
Oil	4	6	8	11	12	2.0%	0.7%	1.3%	34%	11%	49%	12%	13%	12%
Gas	4	5	8	12	14	2.8%	1.4%	2.1%	52%	23%	87%	12%	14%	15%
Biomass/waste	24	27	30	31	29	0.2%	-0.6%	-0.2%	3%	-8%	-5%	46%	37%	30%
Electricity	3	6	11	22	34	4.8%	2.9%	3.8%	101%	53%	209%	17%	26%	35%
Other	12	8	8	9	8	0.6%	-0.7%	0.0%	9%	-10%	-1%	12%	10%	8%
Transportation														
Total	21	26	42	67	87	3.2%	1.7%	2.5%	59%	30%	107%	100%	100%	100%
Oil	20	25	40	61	76	2.9%	1.5%	2.2%	54%	25%	92%	95%	91%	88%
Biofuels	0	0	1	2	4	6.5%	4.3%	5.4%	157%	88%	382%	2%	3%	5%
Gas	0	0	1	3	5	8.9%	4.3%	6.6%	258%	89%	577%	2%	4%	6%
Other	1	0	1	1	1	2.8%	1.9%	2.3%	52%	32%	100%	1%	1%	1%
Industrial														
Total	75	79	125	179	195	2.5%	0.6%	1.5%	44%	9%	57%	100%	100%	100%
Oil	19	21	30	45	53	2.7%	1.1%	1.9%	49%	17%	75%	24%	25%	27%
Gas	16	19	27	38	47	2.3%	1.4%	1.8%	40%	23%	72%	22%	21%	24%
Coal	19	19	36	47	37	1.9%	-1.6%	0.1%	33%	-22%	3%	29%	26%	19%
Electricity	8	9	19	33	42	3.9%	1.7%	2.8%	78%	28%	128%	15%	18%	22%
Other	12	10	13	16	16	1.4%	0.2%	0.8%	23%	3%	27%	10%	9%	8%
Power generation														
Primary	51	60	102	166	203	3.3%	1.3%	2.3%	63%	22%	98%	100%	100%	100%
Oil	9	7	7	8	7	1.0%	-0.7%	0.2%	16%	-10%	5%	7%	5%	4%
Gas	17	17	26	41	52	3.0%	1.7%	2.3%	56%	28%	101%	25%	24%	26%
Coal	18	27	54	82	82	2.9%	-0.1%	1.4%	53%	-1%	52%	53%	50%	40%
Nuclear	3	4	5	14	29	7.1%	5.2%	6.2%	180%	115%	500%	5%	8%	15%
Hydro	3	4	7	11	15	3.2%	1.7%	2.5%	61%	29%	107%	7%	7%	7%
Wind	0	0	0	2	5	16.1%	4.8%	10.3%	844%	101%	1797%	0%	1%	2%
Other renewables	1	1	3	8	13	6.0%	3.3%	4.7%	141%	64%	295%	3%	5%	6%

Energy demand (quadrillion BTUs)						Average annual change			% change			Share of total		
Regions	1990	2000	2010	2025	2040	2010 2025	2025 2040	2010 2040	2010 2025	2025 2040	2010 2040	2010	2025	2040
AFRICA														
Primary	17	22	29	43	59	2.5%	2.2%	2.4%	46%	38%	101%	100%	100%	100%
Oil	4	5	7	12	18	3.5%	2.8%	3.2%	69%	52%	157%	24%	28%	31%
Gas	2	4	5	8	11	3.4%	2.3%	2.9%	66%	42%	135%	16%	18%	19%
Coal	3	3	4	5	7	1.1%	2.2%	1.6%	18%	38%	62%	14%	11%	11%
Nuclear	0	0	0	0	1	2.6%	13.1%	7.7%	47%	536%	838%	0%	0%	2%
Biomass/waste	8	10	13	17	19	1.7%	1.0%	1.3%	28%	16%	49%	44%	39%	33%
Hydro	0	0	0	1	2	7.3%	3.4%	5.4%	188%	66%	378%	1%	2%	3%
Other renewables	0	0	0	0	1	12.1%	5.9%	8.9%	452%	136%	1200%	0%	1%	1%
Demand by sector														
Total end-use (including electricity)	16	20	26	37	50	2.5%	2.0%	2.3%	45%	34%	95%	100%	100%	100%
Residential/commercial	7	9	12	18	23	2.3%	1.6%	2.0%	42%	28%	81%	48%	47%	45%
