2017

GLOBAL GAS OUTLOOK

GECF

GAS EXPORTING COUNTRIES FORUM

ABOUT THE GECF

The Gas Exporting Countries Forum (GECF or Forum) is an intergovernmental organisation established in May 2001 in Tehran, Islamic Republic of Iran. The GECF Statute and the Agreement on its functioning were signed in 2008, in Moscow, Russia. It became a full-fledged organization in 2008 with its permanent Secretariat based in Doha, Qatar.

The GECF comprises twelve Members and seven Observer Members (hereafter referred to as GECF Countries). The Member Countries of the Forum, are: Algeria, Bolivia, Egypt, Equatorial Guinea, Iran, Libya, Nigeria, Qatar, Russia, Trinidad and Tobago, the United Arab Emirates and Venezuela (hereafter referred to as Members). Azerbaijan, Iraq, Kazakhstan, the Netherlands, Norway, Oman and Peru have the status of Observer Members (hereafter referred to as Observers).

The GECF is a gathering of the world's leading gas producers, whose objective is to increase the level of coordination and to strengthen collaboration among Members. The Forum provides a framework for the exchange of views, experiences, information, and data, and for cooperation and collaboration amongst its Members in gas-related matters.

The GECF represents more than two-thirds of the world's proven gas reserves, almost half of global natural gas production, and around two-thirds of gas exports.

In accordance with the GECF Statute, the organization aims to support the sovereign rights of its Member Countries over their natural gas resources and their abilities to develop, preserve and use such resources for the benefit of their peoples, through the exchange of experience, views, information and coordination in gas-related matters.

In accordance with the GECF Long-Term Strategy, adopted during the 18th GECF Ministerial Meeting, the priority objectives of the GECF are as follows:

Objective No. 1: Maximizing gas value, namely to pursue opportunities that support the sustainable maximization of the added value of gas for Member Countries.

Objective No. 2: Developing the GECF View on gas market developments through short-, medium- and long-term market analysis and forecasting.

Objective No. 3: Co-operation, namely to develop effective ways and means for cooperation amongst GECF Member Countries in various areas of common interests.

Objective No. 4: Promotion of natural gas, namely to contribute to meeting future world energy needs, to ensure global sustainable development and to respond to environmental concerns, in particular with regard to climate change.

Objective No. 5: International positioning of the GECF as a globally recognized intergovernmental organization, which is a reference institution for gas market expertise and a benchmark for the positions of gas exporting countries.

The GECF Global Gas Outlook is among the main Key Initiatives and Instruments identified by the GECF Long-Term Strategy.

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The data, forecast, analysis, and any other information contained within this Outlook are for information purposes only and are provided on a non-reliance basis. The forecasts have been quantified through the use of the GECF Global Gas Model (GGM) at the reference case scenario. Neither the GECF, nor any of the GECF Member and Observer Countries, nor any of their agents or their employees (the 'Parties') assumes any liability or responsibility for the use of these forecasts, or the results of any actions taken on the basis of information contained in this report and any data, analysis, or any other information within it.

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Download: All of the data presented in this Outlook is available at www.gecf.org.

FOREWORD

This 2017 edition of the GECF Global Gas Outlook was prepared by the GECF Secretariat after thorough review of gas market developments during the 2017 year, and following discussions with the GECF Technical and Economic Council, as well as consultation with other peer organizations, with the objective to capture all major events for the 2017 Outlook update.

The analysis is built on the GECF's GGM (October 2017 Update), which integrates existing and future gas supply by type and cost, energy demand forecasting modules, and the pipeline and LNG infrastructure that links demand and supply. The output is an analysis of long-term import and export trade. It presents least-cost solutions based on contractual flows, cost curves, and other constraints influencing global gas markets.

This year, certain policy developments in the US, Europe and China were enacted that could impact the long-term gas market perspective. The new US administration has chosen an energy policy trajectory that will impact energy trends to the benefit of natural gas. In Europe the adoption of the new energy package, "Clean Energy for All," will impact prevailing mechanisms affecting different sources of energy. As a result, natural gas will play an increasing role in the European energy mix. In China, the new Five-Year Plan, which calls for stringent CO_2 emission measures, will propel natural gas and renewables.

On the supply side, many new developments have been considered in the 2017 edition: Qatar's announcement to increase gas production by 30%, Egypt's progress in developing the Al-Zohr field, China's plan to increase production, as well as the gas production surge in Iran's South Pars field.

The GECF Outlook estimates that, by 2040, the global population will increase by 1.7 billion people and gross domestic product (GDP) per capita will increase by 80%. These demographic and economic trends will catalyse energy demand, making energy accessibility a top priority for policymakers.

Global commitments toward clean and environmentally friendly energy sources are increasing, with the aim of promoting economic development with a smaller carbon footprint. These commitments include the adoption of the Sustainable Development Goals (SDGs) and the 2015 Paris Agreement, which aimed at addressing energy poverty and limiting global warming, while balancing between economic development and sustainability.

SDG #7 underscores the importance of energy accessibility and the imperative need to alleviate energy poverty, while balancing economic and environmental commitments. Increased energy accessibility is expected to unlock new global demand, while environmental issues impact the fuel mix significantly.

The net result of all of these developments outlines the critical need to provide access to affordable, reliable, sustainable and modern energy for all, while simultaneously upholding environmental commitments. It is here that the role of natural gas emerges, as reliable, efficient, accessible, and outstanding.

The GECF Countries have the largest share of gas reserves and production capacity in the world. They will continue to play their role in insuring market stability, as well as security of supply and demand.

I would like to express my thanks to the many experts in the GECF countries who participated in preparing this Outlook, and to all the people in the GECF Secretariat.

Seyed Mohammad Hossein Adeli
Secretary General
Gas Exporting Countries Forum

ACKNOWLEDGEMENTS

The publication of the GECF Global Gas Outlook 2017 could not have been possible without valuable assistance from many experts. We would like to thank all those who contributed to the development of this report, especially the GECF Executive Board, Technical Economic Council Members, and the Secretary General Office.

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The OIES has provided an extensive review of the report, checking for consistency and factual accuracy. However, the views and conclusions expressed are those of the GECF and do not necessarily coincide with the opinions of OIES or its staff.

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EXECUTIVE SUMMARY

Energy markets are liable to experience a significant transformation through to 2040. In 2017-2018, global growth will be supported by several emerging economies that have entered the recovery phase. Commodity markets are rebalancing after a period of increased volatility. Global GDP is expected to grow by 3.7% over the next five years, a slight upswing from the 3.4% seen over the previous five years.

In the long-run, population growth and household wealth are strong drivers for energy demand transformation. The global population will reach 9.2 bn by 2040— a 1.7 billion (bn) person increase from today. This substantial population increase is paired with an 80% forecasted increase in average GDP per capita relative to current levels.

These demographic and socioeconomic trends will catalyse energy demand both directly and via the industrial sector, with the number of households totalling 2.8 bn by 2040 (a 33% increase from 2017). Furthermore, a growing population with more access to wealth will drive vehicle fleet expansion by 60%, with 2 bn cars on the road by 2040.

Energy accessibility will become a top priority in the long-term. Most population and income growth will come from Asia and Africa. These two regions currently have the poorest access to energy and the largest fuel substitution potential. Biomass and waste support 60% of energy consumption in the domestic sector in developing Asia and 80% in Africa, compared to less than 6% in developed countries.

World energy demand is projected to grow by 1.1% per annum, rising 29% between 2017 and 2040, from 13.8 to 17.8 gigatonne of oil equivalent (Gtoe). By 2040, fossil fuels are expected to meet 75% of the world's energy demand.

The share of natural gas in the global energy mix will increase from 22% in 2016 to 26% in 2040. Coal will see a 7% decrease (from 27% to 20%), to be gradually replaced by natural gas, renewables (17%) and nuclear (6%). Concurrently, the share of oil in the global energy mix will decrease by 3%, to 29% in 2040.

Consumers of natural gas benefit from its economic and environmental advantages, namely low prices, ample reserves, and relatively low emissions. Therefore, demand for natural gas is expected to grow during the period under review in this Outlook, as customers seek an energy source that supports economic development and addresses environmental concerns.

Global gas consumption will increase by 53% between 2017 and 2040. This growth will be led by non-OECD Asia, followed by the Middle East and Africa. Natural gas will become the fastest growing fossil fuel, with an annual growth rate of 1.8%, reaching 5395 billion cubic metres (bcm) in 2040.

Demand for gas in the power sector increased from 692 bcm in 2000 to 1280 bcm in 2016, with an annual average growth rate of 3.9%. This represents 36% of the gas consumed in all energy sectors in 2016. The GECF expects that consumption in the power sector will continue to increase by an average growth rate of 2.5% per annum, reaching 2329 bcm in 2040.

Global electricity demand has been increasing since 2000 and is projected to peak at 41235 terawatt hours (TWh) in 2040. Demand for electricity grew at an average rate of 3% per annum between 2000 and 2016, and is expected to grow at an annual rate of 2.2% between 2017 and 2040. Urbanisation and the associated increase in residential energy demand, coupled with industrial expansion, particularly in developing economies such as China and India, are the main drivers propelling electricity demand.

Rapidly expanding production and trade of pipeline gas and, especially, liquefied natural gas (LNG) has been observed in recent years. In 2016, global trade of LNG totalled 257.7 million tonnes (MT) — a 15 MT increase from the previous year. This is the largest incremental growth in LNG volume since the 2011 Fukushima Daiichi nuclear accident. In this Outlook, this boom in LNG trade is expected to continue, with liquefaction facilities coming online in the US and Australia at increasingly higher rates. The second wave of expansion will come primarily from Qatar and other GECF Members in approximately 2025, as well as from the US. Significant developments in pipeline infrastructure are also taking place in the CIS region, expanding pipeline capacity that will drive exports to China and Europe through the

Power of Siberia and the Southern Gas Corridor, respectively.

Unconventional natural gas resources will play an increasingly greater role in global supply. This Outlook projects that the share of unconventional gas in total gas production will rise from approximately 16% today, to more than 30% in 2040.

A low-carbon future is emerging as a key concern for the international community, especially with the adoption of the Paris Agreement in December 2015. This Agreement has galvanised the energy community, with more than 190 countries pledging to mitigate their greenhouse gas (GHG) emissions through Intended Nationally Determined Contributions (INDCs).

Paving the way to a low carbon future must take into account the compatibility of CO_2 mitigation with sustainable development, including its economic, social, and environmental dimensions.

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The GECF Secretariat will continue to support GECF Members both in dialogue in the international community and with analytical support, such as that contained in this GECF Global Gas Outlook 2017.

INTRODUCTION AND SCOPE

This Outlook reflects the impartial views of the GECF Secretariat and is prepared in accordance with the resolutions adopted in the 18th GECF Ministerial Meeting. It aims to support the Long-term Priority Objectives of the GECF Long-Term Strategy.

The present document is based on proprietary assessment of the evolution of energy and gas market fundamentals through to 2040. This Outlook was developed in a framework of specialized committees created within the Forum, to guide and monitor extensive research on global gas markets.

The GECF Global Gas Outlook is unique, as it is the only energy outlook worldwide to focus solely on natural gas. It aims to be a global reference for insights into gas markets. The document also represents an impartial view on gas market evolution by highlighting the most likely developments that are going to occur in the medium- and long-term.

The GECF reference case scenario highlights the current situation and the evolution of gas market and energy trends to 2040, in terms of global energy demand (by region/sector/fuel) and global gas supply (conventional and unconventional), for GECF and non-GECF Countries. It also reflects current energy policies and the potential introduction of new policies that are likely to materialize throughout the forecast period, in accordance with our assessment.

In addition, this document explores the subject of competition from alternative sources of energy (mainly coal and renewables), as well as technological developments and their eventual impact on the energy mix and gas market shares, with a focus on power generation as a strategic sector for gas demand growth. Energy efficiency, environmental policies and other regulations have been considered in the reference case scenario, in order to study their impact on gas penetration in key markets/sectors.

The GECF Secretariat believes that it is impossible to cover all future uncertainties with a single scenario. Therefore, multiple scenarios are needed in order to have a broader mapping of the uncertainties shaping the development of gas markets. In this regard, the Secretariat will address future uncertainties and their possible impact on alternative scenarios through the annual publication of the GECF Global Gas Outlook.

The outcomes of the GECF reference case scenario will serve as a basis to support the formulation of a consistent Long-Term Strategy for the Forum, and that will allow it to achieve the agreed upon objectives included in the GECF Statute and summit declarations.

This document is divided into four main chapters. Chapters I and II introduce key global gas demand assumptions, including economic, energy price, and policy assumptions. Chapter III highlights energy and gas demand trends, followed by supply assumptions in Chapter IV, which include global gas resources, upstream production, pipeline, LNG and regasification capacity assumptions, as well as the corresponding investment figures. The final chapter is dedicated to global gas production and trade outcomes resulting from the equilibrium between supply and demand. It takes into consideration gas market constraints, in terms of supply infrastructure, international supply contracts, and gas supply policies (e.g. the satisfaction of domestic gas demand as a priority for some countries).

The reference case scenario is quantified through the use of the GECF GGM, which is a unique energy model developed in-house at the GECF Secretariat, and which includes different sub-models with each one focused on one segment of the gas value chain (production, pipelines, LNG, shipping, regasification, contracts and demand).

Our model is characterized by its uniquely high granularity, encompassing:

- 113 country-level forecasts, with 60 regional aggregates and a global projection
- Complete energy balance estimates, covering 29 sectors and 34 fuels annually, from 1990 to 2040
- 4300 gas supply entities representing gas supply potential at the global scale, divided into:
  - 740 existing and operational production facilities (including aggregates)

  - 2120 new projects based on existing reserves
  - 1300 yet-to-find (YTF) entities
  - 160 unconventional resources (existing and YTF), generating the most comprehensive database available of global shale and tight gas, coalbed methane (CBM) and methane hydrates

The infrastructure database contains:

- 240 liquefaction plants
- 400 regasification plants
- More than 5000 gas pipeline and shipping routes

The gas contracts database contains:

- Annual contracted and delivered volumes, including 600 contracts (country-to-country and non-dedicated), based on more than 1000 company-to-company contracts

Another important characteristic of our model is that it endogenously calculates gas demand curves and gas production profiles country by country based on corresponding assumptions and inputs. All of the sub-models have been calibrated and based on 2016 as the last available year of historical data.

Energy and natural gas demand forecasts are derived based on a set of primary and secondary assumptions fed with macro and energy price data, utilizing econometric modelling techniques using time-series back to 1990. Policy measures are taken into consideration at each stage of this process.

In terms of data sources and historical data, we mainly reference the United Nations (UN) for demographic data, the International Monetary Fund (IMF) for economic data, and the International Energy Agency (IEA) for energy and gas demand data. These are cross checked with other international and regional statistical sources, especially for the GECF Countries. For data on gas supply we use an in-house database updated by the GECF Countries and secondary sources, which also plays an important role in the GECF GGM calculations. The starting year of our projections is 2017. Therefore, all data from 2017 to 2040 in the following analysis is considered to be a part of the GECF forecast, unless otherwise stated.

The core engine of the GECF GGM is the Global Gas Trade Model, which matches gas supply with gas demand for all the countries under consideration. The global gas trade projections in the GECF modelling exercise are derived from three fundamental inputs.

The first input is the gas demand curve for each country/region. Econometric time-series and stock models are based on Eviews software that links with other modelling outputs and a global gas trade model to produce a comprehensive global energy outlook.

The second key input is the available/potential domestic gas supply in each country/region that will define either the call for imports in any specific region or its export capacity, depending on whether the country is an importer or an exporter.

The third, most technical, input is the configuration of the trade network, either in terms of pipelines or shipping routes. Virtually all potential shipping routes are considered, while for the pipeline routes we consider only the main trans-border pipelines between the different trading regions and hubs. Our modelled gas pipeline network is a simplification of the actual physical network, which cannot be reproduced with the same level of detail and granularity as the shipping routes.

These three elements together - demand, supply and infrastructure - shape the projections for global gas trade. The consistency of the trade is always ensured in terms of total traded volumes between each source of supply and corresponding source of demand.

CHAPTER 1: MAIN ASSUMPTIONS ON GLOBAL ECONOMIC SITUATION, PROSPECTS AND ENERGY PRICES

Key assumptions and findings:

- Average global GDP per capita will grow 80% by 2040, as the global population will increase by 1.7 bn, with global GDP growth averaging 3.4% per year.
- GDP and population growth will continue to drive energy demand strongly through increased consumption of industrial goods, larger car fleets (a 60% increase, with 2.07 bn cars on the road by 2040), and more residential housing (33% more households to 2.8 bn).
- Most growth will be localized in developing Asia and developing Africa with prospective populations of 3.8 bn and 4.4 bn, respectively.
- These regions have the lowest energy accessibility as of now: biomass and waste provide for 60% of domestic sector energy consumption in developing Asia and 80% in Africa.
- Therefore, in the next 25 years half of the world's population will see a significant transformation in energy demand.
- In the medium term, growth in the emerging economies shows signs of wavering due to the impact of low commodity prices, tighter financing conditions, and rebalancing measures in China.

This section describes key quantitative assumptions behind the Outlook. Key assumptions include population growth and urbanisation, economic prospects, size and structure of the global car fleet, developments in global housing construction, as well as projections for the natural gas, oil, and coal prices.

The projections are based on UN population and urbanisation forecasts, as well as GECF long-term macroeconomic, vehicle fleet and housing outlooks. The reference price projections are market-neutral and do not necessarily reflect the views of individual Members.

Population growth and urbanisation

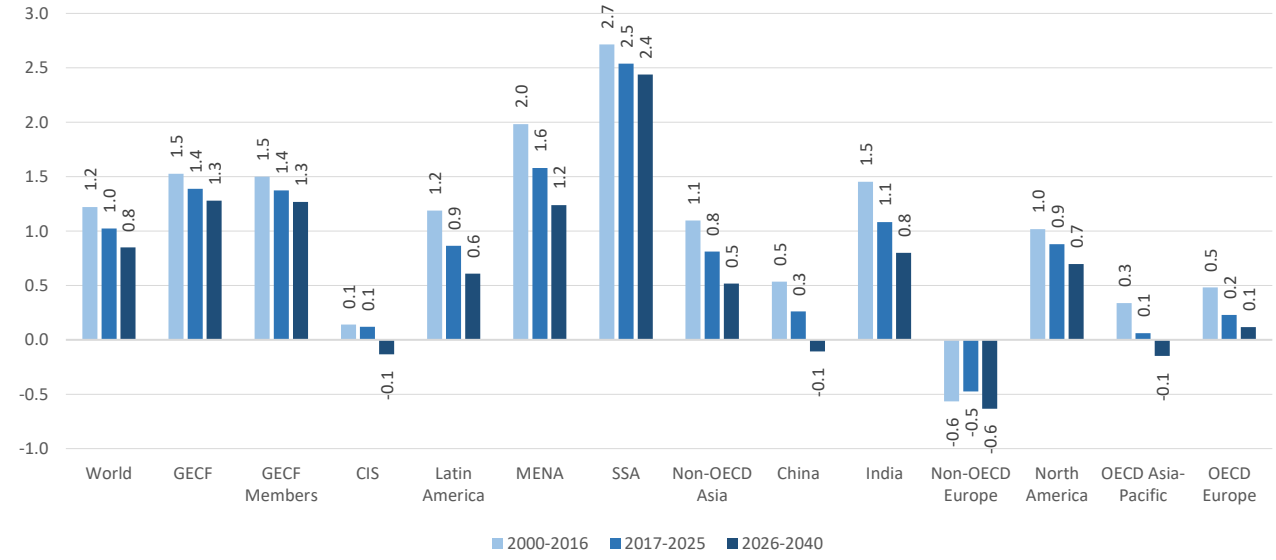
Population growth is the primary driver of future energy trends, reinforced by the process of urbanisation.

This Outlook is based on the medium fertility scenario outlined in UN population projections, which see global population rising from 7.5 bn in 2016 to 9.2 bn by 2040.

Population growth is expected to slow over the projection period (see Figure 1.1), in line with trends of the last three decades, from 1.0% per annum between 2016 and 2020 to 0.7% per annum from 2020 to 2040. Africa, especially Sub-Saharan Africa (SSA), and the Middle East are expected to contribute most to the global population, as developing Asia did in the previous decades. Population growth in India is expected to subside, and in China it is expected to level off, despite the lifting of the one-child policy.

The objective of the GECF is "to support the sovereign rights of member countries over their natural resources … for the benefit of their peoples." As GECF comprises 10 Members from the Middle East and Africa, the combined population of GECF countries expected to grow strongly at a rate of 1.4%, amounting to almost 1 bn by 2040.

Figure 1.1: Average annual population growth rates by region (%)



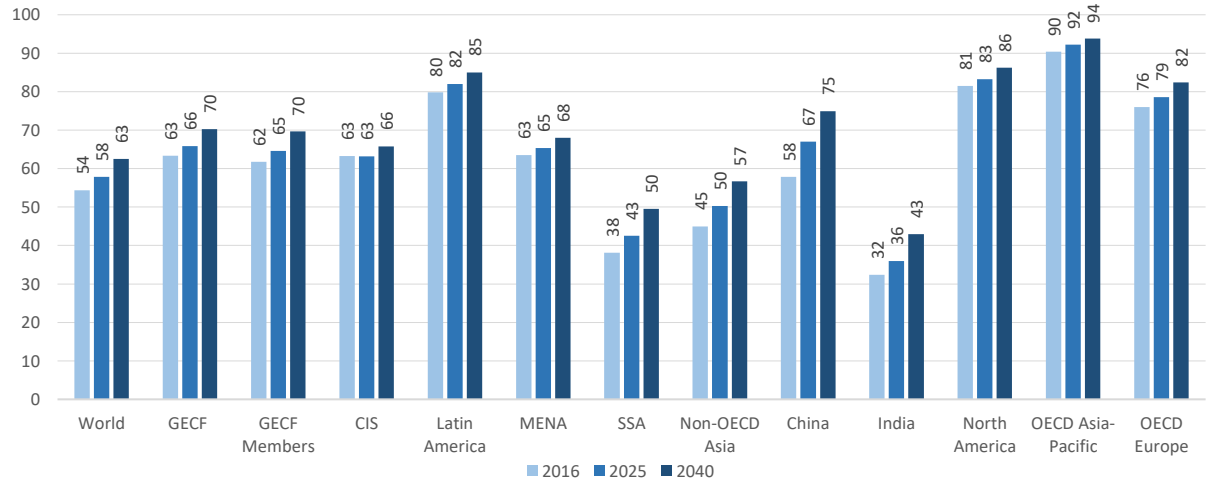
Source: UN Population Division, World Population Prospects

Urbanisation prospects for the Outlook are also based on UN projections. A strong urbanisation trend is envisaged over the outlook period: almost all population growth to 2040 is expected to add to the urban population, with the rural population being flat to 2040. The population growth shift to cities also implies a rise in the number of homes with fewer people per household (3.2 in 2040 compared to 3.6 in 2016).

Ongoing rapid urbanisation is expected to transform societies in Africa and non-OECD Asia from largely rural (over 70% in 1990) to increasingly urban (respectively, 40% and 44% urban population in 2016 and forecast to be 50% and 57% by 2040).

While urban energy consumption is perceived to be more efficient, in developing countries growth in urban population induces an increase in energy consumption per capita as household income grows and energy infrastructure is readily available. Thus the urbanisation trend is laying the foundation for an increase in energy demand in developing countries, not just in terms of the manufacturing base linked to these new and larger urban settlements, but also to fuel the domestic sector of the growing cities.

Figure 1.2: Percent share of urban population by region (%)



Source: UN Population Division, UN World Urbanization Prospects

Global economic prospects

The last decade was overshadowed by economic and financial depression in the aftermath of the global economic crisis of 2008-2009. Despite unprecedented monetary stimuli, economic recovery was long and unevenly distributed due to weakness in the financial sector, the legacy of several crises (such as the European debt crisis) and long-term structural challenges to economic growth.

While financial and fiscal problems have now been largely contained, the long-term structural challenges exposed almost ten years ago are only now beginning to unravel. These structural challenges are expected to dampen global GDP growth until new global economic architecture emerges.

Structural economic and institutional challenges are naturally affected by geopolitical dimensions. Over the last several years, the largest global economies, including the US and China, have unveiled tectonic shifts in their global strategies, including changes to their geopolitical and geo-economic stance. This has brought about elevated tensions at both national and geopolitical levels, which will remain a risk factor for global economic growth in the medium-term.

Short- and medium-term global economic prospects: 2017–2025

Global economic growth hit an impasse in 2016, with both the US and Chinese economies decelerating. This was coupled with a continuous drag on oil and gas exporting economies spurred by the need to adjust to lower oil prices. Growth in 2017-2018 and over the medium-term is expected to be stronger, as developed economies gain momentum, the Chinese economy deceleration stabilizes, and the Brazilian and Russian economies enter recovery.

In 2016, lack of confidence in markets restrained global investment and took a toll on consumption and production. These trends are expected to reverse in 2017-2018, with investment demand accelerating significantly in developed countries through 2018, as well as in India, Brazil and Russia.

It was expected that lower energy prices would boost global growth by reallocation of gains from exporters to importers, who would be able to spend more than exporters. As economic results from 2015-2016 show, benefits to final consumers resulting from lower energy prices were limited, both geographically and on a sectoral level.

Conversely, oil and gas-exporting economies experienced a pronounced direct macroeconomic impact from the fall in oil prices to $40-50 per barrel, resulting in economic slowdown or recession. The most notable declines were experienced in Russia, Nigeria and the MENA region. Slowdowns and recessions in these economies alone subtracted 0.15 percentage points per annum from global GDP growth over 2015-2016. Correction of shale oil industry output and investments brought about by lower oil prices had a profound impact on the US economy as well.

Deflationary pressure also affected most economies, especially the advanced economies and China. While oil demand responded to lower prices, positive economic impacts were limited, possibly due to the lower energy intensity of growth.

Aggregate demand reductions in oil-exporting countries limited global trade in 2015 and 2016. Furthermore, global financial markets reacted negatively to oil price slumps, reflecting negative trade flows from energy exporters to the global economy, as well as an increase in fiscal and balance of payments risks.

These factors compound and affect expectations for global economic growth. In turn, this could impact future demand for energy products.

For 2017-2018, prospects seem much brighter for both developed and developing economies, as several drivers coalesce in favour of faster growth.

First, several major geopolitical and macroeconomic uncertainties and risks have significantly diminished. From the geopolitical perspective, tensions resulting from Brexit have lessened slightly, political power transition in the US and major European countries went smoothly, and tensions in the Middle East have subsided, especially in Libya and Syria. From the macroeconomic perspective, global oil markets have stabilized after OPEC and non-OPEC countries reached an output deal; rate hikes by the Federal Reserve normalized the tapering process, and the Chinese economy and balance of payments have entered a period of “new normal.”

Secondly, new sources of growth have emerged in the global economy that will have an impact in the medium-term. Economies of energy exporters adjusted and bounced back from recessions of 2015-2017. At the same time, acceleration in a number of large developed European economies, boosted by ECB monetary easing, has been another source of global economic growth. Finally, the uptick in global trade after almost a decade of missed expectations has been pronounced, and trade has buoyed growth both in developed and developing economies.

Taking on these drivers, global growth at current PPP weights for 2017 is expected to accelerate to 3.4% from 3.0%, and further grow by 3.7% in 2018. This momentum will be supported by gradual acceleration: by 2020 the global economy is expected to reach a growth rate of 3.8%.

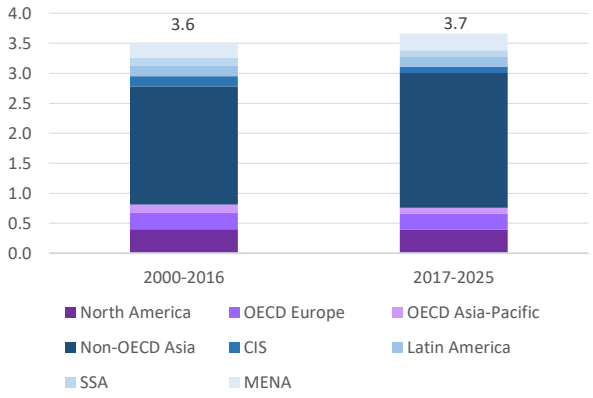
While developed economies are expected to significantly contribute to growth in 2017-2018, their impact on global growth is limited over the medium-term. The European economy overcame consequences of the sovereign debt crisis 5 years ago. Monetary easing by the ECB promoted credit growth in peripheral economies, and among the core ones, the French economy emerged from stagnation with the expectation of an ambitious package of structural reforms under new leadership. For the US economy, the compounded impact of growth in the digital economy and energy sector recovery are expected to accelerate expansion in 2017-2018, despite large political uncertainties.

Most developing economies are expected to experience impressive growth both in the short- and medium-term, as global demand boosts trade flows after almost a decade of stagnation.

The Chinese economy is expected to continue gradual deceleration as financial stabilization takes a toll on investment and consumption growth. In the medium-term, the economy will struggle with the consequences of rapid credit expansion, coupled with asset price bubbles. However, the government could further its goal of stability through a variety of policy mechanisms, including semi-closed capital accounts, state-controlled banking systems and accumulated foreign reserves, in addition to significant changes to industrial policy and regulation.

