International Energy Outlook 2017

Independent Statistics & Analysis
U.S. Energy Information Administration

#IEO2017

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www.eia.gov/ieo

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Overview

Overview/key takeaways

- EIA's *International Energy Outlook 2017* (IEO2017) presents an assessment of long-term world energy markets. The IEO2017 is the first edition of this report to include model results through 2050, which are available on the IEO page of the EIA website. The graphics in this presentation focus on projections through 2040. IEO2017 energy consumption projections are provided for 16 world regions, divided according to Organization for Economic Cooperation and Development (OECD) members and nonmembers (non-OECD).

- U.S. projections appearing in IEO2017 are consistent with those released in the *Annual Energy Outlook 2017*. Between 2015 and 2040, world energy consumption increases by 28% in the IEO2017 Reference case, with more than half of the increase attributed to non-OECD Asia (including China and India), where strong economic growth drives increasing demand for energy.

The *International Energy Outlook 2017* provides long-term energy projections for the major world regions

- Projections in *International Energy Outlook 2017* (IEO2017) are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions under different scenarios.

- The IEO is developed using the World Energy Projection System Plus (WEPS+), an integrated model that aims to capture various interactions of economic changes and energy supply, demand, and prices across regional markets.

- Energy market projections are subject to much uncertainty, as the events that shape future developments in technology, demographic changes, economic trends, and resource availability that drive energy use cannot be foreseen with certainty.

- The IEO projections are published under to the Department of Energy Organization Act of 1977, which requires the U.S. Energy Information Administration (EIA) to prepare reports on trends and projections for energy use and supply.

What is the Reference case?

- The Reference case assumes continual improvement in known technologies based on current trends and relies on the views of leading economic forecasters and demographers related to economic and demographic trends for 16 world regions based on OECD membership status.

- The IEO2017 considers current policies—as reflected in current laws, regulations, and stated targets that are judged to reflect an actual policy commitment—for major countries with the goal of realistically capturing their effects in the projections.

- Projections in the IEO should be interpreted with a clear understanding of the assumptions that inform them (e.g., economic growth, population, world oil prices, and existing government regulations and policies) and the limitations inherent in any modeling effort.

What are the side cases?

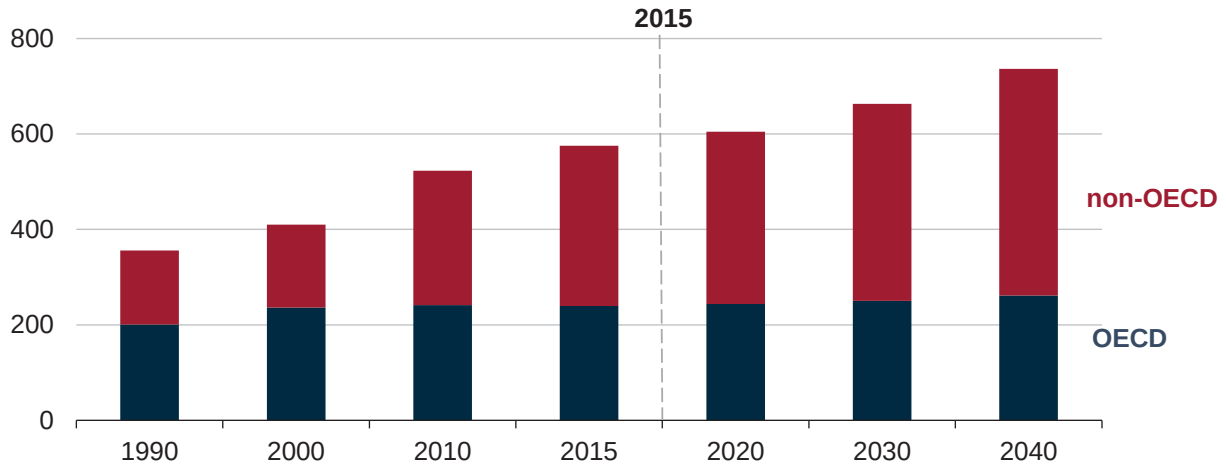
- EIA addresses the uncertainty inherent in energy projections by developing side cases reflecting different economic growth rates and world oil prices.

- The effects of economic growth assumptions on energy consumption are addressed in the High and Low Economic Growth cases. World gross domestic product (GDP) increases by 3.3%/year from 2015 to 2040 in the High Economic Growth case and by 2.7%/year in the Low Economic Growth case, compared with 3.0%/year in the Reference case.

- The High and Low Oil Price cases address the uncertainty associated with the trajectory of world energy prices. In the Low Oil Price case, the price of North Sea Brent crude in 2016 dollars reaches $43/barrel by 2040, compared with $109/barrel in the Reference case and $226/barrel in the High Oil Price case.

World energy consumption rises 28% between 2015 and 2040 in the Reference case—

World energy consumption
quadrillion Btu

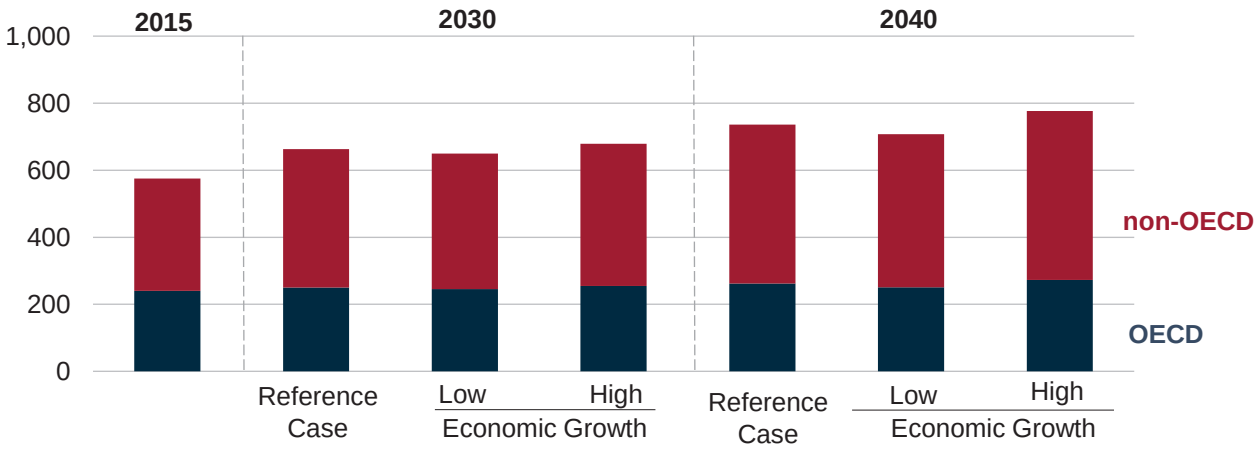


—with most of the increase occurring in non-OECD countries

- In the Reference case, world energy consumption increases from 575 quadrillion British thermal units (Btu) in 2015 to 663 quadrillion Btu by 2030 and then to 736 quadrillion Btu by 2040.
- Most of the increase in energy demand is expected to come from non-OECD countries, where strong economic growth, increased access to marketed energy, and quickly growing populations lead to rising demand for energy.
- Energy consumption in non-OECD countries increases 41% between 2015 and 2040 in contrast to a 9% increase in OECD countries.

Energy consumption varies across the High and Low Economic Growth cases—

World energy consumption in three economic growth cases
quadrillion Btu



—with most of the variation found across non-OECD regions

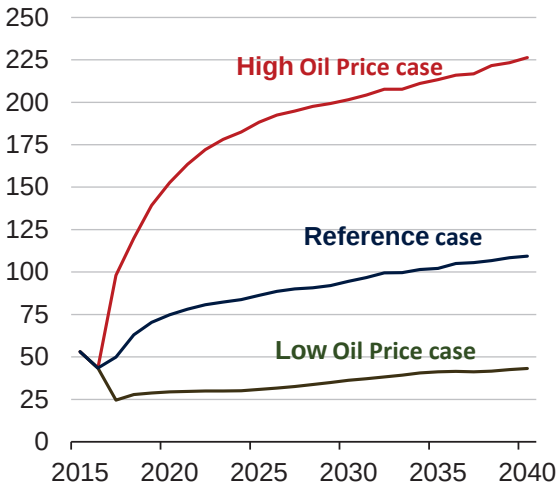
- In the Reference case, world energy consumption totals 736 quadrillion Btu in 2040—262 quadrillion Btu in the OECD countries and 475 quadrillion Btu in the non-OECD countries. In the High Economic Growth case, world energy use in 2040 is 40 quadrillion Btu higher than in the Reference case. In the Low Economic Growth case, world energy use in 2040 is 29 quadrillion Btu lower than in the Reference case.

- In the High Economic Growth case, real GDP in the OECD countries increases by 2.0%/year from 2015 to 2040, as compared with 1.7%/year growth in the Reference case. Similarly, the High Economic Growth case projects GDP growth of 4.2%/year in the non-OECD countries as a whole, compared with 3.8%/year in the Reference case.

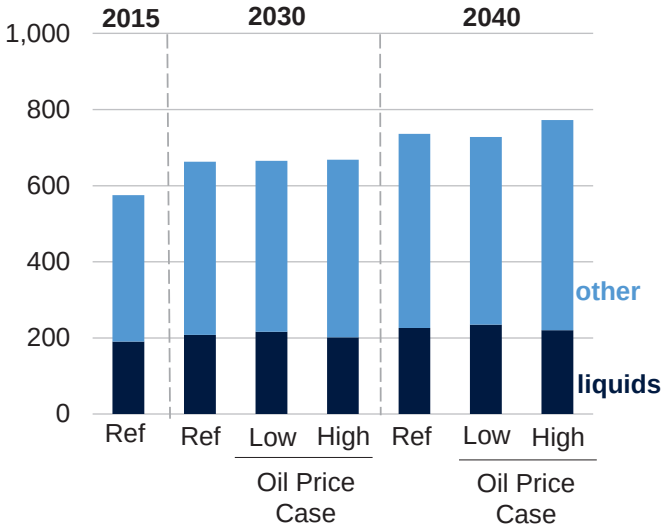
- In the Low Economic Growth case, OECD GDP increases by 1.4%/year, or 0.3 percentage points lower than in the Reference case. GDP growth in the non-OECD grows by an average 3.5%/year in the Low Economic Growth case, or 0.3 percentage points lower than in the Reference case.

Future oil prices are another key source of uncertainty in the projections—

World oil prices in three cases
real 2016 dollars per barrel



World energy consumption in three cases
quadrillion Btu



—but end-use demand doesn't vary significantly

- In addition to the Reference case, EIA includes a Low Oil Price case and a High Oil Price case that use different assumptions about future oil prices, based on different views of supply and demand of liquid fuels.

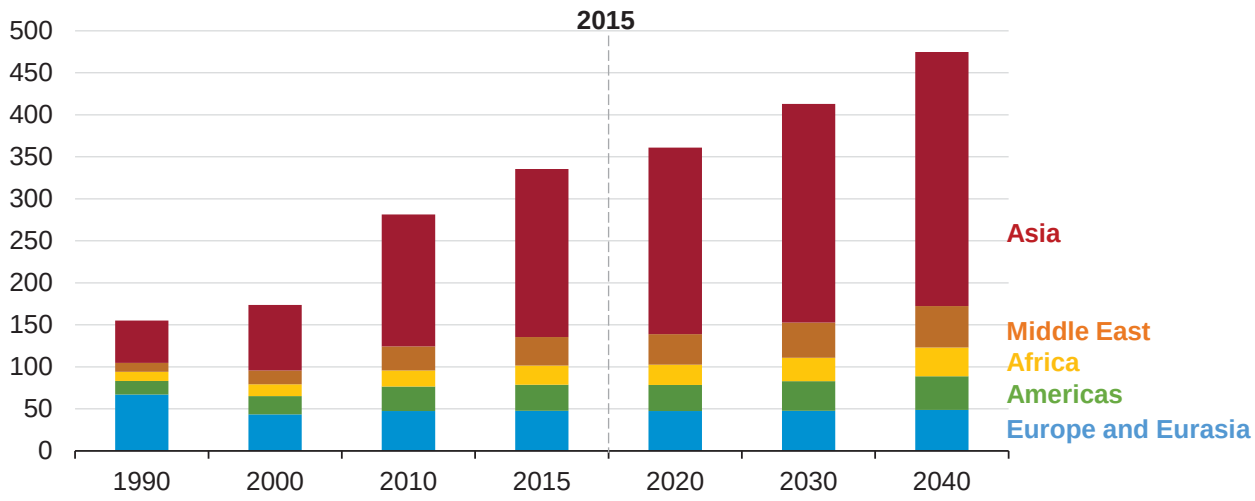
- In the Reference case, oil prices rise to $109/barrel (real 2016 dollars) in 2040. Total liquids consumption increases from 191 quadrillion Btu in 2015 to 228 quadrillion Btu in 2040, when it accounts for 31% of total world energy use.

- In the Low Oil Price case, oil prices are $43/barrel in 2040, in part because of lower economic activity, especially in the developing world. Lower oil prices spur the demand for liquid fuels and discourage energy conservation and fuel switching. In 2040, liquids account for 32% of total world energy use.

- In the High Oil Price case, oil prices reach $226/barrel in 2040, as non-OECD economies grow more quickly and supply conditions are tighter than in the Reference case. Higher oil prices discourage liquids consumption, and consumers conserve or switch to alternative fuels whenever possible. Liquids account for 28% of total world energy use.

In the Reference case, Asia accounts for most of the increase in energy use in non-OECD regions—

Non-OECD energy consumption by region
quadrillion Btu



—but there is substantial growth in other regions

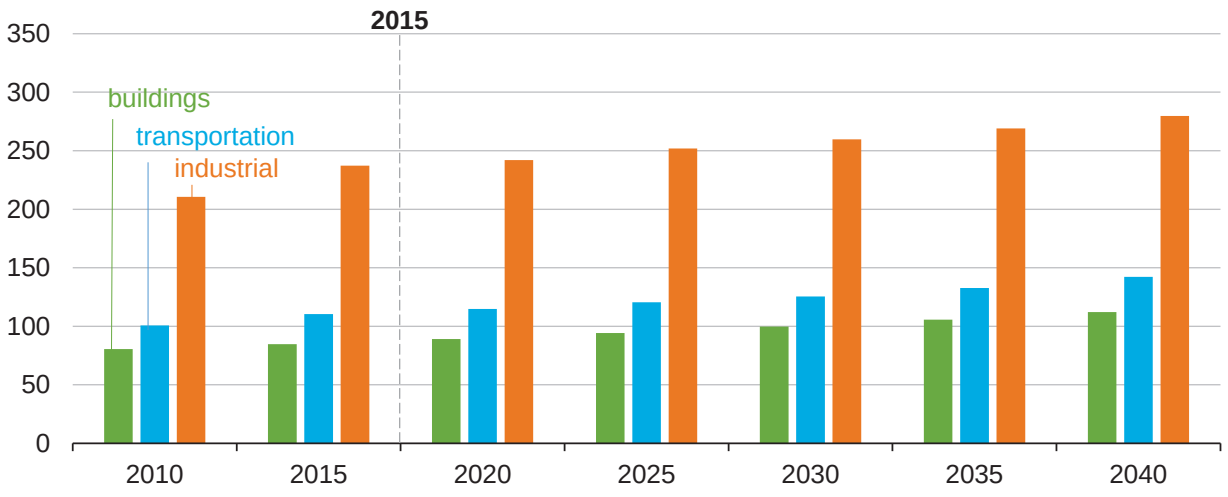
- In the Reference case, more than half of the projected increase in global energy consumption occurs in non-OECD Asia, a region that includes China and India. Energy demand in non-OECD Asia is projected to increase by 51% (or by 102 quadrillion Btu) during the period of 2015–40. While much slower than the nearly 300% increase in energy use from 1990 to 2015, the projected growth in non-OECD Asia energy use still represents the largest regional growth in the world.

- Non-OECD regions outside of Asia are also projected to contribute to substantial increases in energy demand. Fast-paced population growth and access to ample domestic resources are both important determinants of energy demand in Africa and the Middle East, where energy use is expected to increase 51% and 45%, respectively, between 2015 and 2040.

- The smallest projected increase in energy demand is 2% in non-OECD Europe and Eurasia. Much of the low growth is related to Russia, where the population is expect to decline over the projection, and significant gains in energy efficiency are achieved by replacing older physical assets with more efficient ones.

The industrial sector continues to account for the largest share of energy consumption through 2040 in the Reference case—

World energy consumption by end-use sector
quadrillion Btu



—but energy use in all other end-use sectors is projected to grow more quickly

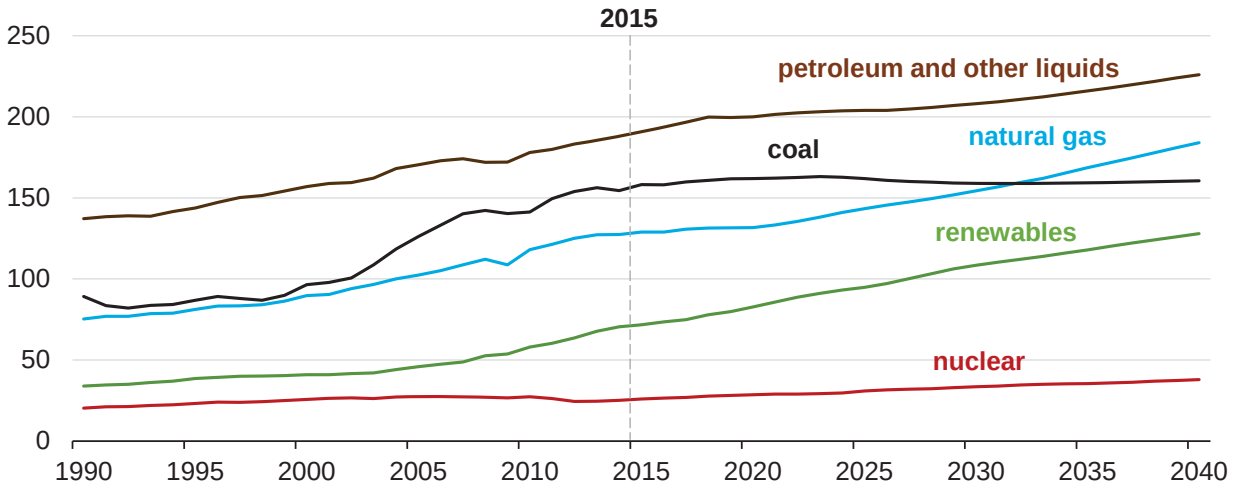
- The industrial sector, which includes mining, manufacturing, agriculture, and construction, accounts for the largest share of energy consumption of any end-use sector, accounting for more than 50% over the entire projection period. World industrial sector energy use increases by 18% from 2015 to 2040, reaching 280 quadrillion Btu by 2040.

- Although the industrial sector remains the world's largest energy-consuming sector throughout the projection period, energy demand in all other sectors grows more quickly than in the industrial sector in the Reference case. World industrial sector energy use rises by 0.7%/year from 2015 to 2040, compared with an increase of 1.0%/year for transportation and 1.1%/year for buildings.

- Most of the industrial sector energy use increase (89%) occurs in non-OECD nations. Industrial sector energy use in non-OECD countries grows by 0.8%/year in the Reference case compared with an increase of 0.2%/year in OECD countries.

Energy consumption increases over the projection for all fuels other than coal in the Reference case—

World energy consumption by energy source
quadrillion Btu



—with renewables being the fastest-growing energy source

- Use of all fuels except coal grows throughout the Reference case. Although renewable energy and nuclear power are the world's fastest growing forms of energy, fossil fuels are expected to continue to meet much of world's energy demand.

- Petroleum and other liquids remains the largest source of energy, but its share of world marketed energy declines from 33% in 2015 to 31% in 2040. On a worldwide basis, liquids consumption increases in the industrial and transportation sectors, and declines in the electric power sector.

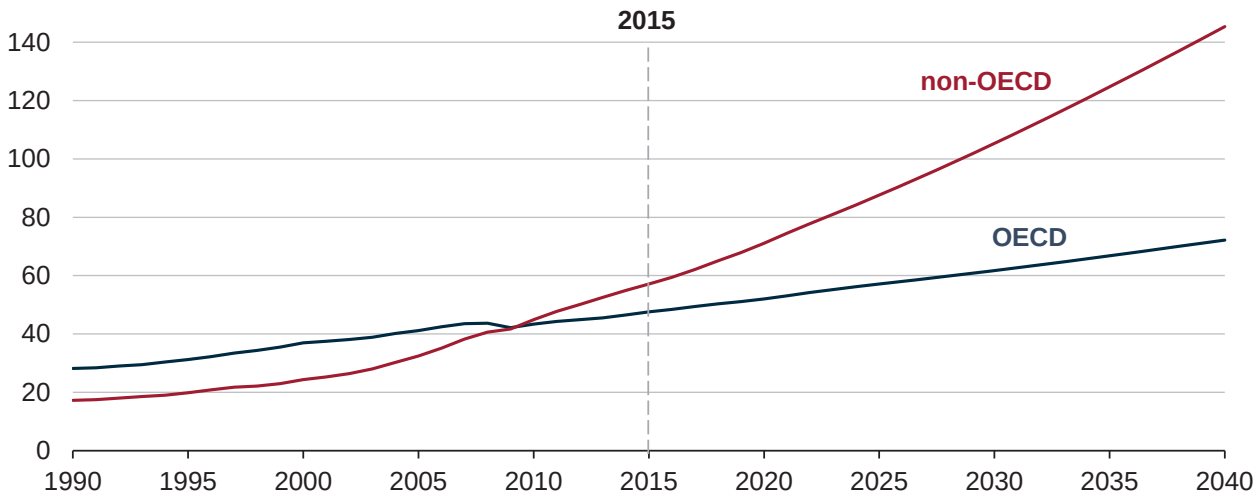
- Natural gas is the world's fastest growing fossil fuel, increasing by 1.4%/year, compared with liquid's 0.7%/year growth and virtually no growth in coal use (0.1%/year).

