

# ExxonMobil

2017 Outlook for Energy: A View to 2040



# 2017 Outlook for Energy:

## **A View to 2040**

The *Outlook for Energy* is ExxonMobil's global view of energy demand and supply through 2040. We use the data and findings in the book to help guide our long-term investments. It also highlights the dual challenge of ensuring the world has access to affordable and reliable energy supplies while reducing emissions to address the risk of climate change. We share the *Outlook* with the public to help promote a better understanding of the issues shaping the world's energy needs.

Why is this important? Because energy is fundamental to modern life. It is critical to human progress and to improving living standards for billions of people across the globe.

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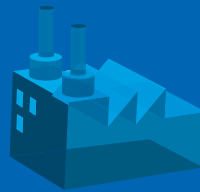
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# Our energy to 2040: Seven things to know

Modern energy is one of mankind's most complex endeavors, and its path is shaped by countless forces. However, we see seven key themes that will play a major role in defining our global energy landscape through 2040.



## Energy underpins economic growth

High levels of growth mean rising living standards. Across the world, the middle class will more than double in the next 15 years. As this growth accelerates so does consumption. Demand for energy increases with more people expecting access to air conditioned homes, cars and appliances like refrigerators, dishwashers and smartphones.



## Non-OECD countries lead the way for energy demand

Continuing urbanization in China and India, with people moving from rural areas to cities, will help to drive economic growth. China is likely to be the largest contributor of Gross Domestic Product (GDP) gains. India is also growing strongly with its share of global GDP doubling.



## The global energy mix is evolving

As global economies grow and government policies change, the energy mix will continue to diversify. Nuclear and renewables will grow strongly with natural gas growing the most. The diversification of energy supplies reflects economics and advanced technologies as well as policies aimed at reducing emissions.



## Oil remains the world's primary energy source

Oil will continue to play a leading role in the energy mix with demand being driven by fuel for transportation and feedstock for the chemicals industry. These feedstocks help to make plastics and other advanced materials that provide advantages to manufacturers and consumers including energy efficiency gains.



## Natural gas leads growth in energy

Natural gas is the largest growing fuel source, providing a quarter of global energy demand by 2040. The abundance and versatility of natural gas is helping the world shift to less carbon-intensive energy for electricity generation while also providing an emerging option as a fuel for certain types of transportation.



## Cost-effective options to reduce CO<sub>2</sub> emissions

Delivering on the increased demand for energy needs to go hand in hand with finding constructive solutions that mitigate the risk of climate change. This is supported by the continuing shift to less carbon-intensive energy for power generation and increased energy efficiency in every sector. Global energy-related CO<sub>2</sub> emissions are likely to peak during the 2030s, even as global GDP doubles by 2040.



## The potential of technology

As the pace of technology development continues to accelerate, new – and still uncertain – solutions are likely to emerge to contribute to meeting energy and environmental goals. Recent advances in technology are promoting energy efficiency gains to slow demand growth, and also opening up new energy supply options including unconventional oil and natural gas, nuclear and renewables.

# Fundamentals

What will the world's energy picture look like in the future?



To find the answer, start by studying the world's long-term demographic and economic trends. By 2040, world population is expected to reach 9.1 billion, up from 7.3 billion today.

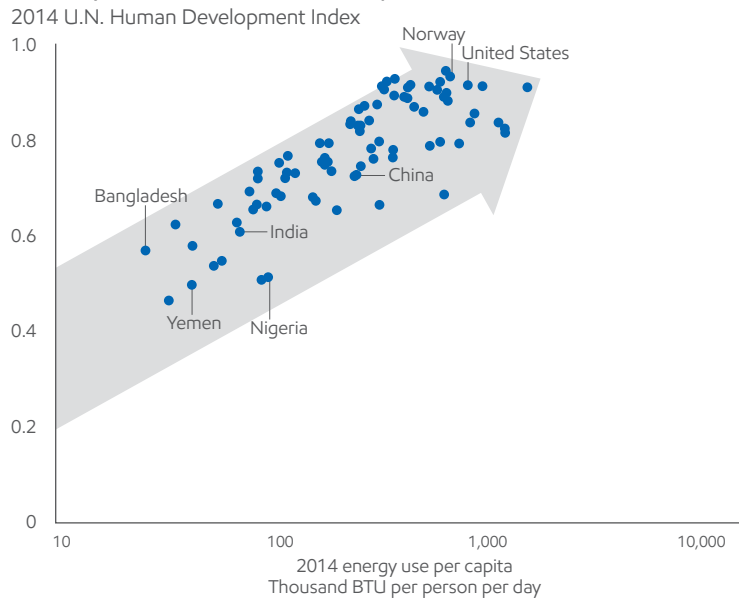
Over that same period, global GDP will effectively double, with non-member countries of the Organisation of Economic Co-operation and Development (OECD) seeing particularly high levels of economic growth. This means rising living standards in essentially every corner of the world, and billions of people joining the global middle class.

This economic expansion, coupled with growing numbers of people, will help drive up global energy demand by about 25 percent by the year 2040, similar to adding another North America and Latin America to the world's current energy demand.

The world will need to pursue all economic energy sources to keep up with this considerable demand growth. Oil and natural gas will likely be nearly 60 percent of global supplies in 2040, while nuclear energy and renewables will grow about 50 percent and be approaching a 25 percent share of the world's energy mix.

## Global fundamentals – projections

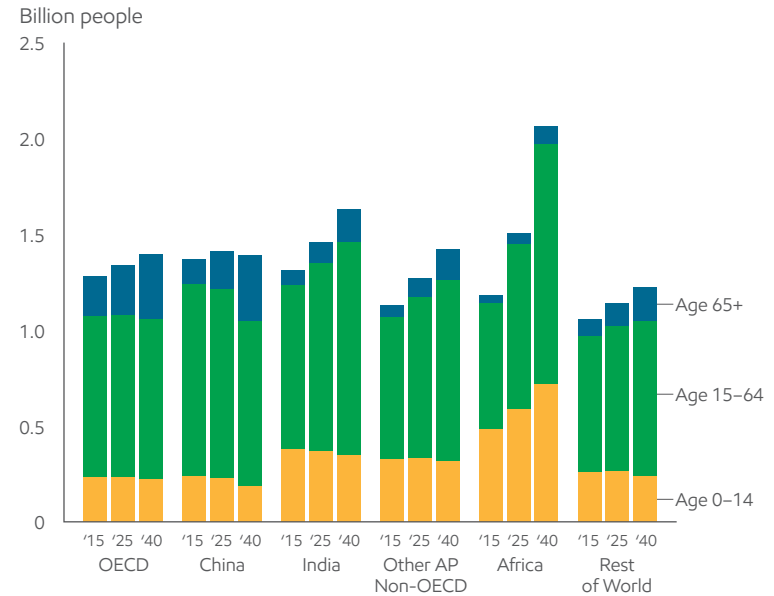
### Energy fuels human development



Source: United Nations, ExxonMobil estimates

- Energy plays a critical role in supporting modern living standards around the world
- The U.N. Human Development Index summarizes a society's achievements in its citizens' life expectancy, education and income
- A country's energy use per capita is well-aligned with its level of human development

### World demographics continue to shift



Source: World Bank, ExxonMobil estimates

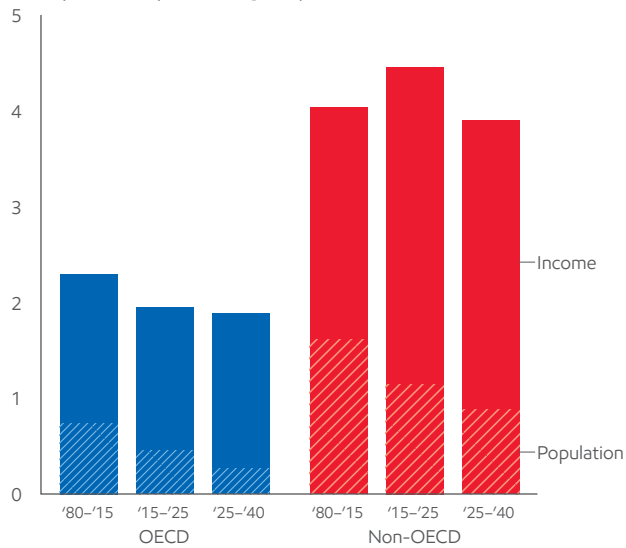
- World population grows from 7.3 billion today to 9.1 billion people in 2040
- India likely to replace China as the most populous nation by 2025
- Working age population has already peaked in China; likely to remain flat in OECD nations but expand in other regions
- Africa's population increases at the fastest rate across major regions
- The share of people age 65+ gains significance, notably in OECD and China

# 01 Fundamentals

## Global fundamentals – projections

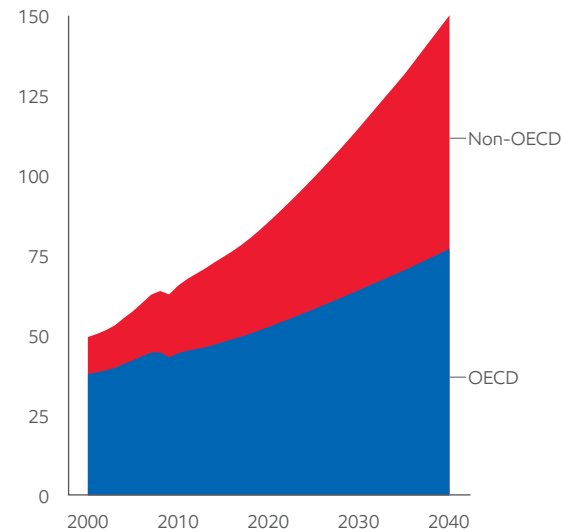
### Non-OECD leads economic expansion

GDP, year-over-year average in percent



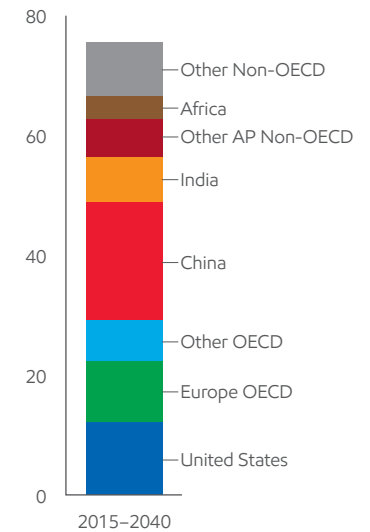
### World GDP doubles

Trillions of 2010 dollars



### World GDP growth

Trillions of 2010 dollars



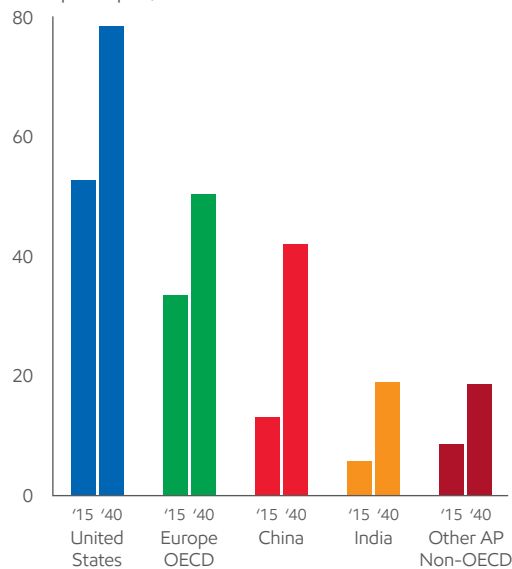
- Economic output (GDP) growth consists of both income (measured by GDP per capita) and population growth
- OECD GDP growth trend reflects declining population growth and steady rise of income
- Non-OECD GDP growth to 2025 reflects improving outlook for income growth while population growth slows
- Non-OECD GDP growth post 2025 will moderate due to lower population growth and slowing gains in income

- World GDP doubles from 2015 to 2040, with non-OECD GDP increasing 175 percent and OECD GDP growing 60 percent
- Non-OECD share of global GDP will rise to about 50 percent by 2040, up from about 35 percent in 2015
- China is likely to be the largest contributor of GDP gains, with its share of global GDP in 2040 similar to that of Europe OECD and the U.S. at close to 20 percent
- India will grow strongly with its share of global GDP doubling



## Purchasing power expands

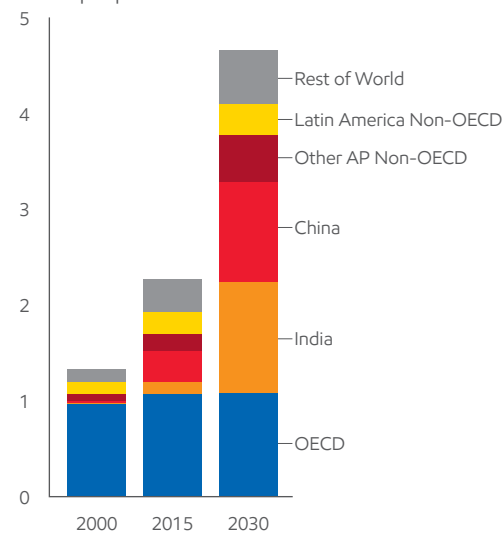
GDP per capita, thousand of PPP dollars



- All regions show significant gains in GDP per capita by 2040
- GDP per capita in OECD nations currently averages about four times that of non-OECD economies
- U.S. GDP per capita is likely to reach almost \$80,000 by 2040, while Europe OECD reaches \$50,000
- China GDP per capita likely to triple, reaching over \$40,000
- India also triples but at less than half of China's level in 2040

## Middle-class expansion accelerates

Billion people



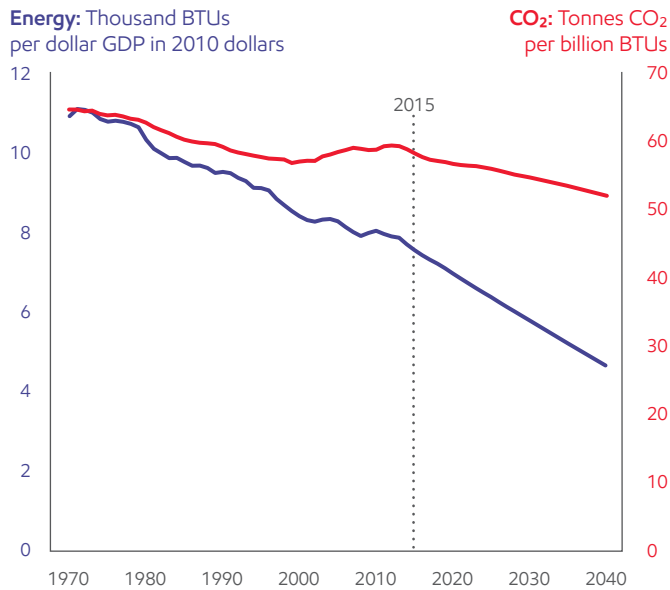
Source: The Brookings Institution

- Middle class expands on a global basis, more than doubling by 2030 to reach almost 5 billion people
- All of the growth is projected to come from non-OECD with OECD holding its middle-class population steady
- India and China show the largest increases with each reaching more than 1 billion middle-class citizens
- These gains will enable longer, healthier and better lives for billions

# 01 Fundamentals

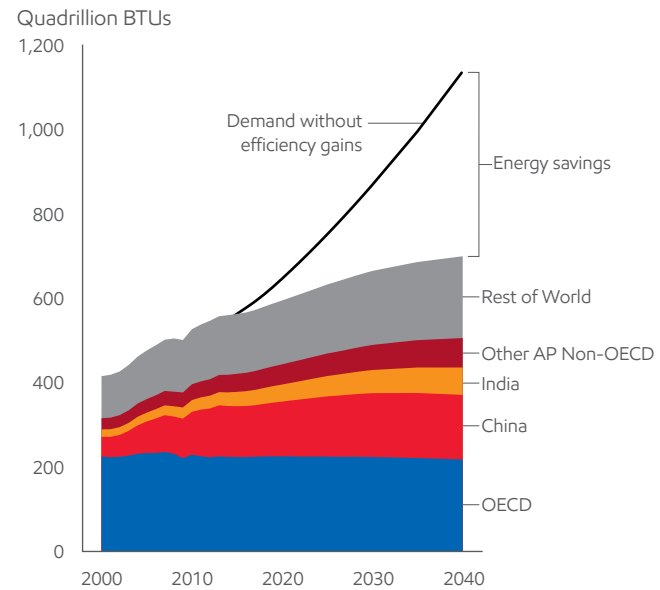
## Global fundamentals – projections

### Technology helps us do more with less



- Technology helps the world use energy more efficiently by reducing energy intensity (the amount of energy used per unit of economic output)
- Since 1970, global energy intensity has fallen about 1 percent per year on average; this decline is likely to average about 2 percent per year from 2015 to 2040
- Technology also helps moderate the carbon intensity of energy use, which will help lower the carbon intensity of the world economy (tonnes CO<sub>2</sub> per unit of GDP) by 45 percent by 2040

### Global efficiency limits demand growth



- Without efficiency improvements, global energy demand would increase significantly
- Actual demand is expected to increase about 25 percent from 2015 to 2040, reflecting large savings due to efficiency improvements
- Demand growth will come from non-OECD nations, where energy use will rise about 40 percent, led by Asia Pacific
- Demand in Africa, Latin America and the Middle East will also grow strongly

# Demand

Global demand for energy is expected to climb about 25 percent by 2040, and would soar significantly higher – closer to a 100 percent increase – but for anticipated efficiency gains across the economy.



Essentially all of this demand growth will come from non-OECD nations, particularly the expanding economies in the Asia Pacific region.

Continuing urbanization and a significant expansion of the middle class, particularly in China and India, will help drive this trend, highlighted by greater access to modern energy in homes, rising industrial demand, and significant increases in personal and commercial transportation needs.