One important feature of forecasted medium-term recovery in growth will be the even spread of growth over the CIS, Latin America, and Middle-Eastern regions (see Figure 1.3). Another one is that for the first time ever India, rather than China, is expected to lead emerging Asian economies with economic acceleration.

Figure 1.3: Regional structure of medium-term growth (%)



Source: GECF Secretariat based on data from GECF GGM

Another important feature, especially for the economies of GECF countries, is the expected lower level of commodity prices. We estimate that the lower prices of commodity exports will reduce the average economic growth rate in the commodity-exporting nations by 1.0 percentage points per annum. Among energy exporters, the decline is even more significant, at 2.25 percentage points on average, which is reflected in the economic perspectives of GECF, MENA and Russia regions, among others.

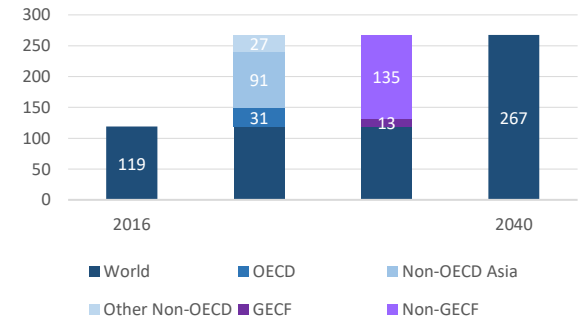
Long-term global economic prospects: 2026–2040

Based on our assumptions regarding medium- to long-term economic projections, the trend of potential GDP growth is slower than previously expected, especially for developing countries (see Figure 1.4).

An ageing population, lower rates of productivity growth, and lower rates of capital accumulation all weigh negatively on global, long-term GDP growth forecasts. This remains true despite technological development and higher educational attainment, both of which drive labour and total factor productivity. Coupled with proactive structural reforms, however, these trends could cushion the impact.

Global growth is projected to average 3.4% per year over the outlook period, which is slightly lower than the 2000-2016 historical average (see Table 1.1). The main contributing region will remain in developing Asia, consistent with the past trends. However, ASEAN economies and India will outpace China.

Figure 1.4: Projected composition of GDP growth to 2040 (trillion 2016$ in PPP)



Source: GECF Secretariat based on data from GECF GGM

The growth of the Chinese economy is expected to stutter in the long-term, due to structural shifts in its GDP following a transition from investment-driven to consumption-driven growth. This transition is still in progress and will present a strategic challenge for China. As urbanisation potential is exhausted in the medium-term and growth declines following the transition to a service-oriented economy, an ageing labour force and reduced competitiveness will add additional challenges. It is worth noting that most of these challenges are developmental and not limited to the Chinese economy. Thus, it is expected that the Indian economy will decelerate post-2025 under similar premises.

For energy-exporting countries, the economic impact of lower prices is expected to persist in the medium-term (this will be further discussed in the following Section). This will affect long-term investment and hamper growth over the outlook period. For GECF economies, energy sector value added is projected to power about 25% of long-term growth (compared to 15% from 2000 to 2016) — the second-largest sectoral growth driver after services.

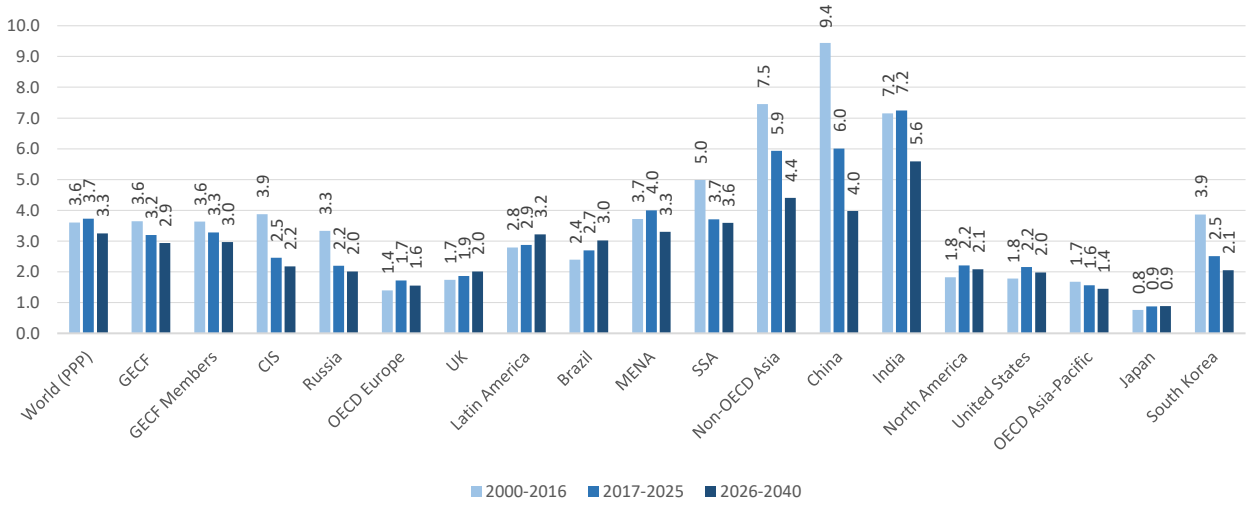
Figure 1.5 shows the relationship between these trends in five-year intervals across the outlook horizon. Global growth is expected to recover in the medium-term (2017-2025), to 3.7% per annum, and then decline to 3.3% after 2025 in accordance with demographic trends. By then, China and the other major emerging economies are projected to slow to a more sustainable, consumption-driven long-term growth rate.

Table 1.1: GDP growth rates in constant 2016$ (%)

	Historical				Forecast					
	1991-2000	2001-2010	2011-2016	Mean growth rate 1991-2016	2017-2020	2021-2025	2026-2030	2031-2035	2036-2040	Mean growth rate 2017-2040
World (PPP)	3.6	3.8	3.3	3.6	3.6	3.8	3.5	3.2	3.1	3.4
GECF	-0.1	4.9	1.5	2.2	2.8	3.5	3.1	2.9	2.8	3.0
CIS	-4.4	5.4	1.4	0.6	2.2	2.6	2.4	2.1	2.0	2.3
Russia	-3.9	4.8	0.9	0.5	1.8	2.5	2.3	1.9	1.8	2.1
EU	2.4	1.5	1.2	1.8	1.7	1.8	1.6	1.5	1.5	1.6
UK	2.4	1.6	2.0	2.0	1.5	2.2	2.0	2.0	2.0	2.0
Latin America	11.7	3.6	1.4	6.1	2.4	3.3	3.3	3.2	3.2	3.1
Brazil	2.7	3.7	0.3	2.5	2.3	3.0	3.1	3.0	3.0	2.9
MENA	3.4	4.7	2.1	3.6	3.8	4.2	3.5	3.3	3.2	3.6
SSA	2.2	5.8	3.7	3.9	3.3	4.0	3.8	3.6	3.4	3.6
Non-OECD Asia	7.1	8.0	6.6	7.3	6.1	5.8	4.9	4.2	4.1	5.0
China	10.4	10.5	7.7	9.8	6.2	5.8	4.8	3.7	3.4	4.7
India	5.7	7.5	6.6	6.6	7.6	7.0	5.8	5.5	5.5	6.2
North America	4.4	1.7	2.1	2.8	2.3	2.1	2.0	2.1	2.1	2.1
US	3.4	1.6	2.0	2.4	2.3	2.0	1.9	2.0	2.0	2.0
OECD Asia-Pacific	2.3	1.7	1.7	1.9	1.5	1.6	1.5	1.4	1.4	1.5
Japan	1.4	0.6	1.0	1.0	0.7	1.0	0.9	0.9	0.8	0.9
South Korea	6.9	4.4	2.9	5.0	2.8	2.3	2.2	2.1	1.9	2.2

Source: GECF Secretariat based on data from GECF GGM

Figure 1.5: Projected GDP growth rates (%)



Source: GECF Secretariat based on data from GECF GGM

Developed countries are expected to see stable growth as their populations stabilize, migration flows remain moderate, and technological development sustains labour productivity growth. The only exception is Japan, where migration is limited and an ageing population is expected to slow economic growth. The problems resulting from an increasingly aging population for developed countries is already posing long-term fiscal and aggregate demand challenges. It is currently unclear how these economies will adapt, not least in terms of energy use patterns.

Background uncertainties for medium- and long-term economic development

There are several key uncertainties and risks associated with the medium- and long-term economic outlook worth mentioning while not being considered as drivers for a separate scenario.

First, the increasing number and severity of challenges to regional geopolitical stability in Northeast Asia, the Middle East, South Asia, and Eastern Europe pose a major risk in the medium-term. Geopolitical instability is already expected to depress growth in several key regions, as ongoing conflicts take time to reach a resolution. The potential for new conflicts cannot be ignored, given their impact on global economic perspectives. In the reference case scenario, it is assumed that, in the long-term, these disturbances either subside or remain constant, limiting the impact on global growth trends.

Secondly, aside from the conflicts themselves, there are important uncertainties for long-term global geopolitical and economic architecture, including the global balance of powers. Evidence of a change in strategy by the largest geopolitical actors already includes the surge in defense spending, a growing number of trade disputes and multilateral sanctions worldwide, and a string of intraregional military conflicts. As a part of this trend, it is reasonable to expect an escalation of current multilateral geopolitical competition to continue in the Pacific and the Middle East from 2017 to 2025. While recognizing the importance of the underlying medium-term shifts in power balance, the reference case is built with the assumption that, in the long-term, new global growth architecture will emerge without major disruptions to global growth.

Thirdly, there are significant structural risks to global economic growth as an ageing population has the potential to decrease global economic growth rates. The combined effects of an ageing population, diminishing capital returns and total factor productivity already poses a challenge to global long-term growth over the outlook period. Previously, growth challenges of this scale have been successfully addressed by

decades-long comprehensive structural reforms in key economies which brought about a new global economic growth architecture. While the impediment to global growth will persist, it is assumed that these issues will be successfully addressed by structural reforms that bolster competitiveness through the promotion of infrastructure penetration, technological development, innovation spillovers, and labour productivity improvements.

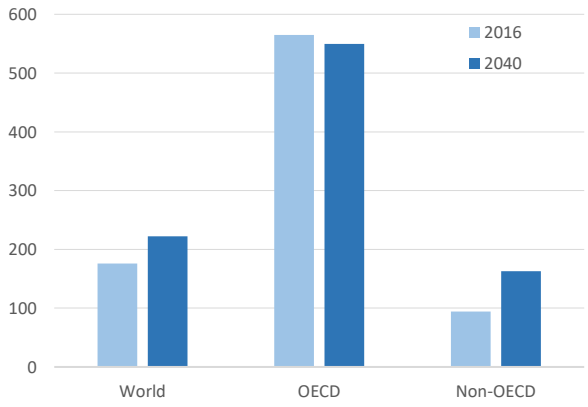
Fourth, we do not foresee low oil price levels as a "New Normal" for either the medium- or long-term. The likely consequence of low prices is that decreased petroleum investment and lower levels of capital accumulation in petroleum production will further increase prices, as future demand growth is not matched by growth in supply. However, as the cost reduction potential of shale extraction technology and competitiveness of US shale oil is still somewhat unclear, depressed oil prices remain a medium-term risk in the Outlook.

Vehicle fleet projections

While the transport sector accounted for just over 8% of global natural gas consumption in 2016, electric vehicles (EVs), compressed natural gas (CNG) vehicles, and liquefied petroleum gas (LPG) vehicles are expected to achieve significant market penetration over the Outlook period, making vehicle fleets a driver for natural gas demand in the long-term.

Global car fleets are significantly influenced by population growth and income per capita. The largest automobile markets worldwide have changed in the 21st century, with vehicle fleets growing much faster in developing countries compared to developed countries. However, developing countries are still markedly behind developed countries in terms of motorisation. This gap is expected to persist in the long-term, as even the fastest growing countries in non-OECD Asian will not reach OECD motorisation levels from the year 2000 (see Figure 1.6). Accordingly, wealthier countries see slower vehicle fleet growth as their markets are saturated in terms of cars per capita.

Figure 1.6: Cars per one thousand people

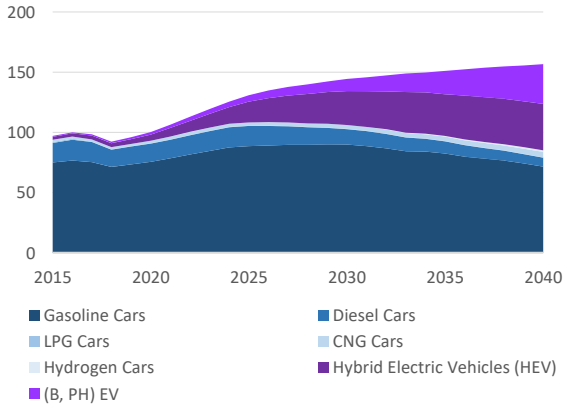


Source: GECF Secretariat based on data from GECF GGM

The automobile industry will be transformed in the long-term, as new technologies and trends disrupt existing transportation markets. Regulatory pressure towards low- or zero-emission vehicles (ZEVs) is generally expected to become the shaping force behind this transformation, compounded by gradually increasing competitiveness of electric powertrains and hybrid cars. This is already reflected in global policy targets, such as the Electric Vehicle Initiative, as well as in the policy priorities of developing countries including India and China. Climate change policies and emission controls in developed countries, including the EU, already mandate the replacement of traditional gasoline- and diesel-powered car fleet in favour of ZEVs.

The share of battery-powered and plug-in hybrid EVs (BEV and PHEV, respectively) is expected to reach 20% of total global sales by 2040 (see Figure 1.7). The prime mover for EV fleet expansion is expected to be the OECD, with over 32% of new car sales coming from electric powertrains as a result of policy pressures.

Figure 1.7: Global car sales by vehicle class (thousand)



Source: GECF Secretariat based on data from GECF GGM

A shift to EVs will be costly, however, as it involves a massive upgrade in existing infrastructure, particularly in developing countries. In addition to the investment costs, further advances are likely to be constrained by

the capacity and cost of available battery technologies. Unless technological innovation picks up, further transition to EVs will not happen over the outlook period.

Due to technological and competitiveness challenges, most of the global EV penetration is expected to come after 2035, with even EV fleets in developed countries being negligible in 2030. By 2040, EVs are expected to amount to 9.2% of global car fleets worldwide and 13% in OECD countries by 2040.

As electric powertrains are increasingly cited as policy priority for developing countries, the momentum to develop CNG and LPG car fleets has slowed. However, despite being out of the policy spotlight, these vehicles are competitive under new emission control regulations, especially in China and India. The global stock of CNG and LPG vehicles is expected to grow by almost threefold, to over 55 million cars by 2040, accounting for around 2.6% of the global car fleet compared to 2.1% in 2016. The market of LNG-powered heavy goods vehicles is also rapidly increasing.

Penetration of autonomous vehicles together with marketplaces for carpooling is expected to impact the vehicle fleet projections after 2030, and will reduce the overall miles travelled and, eventually, the car ownership rate. This is beneficial to consumers as efficiency will increase, driving down prices and improving air quality and longevity, as well as lowering overall energy demand per km driven.

Housing projections

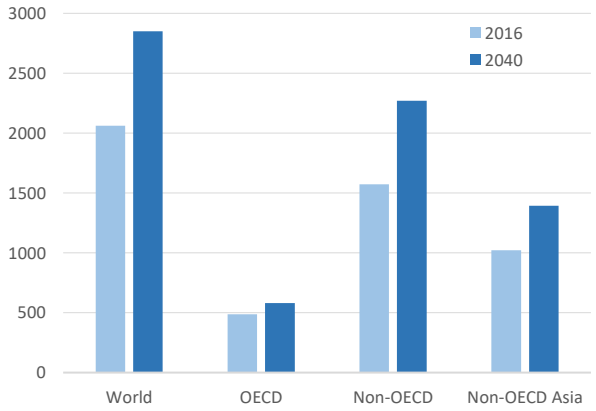
Over 30% of global natural gas is consumed in the domestic sector, and 2/3 of that goes to residential housing. This makes housing trends one of the most important long-term drivers for global natural gas markets.

Through 2017-2040, almost 800 mn new houses will be constructed (see Figure 1.8), 700 mn in non-OECD countries, including 370 mn in non-OECD Asia. Throughout the outlook period, the number of people per household decreases from the current 3.6 to 3.2 persons per household globally by 2040. This reflects the social atomization trend, as economic development is accompanied with an increase in the age of first marriage, the rate of divorce, number of lone parent families, longevity, and a resulting decrease in average family size.

While developing economies sustain vibrant growth rates, so do the rates of new homes being built. The number of new homes is expected to grow annually at an average rate of 1.4%, with growth concentrated in non-OECD Asia and Africa. This growth is very gradual over the forecasting horizon, sustained by the social atomization trend after economic growth drivers in developing countries become less supportive.

New household construction is influenced by GDP per capita, urbanization rate, and trends in the average number of individuals per household. The slowdown in global economic growth, population and urbanization rates means that rates of housing construction are also decreasing in OECD countries. Housing growth in non-OECD countries will be determined by construction trends in Africa, an emerging housing energy consumer.

Figure 1.8: Number of households (millions)



Source: GECF Secretariat based on data from GECF GGM

Energy Prices

The Outlook assumes no structural, game-changing shifts either to demand or to supply trends in the energy markets. Long-term trends such as steady gains in efficiency on the demand side—including increasing vehicle fuel economy—are built into the Outlook.

Natural gas prices will reflect a mix of oil-linked and spot gas prices, with varying influences from the marginal cost of supply. Natural gas prices will slump in the medium-term and recover in the long-term.

Oil prices are expected to be predicated on the same determining factors that shape today's oil prices. In the long term, the marginal cost of supply for oil sands and deep-water offshore will set a ceiling for a price range for oil.

Coal prices will tend to weaken due to reduced demand in China, which will be only partly compensated by demand growth elsewhere. Wider application of carbon taxes and pricing will also put downward pressure on coal demand.

Natural Gas

The structure of the natural gas market over the outlook period is expected to remain largely segmented by geography. Short term price differences between regional markets could be eliminated via LNG shipments; however, this requires price differences of over $5-6/mmBtu, defined by liquefaction, transport and regasification costs, as well as by supply and demand balance. The American, European, Asian and Latin American markets will remain integrated market regions with the most natural gas turnover.

Oil indexation pricing mechanisms were used for at least 49% of imported volumes of natural gas in the global market in 2016, according to an IGU survey (IGU, 2017). Hybrid-priced import volumes are not reported as oil-indexed by IGU, but might, in fact, be largely tied to the oil price. If hybrid volumes are accounted for, oil indexation might influence as much as two-thirds of the volumes that are delivered on long-term contracts. The effort to create hubs in various regional markets, including Europe, has so far only made progress for spot and short-term deliveries. Not enough momentum has been accumulated for hub pricing to account for the majority of long-term gas exports to Europe. With more regulatory pressure, hub-indexed pricing is expected to expand, further increasing natural gas price volatility.

In Asian markets, there is no integrated trading network or single regulator, making hub creation less feasible for the outlook period, unless significant investment is undertaken into market infrastructure to support liquidity in candidate hubs and price assessments, such as Japan Korea Marker. Even in this case, liquidity requirements to support long-term import arrangements appear to be too high. Consequently, the majority of natural gas export volumes traded are expected to remain in long-term contracts and outside the hubs.

While all volumes exported from the US are priced through the gas-to-gas competition mechanism in the Henry Hub quotation, volumes on Asian and Latin American import markets are largely oil- and quasi-oil indexed. An IGU survey (IGU, 2017) puts oil-indexed shares of natural gas at 88% of Asian and 68% of Latin American imports. This difference in dominant pricing mechanisms between integrated market regions is expected to persist over the outlook period. Most of the volumes imported into the European market are currently priced with hybrid mechanisms, including oil indexation and hub indexing, although the influence of each is unclear. Most changes to European pricing were introduced after the regulatory pressure which violated existing contracts. Unless more regulation is enforced, the current pricing structure is expected to remain.

Notwithstanding the pricing structures described above, prices will define the role of natural gas in the global energy mix. This will be compounded by competition from other energy sources across the main consuming sectors, distributed across regional markets. This multidimensional competition will determine the price range of natural gas.

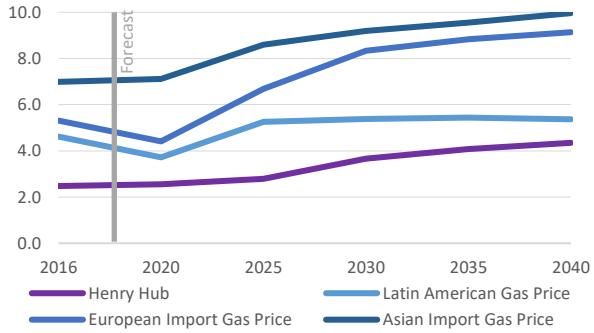
After the sharp fall in 2014-2015, natural gas prices rebounded and have been growing strongly for the last two years, with the growth rate from January to October 2017 totalling 25% across the main global markets. This is compounded by three factors: coal to gas switching in the US, the UK, China and India ahead of schedule; stabilization and subsequent rebound in oil prices in 2016-2017; and proactive GHG mitigation policies in European countries that drove up gas-fired electricity demand.

In 2017-2018, part of this growth is expected to be offset by the following factors: new LNG capacities coming online (up to 65 MTPA globally); a decrease in Japanese demand after a partial restart of nuclear capacities; correction of energy demand imbalances in China; and indigenous production growth in several niche markets.

While the LNG market remains under pressure from projects that were planned when oil prices were twice as high, it has been announced that a significant portion of those projects on stages before final investment decision will be cancelled or postponed indefinitely. Consequently, in the medium-term, new US LNG projects are unlikely to fulfil both the US and global demand growth. In the near future, supply from projects with a higher cost base than that of the US will be required, including indigenous production and greenfield projects in Russia, East Africa and Australia.

This supports our projection that the natural gas market is expected to rebalance within two or three years, and will exhibit a slow but steady upward price trend for all regional markets from 2020 to 2025 (see Figure 1.9). For the long-term, increased pressure from global energy transitions and power mix substitutions, along with the increasing long-run marginal cost of new projects, are expected to significantly drive up prices in every region except Latin America. Given current trends, Latin America is expected to experience growth in indigenous natural gas production and to take more US LNG supplies.

Figure 1.9: Natural gas price (2016$ per mmBtu)



Source: GECF Secretariat based on data from GECF GGM

Crude oil

The Brent oil price plays a pivotal role in the determination of energy prices, with natural gas markets still being largely influenced by oil-indexed contracts. The Brent price also plays an important role in the calculation of other prices, such as other crudes (WTI, Dubai, Ural, etc.), oil products based on differentials, and regional average product worth.

There are four main assumptions that lay the foundations of the GECF's long-term oil price projections:

- geopolitical tensions are not expected to be a major driver over the long-term, though they may induce significant price volatility in the short-term;
- OPEC is expected to, once again, emerge as a swing producer in the long-term, as production potential of shale deposits in North America is expected to be limited following robust demand growth in the medium-term;
- the cost of producing the most expensive (marginal) barrel is the defining component for oil price projections. It is expected to increase in the long-term, as new demand facilitates projects higher up the cost curve faster than technological development pushes the cost curve down;
- car fleets will predominantly run on internal combustion engines through to 2035, after that

oil demand from the transport sector is expected to flatten out.

The GECF expects oil prices in 2018-2019 to remain weak due to resilient non-OPEC output. A coalition of selected non-OPEC countries led by Russia together with OPEC is expected to maintain supply restraint while spearheading market rebalancing around 2020. By that time, growing demand from developing countries is expected to outpace US shale oil production and reinstate OPEC to the swing producer role.

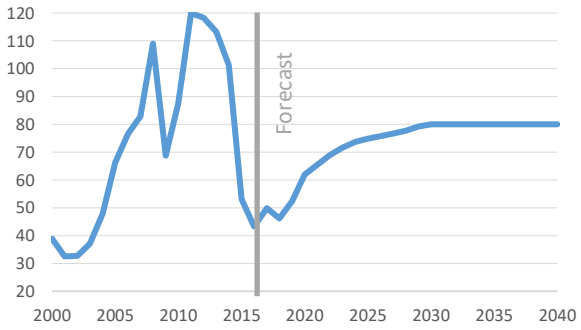
In the wake of the oil price slump of 2014-2016, there has been general deflation of materials' cost, and efficiency and design improvements have brought production costs down. This will be reflected in breakeven prices for new projects in the medium- to long-term. The deflationary elements will unwind in the next few years amid increase in oil demand. Declining production rates from existing fields mean that new fields will also be required. Along with the accumulated investment gap, this points to continued oil price recovery from 2025 to 2030.

Innovations in mobility, such as electric and autonomous vehicles, and ride-sharing, are expected to lead to a gradual flattening of oil demand from the transport sector in the long-term. However, given current prospects for powertrain competition and the motorisation rate gap between developed and developing countries, it is highly unlikely that the structure of global car fleets will change and cause oil demand to peak before 2040.

Geopolitical changes, especially in certain oil-producing regions, have always been an important component of oil price dynamics. However, direct contributions from geopolitical tensions to long-term trends were considered negligible. While geopolitical tensions are expected to contribute to short-term price volatility, their trend influence is expected to be limited.

Over the medium- to long-term, Brent prices will converge to $80 per barrel in constant (2016) dollars (see Figure 1.10), reflecting the long-run marginal cost of supply. This reflects the rising cost of supply needed to meet growing demand— meaning that the expected long-term growth in the global economy would sustain these new levels. Given long-term extraction technology improvements, these price levels will support the most expensive sources of production, such as Canadian oil sands, Venezuelan heavy crude, and offshore deep-water African projects. Capital-intensive bitumen mining projects (without upgrades) in the Canadian oil sands are currently considered the most expensive.

Figure 1.10: Brent oil price (2016$ per barrel)



Source: GECF Secretariat based on data from GECF GGM

Coal

Despite the strong narrative to reduce carbon emissions, coal will remain a key component in global electricity generation over the outlook period. However, significant growth in renewables and gas-fired capacity will reduce the share of coal in the global energy mix. Coal prices are expected to remain one of the key drivers of gas price formation.

A prolonged period of price increase during the 2000s spurred growth in investment and supply, allowing thermal coal prices to peak in 2011 after the market became oversupplied. Prices bottomed out in 2015 as the Chinese government started its annual phase-out of older coal mine capacity, with a goal to replace 800 MT of inefficient coal capacity with 500 MT of advanced coal capacity by 2020. In 2012-2016, domestic coal output in China went down about 1%, while consumption decreased by 1.5%. This brought the share of coal in primary energy consumption to 62% in 2016, down from 67% in 2012. This share is projected to drop to 58% under the government's 13th Five Year Plan (FYP).

The supply overhang was liquidated so aggressively that China became the largest importer of coal in 2016, bringing in 228 MT. As its domestic power balance still

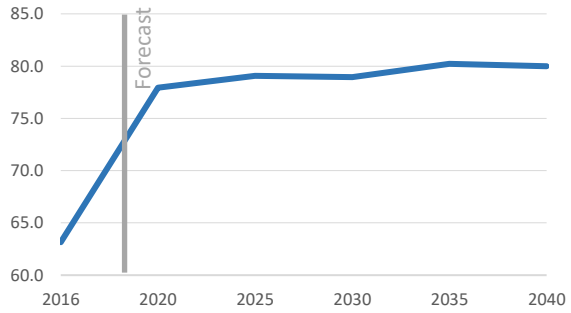
requires coal, China is poised to remain the largest coal importer in 2017-2018, on par with India. Unless thermal coal prices rise even more strongly, administrative measures, such as port terminal shutdowns, will be unable to curb coal consumption.

Capacity elimination in China left coal markets prone to external volatility in 2016-2017. As a result, prices spiked strongly starting from the second half of 2016 (see Figure 1.11), promoting massive coal-to-gas switching in several key markets. As 2016 strikes disrupted thermal coal supply in India and 2017 weather conditions disrupted thermal coal supply in Australia, the market reacted strongly, clearing at 5-year record prices. Given the current energy policy profile, new coal projects are very likely to run into hurdles both in licencing regulation and financing, as global financial institutions increasingly pledge to implement greener financing priorities.

In the medium-term, the market is expected to rebalance as Chinese policies already have coal consumption peaked, and India is to remain price-sensitive, switching to LNG-fired generation as coal price rises. More European countries are expected to follow the example of the UK which has almost phased out coal generation in favour of natural gas, especially if the new US energy export strategy favours LNG instead of coal. Coal use in the US is expected to decline another 25% by 2025, as numerous regions and municipalities continue to follow climate change policies initiated under the previous administration.

The long-term outlook for coal prices depends not only on supply factors but also and most importantly on the implementation of government policies, including Chinese policies to reduce demand and the fuel profile off new generation capacity.