- Compared with the strong growth in coal use in the early 2000s, worldwide coal use is projected to remain flat—with declines in OECD regions and China offsetting growth in India and the other non-OECD Asian nations. Coal is increasingly replaced by natural gas, renewables, and nuclear power (in the case of China) in electricity generation. Industrial demand for coal also weakens.

Economic growth is anticipated to be highest in non-OECD regions–

World gross domestic product

trillion 2010 dollars, purchasing power parity

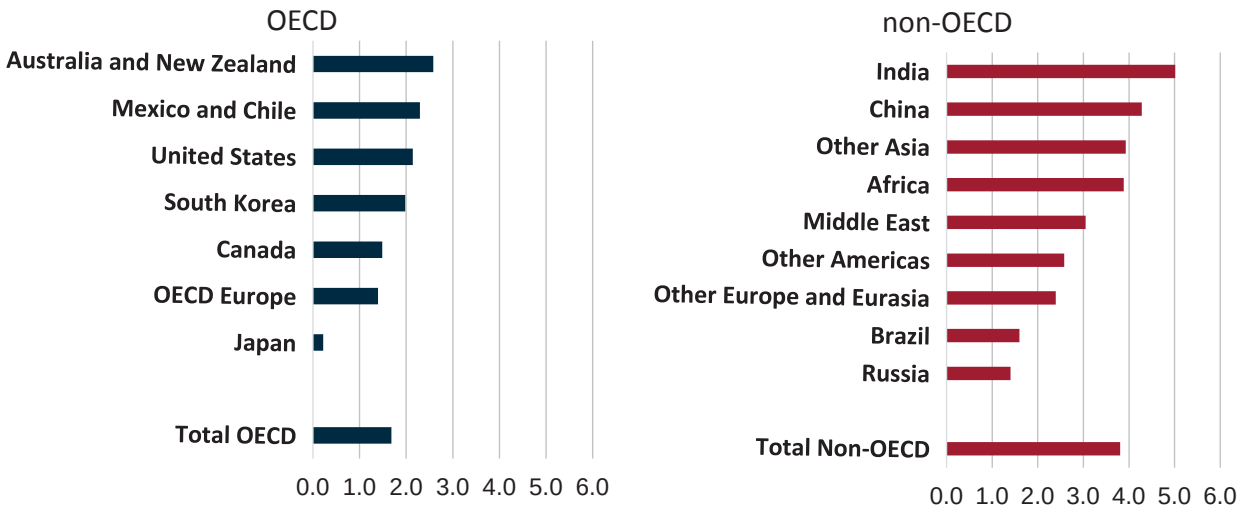


—and, as these economies continue to grow, energy demand grows as well

- In the Reference case, average GDP in the non-OECD grows by 3.8%/year from 2015 to 2040, compared with 1.7%/year in the OECD.
- Over the past 25 years, world economic growth has been led by the non-OECD countries, accompanied by strong growth in energy demand in those countries. From 1990 to 2015, real GDP grew by 4.9%/year in the non-OECD, compared with 2.1%/year in the OECD.
- In the future, the difference in economic growth rates between OECD and non-OECD countries is expected to narrow somewhat, as economic growth in non-OECD countries moderates, and as their industrial sectors move from reliance mainly on production in energy-intensive industries to more service-oriented industries.

Economic growth varies widely across non-OECD regions in the Reference case—

Average annual percent change in GDP, 2015-40
percent per year

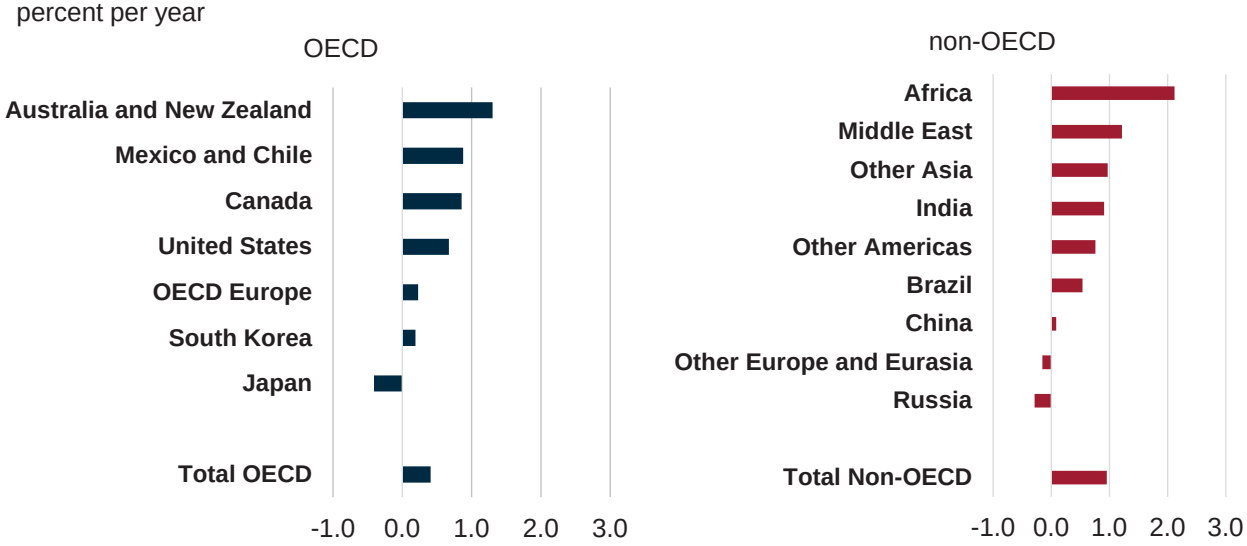


—with the highest rates occurring in non-OECD Asia and Africa

- Australia and New Zealand combined has the fastest economic growth across the OECD regions. GDP in this region grows by an average 2.6%/year from 2015 to 2040.
- Japan is the slowest-growing economy, averaging 0.2%/year, primarily attributable to declining population and aging workforce.
- India has the world's fastest-growing economy in the Reference case, averaging 5.0%/year from 2015 to 2040.
- In China, average GDP expected to increase by 4.3%/year between 2015 and 2040. GDP growth in China slows considerably compared with growth over the past decade when GDP increased by an average 9.6%/year.

Non-OECD total population grows at more than twice the rate as the total OECD population—

Average annual percent change in population, 2015-40
percent per year

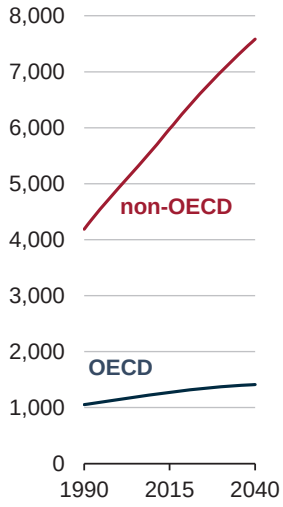


—which has implications for future energy consumption

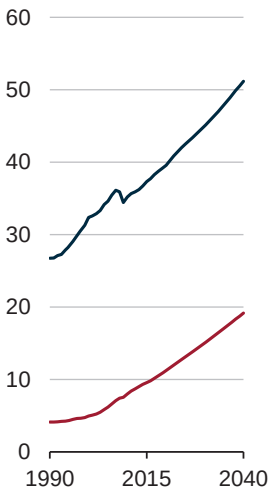
- Population is an important driver of energy demand.
- In Japan and many parts of non-OECD Europe and Eurasia, the population is expected to decline from 2015 to 2040. The populations of OECD Europe, South Korea, and China are expected to grow by about 0.2%/year or lower.
- Within the non-OECD, Africa, the Middle East, and countries in non-OECD Asia other than China are expected to experience among the highest rates of population growth in the world. However, relatively underdeveloped energy infrastructures and large rural populations constrain growth in energy consumption in many countries of these regions.

Although population and per capita output continue to rise—

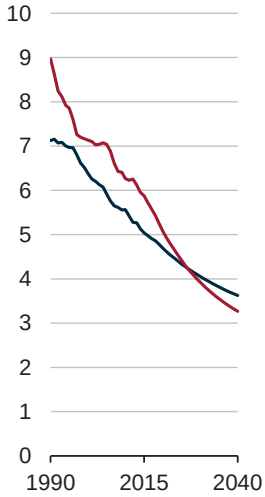
Population
million people



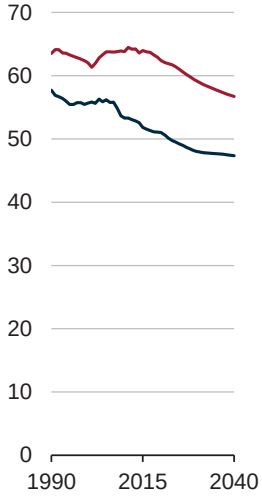
Gross domestic product per capita
thousand dollars



Energy intensity
thousand Btu per dollar



Carbon intensity
metric tons CO2 per billion Btu

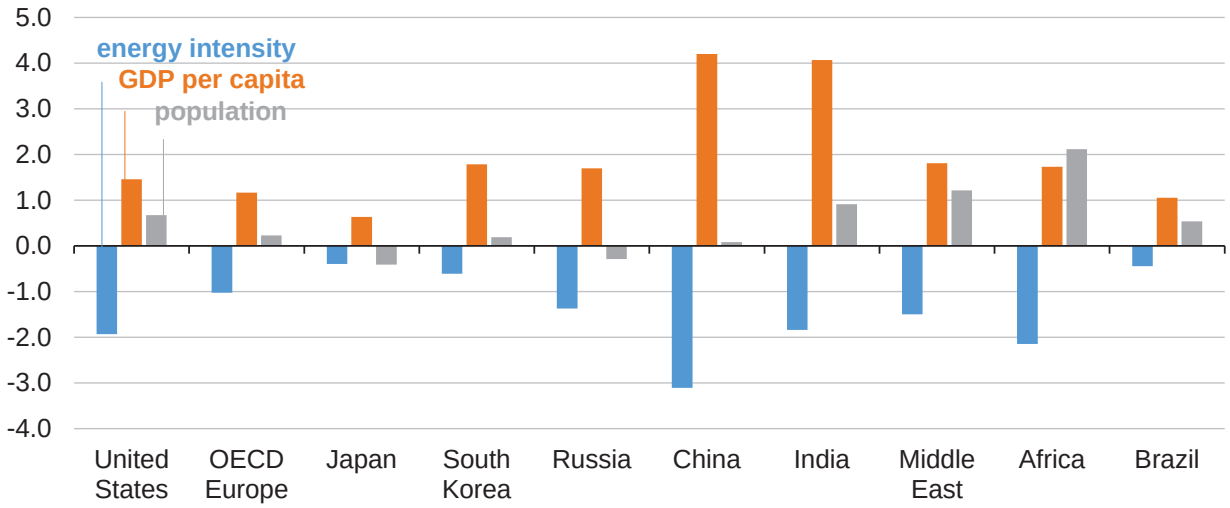


—energy and carbon intensity are projected to continue to fall in the Reference case

- Worldwide, the amount of energy used per unit of economic growth (energy intensity) has declined steadily for many years, while the amount of CO2 emissions associated with energy consumption (carbon intensity) has generally declined in OECD countries since 2008.
- In OECD countries, these trends continue as increases in energy efficiency and fuel economy lower energy intensity.
- In non-OECD countries, declines in energy intensity are particularly strong in the first 10 years of the projection as many of the larger economies begin to shift production into less energy-intensive industries and services.
- Carbon intensity continues to decline largely as a result of a move away from coal in China and worldwide growth in the use of non-CO2-emitting sources of energy, such as wind and solar.

Income and population growth heavily influence energy demand—

Energy intensity, per capita GDP, and population growth in selected regions
average annual percent change, 2015-40



—but improvements in energy intensity can offset associated increases in energy consumption

- Rising income and population drive the increased demand for energy, but that growth is tempered by declining energy intensity (energy consumed per dollar of GDP).

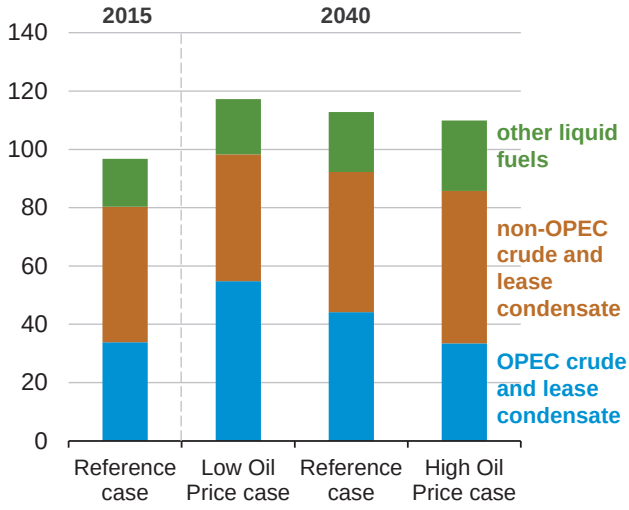
- India and China are the two regions with the fastest projected growth in per capita income in the Reference case. But sizable declines in energy intensity in these countries reduce the amount of energy required to meet demand in the future.

- Japan has an aging workforce and a declining population that already has relatively high per capita income levels. It is also among the world's most efficient consumers of energy. The combination of the demographic and economic factors means the country has less potential to improve energy intensity in the future. Japan's energy intensity improves by 0.4%/year from 2015 to 2040, compared with the world average of 1.9%/year.

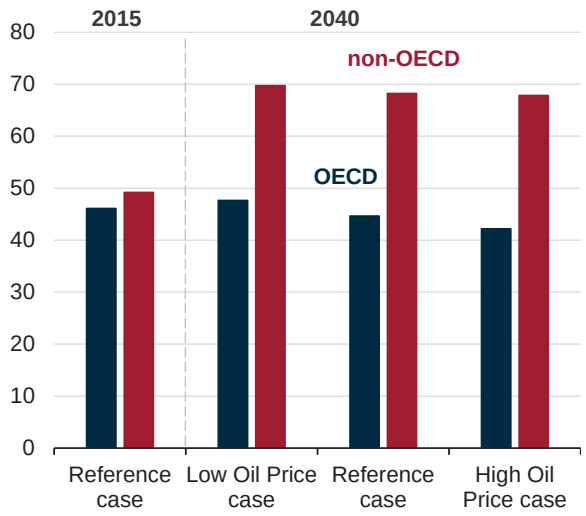
Petroleum and other liquids

Oil prices vary widely across the High Oil Price, Reference, and Low Oil Price cases—

World petroleum and other liquid fuels production
million barrels per day



Petroleum and other liquids consumption, 2015 and 2040
million barrels per day



—but without a large effect on global liquid fuels consumption

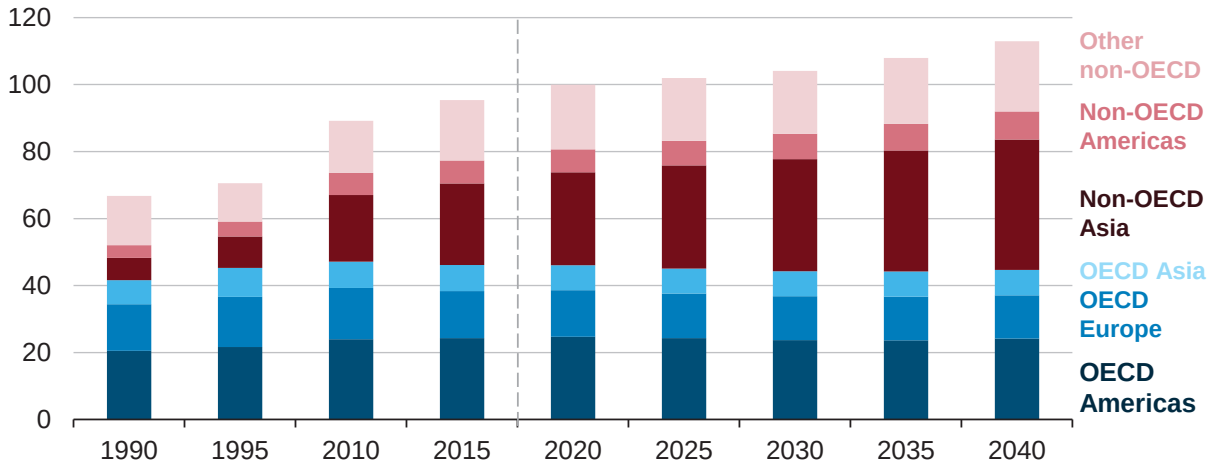
- In the Reference case, world consumption of liquid fuels rises from 95 million barrels per day (b/d) in 2015 to 113 million b/d in 2040. Non-OECD nations account for most of the increase, with demand rising by 1.3%/year compared with a slight decrease in the OECD. OPEC countries maintain or increase their combined market share of crude and lease condensate production.

- The High Oil Price case assumes faster economic growth among emerging, non-OECD nations, which contributes to higher energy demand; however, consumers switch to alternative fuels, act to conserve liquids, and adopt more-efficient technologies. World liquid fuels consumption in 2040 is 2.9 million b/d lower than in the Reference case. In this case, there is more production of crude and lease condensate from high-cost producers and less production from low-cost conventional resources.

- In the Low Oil Price case, slower non-OECD economic growth leads to lower energy demand, but the lower prices mean that consumers use more liquid fuels. In 2040, world liquids consumption is 4.5 million b/d higher than in the Reference case. There is more production of crude and lease condensate for low-cost producers and less production from high-cost producers.

World petroleum and other liquid fuels consumption grows by 18% between 2015 and 2040 in the Reference case—

Petroleum and other liquids consumption
million barrels per day



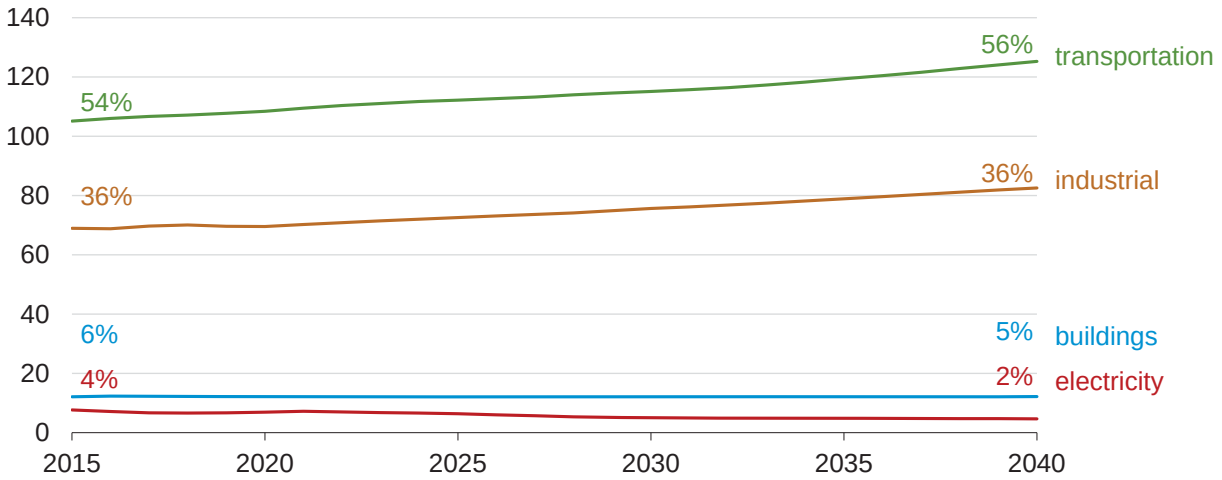
—because of growth in non-OECD regions

- Most of the growth in world liquid fuels consumption from 2015 to 2040 comes from non-OECD countries, where strong economic and population growth increase the demand for liquid fuels by 39%. Overall OECD consumption of liquid fuels decreases by 3%.
- More than 80% of the total increase in liquid fuels consumption is in non-OECD Asia, as China and India experience rapid industrial growth and increased demand for transportation.
- China's use of liquid fuels for transportation is projected to increase by 36% from 2015 to 2040 and India's use over that period increases by 142%.
- In OECD countries, demand for liquid fuels grows slowly or declines between 2015 and 2040.

World shares of liquids use hold relatively constant across sectors—

Refined petroleum and other liquids consumption by end-use sector

quadrillion Btu



—even as total consumption increases

- The transportation sector remains the largest consumer of refined petroleum and other liquids as their use for travel and freight services increases at a faster rate than their use in other applications between 2015 and 2040.