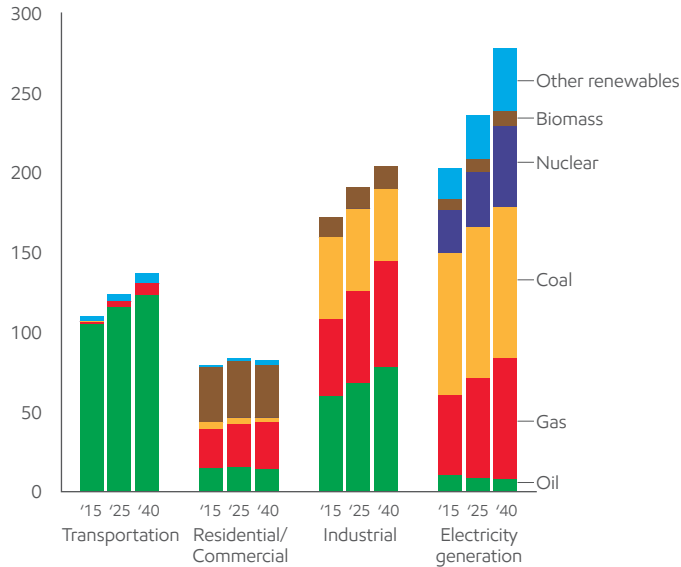
Growth in global energy demand will be led by the increasing electrification of the global economy; 55 percent of the world's energy demand growth over the next quarter century will be tied to power generation to support our increasingly digital and plugged-in lives. A consequence of this trend will be a large uptick in demand for many types of energy used to generate electricity, notably less carbon-intensive sources such as natural gas, nuclear, solar and wind.

# 02 Demand

## Demand – projections

### Energy demand varies by sector

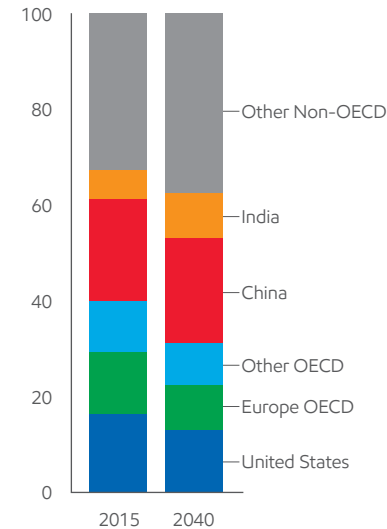
Primary energy—quadrillion BTUs



- Energy used in each sector reflects economic supply options and their general fitness for purpose
- Electricity generation is the largest and fastest growing demand sector, reflecting strong growth in global electricity demand
- A wide variety of energy types will support electricity generation, with natural gas, nuclear and renewables increasing their share
- Natural gas demand increases significantly and gains share in all sectors
- Oil demand grows to support commercial transportation and chemical needs

### Global energy demand shifts toward non-OECD

Percent share

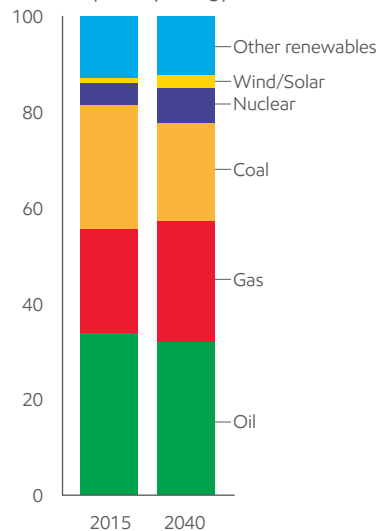


- Global demand reaches 700 quadrillion BTUs in 2040, up about 25 percent
- Non-OECD share of global energy demand reaches about 70 percent in 2040, as efficiency gains and economic growth slows in the U.S. and OECD nations, helping keep energy demand relatively flat
- China and India contribute about 45 percent of world energy demand growth to 2040
- The combined share of energy used in the U.S. and Europe OECD nations will decline from 30 percent in 2015 to close to 20 percent in 2040, similar to China's share of world energy demand



## Global energy mix evolves

Share of primary energy



- Oil remains the world's primary energy source through 2040, meeting about one-third of demand
- Natural gas grows the most of any energy type, reaching a quarter of all demand
- Coal remains important in parts of the world, but loses significant share as the world transitions toward energy sources with lower emissions
- Nuclear and renewables see strong growth, contributing close to 40 percent of incremental energy supplies to meet demand growth

## Learn more

Want to learn more about global trends in energy demand?

### Visit us at:

[exxonmobil.com/energyoutlook](http://exxonmobil.com/energyoutlook)  
and see our infographic

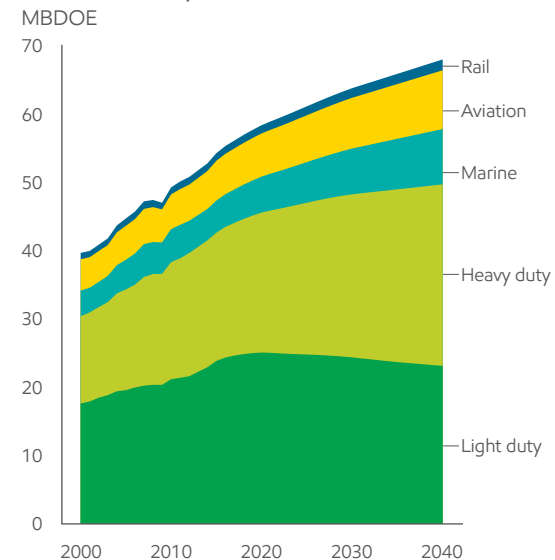
"A global economy on the move"

## Transportation

Advancements in transportation have shrunk our world, while opening up new vistas and possibilities. One consequence of billions of people joining the global middle class in the next quarter century is that it will lead to greater travel, additional cars on the road, and increased commercial activity. Global transportation-related energy demand is projected to increase by about 25 percent. At the same time, total miles traveled per year by cars, sport utility vehicles (SUVs) and light trucks will increase about 60 percent, reaching about 14 trillion in 2040. As personal mobility increases, average new-car fuel economy (including SUVs and light trucks) will improve as well, rising from about 30 miles per gallon (mpg) now to close to 50 mpg in 2040.

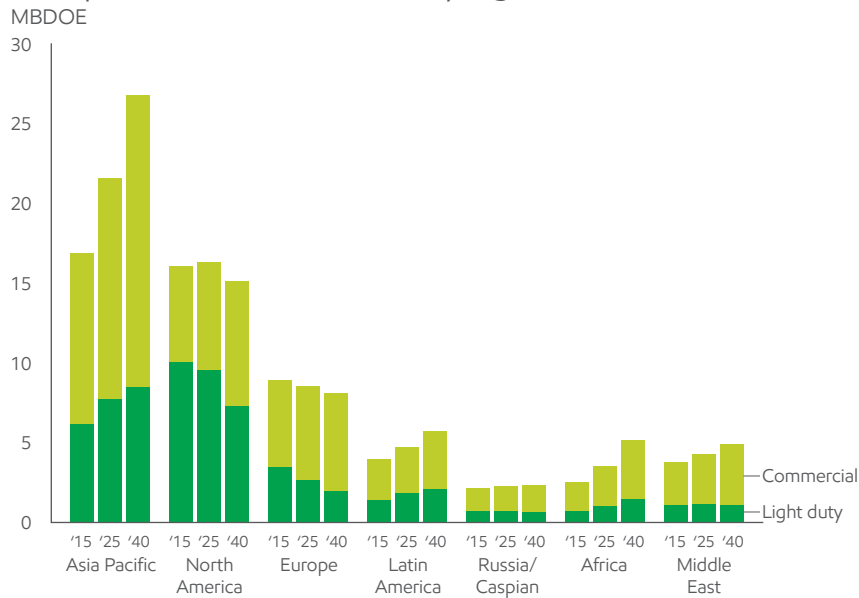
### Transportation – projections

Global transportation demand moves higher



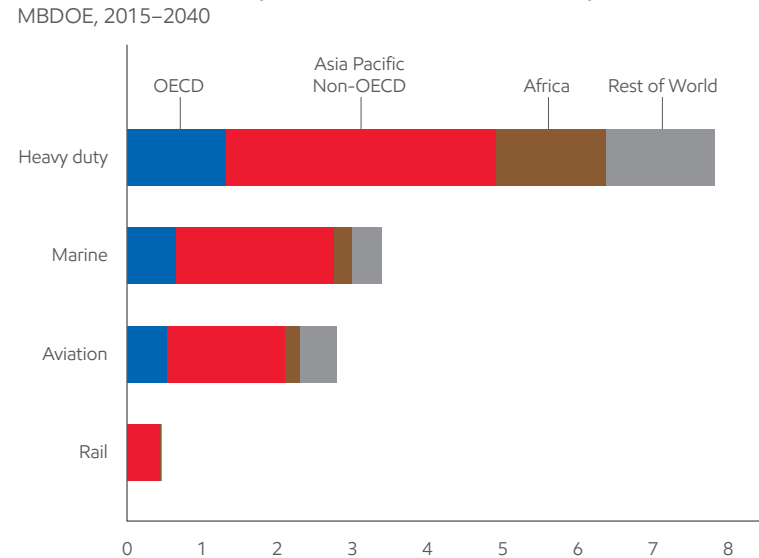
- Global transportation demand grows about 25 percent from 2015-2040
- Personal mobility demands continue to increase, but more efficient vehicles lead to a peak and eventual decline in light-duty vehicle (LDV) energy demand
- Growth in economic activity and personal income drives increasing trade of goods and services, leading to higher energy demand in the commercial transportation sectors
- Heavy duty growth is the largest by volume, but marine and aviation grow the largest by percentage

## Transportation demand varies by region/sector



- Commercial transportation energy demand grows in all regions as economic growth stimulates demand for trucking, aviation, marine and rail
- Majority of growth in commercial transportation occurs in the non-OECD, consistent with the growth in GDP
- Light-duty vehicle energy demand decreases throughout much of the OECD, including North America and Europe, as efficiency gains outweigh the increases in the number of vehicles and miles traveled
- LDV energy demand increases throughout the non-OECD, led by Asia Pacific, Africa and the Middle East as car penetration rises with economic growth

## Commercial transportation grows in all aspects

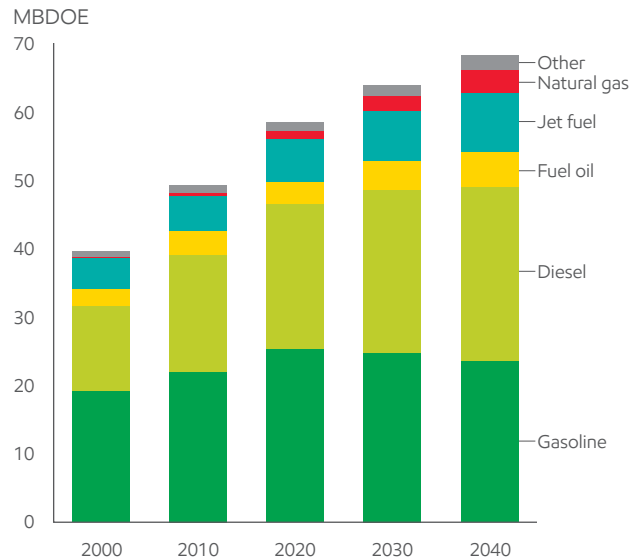


- Significant efficiency gains help limit growth in commercial transportation energy use to about 70 percent in the non-OECD and 20 percent in the OECD from 2015-2040
- Technology advances in trucks will come from engine designs, aerodynamic improvements to the body design and hybridization
- Marine and air transport see efficiency gains from improved body design, engine improvements and logistics

# 02 Demand

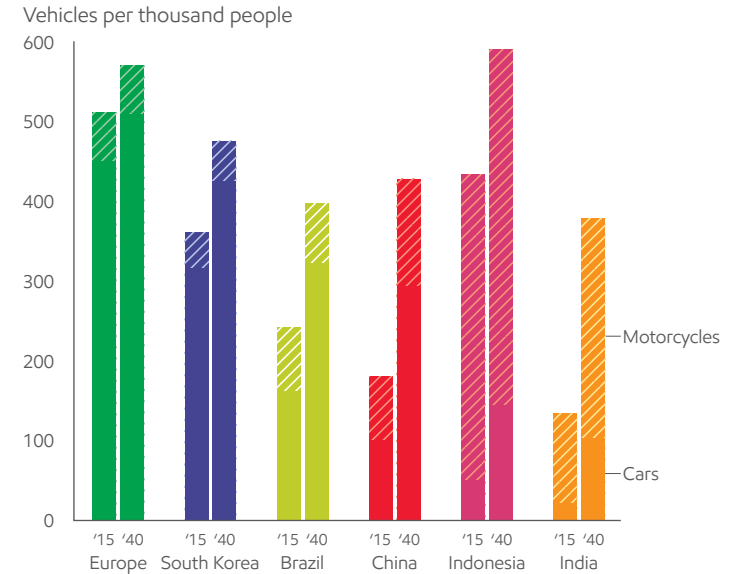
## Transportation – projections

### Global transportation energy mix evolves



- Oil meets about 95 percent of transportation energy needs due to widespread availability, economic advantages and high energy density
- Gasoline demand flattens as average new-car fuel economy improves
- Diesel demand grows 30 percent to meet trucking and marine needs, while jet fuel demand rises about 50 percent
- Fuel oil will continue to be used in marine shipping, though utilized with scrubbers or desulfurized to meet regulatory requirements
- Natural gas, biofuels and electricity grow significantly in select sectors

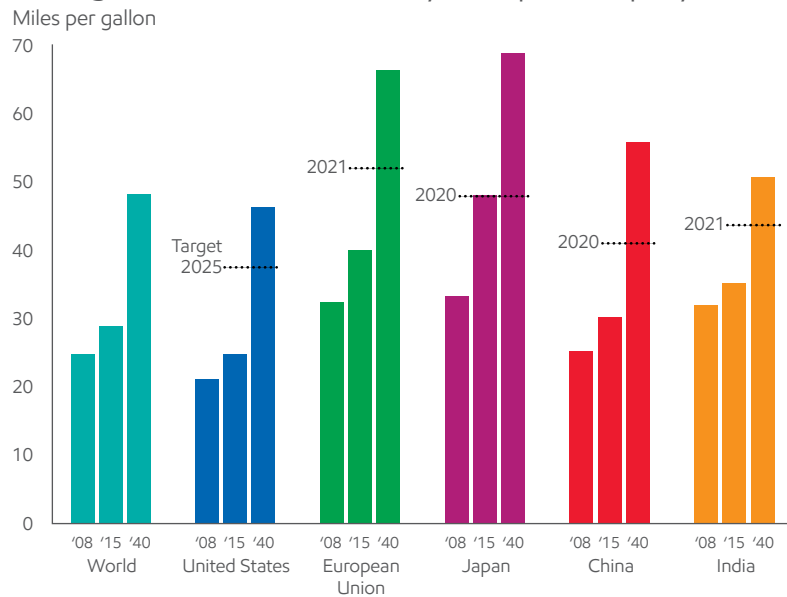
### Access to personal mobility increases



- As incomes rise, individuals seek access to personal mobility that is afforded by cars and motorcycles
- Motorcycles facilitate a lower cost entry point to personal mobility, with ownership particularly high in Asia Pacific
- Car ownership significantly increases in the non-OECD, with Asia Pacific leading the growth
- In the OECD, the fleet grows but cars per 1,000 people increases only by about 10 percent from 2015-2040

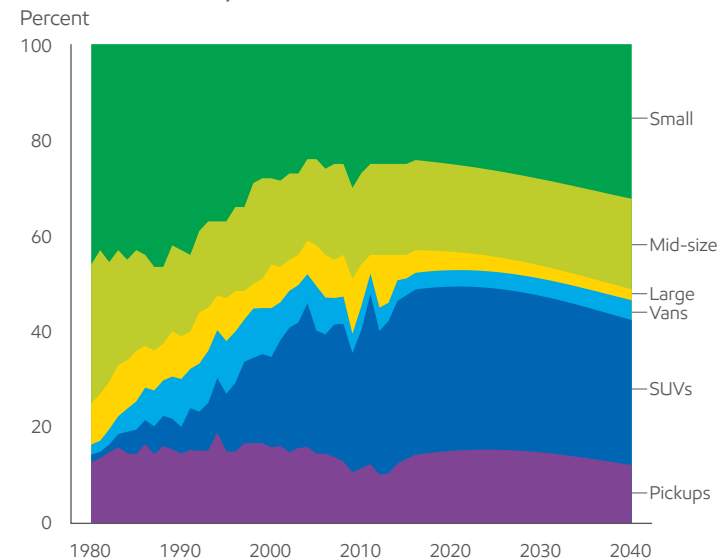


## Average new-car fuel economy to improve rapidly



- Fuel economy of cars has improved in recent years as many nations adopt fuel economy standards
- Progress on fuel economy targets is dependent on technology, costs and consumer preferences for vehicle types
- The fuel economy of the light-duty fleet will continue to improve over the *Outlook* period, with substantial gains beyond current policy targets
- Average fuel economy of new cars worldwide will rise from about 30 mpg in 2015 to close to 50 mpg in 2040

## U.S. car sales by class evolve

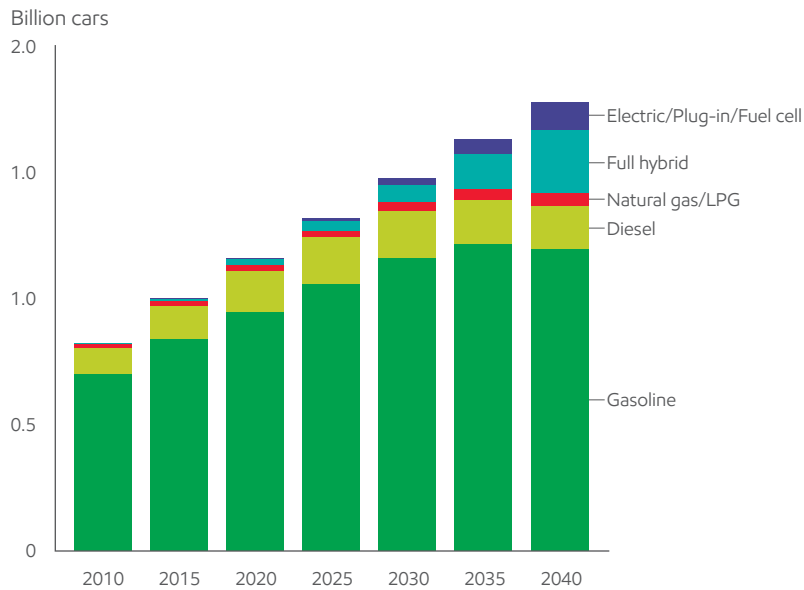


- Over the past 35 years, the share of SUVs in U.S. sales has been growing, reflecting consumer preferences versus small cars
- In the near term, SUVs and pickup trucks will maintain market share; however, post 2020 small cars are likely to gain share versus these categories
- Smaller vehicle options are likely to grow in the SUV and pickup categories
- Falling battery costs will enable small, shorter-range electric cars to exceed more than 10 percent of new car sales in the U.S. by 2040, as high cost differentials begin to narrow versus conventional cars