Figure 1.11: Thermal coal price* (2016$ per tonne)



*average of Richards Bay, ARA and Newcastle prices
Source: GECF Secretariat based on data from GECF GGM

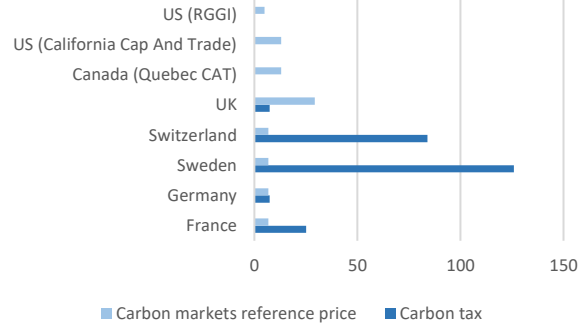
In this Outlook, it is assumed that the measures to protect the Chinese market from an inflow of cheap coal will continue to be successful. It is expected that coal overcapacity will return in the medium-term, as developing countries' infrastructure unites Asian coal markets, such as the Indian and ASEAN markets, and that there will be no further significant upside price drivers. Long-term real prices will trend slightly higher than today, as overcapacity will cap further price increases post-2020, with the exception of a certain degree of real mining cost inflation. In the Outlook, coal prices average slightly lower than $80/t (FOB Richards Bay) throughout the outlook period.

Carbon

Carbon can be priced in various ways, including carbon taxes, price references from emissions trading systems (CO_2 markets), or a combination of both. The recent evolution of carbon prices showed that in many countries where these prices have been applied, price levels remain relatively low. It is estimated that around three quarters of carbon emissions are priced below $10/t$CO_2$.

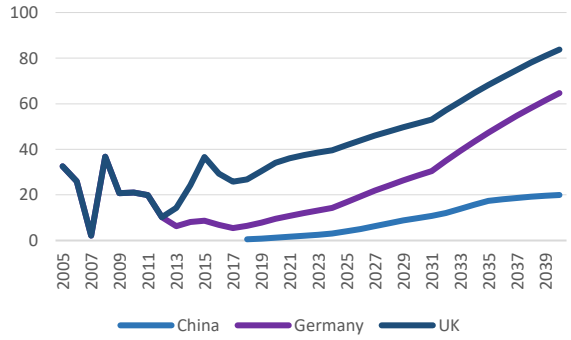
However, some countries have recently increased carbon taxes. Sweden and Switzerland implemented the highest carbon taxes in the world in 2016, with $130/t$CO_2$ and $85/t$CO_2$, respectively (see Figure 1.12). France has also applied a carbon tax, estimated at around $25/t$CO_2$. In Europe, carbon taxes are mainly applied to the sectors not covered by the emissions trading system (ETS), transport in particular.

Figure 1.12: 2016 carbon prices: taxes vs reference prices from carbon markets ($/t$CO_2$)



Source: GECF Secretariat based on data from GECF GGM

Figure 1.13: Carbon ETS reference price forecasts ($/tCO2)



Source: GECF Secretariat based on data from GECF GGM

Carbon market price references are at relatively low levels in Europe, reaching around \$6.8/tCO_2 on average in 2016 (price references from the EU ETS). The UK is the exception, where a carbon price floor has been applied, adding a carbon price support (CPS) to the EU ETS reference price. (The carbon floor is estimated at around 29.3 \$/tCO_2.)

In the US and Canada, the carbon price reached around \$13 /tCO_2 based on reference prices set in the California and Quebec linked ETS. The price is lower for the RGGI (Regional Greenhouse Gas Initiative) carbon market involving eastern American states, amounting to \$5/tCO_2 on average in 2016, which is mainly due to an excess of emission credits in this eastern carbon market.

The following chart illustrates the prospects of carbon price references from ETS in Europe and China, the most important carbon markets in the world. For China, the projection is for the national carbon market, which is expected to start in 2018 (see Figure 1.13).

There is a divergence between the UK carbon price floor and the EU ETS reference prices used by Germany, reflecting the UK policy to apply higher carbon prices. UK prices decreased in 2016 due to the fall in the EU ETS prices, the depreciation of the UK Pound against the Euro, as well as the freeze of Carbon Price Support decided by the government to limit competitive disadvantages for UK businesses (Ares et al., 2016).

The UK carbon price is, however, forecasted to remain connected to EU ETS reference prices even after Brexit, and this is in line with the UK's willingness to reduce its carbon footprint and to consider market-based signals in doing that. The UK price is expected to reach around \$50/tCO_2 in 2030, and more than \$80/tCO_2 in 2040.

Despite the challenges faced by the EU ETS to support the development of higher carbon prices, this Outlook forecasts an important increase which will result from significant reductions of CO_2 emissions allowances, driven by the implementation of Phase IV reforms for the post-2020 period (see Chapter 2).

The Chinese ETS is expected to deliver low carbon price references at the initial stages of its development and the prices are forecasted to exceed \$10/tCO_2 only after 2030. This market is facing many challenges to deliver pertinent prices which will efficiently mitigate CO_2 emissions (See Chapter 2).

CHAPTER 2: POST-PARIS AGREEMENT POLICY DEVELOPMENTS

Key assumptions and findings:

- The Paris Agreement has emerged as an important driver of energy market development. However, implementation of the Agreement and of related GHG mitigation policies remains a big uncertainty.
- Renewable policies will continue to be a mixture of direct government intervention and market-based support schemes; the latter are expected to develop particularly where large-scale penetration of renewables has been achieved (e.g. the EU and China).
- Integrating large shares of renewables is emerging as one of the major issues for the future prospects of renewables in power generation, with an increasing need to achieve power system flexibility. Natural gas will play an important role in providing this flexibility.
- Policy support for gas infrastructure development, network integration, and upstream projects is assumed to play a key role in driving progress of gas in primary energy mixes. However, gas is still facing challenges and lack of policy visibility, which will affect its development potential.
- Restricting the use of coal for environmental reasons is assumed to be the policy orientation in many countries, especially in the EU and China. However, it is anticipated that a number of European countries, as well as India and Southeast Asian countries, will continue to rely heavily on coal, although policies to increase the efficiency of its use will be implemented.
- Enforcement of mandatory efficiency standards in many sectors, in addition to price signals and deployment of smart technologies, will play key roles in improving energy efficiency. The structural economic shift in some key emerging countries is also expected to drive the reduction of energy and carbon intensities.
- Carbon pricing via ETS will continue to experience challenges in developing market-relevant prices for carbon. However, we anticipate efforts being made to address these challenges in some key regions. This Outlook assumes that proposed reform of the EU ETS will reduce excess emissions' allowances, leading to a tightening of the market with upward pressure on carbon prices.

The Paris Agreement and GHG mitigation policies: the implementation challenge

Policies aimed at mitigating GHG emissions have emerged as key drivers of energy market development after the adoption of the Paris Agreement. The Agreement was signed by more than 190 countries in December 2015 and entered into force one year later, following its ratification by more than 55 Parties (54 countries, plus the EU) that represent more than 55% of global GHG emissions. By September 2017, 169 parties had ratified the Agreement, accounting for the majority of global GHG emissions.

In the framework of the Agreement, countries pledge to reduce GHGs through the submission of Nationally Determined Contributions (NDCs) and commit to climate change mitigation actions that mainly target CO_2 emissions from energy-related activities. However, many uncertainties remain regarding the implementation of these commitments and their contribution to low carbon economies.

Political uncertainty is one of the major challenges for GHG mitigation and implementation of the Agreement,

especially with the announcement of US withdrawal from the Agreement. The extent to which this decision will affect global climate change efforts is still unclear, but the leading role the US held under the Obama administration is clearly weakening. Political developments in other regions, particularly Europe and, specifically, the UK, are also driving political uncertainty that could affect climate commitments set in the framework of EU policies.

Another big challenge relates to the level of implementation and efficiency of policy measures in supporting NDCs objectives and pledges, particularly for developing countries. We can distinguish between two categories of instruments affecting the implementation of GHG mitigation policies in accordance with the cooperation mechanisms and procedures proposed by the Agreement, and national policy measures and initiatives that aim to support individual countries' NDCs (see Box 1).

A key measure in achieving GHG mitigation commitments is to strengthen the role of natural gas in the energy transition. However, this role is not highlighted clearly in policy orientations set in most countries' NDCs. It is estimated that around 20 countries have cited natural gas as part of their decarbonisation strategies (Stern, 2017), and natural gas is still not recognized by policymakers as a key contributor to CO_2 mitigation, or to the transition to low-carbon economies. Barriers to natural gas development need to be well understood by gas exporting countries, in order to introduce appropriate solutions and promote constructive dialogue between producers and consumers.

Box 1: Drivers and instruments affecting the implementation of the Paris Agreement

Cooperation mechanisms proposed by the Paris Agreement aim to improve the ability of countries to implement their NDC commitments. Among these mechanisms are: i) mobilization of finance, particularly for the least developed countries; ii) supporting technology and knowledge transfer; iii) supporting capacity building in developing countries, in particular through the improvement of institutional capacities and the ability of countries to take effective action in addressing climate change; iv) supporting continued efforts to enhance GHG mitigation targets; and v) supporting transparency frameworks, especially by establishing common principles in tracking and reporting emissions, as well as the undertaking of climate change actions.

Many details need to be further elaborated on the proposed cooperation mechanisms and procedures, in order to make them more operational and improve their applicability for different countries featured in the Agreement. The COP 22 in Morocco evaluated the various mechanisms detailed in the Agreement, and identified actions and initiatives that lead to the best improvement. The conference has set a 2018 deadline to deliver a detailed operational framework (Agreement rulebook) and clarification of its main procedures. Furthermore, COP 22 highlighted the challenges that exist, specifically finance mechanisms, transparency frameworks, capacity building and technology transfer.

The COP 23 in Bonn held on November 2017 was expected to make real progress regarding the main Agreement cooperation mechanisms. However, the conference outcomes highlighted the need to step up efforts and to make additional negotiating sessions and assessments in order to overcome the challenges and emerging difficulties that hinder the progress in the implementation of these cooperation mechanisms. Particularly, the COP 23 recognized that efforts should be accelerated in delivering the Agreement rulebook, and in supporting the mobilization of finance (UNFCCC, 2017).

One of the key Agreement mechanisms which is experiencing a high level of uncertainty is the mobilisation of finance, in order to support investments required to meet NDC mitigation pledges. The IPCC estimates that, through 2030, $13 tn in investments are needed to stabilize GHGs (around $1 tn annually). Mobilising finance for developing markets and vulnerable populations remains an important challenge. Developed countries have pledged to provide $100 bn to support developing countries in executing climate actions by 2020 and to maintain this effort up to 2025. However, actual financial flows are far below this pledge.

One of the key financing mechanisms under the UNFCCC is the Green Climate Fund (Article 15 of the Agreement). The contribution of this fund is limited compared to its ambitions (only 35 projects received funding in 2016, totalling $1.5 bn) (CFAS, 2017). In addition, there are uncertainties regarding pledged financial contributions. For instance, President Trump has announced that the United States will not fulfil its pledges of $3 bn.

National policy measures and initiatives to support NDC commitments are key determinants in achieving GHG emissions reductions. The review of countries' NDCs provides some indication about proposed policy directions which aim to mitigate GHG emissions, such as: switching to less carbon-intensive energy sources, promoting carbon-free sources, and supporting demand rationalization or carbon capture and removal options. Despite these proposals, uncertainties remain regarding their implementation and also the expected outcomes of these policies. These uncertainties drive our assumptions in the reference case scenario.

Another important aspect of countries' climate change commitments is related to the updating process. The Agreement obligates Parties to regularly revise NDCs every five years, with upward ambition (Article 4.3). This means improving NDC mitigation targets and the policies supporting these targets.

The Agreement also established a "Global Stocktake" mechanism, which aims to assess collective progress toward NDCs targets every five years, starting in 2023. However, the Agreement also considers a preliminary progress assessment by 2018, before the submission of the first updated NDCs in 2020. Enhancing NDC targets could be a key driver in mitigating GHGs over the long term, but effective implementation remains a serious challenge for many countries.

Implementation of carbon mitigation policies: recent developments in key CO_2 emitting markets

This section examines recent developments in GHG mitigation policies in the largest energy consuming and CO_2 emitting markets, namely: the United States, China, India and the European Union. Together, these markets represent nearly 60% of global energy-related CO_2 emissions.

US

Repealing the Clean Power Plan: the Trump administration dismantles Obama's key climate policy

The Trump administration has taken many actions to dismantle environmental policies established by his predecessor, under the pretence of economic development and job creation. Among these actions is the Executive Order on Energy Independence, which calls for repeal of the Clean Power Plan (CPP), a historic initiative by the Obama administration to reduce carbon pollution and reach emissions targets.

The CPP mainly defines emissions standards for power plants, aiming to cut emissions by 32% by 2030 relative to 2005 levels (WH Press Office, 2015). The CPP has been challenged by Congress and many American states, and its enforcement has been halted by the Supreme Court. The Trump administration has requested the suspension of the court case and has asked the EPA to consider a new version.

Other measures have been proposed to weaken regulations on coal, methane emissions and energy performance standards

Trump's executive order, signed March 28, 2017, asked to review the carbon standards for new coal plants, to lift the barriers on federal coal leasing, and to reconsider methane emissions standards from oil and gas activities.

Initiatives have been announced by the Trump administration to review and weaken energy performance standards, such as Obama's fuel economy standards for cars and light trucks in the post-2022 period.

The Trump administration has also proposed deep budget cuts to key government agencies responsible for environmental and energy efficiency programs, mainly

those supervised by the Environmental Protection Agency (EPA) and by the Department of Energy (e.g. the ENERGY STAR® program). Despite that these budget proposals are being challenged by Congress, they highlight the willingness of the current administration to minimize government involvement in domestic environmental policy.

Trump's proposed tax reductions would not support renewables

The Trump administration has proposed corporate tax reductions, which could affect the development of clean and renewable projects that benefit from federal tax credits. These tax credits are used by developers as financing mechanisms and are sold in the form of tax equities to companies (especially banks and insurance companies), which can apply for credits and benefit from tax exemptions. Tax equity to finance clean projects can therefore be affected because of fewer incentives to buy tax credits after corporate tax reduction.

Opposition to Trump's proposed regulation and measures brings large uncertainties regarding their enforcement and effects

Many of the Trump administration's proposed regulations and initiatives to weaken environmental commitments are facing a high level of opposition from states, municipalities, American society and environmental groups.

For instance, state governments in California, New York, and Washington have initiated the United States Climate Alliance just after Trump's announcement to withdraw from the Paris Agreement. The Climate Alliance aims to pursue GHG mitigation efforts in line with the Agreement objectives and includes fourteen states with both Democratic and Republican governors (Climate Alliance, 2017).

Moreover, some of the proposed regulations have been objected to and even blocked by the courts. A case in point is the Obama administration's ruling to restrict methane emissions from oil and gas fields. The EPA had imposed a moratorium on the implementation of this rule, but following a lawsuit brought by environmental groups, a federal appeals court ruled against the EPA suspension, stating that the Agency does not have authority to block this rule.

The legal process to enforce many of the regulations and amendments proposed by Trump could be challenging and time consuming, and could even lead to rejection of the proposed measures. In this context, the forces opposing the Trump administration's policy, which include the position of certain states and legal challenges, have resulted in a high degree of uncertainty over the implementation of this policy, as well as its ultimate impact on the climate and environmental agenda in the US.

China

Ambitious 13th FYP to support climate commitments and sustainability

China's 13th FYP (2016 -2021) makes important efforts to restructure the Chinese economy by targeting reductions in energy intensity, fostering a transition towards a service-based economy, developing renewable technologies and reducing pollution.

Mitigating climate change is central to the Chinese energy plan, which has set ambitious targets to reduce GHG emissions. Enforcement is a key feature, as many of these targets are binding in the FYP and subsequent planning reports released in January 2017.

The primary binding targets to be achieved by 2020 are related to increasing the share of non-fossil fuels in the country's energy mix from 12% in 2015 to 15%; reducing the share of coal in the primary energy mix from 64% in 2015 to 58%; capping the consumption of coal to 4.1 billion tonnes; and reducing energy intensity by 15% and carbon emissions by 18% relative to 2015 levels.

Controlling coal consumption is considered pivotal to achieving these ambitious goals, which will simultaneously allow policymakers to reduce local pollution and achieve public health benefits. China has imposed limitations on coal use in power generation and in other sectors, such as industry and buildings.

The cap on coal consumption has focused on large metropolitan areas, such as Beijing, where the last urban coal-fired power plant, "Huaneng", was closed in March 2017. The Chinese government has shut down many existing coal-fired plants and halted construction of more than 100 new stations at the beginning of this year.

The country has also considered retiring existing coal mines and has frozen approval of new mining projects in many provinces, in order to reduce coal market overcapacity. According to the 13th FYP, the Chinese government expects to shut down around 800 MT of coal mining capacity between 2016 and 2020.

Costly renewable policy encourages China to reduce subsidies and to look for enhancing market-based support schemes

Renewables in China have achieved huge progress in recent years, and policy support has been key in achieving this, in addition to large cost reductions for solar and wind. China's 13th energy plan has set more ambitious targets for renewables, increasing the share of solar, wind and hydro by more than 50 gigawatts (GW) compared to the previous energy plan. (The new 2020 target is to reach more than 700 GW with solar, wind, and hydropower.)

The main renewables support schemes implemented in China are based on subsidies, particularly in the form of tax credits and feed-in tariffs (FITs). However, China is looking to adjust its policy support in order to reduce subsidy costs, achieve more efficiency in supporting renewables and to allow better integration of renewables in Chinese power systems. The country has recently considered cuts in subsidies for large-scale solar and onshore wind projects, in a move to reduce the costs of these subsidies and to reflect the decreasing cost trends of solar and wind.

Gas is promoted as an important option to reduce pollution and carbon intensity, but challenges remain in developing domestic production

To reduce air pollution and carbon emissions, natural gas is supported in China's FYP, especially by encouraging infrastructure development, upstream projects and gas markets reforms. For the latter, China is undertaking gas price reforms aimed at incentivising gas players to develop projects which support domestic production. The country is also considering opening the gas sector to improve competition and efficiency. China has posted targets for natural gas to reach 10% of the energy mix by 2020 and 15% by 2030.

The rigorous environmental regulations and strong enforcement policies outlined in China's FYP are key drivers of gas penetration in the power generation sector, as well as buildings and transportation.

However, despite government support, the gas sector is facing challenges and uncertainties, mainly related to the development of domestic unconventional gas supply. Tellingly, the Chinese government has considered a downward revision of targeted production of shale gas to 30 bcm (the previous target was more than 60 bcm).

India

Government scaled up efforts to support renewables, solar in particular

Promoting renewable energy is a main strategic focus for India, in support of its NDC pledges. India aims to lower the emissions intensity of GDP by 33-35%, relative to 2005 levels, and to increase the share of non-fossil fuel based power generation capacity to 40% of installed capacity by 2030.

Solar is of particular importance, supported by the National Solar Mission. India's solar target has been scaled up five-fold under the Modi Ministry, from previous 20 GW objective to 100 GW by 2022. India is also leading the International Solar Alliance, whose main objective is to promote the development of solar projects and the improvement of solar-based technologies.

Renewable energy is encouraged by a set of policies and initiatives, specifically energy sector reforms that aim to reduce energy price subsidies (which could make renewable projects more attractive and competitive, especially compared to oil products), and improved accessibility to power grids. India is also implementing renewable support schemes, such as renewable purchase obligations, renewable certificates trading, and fiscal incentives for renewable projects (particularly through revenues earned from coal taxation). It is also undertaking a program to increase access to energy in rural areas, especially by supporting the development of distributed renewable energy - an option which reduces power transmission and distribution constraints.

Measures have been adopted to incentivize the use of efficient coal-based technologies to reduce air pollution

The Indian government is making efforts to reduce emissions from coal by introducing a mandate supporting more efficient coal-based technologies in

the power generation and industrial sectors. Moreover, strengthened emissions standards were announced in 2015 targeting coal power plants— aimed at improving air quality.

Natural gas is encouraged by ambitious gas penetration targets and subsidies

India strongly supports the penetration of natural gas, with an ambitious announced target to increase the share of gas in its primary energy mix to 15% in the medium term. The government is focusing its effort on polluted urban areas and is targeting particularly power generation, industry and transportation sectors.

For power generation, India has already adopted a temporary subsidy scheme for natural gas-fired power plants, in order to improve utilization rates of the plants that have experienced difficulties resulting from affordability issues. The extension of this scheme is still a matter of debate in India, despite a recent proposal by the government to consider subsidies as a policy lever for improved gas penetration.

The Central Electricity Authority (CEA) forecasts less reliance on coal over the long-term, but this looks optimistic

In December 2016, the CEA issued a draft plan (CEA, 2016), highlighting no additional need for coal power plants beyond the current capacities under construction (around 50 GW) until at least 2027. This forecast seems to be optimistic, since it will depend on the progress of alternative sources (renewables, nuclear and natural gas) targeted by the Indian government, which face many uncertainties and challenges, especially the funding of large necessary investments and the improvement of domestic energy pricing mechanisms.

The European Union

Proposal of New Clean Energy Package to support ambitious climate policy

The European Union has aggressive plans to reduce carbon emissions. By 2030, the EU plans to reduce CO_2 emissions by 40% relative to 1990 levels, increase the penetration of renewables to at least 27% of gross final energy consumption, and reduce energy demand by at least 27% compared to a 'business as usual' scenario.

The European Commission (EC) proposed the 'Clean Energy for all Europeans' package (CEP) on 30 November 2016. It includes regulation proposals to support decarbonisation, enhance the integration and functionality of energy markets, and to improve governance and cooperation in line with Energy Union priorities (EC, 2016(1)).

The CEP places particular importance on energy efficiency through a proposal to revise the Directive on Energy Efficiency. This revision will increase previous efficiency targets to 30% by 2030 and will require energy suppliers and distributors to achieve 1.5% of energy savings every year from 2020 to 2030. The EC strongly targets the building sector, which accounts for 40% of Europe's energy consumption and offers important energy savings potential. The CEP proposes to accelerate building renovations and launch the new Smart Finance for Smart Building initiative, aiming to promote investments and use of smart technologies in management and rationalisation of energy demand.

EC proposes to review the Renewable Energy Directive; electricity market design, targeting the achievement of more efficiency in support schemes for renewables

The EC has also proposed a review of the Renewable Energy Directive and Regulation No 714/2009 on electricity market design. These actions aim to: achieve more market-oriented and cost-effective renewable support schemes; promote market price-signals for investments in renewable capacities (rather than subsidy-signals), and improve the integration of renewables in a way that ensures stability and reliability of power systems.

In this context, the EC proposed the following initiatives (EC, 2016(2)):

- Facilitate the development of a power market design which fits renewable energies.
- Promote cooperation and an EU-wide approach for renewables.
- Promotion of trading across borders and the removal of barriers for new market entrants.

The CEP also focuses on renewables in the heating, cooling and transportation sectors. The EC has set a target to increase the share of renewable energy in cooling and heating services by 1% per annum through to 2030. In the transport sector, fuel suppliers will now

be obligated to increase the share of renewables in their fuel supplies to 1.5% by 2021 and 6.8 % by 2030.

Measures have been announced to reduce the role of coal; disparities exist between European countries

Many European countries have also made individual commitments to limit their coal use. Certain EU Member States (e.g. Belgium) have eliminated coal from their power sectors, while others have announced targets to phase out coal (e.g. France by 2023, the UK by 2025 and Portugal by 2030).

The EC is also considering the phasing out of inefficient fossil fuel subsidies, particularly those attributed to coal. A study estimated that coal subsidies in 10 European countries that produce 84% of Europe's energy-related greenhouse gas emissions total around €6.3 bn (on average from 2005 to 2016). Germany accounts for the largest coal subsidies— around half of the European average— €2 bn of which are allocated for coal mining. (Whitley et al., 2017)

Recently implemented coal subsidies come in the form of capacity payments for coal-fired generators, introduced by some European countries to keep reserve capacities, especially for backing up intermittent renewables. The EC has proposed a CO_2 emissions limit (550 g/kWh) on power plants benefiting from these capacity mechanisms.

The EC is also considering the tightening of pollutant emissions from large combustion plants and industries through the Industrial Emissions Directive (IED) (EC, 2010), which sets limits on emissions, especially from NOx and SOx. These emissions standards were updated in 2017, based on the Best Available Techniques reference documents (BREFs), and referred to in the IED. The EC requires that these new standards should be met within four years (by 2021).

Some European countries still do not have a clear policy to reduce pollution from coal. Greece and Poland are still building new coal power plants, while Poland and some Eastern European countries are challenging the CEP and considering coal an important option for energy security. Furthermore, the phase-out timeline has been met with resistance by some countries, for example, Germany.

EU gas policy brings large uncertainties for gas suppliers and prevents gas from playing a key role in decarbonisation

The European Commission has been focusing on developing internal and competitive gas markets, through: the implementation of the Third Energy Package, which sets market rules and network codes for supplying natural gas; and the challenging of traditional long-term indexed contracts, which have provided visibility on gas revenues for investors and developers of gas-intensive supply chains.

This policy has introduced many uncertainties, since the final configuration of European gas markets remains unclear, especially with continuing changes in market rules and design, as well as dominance of national policies and priorities in Europe. Additionally, the existence of illiquid hubs cannot be a reliable alternative in pricing gas volumes and capacities in many European zones. Some network codes, like capacity allocation mechanisms, are posing challenges on transit routes and supply costs. Furthermore, gas suppliers are facing regulatory constraints in infrastructure investments and downstream development.

Main policy assumptions

This Section presents the main assumptions adopted in the Outlook regarding the development of post-Paris Agreement policies. We consider the aforementioned developments affecting climate change mitigation policies in the key countries. We also highlight a global view and refer to countries, other than those mentioned above, in terms of recent and expected policy developments. Policy drivers and assumptions are presented in various domains, including renewable and non-renewable energy, energy efficiency, carbon pricing, and support to electrification.

Renewable energy policies

Renewable policies on a global scale

In this Outlook, we assume that renewable policies continue to be a combination of direct government

support and other market-based mechanisms, driven by countries' renewable targets and commitments.

Many countries have proposed ambitious renewables targets, particularly in power generation. In order to encourage renewable deployment, several mechanisms and support schemes have been developed, including price based schemes (e.g. FITs); quantity based schemes (e.g. renewables obligations and standards); and fiscal and financial incentives. Some of these are based on direct government regulation, while others are more market-based (Yang et al., 2017). Table 2.1 presents a summary of the main support schemes available for renewable energies.

Table 2.1: Support schemes and incentives for renewables

	Price based schemes	Quantity based schemes	General
Support schemes based on regulation & government intervention	FITs; Reduced tariffs for power network access	Renewable Capacity Obligations. Power Purchase Agreements	
Support schemes based on market mechanisms	Feed-in premiums; contracts for difference	Renewable portfolio standards with renewables certificates trading. Renewable auctioning	
Fiscal and financial incentives			Privileged fiscal regimes. Privileged financing conditions for renewable projects

Source: GECF Secretariat, Yang et al., 2017

Several countries are looking to introduce and strengthen market-based mechanisms, and to improve the design of electricity markets to better integrate renewables and incentivise capacity investments and power system flexibility. The effect of these market-oriented schemes on renewable development remains uncertain, however, since they introduce more risks for developers.

There is an increasing concern about the efficiency and effectiveness of these support schemes, especially increased subsidy costs, strained funding capabilities, affordability issues for end users, maturation of renewable potential in some markets, as well as the challenges associated with integrating renewables into power grids. The latter is emerging as one of the major issues for the prospects of renewables in power generation since it requires power systems to be more flexible in order to balance renewable intermittency. Natural gas can play an important role in providing this flexibility.

Auctions for renewable capacities have been used extensively recently as a market-based instrument to develop renewable capacities and to ascertain prices. These auctions have increased competition between renewable players and led to significant price drops in many regions, especially in the MENA region (the UAE and Morocco) and Latin America (Brazil and Mexico). However, there is an important challenge with regards to the profitability of renewable projects under low auction prices, and this poses an important risk to developers.

In this Outlook, market-based renewable support schemes will advance in countries which have already achieved large variable renewable penetration, particularly developed countries, like those in the EU, and emerging economies like China. Many other nations will experience difficulties boosting renewable capacities and meeting their announced targets, especially those with funding constraints, rigid power systems and competition from conventional energy sources (coal for India and other Southeast Asian countries; natural gas for MENA countries).

Policy support for renewables is particularly oriented towards the power sector. Some policy measures are being implemented to incentivise renewables in other sectors, especially in transportation, cooling and heating. These include blending mandates for biofuels in the transport sector in countries like China, India, Brazil and the United States. There are also policy measures to support solar for heating (in some MENA countries) or to support biomass in district heating, particularly in Japan, and in the EU. The proposed revision of the Renewables Directive emphasizes the role of renewables in district heating; however, this potential remains challenged by the competition of other alternatives, particularly natural gas.

Despite these policy developments, this Outlook adopts a cautious view toward renewable penetration in transportation, as well as heating and cooling, mainly because of competitiveness issues when these

alternatives are compared to oil and gas. See Table 2.2 for a summary of the main policy targets adopted by key nations in developing renewable energies, as well as the main policy instruments, which are implemented to cope with the targets.