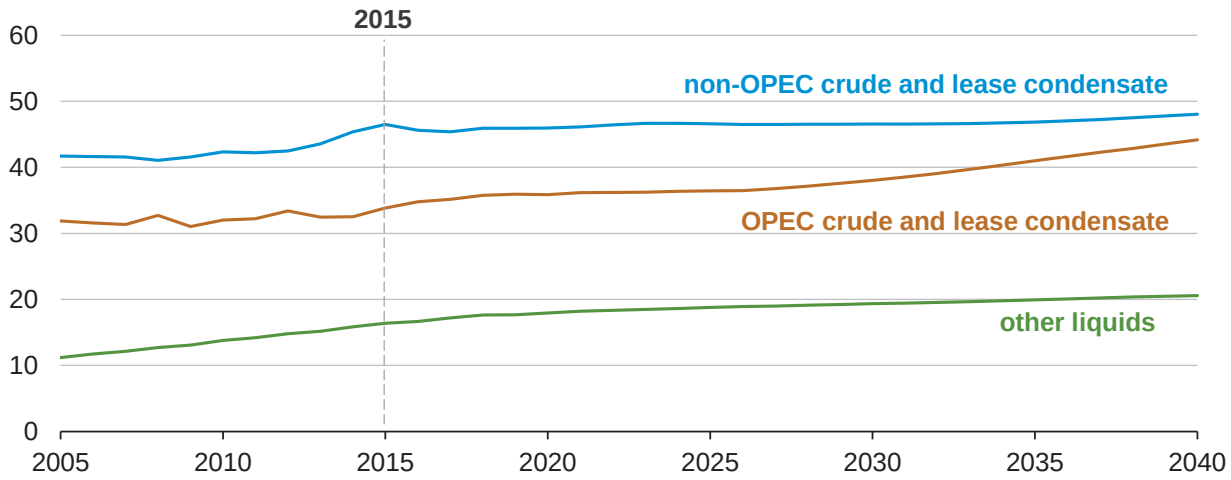
- Petroleum and other liquids are used in the industrial sector to power equipment, serve as chemical feedstocks, and provide industrial heat. These uses increase slowly between 2015 and 2040.

- The use of liquid fuels in buildings, mainly liquefied petroleum gas (LPG) to provide space heat in regions where natural gas infrastructure is less developed, is nearly flat from 2015 to 2040.

- The use of petroleum and other liquids to generate electricity declines over the projection as various factors, including increasing oil prices and relatively less costly natural gas, encourage producers to switch to alternative energy sources.

In the Reference case, liquid fuel supplies increase from 2015 to 2040—

World liquid fuels production by region and type
millions barrels per day



—with most of the growth occurring in OPEC crude oil and lease condensate

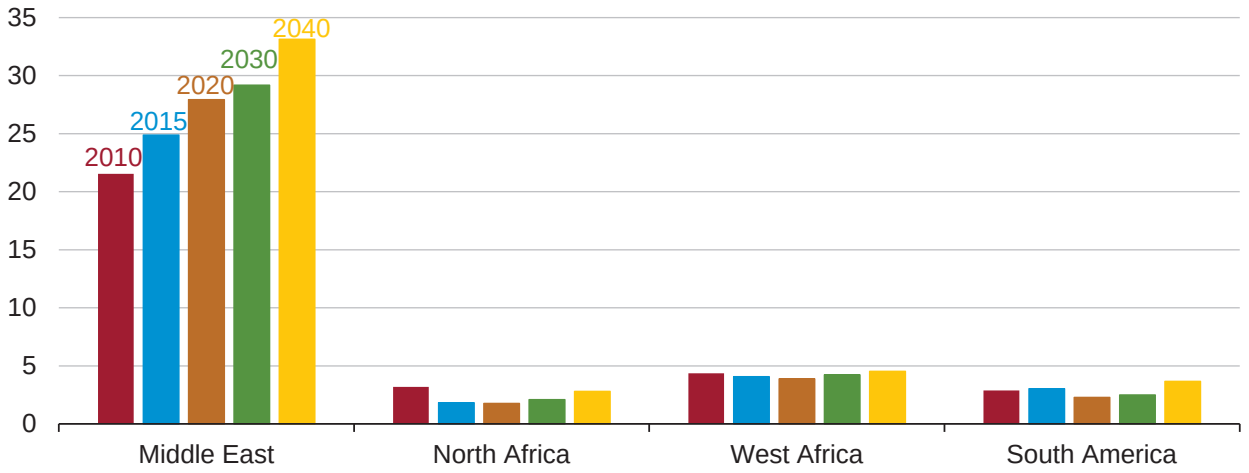
- World liquid fuels production rises by 16.1 million b/d from 2015 to 2040, with more than half of the increase coming from a 10.3 million b/d increase in crude oil and lease condensate, including production from tight and non-tight resources, and extra-heavy crude oils and processed bitumen from oil sands from OPEC member countries.

- Production of other liquids (natural gas plant liquids, gas-to-liquids, coal-to-liquids, oil shale, refinery gain, and biofuels) increases by 4.2 million b/d (25%) from 2015 to 2040.

- Natural gas plant liquids, refinery gain, and biofuels account for about 95% of growth between 2015 and 2040 in the production of other liquid fuels.

In the Reference case, OPEC crude oil production increases between 2015 and 2040—

OPEC crude and lease condensate production by region
million barrels per day

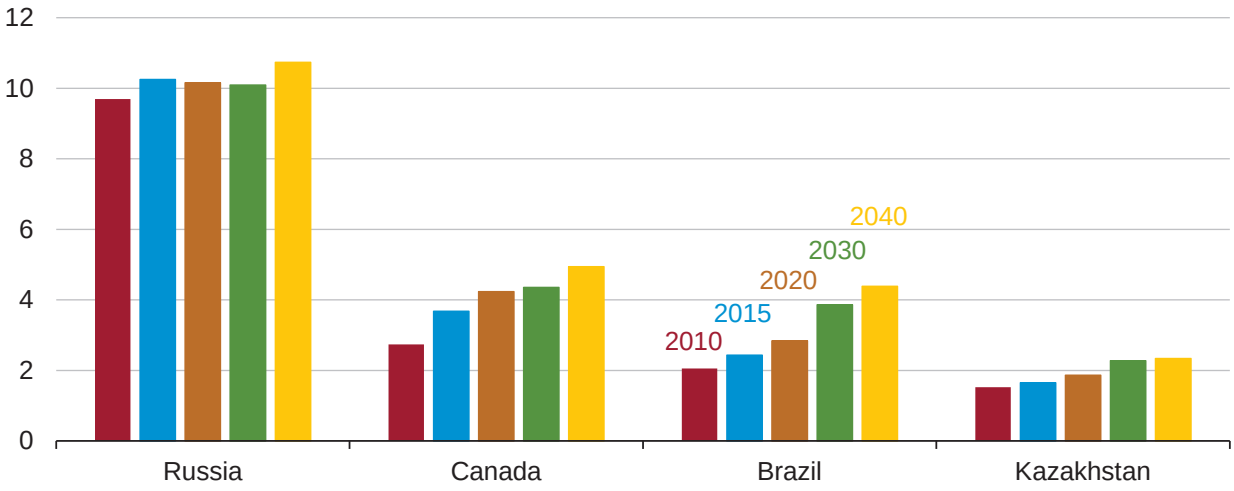


—with most of the growth occurring in the Middle East

- Middle East OPEC production of crude oil and lease condensate increases in the Reference case projection.
- Production from large and low-cost resources in the Middle East is expected to remain a critical part of global crude supply for the entire projection period.
- OPEC is expected to maintain its strategy of capturing market share during price downturns.

Non-OPEC crude oil production in the Reference case increases less than 2% between 2015 and 2040—

Crude and lease condensate production
million barrels per day

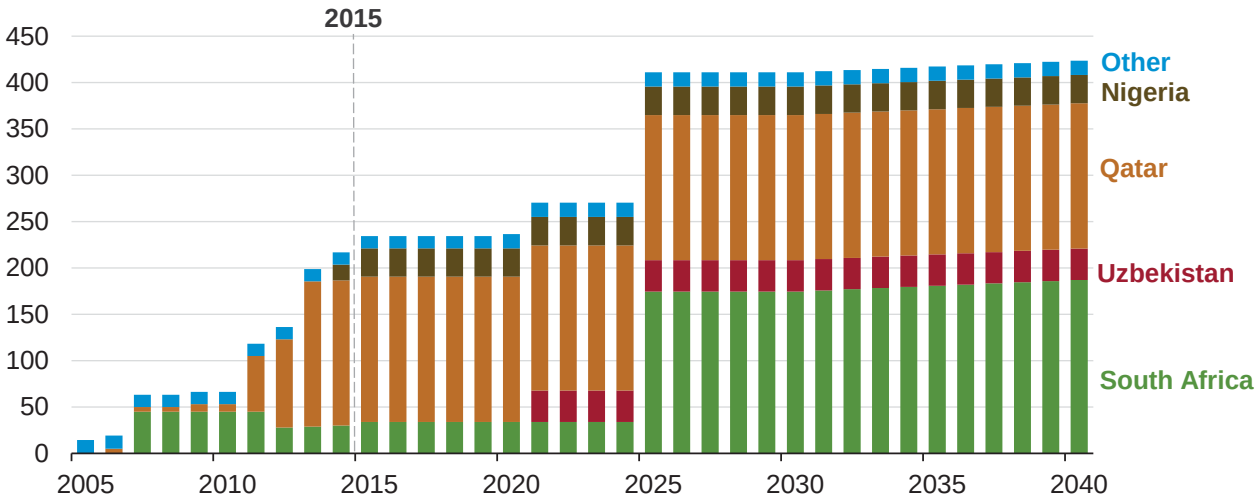


—but growth coming from Russia, Canada, Brazil, and Kazakhstan increases by 24%

- Non-OPEC crude oil production outside of the United States grows by 630,000 b/d from 2015 to 2040, with increases in Russia, Canada, Brazil, and Kazakhstan. There are sizeable decreases projected for crude oil production from OECD Europe and China.
- Brazil's 1.95 million b/d projected increase from 2015 to 2040 is attributable to greater offshore production, largely occurring after 2030.
- Russia's 485,000 b/d increase in production by 2040 comes mainly from non-tight resources, but the country also sees moderated growth in tight oil production after 2030.
- Canada's 1.26 million b/d increase in production by 2040 mainly comes from oil sands production, with small additions from tight and non-tight resources.
- Kazakhstan's 687,000 b/d increase in production by 2040 is the result of increased supply from the Kashagan oil field.

In the Reference case, gas-to-liquids growth is dominated by two large-scale projects—

Gas-to-liquids plant production
thousand barrels per day

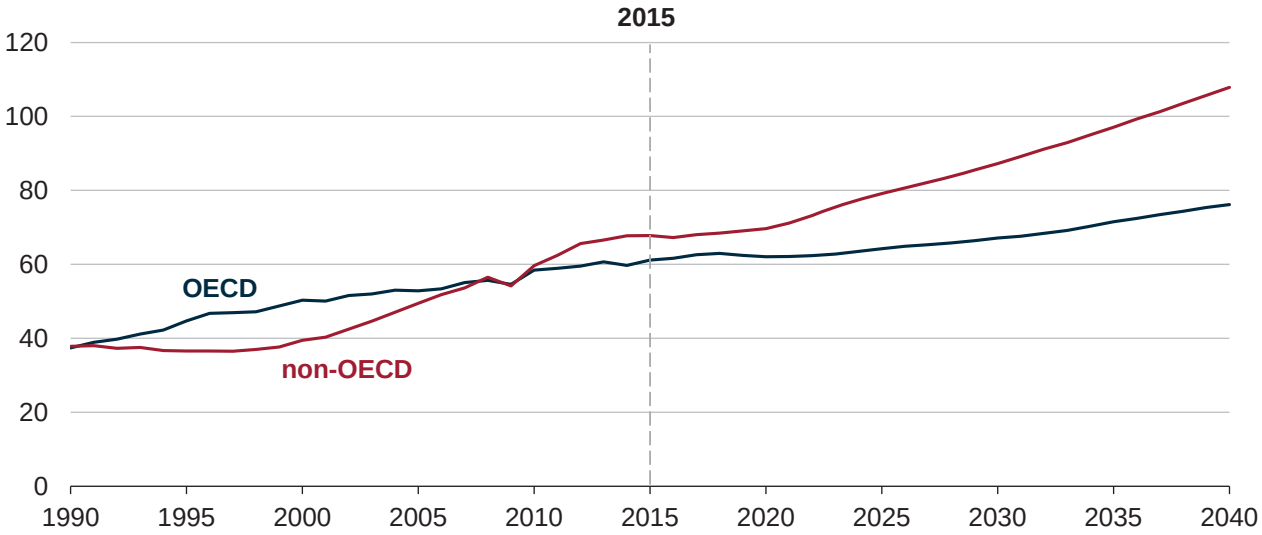


—located in South Africa and Uzbekistan

- Gas-to-liquids (GTL) development is sensitive to product prices and regulatory factors, and small-scale projects may be used as an alternative to flaring natural gas or to capture emissions from landfills.
- Two large-scale GTL projects are projected to come online in the Reference case—a new 37,600 b/d GTL facility in Uzbekistan in 2021 and a conversion of a 160,000 b/d coal-to-liquids to GTL plant in South Africa in 2025.
- Besides the South Africa and Uzbekistan projects, the remaining growth in GTL output is expected to come from small (capacity of 5,000 b/d or less) facilities.

Natural gas

World natural gas consumption increases by 43% from 2015 to 2040 in the Reference case—

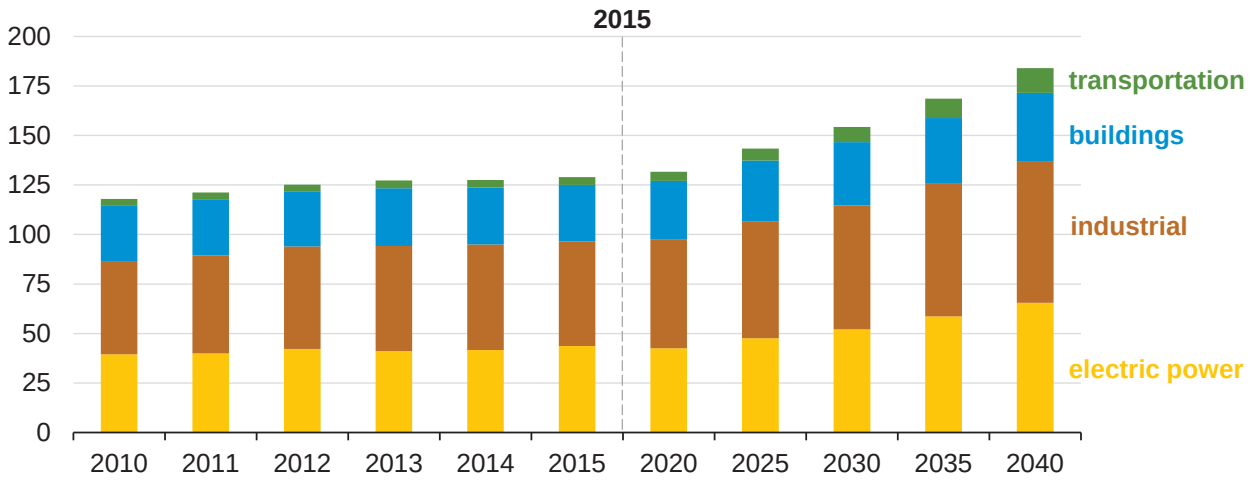


—largely because of growth in non-OECD countries

- Natural gas consumption grows in both the OECD and non-OECD from 2015 to 2040, but growth is greatest in non-OECD countries which have expanding industrial sectors and electricity demand.
- Consumption in non-OECD countries is projected to grow an average of 1.9%/year from 2015 to 2040 in contrast to 0.9%/year in OECD countries.
- The share of world natural gas consumption in non-OECD countries increases from 53% in 2015 to 59% in 2040.

Reference case natural gas consumption increases in all sectors—

Natural gas consumption by sector
quadrillion Btu



—with the electric power and industrial sectors accounting for nearly 75% of the increase between 2015 and 2040

- Natural gas continues to be an attractive fuel for the electric power and industrial sectors in many countries. These two uses account for nearly 75% of the projected increase in total consumption between 2015 and 2040.

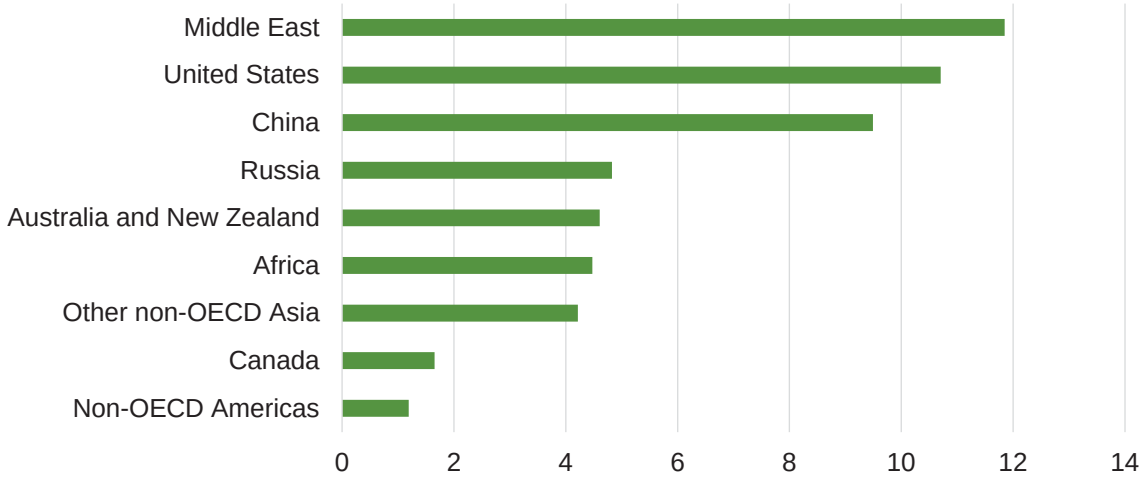
- Natural gas-fired generation is attractive for new power plants because of low capital costs, favorable heat rates, and relatively low fuel cost.

- Natural gas-intensive industries, such as chemicals, refining, and primary metals, expand over the period of 2015–40—particularly in non-OECD countries—driving industrial demand.

- The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, which limits the sulfur content of marine fuels, and the growing spread between oil and natural gas prices are projected to lead to a greater use of liquefied natural gas (LNG) as a bunkering fuel towards the end of the projection.

The largest increases in Reference case natural gas production occur in the Middle East, United States, and China—

Increase in natural gas production 2015-40
trillion cubic feet

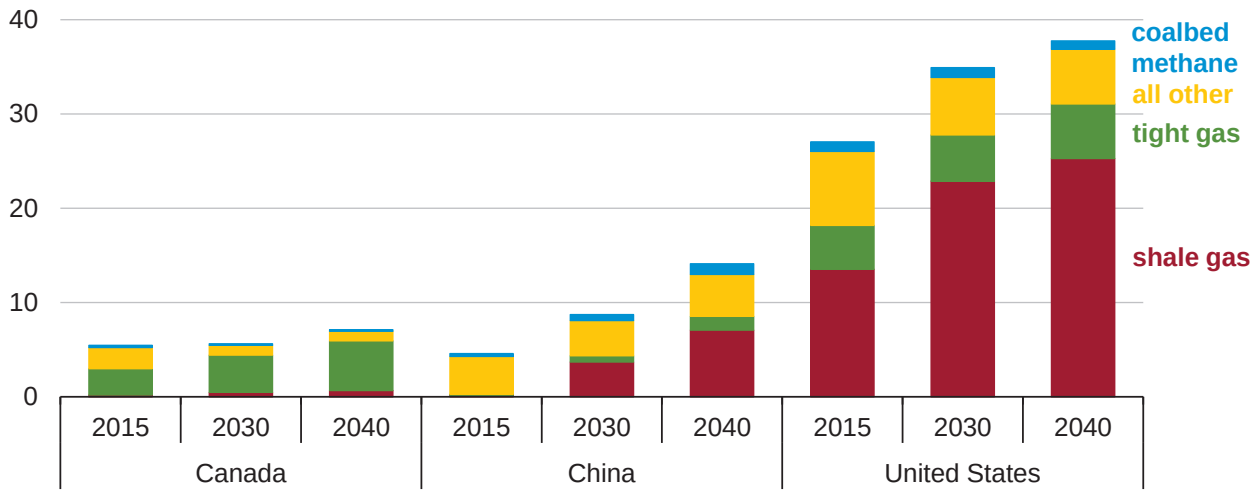


—accounting for 12%, 20%, and 18% of growth respectively

- In the United States and China, increases in natural gas production between 2015 and 2040 are projected to mainly come from the development of shale resources.
- Russia's growth in natural gas production over the period of 2015–40 is supported by an increased development of resources in the country's Arctic and the Eastern regions.
- Newly developed offshore fields in Mozambique and Tanzania and increasing production in Egypt's Zohr field support LNG exports from Africa.

Shale and tight resources become increasingly important to natural gas supplies in the Reference case—

Natural gas production
trillion cubic feet

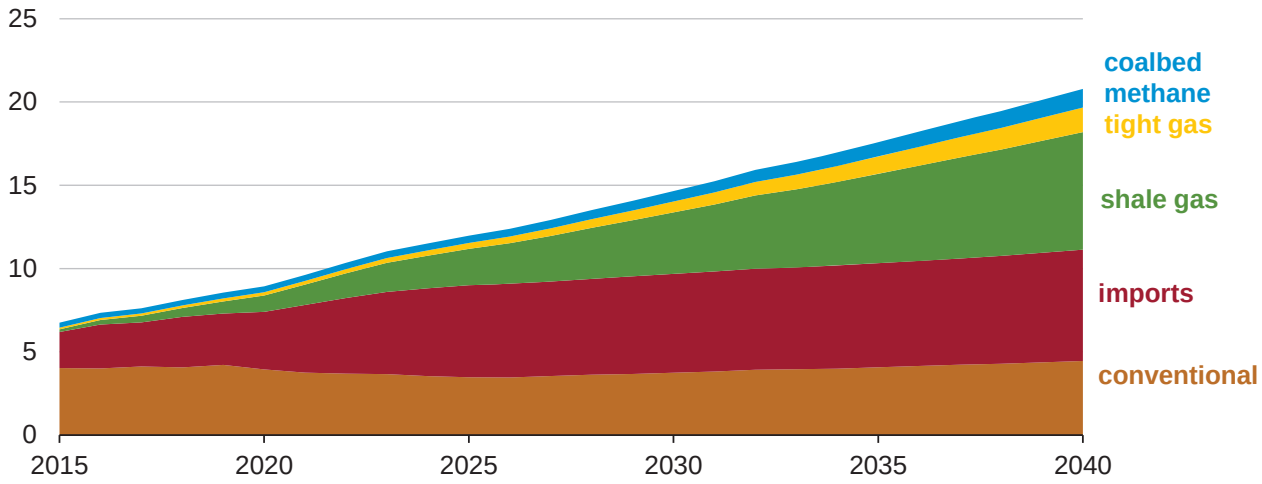


—not only in the United States, but also in China and Canada

- Shale resource development accounts for 50% of U.S. natural gas production in 2015, increasing to nearly 70% in 2040, as the country leverages advances in horizontal drilling and hydraulic fracturing techniques and taps into newly discovered technically recoverable reserves.
- Shale resource developments are projected to account for nearly 50% of China's natural gas production by 2040, making the country the world's largest shale gas producer after the United States.
- In Canada, future natural gas production is expected to come mainly from tight resources, from several regions in British Columbia and Alberta.