# 02 Demand

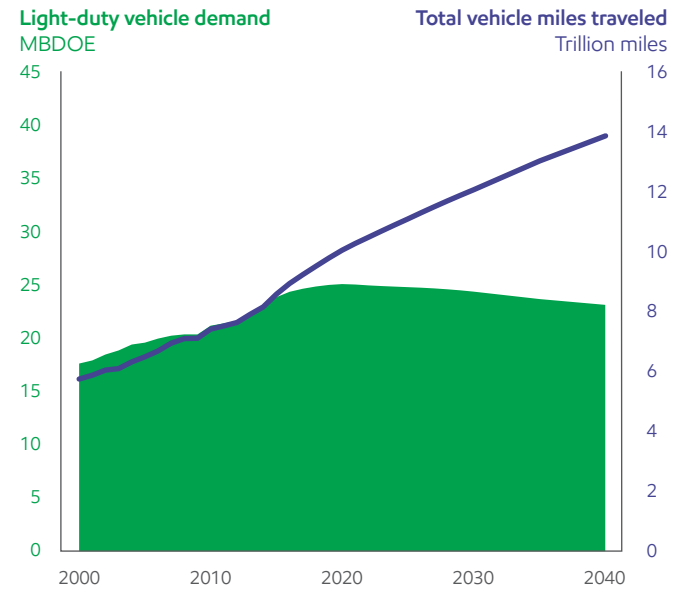
## Transportation – projections

### Global fleet increases and diversifies



- Driven by increases in personal income and population, the global fleet of cars, SUVs and pickups grows about 80 percent to approximately 1.8 billion vehicles
- Conventional cars (primarily gasoline-powered) will remain the most popular due to their cost, functionality and increasing fuel efficiency
- Full hybrid vehicles reach approximately 15 percent of the fleet, though many hybrid features, such as start-stop engines, penetrate into conventional vehicles
- Electric vehicles penetrate the small to mid-size car segment across the world, and in certain places grow faster with policy support

### Fuel economy gains stem demand growth



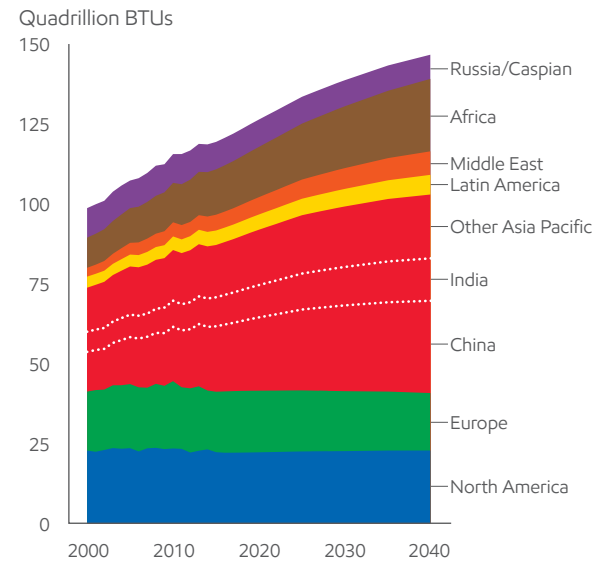
- Improving new-car fuel economy will enable energy demand to peak in the 2020s, even as total miles traveled increases significantly to 2040
- Out to 2040, energy demand decreases in the OECD more than it increases in the non-OECD, driving down global LDV energy demand
- Although energy demand peaks, personal mobility continues to increase globally as total miles traveled by all cars, SUVs and pickups rises to almost 14 trillion in 2040
- About two-thirds of energy savings reflect more efficient internal combustion engines, with the balance resulting from adoption of hybrid or electric vehicles

# Residential and commercial

As populations grow and prosperity rises around the world, we will need more energy to power homes, offices, schools, shopping centers, churches and the like. Combined residential and commercial energy demand is projected to rise by about 25 percent by 2040. About 90 percent of this demand growth will be met by electricity. Led by the growing economies of non-OECD nations, average worldwide household electricity use will rise about 30 percent between 2015 and 2040.

## Residential and commercial – projections

### Residential & commercial demand shifts to non-OECD

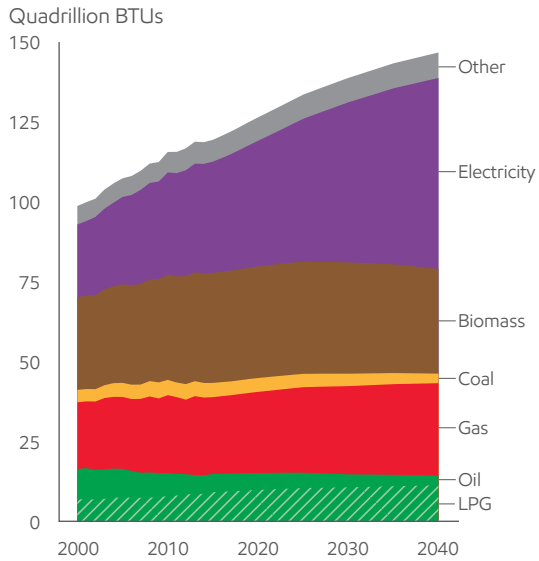


- Growth in households, rising prosperity and expanding commercial activity will spur higher demand for lighting, heat and power in homes and offices
- Residential and commercial energy demand will rise about 25 percent by 2040, consistent with overall population growth
- Essentially all growth will be in non-OECD nations where demand will rise close to 40 percent
- Africa and China will each account for about 30 percent of the increase in demand

# 02 Demand

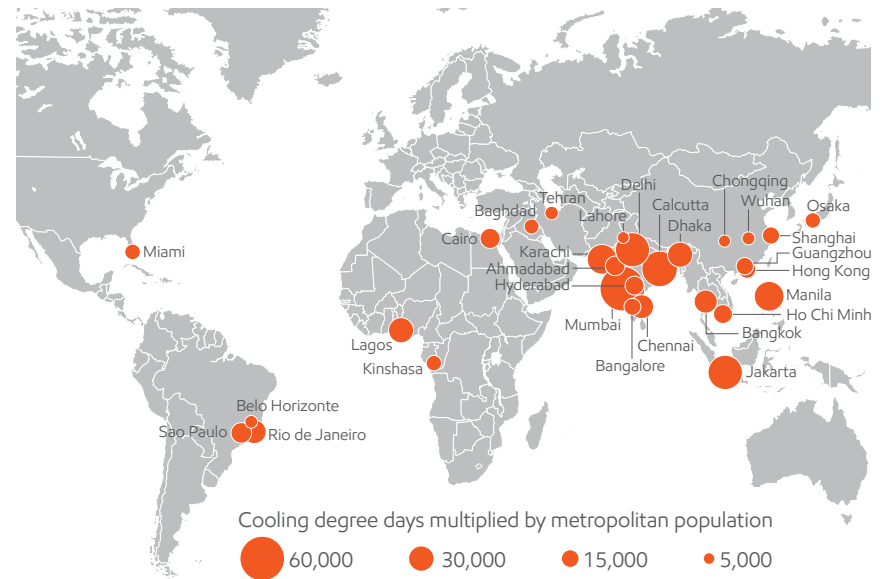
## Residential and commercial – projections

### Residential/Commercial electricity demand surges



### Rising prosperity promotes air conditioning

Potential air conditioning requirement for 30 major metropolitan areas



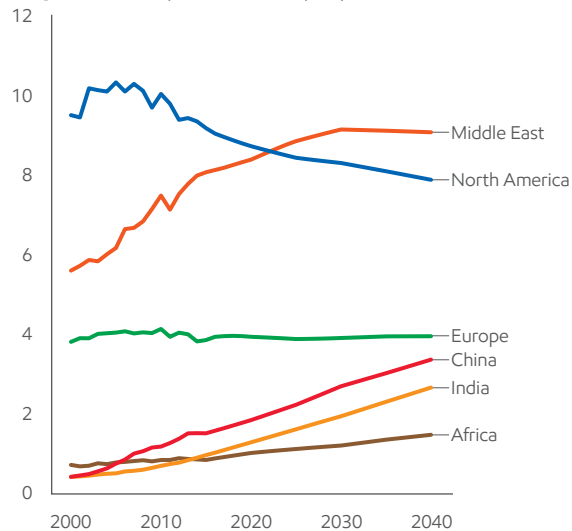
Source: Sivak

- Energy shifts reflect rising living standards and increasing urbanization through 2040
- Electricity demand rises 70 percent, accounting for 90 percent of demand growth from 2015-2040, and reaching a share of 40 percent in 2040
- Natural gas use grows about 20 percent, keeping its share around 20 percent through 2040
- Biomass demand peaks, aided by growing access to modern energy in non-OECD nations, with its share declining to about 20 percent in 2040

- Cooling degree days multiplied by population is indicative of an urban area's potential need for air conditioning
- Nearly all of the highest ranking metropolitan areas by cooling degree days are in the developing world
- Demand for air conditioning typically increases with rising incomes and urbanization
- 5 of the 15 warmest, most densely populated cities are in India
- Smart design, insulation and temperature controls can greatly improve building energy efficiency and comfort

## Household electricity up in non-OECD

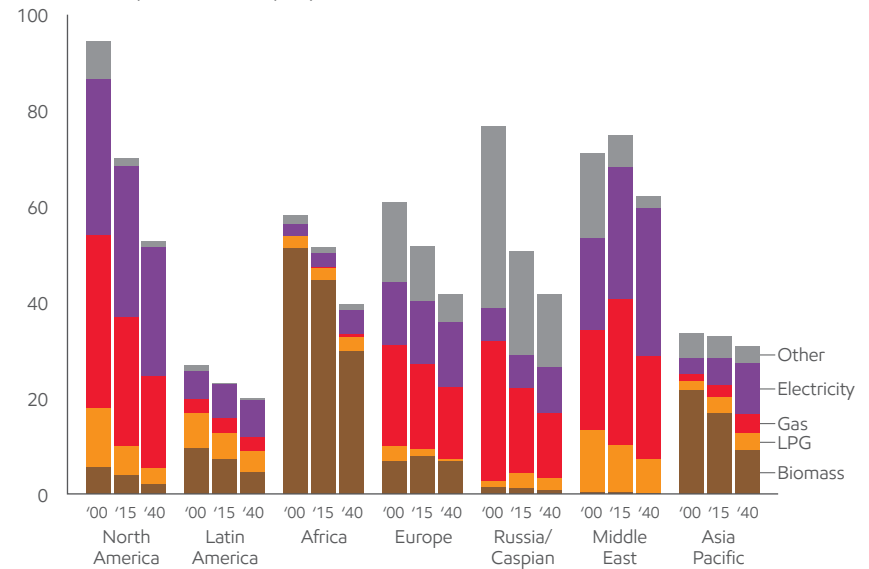
Megawatt hours per household per year



- Residential electricity use will rise about 75 percent by 2040, driven by a nearly 150 percent increase in non-OECD nations
- Electricity use per household will rise about 30 percent globally, as household use in non-OECD countries rises about 70 percent
- Electricity use per household in OECD nations will be flat-to-down as efficiencies help limit electricity requirements
- Residential electricity use in Africa and India is likely to increase about 250 percent though both areas will continue to lag in terms of electricity use per household

## Residential energy use reflects efficiency gains

Million BTUs per household per year



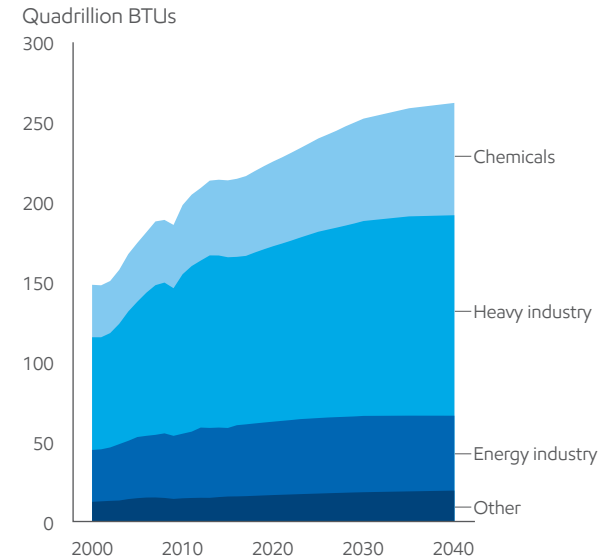
- Household energy use continues to improve, reflecting more efficient buildings and appliances
- Energy use evolves to favor use of electricity
- People in Africa and Asia Pacific still rely on biomass products to a large degree; about 2.7 billion people worldwide still use biomass for cooking and about 1.2 billion people still lack access to electricity

## Industrial

Almost half of the world's energy use is dedicated to industrial activity, including half of global electricity demand. Those statistics often get lost in discussions about energy that focus on direct consumption at the individual or household level – the miles per gallon a car gets, for instance, or the size of one's utility bill. What this "unseen" energy consumption reveals is the critical importance of manufacturing, infrastructure and agriculture to the modern economy. That importance will continue as industrial energy demand rises by about 25 percent by 2040, led by growth in the chemicals sector.

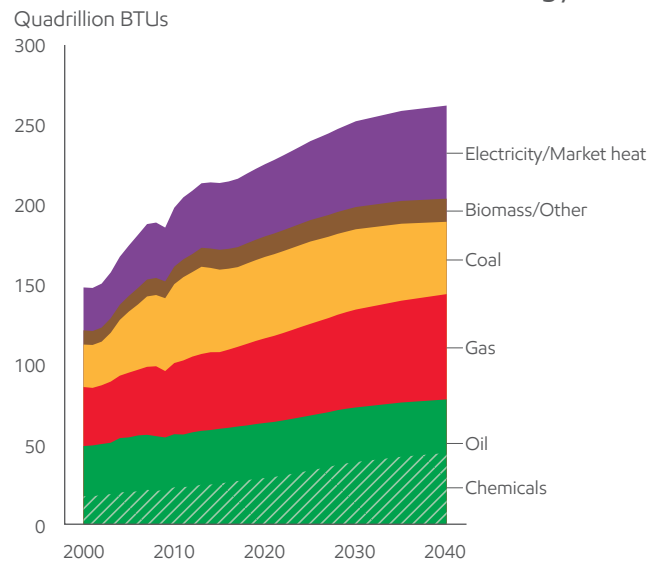
### Industrial – projections

#### Industrial demand fuels economic activity



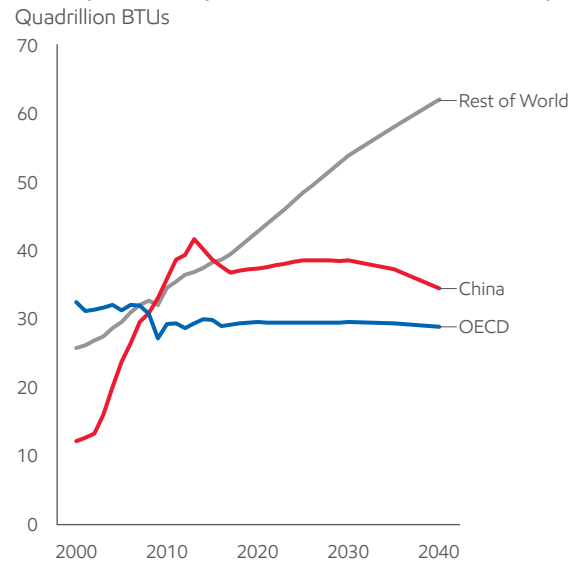
- Industrial activity spurs economic growth while meeting consumer demand for buildings, roads, durable goods, etc.
- Almost half of the world's energy is dedicated to industry
- Industrial energy demand will rise by about 25 percent 2015-2040; the chemicals sector sees the highest growth
- Efficiency improvements in industrial processes moderate energy demand growth
- Energy industry demand is linked to trends in production of oil, gas and coal
- Other (agriculture, asphalt, lubricants) grows modestly

## Industrial demand reflects diverse energy mix



- Industry uses energy as a chemical feedstock and fuel to produce heat, drive motors, power robots, etc.
- Natural gas and electricity/market heat each rise by about 40 percent 2015-2040
- Industrial coal use is expected to plateau then gradually decline
- Oil declines as a fuel but grows as a building block for chemicals, roads and lubricants

## Heavy industry demand shifts regionally

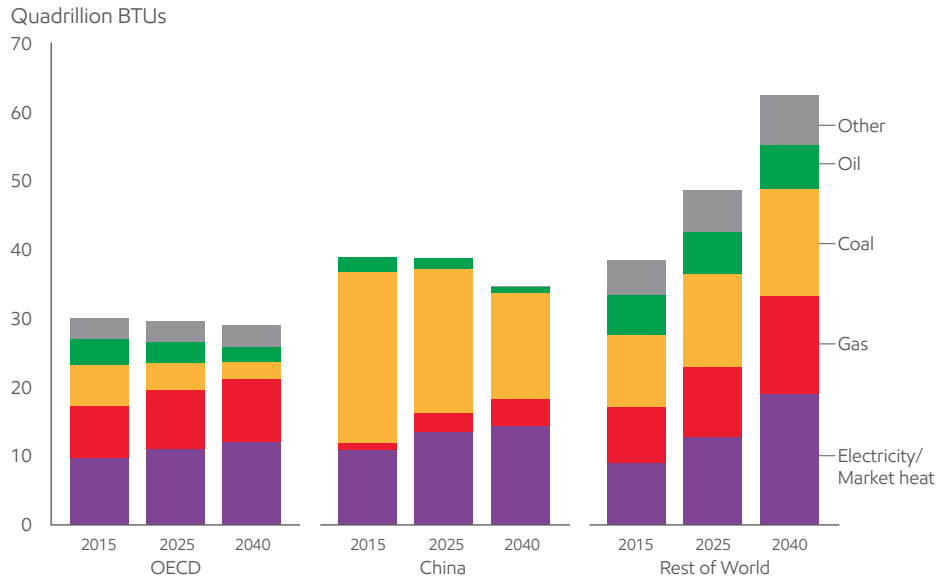


- After a decade of rapid growth, China's heavy industry energy demand (for steel, cement, etc.) contracts
- China's demand begins to parallel the OECD's path as its economy shifts toward higher value manufacturing and services
- Growth in heavy industry moves to other emerging markets, led by India, Africa and Southeast Asia
- Globally, heavy industry energy demand grows around 15 percent 2015-2040