Table 2.2: Targets and existing support schemes for renewables in selected markets

	Renewables targets	Primary support schemes
US	State level targets (e.g. California = 33% by 2020 and 50% by 2030)	Renewable Portfolio Standards with renewables certificates trading; fiscal and financial incentives; federal tax credits
EU	Renewable share in gross energy consumption: 20% (2020) and 27% (2030)	FITs, feed-in premiums (applied in some countries like Germany); renewable auctioning; privileged fiscal regimes; privileged financing conditions for renewable projects
China	Share of non-fossil fuels in energy mix: 15% (2020) and 20% (2030)	FITs, priority in renewable electricity dispatch; obligation of grid companies to purchase output from renewable generators; renewable portfolio standards with renewables certificates trading; renewable auctioning
India	Share of non-fossil fuels in power generation: 40% of installed capacity by 2030	Energy sector reforms (improved competition, improved accessibility to power grids); renewable purchase obligations; renewable certificates trading; renewable auctioning; fiscal incentives and funding supports for renewable projects (particularly coal taxation revenues)
Southeast Asia	Indonesia: Renewable share in primary energy: 23% by 2025 Malaysia: Renewables capacities: 4000 MW by 2030	Indonesia: FITs; fiscal and financial incentives; Power Purchase Agreement Malaysia: FITs; fiscal and financial incentives
Latin America	Mexico: Share of non-fossil fuels: more than 35% by 2024, more than 40% by 2035 Brazil: Share of renewables in the energy mix: 45% by 2030; share of non-hydro renewables in the power 23% by 2030	Mexico: Renewable auctioning; fiscal and financial incentives; Renewable certificate trading Brazil: Renewable auctioning; fiscal and financial incentives; Power Purchase Agreement

Source: GECF Secretariat

Renewable policy assumptions in key markets

In the US, the Outlook expects renewable energy policies to be driven largely by state-level initiatives, mainly the Renewable Portfolio Standards applied in 30 states and districts. The Outlook considers also a cautious view on the role of federal tax credits in supporting renewable projects, given the uncertainties surrounding American fiscal policy and environmental commitments under the Trump administration. However, the involvement of non-federal actors in developing green projects is considered an important factor in driving renewable penetration in the country.

China is also expected to maintain strong policy support for renewables through both market based (renewable certificates, capacity auctioning) and regulated (FITs, tax credits) instruments, in line with its ambitious targets. Because of policy support as well as a decrease in renewable costs, China is expected to overachieve its solar penetration target and to reach its wind target in power generation by 2020. China is also expected to better manage the curtailment of renewable power, by improving power grid integration and by reducing power system rigidities, particularly with the penetration of flexible gas-fired power generation.

In the Outlook, India is projected to continue with renewable development, particularly through energy price subsidy reforms, power purchase obligations and other fiscal incentives. India is also expected to benefit largely from the decreasing cost of solar panels, especially for use in distributed systems. Funding constraints and competition from coal, in addition to power grid bottlenecks and difficulties integrating renewables, are expected to hinder India in the achievement of its impressive renewables targets, particularly with respect to solar energy.

For Europe, this Outlook assumes implementation of the new EU Renewables Directive and electricity market design in the Member States, and increasing use of market-based schemes, especially in countries with large penetration of renewables, like Germany. However, government intervention and support through pricing mechanisms and fiscal incentives are still expected to play a key role in encouraging the momentum of renewables.

The EU should make significant progress toward its renewable targets by 2020 and 2030, despite differences between the Member States. The role of natural gas in providing the required flexibility of power systems in Europe is expected to be crucial. Natural gas power plants can operate in baseload, intermediate load and peak load regimes, and are well positioned to bring efficient and environmentally friendly back-up to renewables' intermittency.

Table 2.3 summarises the main assumptions included in the GECF reference case scenario, concerning the future development of renewable policies at the global scale and by key markets.

Table 2.3: Summary of main renewable policies and assumptions in the GECF reference case, including key markets

Global	▪ Renewable policies will continue to be a mixture of direct government and market-based support schemes ▪ Market-based support schemes are expected to develop where large-scale penetration has been achieved ▪ Natural gas will play a key role in providing flexibility to power systems and in dealing with renewable integration ▪ A cautious view is adopted, regarding renewable penetration in transportation, heating and cooling
USA	▪ Implementation of strengthened policies at the state-level ▪ Cautious view regarding the role of federal tax credits ▪ Increasing role of non-federal players in supporting renewables
China	▪ Expected to overachieve its solar penetration target and to reach its wind target in power generation by 2020 ▪ Expected to improve power system flexibility and management of renewables curtailment. ▪ Gas will play a key role in providing flexibility for intermittent renewables
India	▪ Challenges regarding funding, persisting power grid bottlenecks and competition from coal will constraint the country in meeting its targets
EU	▪ EU renewable directive and electricity market design will be implemented ▪ Increasing use of market-based schemes, especially in countries with large penetration of renewables ▪ Government intervention and support will take place through pricing mechanisms and fiscal incentives ▪ Natural gas will play an important role in supporting renewable deployment
Latin America	▪ Auctioning will play an important role in supporting the development of renewable capacities (driving competition among renewable developers)

Source: GECF Secretariat

Non-renewable energy policies

This section focuses on policy drivers and assumptions that are specific to coal and natural gas and will affect the future of these two fuels. We also highlight the prospects of nuclear policies in some countries, as an option to support climate change commitments.

Natural gas

Natural gas policies on a global scale

Natural gas plays an important role in reducing CO_2 emissions, given its environmental advantage, in addition to its abundance, technical and economic benefits. This vision is supported by the observed evidence that switching to natural gas from coal has recently supported the reduction in carbon intensities in many countries. We estimate that more than 50 countries have increased the share of natural gas and decreased the share of coal in their energy mixes between 2012 and 2016. This has resulted in CO_2 emissions decrease (e.g. the US and the UK), or in emissions slow-down compared to the previous period (e.g. China).

In the Outlook, policy supports to gas infrastructure development, network integration and upstream projects are assumed to play a key role in driving the progress of gas in the primary energy mix. Gas is also promoted as a flexible back-up to intermittent renewable energy in the reference case scenario.

One of the main policies supporting the development of gas supply chains are reforms that encourage competition and investments in infrastructure, support more attractive domestic prices for project developers and accelerate the permit process for the execution of infrastructure projects. Developing bilateral and multilateral cooperation frameworks (e.g. the Silk Road initiative launched by China) is another policy support to increase investments in gas supply chains.

The Outlook assumes that policies encouraging natural gas in transportation are reinforced in many countries like China and India. These policies would tighten regulations on fuel quality, as well as introduce measures encouraging the development of distribution networks and natural gas vehicles.

Furthermore, the implementation of the International Maritime Convention on the Prevention of Pollution (MARPOL), establishing emission standards for shipping (IMO, 2017), strongly supports the progress of gas in LNG bunkering.

Natural gas policies in key markets

China and India have set ambitious objectives to facilitate penetration of natural gas into their primary energy mix. To support these targets, the two countries have launched gas sector reforms that aim to promote competition and domestic market price mechanisms and to improve the attractiveness of investments in gas supply chains. However, these reforms face many challenges, mainly those related to the rigidity of market structure, discrepancies between central and provincial level policies, as well as organisational issues in the energy sector (particularly in India).

China and India are also supporting gas-based projects in transportation, heating and power generation, particularly via air pollution agendas. Competition from coal, affordability concerns for end-use consumers, as well as domestic supply uncertainties in the context of increasing energy demand, remain important challenges for gas. This could affect the large gas demand potential that exists in China and, particularly, India.

This Outlook expects the gas penetration targets (especially medium-term targets) will be reached later than expected for China and will not be reached during the forecast period for India.

In other Southeast Asian countries, this Outlook considers policy support to gas market integration in the context of the ASEAN cooperation framework. This policy aims to encourage gas network connectivity, promote a common regulatory framework, and increase LNG cooperation, especially with the emergence of the region as a key LNG demand centre.

Despite ambitions in many Southeast Asian countries to increase the role of natural gas due to pollution and emissions concerns, the need for cheap energy (particularly coal) to satisfy energy demand growth remains a significant obstacle to gas market penetration. As with China, domestic supply challenges in Malaysia and Indonesia will affect gas demand potential.

In the US, policy support for gas chain development comes from the 'America First' Energy Plan, which aims to promote upstream projects, improve the permit process for exploration and drilling, remove environmental restrictions and barriers to infrastructure development, and lend support to LNG export projects (Vakhsouri, 2017).

For Europe, the outlook assumes policy support for some identified projects, especially those considered in the framework of EU gas priority corridors (EC, 2014). Uncertainties over gas demand perspectives and gas market design, in addition to some geopolitical constraints, are likely to affect these projects and cause delays in their execution.

This Outlook assumes that natural gas will be encouraged in power generation, as the best flexible back-up to renewables and to comply with emissions standards. In the EU, the implementation of CO_2 emissions standards (550 g/kWh) for eligible power plants participating in capacity mechanisms is expected to be supportive of clean power plants, mainly gas-fired.

Table 2.4 summarises the main assumptions included in the GECF reference case scenario, concerning the future development of natural gas policies at the global scale and by key markets.

Coal

Coal policies on a global scale

This Outlook assumes that policies will increasingly impose restrictions on coal consumption in many key markets. These restrictions are driven by air pollution reduction requirements, particularly in urban areas, and by measures to reduce CO_2 emissions from carbon-intensive coal-based technologies and processes.

Limitations on coal consumption will also be driven by policies which are not only specific to coal, such as the introduction of carbon emissions and pollution standards (e.g. the EU's IED), energy efficiency performance standards, and carbon pricing.

Table 2.4: Summary of natural gas policies and assumptions in the GECF reference case, including key markets	
Global	▪ Policy supports to gas infrastructure development, network integration and upstream projects are assumed to play a key role in driving the progress of gas in the primary energy mix, especially in emerging markets ▪ Supports to gas in the transportation sector, especially for heavy trucks and shipping to reduce pollution effects
US	▪ Implementation of policies that promote upstream exploration, expediting the permitting process for gas infrastructure development, and weaken environmental regulations
China and India	▪ Gas continue to be supported through market and prices reforms, infrastructure development, and clean air programs; but difficulties are expected in achieving ambitious targets, especially in India
Southeast Asia	▪ Policy support to gas market integration, particularly in the context of ASEAN partnerships; but, competition of cheap coal to satisfy growing energy needs will affect gas penetration potential
EU	▪ Policy support to some infrastructure projects, especially those considered in the framework of EU gas priority corridors; but, market design and geopolitics may cause delays in the execution of these projects ▪ Implementation of CO_2 emissions standards (550 g/kWh) for generation capacity participating in capacity mechanisms will support the flexible role of natural gas

Source: GECF Secretariat

Coal policies in key markets

China and the EU are expected to be key drivers in restricting the consumption of coal. For China, important progress will be made in reaching the coal reductions outlined in the 13th FYP. This progress will be driven by the closure of inefficient coal-based power plants and industries, as well as strengthened emissions standards.

In the EU, several countries will begin to implement their phase-out plans for coal, mainly: the UK, France, Finland and Portugal. However, some delays are expected, due to internal challenges. France needs to ensure sufficient reserve capacities and security of power supply over the medium-term, following the expected closures of outdated nuclear power plants. Other European countries, like Poland and Germany, are expected to continue their reliance on coal and to improve the use of clean coal technologies to reduce emissions.

The implementation of pollution standards and carbon pricing mechanisms in European countries are also important factors that will affect coal consumption, especially in the power sector.

In the US, despite the attempt of the Trump administration to revive the coal industry through various measures, mainly those aimed at reducing the environmental constraints on coal and lifting the barriers on federal leasing, we believe the coal industry will continue to experience serious difficulties driven by market fundamentals.

The main market forces which strongly affect the American coal industry are related to: i) availability of competitive natural gas; ii) progress of renewables; iii) Challenges for American coal exports driven by the effects of widespread environmental policies and restrictions adopted in different export markets; and iv) the decrease of coal mine productivity affecting the profits and margins of American coal companies.

For India and other key Southeast Asian countries, the GECF reference case assumes that improved efficiency measures and clean-coal technologies will be employed to meet emissions standards. These countries are expected to remain reliant on coal, in order to achieve competitiveness and to secure energy supply in the face of increasing energy demand. Several Asian countries are expected to adopt measures that improve the quality of coal supply, as a means of reducing air pollution.

Coal is expected to continue to play a key role in India, as the country is expected to face many challenges that will hinder achievement of the ambitious targets outlined above, for renewables, natural gas, as well as for nuclear.

Table 2.5: Summary of coal policies and assumptions in the GECF reference case, including key markets	
Global	▪ Policy orientation to impose more restrictions on coal consumption in many key markets, in order to reduce pollution and carbon intensity ▪ Many countries in Europe and Asia will continue to rely heavily on coal, although policies to increase the efficiency of its use will be implemented
US	▪ Policy measures to revive coal industry will not be very successful in supporting coal demand ▪ Market fundamentals are expected to predominate over policy supports and to continue to hit the coal industry
China	▪ Important progress towards the coal limitations targeted in the 13th energy plan, driven by the closure of inefficient coal-based power plants and industries, and strengthening CO_2 and pollutants' emissions standards.
India	▪ Coal is expected to continue to play a key role given the challenges of meeting ambitious targets for penetration of alternative sources to coal (renewables, nuclear, and natural gas) ▪ Coal policies are assumed to focus mainly on improving efficiency and low emission coal-based technologies in order to keep pollutants' emissions under control
EU	▪ Implementation of announced coal phase out plans in countries such as UK, France, Finland and Portugal. However, some delays are expected compared to the announced targets due to internal challenges (competitiveness and security of supply)

Source: GECF Secretariat

Nuclear

Nuclear policies on a global scale

Concerns about climate change and GHG mitigation have significantly reduced policymakers' negative perception of nuclear power, which prevailed after the Fukushima disaster. Nuclear power has re-emerged as a decarbonisation option, despite the security challenges and high costs associated with nuclear safety. More than 60% of nuclear power plants are more than 30 years old, heightening concerns about ageing plants' safety.

This Outlook considers the overall direction of energy policy to support nuclear energy, by focusing on strengthened safety requirements and controls. This will lead to lifetime extension of many nuclear plants in developed countries. The reinforcement of security standards will significantly increase the costs of nuclear power, according to the GECF reference case.

The development of new nuclear power plants, especially in emerging countries, will face many challenges related to technology transfer, high project development costs, resistance from the local population, and constraints on fuel supply and skilled labour. These can lead to discrepancies between announced objectives and realised targets

Nuclear policies in key markets

China and India have ambitious nuclear capacity development programs. India has the strongest nuclear ambitions, setting a target of 63 GW by 2032 (around 10 times the current capacity level) (India NDC, 2015). China has a medium-term target of 58 GW of capacity by 2020 (SEAP, 2014). These two countries have developed measures and initiatives to support their nuclear ambitions, such as the development of cooperation with experienced partners to undertake nuclear projects; strengthening institutional frameworks and nuclear safety measures; supporting technology transfer and innovation; and promoting new-generation reactors (India, for instance, is promoting thorium based reactors).

In this Outlook, it is expected that China will achieve significant progress toward its nuclear capacity targets by 2020. India, however, will experience important challenges and will not achieve its very ambitious target during the forecasting period. Technology transfer and availability of nuclear fuel are the main concerns in India.

For many countries with nuclear programmes, the 'Fukushima effect' seems to be weakening, and there is hesitation in phasing out nuclear capacities, despite the ageing nuclear fleet. For example, France's parliament made a decision to reduce the share of nuclear power from 76% in 2014 to 50% in 2025; however, the government will have to take into account energy competitiveness and security issues, as well as the impact on employment in the nuclear industry. France is not expected to achieve its nuclear capacity target by 2025 and will postpone the decommissioning of its oldest power plants until after 2030.

The UK is considering the installation of new nuclear power plants which would replace those expected to be decommissioned as an option to reduce carbon emissions. Specifically, the Hinkley Point C project has been approved. The UK is facing challenges after Brexit that could negatively affect nuclear projects by increasing service and labour costs (The UK is significantly dependent on imported equipment and services from the EU, and on European nuclear specialist skills. Withdrawal from the EU could lead to an increase in the costs of importing services and expertise).

In the Outlook, it is forecasted that the closure of the oldest nuclear capacities will be relatively offset by the commissioning of the HPC, expected after 2025.

In the US, despite uncertainties concerning the future role of nuclear power, there is some policy support. In 2014, a decision was made to extend the lifetime of 74 of the 100 operating reactors in the country by 20 years. There was also a DOE proposal to support a more diversified power generation mix, including nuclear and coal-fired power plants, to improve the resilience of power systems to external shocks, such as natural disasters. Despite this policy support, competitiveness and the costs associated with an ageing nuclear power fleet will be key drivers for the future prospects of nuclear in the US.

Japan is also expected to reinstate its nuclear capacity following the Fukushima accident. In its NDC, the country states that between 20-22% of its power generation mix will come from nuclear energy by 2030.

In South Korea, the new government is considering a significant reduction in the role of nuclear by halting construction of new power plants, as well as closing and decommissioning existing plants. South Korea will face challenges securing large energy supplies without nuclear, especially when the nation is positioning itself to become a nuclear technology provider and would lose its expertise by withdrawing. The country is active in developing nuclear facilities in other parts of the world, especially in the Middle East, where it has contributed to a project in the UAE.

Table 2.6: Summary of nuclear policies and assumptions in the GECF reference case, including key markets

Global	▪ Policy orientation will support nuclear energy, by focusing on safety requirements ▪ Lifetime extensions for many nuclear power plants in developed countries ▪ Technology transfer and high project development costs expected to hinder the development of new nuclear plants
China	▪ Significant progress toward targeted nuclear capacity will be achieved by 2020
India	▪ Targets will not be achieved due to high costs, technology transfer and concerns over the availability of nuclear fuel
EU	▪ Nuclear safety standards will be strengthened ▪ Security of supply, competitiveness and employment issues will postpone decommissioning of several nuclear plants ▪ France will not achieve nuclear reductions by 2025 and will postpone decommissioning of its oldest power plants after 2030 ▪ Germany expected to achieve decommissioning target by 2022.
US	▪ Lifetime extension of nuclear power plants
Japan	▪ Nuclear program to be reinstated and to reach around 13% of power generation mix by 2030 (less than the NDC target)
South Korea	▪ Nuclear will continue to play an important role in energy mix

Source: GECF Secretariat

Energy efficiency policies

Energy efficiency policies on a global level

Policies promoting energy efficiency are recognized as an important lever to mitigate GHGs in the post-Paris Agreement era. Indeed, more than 140 INDCs refer to energy efficiency measures as key procedures to reduce carbon emissions. Many countries have also identified quantitative energy efficiency targets. A recent survey of 54 countries conducted by the World Energy Council concluded that 90% of countries had established at least one target related to energy efficiency (WEC, 2016). Some have even considered upward revision of their energy efficiency targets, such as the EU and China. The majority of countries have also established institutions to monitor and implement efficiency programs and policies.

Several measures are highlighted in Table 2.7, as the main policy instruments adopted to support energy efficiency worldwide.

In this Outlook, mandatory regulations and energy performance standards are assumed to be the key drivers of energy efficiency developments in the residential, industry and transportation sectors. These measures are expected to contribute to the penetration of efficient appliances and technologies, especially electricity- and gas-based technologies.

Cooling and heating services are expected to become more energy efficient, through the adoption and strengthening of building codes and retrofitting programs, especially in OECD countries. Promoting price signals, particularly through energy subsidy cuts, and deployment of smart technologies, are also important drivers that will play a role in the Outlook. Several countries, particularly non-OECD countries, are expected to implement energy subsidy reductions that will increase the role of end-use prices in the rationalization of energy demand.

Table 2.7: Existing policy instruments that support energy efficiency

Mandatory standards and measures	Appliances and equipment standards; building codes); standards in transportation sectors
	Obligations to phase out inefficient equipment and processes, or to conduct audits and energy efficiency reporting
Fiscal and financial supports	Energy efficiency funding, tax exemptions
	Support to modernization of energy generation and transmission infrastructure,
Information and labelling	Energy efficiency rating and information incentives
Market-based instruments	Energy performance certificate trading
Price signals	Subsidies reduction; price signals using smart technologies
Structural changes	Reduction of over capacities in industrial sector, penetration of service sector in the economies,

Source: GECF Secretariat

Policies that support industrial shifts in emerging economies, which target sustainable development, will support the reduction of energy intensity.

Table 2.8 presents a summary of the main energy efficiency policy targets, as well as the main existing supporting policy instruments, which are implemented to cope with these targets.

Energy efficiency assumptions in key markets

Much of China's energy intensity reductions are expected to stem from industrial productivity and the utilization of existing capacity for industry and power generation. Improvements in energy performance will be supported by the establishment of energy performance standards and price signals for energy consumption. The heating sector in China is expected to improve efficiency through the promotion of highly efficient boilers and the implementation of heating standards.

For India, economic reforms, especially in the power sector and other energy-intensive industrial sectors, are expected to achieve efficiency improvements and reduce losses in power transportation and distribution systems. Other main energy efficiency measures are highlighted in Table 2.9.

The Outlook adopts a cautious view regarding federal energy efficiency programs in the US, given recent budget cuts. This cautious view is also adopted for appliance and equipment standards, and for transportation standards. Opposition to the current administration, by states, municipalities and American society, could hinder these policy developments. It is worth noting that economic fundamentals are expected to be key drivers in improving energy efficiency in the US, such as the competitiveness of natural gas, which allows for increased penetration of energy efficient gas-based technologies, particularly in industry and power generation.

For the EU, the Outlook considers the strengthening of energy efficiency measures through the CEP to be a key assumption. However, large discrepancies will exist between the Member States in designing and implementing these measures. The EU building sector is expected to play a key role through the strengthening of energy performance standards for new buildings and residential appliances.

Efficient gas-based technologies for heating, such as cogeneration (CHP), are expected to increase their penetration in order for countries to meet their performance standards. In this Outlook, many European countries are assumed to improve the renovation rate of existing residential and commercial buildings to increase their energy performance.

Table 2.8: Targets and existing support schemes for energy efficiency in selected markets		
	Energy efficiency targets	Primary support schemes
US	State level targets (e.g. California will achieve a cumulative doubling of energy efficiency savings by 2030 (SB 350, 2015)	State level programs and energy performance standards; mandatory energy performance standards (MEPS) for equipment and transportation vehicles; building codes; federal support for building renovation (weatherization assistance program)
EU	Efficiency improvements compared to 'business as usual' scenario: 20% by 2020 and 30% by 2030	MEPS in different sectors; funding of energy performance projects; building codes (eco-design directive); support to building sector renovations; price signals and smart metering
China	Improve energy intensity by 15% by 2020 relative to 2015 levels	Structural shift in economic model; reduction of over capacities in energy-intensive industries; MEPS for industrial, buildings and transportation sectors; industrial programs (China top 10000 programs)
India	Avoid a capacity addition by nearly 20GW and achieve fuel savings by around 23 Mtce per year; government targeting to save 10% of current energy consumption by 2018-19	Modernization of Indian economy; incentives to reduce losses in power sector, price signals (subsidy reductions); labelling and information (voluntary performance standards); energy efficiency measured (upscaling energy efficient technologies), performance and trade scheme for industrial sector
Southeast Asia	Indonesia: Reduce energy intensity by 1% annually to 2025 and achieve average savings of 17% in final energy consuming sectors Thailand: reduce energy intensity by 30% by 2036 relative to 2010 levels	MEPS, for transportation and buildings; performance standards in air conditioning (a program of harmonization of performance standards adopted in the framework of ASEAN partnership); price signals (subsidies reduction) building codes; funding energy efficiency (Thailand Energy Efficiency Revolving Fund)
Brazil	Achieving 10% efficiency gains in the electricity sector by 2030 (a cumulative goal of 1.69 Mtoe)	MEPS (standards and labelling) for electrical equipment; building codes; fiscal and financial incentives (e.g. financial support facility for energy efficiency projects developed by the National Bank of Social and Economic Development)
Japan	Save 50 mn kiloliters (around 42 Mtoe by 2030 compared to business as usual)	MEPS; Top Runner industrial energy efficiency programs; mandatory obligations for companies to achieve energy savings; building codes

GECF Secretariat; Renewable targets are taken from national plans and NDCs

Japan is expected to be at the forefront of energy efficiency, with key policy measures in industry and the building sector. Japan has recently updated energy conservation codes for buildings that strengthened energy performance standards.

Furthermore, the Outlook considers the important potential of energy efficiency policies in the industrial sectors of some Eastern European countries, Russia and the Middle East.

Table 2.9: Summary of energy efficiency policies and assumptions in the GECF reference case, including key markets	
Global	▪ Enforcement of mandatory efficiency standards in many sectors, in addition to price signals and deployment of smart technologies ▪ Structural economic shifts in some key emerging countries are also expected to drive energy and carbon intensity reductions in these countries
US	▪ Cautious view regarding implementation of federal energy efficiency programs and energy performance standards ▪ Economic fundamentals are expected to be key drivers in improving energy efficiency ▪ Gas competitiveness supports penetration of energy efficient gas-based technologies
China	▪ Policy supports changes in industrial productivity and realization of existing capacity for industry and power generation ▪ Support to price signals (taxes, subsidy reductions, carbon markets) to reduce energy consumption ▪ Large progress in the heating sector, driven by penetration of gas
India	▪ Continued implementation of Perform, Achieve and Trade and its extension to other sectors such as transportation sector ▪ Promotion of smart grid and technologies in the framework of "Smart Grid Mission"
EU	▪ Strengthening of energy efficiency measures after the adoption of the Clean Energy Package ▪ The building sector is expected to be a key driver of energy efficiency policies ▪ Deployment of smart technologies as a lever to improve energy efficiency
Japan	▪ Strengthened energy performance standards, particularly in the building sector ▪ Support in the development of energy efficient technologies and processes in industry ▪ Smart technologies are expected to play a key role

Other measures to mitigate GHGs

Carbon pricing policies

Putting a price on carbon, either in the form of carbon taxation or through the application of carbon price references from the ETS, is considered by many countries as an important lever to mitigate CO_2 emissions. It is estimated that 2/3 of the parties submitting NDCs to the UNFCCC, stated in their NDCs that they are considering the use of carbon pricing (taxes, ETS or international carbon pricing) as a mechanism in order to make progress with their climate commitments and pledges. A large portion of these parties refer to international carbon pricing mechanisms to support mitigation actions (World Bank, 2016). More than 40 carbon pricing initiatives (taxes and ETS) exist today, including national, subnational and regional initiatives. This compares to just 9 initiatives in 2005. These initiatives cover around 15% of global GHG emissions (World Bank, 2017).

In this Outlook, carbon taxation is assumed to become more widespread, especially in OECD countries. For Europe, taxation is expected to increase particularly for the non-ETS energy consuming sectors, to meet the GHG emissions targets stated in the framework of the European Commission's Effort Sharing Decision.

The use of carbon taxation is also expected to progress in non-OECD countries, particularly in key emerging countries, like China and India, which have mentioned carbon taxes in their respective NDCs. Domestic carbon taxes in non-OECD countries and their impact on energy end-use prices are expected to remain relatively low. This allows the avoidance of a large cumulative effect with other factors increasing the end-user prices, such as the expected reduction of energy subsidies.

Carbon pricing via the ETS route is likely to experience some challenges in developing market-relevant prices. Efforts are underway to address these challenges in some key regions.

For the European carbon market, the EC has considered post-2020 Carbon Market Reforms, in order to address the structural unbalances between supply and demand of emission allowances. Two main measures are considered in the framework of these reforms: firstly, the creation of a Market Stability Reserve mechanism by 2019 as a tool which manages the balance between the supply and demand of emission allowances; and secondly, the adoption of an accelerated reduction factor of the emissions cap as a way of tightening the supply of emission allowances, thus encouraging a strengthened CO_2 mitigation effort in line with Paris Agreement commitments.

Regardless, some key challenges could constrain the development of relevant carbon prices from the EU ETS, including i) Brexit and its potential effect on the functioning and liquidity of the EU carbon market; ii) Evolution of the supply of emission allowances and the issue of efficient allocation of these allowances, especially for energy-intensive industries (these industries are receiving free allocation to avoid their migration outside EU and consequent carbon leakage) ; iii) overlaps between emission trading systems and aggressive regulatory measures to phase out coal, push for renewables, and promote energy efficiency. These measures could affect the demand for emission allowances and limit the need for carbon pricing to achieve CO_2 reductions.

It is assumed in the Outlook that the EU ETS carbon market reforms will remove excess emissions allowances and, therefore, tighten the market resulting in upward pressure on the prices.

For the UK, the government has supported higher carbon prices than those observed in EU ETS since 2013, with the introduction of a carbon price floor. The latter adds to the EU ETS price reference, a CPS that is calculated periodically, taking into account targeted future trajectory of carbon price floor, projected EU ETS prices, as well as economic and competitiveness drivers. It is worth noting that the UK has recently decided to freeze the CPS at GBP18/tCO_2 (inflation corrected) to limit its competitive disadvantage for UK businesses.

Brexit has raised a large uncertainty over the future of the carbon market in the UK as it raises the question of the potential withdrawal of the UK from the EU ETS. In the GECF outlook, it is assumed that the UK will continue to link its carbon market to the EU ETS and to apply higher carbon floor prices, in line with the country's ambitious policies to reduce CO_2 emissions.

One of the main carbon pricing initiative announced for 2017 is the Chinese national carbon market, which is

expected to be an extension of the eight pilot carbon markets already initiated at provincial and city levels.

Despite the apparent willingness of the Chinese government to progress with this initiative, the national carbon market is facing some key challenges, including i) the need to address large regional disparities in terms of economic development; ii) differences between pilot carbon markets in terms of scope, coverage and design which complicate the linkage between these markets; iii) regulatory issues and complexity of harmonizing the legal framework and designing applicable rules at national level; iv) reliability issues for emissions data, monitoring, reporting and verification systems; and v) the need to support and facilitate trading activities on carbon markets in order to improve the liquidity of these markets (the pilot projects have experienced lack of trading and liquidity with large fluctuations in reference prices).