Shale resources lead natural gas production growth in China—

China's natural gas supply mix
trillion cubic feet

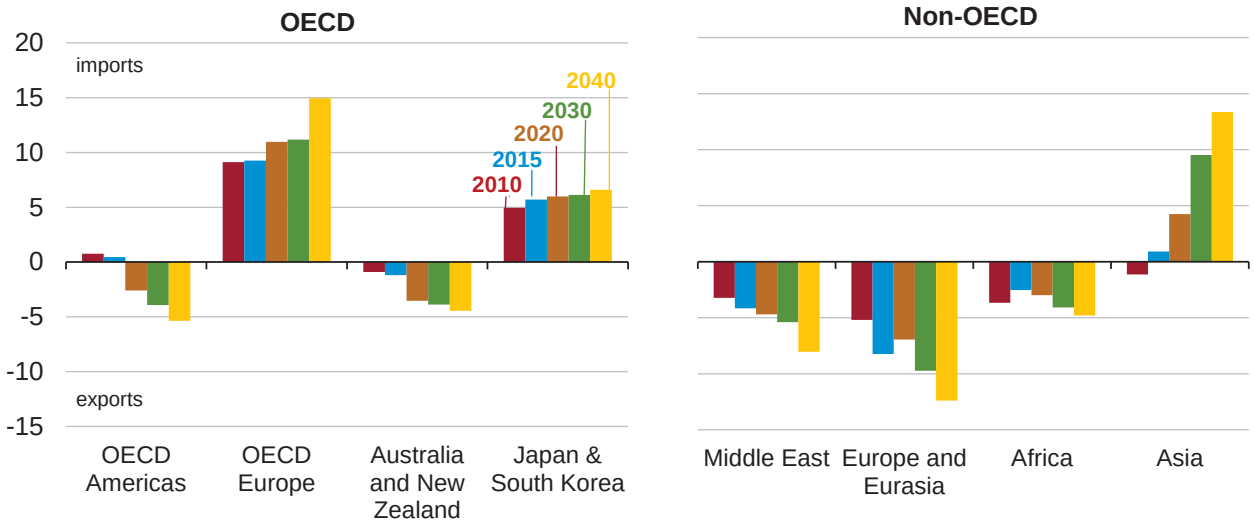


—while production from coalbed methane resources continues to remain low

- China's imports of natural gas remain at 32% of supply in 2015 and 2040 as the country's domestic shale gas production grows from 2% in 2015 to 33% over the same period.
- Despite China's prolonged developmental efforts in the past, coalbed methane is expected to remain a modest source of natural gas from 2015 to 2040 because of lower productivity compared with other production methods.
- Russian exports account for a growing share of China's pipeline imports as pipeline capacity expands. China's LNG imports are also projected to grow—supplied by an increasingly diversified pool of exporters.
- Tight gas is projected to increase by only 1.5 trillion cubic feet over the period of 2015–40 largely because of high production costs relative to other sources.

Non-OECD Asia growth rate propels it to the second highest net natural gas importer after OECD Europe by 2040 in the Reference case—

Net trade of natural gas
trillion cubic feet



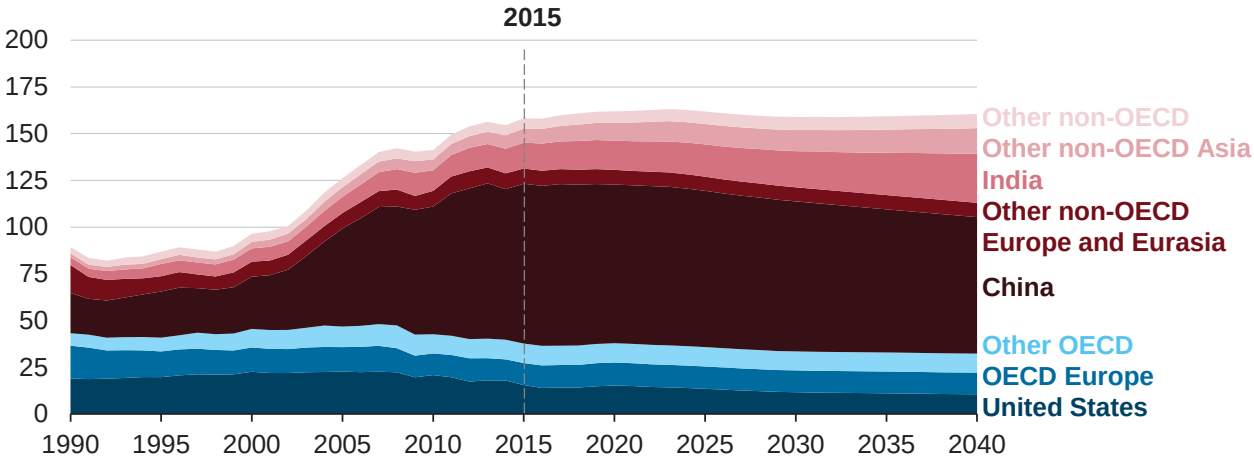
—with import demand increasingly met by non-OECD Europe and Eurasia

- World liquefied natural gas (LNG) trade is projected to nearly triple, from 12 trillion cubic feet to 31 trillion cubic feet, between 2015 and 2040.
- Despite strong growth in LNG trade, pipeline flows are projected to continue to account for 48% of the interregional natural gas flows in 2040 as pipeline infrastructure is further developed.
- Europe is projected to remain largely dependent on Russian pipeline gas, while Asia is projected to import a large share of the traded LNG.
- North America is projected to become a major exporter of natural gas by 2020, even though pipeline flows from Russia to Europe and Asia are expected to show the largest volumetric growth in trade.

Coal

Worldwide coal consumption is projected to remain near the current level in the Reference case—

World coal consumption
quadrillion Btu

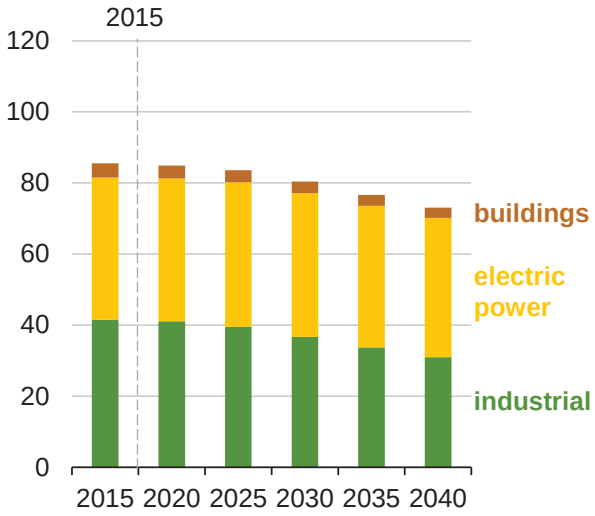


—as decreasing demand in China and the United States is offset by growth in India

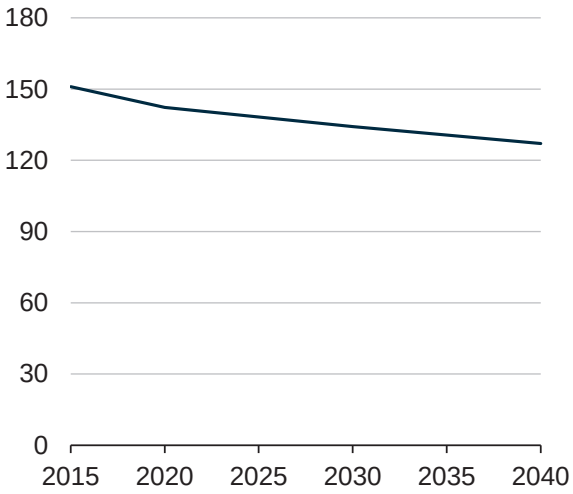
- Worldwide coal consumption remains roughly the same between 2015 and 2040 (about 160 quadrillion Btu), with decreasing consumption in China and the United States offsetting growth in India.
- China remains the largest single consumer of coal in 2040 (about 73 quadrillion Btu), despite a steady decline in the country's consumption over time.
- India's coal consumption continues to grow by an average 2.6%/year from 2015 to 2040, with the country surpassing the United States as the second-largest coal consumer before 2020.
- In OECD countries, coal consumption declines by an average 0.6%/year over the period of 2015–40 because of increasing competition from natural gas and renewables and only moderate increases in electricity demand.
- Africa, the Middle East, and other non-OECD Asia, are projected to gradually expand coal capacity and generation through 2040, but their use of this resource starts from a low base.

China's coal consumption in the Reference Case decreases through 2040—

Coal consumption in China
quadrillion Btu



Coal imports in China
million short tons

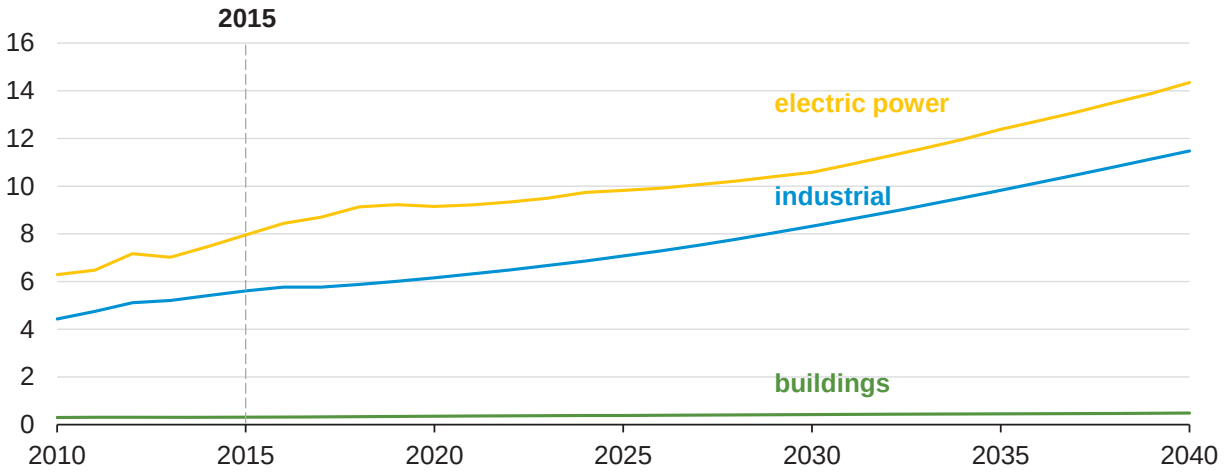


—as a result of changes in industry mix and policies to encourage nuclear and renewable energy use

- The use of coal in Chinese electricity generation is projected to increase slightly through 2023 and then slowly decline to less than the 2015 level of 40 quadrillion Btu by 2035.
- Non-electricity consumption of coal in China is projected to fall from 46 quadrillion Btu to 34 quadrillion Btu between 2015 and 2040 because of a decreasing use of steam and metallurgical coal in industrial steam applications and steel manufacturing.
- China is expected to continue to import only about 3% of its coal for consumption through 2040 because of the country's policy to maintain a course of self-sufficiency.

India’s use of coal in the Reference Case increases throughout the projection period—

India's coal consumption by sector
quadrillion Btu

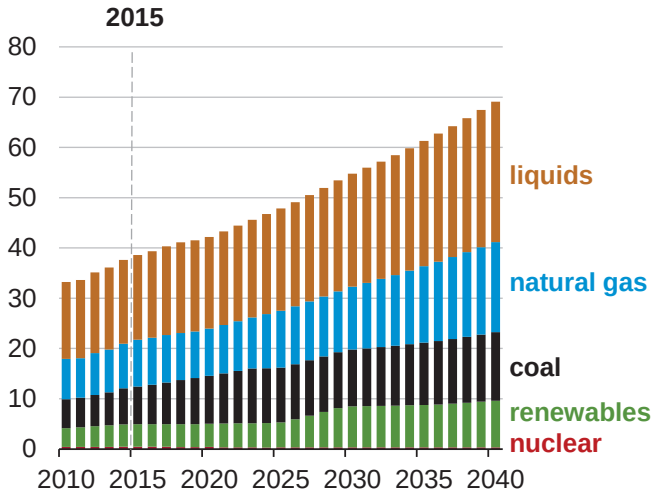


—but its share of the country’s total energy consumption declines

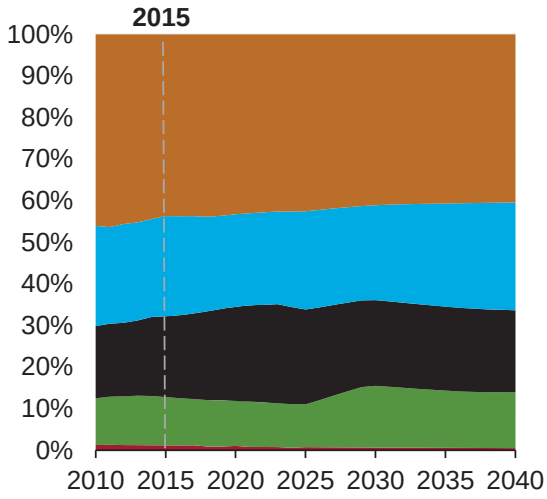
- EIA estimates that India became the world’s second-largest coal consumer after China in 2016, when its coal use exceeded that of the United States. Sustained industrial growth and significant efforts to further electrify the country’s rural areas are expected to drive the increase in India’s coal consumption throughout the projection period.
- Coal demand increases by 90% between 2015 and 2040 in India, as new coal-fired electricity generating capacity is installed.
- Strong growth in the use of coal in industrial applications leads projected industrial consumption in India to increase from 6 quadrillion Btu to 11 quadrillion Btu between 2015 and 2040.
- Despite significant increases in coal consumption, coal’s share in overall energy consumption in India is projected to decrease from 49% in 2015 to 43% by 2040, due in part to policies promoting renewable- and nuclear-based generation.

Coal use in non-OECD Asia outside of China and India increases in the Reference case—

Energy consumption in other non-OECD Asia
quadrillion Btu



Energy consumption in other non-OECD Asia
percent of fuel share

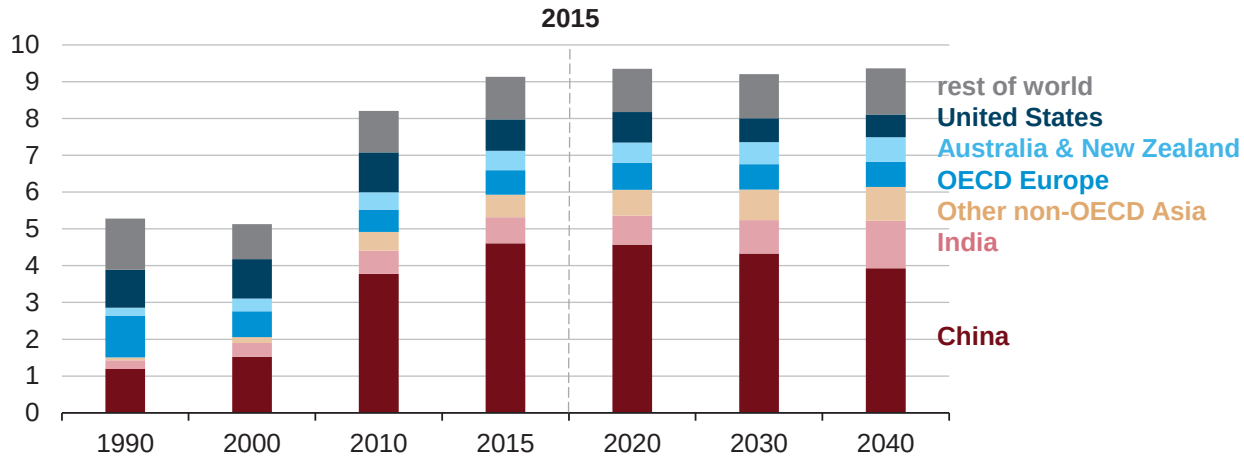


—but it maintains a constant share of energy consumption

- Total energy consumption in non-OECD Asia outside of China and India (other non-OECD Asia) is projected to increase by almost 80% from 2015 to 2040, reaching 69 quadrillion Btu.
- Coal consumption in the region increases by 2.4%/year from 2015 to 2040—maintaining a 20% share of total energy consumption—as many countries continue to take advantage of coal's relatively low cost in their efforts to further develop their economies.
- The other non-OECD Asia region is projected to import a significant share of its coal requirements, even though Indonesia is a major exporter.

Worldwide coal production remains flat through 2040 in the Reference Case—

World coal production
billion short tons

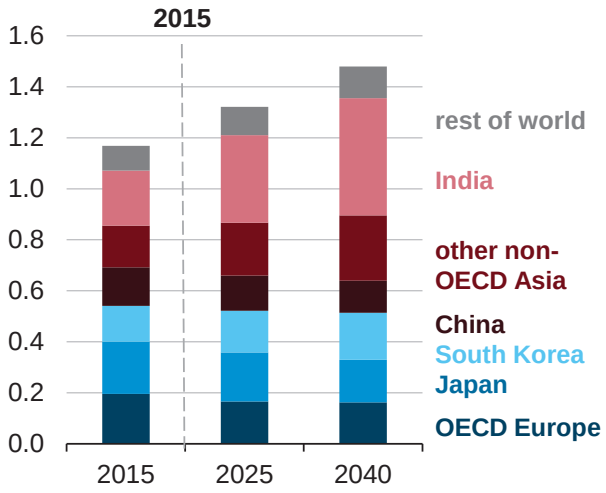


—with decreases in China offset by increases in India

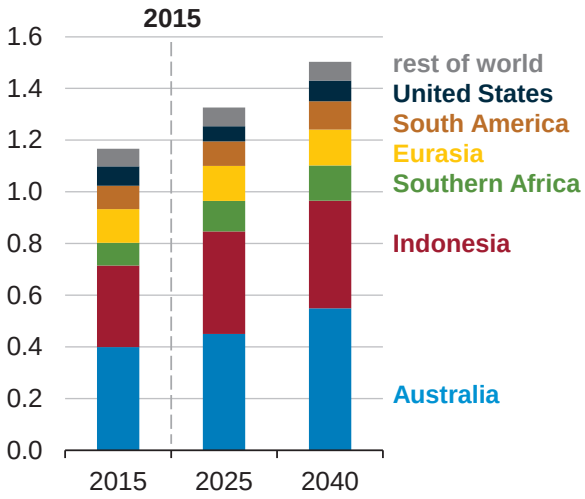
- World coal production is projected to increase 3% from 2015 to 2040, almost reaching 9.4 billions short tons.
- China, India, Australia, and the United States are projected to remain the largest coal-producing nations through 2040.
- China, which consumes nearly all of its coal production domestically, is projected to decrease production by 0.7 billion tons (15%) from 2015 to 2040 as demand within the country falls.
- India is projected to increase its annual coal production by 0.6 billion tons by 2040 to help meet growing domestic demand.

Asia remains the world's largest importer of coal in 2040—

Coal imports
billion short tons



Coal exports
billion short tons



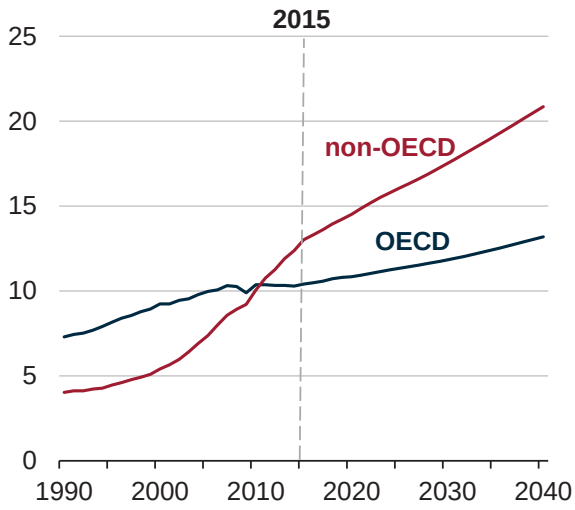
—and Australia and Indonesia remain the largest exporters

- Trade in coal (as measured by imports between regions) is projected to grow gradually from 2015 to 2040 at an average rate of 1%/year.
- Growth in Asian coal imports follows trends in coal consumption as countries other than China increase their demand in industrial applications and electricity generation.
- Metallurgical coal trade increases gradually over time as industrial consumption shifts to India and other countries with limited or no metallurgical coal production.
- In contrast to Asia, coal imports into the Americas and Europe remain flat through 2040 as demand for coal decreases in these regions.
- Australia continues to be the world's top coal exporter, followed by Indonesia. In 2040, Australia provides 37% of coal exports, and Indonesia provides 28%.