# 02 Demand

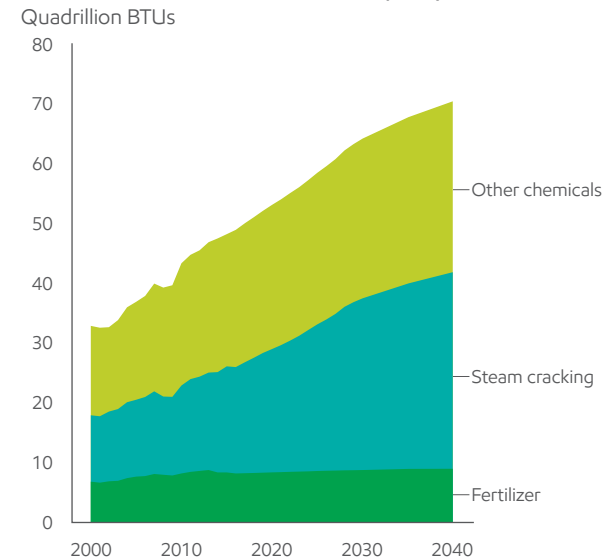
## Industrial – projections

### Heavy industry energy mix shifts to electricity and gas



- Heavy industry's energy mix will shift toward lower direct emissions energy sources
- Electricity and gas demand grow three times as fast as total energy
- China's heavy industry coal demand drops by almost 40 percent 2015-2040
- Coal continues to play a role in steel and cement manufacturing

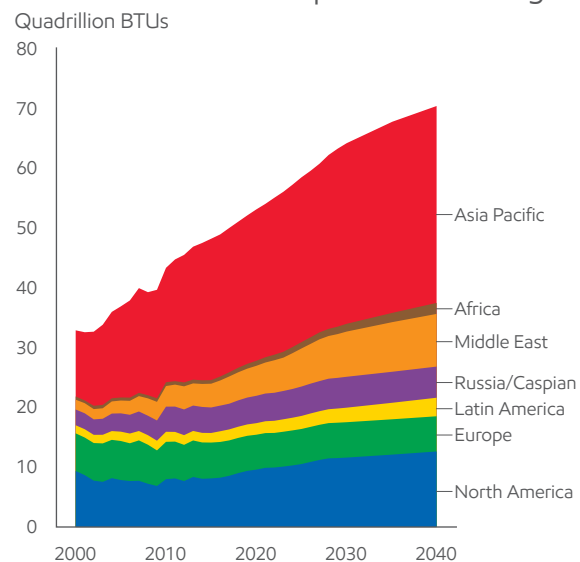
### Chemicals demand rises rapidly



- Demand for chemical products outpaces GDP in many emerging markets
- Rising prosperity propels demand for fertilizer, plastics and other chemical products
- Steam cracking transforms hydrocarbon molecules into the basic building blocks for plastic products used in homes, health care, cars and commerce
- The chemicals sector uses energy in two ways: as a fuel and as a feedstock
- Chemicals energy demand grows by 45 percent 2015-2040

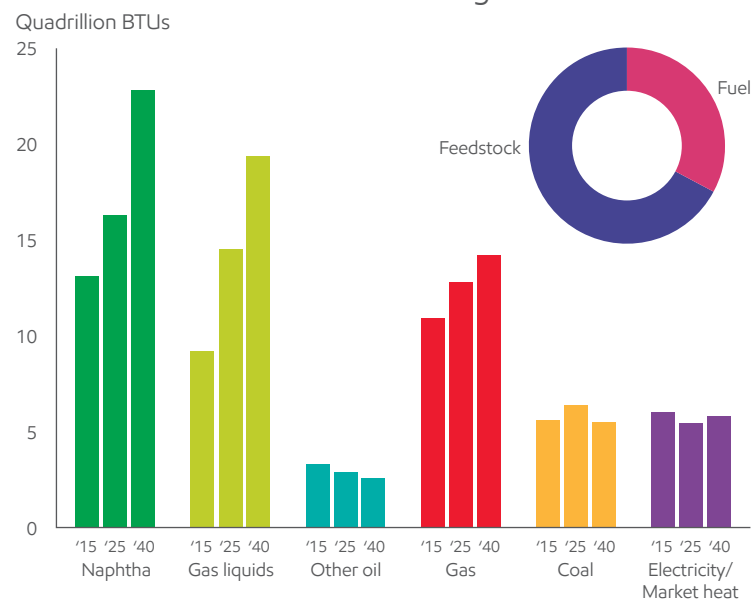


## Chemicals demand expands with rising incomes



- Chemicals production, and the associated energy demand, migrates to regions with competitive advantages like low-cost feedstocks or burgeoning local demand
- Developing Asia Pacific sees the largest growth driven by population size and robust GDP growth
- Middle East chemicals energy demand more than doubles
- Access to low-cost natural gas liquids (NGL) feedstocks triggers U.S. chemicals expansion
- Chemicals produced in these key regions are traded globally as intermediate or final products

## Chemicals demand favors oil and gas



- Feedstock comprises about two-thirds of chemicals energy demand, fuel about one-third
- Since 2000, gas liquids use has grown by two-thirds as unconventional oil and gas have expanded supplies, particularly in the U.S.
- Naphtha and gas liquids are expected to see similar volume growth and together account for about 60 percent of demand by 2040
- Gas is a feedstock for fertilizers and other chemicals, and is also used as a fuel
- China uses coal as a fuel and an alternative chemical feedstock

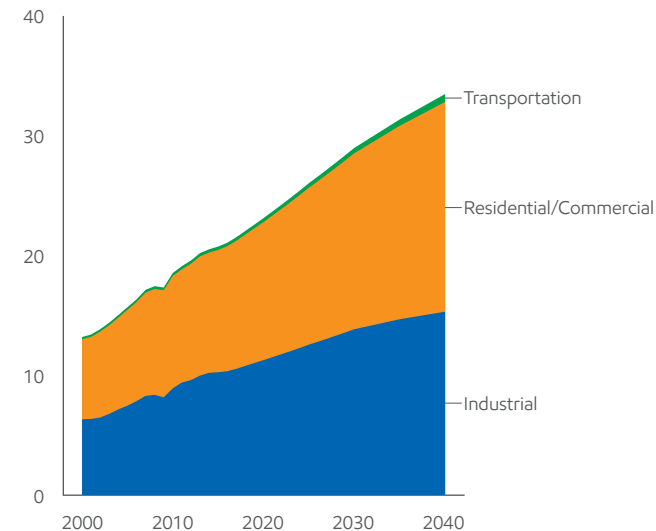
## Electricity and power generation

Economic growth and development worldwide will increasingly be powered by electricity, notes the International Energy Agency (IEA). Global electricity demand will rise by 60 percent between 2015 and 2040, accounting for 55 percent of the world's energy demand growth. These facts offer challenges alongside opportunities, and will alter the global energy landscape. As electricity use rises, the types of energy used to generate it will diversify, globally and regionally, led by natural gas, nuclear and renewables.

### Electricity and power generation – projections

#### Electricity demand grows in all sectors

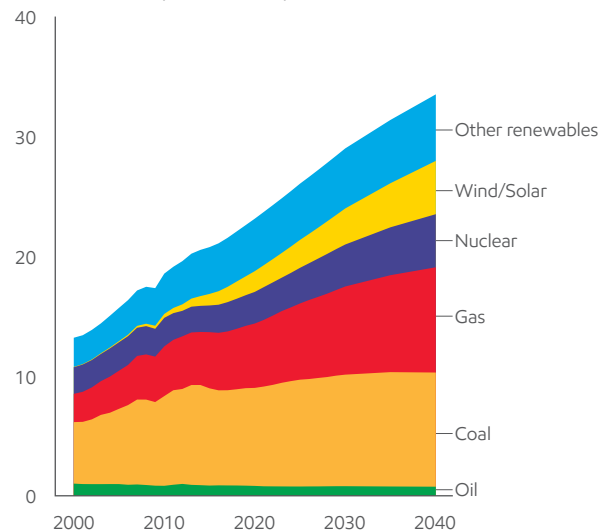
Thousand TWh (net delivered)



- Global electricity demand rises by 60 percent 2015-2040
- Residential and commercial electricity demand seen rising by 70 percent from 2015-2040; industrial demand grows by 50 percent
- Industrial electricity demand growth moderates post-2030 as China's economy shifts from heavy industry to services and lighter manufacturing
- Transportation demand more than doubles 2015-2040, but makes up only 2 percent of total use

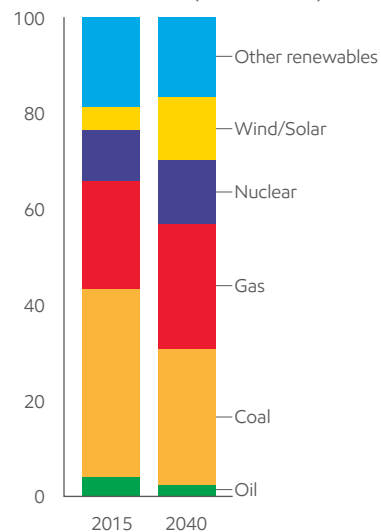
## Electricity supplies reflect diverse sources

Thousand TWh (net delivered)



## Electricity supply mix shifts

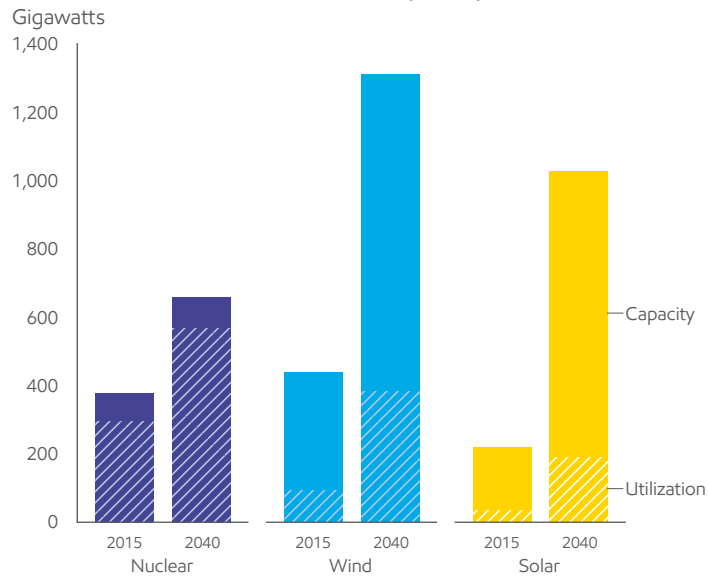
Percent share TWh (net delivered)



- World shifts to less carbon-intensive energy for electricity generation, led by gas, renewables (wind, solar) and nuclear
- Electricity supplies from coal plateau around 2035 as natural gas, nuclear, wind and solar continue to grow
- Coal provides less than 30 percent of world's electricity in 2040, versus about 40 percent in 2015
- Wind and solar electricity supplies grow about 360 percent, approaching 15 percent of global electricity by 2040
- Renewables growth supported by policies to reduce CO<sub>2</sub> emissions

## Electricity and power generation – projections

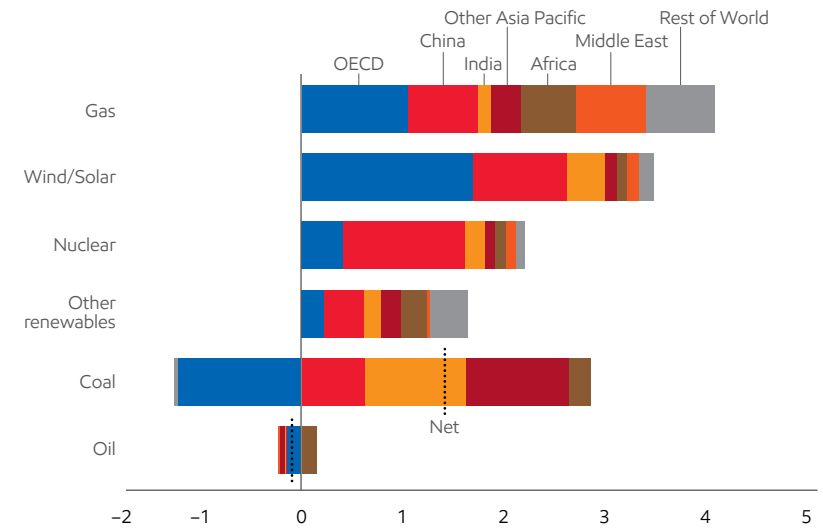
### Global nuclear, wind, solar capacity surges



- Global nuclear, wind and solar see significant capacity additions
- Nuclear capacity grows by 75 percent 2015-2040, led by China
- Although utilization improves over time, intermittency limits worldwide wind and solar capacity utilization to nearly 30 percent and 20 percent, respectively
- Wind and solar together provide similar electricity as nuclear in 2040

### Electricity sources shift regionally

Thousand TWh, 2015-2040

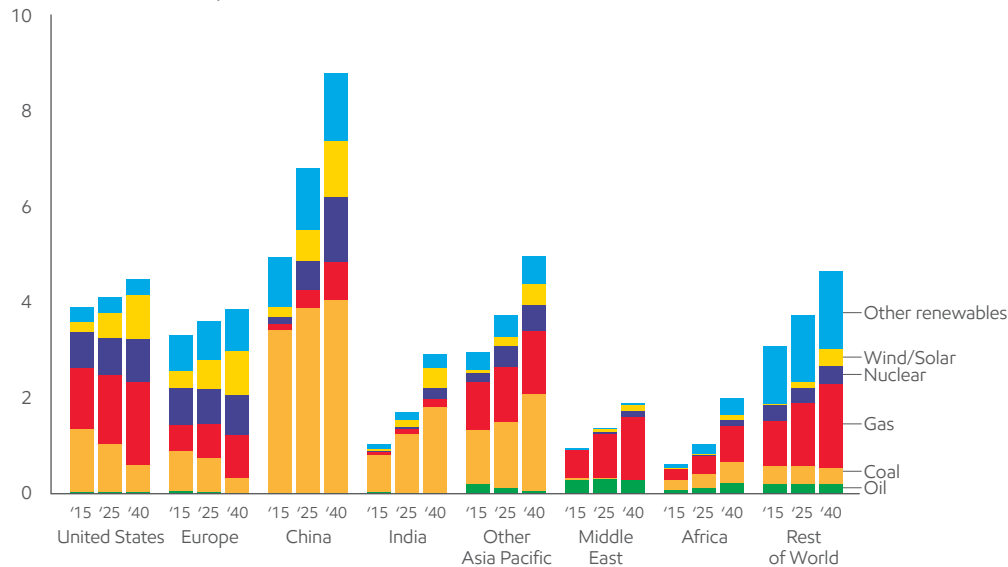


- Sources for electricity generation change from 2015-2040, and the shifts vary regionally
- Gas leads growth as a source for electricity generation, with growing demand in OECD, China, and in countries where domestically available
- Wind, solar grow significantly, with about three-quarters of the growth from OECD and China; other renewables, particularly hydro, grow across all regions
- Nuclear grows, with more than 50 percent of the growth coming from China
- Coal-fired generation shrinks in OECD, but is more than offset by growth in many countries in Asia Pacific to support their rapidly expanding economies
- Global generation from oil shrinks, with growth seen only in Africa



## Electricity generation by region highlights diversity

Net delivered electricity, thousand TWh



- 60 percent of the rise in electricity demand will come from Asia Pacific
- Mix of electricity generation sources will vary significantly by region
- The U.S. and Europe lead shift from coal, with significant gains in gas, wind and solar
- China's coal share of power generation falls; looks to nuclear, renewables and gas to meet electricity growth
- Middle East, Africa and Rest of World draw on gas when domestically available
- Coal-fired electricity use grows in Asia Pacific; India's use of coal for electricity more than doubles from 2015-2040

## Learn more

Interested in knowing more about how electricity powers economic growth and development?

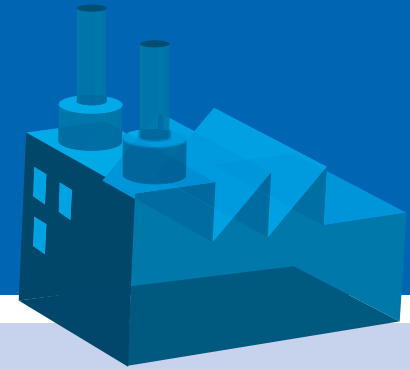
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“Why the world needs more watts”

# Emissions

The challenge of providing the energy supplies that power the global economy is coupled with the need to do so in ways that reduce energy-related greenhouse gas emissions and mitigate the risk of climate change.



The next quarter century will witness a number of developments driven by technology advances and policy decisions that will substantially influence the world's greenhouse gas emissions profile.