Transportation	2	3	4	7	10	3.4%	2.8%	3.1%	66%	50%	150%	16%	18%	20%
Industrial	7	8	9	13	17	2.3%	2.0%	2.2%	40%	35%	89%	36%	34%	35%
Memo: electricity demand	1	1	2	4	7	4.8%	4.2%	4.5%	102%	85%	272%	8%	10%	14%
Power generation fuel[1]	3	4	6	9	16	3.5%	3.6%	3.6%	68%	71%	187%	19%	22%	27%
ASIA PACIFIC														
Primary	90	128	202	294	324	2.5%	0.6%	1.6%	46%	10%	61%	100%	100%	100%
Oil	29	43	57	76	86	2.0%	0.8%	1.4%	34%	12%	50%	28%	26%	26%
Gas	6	11	21	40	56	4.5%	2.2%	3.3%	93%	39%	168%	10%	14%	17%
Coal	32	45	89	126	113	2.3%	-0.7%	0.8%	42%	-10%	27%	44%	43%	35%
Nuclear	3	5	6	13	26	5.5%	4.6%	5.0%	122%	97%	336%	3%	5%	8%
Biomass/waste	19	20	23	25	23	0.5%	-0.6%	0.0%	8%	-8%	-1%	11%	8%	7%
Hydro	1	2	4	6	8	3.6%	1.7%	2.6%	71%	28%	119%	2%	2%	3%
Other renewables	0	1	2	7	12	8.2%	3.6%	5.9%	227%	70%	455%	1%	2%	4%
Demand by sector														
Total end-use (including electricity)	75	100	152	214	234	2.3%	0.6%	1.4%	41%	9%	54%	100%	100%	100%
Residential/commercial	28	33	42	52	58	1.5%	0.7%	1.1%	25%	10%	38%	27%	24%	25%
Transportation	11	18	27	42	54	2.9%	1.7%	2.3%	53%	28%	96%	18%	20%	23%
Industrial	36	50	83	120	122	2.5%	0.1%	1.3%	45%	2%	47%	55%	56%	52%
Memo: electricity demand	7	12	24	44	58	4.0%	1.8%	2.9%	81%	31%	138%	16%	20%	25%
Power generation fuel	22	41	77	128	152	3.4%	1.2%	2.3%	66%	19%	97%	38%	43%	47%
EUROPE														
Primary	74	78	82	77	72	-0.4%	-0.4%	-0.4%	-6%	-6%	-12%	100%	100%	100%
Oil	30	32	31	26	24	-1.1%	-0.6%	-0.8%	-15%	-8%	-22%	38%	34%	33%
Gas	13	17	20	20	20	0.0%	0.2%	0.1%	-1%	3%	2%	24%	26%	28%
Coal	19	14	13	10	6	-1.4%	-3.9%	-2.7%	-19%	-45%	-55%	15%	13%	8%
Nuclear	8	10	10	9	10	-0.3%	0.4%	0.0%	-5%	6%	0%	12%	12%	14%
Biomass/waste	2	3	5	6	5	0.7%	-0.6%	0.1%	12%	-8%	3%	6%	7%	7%
Hydro	2	2	2	2	2	0.0%	0.2%	0.1%	0%	2%	2%	3%	3%	3%
Other renewables	0	0	2	4	5	5.1%	2.2%	3.6%	111%	38%	192%	2%	5%	7%
Demand by sector														
Total end-use (including electricity)	57	61	64	61	59	-0.3%	-0.2%	-0.3%	-5%	-3%	-8%	100%	100%	100%
Residential/commercial	17	18	21	21	20	-0.1%	-0.3%	-0.2%	-2%	-4%	-6%	33%	34%	34%
Transportation	14	17	19	17	17	-0.5%	-0.1%	-0.3%	-7%	-1%	-8%	29%	29%	29%
Industrial	26	25	24	23	22	-0.4%	-0.3%	-0.3%	-6%	-4%	-10%	38%	37%	37%
Memo: electricity demand	9	10	12	13	13	0.5%	0.3%	0.4%	8%	5%	14%	18%	21%	23%
Power generation fuel	27	29	32	31	29	-0.2%	-0.5%	-0.3%	-3%	-7%	-10%	39%	40%	40%

1. Share based on total primary energy

Energy demand (quadrillion BTUs) unless otherwise indicated						Average annual change			% change			Share of total		