In this Outlook, the Chinese national carbon market is expected to launch in 2018 at low initial prices. This is mainly due to a slowdown and expected structural changes in the Chinese economy, and the introduction of aggressive regulatory measures to reduce CO_2 emission, which could reduce the demand for carbon emission allowances and could lead to imbalances between the supply and demand for these allowances.

The US carbon market is expected to be driven by regional and state level initiatives, like the RGGI. Canada is also expected to make progress toward more widespread carbon pricing initiatives, which are so far developed at provincial level (especially in Quebec, and recently with Ontario adopting an ETS).

The country has proposed a national framework for carbon pricing including a carbon tax and ETS to be implemented by all Canadian jurisdictions by 2018. This framework has already been signed by most of the jurisdictions. It is expected that there will be some linkage between carbon prices in the US and Canada due to the integration of power systems between the two countries and also the existing link between two important ETS, namely Quebec and California.

Policy support for electrification

Promoting the electrification of end-use energy sectors is also among the options being considered to reduce the carbon footprint, particularly in the transportation sector.

Several countries, like China, Japan and some European countries, are undertaking measures to increase electricity usage in transport, mainly by supporting the penetration of EVs. These measures include: i) direct subsidies aiming to reduce the gap between the costs of Internal Combustion and electric vehicles; ii) fiscal incentives; iii) supports for research and innovation (e.g.: innovation in vehicle batteries); iv) support for the development of infrastructures and charging points for EVs; v) exemptions from driving restrictions in urban areas; and iv) support to car manufacturers in developing their supply of EVs and other accompanying services (incentives to install free batteries in China for instance). The energy performance standards, as well as emissions restrictions aiming to reduce the pollution in urban areas, is also another policy support to electric vehicles.

Moreover, some countries have also considered the introduction of binding targets and mandates for car makers to produce and sell low emissions vehicles, including electric vehicles (ZEV mandates). These mandates have already been enforced in some American states such as California, while China and the European Union are considering the possibility of introducing them in the framework of their decarbonisation policy. India has announced its support for electricity usage under the framework of an ambitious plan (the National Electric Mobility Mission Plan 2020). The plan aims to promote faster adoption and manufacturing of hybrid and electric vehicles with an objective of reaching 6 to 7 million hybrid/electric vehicles by 2020.

On the other hand, it is worth noting that the progress of EVs is very sensitive to costly policy supports and subsidies. We can note in this regard the slowdown of EV sales in Denmark (which saw a reduction of 65% in new sales in 1Q2016 compared to the same period in 2015) after the government initiated a plan to reduce import tax exemption. In the Outlook, policy support to EV penetration is expected to contribute to the growth in EV usage in some key countries, specifically in Europe, China and Japan. However, there are important challenges to be faced, including the costs of these policies as well as the competition from relatively cheap oil and less costly internal combustion vehicles.es compared to EVs. Gas-fuelled vehicles are also a major key competitor to EVs.

Energy-related CO_2 emissions

Global CO_2 emissions: forecasts and drivers

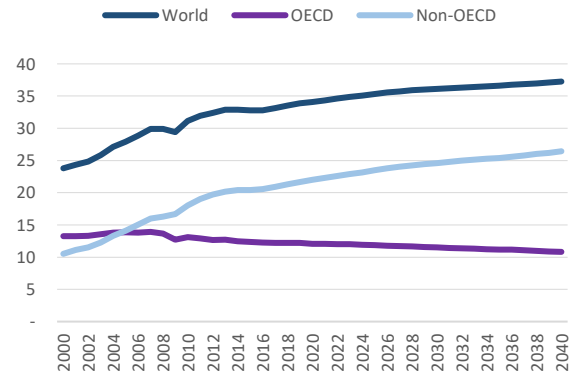
Increasing trends were observed in energy-related CO_2 emissions between 2000 and 2016. These trends were largely driven by non-OECD countries, whose emissions surpassed OECD countries in 2006. The average growth rate of global CO_2 emissions reached approximately 2% between 2000 and 2016, although this global evolution masks the different momentum between developed and emerging countries.

Non-OECD countries have increased emissions annually by 4% (2000–2016), an increase which has been supported by growing energy use due to the progress of population and economy. OECD countries have observed declining trends, driven by sharp reductions in carbon intensities and energy efficiency improvements. Gas versus coal switching, as well as increased penetration by renewables, have been the main catalysts for declining CO_2 emissions in OECD countries.

On a global level, energy-related CO_2 emissions have remained stagnant over the last three years—stabilizing at around 33 Gt CO_2. Coal to gas switching in key energy consuming countries, such as the US and China, has contributed to this observed stagnation of global CO_2 emissions.

The GECF Outlook forecasts that CO_2 emissions will grow at a moderate rate over the long-term, averaging around 0.5% between 2016 and 2040. This projection reflects the continuous decline in CO_2 emissions observed in developed countries, as well as sharp slow-down in the non-OECD region.

Figure 2.1: Energy-related CO_2 emissions ($MtCO_2$)

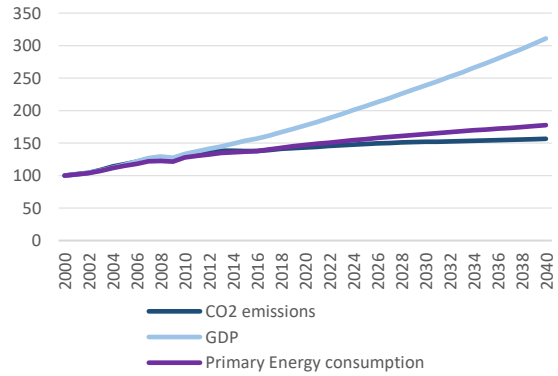


Source: GECF Secretariat based on data from GECF GGM

The projected slow-down of global energy-related CO_2 emissions is further supported by international efforts and momentum triggered by the adoption of the Agreement. Policies and carbon mitigation measures, driven by countries' NDC pledges, are expected to play a key role in decelerating CO_2 emissions and decoupling them from economic growth and primary energy consumption.

Figure 2.2 highlights the divergent trajectories forecasted between CO_2 emissions and GDP (which is expected to more than double by 2040 relative to 2016 levels), and between CO_2 emissions and primary energy demand.

Figure 2.2: CO_2 emissions, GDP and primary energy consumption (index: 2000 = 100)



Source: GECF Secretariat based on data from GECF GGM

Despite mitigation policies implemented following the Agreement, more effort is needed to achieve an emissions pathway that is compatible with the very ambitious temperature targets (2°C) stated in the Agreement.

CO_2 emissions are forecasted to reach 36.1 Gt CO_2 by 2030 and 37.2 Gt CO_2 by 2040. These figures, 10.9 Gt CO_2 (by 2030) and 18.8 Gt CO_2 (by 2040), are respectively more than the estimated emissions in the 2°C scenario (2DC Scenario or 450 Scenario of IEA).

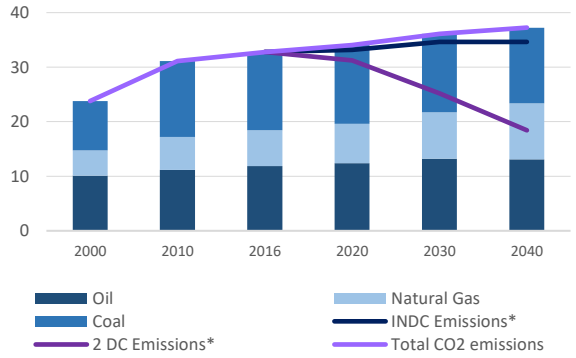
Policy effort is also required to meet the aggregated emissions targets outlined in NDCs pledges, though these pledges are not yet consistent with the Paris Agreement. The emissions gap between the Outlook

and the aggregate NDC targets is estimated to reach 1.5 Gt CO_2 in 2030 and 2.6 Gt CO_2 in 2040.

In 2016, coal and oil were responsible for 80% of global energy-related CO_2 emissions. Together, these two fuel types are forecasted to generate 73% of CO_2 emissions by 2040. Coal will continue to dominate the global share, representing around 37% of CO_2 emissions in 2040; oil will follow with a share of 35%. As natural gas is the least carbon-intensive fossil fuel, it has the potential to drive emissions trajectories toward the global targets outlined in the Agreement.

Natural gas has a key role to play in the transition to low carbon economies. In addition to its economic and technical benefits, the environmental advantages of natural gas should be seriously considered by energy players

Figure 2.3: CO_2 emissions forecasts in the GECF reference case, aggregate NDCs and 2 DC scenario ($GtCO_2$)



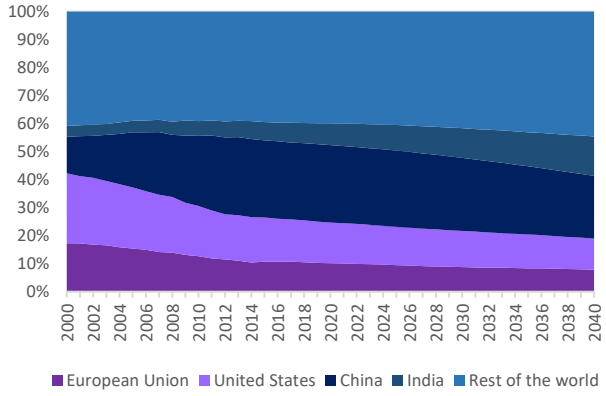
**Note: INDC Emissions: CO2 emissions estimation based on aggregated INDCs targets (UNFCCC, 2016) - 2 DC Emission: based on IEA 450 scenario (WEO, 2016)*

Source: GECF Secretariat based on data from GECF GGM

CO_2 emissions forecasts in the biggest carbon-emitting markets

China, the US, the EU and India are the largest emitters in the world, representing around 60% of energy-related CO_2 emissions. They are projected to maintain these significant shares, comprising 56% of energy-related CO_2 emissions by 2040. The 4% decrease is attributed to emissions shares' reductions in the EU and US, which will be partially offset by an increase in China and India.

Figure 2.4: Forecast shares of CO_2 emissions



Source: GECF Secretariat based on data from GECF GGM

According to the Outlook, India will be the largest contributor to global emissions growth between 2016 and 2040, with emissions growing at an annual rate of 3.5%. A growing and increasingly wealthy population, coupled with continuous dependence on coal, are the main drivers behind this forecast.

India has set a target to reduce its GDP emissions intensity by 33-35% by 2030, relative to 2005 levels. While this target is sensitive to GDP prospects, it is not very ambitious given the huge mitigation potential that exists in the country.

India is expected to achieve its CO_2 emissions targets (estimated at around 4.2 $GtCO_2$), primarily through energy efficiency improvements and increased penetration of gas and renewables. But, despite the expected increase of gas and renewables, the country will experience challenges in meeting its ambitious penetration targets, particularly with regard to solar energy. If India succeeds in overcoming barriers that hinder a transformation toward a gas-based economy, the country will be able to achieve large CO_2 emissions reductions while simultaneously addressing serious air pollution concerns.

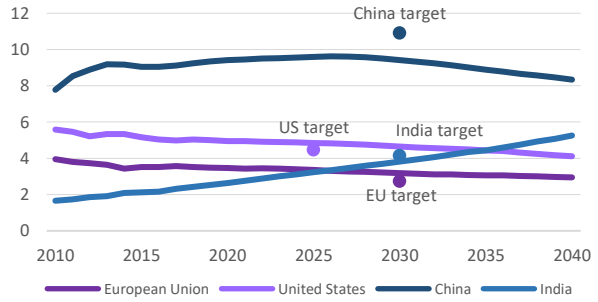
CO_2 emissions in China are forecasted to peak before 2030. China has set a target to reduce emissions intensity by 60-65% by 2030, relative to 2005 levels. The reduction is estimated to bring emissions levels to around 10.8 Gt CO_2 by 2030. The GECF estimates that China will overachieve this target, with CO_2 emissions

expected to reach 9.4 $GtCO_2$, 13% less than the estimated 2030 target.

The US is not expected to reach its CO_2 targets, estimated at around 4.4 $GtCO_2$ by 2025, despite decreasing trends attributed to increased penetration of natural gas and renewables through market fundamentals and state level policies. Energy-related CO_2 emissions are forecasted to reach 4.8 Gt CO_2, 8% more than the estimated target.

The EU is expected to significantly decrease its CO_2 emissions, driven by policies and deployment of clean technologies. However, this reduction will not be sufficient to achieve the 2030 target, estimated at around 2.7 $GtCO_2$. These shortcomings are attributed to disparities amongst Member States' GHG mitigation policies, reliance on coal in some European countries, insufficient carbon price incentives, and policy hurdles that hinder natural gas deployment (especially in baseload power generation).

Figure 2.5: CO_2 emissions in key emitting markets compared to pledged targets ($GtCO_2$)



Source: GECF Secretariat based on data from GECF GGM

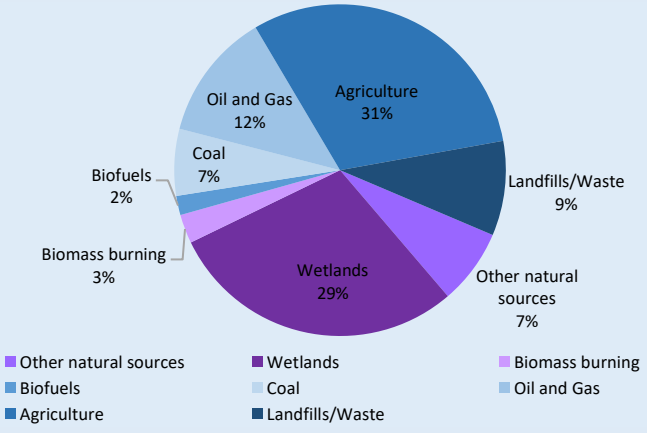
Box 2: Methane emissions from the natural gas supply chain

Methane (CH_4) is an important GHG due to its high global warming potential when compared to CO_2. While there is consensus that the observed increase in ambient CH_4 levels over the past decade can be partially attributed to anthropogenic sources, huge uncertainties remain in measurement and significant variations in estimation methods, data quality, assumptions, and system boundaries have led to reporting discrepancies.

The most abundant GHG is CO_2, which currently represents over 84% of global GHG concentrations (NOAA, 2017) and contributed to 75% of global anthropogenic GHG emissions for the period 1970 to 2010. Although ambient CH_4 concentrations have been on the rise since 2007, anthropogenic methane emissions contribute relatively little (16%) to overall emissions. (IPCC, 2014)

The Global Carbon Project (GCP) estimates that total CH_4 emissions from all sources averaged between 540 and 568 million tonnes from 2003 to 2012. Anthropogenic sources account for approximately 60% of this figure, with agriculture being the largest contributor. Figure 2.6 shows a percentage breakdown of the main sources of global CH_4 emissions based on GCP's bottom-up calculations.

Figure 2.6: Total average methane emissions by source, 2003-2012



Source: Saunois et al., 2016a (methane budget assessed by bottom-up approaches)

Fossil fuel emissions (including oil/gas, and coal) account for approximately 19% of global methane emissions. There is significant uncertainty about the direct input of the natural gas supply chain to total fossil fuel-related CH_4 emissions, best exemplified by the aggregation of oil and gas into a single contributing sector. These uncertainties are further compounded by the fact that wide divergence in measurements exist between countries, and according to the methodology employed (bottom-up versus top-down; for more information, see: Balcombe et al., 2017).

A review of 250 published estimates of total supply chain emissions reported that CH_4 emissions range from 0.2% to 10% of produced CH_4 (Balcombe et al., 2017). This analysis concludes that the majority of emissions estimates are at the lowest end of this range, which is highly skewed due to a small number of outliers. While this study reflects the most recent measurements available specific to the gas industry, the vast majority of emissions data presented is from the US. This underscores the constraints imposed by data availability, and the need for more input data, transparency, and harmonization, if emissions estimates are to be made more reliable and accurate.

While many inconsistencies remain, several conclusions can be reached from an in-depth assessment of the issue. First, there is widespread recognition that coal is the most emissions-intensive fuel source (see: IEA, 2017). Coal mining accounts for 34% of fossil fuel-related emissions of CH_4, underscoring the need to phase out coal-fired power generation if climate commitments are to be realized. Second, marked reductions in CH_4 leakage have been achieved across the entire natural gas supply chain and many countries have reported emissions reductions from the natural gas sector. The rise in atmospheric CH_4 levels observed over the past ten years is not the result of increased gas production (Le Fevre, 2017), but is most likely the result of increased agricultural activities (see: Saunois et al., 2016b; Herrero et al., 2016).

Although emissions from natural gas supply chains have decreased significantly and contribute relatively little to global CH_4 emissions, the image of natural gas remains uncertain. The issue of CH_4 emissions has become increasingly publicized. Public scepticism and reactionary policy decisions are expected to continue, if reliable and transparent data is not presented from the perspective of gas producers. The GECF Countries are in a unique position to spearhead data collection, which is currently sparse. The Russian Federation is the exception, with corporate environmental targets and systematic reporting guidelines in place, as well as a maximum permissible CH_4 concentration guideline.

CHAPTER 3: ENERGY AND GAS DEMAND TRENDS

Key assumptions and findings:

- World energy demand is projected to grow by 1.1% per annum between 2017 and 2040, an overall increase of 29%, climbing from 13.8 Gtoe in 2016 to 17.8 Gtoe in 2040.
- Fossil fuels are expected to meet 75% of the world's energy demand by 2040.
- Coal is the biggest loser in the global energy mix in 2040, being increasingly replaced by natural gas, renewables and nuclear power.
- The share of gas in the overall energy mix will increase from 22% in 2016 to 26% in 2040, and gas will be the fastest growing fossil fuel in 2040, increasing by 1.8% per annum. Non-OECD Asia, the Middle East, and Africa constitute the fastest growing regional energy markets between 2017 and 2040.
- World natural gas consumption will increase by 53% from 3534 bcm in 2016 to 5395 bcm in 2040, led by non-OECD Asia, the Middle East, and Africa.
- Natural gas continues to be an attractive fuel for the power generation, domestic and industrial sectors in 2040.
- In the long-term, the transport sector will be the fastest growing in terms of natural gas consumption, with an annual average growth of 3.9%, eclipsing the power sector which will grow at a rate of 2.5% per annum.
- The industry sector will also contribute to gas demand with growth of 1.2% per year, reaching 838 bcm by 2040, as it replaces oil as a raw material for petrochemical manufacturing.
- Global electricity demand has been increasing since 2000 and is projected to grow to 41235 TWh by 2040. Demand for electricity is expected to grow at 2.2% per annum on average between 2017 and 2040.
- In 2016, coal continued to account for the highest share of fuel for power generation, with a steady market share of 38%. However, the Outlook forecasts that its share of global power generation will drop to 27% by 2040, with a negative growth rate of 1.4% per annum.
- The share of gas in the power generation sector will continue to rise from 23% in 2016 to 28% in 2040, with an average growth rate of 0.9% per annum. This represents the largest market share of any fuel.

Primary energy demand trends

Global energy demand trends: Historical (2000-2016) and forecast (2017-2040)

Developed countries have been the main contributors to primary energy demand over the past decades, particularly during the economic boom of the 1980s and 1990s. In the most recent decade, however, global energy markets have undergone a change through the rise of emerging markets and their increasing influence on the prosperity of the global economy. The major reason for this transition has been the rapid growth in energy demand due to increasing economic development, particularly within Asia (e.g. China and India) and the Middle East. These recent trends highlight the important role that energy plays in driving economic and social development.

Environmental concerns have prompted a shift towards cleaner fuel sources, such as natural gas and renewables. Policies addressing energy efficiency must be devised in such a way as to incorporate risks to economic prosperity and environment.

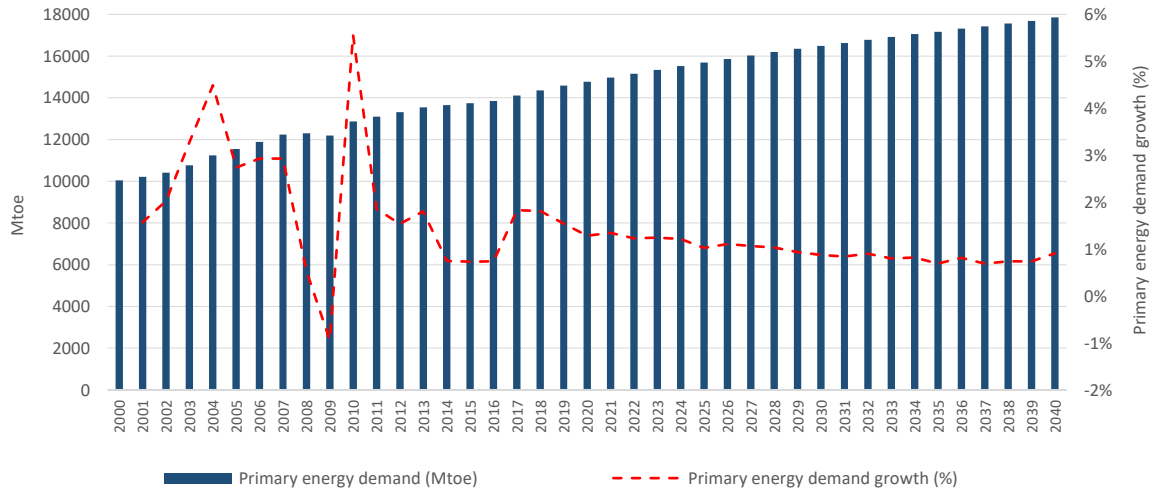
Growth rates in global energy demand have fluctuated since 2000. It accelerated by an average of 4.7% per annum, from levels of 10054 Mtoe in 2000 to 11244 Mtoe in 2004, then increased to 12190 Mtoe in 2009.

The global economic crisis dramatically curtailed energy demand growth, which reached an all-time low of 0.8% in 2009. The global economy rebounded in 2010 and energy demand peaked at 12867 Mtoe, a 5.5% increase from 2009. These substantial improvements in energy demand following the 2009 economic recession did not last long, as political unrest in the Middle East resulted in a dramatic decline in growth rates, from 1.9% in 2011 to 0.7% in 2016.

These declines were followed by a 0.1% increase in 2016, with global energy demand reaching 13852 Mtoe, representing an overall growth rate of 0.8% per annum since 2000.

Figure 3.1 illustrates trends in global energy demand by the annual amount of Mtoe consumed and corresponding growth rates over the historical (2000-2016) and outlook periods (2017-2040).

Figure 3.1: Trends in global energy demand, 2000-2040



Source: GECF Secretariat based on data from GECF GGM

One of the main drivers of global energy demand growth is population. According to UN projections in 2017, the world's population will rise from 7.3 bn in 2017 to 8.5 bn in 2030 and to 9.2 bn in 2040. This considerable increase in population will affect global energy demand for all sectors in the long-term.

Economic growth is the next key driver of energy demand globally. In this Outlook, the global economy is expected to grow by 3.4% annually through 2040, and most of this growth is expected to come from emerging markets.

The advancement of new technology is an important exogenous factor that affects economic growth in emerging economies (e.g. China and India). This implies that energy is the engine driving these developments; however, growth in global energy demand may not follow projected economic growth.

Policies addressing energy efficiency and environmental issues may diminish the energy demand growth rate. As depicted in Figure 3.1, the rate of demand growth plunges from 1.8% in 2017 to 1.3% in 2020, while global economic growth increases from 2.8% to over 3.0% over the same time period.

Nevertheless, the growth rate stabilizes at an average of 1.1% per annum over the forecast period, which is lower than the historical average, with demand increasing from 14106 Mtoe in 2017 to 17853 Mtoe in 2040. Table 3.1 presents historical and projected global energy demand, along with the associated compound annual average growth rate (CAAGR).

Regional energy demand trends

Regional characteristics influence global energy demand. Countries located in the same geographic region often share similarities in all or some of the following aspects: economic prosperity indicators (e.g.

GDP, unemployment rates), population, compliance with international regulations, and political structures. In this section, we present regional primary energy demand trends over the historical and the forecast period (see Table 3.1).

Non-OECD countries have played a prominent role in global energy demand since 2000. Advanced economies and OECD countries have generally experienced slow economic growth, consequently a large share of global energy demand has come from non-OECD markets. Non-OECD Asia constitutes the fastest growing regional market, with an average growth rate of 5.2% per annum, from 2221 Mtoe in 2000 to 5012 Mtoe in 2016. These markets accounted for 36% of total global primary energy in 2016. Regional energy demand has been largely driven by China, India, and the Middle East, with energy demand growth rates of 6.5%, 4.3%, and 4.7% between 2000 and 2016, respectively. Two key determinants explaining their contribution to global energy demand are population and economic growth.

Interestingly, after non-OECD Asia and the Middle East, Africa had the third highest average growth rate over the historical period, rising by 3.0%, from 514 Mtoe in 2000 to 820 Mtoe in 2016. This region is rich in energy reserves, particularly natural gas (North), crude oil (West) and coal (South).

The main drivers of energy demand growth in Africa include a recent shift to power generation from natural gas, high reliance on coal, and population growth. Africa's energy demand indicates that between 2000 and 2016, renewables gained a substantial share of the region's total primary energy demand, with a 48% increase, ahead of oil (25%), natural gas (14%) and coal (12%).

Latin America (including Mexico) experienced the next largest increase in energy demand growth. Over the historical period, Latin America experienced an average growth rate of 2.3%. Between 2000 and 2016, natural gas and oil were among the most consumed primary energies, with the share of 24% and 46%, respectively.

Table 3.1: Global primary energy demand by region Mtoe

Region	Historical				Forecast					
	2000	2010	2016	CAAGR 2000-2016	2020	2025	2030	2035	2040	CAAGR 2017-2040
World	10054	12867	13852	2.0%	14769	15688	16492	17172	17853	1.1%
Africa	514	710	820	3.0%	891	997	1109	1229	1365	2.1%
CIS	920	1045	985	0.4%	1013	1030	1049	1056	1058	0.3%
Latin America (incl. Mexico)	616	816	888	2.3%	950	1011	1089	1171	1263	1.5%
Brazil	191	272	290	2.6%	307	333	365	399	436	1.7%
Middle East	398	683	830	4.7%	913	1023	1125	1218	1302	1.9%
Non-OECD Asia	2221	4133	5012	5.2%	5580	6200	6744	7175	7626	1.8%
China	1122	2510	3058	6.5%	3310	3574	3760	3836	3873	1.0%
India	443	696	870	4.3%	1041	1257	1465	1681	1950	3.4%
Non-OECD Europe	99	106	103	0.2%	106	107	107	109	111	0.3%
North America (excl. Mexico)	2595	2535	2502	-0.2%	2542	2553	2518	2488	2422	-0.1%
US	2340	2279	2331	-0.3%	2271	2278	2245	2216	2148	-0.2%
OECD Asia-Pacific	858	926	896	0.3%	933	930	926	914	895	0.0%
Australia	113	136	137	1.2%	150	151	152	155	158	0.6%
Japan	530	509	448	-1.0%	457	448	430	406	381	-0.7%
South Korea	197	262	289	2.4%	303	311	320	330	332	0.6%
OECD Europe	1833	1913	1814	-0.1%	1842	1836	1825	1811	1812	0.0%
France	260	269	247	-0.3%	250	248	241	232	228	-0.3%
Germany	344	337	326	-0.3%	320	300	289	277	267	-0.8%
UK	235	216	191	-1.3%	189	188	188	185	183	-0.2%

Source: GECF Secretariat based on data from GECF GGM

Brazil, one of the emerging economies included in the BRIC countries, is a major contributor to regional energy demand in Latin America. Industrial and urban development, along with a diverse natural resource base, have led to economic improvements and an increase in energy consumption. Between 2000 and 2016, Brazil's annual energy demand growth rate averaged 2.6%, from 191 Mtoe to 290 Mtoe, close to the regional average.

In 2016, Mexico (200 Mtoe), Argentina (89 Mtoe), Venezuela (59 Mtoe), and Colombia (38 Mtoe) also contributed to regional energy demand.

In last position with respect to energy demand growth rates, are OECD Asia-Pacific, OECD Europe and North America (excluding Mexico), with 0.3%, -0.1% and -0.2% between 2000 and 2016, respectively.