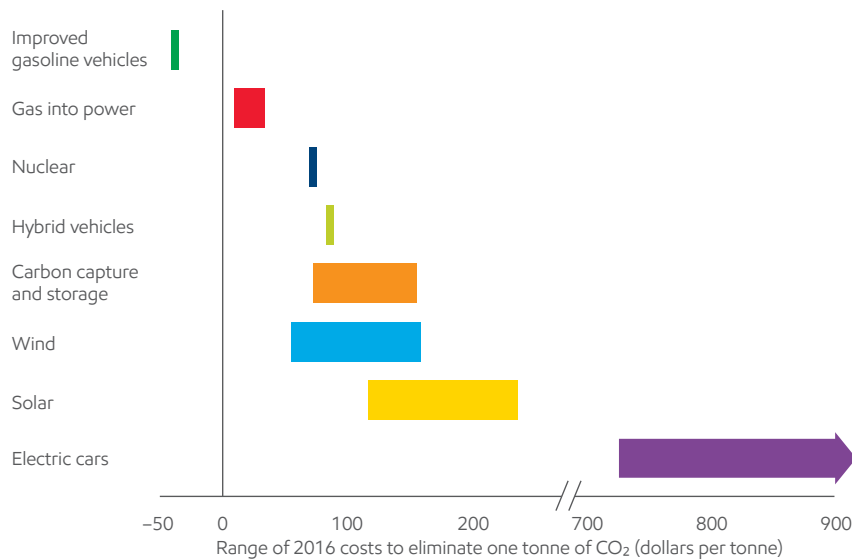
As policymakers develop mechanisms to meet the goals set forth in the 2015 Paris climate agreement, the research and development efforts of the world's scientists, engineers and entrepreneurs will propel energy's evolution. Advances will promote not only new energy supply options and greater energy efficiency, but also emerging opportunities for technologies like carbon capture and storage (CCS).

Between 2015 and 2040, innovation in the transportation sector will deliver significant increases in fuel economy for cars and commercial vehicles. We will also see a shift in the types of energy used for electricity generation, led by natural gas and renewables. Coal's share of global power generation has been falling recently and will continue to drop, with gains being made by less carbon-intensive energy sources such as natural gas, nuclear, wind and solar.

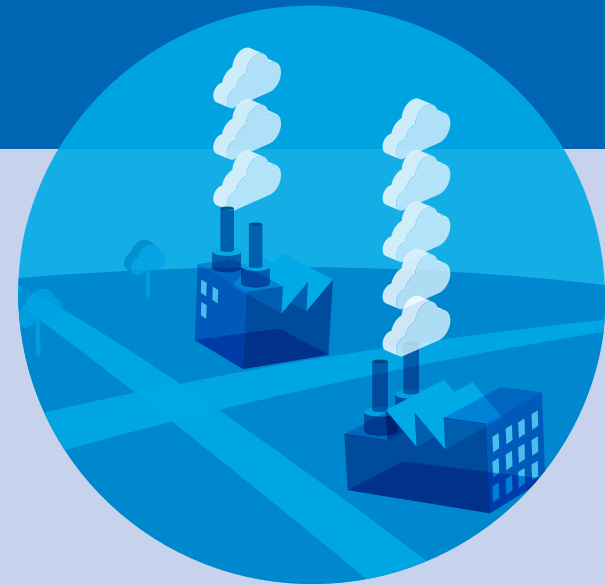
The initial result will be a continued slowdown in the growth of global carbon dioxide emissions. Global energy-related CO<sub>2</sub> emissions are likely to peak during the 2030s and begin to decline – all the more remarkable considering the fact that global GDP is expected to double in the period from 2015 to 2040.

## Emissions – projections

Average U.S. CO<sub>2</sub> abatement costs clarify best options



- Many options exist to reduce CO<sub>2</sub> emissions, each with different costs as of 2016
- Improving fuel economy of conventional vehicles is the lowest cost option
- Switching to natural gas (vs. coal) in power generation also offers low-cost results
- Solar energy is about double the cost of wind for curbing emissions (vs. coal) in U.S.
- Electric cars are a high-cost option, upward of \$700/tonne of CO<sub>2</sub> abated



$$\text{CO}_2 \text{ abatement cost} = \frac{\text{Change in capital \& operating costs}}{\text{Change in CO}_2 \text{ emissions}}$$

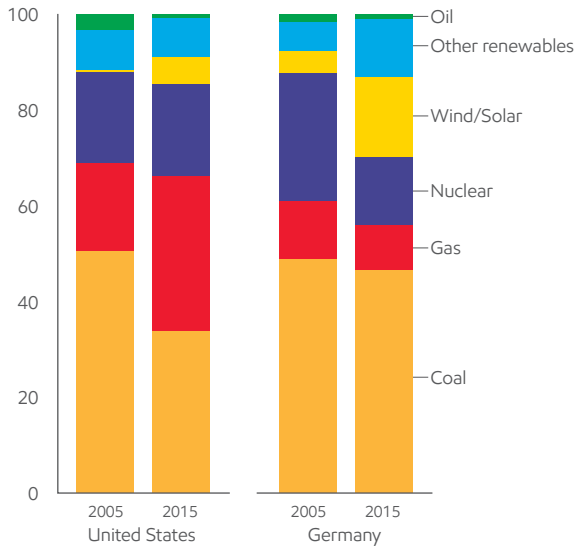
- Progress on energy and climate goals requires practical solutions that are reliable, affordable and cost-effective
- Many opportunities exist to reduce CO<sub>2</sub> emissions, and since the costs vary widely and can be substantial, societies should adopt policies targeting CO<sub>2</sub> emissions that will minimize the related costs that are ultimately borne by consumers and taxpayers
- The best policy options to achieve that goal will be market-based, predictable, transparent and globally applicable to promote innovation and technology breakthroughs to address climate change risks
- Properly designed market-based policies, such as a revenue-neutral carbon tax, are most likely to fully capitalize on the ability and interests of individuals and businesses across society to find, develop and pursue the most cost-effective options to reduce emissions
- According to the U.S. Congressional Budget Office, putting a transparent and reliable price on CO<sub>2</sub> emissions would be society's most cost-effective approach to reduce emissions



## Emissions – projections

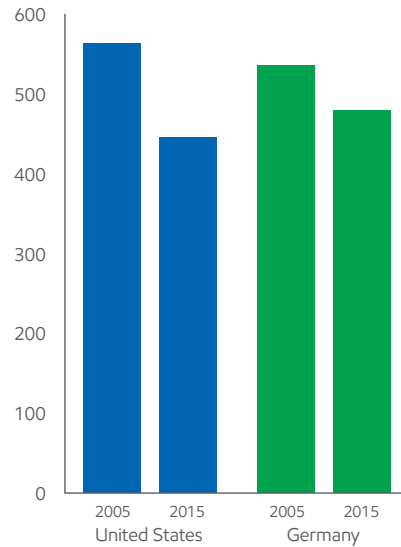
### Comparison of the U.S. and Germany

Share of electricity generation



### CO<sub>2</sub> intensity gains favor the U.S.

Grams CO<sub>2</sub>/kWh generation



Source: EIA, UBA

- The U.S. and Germany illustrate different options available to reduce CO<sub>2</sub> emissions
- A shift in the U.S. has favored natural gas, along with growth in wind and solar
- In contrast, Germany targeted greater use of wind and solar while phasing out nuclear
- As a result, from 2005 to 2015, the CO<sub>2</sub> intensity of power generation fell more than 20 percent in the U.S., or more than twice the improvement shown in Germany, where it fell about 10 percent

## Learn more

Want to learn more about how technology is helping to reduce greenhouse gas emissions?

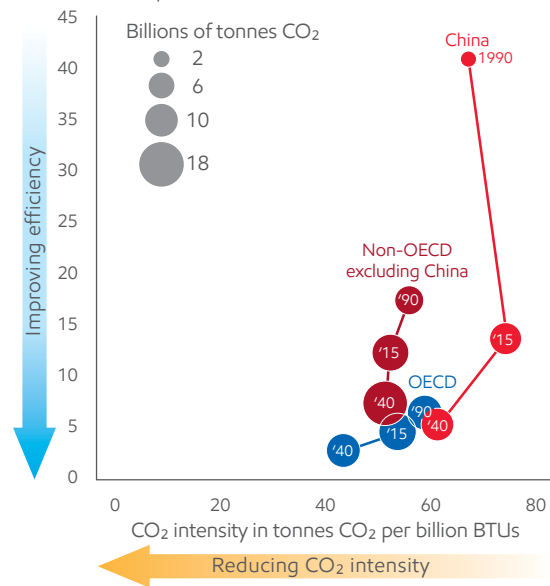
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“Technology takes on CO<sub>2</sub>”



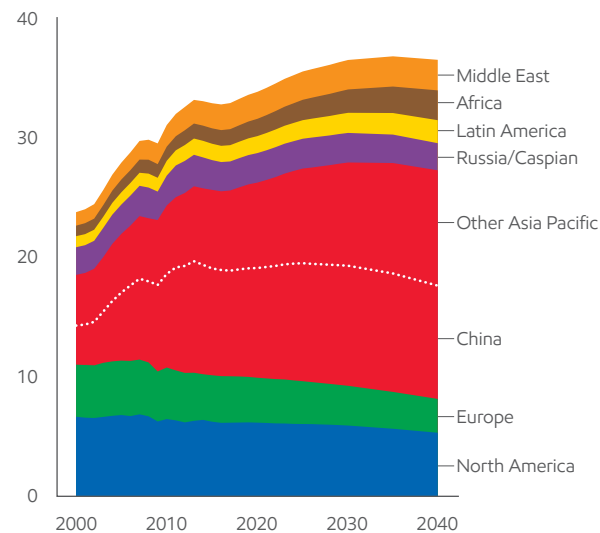
## Restraining energy-related CO<sub>2</sub> emissions

Thousand BTUs per dollar of GDP, in 2010 dollars



## Energy-related CO<sub>2</sub> emissions peak

Billion tonnes



- Improving efficiency and decreasing the CO<sub>2</sub> intensity of energy use help stem emissions as populations and GDP grow
- China's GDP rose about 1,000 percent from 1990-2015 but energy efficiency gains kept a rise in CO<sub>2</sub> emissions to about 300 percent; efficiency gains and lower CO<sub>2</sub> intensity will help emissions peak around 2030
- OECD nations improved efficiency and CO<sub>2</sub> intensity from 1990 to 2015, keeping emissions relatively flat; accelerating gains will help reduce emissions 20 percent by 2040
- CO<sub>2</sub> emissions in other non-OECD nations rose about 50 percent from 1990 to 2015, and are likely to increase 50 percent by 2040 despite a 40 percent gain in efficiency across these emerging economies

- Global CO<sub>2</sub> emissions rose close to 40 percent from 2000 to 2015, despite a modest decline in OECD nations
- From 2015 to 2040, global CO<sub>2</sub> emissions are likely to peak and gradually decline, ending about 10 percent above the level in 2015
- Emissions are declining in the OECD; will drop about 20 percent from 2015-2040
- China contributed about 60 percent of the growth in emissions from 2000-2015; its emissions peak about 2030, higher than North America and Europe combined
- Emissions outside North America, Europe and China rise about 35 percent from 2015-2040, with the share of global emissions reaching 50 percent by 2040

# Supply

What resources will be available to meet the world's increasing demand for more energy?



Recent technology advancements have provided an abundance of supply and unprecedented range of energy choices – from the oil and natural gas in America's shale regions to the deepwater fields off the African coast; from new nuclear reactors in China to wind turbines and solar arrays in nations around the world.

The global energy supply mix will shift over the next two-and-a-half decades. Society's push for lower-emission energy sources will drive substantial increases for nuclear power as well as renewables such as wind and solar. By 2040 nuclear and all renewables will be approaching 25 percent of global energy supplies.

Oil will remain an essential energy source for transportation and chemicals production. Natural gas, increasingly used for power generation as utilities look to switch to lower-emissions fuels, will expand its share of the energy mix. Gas will overtake coal as the world's second-largest fuel within a decade.

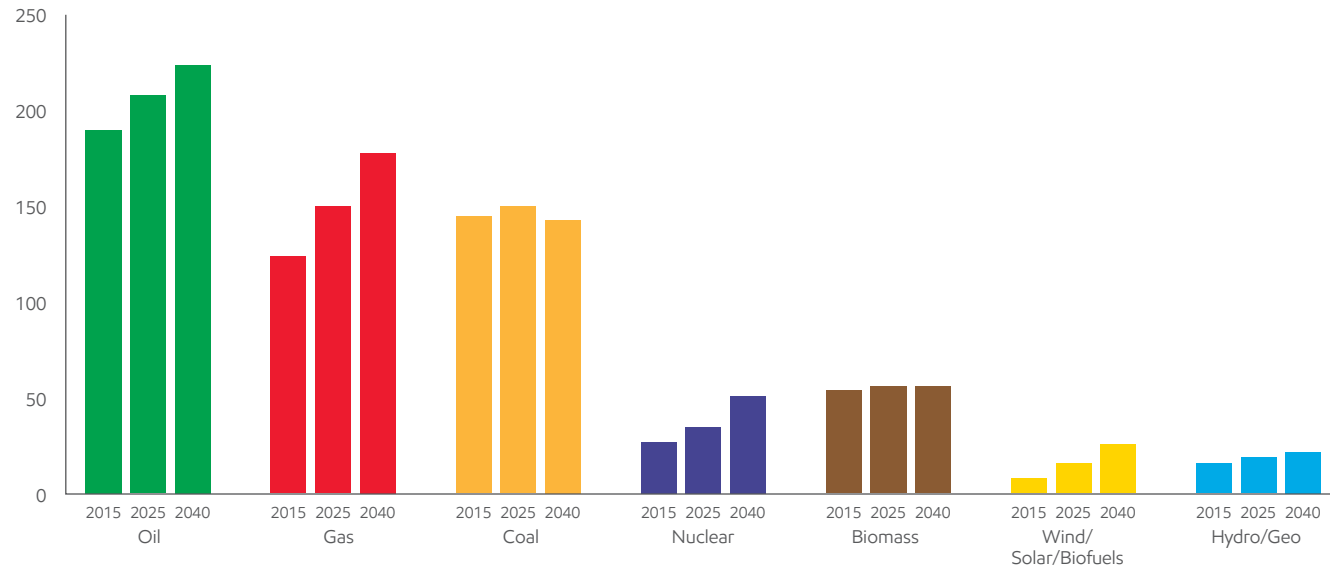
The world has been undergoing an energy supply revolution in recent years, with significant oil and natural gas production increases from American shale fields rewriting the narrative of scarcity and limits that has prevailed since the 1970s. North America, which has been an oil importer for decades, is on pace to become a net exporter of oil in just a few years.

These advances have stimulated a new "age of abundance" in energy supplies, which is good news for billions of people seeking to advance their standards of living.

## Supply – projections

### Energy supply evolves to meet diverse demand

Quadrillion BTUs



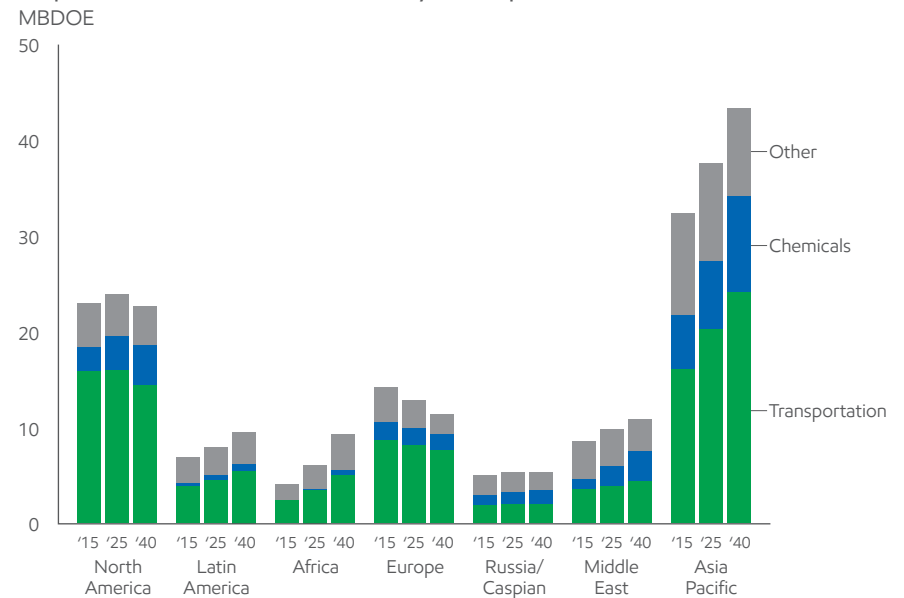
- Oil remains the primary fuel, essential in transportation and chemicals
- Gas demand rises the most, largely to help meet increasing needs for electricity and to support rising industrial demand
- Oil and gas continue to supply about 55 percent of the world's energy needs through 2040
- Coal's share falls as the OECD and China turn to lower emission fuels
- Nuclear demand almost doubles 2015-2040 led by China
- Wind, solar and biofuels average combined growth of about 5 percent per year, reaching about 4 percent of global energy demand

# Liquids

The abundance of supply and a broad range of energy choices have been enabled by technological innovation. Supplies of oil and other liquid fuels are projected to grow 20 percent over the next quarter century, essentially matching expected growth in demand. The gains largely will come from technology-enabled sources, such as tight oil, deepwater and oil sands. As energy markets shift, North America will become a net exporter as tight oil and NGL production grows.