Regions	1990	2000	2010	2025	2040	2010 2025	2025 2040	2010 2040	2010 2025	2025 2040	2010 2040	2010	2025	2040
LATIN AMERICA														
Primary	15	20	27	37	47	2.2%	1.5%	1.9%	39%	25%	74%	100%	100%	100%
Oil	8	10	13	17	19	2.0%	0.9%	1.4%	35%	14%	54%	47%	45%	41%
Gas	3	4	6	9	13	2.7%	2.6%	2.6%	48%	46%	117%	22%	23%	27%
Coal	1	1	1	1	2	3.2%	0.5%	1.8%	59%	7%	71%	4%	4%	3%
Nuclear	0	0	0	0	0	3.5%	1.6%	2.5%	68%	26%	112%	1%	1%	1%
Biomass/waste	3	3	4	5	5	0.9%	0.4%	0.7%	15%	7%	23%	15%	13%	11%
Hydro	1	2	2	3	4	2.3%	1.3%	1.8%	41%	22%	71%	9%	9%	9%
Other renewables	0	0	1	2	3	5.8%	4.2%	5.0%	133%	86%	333%	3%	5%	7%
Demand by sector														
Total end-use (including electricity)	14	18	24	33	41	2.3%	1.5%	1.9%	40%	24%	74%	100%	100%	100%
Residential/commercial	3	4	4	6	7	1.8%	1.1%	1.5%	31%	19%	55%	18%	17%	16%
Transportation	4	5	7	11	13	2.7%	1.2%	1.9%	48%	19%	77%	31%	33%	31%
Industrial	7	9	12	17	22	2.2%	1.7%	2.0%	38%	29%	79%	51%	51%	53%
Memo: electricity demand	1	2	3	5	7	3.3%	2.4%	2.9%	63%	43%	134%	13%	16%	18%
Power generation fuel	3	4	6	9	13	2.7%	2.1%	2.4%	48%	37%	104%	23%	25%	27%
MIDDLE EAST														
Primary	11	18	30	45	53	2.8%	1.2%	2.0%	51%	20%	81%	100%	100%	100%
Oil	7	11	15	23	26	2.8%	0.8%	1.8%	51%	13%	71%	52%	52%	49%
Gas	4	7	14	20	25	2.6%	1.4%	2.0%	47%	22%	80%	46%	45%	46%
Coal	0	0	0	0	0	-2.2%	-6.1%	-4.2%	-29%	-61%	-72%	1%	1%	0%
Nuclear	0	0	0	0	1	-	7.6%	-	-	202%	-	0%	1%	3%
Biomass/waste	0	0	0	0	0	7.2%	6.6%	6.9%	183%	163%	643%	0%	0%	0%
Hydro	0	0	0	0	0	4.8%	2.5%	3.6%	101%	46%	192%	0%	0%	0%
Other renewables	0	0	0	0	1	11.5%	6.2%	8.8%	409%	145%	1148%	0%	1%	1%
Demand by sector														
Total end-use (including electricity)	9	14	23	35	43	2.8%	1.4%	2.1%	51%	22%	85%	100%	100%	100%
Residential/commercial	1	3	4	6	8	2.5%	1.6%	2.1%	45%	27%	85%	19%	18%	19%
Transportation	3	4	6	9	11	2.3%	1.3%	1.8%	40%	21%	70%	27%	25%	25%
Industrial	5	8	13	20	24	3.1%	1.3%	2.2%	59%	21%	93%	54%	57%	57%
Memo: electricity demand	1	1	2	5	7	4.3%	2.6%	3.4%	88%	46%	175%	11%	13%	16%
Power generation fuel	3	5	9	14	17	3.2%	1.4%	2.3%	59%	24%	97%	29%	31%	32%
NORTH AMERICA														
Primary	95	114	113	118	115	0.3%	-0.2%	0.0%	4%	-3%	1%	100%	100%	100%
Oil	42	49	47	47	44	0.1%	-0.5%	-0.2%	1%	-7%	-6%	41%	40%	38%
Gas	21	26	28	36	40	1.7%	0.6%	1.2%	29%	10%	42%	25%	31%	34%
Coal	20	23	21	14	6	-2.6%	-5.3%	-3.9%	-32%	-56%	-70%	19%	12%	5%
Nuclear	7	9	10	10	13	0.3%	1.4%	0.9%	5%	23%	30%	9%	9%	11%
Biomass/waste	3	4	3	3	3	0.1%	-0.7%	-0.3%	2%	-10%	-8%	3%	3%	3%