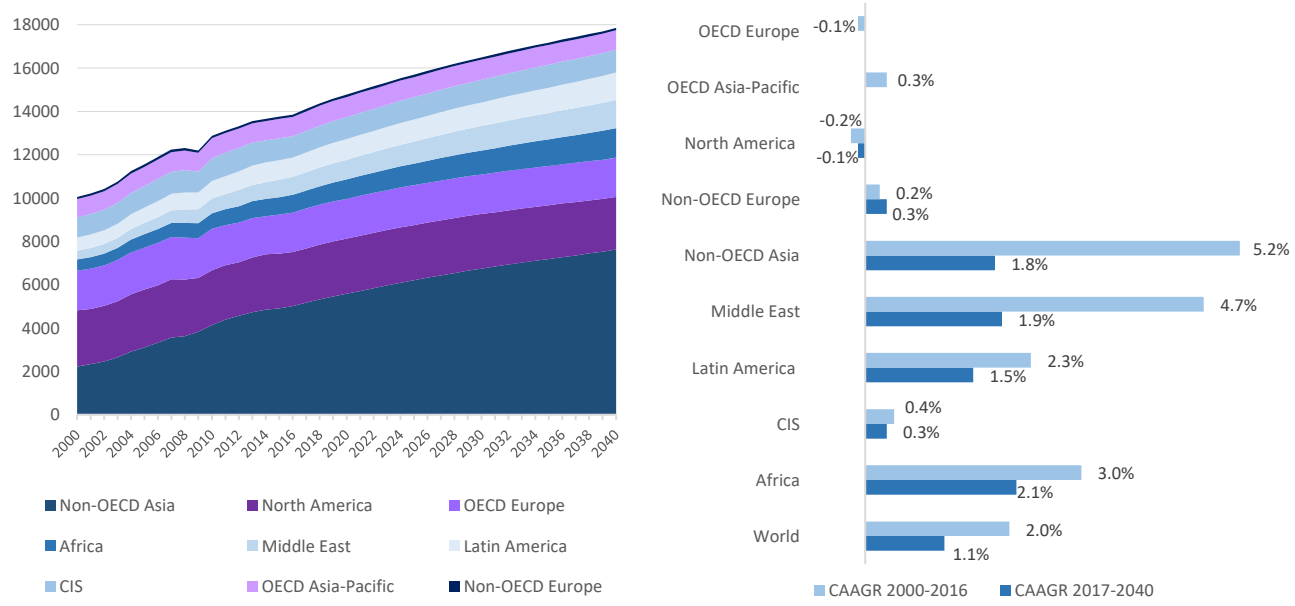
Australia, Japan, and South Korea are key players in the OECD Asia-Pacific region. These countries are considered advanced economies, but their energy demand growth has been relatively slow compared to non-OECD countries. Between 2000 and 2016, the growth in energy demand grew by 1.2% and 2.4% per annum in Australia and South Korea respectively, and dropped by 1.0% in Japan.

OECD Europe's growth rate stagnated over the historical period. This can be mainly attributed to the EU's ambitious 2020 energy efficiency strategy to optimize energy consumption across EU Member States (including OECD and non-OECD), slower economic development, and an ageing population. France, Germany and the UK are the largest energy consumers in the region and their historical growth rates indicate that all three experienced a decline in total energy consumption by a rate of -0.3%, -0.3% and -1.3%, respectively. These declines are a result of energy mix reforms. To secure energy supplies, the EU has set energy efficiency targets to reduce fossil fuel dependence and to promote the use of renewables and advanced generation biofuels as alternative energies.

Finally, North America (excluding Mexico) also experienced a negative annual average growth rate of 0.2% between 2000 and 2016. The 2009 economic crisis which originated in the US substantially decreased total primary energy consumption in the country from 2618 Mtoe in 2008 to 2482 Mtoe in 2009.

Figure 3.2 illustrates projected global energy demand and associated growth rates by region. All regions maintain their demand growth at a slower rate than during the historical period, except for Europe (OECD and non-OECD), and North America. Over the forecast period (2017-2040), this Outlook predicts the following growth rates: Africa (2.1%), non-OECD Asia (1.8%), the Middle East (1.9%), Latin America (1.5%), non-OECD Europe (0.3%) and the CIS (0.3%).

Figure 3.2: Global primary energy demand (Mtoe) and associated CAAGR (%) by region



Source: GECF Secretariat based on data from GECF GGM

Population growth, improved economic conditions and higher living standards are the most prominent drivers of such an increase. However, a downturn in demand growth for giant non-OECD economies like China can be attributed to the government's recent prioritization of short-run economic development over structural economic reforms.

Global energy demand trends by fuel type

The primary energy mix consists of heterogeneous types of energy and each can be considered as a 'fuel' for economic and social development. Conventional fossil fuels (i.e. natural gas, oil and coal) still dominate the global energy mix due to their relative abundance, cheap prices and accessibility.

In 2016, fossil fuels contributed approximately 80% to the world's total energy mix. In recent years, low carbon energy sources (i.e. nuclear and renewables, including biomass and waste, and hydro) emerged as a means of mitigating serious environmental concerns and solving energy security issues. Unlike traditional fuels, particularly natural gas, they are more expensive and in some cases even potentially hazardous. As a consequence, in 2016, low carbon fuels only accounted for 20% of the world's energy mix. The transition from conventional to low carbon fuel sources is a sluggish and expensive process, but nonetheless it is accelerating (Figure 3.3).

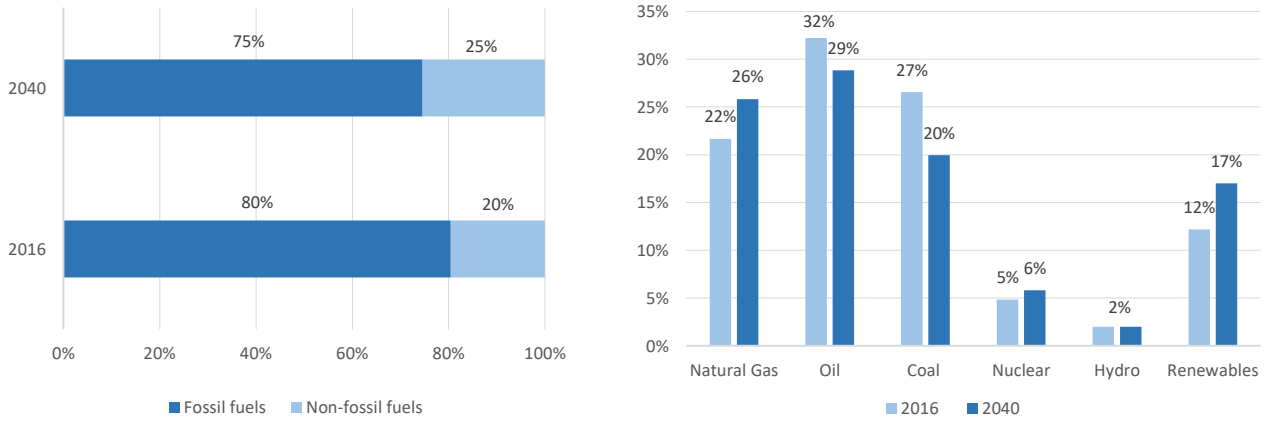
Natural gas provides the most economic and environmental benefits amongst all fossil fuels. The average demand for natural gas has increased 2.3% annually, from 2092 Mtoe in 2000 to 3002 Mtoe in 2016. Over the outlook period, natural gas will grow the fastest, apart from renewables, with a 1.8% annual average growth rate to 4611 Mtoe in 2040.

This report expects the global share of natural gas demand to rise from 22% in 2016 to 26% in 2040, for several reasons. First, a growing urban population will require more gas-powered electricity. Second, both economic and environmental considerations favour natural gas, due to the combination of low prices and low CO_2 emissions, relative to other fossil fuels. Finally, growing extraction of unconventional natural gas reserves (such as shale, tight gas and CBM) in the US and China will dramatically increase natural gas demand over the outlook period. This is mainly due to lower prices resulting from higher natural gas supplies.

In 2011, the Fukushima Daiichi nuclear accident in Japan changed the course of nuclear energy use across the globe. Since the accident, global nuclear energy demand declined from 675 Mtoe in 2011 to 672 Mtoe in 2016. Many countries have restructured their energy mix by excluding nuclear energy from their demand priorities.

Apprehension towards potential risks surrounding nuclear energy has encouraged many countries to retire their old nuclear units and discontinue investment in existing ones.

Figure 3.3: Global energy demand in 2016 and 2040 by fuel source and fuel type (%)



Source: GECF Secretariat based on data from GECF GGM

According to the World Nuclear Industry Status Report, there was a significant decrease in the number of nuclear projects commissioned around the world in 2017. The number of newly constructed nuclear plants totalled 15 in 2010, decreasing to 10, 8 and 3 in 2013, 2015 and 2016, respectively. Only one new plant was built in the first half of 2017.

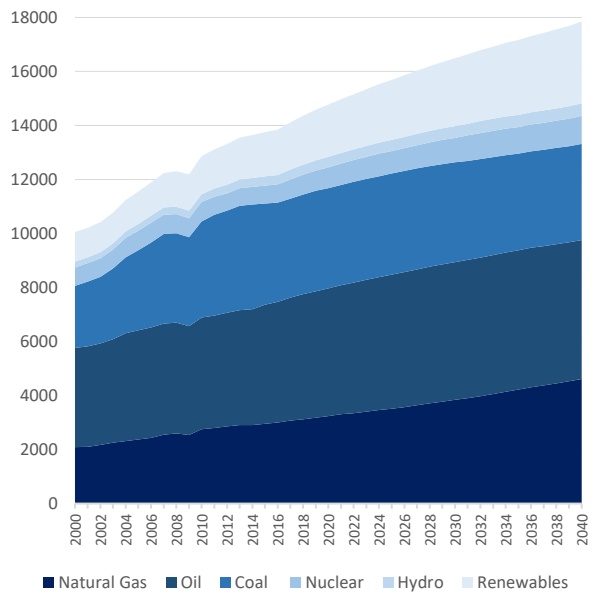
However, many governments have given initial approval to restart reactors after they passed comprehensive inspections which took into account revised regulatory standards post-Fukushima. Therefore, this Outlook considers 2017 to be a turning point for nuclear energy demand, which will start to increase and maintain a growth rate of 1.8% per annum over the long-term, reaching 1035 Mtoe in 2040.

In this Outlook, renewable energies are the fastest growing amongst all energy sources (fossil and non-fossil fuels) in terms of energy demand, with an average growth rate of 2.5% per annum. The 2.8% annual growth rate seen during the historical period is higher than for the forecast period due to energy efficiency reforms undertaken in some regions, such as the EU.

Renewables are not rivals to natural gas from the GECF standpoint: both have their own economic and environmental advantages, and this Outlook considers renewables as complementary fuels. Despite ambitious plans in some countries to increase the share of renewables in their energy mix and power sectors, natural gas is expected to remain the most prominent alternative fuel in the energy market over the outlook period.

Oil and coal will both lose their positions respective to other fuels. Over the historical period, oil and coal demand increased at an average growth rate of 1.2% and 3% per annum, respectively.

Figure 3.4: Global energy demand trends by fuel type (Mtoe)



Source: GECF Secretariat based on data from GECF GGM

Over the forecast period, demand for these carbon intensive fuels is expected to slow down, resulting in average growth rates of 0.6% for oil and -0.1% for coal. The share of oil will fall from 32% in 2016 to 29% in 2040. Coal will experience a decrease from 27% to 20% over the same period. Environmental policies and regulations, like the Paris Climate Agreement (COP 21) which obliges all regions to comply with emissions reductions, can explain this fall in oil and coal demand in the long-term.

Figure 3.4 and Table 3.2 outline energy demand trends and average growth rates by fuel source over the historical and forecast period, demonstrating growing demand for all fuels, except coal.

Table 3.2: Global primary energy demand by fuel type — Mtoe

Fuel	Historical				Forecast					
	2000	2010	2016	CAAGR 2000-2016	2020	2025	2030	2035	2040	CAAGR 2017-2040
Natural Gas	2092	2747	3002	2.3%	3237	3511	3839	4218	4611	1.8%
Oil	3671	4148	4462	1.2%	4730	4966	5107	5163	5146	0.6%
Coal	2300	3550	3678	3.0%	3716	3742	3689	3578	3562	-0.1%
Nuclear	676	720	672	0.0%	771	833	910	988	1035	1.8%
Hydro	226	293	350	2.8%	380	412	434	451	464	1.2%
Renewables	1088	1409	1686	2.8%	1935	2223	2513	2774	3034	2.5%

Source: GECF Secretariat based on data from GECF GGM

Global energy demand trends by sector

We posit that one of the key drivers of energy demand growth is economic development. However, economic prosperity cannot be well understood without dismantling its structure into various sectors.

In the context of energy demand, the Outlook classifies the economy into nine main sectors, namely:

- Domestic (residential, commercial, agricultural, fisheries and forestry),
- Industry (iron and steel, basic chemicals, non-ferrous metals, non-metallic minerals, and other manufacturing),
- Transport (road passenger, rail and road freight, shipping, aviation, and other transport such as pipeline transport),
- Feedstocks,
- Power generation,
- Heat generation,
- Hydrogen generation,
- Refinery,
- Other uses.

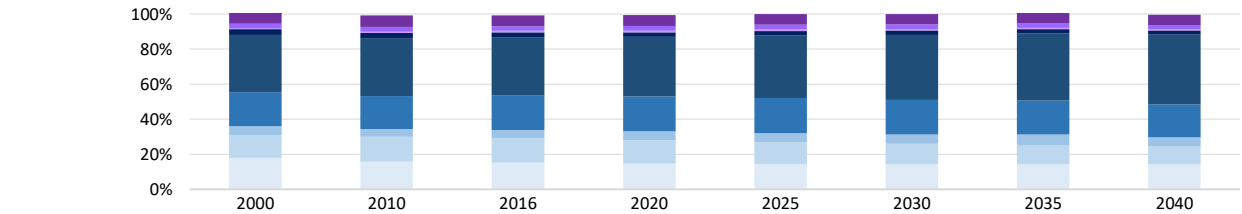
None of these sectors could survive without using energy; however, each has a context-specific energy demand attributed to technical, economic or social concerns. One of the advantages of breaking down energy demand by sector is the ability to explore the policy implications of sectoral energy use. For instance, countries hoping to improve energy efficiency strive to optimize their energy demand with respect to national interests. They need to highlight sectors that overconsume or require structural reforms to reduce inefficiencies.

Historically, the power generation and domestic sectors were major contributors to energy demand. Electricity is considered the most important secondary energy sourced from power plants. Domestic energy demand is largely driven by electricity and natural gas for heating and cooking, because most power plants have already switched, or are planning to switch, from coal and oil to natural gas. Figure 3.5 illustrates the share of global energy demand allocated to each sector over historical and forecast periods.

Over the outlook period, the GECF expects the power generation, transport and domestic sectors to consume more than 70% of global energy, with demand shares of 40%, 19% and 14%, respectively. An increasing global population, the need to generate more electricity and increasing demand for hybrid vehicles are some of the determinants that influence energy demand growth in the power generation, transport and domestic sectors.

On average in comparison to the historical period, growth in energy demand over the outlook period will decelerate for all sectors. However, power generation will maintain its position as the largest consumer over the outlook period. In 2016, the power sector consumed 4752 Mtoe of energy demonstrating a growth rate of 2.3% annually since 2000.

Figure 3.5: Share of global energy markets by sector (%)



	2000	2010	2016	2020	2025	2030	2035	2040
Other Uses	6%	7%	6%	6%	6%	6%	6%	6%
Refinery	3%	3%	3%	3%	3%	3%	3%	3%
Hydrogen Generation	0%	1%	1%	1%	1%	1%	1%	1%
Heat Generation	3%	3%	3%	3%	3%	2%	2%	2%
Power Generation	33%	33%	33%	34%	36%	37%	38%	40%
Transport	19%	19%	20%	20%	20%	20%	19%	19%
Feedstocks	5%	4%	5%	5%	5%	5%	6%	5%
Industry	13%	14%	14%	13%	12%	12%	11%	10%
Domestic Sectors	18%	16%	15%	15%	14%	14%	14%	14%

Source: GECF Secretariat based on data from GECF GGM

The transport sector is the second largest energy consumer worldwide. Over the outlook period, the GECF expects the transport sector to consume 3390 Mtoe of energy by 2040.

This indicates a growth rate of 0.8% per annum from 2016, which is however substantially lower in comparison with the 2.3% seen in the historical period.

The increased demand in this sector overall is mainly due to the forecast higher demand in non-OECD Asia countries. Conversely, the main reason for slower growth rates in the future is the improvement of global average fuel consumption.

By 2040, the average global energy demand growth rate per annum in the domestic sectors will drop by 0.2%. One of the key drivers of this decline is an increase in efficiency for household appliances, residential buildings and agriculture, where traditional energy-intensive methods are being replaced with more efficient, automated machinery.

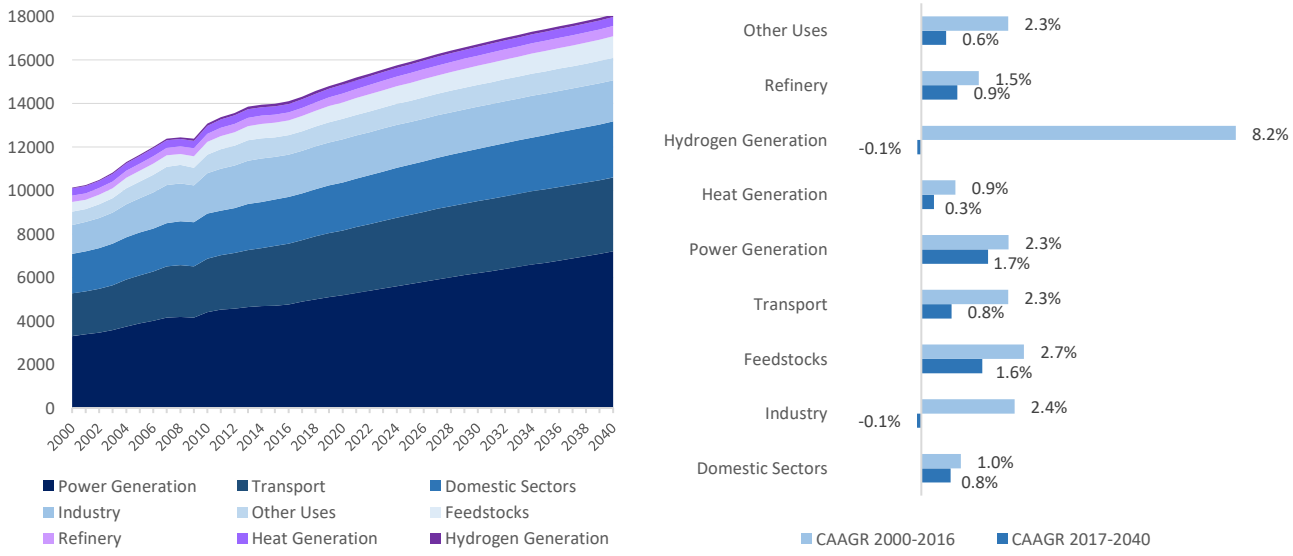
The most sluggish sector in terms of energy demand growth is industry. In 2016, the industrial sector consumed 1940 Mtoe of energy, and we forecast demand will decrease to 1887 Mtoe by 2040. Accordingly, during the outlook period, industrial energy demand growth will decline by 0.1% on average per annum. Sluggish industrial growth is mainly attributed to a prospective shift from heavy industry and manufacturing to a more service-oriented, less energy-intensive economy, particularly in non-OECD countries.

The consumption of energy in the feedstocks sector was 681 Mtoe in 2016, indicating a growth rate of 2.7% over the historical period. Consistent with other sectors energy demand, the feedstocks sector will experience a lower growth rate over the outlook period. It is projected that the sector will consume 995 Mtoe of energy in 2040, demonstrating a growth rate of 1.6% on average per annum.

Refinery and heat generation are forecast to be the next largest consumers of energy on a global scale by 2040. In 2016, the energy consumption in these sectors was 371 Mtoe and 385 Mtoe, representing a growth rate of 1.5% and 0.9% over the historical level. However, the GECF expects that refinery sector energy demand will exceed that of the heat generation sector over the outlook period and reaches to 465 Mtoe and 417 Mtoe, showing a growth rate of 0.9% and 0.3%, respectively.

Figure 3.6 illustrates projected global energy demand and associated growth rate by sector.

Figure 3.6: Global primary energy demand (Mtoe) and associated CAAGR (%) by sector



Source: GECF Secretariat based on data from GECF GGM

GECF Members energy demand trends: historical (2000-2016) and forecast (2017-2040)

GECF Member countries constitute the world's leading natural gas producers and exporters. In this section, we briefly report on the energy demand trends of GECF Members with respect to region, fuel and sector.

Since 2000 (one year before the GECF was officially established), energy demand in GECF Member countries increased from 1064 Mtoe in 2000 to 1497 Mtoe in 2016 (Table 3.3).

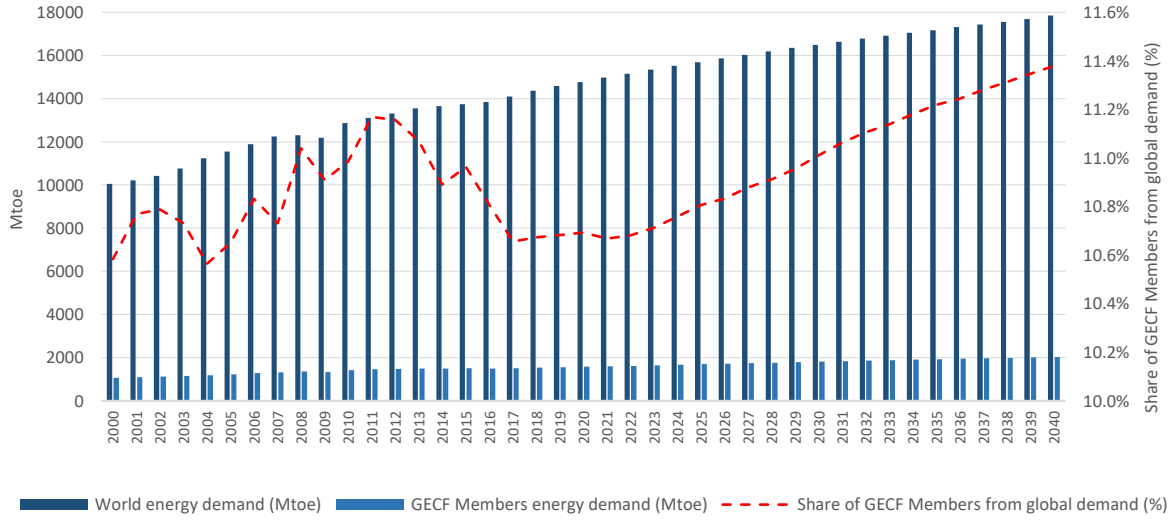
GECF Members' share of global energy demand fluctuated from 10.8% in 2000 to 11.2% in 2011, and 10.8% in 2016 (Figure 3.7).

Over the 2017 to 2040 outlook period, we expect that the GECF Members' energy demand will reach 2031 Mtoe, a 36% increase from 2016 levels, implying an average annual growth rate of 1.3%.

However, this growth rate is slower than the 2.2% per annum which was achieved over the historical period. The forecast slowdown is partially attributable to a 1.1% decrease in the average growth rate of global energy demand, which will impact on the economic development of the gas-exporting GECF Members.

The GECF's share of global demand declines in the mid-term to 10.8% in 2025, but increases to 11.4% by 2040. The GECF Members intend to enhance energy efficiency by implementing economic policies which decrease fossil fuel subsidies and facilitate price liberalization, and this will also contribute to the slowdown in energy demand growth rates over the forecast period.

Figure 3.7: Global and GECF Members' energy demand trends



Source: GECF Secretariat based on data from GECF GGM

Figure 3.7 compares global energy demand for the GECF Members over the historical and forecast period, along with GECF Member countries' share of global energy demand. Looking at historical trends in the GECF Member countries' fuel mix, the share of natural gas has increased at an annual average growth rate of 2.9%, from 483 Mtoe in 2000 to 764 Mtoe to reach a share of 51% in 2016 (Figure 3.8). Rich natural gas reserves, lower CO_2 emissions targets, and policies promoting energy self-sufficiency are the main drivers for such a dramatic increase.

Between 2000 and 2016, oil with an annual average growth rate of 1.8%, took second place in the GECF Members energy mix. Most GECF countries, (e.g. Iran, Iraq, Russia, Venezuela, Algeria, UAE), are also net crude oil exporters who use oil in their petrochemical and refinery sectors.

Accordingly, the consumption of oil has increased from 323 Mtoe in 2000 to 430 Mtoe in 2016. In 2016, coal, nuclear, hydro and renewables (including biomass and waste) were the next most popular energy sources among GECF Members, with the share of 7%, 3%, 2% and 8%, respectively. Over the historical period, after natural gas, renewables grew faster than other fuels with an annual average growth rate of 2.8%.

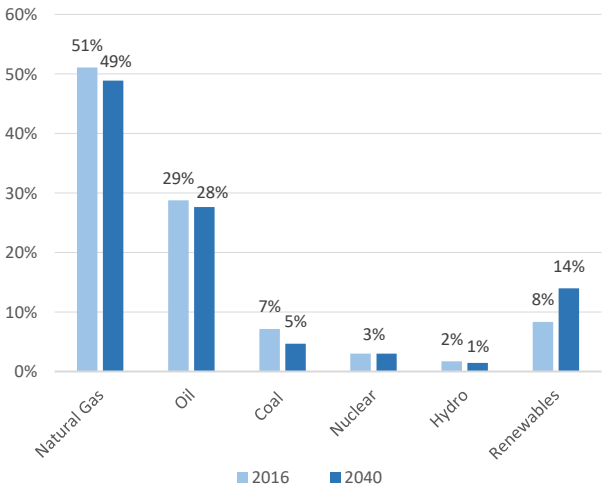
GECF Member countries have been largely dependent on fossil fuels due to their abundant reserves. However, global environmental concerns will drive the use of renewables over the outlook period. This report expects that by 2040 the share of renewables increases to 14%, with an average growth rate of 3.5% per annum.

In 2040, the share of natural gas will drop to 49% and its annual average growth rate will decline to 1.1% over forecast period, from 2.9% between 2000 and 2016. Coal will lose market share to natural gas and renewables, reaching 95 Mtoe in 2040, an annual decrease of -0.5% from 107 Mtoe in 2016 to 95 Mtoe in 2040. Russia is the main contributor to decreasing coal demand, reducing consumption from 104 Mtoe in 2016 to 73 Mtoe in 2040 at -1.4% growth per annum.

Increased use of natural gas is expected to offset this dramatic reduction. Nuclear and hydro should remain stable, with no changes to their shares of GECF Member countries' energy mix at 3% and 2%.

Overall, we expect natural gas to remain the dominant fuel in GECF Member countries' energy mix over the outlook period, due to economic and environmental advantages. Figure 3.8 and Table 3.3 outline energy demand trends in GECF Member countries and average growth rates by fuel source, over the historical and forecast period.

Figure 3.8: GECF Members' energy mix in 2016 and 2040 by fuel type (%)



Source: GECF Secretariat based on data from GECF GGM

Table 3.3: GECF Members' primary energy demand by fuel type Mtoe

Fuel	Historical				Forecast					
	2000	2010	2016	CAAGR 2000-2016	2020	2025	2030	2035	2040	CAAGR 2017-2040
Natural Gas	483	700	764	2.9%	809	846	897	946	992	1.1%
Oil	323	419	430	1.8%	447	482	514	542	561	1.1%
Coal	123	118	107	-0.9%	113	114	111	103	95	-0.5%
Nuclear	35	45	48	1.9%	46	61	69	72	72	1.7%
Hydro	22	24	25	1.0%	27	29	29	29	29	0.6%
Renewables	80	110	125	2.8%	139	166	199	236	284	3.5%
Total Consumption	1064	1413	1497	2.2%	1579	1695	1816	1927	2031	1.3%

Source: GECF Secretariat based on data from GECF GGM

GECF Members' energy demand trends by sector

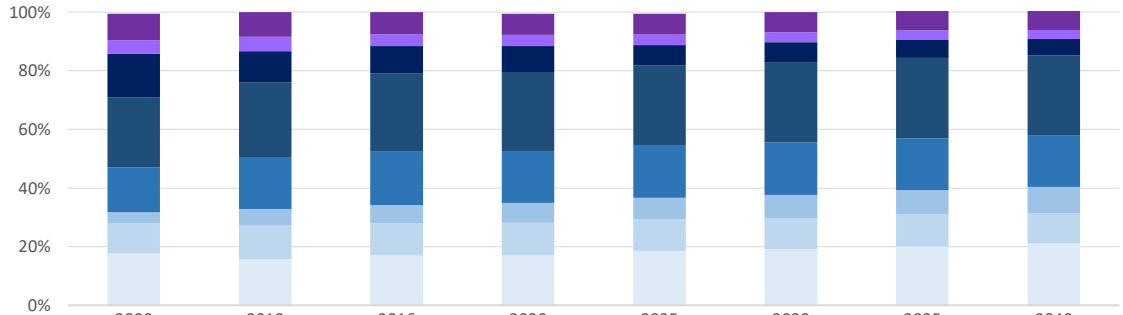
It is also essential to see which economic sectors in GECF Member countries contribute most to global energy demand. Most GECF Members are developing countries (e.g. Russia, Iran, Qatar, UAE), with economic growth potential over the next decades.

These countries possess rich fossil fuel resources, particularly natural gas, which contributes to rapid growth in most sectors and associated energy consumption over the outlook period.

As illustrated in Figures 3.9 and 3.10, the power sector is the largest consumer of energy over both the historic and outlook periods. In 2016, the power sector consumed over 400 Mtoe of energy, demonstrating an annual growth rate of 2.8%. By 2040, the GECF expects that power sector energy demand will rise to 558 Mtoe, but with a slower average growth rate of 1.4% per annum.

The main reason for such an increase in demand in the power sector is the change in population levels. It is projected that the number of households in GECF Member countries will increase to over 218 million by 2040. Consequently, the demand for electricity will increase significantly and therefore the power sector will require more energy to generate power.