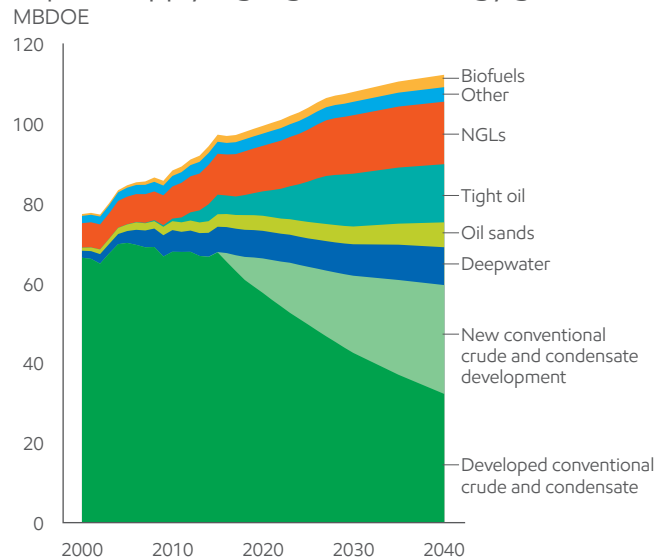
## Liquids – projections

Liquids demand dominated by transportation and chemicals



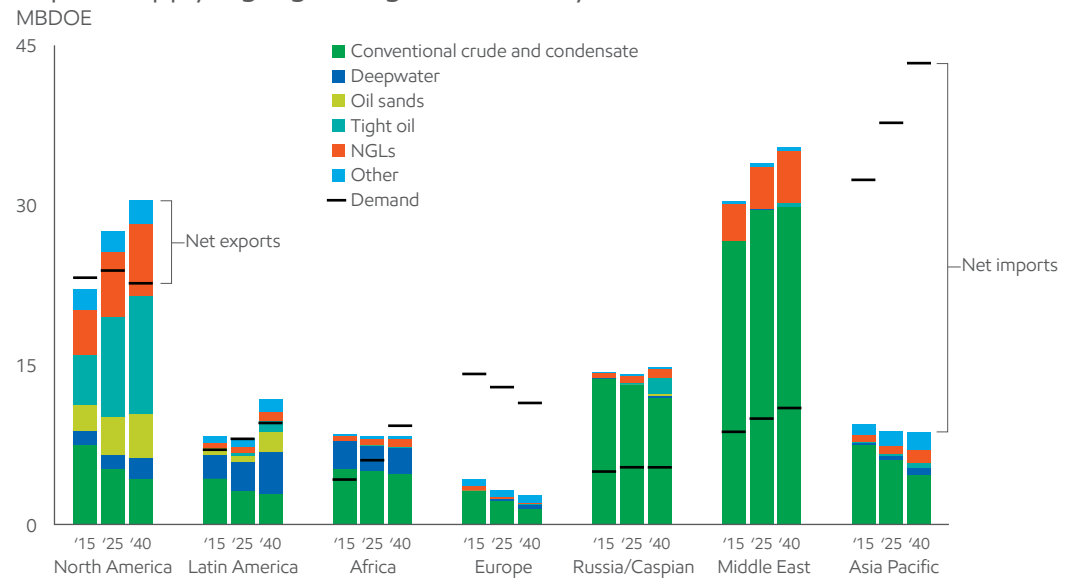
- Global liquids demand grows about 20 percent from 2015 to 2040
- Demand grows in commercial transportation and chemicals
- North America and Europe liquids demand declines with advances in light-duty vehicle efficiency
- Africa has the fastest growth rates as emerging economies advance
- Asia Pacific accounts for about 60 percent of the increase in global liquids demand to 2040, and surpasses the combined liquids demand of North America and Europe around 2025

## Liquids supply highlights technology gains



- Global liquids production rises to meet demand growth
- Technology-enabled NGLs, tight oil, deepwater and oil sands see strong gains
- Tight oil plus NGLs exceed 25 percent of global liquids supply in 2040
- Continued investment in conventional oil is needed to mitigate decline in existing fields and meet demand for liquid fuels

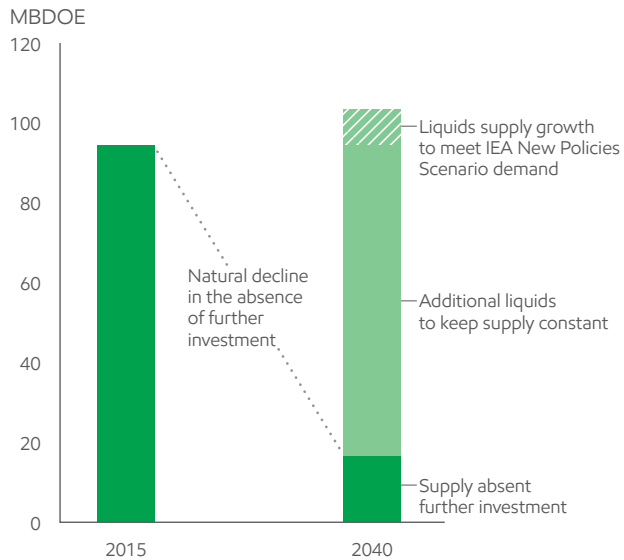
## Liquids supply highlights regional diversity



- Liquids trade balances shift as supply and demand evolve
- North America swings to a net exporter as shale growth continues
- Latin America exports increase from added deepwater, oil sands and tight oil supplies
- Middle East, Russia/Caspian remain major oil exporters to 2040, but Africa shifts to an importer
- Europe remains a net oil importer as its demand and production decline
- Asia Pacific imports increase to 80 percent of oil demand in 2040

## Liquids – projections

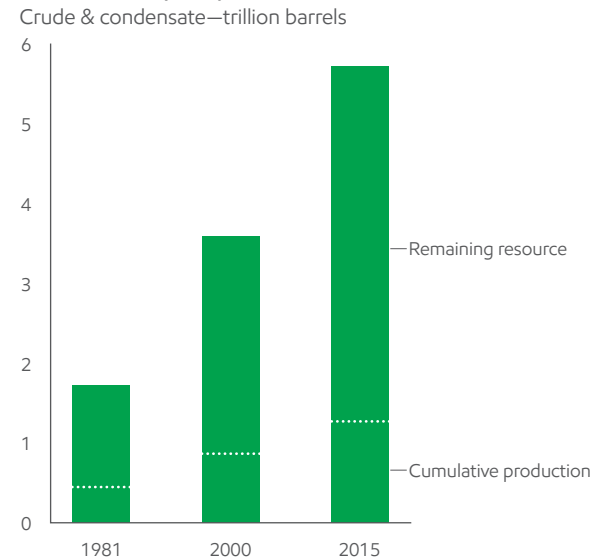
### Liquids demand & supply warrant investment



Source: IEA, excludes biofuels

- Upward of \$450 billion a year of upstream oil investment is needed to meet demand
- Without further investment, liquids supply would decline steeply
- Over 80 percent of new liquids supply needed to offset natural decline

### Technology expands recoverable resources



Source: USGS, IEA

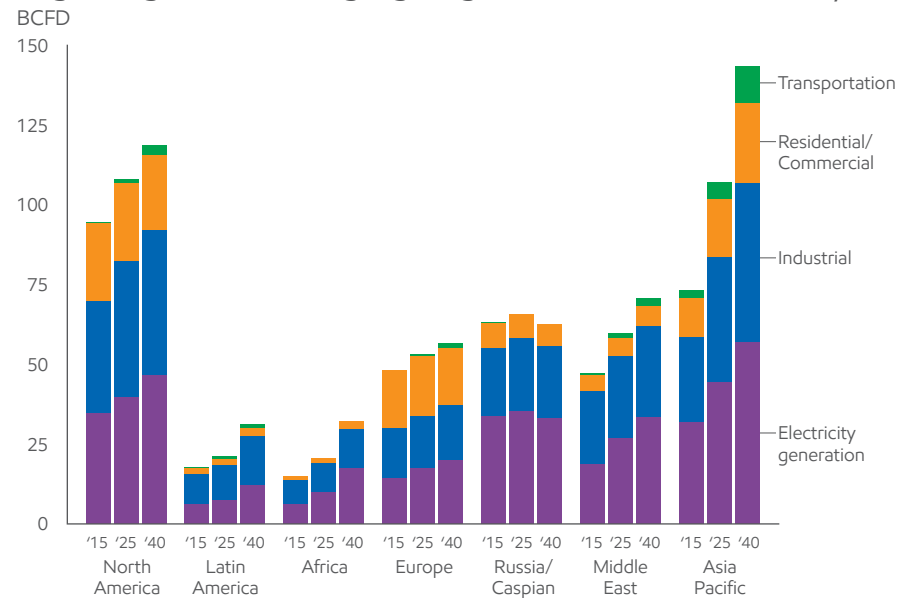
- Global oil resources are abundant
- Less than one-quarter of global oil resources have been produced
- Remaining oil resources can provide 150 years of supply at current demand
- Oil resource estimates keep rising as technology advances
- Technology has added tight oil, deepwater and oil sands resources

# Natural gas

As technology unlocks resources previously considered too difficult or costly to produce, the prominence of natural gas in the global energy mix will continue to grow over the period from 2015 to 2040. Total worldwide gas demand is projected to grow by about 45 percent, with growth seen in every sector, particularly power generation. Natural gas production from North America will continue to grow, helping establish the region as a natural gas exporter.

## Natural gas – projections

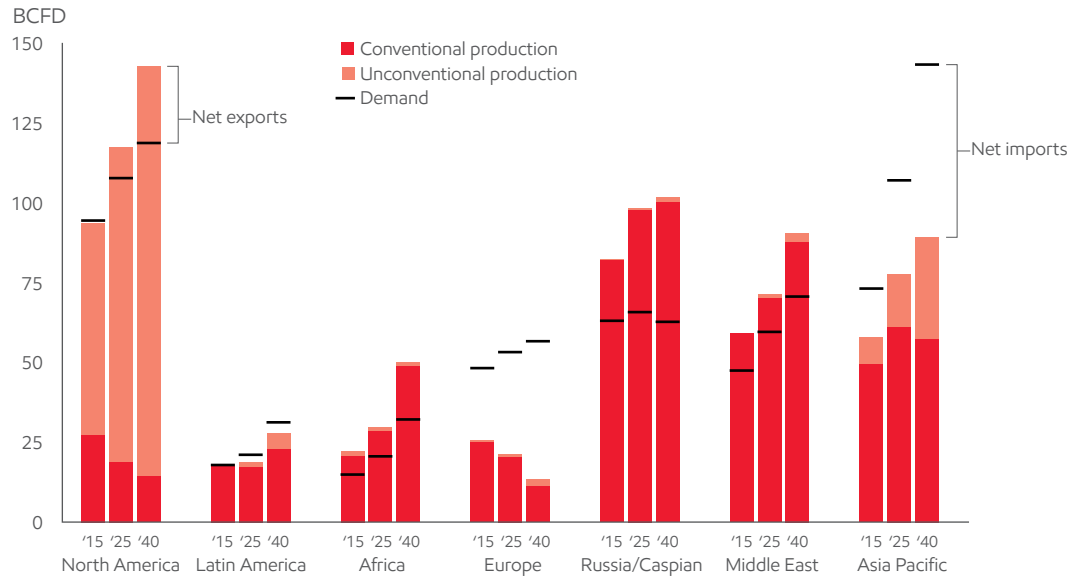
Regional gas demand highlights growth & end-use versatility



- Global gas demand grows by about 45 percent from 2015 to 2040
- Gas demand grows in all major sectors led by electricity generation
- North America shows strong growth as energy choices shift to lower carbon fuels
- Africa gas demand more than doubles as local supplies increase and economies develop
- Asia Pacific gas demand rises the most accounting for 45 percent of global growth

## Natural gas – projections

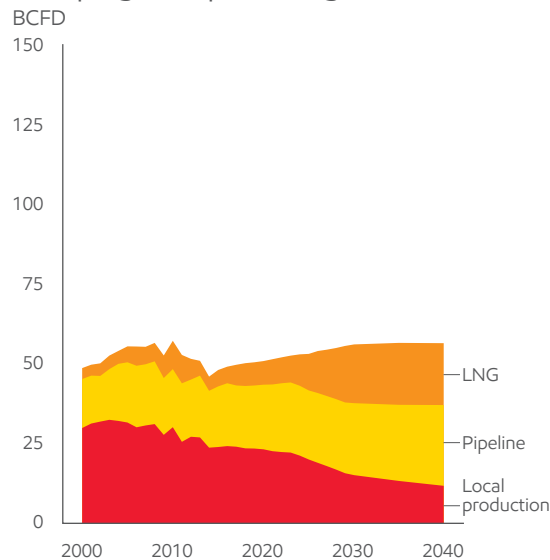
### Gas supply highlights regional diversity



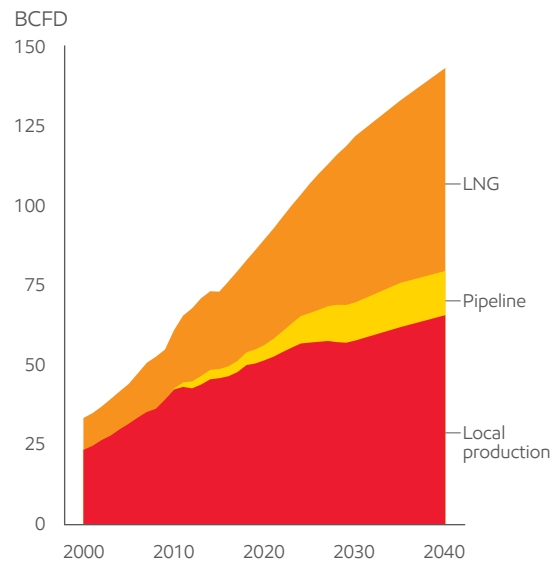
- Gas trade balances shift as supply and demand evolve
- North America becomes a natural gas exporter as unconventional production grows
- Russia/Caspian expands lead as top gas exporter
- Asia Pacific gas production and imports grow to meet rapidly rising demand
- Asia Pacific becomes the largest importer as gas demand doubles by 2040
- By 2040, unconventional gas will account for about one-third of gas production



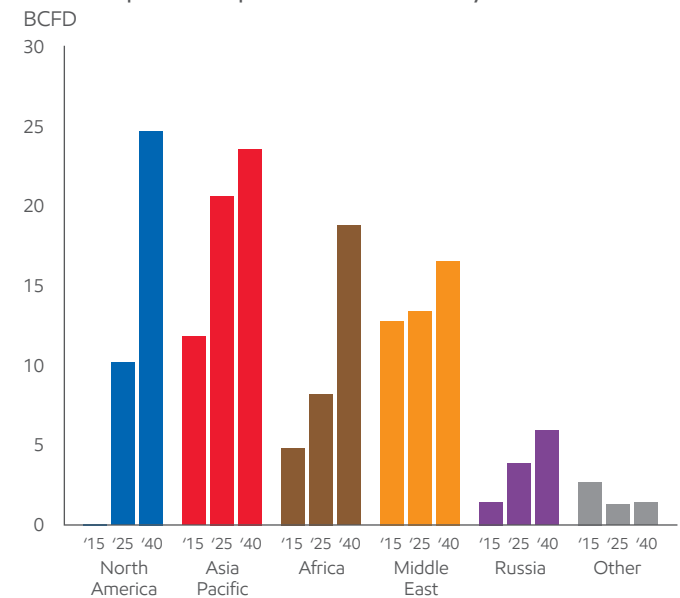
### Europe gas imports to grow



### Asia Pacific demand drives LNG trade



### LNG exports expand and diversify



- Europe and Asia Pacific account for about 90 percent of global imports
- Europe liquefied natural gas (LNG) and pipeline imports rise to offset production decline
- Asia Pacific accounts for over two-thirds of global LNG growth
- Asia Pacific LNG is partly sourced from within the region
- Global LNG trade rises more than 2.5 times from 2015 to 2040

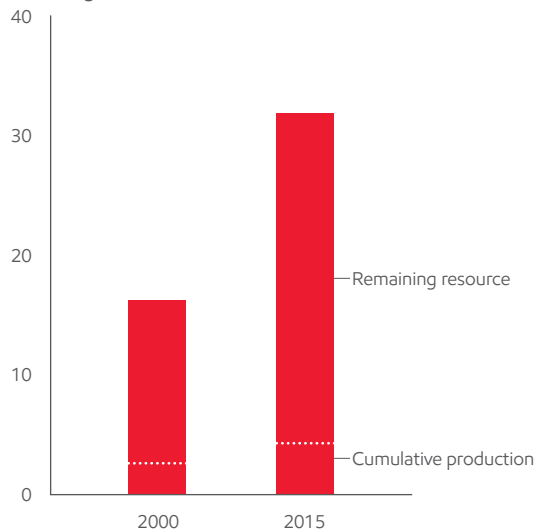
- LNG export supplies diversify as demand grows
- Significant new exports expected from the United States, Canada, Australia and East Africa
- North America becomes the largest LNG exporter from growth in unconventional gas production
- LNG will remain highly competitive due to abundant gas resources and many aspiring exporters
- Low-cost LNG supply sources will be advantaged in the marketplace



## Natural gas – projections

### Technology expands recoverable resources

Natural gas—thousand TCF



Source: USGS, IEA

- Global natural gas resources are abundant
- Less than 15 percent of global gas resources have been produced
- Remaining gas resources can provide more than 200 years of supply at current demand
- Gas resource estimates keep rising as technology unlocks resources previously considered too difficult or costly to produce
- Over 40 percent of the remaining gas resource is from unconventional sources such as tight and shale gas

## Learn more

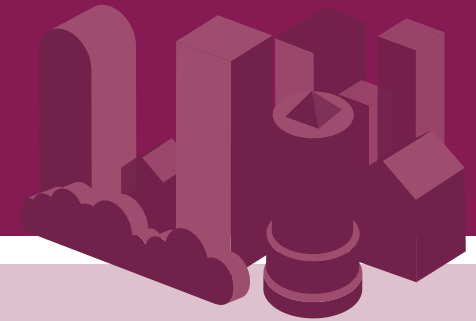
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“Natural gas is an energy  
game-changer”

# Energy matters

With more people using energy to improve their lives, we estimate that global energy demand will be about 25 percent higher in 2040 than it was in 2015.



Meeting energy demand safely, reliably and affordably – while also minimizing risks and environmental impacts – 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.

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. Energy matters to everyone, and we all play a role in shaping its future.