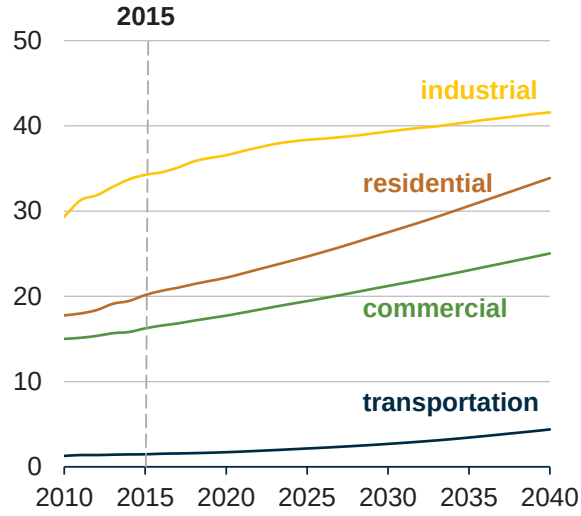
Electricity

In the Reference case, net electricity generation in non-OECD countries increases twice as fast as in the OECD—

OECD and non-OECD net electricity generation
trillion kilowatthours



World electricity use by sector
quadrillion Btu

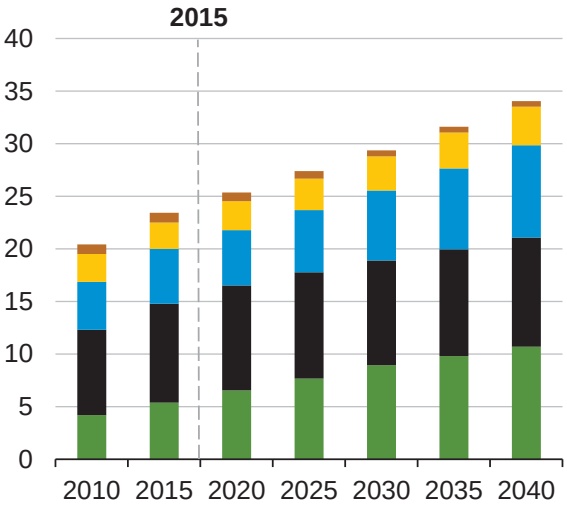


—with building use being a major contributor to growth

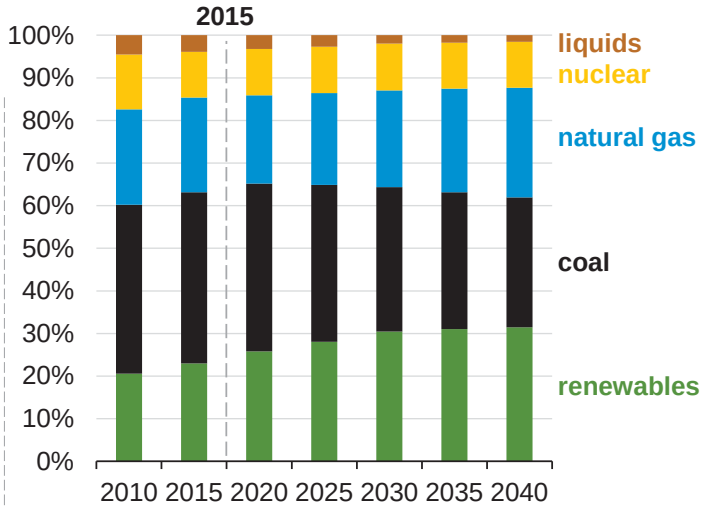
- Net electricity generation in non-OECD countries increases an average 1.9%/year from 2015 to 2040, compared to 1.0%/year in OECD countries.
- Electricity use increases the most in residential and commercial buildings over the period of 2015–40 as personal incomes rise and as urban migration continues in non-OECD countries.
- The share of electricity used in transportation doubles between 2015 and 2040 as more plug-in electric vehicles enter the fleet and electricity use for rail expands, but this share accounts for only 4% of total delivered electricity consumption in 2040.

In the Reference case, renewables and natural gas provide much of the growth in electricity generation—

World net electricity generation by fuel
trillion kilowatthours



Share of net electricity generation
percent



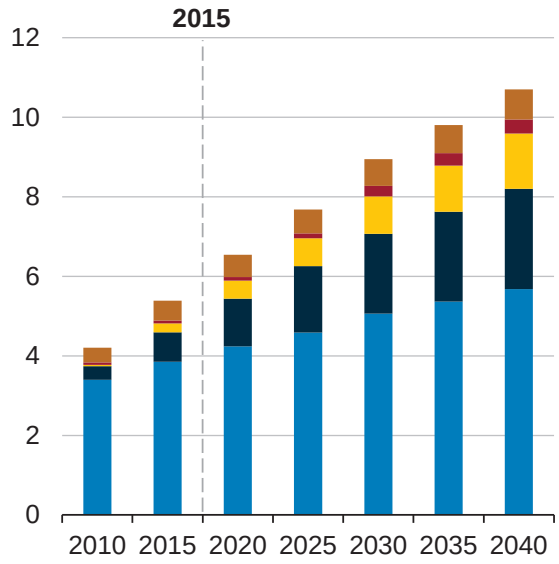
—with their combined share of the total rising to 57% in 2040

- Renewables (including hydropower) are the fastest-growing sources of generation over the period of 2015–40, rising by an average of 2.8%/year, as technological improvements and government incentives in many countries support their increased use.
- Natural gas generation grows by an average 2.1%/year from 2015 to 2040, whereas nuclear generation grows by 1.5%/year.
- Coal's generation share declines from 40% in 2015 to 31% by 2040.
- In 2040, renewables provide the same share of world electricity generation as coal at 31%.

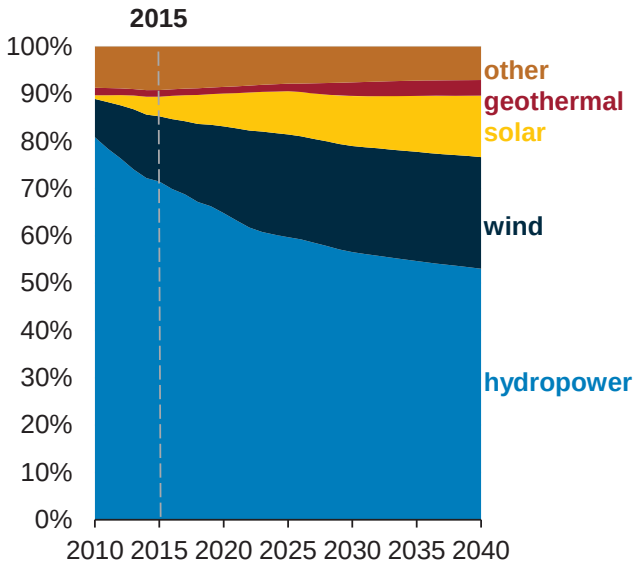
Wind and solar dominate growth in renewables—

World net electricity generation from renewable power

trillion kilowatthours



percent share of renewable energy

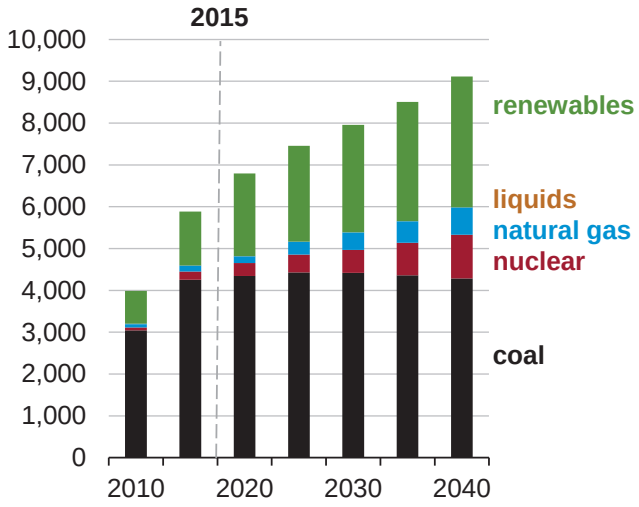


—and represent over two-thirds of related capacity additions by 2040

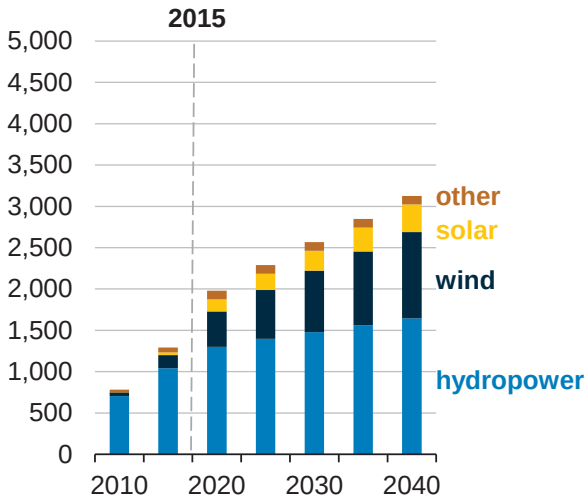
- Hydropower's share of renewable generation falls from 71% in 2015 to 53% in 2040 as resource availability in OECD countries and environmental concerns in many countries limit the number of new mid- and large-scale hydropower projects.
- Generation from non-hydropower renewables rises an average 4.9%/year from 2015 to 2040.
- Among non-hydroelectric renewable energy sources, wind and solar increase the most over the period of 2015–40, reaching 2.5 and 1.4 trillion kilowatthours, respectively, as these technologies become more cost competitive over time.

China's use of coal to produce electricity starts to decline by 2030—

Sources of electricity generation in China
billion kilowatthours



Renewable generation in China
billion kilowatthours



—as shares of renewable and nuclear generation grow

- China's share of coal generation declines from 72% in 2015 to 47% in 2040. The Chinese government's 13th Five-Year Plan set a goal of capping coal capacity at 1,100 gigawatts (GW) by 2020, and the country has committed to cancelling 120 GW of previously planned additions to coal generating capacity.

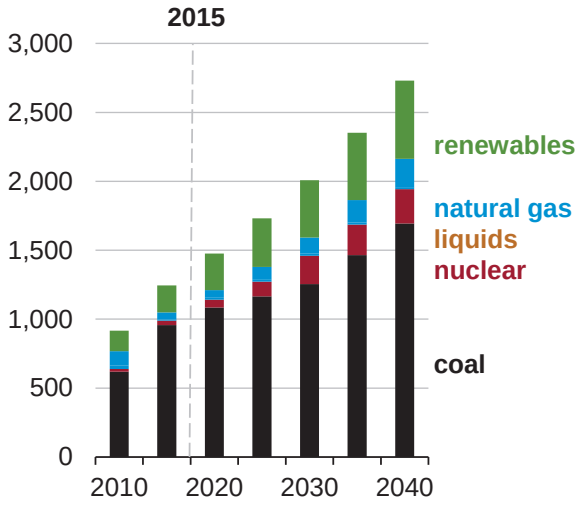
- By displacing coal with renewables, nuclear, and natural gas, China is projected to achieve its maximum level of CO2 emissions before its 2030 targeted deadline.

- The renewable share of total generation in China rises from 22% in 2015 to 34% in 2040, as wind generation increases by more than six-fold.

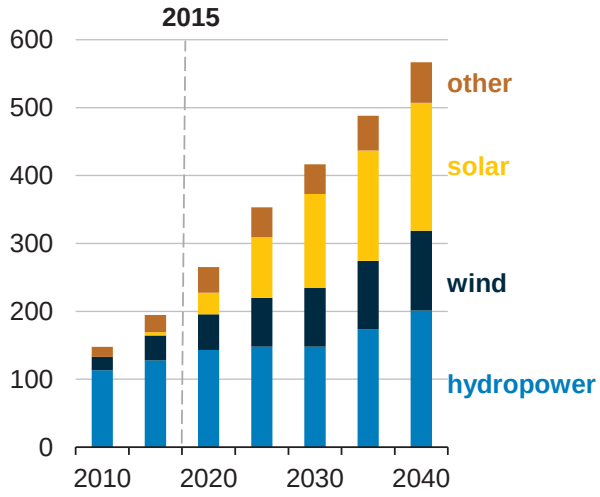
- China's share of nuclear generation increases from 3% in 2015 to 11% in 2040. Over the same period, the natural gas share increases from 2% to 7%.

Electricity from renewables in India increases rapidly in the Reference Case—

Sources of electricity generation in India
billion kilowatthours



Renewable generation in India
billion kilowatthours

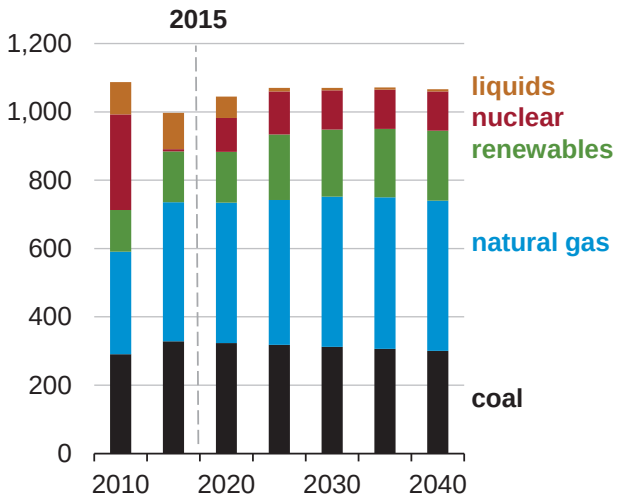


—but coal remains the primary generation source through 2040

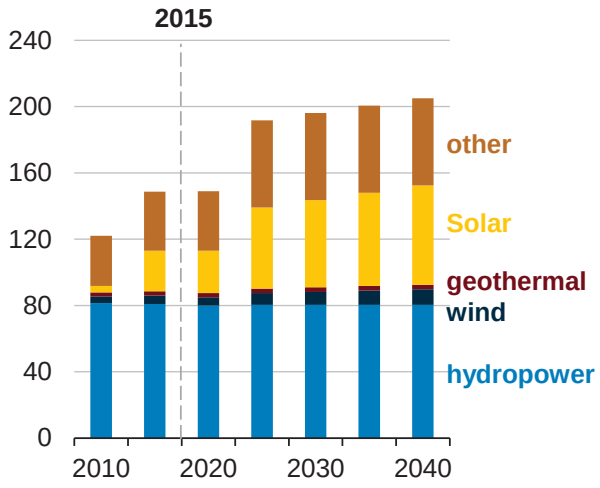
- Net electricity generation in India increases by an average of 3.2%/year from 2015 to 2040, driven by strong industrial growth and policies to increase the availability of electricity in rural areas.
- Coal's share of total generation in India decreases from 77% in 2015 to 62% in 2040 as policies are implemented to promote non-CO2-emitting sources of electricity.
- The non-fossil fuel share of total capacity in India rises to 46% from 2015 to 2040, with 131 GW, 47 GW, and 35 GW of added solar, wind, and nuclear generating capacity, respectively.
- Indian nuclear capacity increases from 5 GW in 2015 to 17 GW in 2025 and then to 41 GW in 2040 and is limited by uncertainties in completing large-scale projects.

Slow economic growth and an aging and declining population translates to largely flat electricity demand in Japan—

Sources of electricity generation in Japan
billion kilowatthours



Renewable generation in Japan
billion kilowatthours

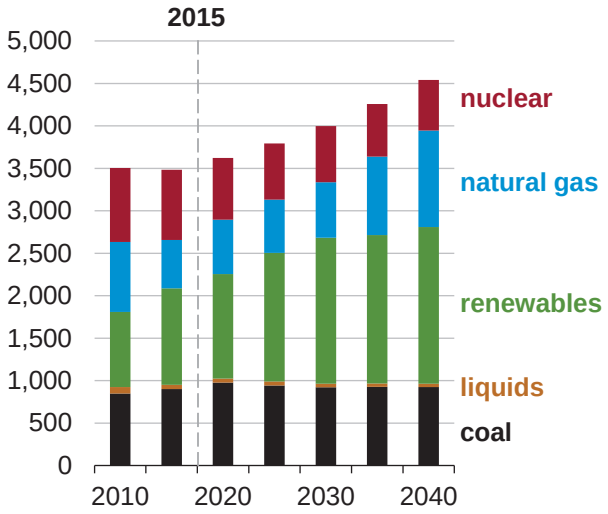


—with natural gas and renewable shares increasing

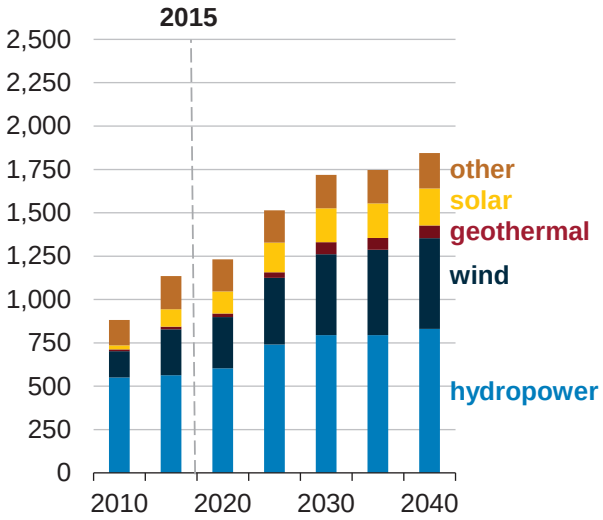
- In the near term, Japan's electric power sector continues to recover from the 2011 Fukushima Daiichi nuclear disaster. Generation from operating nuclear power reactors rises to 11% by 2030.
- Japan committed to reducing its greenhouse gas emissions 25% by 2030, a challenge without a substantial nuclear contribution.
- In an environment with flat demand and growing nuclear, renewable growth is limited after 2025. Fossil fuels account for 70% of Japan's electricity generation mix in 2040, while nuclear accounts for 11%, and renewables the remainder.

OECD Europe reduces nuclear generation—

Electricity generation in OECD Europe
billion kilowatthours



Renewable generation in OECD Europe
billion kilowatthours



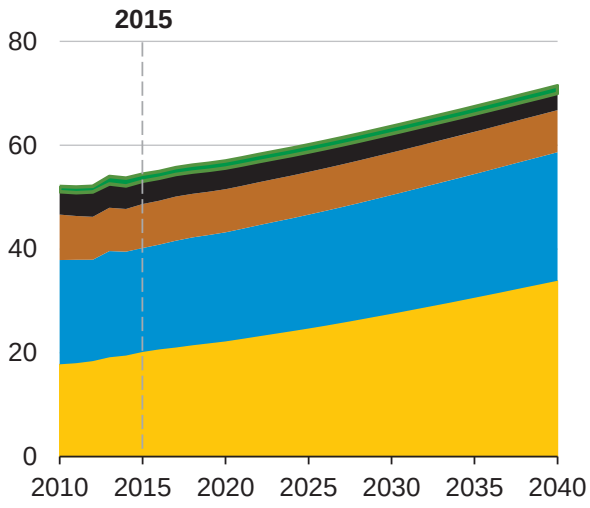
—and adds capacity with natural gas and renewables

- Net electricity generation in OECD Europe is expected to increase slowly, by an average of 1.1%/year from 2015 to 2040, compared to the world average increase of 1.5%/year.
- The generation mix in OECD Europe changes considerably by 2040, with renewables and natural gas growing, coal remaining flat, and nuclear power and liquid fuels declining.
- Nuclear generation's share is expected to decline from around 25% in 2015 to less than 15% by 2040 because of stated policies to either cap or phase out nuclear power, including those adopted in France, Germany, and Sweden.
- The use of natural gas electricity generation in OECD Europe does not expand until 2030, mostly because of the large increases in projected renewables generation. In OECD Europe, when natural gas begins to gain market share in 2030, it displaces nuclear power, coal, and renewable generation.