Hydro	2	2	2	2	3	0.7%	0.4%	0.6%	12%	6%	18%	2%	2%	2%
Other renewables	1	1	2	4	7	4.5%	3.2%	3.8%	93%	60%	209%	2%	4%	6%
Demand by sector														
Total end-use (including electricity)	73	86	87	93	92	0.4%	0.0%	0.2%	7%	-1%	6%	100%	100%	100%
Residential/commercial	18	22	23	23	23	0.2%	0.0%	0.1%	2%	0%	3%	26%	25%	25%
Transportation	25	31	32	32	31	-0.2%	-0.2%	-0.2%	-2%	-3%	-6%	37%	34%	33%
Industrial	30	34	32	38	38	1.2%	0.1%	0.6%	19%	1%	21%	36%	41%	41%
Memo: electricity demand	11	15	16	18	20	0.9%	0.8%	0.8%	14%	13%	29%	18%	20%	22%
Power generation fuel	33	42	43	44	44	0.1%	0.0%	0.1%	2%	0%	2%	38%	37%	38%

Energy demand (quadrillion BTUs) unless otherwise indicated						Average annual change			% change			Share of total		
Regions	1990	2000	2010	2025	2040	2010 2025	2025 2040	2010 2040	2010 2025	2025 2040	2010 2040	2010	2025	2040
RUSSIA/CASPIAN														
Primary	57	38	42	49	46	0.9%	-0.4%	0.3%	15%	-5%	9%	100%	100%	100%
Oil	18	8	8	10	10	1.6%	0.0%	0.8%	26%	0%	26%	19%	21%	22%
Gas	23	20	23	26	25	0.7%	-0.3%	0.2%	11%	-4%	6%	55%	53%	53%
Coal	13	7	7	7	5	0.3%	-2.3%	-1.0%	5%	-30%	-26%	17%	15%	11%
Nuclear	2	2	3	4	4	2.2%	1.2%	1.7%	38%	19%	64%	6%	8%	10%
Biomass/waste	1	0	0	1	1	1.7%	0.2%	0.9%	29%	2%	32%	1%	1%	1%
Hydro	1	1	1	1	1	0.3%	0.2%	0.2%	4%	3%	7%	2%	2%	2%
Other renewables	0	0	0	0	0	9.1%	5.0%	7.0%	269%	107%	662%	0%	0%	0%
Demand by sector														
Total end-use (including electricity)	46	29	33	38	37	0.9%	-0.2%	0.4%	15%	-3%	12%	100%	100%	100%
Residential/commercial	12	9	9	10	9	0.4%	-0.5%	-0.1%	6%	-8%	-2%	27%	25%	24%
Transportation	6	3	4	5	5	1.5%	0.2%	0.9%	24%	4%	29%	12%	13%	14%
Industrial	28	17	20	24	23	1.1%	-0.1%	0.5%	17%	-2%	15%	61%	62%	63%
Memo: electricity demand	5	3	4	5	6	1.7%	0.6%	1.1%	29%	9%	40%	12%	14%	16%
Power generation fuel	27	19	20	22	21	0.9%	-0.5%	0.2%	14%	-8%	5%	47%	46%	45%
GDP by region (2010$, trillions)														
World	37	49	64	102	155	3.1%	2.8%	3.0%	58%	52%	140%	100%	100%	100%
OECD	29	37	44	60	80	2.1%	2.0%	2.0%	36%	34%	82%	68%	58%	51%
Non-OECD	8	11	21	42	75	4.9%	3.9%	4.4%	105%	77%	264%	32%	42%	49%
Africa	1	1	2	3	6	4.3%	4.0%	4.1%	88%	79%	236%	3%	3%	4%
Asia Pacific	8	12	19	36	61	4.4%	3.6%	4.0%	92%	70%	227%	29%	35%	39%
China	1	2	6	16	30	6.7%	4.4%	5.5%	165%	90%	402%	9%	15%	19%
India	0	1	2	4	8	5.7%	5.0%	5.3%	129%	108%	375%	3%	4%	5%
Europe	13	16	18	23	30	1.7%	1.7%	1.7%	28%	29%	66%	28%	23%	19%
European Union	11	14	16	20	26	1.5%	1.6%	1.6%	25%	27%	60%	25%	20%	17%