Figure 3.9: Share of GECF Members' energy markets by sector (%)



	2000	2010	2016	2020	2025	2030	2035	2040
Other Uses	9%	8%	8%	7%	7%	7%	7%	7%
Refinery	5%	5%	4%	4%	4%	3%	3%	3%
Hydrogen Generation	0%	0%	0%	0%	0%	0%	0%	0%
Heat Generation	15%	11%	9%	9%	7%	7%	6%	6%
Power Generation	24%	26%	27%	27%	27%	27%	27%	27%
Transport	15%	17%	18%	18%	18%	18%	18%	17%
Feedstocks	4%	6%	6%	7%	7%	8%	8%	9%
Industry	10%	11%	11%	11%	11%	11%	11%	10%
Domestic Sectors	18%	16%	17%	17%	19%	19%	20%	21%

Source: GECF Secretariat based on data from GECF GGM

Higher population and urbanization growth in GECF Members countries will also substantially influence energy demand in the domestic sectors. In 2016, these countries consumed 256 Mtoe of energy in the domestic sectors indicating a growth rate of 1.8% per annum over the historical period.

The GECF projects that in 2040, domestic energy demand will increase to 433 Mtoe with a growth rate of 2.2% annually. Consistent with global energy demand trends, transport energy demand in GECF Member countries also will increase by 2040. It is expected that 357 Mtoe of energy will be consumed in this sector over the outlook period indicating a growth rate of 1.1% annually, compared to 2016 when the energy consumption of the transport sector was 276 Mtoe.

This increase can mainly be attributed to a growing number of personal cars, an increase in road transportation due to the development of infrastructure and a corresponding increase in rail and air transportation. For instance, lifting Iran's economic sanctions since 2015 has allowed the country to renovate its aviation sector through purchasing new aeroplanes that in the long-term will influence the associated energy consumption in this sector.

Unlike global energy trends, demand in the heat generation sector of GECF Member countries will continue to decline from 143 Mtoe in 2016 to 115 Mtoe in 2040 indicating a negative growth rate of 0.9%. This fall in consumption may be attributed to potential climate change in the future, resulting in less intensive winters.

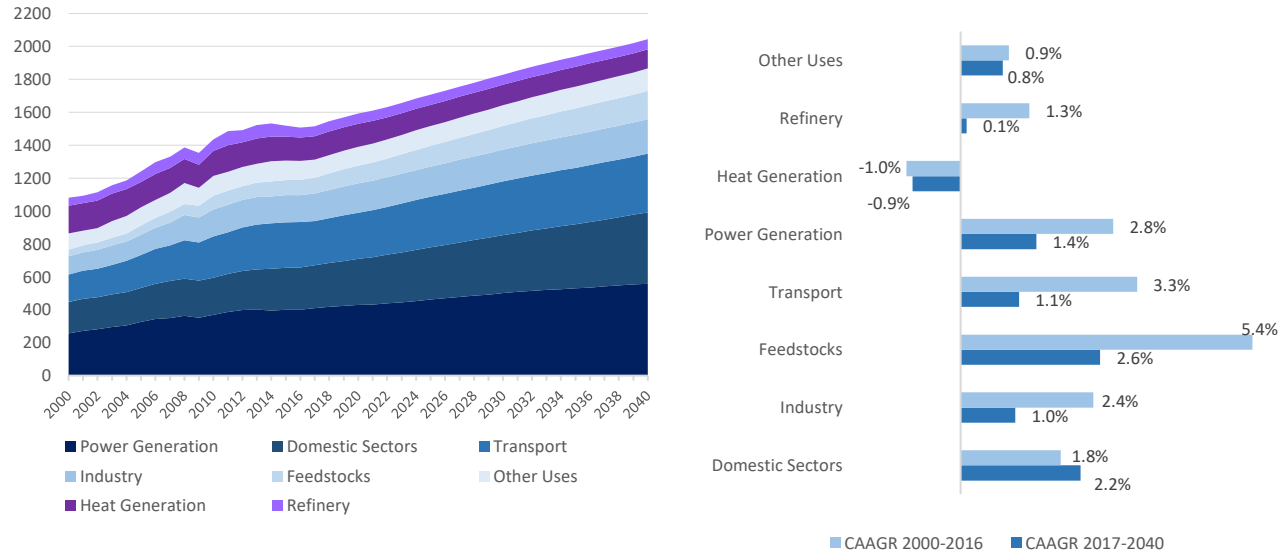
Demand in the refinery sector is also forecast to be sluggish in the GECF Member countries. By 2040, the sector energy demand will be 62 Mtoe compared to 60 Mtoe in 2016. This shows a growth rate of 0.1% over the outlook period.

Feedstocks is the fastest growing sector in both the historical and the outlook periods. In 2016, energy consumption in this sector was 94 Mtoe with a growth rate of 5.4% on average since 2000.

The GECF expects that by 2040, feedstocks will consume 172 Mtoe implying an annual average growth rate of 2.6%, and thus remain the fastest growing sector in the GECF Member countries.

Figure 3.9 illustrates the share of GECF Members energy demand allocated to each sector over the historical and forecast periods. Figure 3.10 demonstrates projected GECF Members energy demand and associated growth rate by sector.

Figure 3.10: GECF Members' primary energy demand (Mtoe) and associated CAAGR (%) by sector



Source: GECF Secretariat based on data from GECF GGM

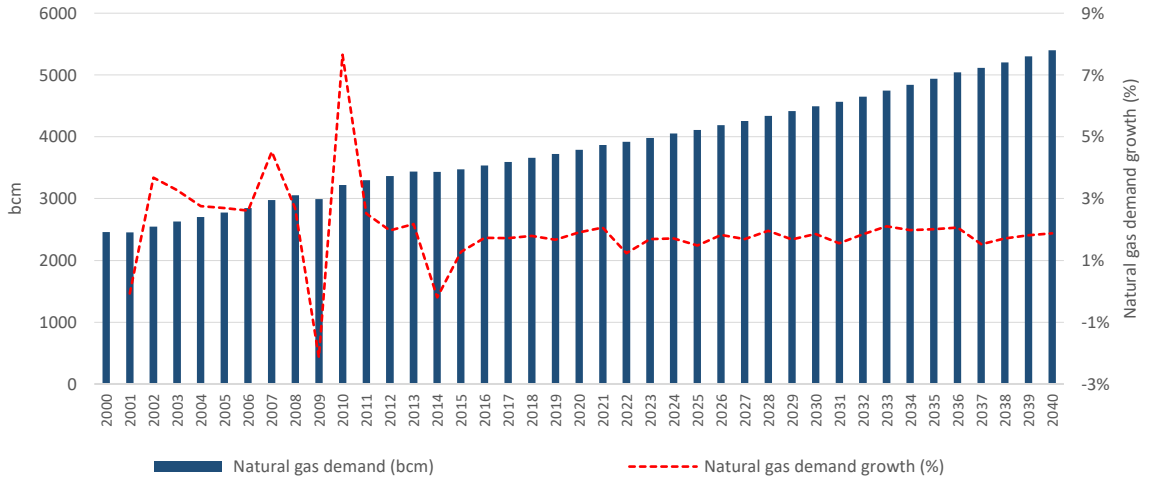
Natural gas demand trends

Global natural gas demand trends: historical (2000-2016) and forecast (2017-2040)

Natural gas is a relatively favourable fuel among all types of energy. Natural gas consumers can benefit from a combination of a lower-price environment, ample reserves and fewer emissions than other fossil fuels. Other fuels, whether conventional or unconventional, possess only one of these advantages. For instance, coal is the cheapest fossil fuel, but releases the most carbon emissions; wind turbines and solar panels have almost no negative effects on the environment, but their provision is relatively expensive and dependent on technological advancement. Flexibility makes natural gas an appealing alternative fuel that can be applied in all sectors.

The main consumer of natural gas is the power generation sector. Domestic consumption of natural gas is primarily for cooking, heating and cooling purposes. Furthermore, new reforms in natural gas markets are taking place, where countries attempt to consume more LNG and CNG in the transportation sector. These considerations make natural gas a reliable, cheap and clean fuel for the simultaneous benefit of the economy and environment. This section presents global natural gas demand, with respect to different regions and energy sectors, to investigate market trends given the aforementioned considerations. Figure 3.11 depicts trends in global natural gas demand by the annual amount of gas consumed and corresponding growth rates over the historical (2000-2016) and outlook periods (2017-2040).

Figure 3.11: Trends in global natural gas demand, 2000-2040



Source: GECF Secretariat based on data from GECF GGM

Regional natural gas demand trends

Regional differences in energy efficiency and self-sufficiency policies exist and affect natural gas consumption. In this section, we present regional natural gas demand according to economic, political or geographic characteristics.

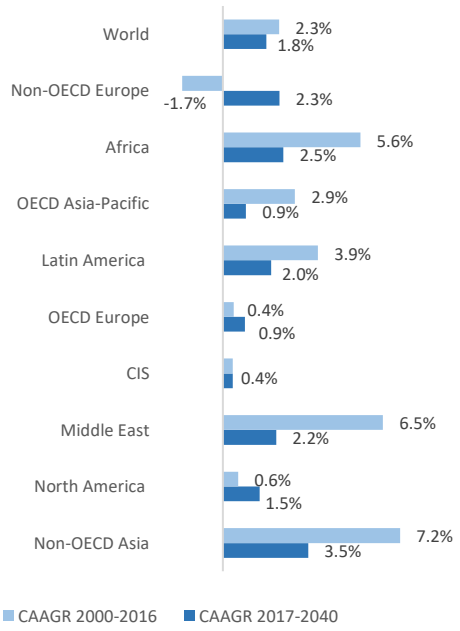
As illustrated in Table 3.4 and Figures 3.11 and 3.12, global natural gas consumption increased from 2457 bcm in 2000 to 3534 bcm in 2016, corresponding to an annual average growth rate of 2.3%.

The 2009 financial crisis negatively impacted natural gas consumption, which dropped from 3055 bcm in 2008 to 2990 bcm in 2009. The GECF expects that, over the forecast period, global natural gas demand will continue to increase around 5395 bcm in 2040, representing an average growth rate of 1.8% per annum.

This can mainly be attributed to continued economic development in non-OECD emerging economies, such as India and China, coupled with increasing environmental concerns and carbon emission reduction policies.

In 2016, North America (excluding Mexico) was the largest consumer of natural gas, at 835 bcm, accounting for 24% of global demand (Figure 3.13). Between 2000 and 2016, the average growth rate of gas consumption in the region was 0.6% per annum, indicating only a slight increase in demand during that period. The GECF expects that gas demand will keep rising and reach 1194 bcm by 2040, with an average growth rate of 1.5% per annum.

Figure 3.12: Natural gas demand growth rate by region (%)



Source: GECF Secretariat based on data from GECF GGM

This projection shows that North America will remain one of the main drivers of global natural gas demand, which is not surprising given it is the largest developed economy in the world.

This is primarily attributable to shale gas development in the US over the past decade. Exploitation of abundant unconventional reserves has lowered prices and made natural gas an attractive alternative for power generation, when compared to other fuel types,

such as nuclear. Natural gas demand in the US will increase during the forecast period by an annual rate of 1.6%, from 741 bcm in 2016 to 1086 bcm in 2040. The role of the power and industry sectors are key drivers for demand during the outlook period.

In 2016, the region that contributed most to natural gas demand after North America was the CIS, with respect to actual consumption (586 bcm). However, the average growth rate over the historical period was 0.4%, indicating a very slow annual increase in demand.

This report expects that by 2040, growth in the CIS region will remain at 2016 levels, corresponding to demand of 648 bcm by 2040 (see Figure 3.13). As a result, demand from the region as a percentage of total global demand will fall from 16% in 2016 to 12% in 2040. Economic and political drivers can explain this lethargic trend, including underdeveloped financial markets, trade embargoes with Russia, economic partnerships that are increasingly oriented toward China, and uncertain political conditions.

Table 3.4: Global natural gas demand by region bcm

Region	Historical				Forecast					
	2000	2010	2016	CAAGR 2000-2016	2020	2025	2030	2035	2040	CAAGR 2017-2040
World	2457	3219	3534	2.3%	3791	4112	4496	4939	5395	1.8%
Africa	58	105	139	5.6%	151	167	187	216	249	2.5%
CIS	549	599	586	0.4%	603	613	630	638	648	0.4%
Latin America (incl. Mexico)	134	223	246	3.9%	255	275	309	342	394	2.0%
Brazil	9	27	35	8.7%	35	42	53	66	83	3.7%
Middle East	174	369	479	6.5%	543	599	665	733	803	2.2%
Non-OECD Asia	174	389	531	7.2%	604	747	899	1040	1207	3.5%
China	24	108	213	14.8%	267	366	469	567	660	4.8%
India	27	64	56	4.6%	68	90	107	117	139	3.9%
Non-OECD Europe	27	24	20	-1.7%	23	27	30	31	35	2.3%
North America (excl. Mexico)	756	765	835	0.6%	883	933	989	1104	1194	1.5%
US	668	678	741	0.7%	785	834	887	1001	1086	1.6%
OECD Asia-Pacific	134	198	212	2.9%	221	214	223	245	266	0.9%
Australia	23	35	40	3.5%	52	50	56	62	68	2.3%
Japan	85	114	122	2.3%	114	106	106	115	113	-0.3%
South Korea	20	45	46	5.3%	50	53	57	64	80	2.4%
OECD Europe	453	546	486	0.4%	507	537	565	588	603	0.9%
France	42	48	44	0.3%	44	45	48	58	59	1.2%
Germany	77	93	85	0.6%	87	94	96	94	91	0.3%
UK	101	99	80	-1.5%	82	89	91	91	90	0.5%

Source: GECF Secretariat based on data from GECF GGM

Although non-OECD Asia was ranked third in terms of actual natural gas consumption in 2016, the region experienced the most dramatic rise in annual average growth rates amongst all regions. Gas demand in non-OECD Asia is largely dependent on China and India adopting policies that favour gas rather than coal in an attempt to improve air quality.

In fact, rapid economic development in these countries has been the main driver, leading to a growth rate of 7.2% in non-OECD Asia over the historical period, from 174 bcm in 2000 to 531 bcm in 2016.

The largest average growth rate amongst all regions can be seen in China, where demand increased dramatically over the historical period, from 24 bcm in 2000 to 213 bcm in 2016, an annual rate of 14.8%. Looking ahead, the switch from coal to gas power plants represents huge potential for further increases in consumption over the forecast period. Earlier this year (May 2017), China overtook South Korea for the first time and became the world's second largest LNG importer, after Japan.

In 2016, gas demand in non-OECD Asia totalled 15% of global consumption. The GECF expects it will rise to 22% of global consumption, with an actual demand of 1207 bcm in 2040 (Figure 3.13). This is primarily attributed on the one hand to China's environmental policies and reforms to address serious air pollution concerns, which could significantly increase the share of natural gas in China's energy mix. Several coal-burning plants are expected to shut down in the next decades, and the Chinese government is making price adjustment policies to encourage natural gas consumption.

On the other hand, natural gas demand in India will go up from 56 bcm in 2016 to 139 bcm in 2040, driven partially by an improvement in the economic prospects of the country, new gas infrastructure, increased domestic supply and low LNG prices. Currently, there are four operational LNG import and regasification terminals in India, and the country has the capacity to import around 28 mn mt per year of LNG through these terminals. However, the public sector oil marketer, Indian Oil Corporation, plans to increase the capacity of Petronet LNG's Dahej terminal by an additional 1 million tonnes per annum.

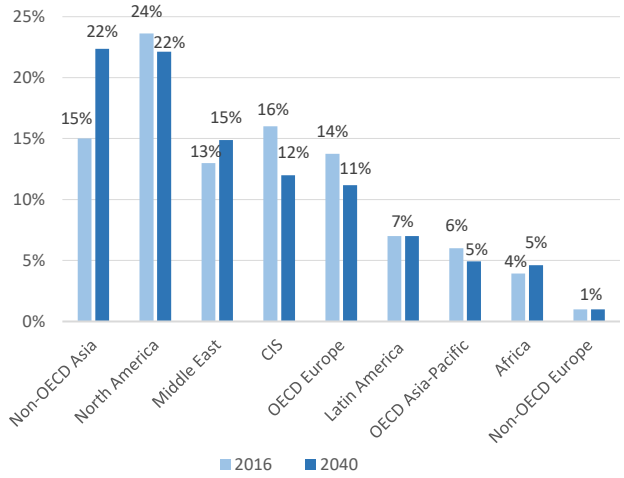
OECD Europe and the Middle East were also important contributors to global natural gas consumption in 2016, with gas demand totalling 486 bcm and 479 bcm, respectively. A large portion of gas consumption in the Middle East is attributed to Iran (Figure 3.15).

Over the outlook period, it is expected that natural gas demand in the Middle East will rise to 803 bcm, with an average growth rate of 2.2% per annum. This is equivalent to 15% of total global demand. Most of the countries in this region possess rich natural gas reserves, which enhance their energy self-sufficiency and the share of natural gas in their energy mix. Moreover, economic development and population growth will be key drivers for increasing gas consumption.

Gas demand in OECD Europe will increase to 603 bcm in 2040, representing an annual average growth rate of 0.9% between 2017 and 2040. This comparable slowdown can be attributed to energy efficiency policies, supply security concerns and declining domestic reserves, factors that make other types of energy, such as renewables, more attractive in this region. France, Germany and the United Kingdom (UK) together consume about 240 bcm of gas in 2040.

In the UK, the carbon price mechanism has significantly improved the economics of burning gas in power generation compared to coal. However, the withdrawal of the UK from the EU perhaps affects the UK's energy security and gas demand in the future (see Box 3).

Figure 3.13: Regional share of overall natural gas consumption in 2016 and 2040 (%)



Source: GECF Secretariat based on data from GECF GGM

Germany as the largest consumer of gas in the EU consumed around 85 bcm of gas in 2016. Over the outlook period, natural gas demand in Germany is projected to grow at an annual average growth rate of 0.3% to 91 bcm in 2040. France also consumed 44 bcm of gas in 2016. The demand for gas will rise by 34% to 59 bcm in 2040, mainly because of nuclear safety issues and carbon emission reduction policies set by EU.

Latin America (including Mexico) consumed 246 bcm of gas in 2016, experiencing a strong annual average growth rate of 3.9%. Brazil was one of the main contributors to this growth, with gas demand increasing from 9 bcm in 2000 to 35 bcm in 2016, a growth rate of 8.7% per annum. Additionally, Mexico consumed about 82 bcm of gas in 2016, making it the ninth biggest consumer of gas in 2016 (see Figure 3.15). Despite a forecast increase in actual consumption to 394 bcm in 2040, the GECF expects that Latin America will experience a slowdown in gas demand growth over the outlook period to a CAAGR of 2.0% per annum.

Box 3. Brexit and the future of UK energy demand

The decision of the UK to withdraw from the EU was made in a referendum on June 23rd, 2016. It was perhaps the most significant political and economic change that has taken place since the EU was created. One of the major aspects of the UK's "Brexit" concerns its energy security and demand.

Under withdrawal regulations, there are certain scenarios that the UK will have to deal with concerning potential energy security issues. However, we do not intend to examine the political and legal aspects of Brexit in this report, focussing instead on how the country's energy mix trends and natural gas in particular will be affected by this referendum.

Between 2000 and 2016, annual average growth for most fuels in the UK was negative except for hydro and renewables. In 2000, natural gas demand reached its highest level, peaking at 101 bcm, and has since declined. This decline can be mainly attributed to the EU's Green Energy Policies which encourage the use of renewables rather than fossil fuels. The extraordinary growth rate of renewables between 2000 and 2016 (a dramatic 10.4% per annum) confirms this supposition.

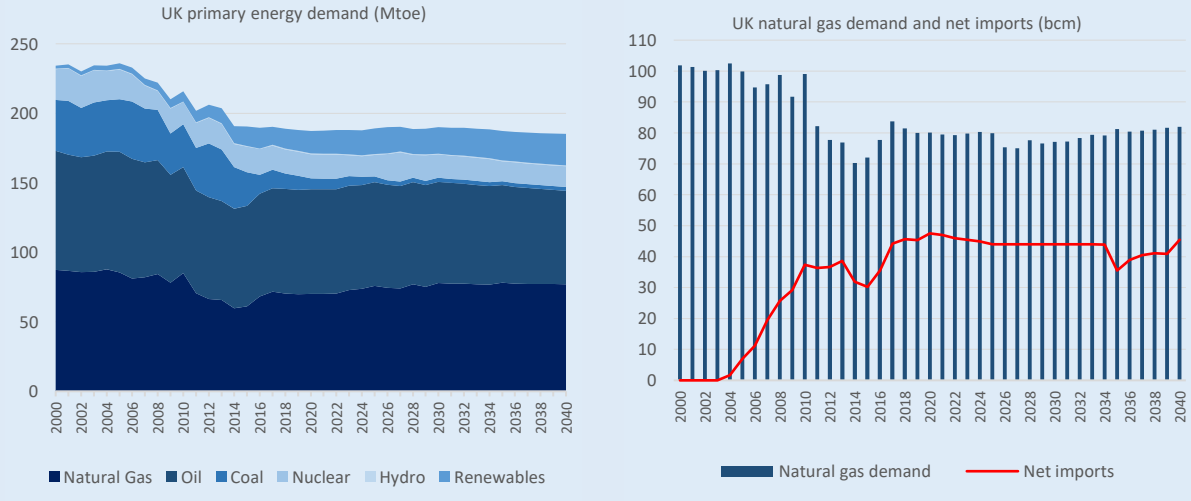
Between 2017 and 2040, the GECF expects an annual average growth rate of around 0.5% per year for the UK, which means gas demand should peak at about 90 bcm in 2040. This implies that the country would have relatively little dependency on natural gas supplies from the EU. However, economic reforms following Brexit will increase gas demand, specifically in power generation which in turn will increase import requirements.

The UK government needs to ensure that the security of gas supplies in the long-term is maintained. Thus, market structures such as appropriate supply contracts in terms of price, source and duration, plus the securing of the country's technical infrastructure such as the production of shale gas or the construction of further gas storage and LNG terminals are two key factors which will influence the UK's security of gas supplies post-Brexit. Figure 3.14 illustrates UK energy demand by fuel type, as well as UK net gas imports over the historical and forecast period.

However, the UK government needs to ensure that the security of gas supplies in the long-term is maintained. Thus, a market structure which includes appropriate supply contracts in terms of price, source and duration and technical infrastructure such as the production of shale gas or the construction of further gas storage and LNG terminals are the two key factors influencing the UK's security of gas supplies after Brexit. Figure 3.14 illustrates UK energy demand by fuel type, as well as net gas imports over the historical and forecast period.

Since 2004, the UK has become a net importer of natural gas either via pipeline or as LNG from EU countries such as France and the Netherlands, or other regions of the world. This has been necessitated by the depletion of British oil and gas reserves in the North Sea. Currently, 43% of UK gas demand is supplied from the North Sea and 13% imported as LNG. The remainder is supplied through gas interconnections between the UK gas network and Europe. Thus, it is forecast that UK natural gas imports will continue to grow over the long-term.

Figure 3.14: The UK's primary energy demand (Mtoe) and net gas imports (bcm)



Source: GECF Secretariat based on data from GECF GGM

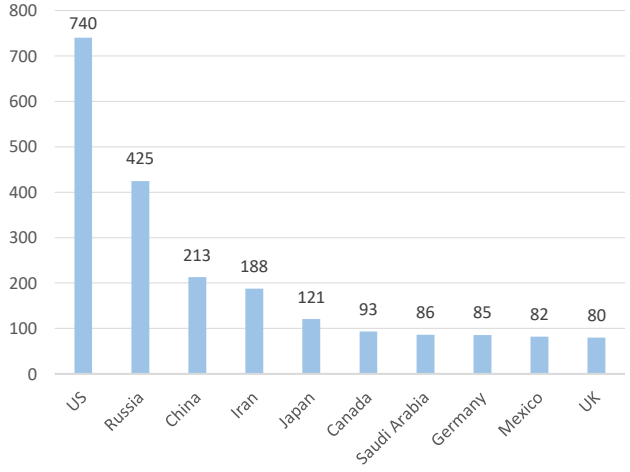
Over the historical period, the OECD Asia-Pacific region consumed 134 bcm of gas in 2000 and 212 bcm in 2016, representing an average growth rate of 2.9% per annum. Economic development was the main driver for this upturn in demand.

Japan and South Korea accounted for 122 bcm and 46 bcm of gas demand respectively in 2016. After the Fukushima nuclear accident in Japan, the country's demand for natural gas (mainly in the form of LNG) significantly increased (see Box 4).

South Korea also plans to replace coal-fired power plants under construction with LNG-based power turbines to address the country's public health concerns. The country has some 60 coal-fired power plants, and dozens more are under construction. The anti-pollution measures would boost demand for LNG.

Natural gas demand in Australia increased from 23 bcm in 2000 to 40 bcm in 2016, mostly due to the decrease of coal-fired power generation. Australia has been facing rising gas prices in recent years and there are concerns of potential shortages in the east coast market in the near future. This report anticipates that domestic market demand will increase to 68 bcm in 2040, due to the completion of the remaining LNG projects.

Figure 3.15: The world's biggest gas consumers in 2016 (bcm)



Source: GECF Secretariat based on data from GECF GGM

Despite an increase in actual consumption, the GECF expects that Latin America and the OECD Asia Pacific region will experience a slowdown in gas demand growth over the outlook period, by 2% and 0.9% respectively. Milder weather conditions and slower economic development are the most important factors influencing this decline. The reopening of nuclear plants in Japan may also drive this trend, along with increased investment in renewables and alternative fuels.

Africa and non-OECD Europe are ranked as the smallest natural gas consumers across all world regions. In 2016, natural gas demand in these regions was 139 bcm and 20 bcm, respectively. The average growth rate over the historical period was 5.6% and -1.7% for Africa and non-OECD Europe.

African natural gas demand growth is mainly attributed to economic development in South Africa and rich natural gas reserves in the northern part of the continent. Other significant gas users are Egypt and Algeria, which consumed 49 bcm and 41 bcm respectively in 2016.

Over the outlook period, Africa's gas demand growth is expected to be significantly lower at 2.5% per annum, with demand rising to 259 bcm in 2040. Gas use will remain concentrated in the power generation and industry sector. Population growth and the associated increase in electricity demand are the main drivers for growth in Africa.

Non-OECD Europe, with 35 bcm consumption in 2040 will remain as the least significant natural gas consuming region. The main factors influencing demand growth in this region are improving economic activities, (e.g. GDP growth) and a lower dependence on international prices, which stimulate more demand for gas.

Figure 3.13 indicates the share of regional gas demand over the historical and forecast period. Figure 3.15 illustrates the world's top 10 gas consumers in 2016.

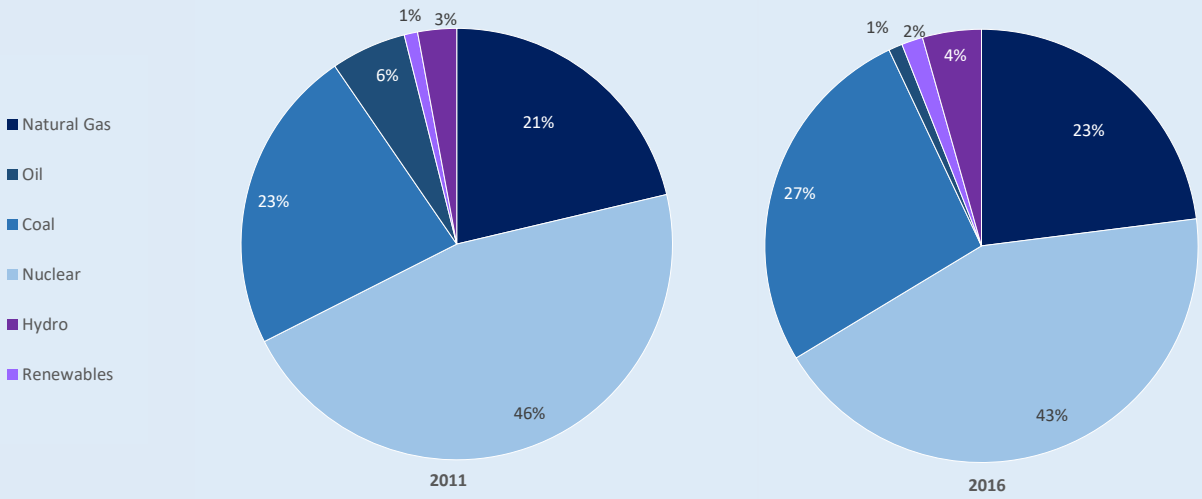
Box 4. Japan and its future natural gas demand

Japan is one of the top five developed economies in the world, and its advanced industries and large population require a vast amount of energy. Significantly, this island on the shore of the Pacific Ocean lacks fossil fuels reserves, in particular, natural gas.

Historically, Japan has not been self-sufficient in terms of its energy needs, depending heavily on imports of oil and LNG. Since 2011's nuclear accident at the Fukushima Daiichi Nuclear Power Station, known as the Great East Japan earthquake, the Japanese government has applied substantial changes to the country's energy policy (i.e. shutting down nuclear plants) which have resulted in a sustained boost to LNG demand through to 2016. Imports of 83 Mt of LNG made Japan the largest LNG consumer in Asia, accounting for 37% of global LNG imports in 2016. Figure 3.16 compares the share of fuels in Japan's energy mix in 2011 and 2016.