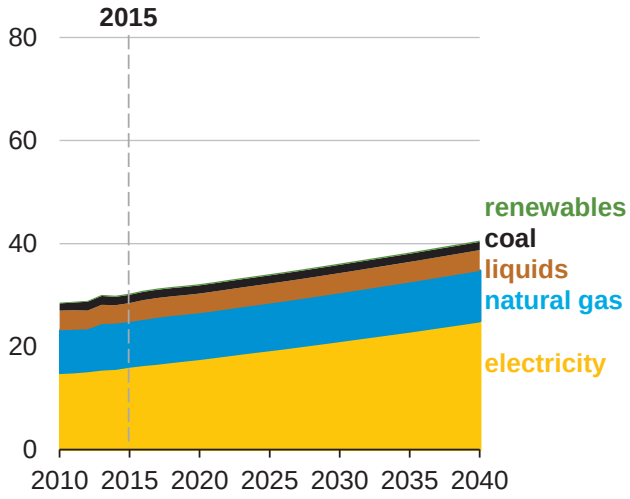
Buildings

In the Reference case, residential and commercial energy consumption increases—

World residential sector energy consumption by fuel
quadrillion Btu



World commercial sector energy consumption by fuel
quadrillion Btu

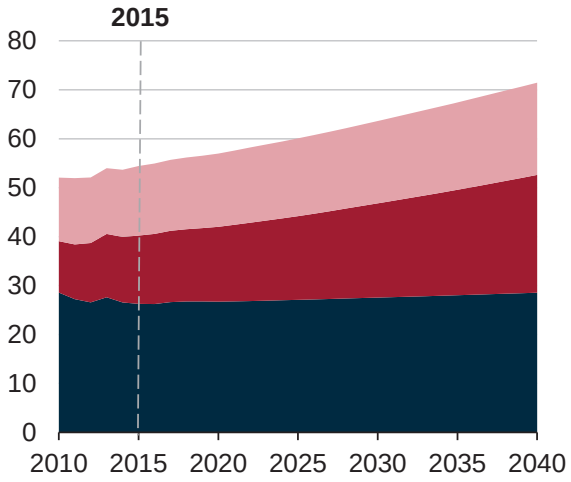


—led by growth in the use of electricity and natural gas

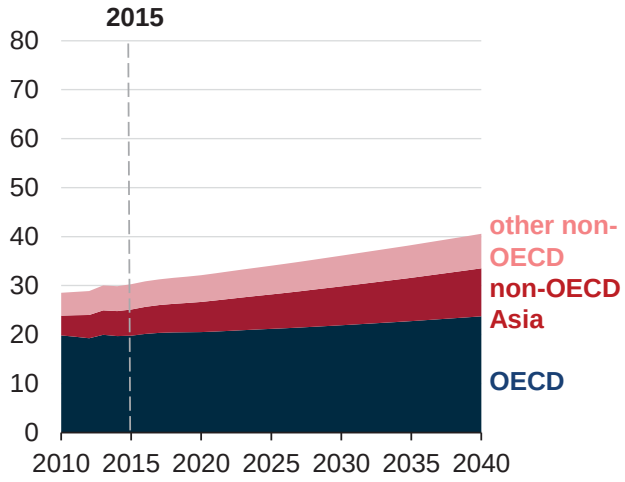
- The buildings sector, which includes residential and commercial structures, accounts for almost 21% of the world's delivered energy consumption in 2040, about the same as its share in 2015.
- Energy use in buildings is projected to increase by 32% between 2015 and 2040. Most of the increase occurs in large, emerging non-OECD countries, where population continues to shift from rural to urban areas.
- Electricity use in buildings grows 2% annually between 2015 and 2040 as rising standards of living in non-OECD countries increase the demand for appliances, personal equipment, and commercial services.
- Natural gas consumption in buildings grows by 20% over the period of 2015–40 as increased demand in non-OECD countries is partially offset by improvements in space heating equipment.
- The consumption of coal, used primarily for space heating, water heating, and cooking, continues to decline in the residential sector and remains relatively flat in the commercial sector.

Non-OECD countries drive increases in residential and commercial energy consumption—

World residential sector energy consumption by region
quadrillion Btu



World commercial sector energy consumption by region
quadrillion Btu



—as demand increases in non-OECD Asia

- In OECD countries, residential energy consumption is projected to increase an average of 0.3 %/year between 2015 and 2040, reflecting slow growth in personal income and gains in energy efficiency from improved building shells, appliances, and equipment.

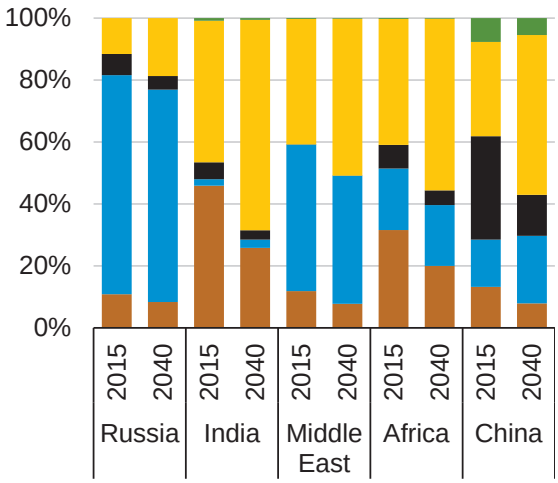
- Non-OECD Asia accounts for more than 50% of the world increase in residential and commercial energy use as the region's per capita income increases by nearly 3.7%/year.

- Despite slower economic growth, China accounts for 46% of the increase in residential consumption and 30% of the increase in commercial consumption in non-OECD countries by 2040.

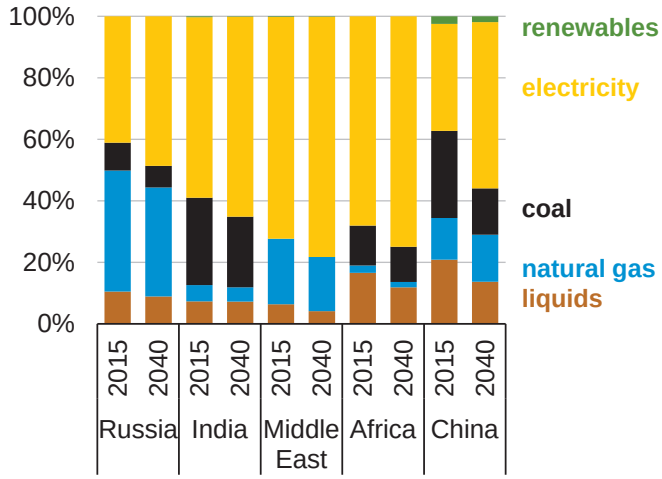
- Building energy consumption in China remains higher than that in any other country in the world (21.1 quadrillion Btu) in 2040, even though India experiences the fastest growth in use (2.7%/year) and surpasses China as the most populous country in the early 2020s.

Electricity consumption leads the increase in non-OECD energy use in residential and commercial buildings—

Residential sector fuel shares in selected non-OECD countries/regions
percentage of total



Commercial sector fuel shares in selected non-OECD countries/regions
percentage of total



—and is influenced by growing income and increased access to electricity

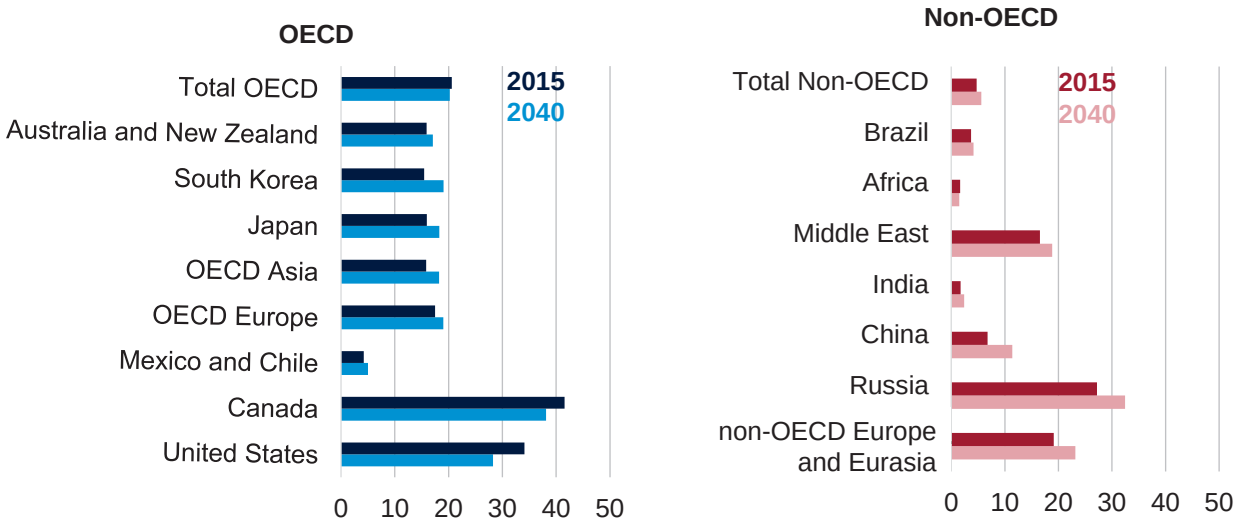
- Electricity, the main source of energy for lighting, cooling, and appliances, is the fastest-growing source of energy used in buildings between 2015 and 2040. Personal incomes rise and urban migration continues over the period, offsetting increases in energy efficiency in building shells, appliances, and equipment.

- China and India account for one-fourth of the world's buildings electricity consumption in 2040. China's buildings fuel mix over the projection period shifts from coal toward electricity and natural gas; however in India, electricity and liquids remain the main energy sources.

- Russia's residential fuel mix over the projection period moves away from natural gas, coal, and liquids toward electricity, but natural gas remains the main source because of its relatively low price.

Per capita residential energy use increases in most non-OECD regions—

Residential sector energy consumption per capita
million Btu per person

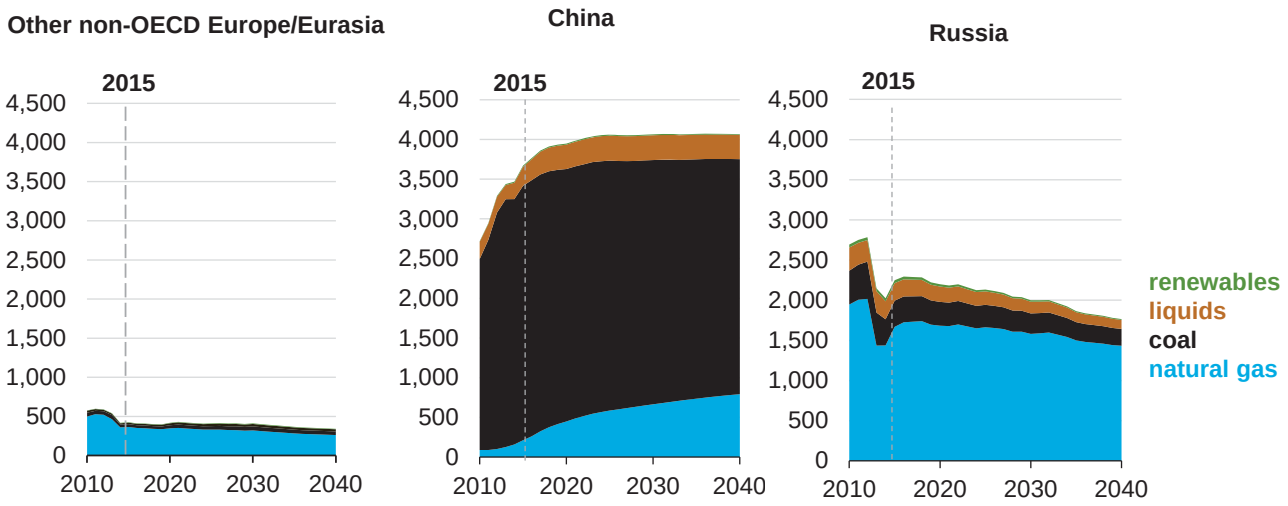


—as consumption grows faster than population

- Per capita energy consumption remains higher in OECD countries than in non-OECD countries because of greater spending on energy-intensive services, such as heating and cooling.
- In OECD countries, per capita residential energy use decreases by an average of 0.1%/year between 2015 and 2040, compared with an average increase of 0.7%/year in non-OECD countries over the same period.
- Russia continues to have the highest per capita residential energy use among all non-OECD regions in 2040, largely because of a great need for space heating.
- China is projected to experience the greatest increase in per capita residential energy use (an average of 2.1%/year) as space cooling equipment and appliances become more widespread. In 2040, China's residential use per capita is expected to be about 40% of that in the United States.

District heat is used in cold northern regions with dense urban areas—

Heat generation
trillion Btu



—and heat-only generation falls in several regions

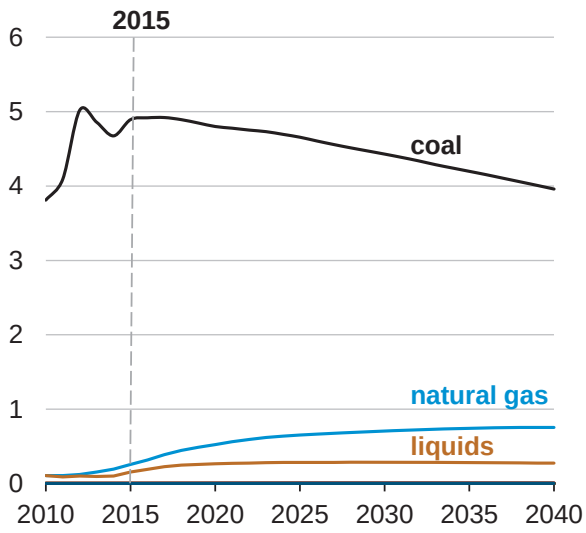
- District heat is generated centrally in boiler or combined heat and power (CHP) facilities and transmitted to buildings through pipes for space heating or industrial processes.

- District heat is cost effective in dense, urban areas with cold climates. As a result, most district heat is used in China, Russia, OECD Europe, and non-OECD Europe and Eurasia. Japan and South Korea use smaller amounts of district heat; in South Korea, CHP satisfies most demand for heat.

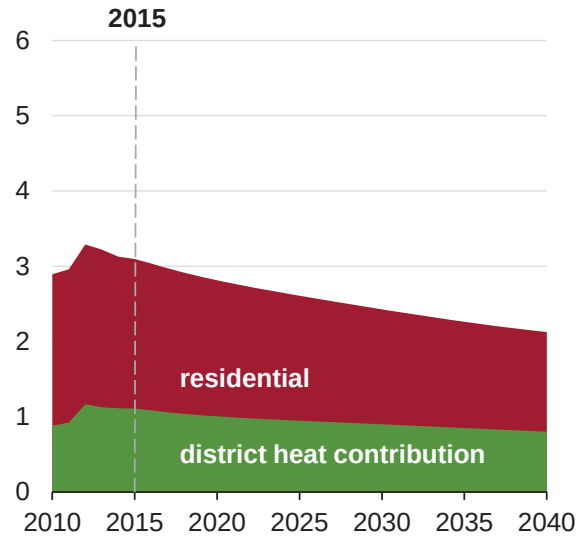
- As electricity sectors grow and industrial heat demand declines between 2015 and 2040, district heat generation shifts towards CHP facilities, and fuel consumption declines. Additionally, aging infrastructure is refurbished or replaced with more energy-efficient equipment, further decreasing fuel consumption.

Coal consumption for district heat declines in China—

District heat fuel consumption in China
quadrillion Btu



Residential coal consumption in China
quadrillion Btu



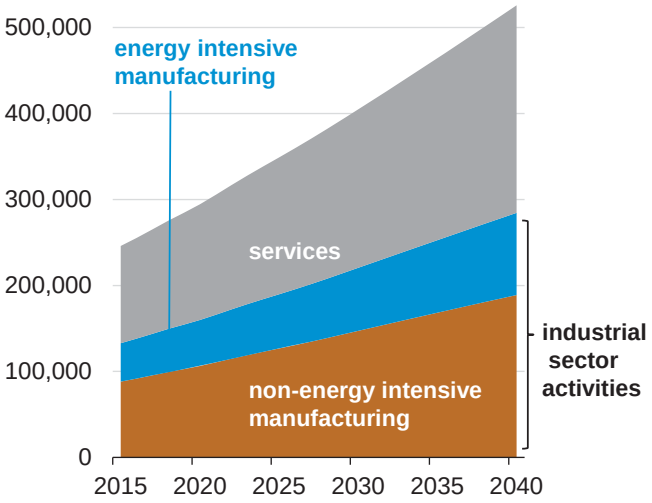
—contributing to a decline in residential coal use

- Many coal-fired district heat boilers in China are projected to be replaced with more energy-efficient natural gas-fired boilers in response to rising coal prices and declining natural gas prices.
- Coal consumption in China's district heat sector is projected to fall by 1.1 quadrillion Btu between 2015 and 2040. This drop is offset by an increase of 0.5 quadrillion Btu in natural gas consumption.
- In 2040, district heat continues to constitute a significant portion of coal consumption in the residential sector (38%). However, it accounts for 0.3 quadrillion Btu of the 1.0 quadrillion Btu total decrease in residential coal consumption between 2015 and 2040.

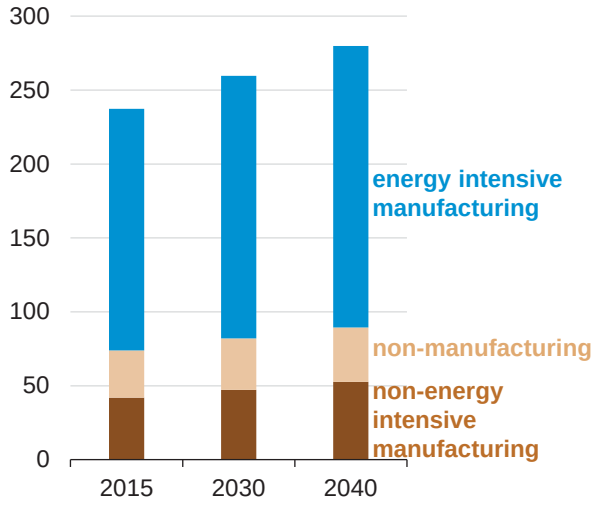
Industrial

Gross output from industrial activities doubles by 2040 in the Reference case—

World gross output by sector
billion 2010 dollars purchasing power parity



World energy consumption by industry
quadrillion Btu



—and industrial energy consumption increases

- Gross output, a measure of total sales across sectors, more than doubles between 2015 and 2040 with about half of this growth attributable to industrial activity. The remaining growth comes from the services sector and reflects non-industrial activities.

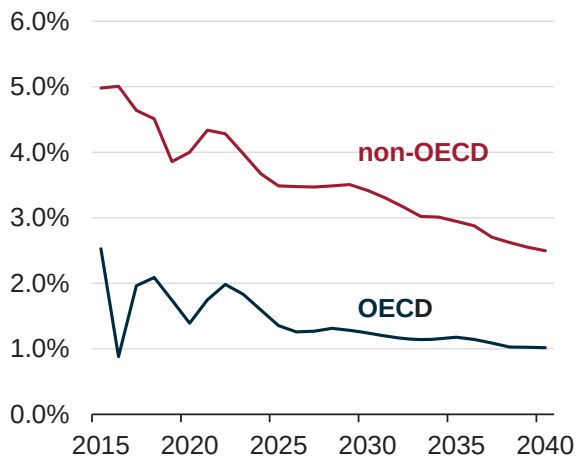
- The value of the output from energy-intensive manufacturing (basic chemicals, food, iron and steel, non-ferrous metals, non-metallic minerals, paper, and refining) more than doubles, but its share of total economic activity holds nearly constant.

- Output from non-manufacturing (agriculture, construction, and extraction) and non-energy-intensive manufacturing (metal-based durables, other chemicals, and other manufacturing) also increase over the forecast period.

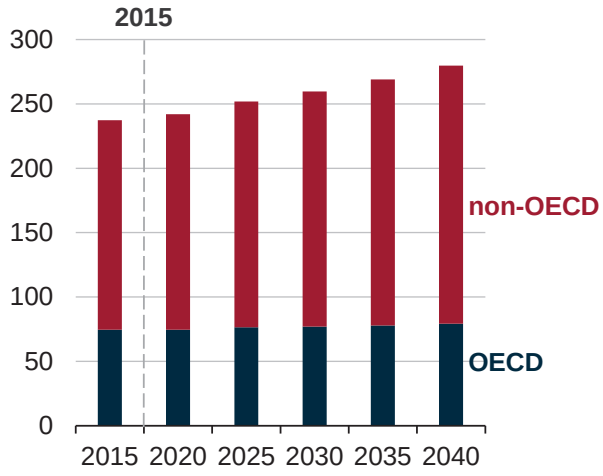
- Following the gross output trends, the share of energy consumed by energy-intensive manufacturing declines slightly from 69% in 2015 to 68% in 2040. Over the same period, the share of energy consumed by non-energy-intensive manufacturing increases from 18% to 19%.

Growth in industrial output slows—

Industrial gross output growth
year-over-year percent



Industrial energy consumption
quadrillion Btu

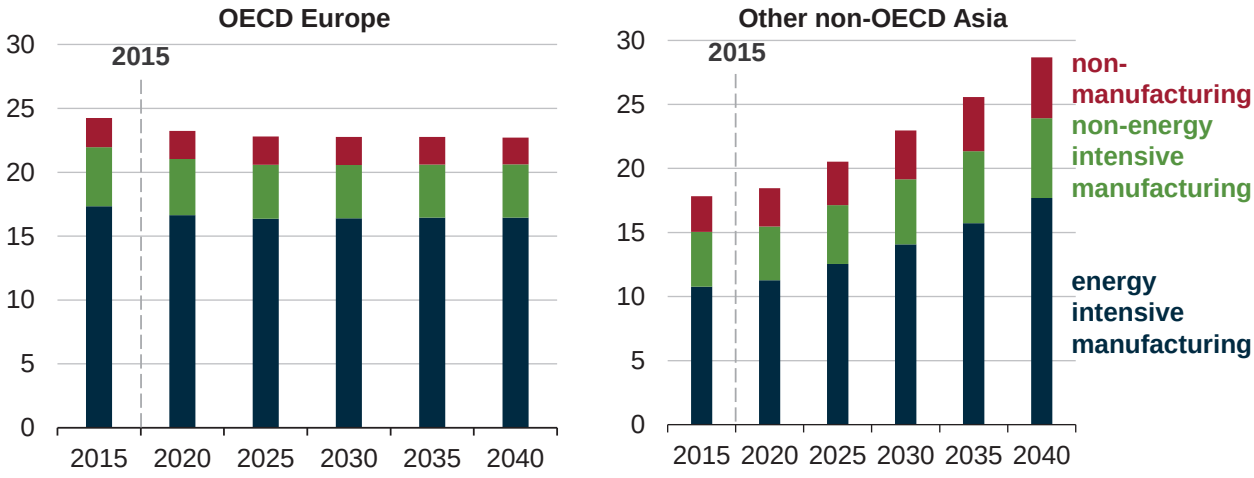


—but still drives growth in non-OECD industrial energy consumption in the Reference case

- Industrial gross output growth slows in the Reference case, but the growth in non-OECD regions continues to outpace that of OECD regions.
- Industrial consumption of delivered energy grows slowly between 2015 and 2040 at less than 0.5%/year in OECD regions, and at less than 1%/year in non-OECD regions.
- Industrial output growth outpaces energy consumption growth because of increased industrial energy efficiency and higher growth in non-energy-intensive manufacturing output, especially in non-OECD regions. The slow-growing energy-intensive manufacturing corresponds to only slight growth in industrial sector energy consumption in the OECD.
- Non-OECD regions are responsible for a growing share of industrial energy consumption, as flat industrial energy consumption in China is more than offset by growth in other non-OECD regions.
- The industrial share of worldwide energy consumption declines from 55% in 2015 to 52% in 2040, largely because of faster growth of the transportation sector.