Latin America	2	3	4	7	10	3.3%	3.0%	3.2%	64%	55%	155%	6%	7%	7%
Middle East	1	1	2	4	6	3.7%	3.3%	3.5%	74%	62%	181%	3%	4%	4%
North America	11	15	18	26	37	2.6%	2.3%	2.5%	47%	41%	107%	27%	25%	24%
United States	9	13	15	22	31	2.6%	2.3%	2.4%	46%	41%	106%	23%	22%	20%
Russia/Caspian	2	1	2	3	5	3.4%	2.9%	3.1%	66%	53%	153%	3%	3%	3%
Energy intensity (thousand BTU per $ GDP)														
World	9.7	8.6	8.2	6.5	4.6	-1.5%	-2.2%	-1.9%	-20%	-29%	-43%			
OECD	6.6	6.0	5.3	3.9	2.8	-2.0%	-2.2%	-2.1%	-27%	-28%	-47%			
Non-OECD	20.1	17.1	14.3	10.2	6.6	-2.2%	-2.9%	-2.5%	-29%	-35%	-54%			
Africa	20.7	20.6	16.5	12.8	9.9	-1.7%	-1.7%	-1.7%	-22%	-23%	-40%			
Asia Pacific	11.1	10.9	10.9	8.3	5.3	-1.8%	-2.9%	-2.3%	-24%	-35%	-51%			
China	41.5	21.7	16.4	9.7	5.2	-3.4%	-4.1%	-3.8%	-41%	-47%	-68%			
India	26.8	22.9	17.0	12.8	8.2	-1.9%	-2.9%	-2.4%	-25%	-36%	-52%			
Europe	5.8	5.0	4.5	3.3	2.4	-2.0%	-2.1%	-2.1%	-27%	-27%	-47%			
European Union	6.0	5.1	4.5	3.3	2.4	-2.1%	-2.1%	-2.1%	-27%	-28%	-47%			
Latin America	7.1	7.1	6.6	5.6	4.5	-1.1%	-1.4%	-1.3%	-15%	-20%	-32%			
Middle East	12.1	13.8	14.1	12.2	9.1	-0.9%	-2.0%	-1.5%	-13%	-26%	-36%			
North America	8.8	7.6	6.4	4.6	3.1	-2.3%	-2.4%	-2.4%	-29%	-31%	-51%			
United States	8.8	7.6	6.3	4.3	2.9	-2.5%	-2.5%	-2.5%	-32%	-32%	-54%			
Russia/Caspian	31.4	31.6	20.9	14.5	9.0	-2.4%	-3.1%	-2.8%	-31%	-38%	-57%			
Energy-related CO_2 emissions (B tons)														
World	21.3	23.9	30.7	37.4	36.9	1.3%	-0.1%	0.6%	22%	-2%	20%	100%	100%	100%
OECD	11.3	12.8	12.8	11.9	10.0	-0.5%	-1.2%	-0.8%	-7%	-16%	-22%	42%	32%	27%
Non-OECD	10.0	11.0	17.9	25.5	26.9	2.4%	0.3%	1.4%	43%	5%	50%	58%	68%	73%
Africa	0.7	0.9	1.2	1.7	2.5	2.7%	2.5%	2.6%	49%	44%	115%	4%	5%	7%
Asia Pacific	5.3	7.7	13.2	18.9	18.9	2.4%	0.0%	1.2%	43%	0%	42%	43%	50%	51%
China	2.3	3.4	7.4	10.8	9.2	2.5%	-1.0%	0.7%	45%	-15%	24%	24%	29%	25%
India	0.6	1.0	1.7	3.2	4.2	4.1%	1.8%	3.0%	83%	31%	140%	6%	8%	11%
Europe	4.5	4.3	4.3	3.7	3.1	-0.9%	-1.3%	-1.1%	-13%	-18%	-28%	14%	10%	8%
European Union	4.2	4.0	3.9	3.2	2.6	-1.2%	-1.5%	-1.3%	-17%	-20%	-33%	13%	9%	7%
Latin America	0.7	0.9	1.3	1.7	2.1	2.2%	1.3%	1.7%	39%	21%	68%	4%	5%	6%
Middle East	0.7	1.1	1.8	2.4	2.6	2.1%	0.7%	1.4%	36%	11%	50%	6%	6%	7%
North America	5.6	6.6	6.5	6.2	5.2	-0.3%	-1.1%	-0.7%	-4%	-16%	-19%	21%	17%	14%
United States	4.9	5.7	5.5	5.0	4.0	-0.7%	-1.4%	-1.0%	-10%	-19%	-26%	18%	13%	11%
Russia/Caspian	3.9	2.3	2.5	2.8	2.5	0.7%	-0.8%	0.0%	11%	-11%	-1%	8%	7%	7%

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