# Data

Energy demand (quadrillion BTUs, unless otherwise noted)														
Regions	2000	2010	2015	2025	2040	Average annual change			% change			Share of total		
						2015 2025	2025 2040	2015 2040	2015 2025	2025 2040	2015 2040	2015	2025	2040
World	416	527	564	634	700	1.2%	0.7%	0.9%	12%	11%	24%	100%	100%	100%
OECD	225	230	224	225	219	0.0%	-0.2%	-0.1%	0%	-3%	-3%	40%	36%	31%
Non-OECD	191	298	339	408	482	1.9%	1.1%	1.4%	20%	18%	42%	60%	64%	69%
Africa	22	30	34	43	60	2.4%	2.3%	2.3%	27%	40%	78%	6%	7%	9%
Asia Pacific	126	205	234	281	322	1.8%	0.9%	1.3%	20%	15%	38%	42%	44%	46%
China	47	102	120	143	153	1.7%	0.5%	1.0%	19%	7%	27%	21%	23%	22%
India	18	28	34	48	65	3.5%	2.0%	2.6%	41%	35%	91%	6%	8%	9%
Europe	79	81	76	74	70	-0.2%	-0.5%	-0.4%	-2%	-7%	-9%	14%	12%	10%
European Union	72	73	68	65	60	-0.4%	-0.6%	-0.5%	-4%	-9%	-12%	12%	10%	9%
Latin America	20	27	29	33	41	1.3%	1.5%	1.4%	14%	25%	42%	5%	5%	6%
Middle East	18	30	35	42	49	1.9%	1.1%	1.4%	21%	17%	41%	6%	7%	7%
North America	114	113	113	116	115	0.3%	0.0%	0.1%	3%	-1%	2%	20%	18%	16%
United States	96	93	93	94	91	0.1%	-0.2%	-0.1%	1%	-3%	-2%	16%	15%	13%
Russia/Caspian	38	43	43	45	43	0.4%	-0.2%	0.0%	4%	-4%	0%	8%	7%	6%
<b>Energy by type - World</b>														
Primary	416	527	564	634	700	1.2%	0.7%	0.9%	12%	11%	24%	100%	100%	100%
Oil	157	178	190	208	224	0.9%	0.5%	0.7%	9%	8%	18%	34%	33%	32%
Gas	89	116	124	150	178	1.9%	1.1%	1.5%	21%	19%	44%	22%	24%	25%
Coal	91	138	145	150	143	0.3%	-0.3%	-0.1%	3%	-5%	-2%	26%	24%	20%
Nuclear	27	29	27	35	51	2.7%	2.6%	2.6%	31%	47%	92%	5%	5%	7%
Biomass/waste	40	49	54	56	56	0.5%	0.0%	0.2%	5%	0%	5%	10%	9%	8%
Hydro	9	12	13	16	18	1.7%	0.8%	1.2%	18%	14%	34%	2%	2%	3%
Other renewables	3	7	11	19	31	5.5%	3.3%	4.2%	71%	63%	179%	2%	3%	4%
<b>End-use sectors - World</b>														
<b>Residential and commercial</b>														
Total	99	116	120	134	147	1.1%	0.6%	0.8%	12%	10%	23%	100%	100%	100%
Oil	16	15	15	15	14	0.2%	-0.4%	-0.2%	2%	-6%	-4%	12%	11%	10%
Gas	21	24	24	27	29	1.1%	0.5%	0.8%	12%	8%	21%	20%	20%	20%
Biomass/waste	29	33	35	35	33	0.2%	-0.5%	-0.2%	2%	-7%	-5%	29%	26%	22%
Electricity	23	32	35	45	60	2.5%	2.0%	2.2%	28%	34%	72%	29%	33%	41%
Other	10	11	11	12	11	0.4%	-0.5%	-0.1%	4%	-7%	-3%	9%	9%	7%
<b>Transportation</b>														
Total	81	101	111	125	139	1.2%	0.7%	0.9%	13%	11%	25%	100%	100%	100%
Oil	80	96	105	116	123	1.0%	0.4%	0.7%	10%	7%	18%	94%	93%	89%
Biofuels	0	3	3	5	6	2.6%	2.3%	2.4%	30%	40%	82%	3%	4%	5%
Gas	0	1	2	3	7	7.9%	5.1%	6.2%	114%	111%	353%	1%	3%	5%
Other	1	1	1	1	2	2.4%	3.4%	3.0%	27%	65%	109%	1%	1%	2%
<b>Industrial</b>														
Total	148	198	214	240	262	1.2%	0.6%	0.8%	12%	9%	23%	100%	100%	100%
Oil	49	56	60	68	78	1.3%	0.9%	1.1%	14%	15%	31%	28%	28%	30%
Gas	37	45	48	57	66	1.8%	0.9%	1.3%	20%	15%	37%	22%	24%	25%
Coal	27	49	52	52	45	0.0%	-0.9%	-0.5%	0%	-12%	-12%	24%	21%	17%
Electricity	22	30	35	43	52	2.0%	1.3%	1.6%	22%	22%	49%	16%	18%	20%
Other	14	17	19	20	20	0.4%	0.2%	0.3%	4%	3%	6%	9%	8%	8%
<b>Power generation - World</b>														
Primary	144	188	203	236	278	1.5%	1.1%	1.3%	17%	18%	37%	100%	100%	100%
Oil	12	10	10	9	8	-1.7%	-0.8%	-1.1%	-16%	-11%	-25%	5%	4%	3%
Gas	31	46	50	62	76	2.2%	1.3%	1.7%	25%	22%	51%	25%	26%	27%
Coal	61	84	89	94	95	0.6%	0.0%	0.2%	6%	0%	6%	44%	40%	34%
Nuclear	27	29	27	35	51	2.7%	2.6%	2.6%	31%	47%	92%	13%	15%	18%
Hydro	9	12	13	16	18	1.7%	0.8%	1.2%	18%	14%	34%	7%	7%	6%
Wind	0	1	3	6	11	8.6%	4.0%	5.8%	128%	80%	309%	1%	3%	4%
Other renewables	4	7	10	14	19	2.9%	2.2%	2.5%	33%	38%	84%	5%	6%	7%
<b>Electricity demand (terawatt hours)</b>														
World	13216	18574	20787	26090	33551	2.3%	1.7%	1.9%	26%	29%	61%	100%	100%	100%
OECD	8601	9680	9614	10443	11432	0.8%	0.6%	0.7%	9%	9%	19%	46%	40%	34%
Non-OECD	4615	8894	11174	15647	22119	3.4%	2.3%	2.8%	40%	41%	98%	54%	60%	66%

Energy demand (quadrillion BTUs)														
OECD Energy by type	2000	2010	2015	2025	2040	Average annual change			% change			Share of total		
						2015 2025	2025 2040	2015 2040	2015 2025	2025 2040	2015 2040	2015	2025	2040
Primary	225	230	224	225	219	0.0%	-0.2%	-0.1%	0%	-3%	-3%	100%	100%	100%
Oil	98	92	90	86	78	-0.4%	-0.7%	-0.6%	-4%	-9%	-13%	40%	38%	36%
Gas	47	54	56	63	69	1.2%	0.6%	0.8%	13%	9%	23%	25%	28%	32%
Coal	43	42	37	28	18	-2.5%	-3.2%	-2.9%	-22%	-38%	-52%	16%	13%	8%
Nuclear	23	24	20	22	24	0.8%	0.6%	0.7%	9%	9%	19%	9%	10%	11%
Biomass/waste	7	9	10	10	10	0.2%	-0.4%	-0.2%	2%	-6%	-4%	4%	5%	4%
Hydro	5	5	5	5	5	0.6%	0.2%	0.3%	7%	2%	9%	2%	2%	2%
Other renewables	2	4	6	10	15	4.5%	2.7%	3.4%	55%	49%	132%	3%	4%	7%
<b>End-use sectors</b>														
<b>Residential and commercial</b>														
Total	47	51	48	48	47	0.1%	-0.1%	0.0%	1%	-2%	0%	100%	100%	100%
Oil	11	8	6	5	3	-2.3%	-3.0%	-2.7%	-21%	-36%	-50%	13%	10%	6%
Gas	16	17	16	16	16	0.2%	-0.2%	-0.1%	2%	-3%	-2%	34%	34%	33%
Biomass/waste	2	3	3	3	2	-0.3%	-1.0%	-0.7%	-3%	-13%	-16%	6%	6%	5%
Electricity	17	21	20	22	24	0.8%	0.6%	0.7%	8%	9%	18%	43%	46%	51%
Other	2	3	2	2	2	0.2%	-0.5%	-0.2%	2%	-7%	-5%	5%	5%	4%
<b>Transportation</b>														
Total	55	58	58	57	53	-0.2%	-0.5%	-0.3%	-2%	-7%	-8%	100%	100%	100%
Oil	55	55	55	53	48	-0.4%	-0.8%	-0.6%	-4%	-11%	-14%	95%	94%	89%
Biofuels	0	2	2	3	3	1.4%	1.3%	1.3%	15%	22%	39%	4%	4%	6%
Gas	0	0	0	1	2	17.6%	6.5%	10.8%	406%	159%	1210%	0%	1%	4%
Other	0	0	0	0	1	0.7%	3.3%	2.3%	7%	64%	75%	1%	1%	1%
<b>Industrial</b>														
Total	70	67	69	72	73	0.4%	0.1%	0.2%	4%	1%	5%	100%	100%	100%
Oil	28	26	27	27	27	0.2%	-0.1%	0.0%	2%	-1%	1%	39%	38%	37%
Gas	18	18	19	22	24	1.7%	0.5%	1.0%	19%	7%	27%	28%	31%	33%
Coal	8	7	7	5	3	-4.1%	-2.8%	-3.3%	-34%	-35%	-57%	10%	6%	4%
Electricity	12	12	12	13	14	0.9%	0.6%	0.7%	9%	9%	19%	17%	18%	20%
Other	4	4	4	5	4	0.1%	-0.3%	-0.1%	1%	-4%	-3%	6%	6%	6%
<b>Power generation</b>														
Primary	84	90	85	86	86	0.1%	0.0%	0.1%	1%	0%	1%	100%	100%	100%
Oil	5	3	2	1	1	-7.1%	-3.0%	-4.7%	-52%	-37%	-70%	3%	1%	1%
Gas	13	20	21	24	27	1.2%	0.9%	1.0%	13%	15%	30%	25%	28%	32%
Coal	35	34	29	23	14	-2.2%	-3.2%	-2.8%	-20%	-38%	-50%	34%	27%	17%
Nuclear	23	24	20	22	24	0.8%	0.6%	0.7%	9%	9%	19%	24%	25%	28%
Hydro	5	5	5	5	5	0.6%	0.2%	0.3%	7%	2%	9%	6%	6%	6%
Wind	0	1	2	4	6	6.9%	3.6%	4.9%	95%	70%	232%	2%	4%	7%
Other renewables	3	4	6	7	8	2.0%	1.0%	1.4%	22%	16%	43%	7%	8%	10%

General note on data tables: Rounding may lead to minor differences between totals and the sum of their individual parts.

# Data

Energy demand (quadrillion BTUs)														
Non-OECD Energy by type	2000	2010	2015	2025	2040	Average annual change			% change			Share of total		
						2015 2025	2025 2040	2015 2040	2015 2025	2025 2040	2015 2040	2015	2025	2040
Primary	191	298	339	408	482	1.9%	1.1%	1.4%	20%	18%	42%	100%	100%	100%
Oil	59	85	100	121	145	2.0%	1.2%	1.5%	22%	20%	46%	29%	30%	30%
Gas	42	61	67	86	108	2.5%	1.5%	1.9%	28%	25%	61%	20%	21%	22%
Coal	48	96	109	122	126	1.1%	0.2%	0.6%	12%	3%	15%	32%	30%	26%
Nuclear	4	5	6	13	27	7.3%	5.1%	5.9%	101%	111%	324%	2%	3%	6%
Biomass/waste	33	40	44	46	47	0.5%	0.1%	0.3%	5%	1%	7%	13%	11%	10%
Hydro	4	7	9	11	13	2.3%	1.2%	1.6%	25%	19%	48%	3%	3%	3%
Other renewables	1	3	5	9	17	6.8%	3.9%	5.0%	93%	77%	240%	1%	2%	3%
<b>End-use sectors</b>														
<b>Residential and commercial</b>														
Total	51	65	72	86	100	1.7%	1.0%	1.3%	19%	16%	38%	100%	100%	100%
Oil	6	7	9	10	11	1.7%	0.5%	1.0%	18%	8%	27%	12%	12%	11%
Gas	5	7	8	11	13	2.8%	1.5%	2.0%	32%	26%	66%	11%	12%	13%
Biomass/waste	27	30	32	33	30	0.2%	-0.4%	-0.2%	2%	-6%	-4%	44%	38%	31%
Electricity	6	11	14	23	36	4.6%	3.1%	3.7%	57%	58%	148%	20%	26%	36%
Other	8	9	9	9	9	0.4%	-0.5%	-0.1%	4%	-7%	-3%	13%	11%	9%
<b>Transportation</b>														
Total	26	43	53	68	86	2.5%	1.6%	2.0%	29%	26%	62%	100%	100%	100%
Oil	25	41	49	62	76	2.4%	1.3%	1.7%	26%	22%	53%	94%	92%	88%
Biofuels	0	1	1	2	3	4.6%	3.4%	3.9%	57%	65%	159%	2%	3%	4%
Gas	0	1	1	3	5	6.2%	4.6%	5.3%	83%	97%	260%	3%	4%	6%
Other	0	1	1	1	2	3.2%	3.4%	3.3%	37%	65%	125%	1%	1%	2%
<b>Industrial</b>														
Total	78	131	145	168	190	1.5%	0.8%	1.1%	16%	13%	31%	100%	100%	100%
Oil	21	30	33	41	51	2.1%	1.5%	1.8%	23%	25%	54%	23%	24%	27%
Gas	19	27	29	35	42	1.9%	1.2%	1.5%	20%	20%	44%	20%	21%	22%
Coal	19	42	45	47	42	0.5%	-0.7%	-0.2%	5%	-10%	-6%	31%	28%	22%
Electricity	9	19	23	30	38	2.6%	1.6%	2.0%	30%	27%	65%	16%	18%	20%
Other	10	13	15	15	16	0.4%	0.3%	0.4%	5%	4%	9%	10%	9%	8%
<b>Power generation</b>														
Primary	59	98	117	150	191	2.5%	1.6%	2.0%	28%	28%	63%	100%	100%	100%
Oil	7	7	8	8	7	-0.6%	-0.5%	-0.5%	-6%	-7%	-12%	7%	5%	4%
Gas	17	26	29	38	48	2.9%	1.5%	2.1%	33%	26%	67%	25%	26%	25%
Coal	26	50	60	71	80	1.7%	0.8%	1.2%	18%	13%	34%	51%	47%	42%
Nuclear	4	5	6	13	27	7.3%	5.1%	5.9%	101%	111%	324%	5%	9%	14%
Hydro	4	7	9	11	13	2.3%	1.2%	1.6%	25%	19%	48%	7%	7%	7%
Wind	0	0	1	3	5	11.4%	4.5%	7.2%	194%	92%	466%	1%	2%	3%
Other renewables	1	3	5	7	11	3.9%	3.3%	3.5%	47%	62%	138%	4%	4%	6%

Energy demand (quadrillion BTUs)														
Regions	2000	2010	2015	2025	2040	Average annual change			% change			Share of total		
						2015 2025	2025 2040	2015 2040	2015 2025	2025 2040	2015 2040	2015	2025	2040
<b>AFRICA</b>														
Primary	22	30	34	43	60	2.4%	2.3%	2.3%	27%	40%	78%	100%	100%	100%
Oil	5	8	9	12	19	3.7%	2.9%	3.2%	43%	54%	120%	26%	29%	32%
Gas	4	5	5	7	11	3.3%	3.0%	3.1%	39%	56%	117%	15%	17%	19%
Coal	3	4	4	5	6	1.4%	1.8%	1.6%	15%	31%	50%	12%	11%	10%
Nuclear	0	0	0	0	1	5.1%	13.6%	10.1%	64%	581%	1020%	0%	0%	2%
Biomass/waste	10	13	15	17	20	1.4%	1.1%	1.2%	15%	18%	35%	45%	40%	34%
Hydro	0	0	0	1	1	7.0%	3.4%	4.8%	97%	65%	225%	1%	2%	2%
Other renewables	0	0	0	0	1	7.5%	4.7%	5.8%	106%	100%	312%	1%	1%	1%
<b>Demand by sector</b>														
Total end-use (including electricity)	20	26	30	37	51	2.3%	2.1%	2.2%	25%	37%	72%	100%	100%	100%
Residential and commercial	9	12	14	18	23	2.1%	1.7%	1.9%	23%	30%	60%	48%	47%	45%
Transportation	3	4	5	7	10	3.2%	2.6%	2.9%	37%	47%	102%	18%	19%	21%
Industrial	7	9	10	12	17	2.0%	2.3%	2.2%	22%	41%	73%	34%	33%	34%
Memo: electricity demand	1	2	2	4	7	5.2%	4.4%	4.7%	66%	92%	219%	7%	10%	13%
Power generation fuel <sup>1</sup>	4	6	6	9	16	4.2%	3.7%	3.9%	50%	73%	160%	18%	22%	27%
<b>ASIA PACIFIC</b>														
Primary	126	205	234	281	322	1.8%	0.9%	1.3%	20%	15%	38%	100%	100%	100%
Oil	43	57	66	77	87	1.5%	0.9%	1.1%	16%	14%	33%	28%	27%	27%
Gas	12	21	25	37	50	3.9%	2.0%	2.7%	46%	34%	96%	11%	13%	15%
Coal	43	92	105	116	119	1.0%	0.2%	0.5%	11%	3%	14%	45%	41%	37%
Nuclear	5	6	4	12	23	11.0%	4.4%	7.0%	184%	92%	445%	2%	4%	7%
Biomass/waste	20	23	24	25	22	0.1%	-0.8%	-0.4%	1%	-11%	-10%	10%	9%	7%
Hydro	2	4	5	7	7	2.2%	0.8%	1.3%	24%	12%	39%	2%	2%	2%
Other renewables	1	2	4	8	14	6.9%	3.8%	5.0%	95%	75%	241%	2%	3%	4%
<b>Demand by sector</b>														
Total end-use (including electricity)	100	159	182	214	240	1.6%	0.8%	1.1%	18%	12%	32%	100%	100%	100%
Residential and commercial	33	41	46	55	62	1.8%	0.8%	1.2%	19%	13%	35%	25%	26%	26%
Transportation	18	28	34	44	55	2.5%	1.5%	1.9%	28%	24%	59%	19%	21%	23%
Industrial	49	90	101	115	123	1.3%	0.5%	0.8%	14%	7%	22%	56%	54%	51%
Memo: electricity demand	12	24	30	42	57	3.2%	2.1%	2.5%	37%	36%	87%	17%	20%	24%
Power generation fuel <sup>1</sup>	40	73	87	112	143	2.6%	1.6%	2.0%	30%	27%	65%	37%	40%	44%
<b>EUROPE</b>														
Primary	79	81	76	74	70	-0.2%	-0.5%	-0.4%	-2%	-7%	-9%	100%	100%	100%
Oil	32	30	28	26	22	-1.0%	-0.9%	-0.9%	-9%	-12%	-20%	37%	34%	32%
Gas	17	20	17	18	20	1.0%	0.4%	0.6%	11%	6%	17%	22%	25%	28%
Coal	14	13	12	10	4	-2.1%	-5.2%	-4.0%	-19%	-55%	-64%	15%	13%	6%
Nuclear	10	10	9	8	9	-0.6%	0.7%	0.2%	-6%	11%	4%	12%	11%	14%
Biomass/waste	3	5	6	6	6	1.0%	-0.4%	0.2%	11%	-6%	5%	7%	8%	8%
Hydro	2	2	2	2	2	0.3%	0.3%	0.3%	3%	4%	7%	3%	3%	3%
Other renewables	0	2	3	4	6	3.9%	2.2%	2.9%	47%	39%	104%	4%	5%	8%
<b>Demand by sector</b>														
Total end-use (including electricity)	61	63	60	59	56	-0.2%	-0.4%	-0.3%	-2%	-6%	-7%	100%	100%	100%
Residential and commercial	18	21	19	19	18	0.1%	-0.4%	-0.2%	1%	-6%	-5%	32%	33%	32%
Transportation	17	19	18	17	17	-0.4%	-0.3%	-0.4%	-4%	-5%	-9%	30%	30%	30%
Industrial	25	24	23	22	21	-0.2%	-0.4%	-0.3%	-2%	-6%	-8%	38%	38%	38%
Memo: electricity demand	10	12	11	12	13	0.9%	0.5%	0.6%	9%	7%	17%	19%	21%	24%
Power generation fuel <sup>1</sup>	29	32	30	30	29	0.1%	-0.3%	-0.1%	1%	-4%	-3%	39%	40%	42%