By 2030, industrial energy consumption in non-OECD Asia surpasses that of OECD Europe—

Energy consumption by industry
quadrillion Btu

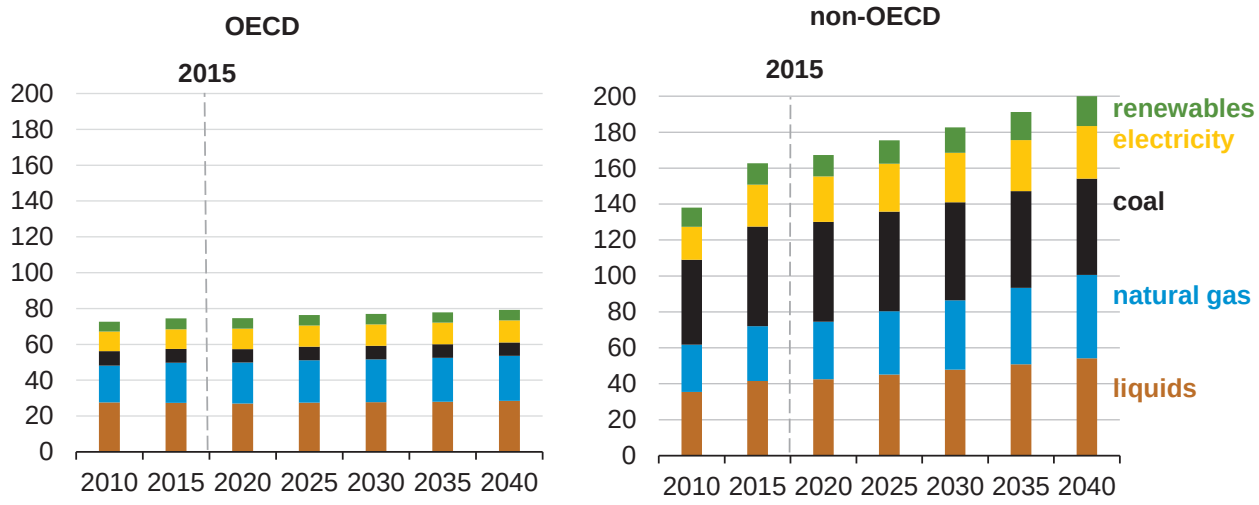


—led by growth in energy-intensive manufacturing

- OECD Europe and non-OECD Asia outside of China and India (other non-OECD Asia) have contrasting government policies and economic development in the industrial sector. In both regions, as the economies transition toward services, the industrial sector shrinks slightly relative to the overall economy.
- In OECD Europe, industrial energy consumption declines slightly, as the economy continues an ongoing transition away from energy-intensive manufacturing as energy efficiency increases.
- Other non-OECD Asia has a much higher non-manufacturing share than OECD Europe; within non-manufacturing, the agriculture gross output share declines, while the gross output in the construction industry grows nearly 5%/year to accommodate increasing urbanization.
- In the rapidly industrializing countries of the other non-OECD Asia region, energy consumption grows by an average of 2% annually across all three industry types.

In non-OECD regions, industrial coal consumption declines slightly and natural gas consumption increases—

Industrial energy consumption by fuel
quadrillion Btu



—but within the OECD, fuel shares remain steady

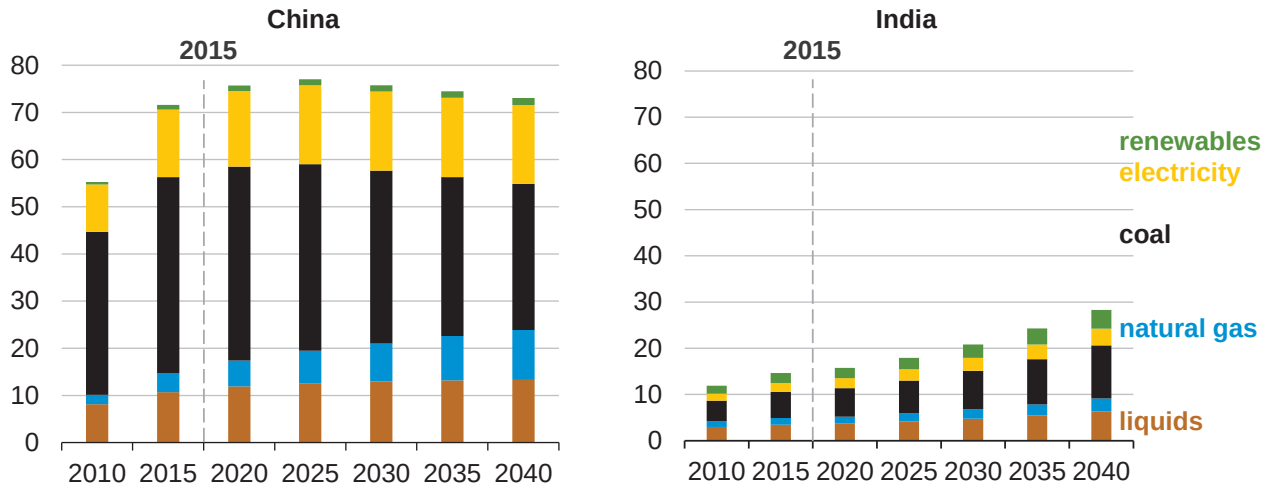
- In non-OECD regions, even as total industrial energy consumption grows, industrial coal consumption declines slightly. Non-OECD regions continue to consume seven times as much coal as OECD regions throughout the projection.

- For industrial equipment that operates on coal, fuel switching opportunities are rare, and the amount of new equipment, such as boilers, that can use other fuels is small relative to the installed base.

- The non-OECD share of natural gas increases from 19% to 23% between 2015 and 2040 as natural gas continues to be a relatively cost-effective industrial fuel.

Industrial coal consumption declines in China but rises in India—

Industrial energy consumption by fuel
quadrillion Btu



—as iron and steel production increases in India

- In the Reference case, growth in output of iron and steel — produced by energy-intensive industries — slows in China between 2015 and 2040. The less energy-intensive metal-based durables industries are the fastest growing and increasingly important contributors to the economy.

- Chinese coal consumption in the industrial sector declines 1%/year, and natural gas consumption increases nearly 4%/year because of slowing growth in steel output. Natural gas is also substituted for coal in industries such as cement and food.

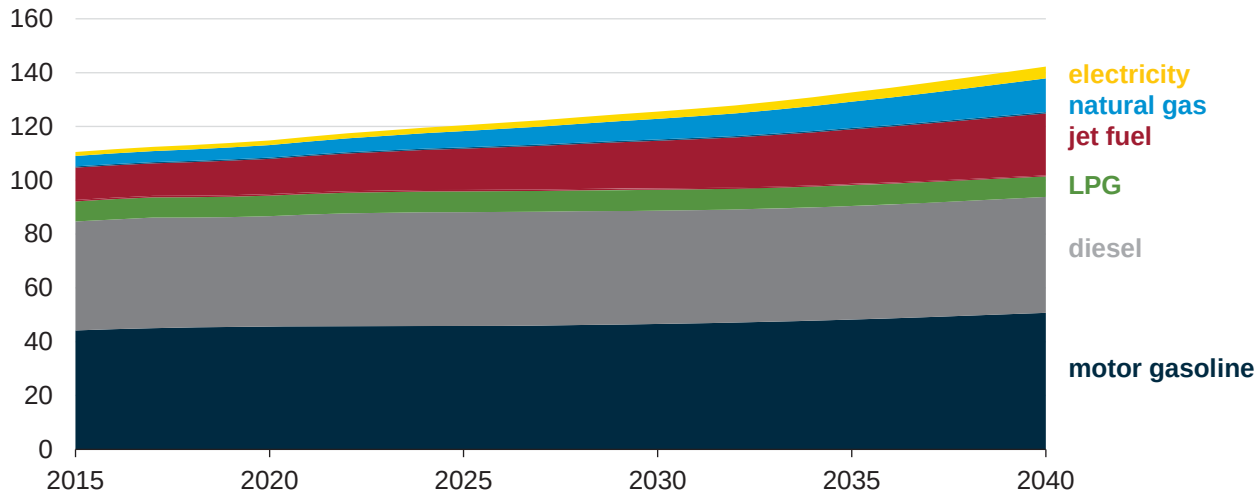
- Indian coal consumption increases nearly 3%/year—a growth rate that is slightly higher than the growth rates for other fuels because of iron and steel industry growth. The iron and steel industry is coal intensive for two reasons: almost half of steel in India is produced in blast furnaces and direct-reduced iron, usually gas-fired in other countries, is largely coal-fired in India.

Transportation

In the Reference case, the share of transportation fuel from alternative energy sources increases through 2040—

World transportation energy consumption

quadrillion Btu



—but refined petroleum and other liquids remain dominant

- The worldwide transportation sector accounts for 55% of total end-use sector liquid fuels consumption in 2040, about the same as its share in 2015.

- The use of refined petroleum and other liquid fuels in the transportation sector continues to increase through 2040, but their share decreases from 95% to approximately 88% as the use of alternative fuels slowly increases. Motor gasoline, including biofuel additives, remains the primary fuel for transportation, accounting for 36% of the world's transportation-related energy use in 2040.

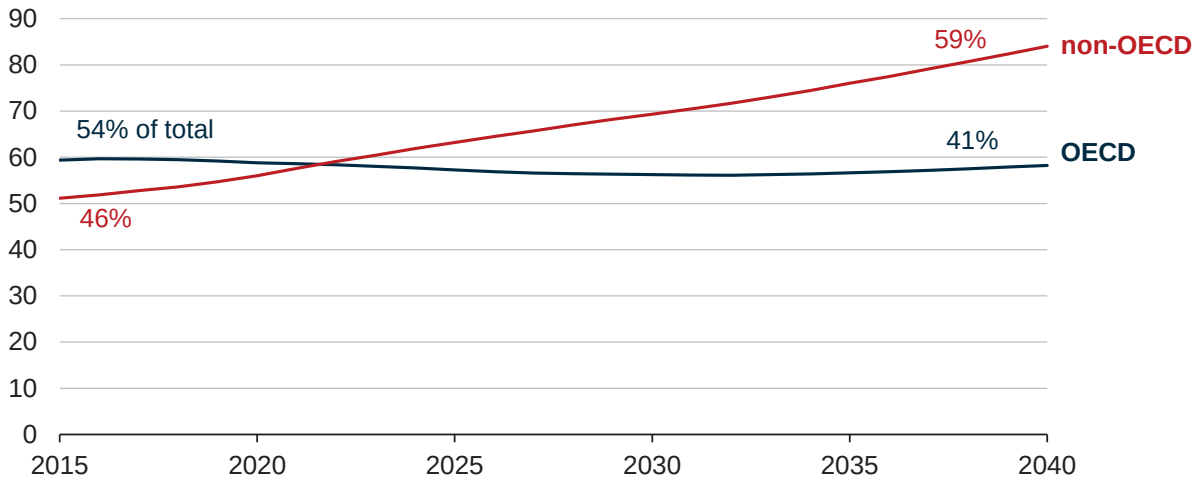
- A continuing global rise in air travel demand leads to a near doubling of jet fuel consumption between 2015 and 2040.

- Natural gas and electricity, while starting from much lower levels of use than liquid fuels in the transportation sector, are the fastest-growing forms of transportation energy use, with consumption of each approximately tripling between 2015 and 2040. Natural gas consumption for passenger and freight transportation increases nearly 500% from 2015 to 2040, up nearly 8 quadrillion Btu.

Transportation energy consumption continues to grow in non-OECD countries—

Transportation energy consumption

quadrillion Btu



—while remaining relatively flat in OECD countries

- In non-OECD countries, transportation energy demand increases 64% between 2015 and 2040. A few of these countries, such as China and India, have particularly large populations, and their energy consumption is projected to grow much more rapidly than in many OECD countries, resulting in large increases in both personal travel and freight demand.

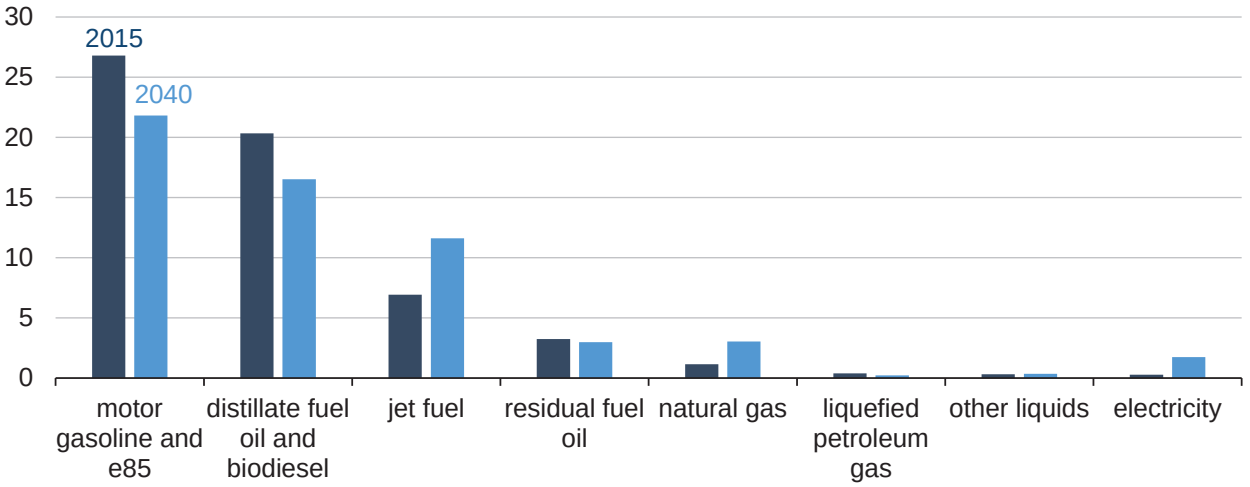
- In OECD countries, improvements in vehicle fuel efficiency outpace projected increases in vehicle-miles traveled, and, as a result, transportation energy use for the region as a whole is projected to decline by 2% between 2015 and 2040.

- In the early-2020s, transportation energy consumption in non-OECD countries is projected to exceed that in OECD countries, and by 2040, their residents will consume almost 60% of the world's transportation related energy use.

In OECD countries, increases in jet fuel consumption are more than offset by declines in motor gasoline and distillate fuel consumption—

Transportation fuel consumption in OECD regions

quadrillion Btu



—as efficiency gains related to on-road vehicles are realized

- Improvements in on-road fuel economy are projected to result in a reduction of motor gasoline consumption in OECD countries by approximately 5 quadrillion Btu between 2015 and 2040. Most of the reduction occurs in the United States, where the effects of increasingly stringent fuel efficiency standards more than offset increases in vehicle-miles traveled.

- Diesel consumption also decreases, mainly in OECD Europe, in part as the result of improving on-road efficiency standards.

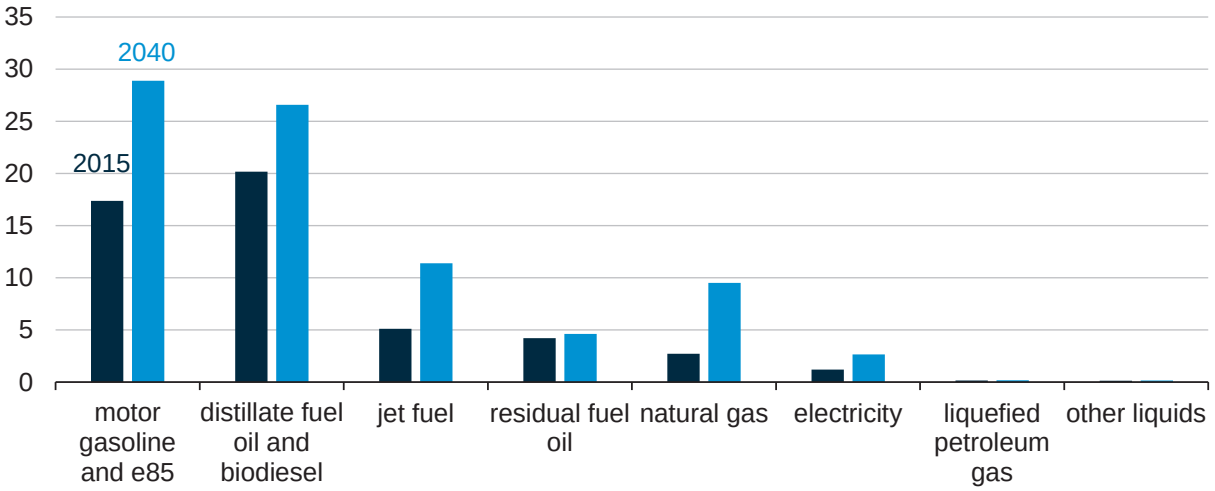
- Natural gas (driven by favorable economics in heavy trucking) and electricity (driven by its use in passenger rail and light-duty vehicles) are expected to be the fastest-growing forms of energy used for transportation in OECD countries on a percentage basis.

- Growing air travel is projected to increase jet fuel consumption by more than any other transportation fuel (4.7 quadrillion Btu between 2015 and 2040) in the OECD.

In non-OECD countries, transportation energy consumption rises across many types of fuel—

Transportation fuel consumption in non-OECD regions

quadrillion Btu

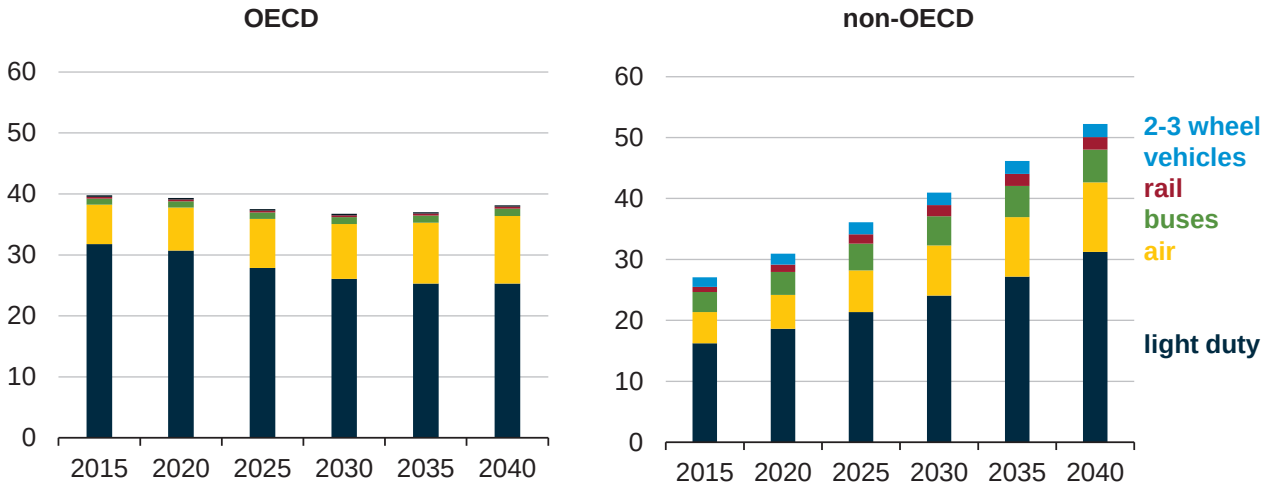


—as a result of large increases in travel in Asia

- Non-OECD Asia, which includes China and India, accounts for more than 70% of the increase in transportation fuel used in non-OECD countries as increased demand for personal transport from growing middle classes largely outpaces vehicle efficiency gains.
- As consumers increase their demand for personal transportation, including the use of light-duty and of 2- and 3-wheel vehicles, motor gasoline consumption grows more than any other transportation fuel.
- On a percentage basis, natural gas used as a transportation fuel experiences the fastest growth over the projection period, driven by increased use in large truck and bus fleets.
- Similar to the trend in OECD countries, jet fuel consumption experiences strong growth in non-OECD countries based on projected increases in personal and business air travel (6 quadrillion Btu between 2015 and 2040).