<sup>1</sup>Share based on total primary energy

# Data

Energy demand (quadrillion BTUs)														
Regions	2000	2010	2015	2025	2040	Average annual change			% change			Share of total		
						2015 2025	2025 2040	2015 2040	2015 2025	2025 2040	2015 2040	2015	2025	2040
<b>LATIN AMERICA</b>														
Primary	20	27	29	33	41	1.3%	1.5%	1.4%	14%	25%	42%	100%	100%	100%
Oil	10	12	13	15	17	1.1%	0.9%	1.0%	12%	15%	29%	46%	45%	42%
Gas	4	6	6	7	11	1.6%	2.7%	2.3%	18%	49%	75%	21%	22%	26%
Coal	1	1	1	1	2	1.9%	1.2%	1.5%	20%	20%	44%	4%	4%	4%
Nuclear	0	0	0	0	0	4.8%	1.7%	3.0%	60%	30%	108%	1%	1%	1%
Biomass/waste	3	4	5	5	5	-0.4%	0.2%	0.0%	-4%	3%	-1%	16%	14%	11%
Hydro	2	2	2	3	3	1.8%	1.4%	1.5%	19%	23%	46%	8%	8%	8%
Other renewables	0	1	1	2	3	5.6%	3.5%	4.3%	73%	67%	189%	4%	6%	8%
<b>Demand by sector</b>														
Total end-use (including electricity)	18	23	25	29	36	1.4%	1.5%	1.4%	15%	24%	43%	100%	100%	100%
Residential and commercial	3	4	5	5	6	1.3%	1.2%	1.2%	14%	19%	36%	18%	18%	17%
Transportation	5	7	8	10	12	1.7%	1.3%	1.4%	19%	21%	43%	32%	33%	32%
Industrial	9	12	13	14	18	1.2%	1.7%	1.5%	13%	29%	46%	50%	49%	51%
Memo: electricity demand	2	3	4	5	7	2.3%	2.4%	2.4%	26%	43%	80%	14%	16%	18%
Power generation fuel <sup>1</sup>	4	6	7	9	12	1.6%	2.0%	1.9%	18%	35%	59%	26%	26%	29%
<b>MIDDLE EAST</b>														
Primary	18	30	35	42	49	1.9%	1.1%	1.4%	21%	17%	41%	100%	100%	100%
Oil	11	16	18	20	22	1.3%	0.6%	0.9%	14%	10%	26%	51%	48%	45%
Gas	7	13	16	21	24	2.3%	1.1%	1.6%	26%	19%	49%	47%	49%	50%
Coal	0	0	0	0	0	-4.8%	-4.6%	-4.7%	-39%	-51%	-70%	1%	1%	0%
Nuclear	0	0	0	0	1	22.6%	7.5%	13.3%	667%	194%	2156%	0%	1%	3%
Biomass/waste	0	0	0	0	0	6.5%	6.1%	6.3%	88%	145%	361%	0%	0%	0%
Hydro	0	0	0	0	0	2.3%	2.1%	2.2%	25%	38%	72%	0%	0%	0%
Other renewables	0	0	0	0	1	8.6%	5.9%	7.0%	127%	137%	439%	0%	1%	1%
<b>Demand by sector</b>														
Total end-use (including electricity)	14	23	27	33	39	1.9%	1.1%	1.4%	21%	18%	43%	100%	100%	100%
Residential and commercial	3	4	5	6	7	2.0%	1.4%	1.6%	22%	23%	49%	18%	18%	19%
Transportation	4	7	8	9	10	1.3%	0.9%	1.0%	14%	14%	30%	28%	27%	26%
Industrial	7	12	15	18	21	2.2%	1.2%	1.6%	24%	19%	48%	53%	55%	55%
Memo: electricity demand	1	3	3	5	6	3.8%	2.2%	2.8%	46%	38%	102%	12%	14%	17%
Power generation fuel <sup>1</sup>	5	9	11	14	17	2.5%	1.3%	1.8%	28%	21%	55%	31%	33%	34%
<b>NORTH AMERICA</b>														
Primary	114	113	113	116	115	0.3%	0.0%	0.1%	3%	-1%	2%	100%	100%	100%
Oil	48	46	46	47	44	0.3%	-0.4%	-0.1%	3%	-6%	-4%	41%	41%	39%
Gas	26	28	32	37	40	1.3%	0.7%	0.9%	14%	10%	26%	28%	32%	35%
Coal	23	21	16	12	7	-2.9%	-3.6%	-3.3%	-26%	-42%	-57%	14%	10%	6%
Nuclear	9	10	10	10	11	-0.2%	0.7%	0.3%	-2%	11%	9%	9%	8%	9%
Biomass/waste	4	3	3	3	3	-0.7%	-0.6%	-0.6%	-6%	-9%	-15%	3%	3%	3%
Hydro	2	2	2	2	3	1.0%	0.1%	0.4%	10%	1%	11%	2%	2%	2%
Other renewables	1	2	3	5	7	4.7%	2.9%	3.6%	58%	53%	141%	3%	4%	6%
<b>Demand by sector</b>														
Total end-use (including electricity)	86	86	88	92	93	0.5%	0.0%	0.2%	5%	1%	6%	100%	100%	100%
Residential and commercial	23	23	22	23	23	0.1%	0.1%	0.1%	1%	1%	2%	25%	24%	25%
Transportation	31	32	33	33	31	0.1%	-0.5%	-0.2%	1%	-7%	-6%	37%	36%	33%
Industrial	33	30	32	36	39	1.2%	0.5%	0.7%	12%	7%	21%	37%	40%	42%
Memo: electricity demand	15	16	16	17	19	0.7%	0.7%	0.7%	7%	10%	18%	18%	19%	20%
Power generation fuel <sup>1</sup>	42	43	42	41	41	-0.1%	0.1%	0.0%	-1%	1%	-1%	37%	35%	36%

<sup>1</sup>Share based on total primary energy



Energy demand (quadrillion BTUs)														
Regions	2000	2010	2015	2025	2040	Average annual change			% change			Share of total		
						2015-2025	2025-2040	2015-2040	2015-2025	2025-2040	2015-2040	2015	2025	2040
<b>RUSSIA/CASPIAN</b>														
Primary	38	43	43	45	43	0.4%	-0.2%	0.0%	4%	-4%	0%	100%	100%	100%
Oil	8	9	10	11	11	0.8%	0.0%	0.3%	8%	0%	8%	24%	25%	25%
Gas	20	23	22	23	22	0.4%	-0.3%	0.0%	4%	-5%	-1%	51%	51%	50%
Coal	7	7	7	6	5	-1.0%	-1.7%	-1.4%	-9%	-23%	-31%	16%	14%	11%
Nuclear	2	3	3	3	4	1.4%	1.4%	1.4%	14%	23%	41%	7%	8%	10%
Biomass/waste	0	0	0	0	0	0.0%	-0.6%	-0.3%	0%	-8%	-8%	1%	1%	1%
Hydro	1	1	1	1	1	0.6%	0.3%	0.4%	6%	4%	11%	2%	2%	2%
Other renewables	0	0	0	0	0	7.1%	5.0%	5.8%	98%	107%	310%	0%	0%	0%
<b>Demand by sector</b>														
Total end-use (including electricity)	29	33	33	35	34	0.5%	-0.1%	0.1%	5%	-2%	3%	100%	100%	100%
Residential and commercial	9	9	9	8	8	-0.2%	-0.7%	-0.5%	-2%	-10%	-12%	26%	24%	22%
Transportation	3	4	4	5	5	0.5%	0.2%	0.3%	5%	3%	8%	13%	13%	14%
Industrial	17	20	20	22	21	0.8%	0.0%	0.3%	8%	0%	8%	60%	62%	64%
Memo: electricity demand	3	4	4	5	6	1.7%	0.9%	1.2%	19%	14%	36%	13%	14%	17%
Power generation fuel <sup>1</sup>	19	20	20	21	20	0.3%	-0.4%	-0.1%	3%	-5%	-3%	47%	47%	46%
<b>GDP by region (2010\$, trillions)</b>														
World	50	66	75	99	150	2.9%	2.8%	2.8%	33%	51%	101%	100%	100%	100%
OECD	38	44	48	58	77	2.0%	1.9%	1.9%	21%	32%	61%	64%	59%	51%
Non-OECD	12	21	27	41	73	4.5%	3.9%	4.1%	55%	78%	175%	36%	41%	49%
Africa	1	2	2	3	6	4.0%	3.9%	4.0%	48%	78%	164%	3%	3%	4%
Asia Pacific	12	19	24	36	61	4.2%	3.6%	3.9%	51%	70%	157%	32%	36%	40%
China	2	6	9	15	29	5.8%	4.2%	4.8%	75%	86%	225%	12%	16%	19%
India	1	2	2	5	10	6.8%	5.3%	5.9%	93%	116%	316%	3%	5%	7%
Europe	16	19	20	24	31	1.8%	1.7%	1.7%	20%	28%	54%	27%	24%	20%
European Union	15	17	18	21	27	1.7%	1.6%	1.7%	19%	27%	50%	24%	21%	18%
Latin America	3	4	5	6	9	2.2%	2.9%	2.6%	25%	53%	91%	6%	6%	6%
Middle East	1	2	2	3	6	3.4%	3.3%	3.3%	40%	62%	127%	3%	4%	4%
North America	15	18	20	24	34	2.3%	2.3%	2.3%	25%	40%	76%	26%	25%	23%
United States	13	15	17	21	29	2.2%	2.2%	2.2%	25%	39%	73%	22%	21%	19%
Russia/Caspian	1	2	2	3	4	2.4%	2.7%	2.5%	26%	48%	87%	3%	3%	3%
<b>Energy intensity (thousand BTU per \$ GDP)</b>														
World	8.4	8.0	7.6	6.4	4.7	-1.7%	-2.1%	-1.9%	-16%	-27%	-38%			
OECD	5.9	5.2	4.7	3.9	2.8	-1.9%	-2.1%	-2.0%	-17%	-27%	-39%			
Non-OECD	16.5	14.0	12.7	9.9	6.6	-2.5%	-2.7%	-2.6%	-22%	-34%	-48%			
Africa	19.0	15.2	14.6	12.5	9.9	-1.5%	-1.6%	-1.6%	-14%	-21%	-32%			
Asia Pacific	10.7	10.9	9.9	7.9	5.3	-2.3%	-2.6%	-2.5%	-21%	-32%	-46%			
China	21.0	16.8	13.7	9.3	5.4	-3.8%	-3.6%	-3.7%	-32%	-42%	-61%			
India	21.7	16.3	14.5	10.6	6.6	-3.0%	-3.1%	-3.1%	-27%	-38%	-54%			
Europe	4.9	4.3	3.8	3.1	2.3	-2.0%	-2.1%	-2.1%	-18%	-27%	-41%			
European Union	4.9	4.3	3.8	3.1	2.2	-2.1%	-2.1%	-2.1%	-19%	-28%	-41%			
Latin America	6.7	6.3	6.3	5.7	4.7	-0.9%	-1.4%	-1.2%	-8%	-19%	-26%			
Middle East	13.9	14.0	14.0	12.1	8.7	-1.5%	-2.2%	-1.9%	-14%	-28%	-38%			
North America	7.6	6.4	5.8	4.7	3.3	-2.0%	-2.3%	-2.2%	-18%	-29%	-42%			
United States	7.6	6.2	5.6	4.5	3.2	-2.1%	-2.4%	-2.2%	-19%	-30%	-43%			
Russia/Caspian	31.6	21.1	19.8	16.3	10.6	-1.9%	-2.8%	-2.5%	-18%	-35%	-47%			
<b>Energy-related CO<sub>2</sub> emissions (billion tonnes)</b>														
World	23.7	31.0	32.8	35.5	36.4	0.8%	0.2%	0.4%	8%	3%	11%	100%	100%	100%
OECD	12.9	12.8	12.2	11.4	9.8	-0.7%	-1.0%	-0.9%	-7%	-14%	-20%	37%	32%	27%
Non-OECD	10.8	18.2	20.6	24.0	26.6	1.6%	0.7%	1.0%	17%	11%	30%	63%	68%	73%
Africa	0.9	1.2	1.3	1.7	2.5	2.8%	2.6%	2.7%	32%	46%	93%	4%	5%	7%
Asia Pacific	7.5	13.5	15.5	17.7	19.1	1.4%	0.5%	0.8%	15%	7%	23%	47%	50%	52%
China	3.3	7.8	8.9	9.8	9.4	1.0%	-0.3%	0.2%	10%	-4%	6%	27%	28%	26%
India	0.9	1.6	2.1	3.1	4.0	3.8%	1.8%	2.6%	46%	31%	91%	6%	9%	11%
Europe	4.3	4.3	3.9	3.6	2.8	-0.8%	-1.6%	-1.3%	-8%	-21%	-27%	12%	10%	8%
European Union	4.0	3.9	3.4	3.1	2.4	-1.0%	-1.4%	-1.4%	-9%	-23%	-31%	10%	9%	7%
Latin America	0.9	1.2	1.4	1.5	1.9	1.3%	1.4%	1.4%	13%	24%	41%	4%	4%	5%
Middle East	1.1	1.8	2.1	2.4	2.5	1.2%	0.5%	0.8%	13%	8%	22%	6%	7%	7%
North America	6.7	6.5	6.2	6.0	5.3	-0.3%	-0.9%	-0.6%	-3%	-12%	-15%	19%	17%	15%
United States	5.8	5.5	5.2	5.0	4.2	-0.5%	-1.1%	-0.9%	-5%	-15%	-20%	16%	14%	12%
Russia/Caspian	2.3	2.5	2.5	2.5	2.3	0.0%	-0.6%	-0.4%	0%	-9%	-9%	8%	7%	6%

<sup>1</sup>Share based on total primary energy

# 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 ( $10^{15}$ ) BTUs.

**Conventional Vehicle:** A type of light-duty vehicle with an internal combustion engine, typically either a gasoline-fueled spark ignition engine or a diesel-fueled compression ignition engine. Conventional includes vehicles with advanced technologies such as turbocharging and “mild hybrid” features such as a stop start engine.

**Hybrid Vehicle:** A “full” hybrid is a type of light-duty vehicle that has a battery (usually a nickel metal hydride) and an electric motor, as well as a conventional internal combustion engine. When brakes are applied, the energy of the moving vehicle is stored in the battery and can be used later, thus saving fuel.

**Hydrogen fuel cell vehicle:** A type of light-duty vehicle where hydrogen is the fuel and is stored onboard. This hydrogen is passed through a fuel cell that then provides electricity to power the vehicle.

**Light-duty vehicle (LDV):** A classification of road vehicles that includes cars, light-trucks and sport utility vehicles (SUVs). Motorcycles are not counted in the light-duty vehicle fleet size or fuel-economy, but the fuel used in motorcycles is included in light-duty transportation demand.

**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 (MBOE):** 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 4 percent of the light-duty vehicles on the world’s roads today.

**Natural Gas Liquids (NGL):** Liquid fuels produced chiefly 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.

**Organisation for Economic Co-operation and Development (OECD):** A forum for about 35 member nations from across the world that work with each other, as well as with many more partner nations, to promote policies that will improve the economic and social well-being of people around the world. Note: OECD data in this report reflects OECD member countries as of June 2016.

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

**PPP:** Purchasing power parity

**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, including electricity and market heat, which are derived from primary energy sources. For example, electricity is a secondary energy type generated using natural gas, wind or other primary energy source.

**TCF:** Trillion Cubic Feet

**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).

**Watt-hour:** A unit of electrical energy. 300 terawatt hours is equivalent to about 1 quadrillion BTUs (Quad). (Kilowatt-hour (kWh) = 1,000 watt-hours; Gigawatt-hour (GWh) = 1,000,000,000 watt-hours; Terawatt-hour (TWh) =  $10^{12}$  watt-hours).

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