Air travel becomes an increasingly large portion of transportation energy consumption in OECD countries—

Passenger transportation energy consumption
quadrillion Btu

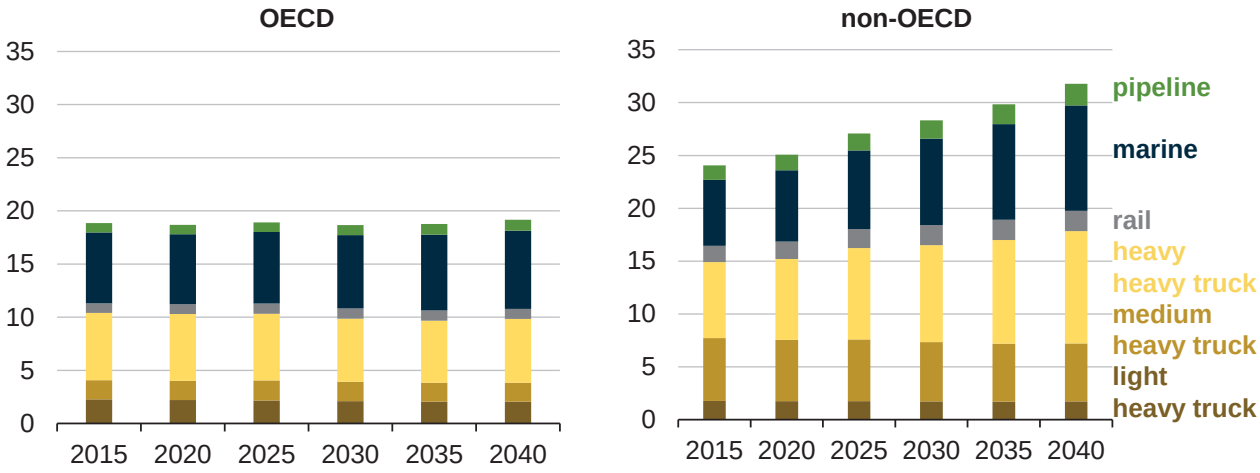


—while light-duty vehicle energy consumption grows rapidly in non-OECD countries

- In OECD countries, many of which are projected to have slower economic growth and stricter fuel economy standards than in non-OECD countries, energy consumption for passenger travel decreases by 4% (1.6 quadrillion Btu) between 2015 and 2040.
- In non-OECD countries, increased demand across all passenger modes of travel is projected to outpace improvements in fuel efficiency standards.
- The largest changes in passenger transportation occur in light-duty vehicles. Between 2015 and 2040, related energy consumption decreases by 6.5 quadrillion Btu in OECD countries and increases by 15.0 quadrillion Btu in non-OECD countries.
- From 2015 to 2040, energy used in air travel nearly doubles in OECD countries and more than doubles in non-OECD countries.

Freight transportation energy consumption remains relatively constant in OECD countries—

Freight transportation energy consumption
quadrillion Btu



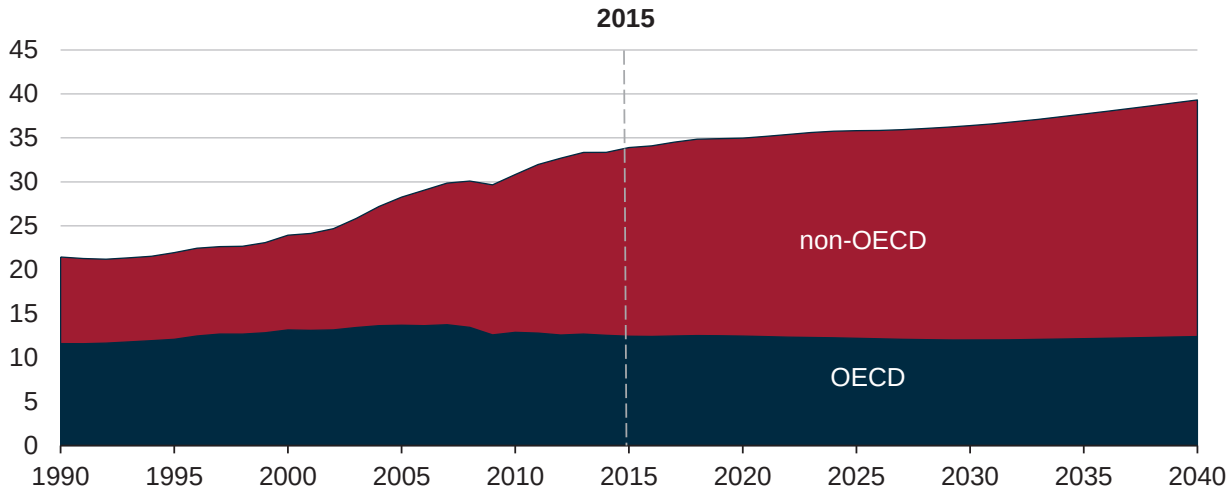
—while international marine transportation continues to grow in non-OECD countries

- In OECD countries, energy used to haul freight hovers just under 20 quadrillion Btu over the entire projection, with heavy trucks and marine vessels remaining the dominant modes of freight transport.
- In non-OECD countries, increases in industrial output lead to growing energy use in all modes of freight transport.
- More than half of the increase in the world's freight travel energy use is attributable to marine vessels, as residents in non-OECD countries continue to increase their demand for goods and services and producers become further integrated into global supply chains.
- As transportation infrastructure improves and roadways become more capable of supporting heavy trucks in non-OECD countries, energy consumption shifts from light and medium heavy-duty trucks to heavier vehicles.

Energy-related carbon dioxide

Reference case energy-related carbon dioxide emissions grow—

Energy-related carbon dioxide emissions
billion metric tons

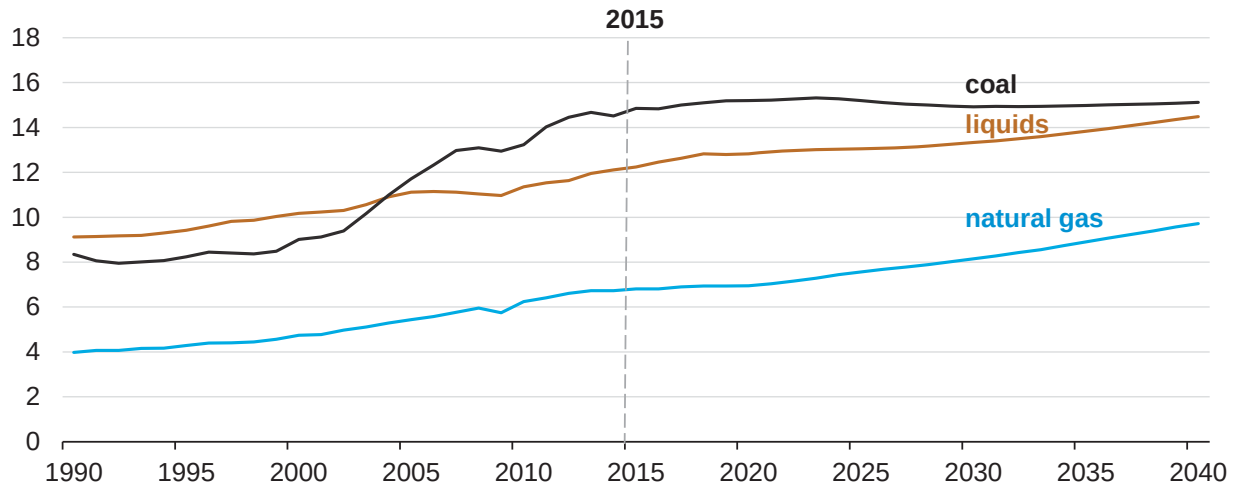


—but at a slower rate than in the recent past

- World energy-related carbon dioxide (CO2) emissions are projected to grow an average 0.6%/year between 2015 and 2040, 1.3%/year below the level from 1990 to 2015.
- Energy-related CO2 emission growth is slowed by increases in energy efficiency and a gradual shift from coal toward natural gas and renewable energy sources that began before 2015 but continue through the projection period.
- In OECD countries, energy-related CO2 emissions remain essentially flat through 2040 at 9% lower than their 2005 level even as their economies gradually expand.
- Energy-related CO2 emissions from non-OECD countries grow at a rate of less than 1%/year from 2015 to 2040, a lower rate than from 1990 to 2015, when emissions grew by 3%/year.

Coal-related carbon dioxide emissions flatten in the Reference case—

Energy-related carbon dioxide emissions
billion metric tons



—while liquids and natural gas emissions continue to grow

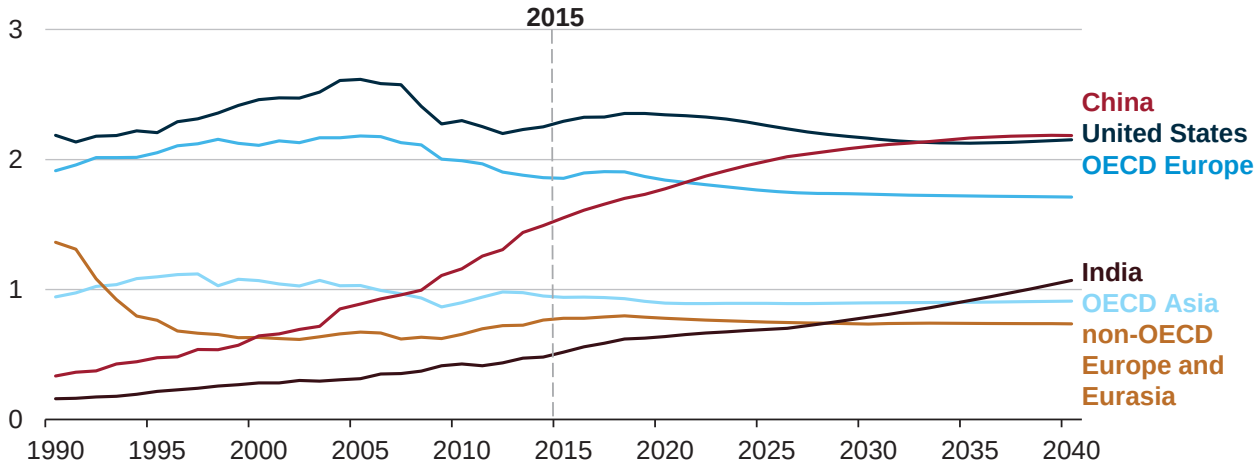
- Coal-related CO2 emissions are projected to increase at an average rate of 0.1%/year between 2015 and 2040, in contrast to the 2.3%/year rate seen from 1990 to 2015.

- Liquids-related CO2 emissions grow an average 0.7%/year between 2015 and 2040. Despite large increases in transportation demand, particularly in China and India, this rate is lower than the 1.2%/year increase seen from 1990 to 2015.

- Natural gas CO2 emissions increase an average 1.4%/year between 2015 and 2040. Even though the use of natural gas in electricity rises over the period, the related emission rates are lower than the 2.2%/year increases seen from 1990 to 2015.

Liquids-related carbon dioxide emissions remain flat in OECD countries—

Liquids-related carbon dioxide emissions for selected countries/regions
billion metric tons



—but grow rapidly in some non-OECD countries

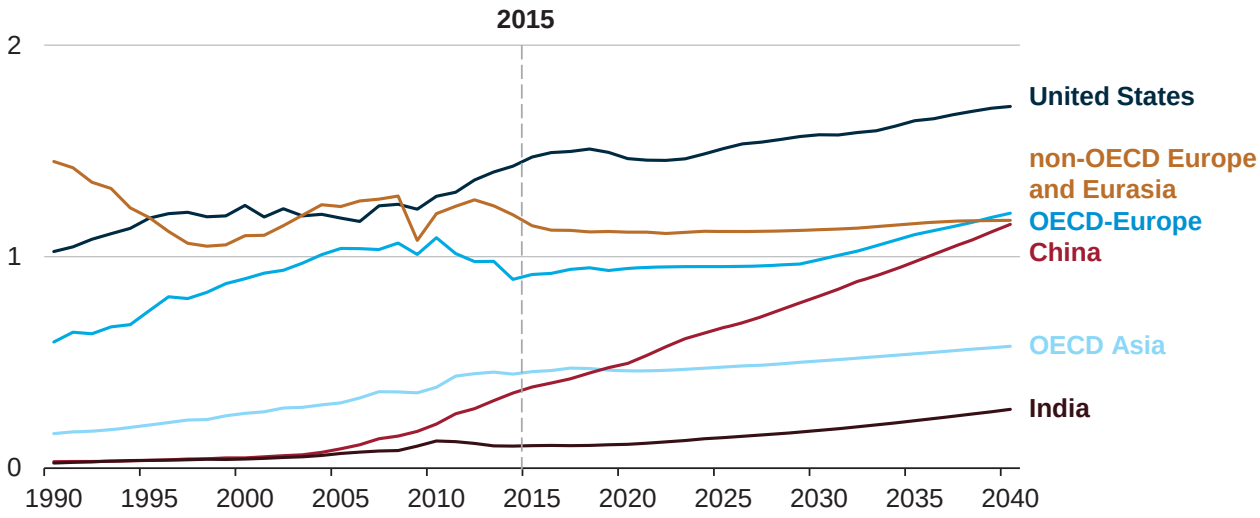
- Growth in CO2 emissions from liquid fuels, about 55% of which is used in transportation, levels off in OECD countries as increases in energy efficiency largely offset increases in passenger and freight services.

- China's liquids-related CO2 emissions grow at a decreasing rate as growth in the country's population slows. By 2040, China and U.S. liquids-related CO2 emissions levels are similar.

- India experiences continuous growth in liquids-related CO2 emissions, but it starts from a low base. By 2040, India's emissions exceed those in OECD Asia and non-OECD Europe and Eurasia.

Natural gas exhibits the greatest carbon dioxide emissions growth in the Reference case—

Natural gas-related carbon dioxide emissions for selected countries/regions
billion metric tons



—with increases in China, Europe, and the United States

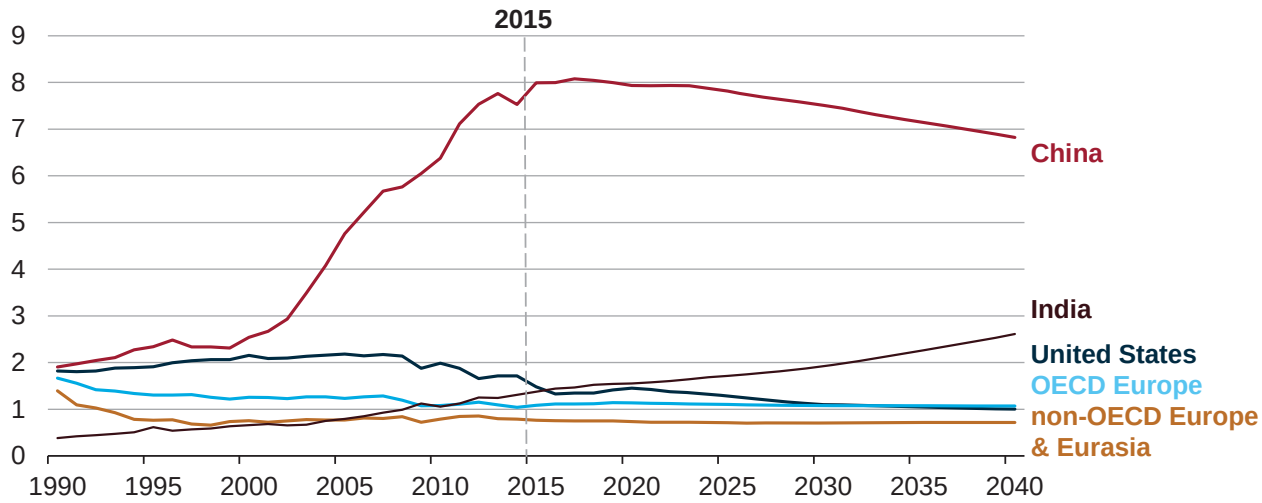
- CO2 emissions from natural gas, a relatively lower emitting fossil fuel used in many applications, grows across all regions between 2015 and 2040 as natural gas prices remain relatively low throughout the projection period.

- The largest growth in natural gas-related CO2 emissions is in China, as the primary fuel used to generate electricity in the country shifts from coal towards less carbon-intensive natural gas.

- In OECD Europe, natural gas-related CO2 emissions begin increasing more rapidly after 2030 as natural gas-fired capacity begins to replace retiring nuclear generation, putting upward pressure on overall emission levels and increasing the carbon intensity of their fuel mix.

China remains the world's largest user of coal—

Coal-related carbon dioxide emissions for selected countries/regions
billion metric tons



—but future declines help to stabilize global coal-related carbon dioxide emissions

- China shifts from the use of coal toward natural gas, nuclear power, and renewable energy between 2015 and 2040. This shift has a major effect on global energy-related CO2 emissions because of the size of China's economy.

- The decline in Chinese coal-related CO2 emissions is partially offset by growth in India's coal-related emissions. However, coal-related emissions in India remain much lower than in China through 2040.

- World coal-related CO2 emissions grow at only 0.1% annually from 2015 to 2040, compared with the growth rate of 2.3%/year from 1990 to 2015.

References

Acronyms and abbreviations used in this report

AEO = Annual Energy Outlook

b/d = barrels per day

BkW = billion kilowatts

Btu = British thermal unit

CHP = combined heat and power

CO2 = carbon dioxide

EIA = U.S. Energy Information Administration

GDP = gross domestic product

GTL = gas-to-liquids

GW = gigawatts

IEO = International Energy Outlook

LNG = liquefied natural gas

LPG = liquefied petroleum gas

MARPOL = “marine pollution,” the International Convention for the Prevention of Pollution from Ships

Acronyms and abbreviations used in this report

OECD = Organization for Economic Cooperation and Development

OPEC = Organization of the Petroleum Exporting Countries = Algeria, Angola, Ecuador, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. (Note: Equatorial Guinea became a member of OPEC on May 25, 2017, but their membership is not yet reflected in the IEO2017 projections.)

Petroleum and other liquids = crude oil and lease condensate (including tight oil, shale oil, extra-heavy oil, field condensate, and bitumen) and other liquid fuels (natural gas plant liquids; liquids from renewable sources—biofuels, including ethanol, biodiesel, and biomass-to-liquids [BTL]; liquids from natural gas—gas-to-liquids [GTL], liquids from coal—coal to liquids [CTL]; and liquids from kerogen—oil shale.

Tcf = trillion cubic feet

WEPS+ = World Energy Projection System Plus

IEO regional definitions – OECD Regions

OECD Americas = United States, Canada, Chile, and Mexico.

OECD Europe = Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and United Kingdom. (Note: Israel is included in OECD Europe for statistical reporting purposes. Latvia became an OECD member country on July 16, 2016, but it is not reported in OECD Europe for IEO2017.)

OECD Asia = Australia, Japan, New Zealand, and South Korea.

IEO regional definitions – non-OECD Regions

Non-OECD Europe and Eurasia = Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Faroe Islands, Georgia, Gibraltar, Kazakhstan, Kosovo, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Russia, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. (Note: Latvia became an OECD member country on July 16, 2016, but it is reported in non-OECD Europe and Eurasia for IEO2017.)

Non-OECD Asia = Afghanistan, American Samoa, Bangladesh, Bhutan, Brunei, Burma (Myanmar), Cambodia (Kampuchea), China, Cook Islands, Fiji, French Polynesia, Guam, Hawaiian Trade Zone, Hong Kong, India, Indonesia, Kiribati, Laos, Macau, Malaysia, Maldives, Mongolia, Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste (East Timor), Tonga, U.S. Pacific Islands, Vanuatu, Vietnam, and Wake Islands.

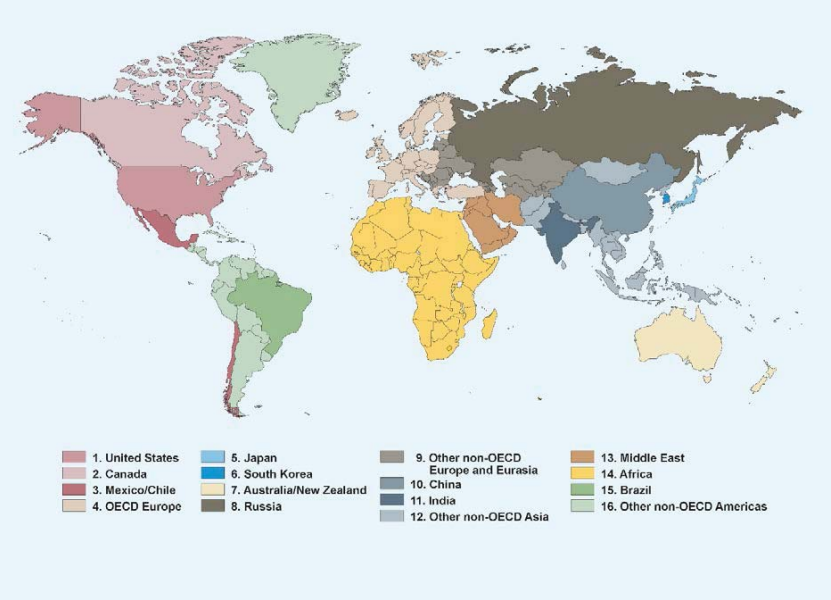
Middle East = Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestinian Territories, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

IEO regional definitions – non-OECD Regions

Africa = Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, St. Helena, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, and Zimbabwe

Non-OECD Americas = Antarctica, Antigua and Barbuda, Argentina, Aruba, The Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands, French Guiana, Greenland, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Pierre and Miquelon, St. Vincent/Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, U.S. Virgin Islands, and Venezuela.

Map of IEO regions



Model Improvements

- This IEO is the first projection to include model results through 2050, which are available on the IEO page at: http://www.eia.gov/ieo. The graphics in this report include projections through 2040.

- IEO2017 improves the representation of district heating to better capture the dynamics between fuel prices and electricity generation as new capacity is added.

- Projections of residential and commercial energy demand are now based a richer set of determinants, including household disposable income and output in service industries. Previously, the projections were based primarily on growth in GDP across regions.

- Projections related to air travel now separately account for movement within and between 13 distinct regions of the world. The projections update 2013–15 regional data, including aircraft sales, stocks, active and parked aircraft, seat-miles traveled, cargo travel, and fuel use.

- Projections related to industrial activity are now based on a more detailed representation of industrial output by expanding the model's coverage from 21 to 37 industries.

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U.S. Energy Information Administration home page | www.eia.gov

Short-Term Energy Outlook | www.eia.gov/outlooks/steo

Annual Energy Outlook | www.eia.gov/aeo

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

Today in Energy | www.eia.gov/todayinenergy