As shown in Figure 3.16, demand for oil decreased by 3%, from around 217 Mtoe in 2011 to 194 Mtoe in 2016. Also, the share of nuclear energy decreased dramatically by 5% per annum from 27 Mtoe in 2011 to 5 Mtoe in 2016. The decrease in Japanese nuclear production was the result of the nuclear disaster at Fukushima, as the shutdown of nuclear facilities precipitated a concomitant increase in LNG imports. The forecast decline in LNG usage is a consequence of the reopening of (currently five) nuclear plants plus the introduction of renewables.

Figure 3.16: Japan's energy mix in 2011 and 2016 (%)



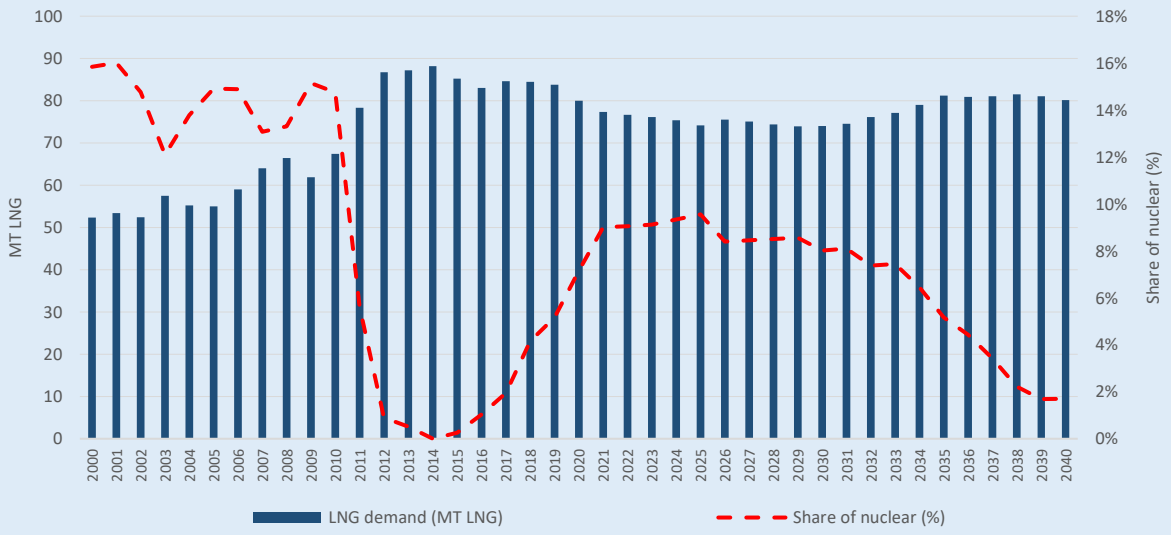
Source: GECF Secretariat based on data from GECF GGM

A major concern derives from the gap between demand and LNG contracted volumes. Japan now faces a new challenge, namely a significant oversupply, as demand starts to lag behind LNG contracted volumes. Currently, there is a major legal issue for LNG contracts which was raised by Japan's Free Trade Commission. In June 2017, the commission stated that LNG contracts contained substantial anticompetitive clauses such as the prevention of the resale of FOB LNG cargoes, which significantly restricts fair competition in this trade. In order to manage the potential oversupply issue, the commission would oblige sellers to eliminate such restrictions in new form or extended LNG contracts.

Figure 3.17 shows LNG demand recovering in the 2030s after a dip in the 2020s, and the share of nuclear peaking around 2022 and declining to 2% by 2040.

However, the Japanese government is still struggling with the potential risks that restarting nuclear power may bring to its country. High levels of radioactive waste and unpredicted tsunamis are among the top risks which are encouraging the use of LNG as a clean and economic fuel substitute.

Figure 3.17: Japan's LNG demand (Mt LNG) and the share of nuclear (%) in energy mix



Source: GECF Secretariat based on data from GECF GGM

Global natural gas demand trends by sector

Electricity dominates all aspects of daily life. It is not surprising that the power generation sector is the main contributor to and consumer of global natural gas demand. Currently, 2790 natural gas-fired power plants are active and operational worldwide, with an average design capacity of 434 MW.

Demand for gas in the power sector increased from 692 bcm in 2000 to 1280 bcm in 2016, with an annual average growth rate of 3.9%. This represents 36% of the gas consumed amongst all energy sectors in 2016. The GECF expects that consumption in the power sector will continue to increase to 2329 bcm in 2040, with an average growth rate of 2.5% per annum. (See Figure 3.18 and Figure 3.19).

Consistent with global trends, power plants in North America are the largest consumers of natural gas in the world. In 2016, they consumed 314 bcm of natural gas to generate electricity. Over the outlook period, the GECF expects these trends to continue, reaching 653 bcm in 2040.

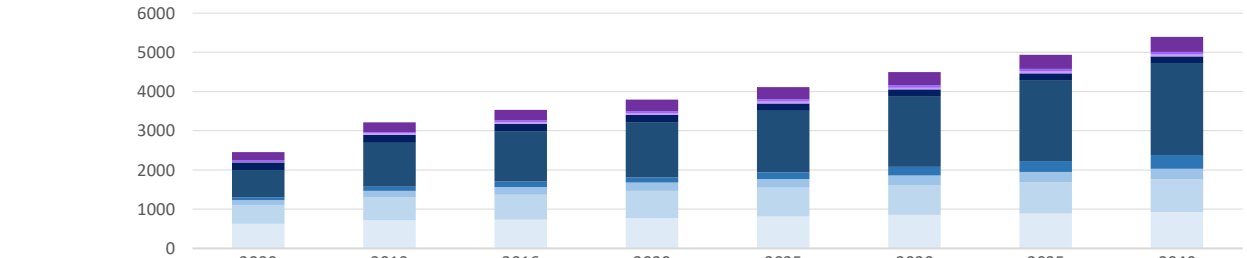
The power sector of non-OECD Asia is the next largest consumer of natural gas accounting for 432 bcm, mainly driven by China and India.

China's government has implemented an air pollution reduction policy, particularly in metropolitan areas. After joining the Paris Agreement, China increased the share of natural gas in its energy mix. According to its Five-Year Plan (FYP) through to 2020, the capacity of gas-fired power plants will increase significantly to 100 GW. This implies that natural gas consumption in the power generation sector will reach 44 bcm by 2020, up from 33 bcm in 2016.

India is another influential player in non-OECD Asia. India's massive demand for electricity has spurred the reopening of gas-fired power plants and an increase in electrical power capacity. Over the outlook period, the GECF expects that demand in India's power sector will rise from 16 bcm in 2016 to 31 bcm in 2040.

Moreover, India's government has initiated a series of gas price reduction reforms to encourage domestically produced gas in line with low international prices. As a result, determinants for gas demand in India in the long-run are: relatively reasonable prices, the advancement of renewables (installed renewables capacity is expected to more than treble by 2022 to 175 GW), coal policies, and the development of infrastructure, specifically in rural areas.

Figure 3.18: Global natural gas demand by sector (bcm)*



	2000	2010	2016	2020	2025	2030	2035	2040
Other Uses	213	253	270	291	307	334	361	387
Refinery	42	30	48	55	59	61	65	66
Hydrogen Generation	8	37	43	47	46	47	48	48
Heat Generation	198	203	190	195	188	188	189	187
Power Generation	692	1122	1280	1397	1570	1783	2052	2329
Transport	70	108	138	130	172	225	277	347
Feedstocks	122	164	194	206	223	243	258	270
Industry	484	583	637	701	732	763	801	838
Domestic Sectors	629	719	734	770	814	852	888	926

**The sector totals are for total gas consumption of, including gas derived from other fuels (e.g. gas works) and incorporated into the gas network.*

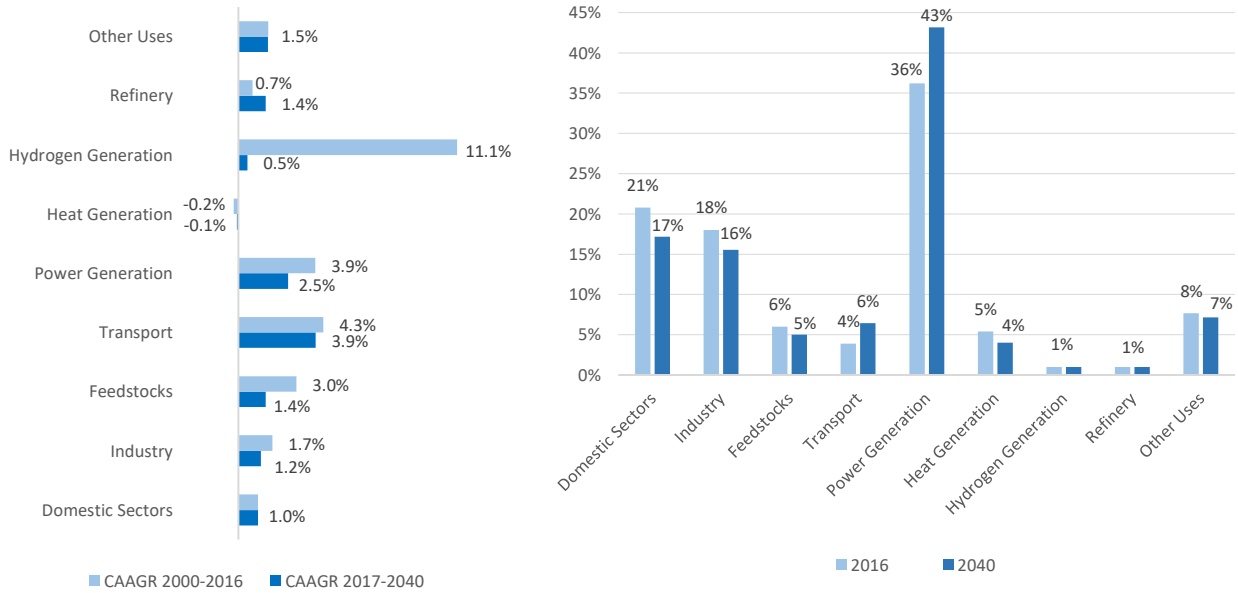
Source: GECF Secretariat based on data from GECF GGM

The Middle East is the third largest consumer of gas in the power sector. Demand in the region will account for 356 bcm in 2040, followed by OECD Europe (215 bcm), the CIS (199 bcm) and Latin America (including Mexico), 187 bcm (Figure 3.20).

The domestic sectors are the second biggest source of natural gas demand, which include the residential, commercial, and agricultural sub-sectors. In 2016, 734 bcm or 21% of total sectoral demand of gas was consumed in the domestic sectors, up from 629 bcm in 2000. This represents an annual average growth rate of 1% over the historical period.

For the GECF forecast period, gas consumption in the domestic sectors will increase to 926 bcm by 2040, representing a similar average annual growth rate of 1%. The growth rate is expected to level off, mainly due to efficiency improvements made in heating and cooling instruments and household appliances.

Figure 3.19: Natural gas demand growth rate by sector (CAAGR) and as a percent of total consumption (%)



Source: GECF Secretariat based on data from GECF GGM

Moreover, self-generated technologies (such as standalone power systems) can have an impact on gas consumption.

Due to ample supply and low prices, natural gas has significant implications and a broad range of uses for domestic manufacturing in the industry sector.

Industry is the third largest consumer of gas, and constituted 18% of total sectoral demand worldwide in 2016, increasing from 484 bcm in 2000 to 637 bcm in 2016, corresponding to an average growth rate of 1.7% per annum. Over the projected period, it is expected that consumption will continue to increase by an additional 201 bcm over the next 24 years, with an average annual growth rate of 1.2%. Although the absolute amount increases, the growth rate drops over the outlook period, mainly due to restricting efficiency measures and economic restructuring towards a more service-oriented society.

In 2040, China (144 bcm) and the US (114 bcm) are the main contributors to gas demand in the industrial sector, totalling 31% of total consumption.

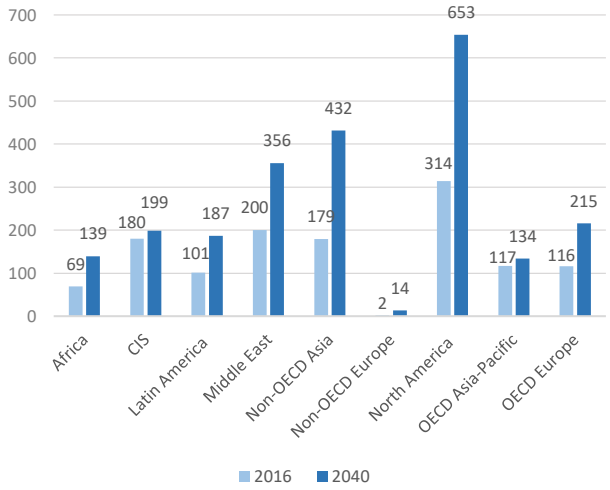
Over the past decade, the transportation sector has received growing attention from an environmental point of view. Currently, air pollution is one of the most challenging debates amongst policy makers and the scientific community, and to this end, car manufacturers have expanded their R&D plans to produce safer and cleaner cars. For both safety and environmental reasons, natural gas is the best substitution for liquid transport fuels such as oil.

Accordingly, natural gas demand from the transport sector was 138 bcm in 2016, having increased at an annual average growth rate of 4.3% from 2000 to 2016. It is expected that between 2017 and 2040, the consumption of gas in the transport sector will more than double, to 347 bcm, representing an average growth rate of 3.9% per annum. Disaggregating the transport sector into road, marine and aviation indicates that the major driving forces behind this dramatic increase are environmental policies, followed by local government policies.

Since January 2015, in restricted emission zones such as Canada, Europe and the US, sea cargo and passenger ships must use fuel with a sulphur content of less than 0.1%. The International Air Transport Association (IATA) has also set ambitious targets for CO_2 reductions by demanding significant improvements in fuel efficiency, with annual average reductions of 1.5% until 2020.

Additionally, natural gas could make significant inroads into the transport sector by increased demand from road transport. The relatively low price of natural gas (e.g. CNG) compared to gasoline and diesel can incentivize fuel switching in truck and train transport. However, this requires higher investments in infrastructural development, such as fuelling stations.

Figure 3.20: Regional natural gas consumption in the power sector (bcm)



Source: GECF Secretariat based on data from GECF GGM

Production in industries for manufacturing processes such as steel, fertilizer, petrochemicals, urea, methanol, and ammonia requires natural gas as a feedstock. In 2016, the feedstocks sector consumed 194 bcm of natural gas, with an average growth rate of 3% since 2000. However, demand growth will slow through to 2040, averaging 1.4% per annum, to reach 270 bcm. Russia, India, Iran, the US and China are the main contributors to natural gas demand in the feedstocks sector over the outlook period.

Natural gas demand is expected to remain limited in other sectors. Declining demand can be seen in the heat generation sector over our projection period, from 198 bcm in 2000 to 190 bcm in 2016 and to 187 bcm in 2040. However, demand in the refinery sector will increase slightly, from 48 bcm in 2016 to 66 bcm in 2040, with an average growth rate of 1.4% per annum.

Hydrogen generation is a relatively new sector in the 2017 GECF Outlook and is being considered due to its importance in energy policies. Hydrogen is derived from other fuels: natural gas reformation (reformation of oil

and coal as an alternative to gas), or via electrolysis using electricity. Hydrogen is used in the transport sector (hydrogen fuel cell vehicles), the power sector (fuel cells), in the refinery sector (hydrogen cracking), the petrochemical sector (hydrogen reforming), and it can also be added to the natural gas grid and blended with methane (in this context CO_2 can be captured post-combustion, combined with hydrogen to create a synthetic gas, and fed into the gas grid). Hydrogen is a prominent element that is used in oil refining and in the production of ammonia and methanol.

Not only are hydrogen fuel cells more efficient than electric batteries for long-distance transportation, but hydrogen-powered vehicles have zero emissions, as they only emit water vapour. Hydrogen therefore has the potential to become a more important energy source in the future and as such needs to be included in energy balances.

Consequently, the demand for natural gas in hydrogen generators is expected to increase over the outlook period to 48 bcm in 2040.

We categorise certain uses of natural gas in a separate sector, under the name "Other Uses," which includes own consumption of gas in power plants and losses from network transmission and distribution pipelines. We expect that consistent with overall gas demand, this sector's contribution to gas consumption will increase from 260 bcm in 2016 to 384 bcm in 2040.

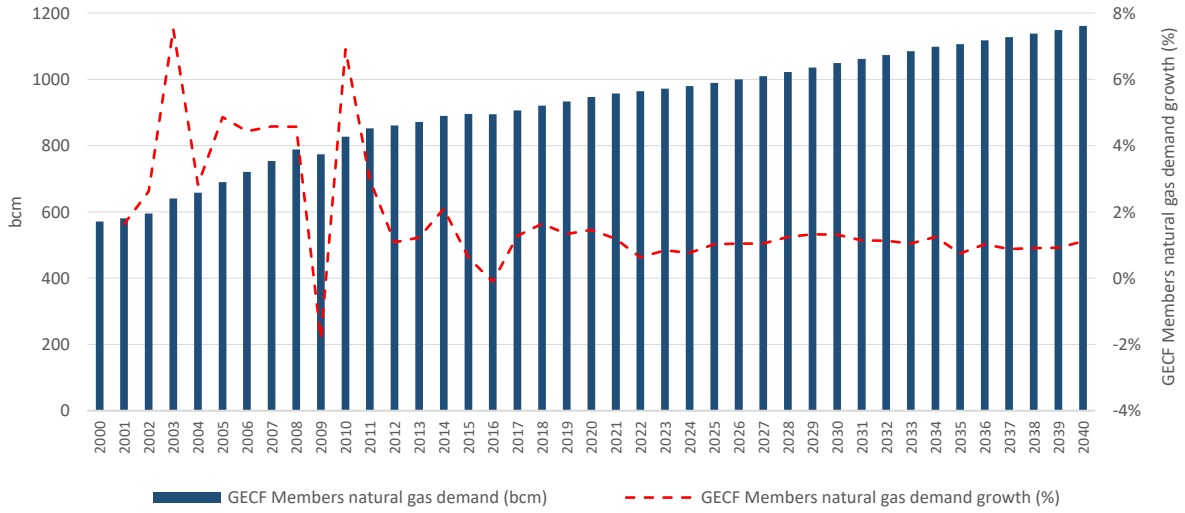
Natural gas demand trends in the GECF countries: Historical (2000-2016) and forecast (2017-2040)

Energy self-sufficiency is a defining unique characteristic of the GECF Member countries. This move to self-sufficiency persuades GECF Members to see natural gas as a favourable alternative fuel to meet their energy needs over other types of fuels. Unlike other fuels, natural gas has both economic and environmental advantages for them. For example, large countries such as Iran and Russia have substantial issues of air pollution in their metropolitan areas, which increased use of natural gas could help alleviate.

Furthermore, the GECF Member countries are major natural gas exporters and their own natural gas demand may impact the future of global natural gas supply. It is therefore important to analyse natural gas demand trends for the GECF Member countries.

As illustrated in Table 3.5 and Figure 3.21, between 2000 and 2016, natural gas demand in GECF Member countries increased from 571 bcm in 2000 to 894 bcm in 2016. Over the projection period, it is expected that demand will grow to 1161 bcm in 2040. An increasing population and strong economic development are key drivers for this growth. However, the growth rate will slacken during the outlook period, from 2.8% to 1.1%.

Figure 3.21: Trends in GECF Members' natural gas demand, 2000-2040



Source: GECF Secretariat based on data from GECF GGM

It is anticipated that virtually all the GECF countries will increase their natural gas consumption through to 2040. The exceptions are Equatorial Guinea and Trinidad and Tobago, with -0.4% and -0.1% growth rates, respectively. Russia and Iran are the major contributors to gas demand, with significantly higher totals than other member countries.

In 2016, Russia consumed over 425 bcm, with an annual average growth rate of 0.7% between 2000 and 2016. This report forecasts Russian gas demand to increase only slightly over the outlook period to 456 bcm (a growth rate of 0.3%), due to population decline and increased energy efficiency, especially in the power sector.

Iran, however, will see tremendous growth in consumption of natural gas. In 2016, Iran's gas demand was 188 bcm, with an annual average growth rate of 7.2% since 2000. Milder political conditions in recent years, the lifting of sanctions and economic development, coupled with population growth, can explain such an increase in consumption.

This report also expects that, over the forecast period, Iran's gas demand will keep rising to 308 bcm, an average growth rate of 2.1% between 2017 and 2040. A possible external perception is that Iran is wasteful in gas consumption due to low subsidised prices.

By far the next most important contributors to the GECF Members' natural gas demand over the outlook period are the UAE and Qatar with 75 bcm and 73 bcm, indicating a growth rate of 0.2% and 1.6% per annum, respectively.

Egypt is also a key player: not only will the country be increasing production and potentially restarting exports but, given the size of recent discoveries and the size of the population, the demand for natural gas could be subject to dramatic change. Over the outlook period, it is expected that natural gas demand will increase to 76 bcm, indicating a growth rate of 1.9% per annum.

Table 3.5: GECF Members' natural gas demand* bcm

Region	Historical				Forecast					
	2000	2010	2016	CAAGR 2000-2016	2020	2025	2030	2035	2040	CAAGR 2017-2040
GECF Members	571	690	827	2.8%	946	989	1049	1106	1161	1.1%
Algeria	22	28	41	4.0%	38	40	42	43	44	0.3%
Bolivia	1	3	4	6.6%	4	5	5	5	6	1.8%
Egypt	17	42	49	6.9%	56	58	60	67	76	1.9%
Iran	62	144	188	7.2%	219	247	271	291	308	2.1%
Libya	5	7	5	0.3%	7	9	11	15	21	6.1%
Nigeria	6	10	19	7.3%	24	29	33	38	42	3.3%
Qatar	11	29	50	9.9%	52	58	60	68	73	1.6%
Russia	379	447	425	0.7%	436	436	448	452	456	0.3%
Trinidad and Tobago	10	22	19	4.2%	19	18	18	19	19	-0.1%
UAE	32	59	71	5.0%	69	64	70	73	75	0.2%
Venezuela	26	36	22	-1.1%	20	23	28	33	38	2.4%

**Data for Equatorial Guinea is currently insufficient and has been omitted from this table.*

Source: GECF Secretariat based on data from GECF GGM

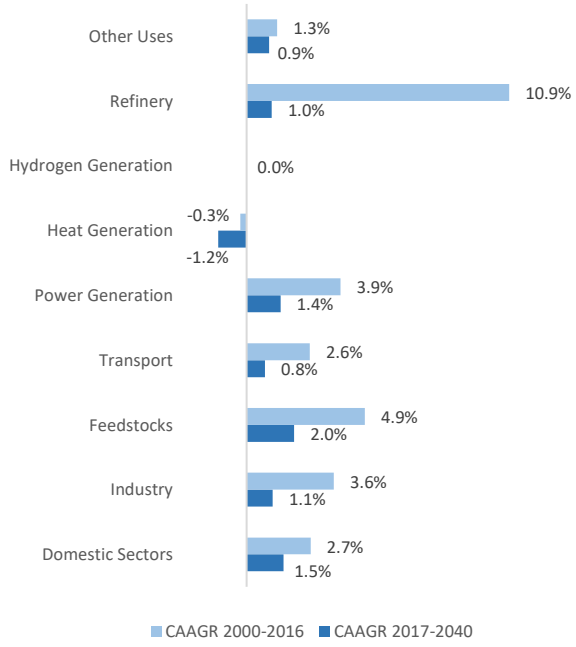
GECF Members' natural gas demand trends by sector

In line with global consumption trends, the power generation sector in GECF Member countries consumed 304 bcm of gas in 2016, with an annual average growth rate of 3.9% since 2000. It is expected that the absolute level of gas demand will increase over the outlook period to 426 bcm, demonstrating a growth rate of 1.4% per annum between 2017 and 2040 (see Figure 3.22 and 3.23).

Demand for natural gas in the domestic sectors for GECF Member countries will increase to 178 bcm in 2040, up from 124 bcm in 2016 indicating a growth rate of 1.5% per annum. Most of the member countries will

experience a population growth over the next decades, with the exception of Russia, and will therefore need more natural gas to produce electricity and to use for heating and cooking purposes.

Figure 3.22: GECF Members' natural gas demand growth rate (%)



Source: GECF Secretariat based on data from GECF GGM

The third largest natural gas consumption sector for the GECF Members is industry. Emerging economies such as Iran, Qatar and the UAE are key drivers here, with a growth rate of 1.1% for the outlook period. Consumption of natural gas in industry in 2016 was 134 bcm and the GECF expects that it will increase to 174 bcm in 2040.

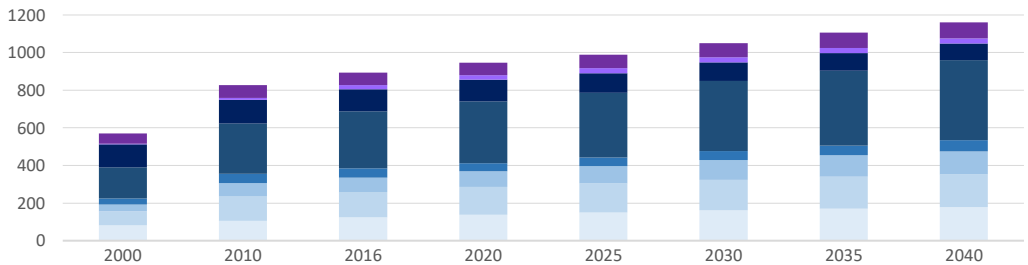
The feedstocks sector is the fastest growing sector for the GECF Members, with natural gas demand rising by 2.0% per annum over the outlook period. The sector's demand will increase from 76 bcm in 2016 to 122 bcm in 2040. The main countries driving this demand are Russia (65 bcm) and Iran (26 bcm).

Heat generation is the only sector which will experience a decline in natural gas demand in GECF Member countries. The sector consumed 117 bcm of natural gas in 2016, which will fall to 88 bcm by 2040, a negative growth rate of -1.2% per annum. Again, Russia is the predominant player in this sector, accounting for 116 bcm of demand in 2016.

The transport and refinery sectors are the smallest sectors over the outlook period, with demand reaching 59 bcm and 28 bcm, demonstrating a growth rate of 0.8% and 1.0% per annum, respectively.

Overall, natural gas demand has healthy prospects in the GECF countries. Some of them are net oil exporters and, in order to enhance oil recovery operations, they need to consume more natural gas. Thus, natural gas plays a prominent role in the economy of GECF Member countries and will dominate their energy mix in the future.

Figure 3.23: GECF Members' natural gas demand by sector (bcm)



	2000	2010	2016	2020	2025	2030	2035	2040
Other Uses	55	69	67	66	72	75	81	84
Refinery	4	9	22	25	27	27	28	28
Hydrogen Generation	0	0	0	0	0	0	0	0
Heat Generation	122	126	117	115	104	99	94	88
Power Generation	164	267	304	328	344	372	398	426
Transport	33	50	49	43	46	48	51	59
Feedstocks	35	71	76	84	93	106	114	122
Industry	76	129	134	148	154	163	170	174
Domestic Sectors	81	106	124	137	150	161	170	178

Source: GECF Secretariat based on data from GECF GGM

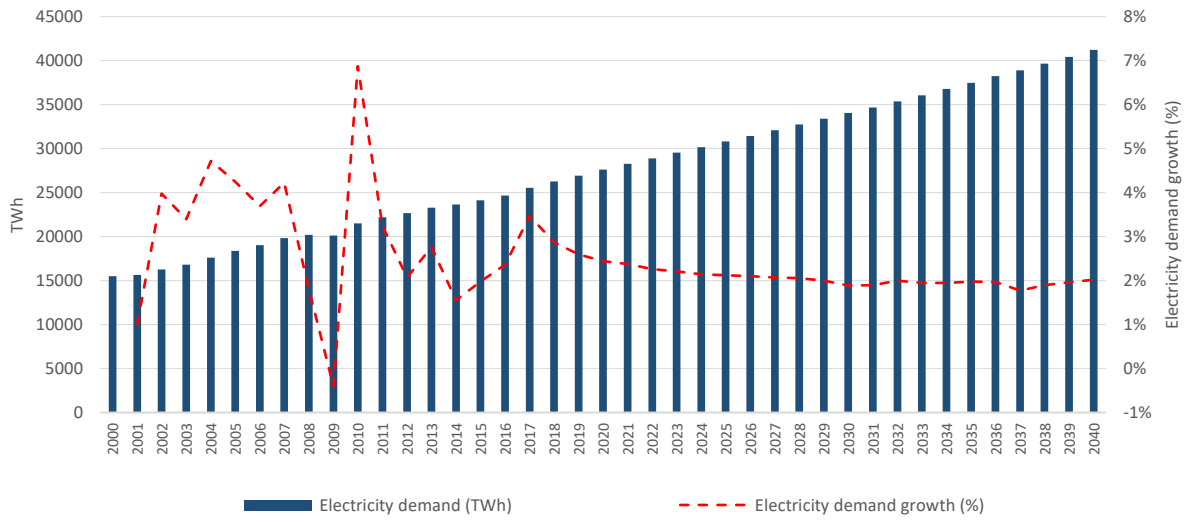
Global electricity demand trends

Electricity is a secondary energy source that currently dominates global energy demand. Electrical power is generated from primary energy sources, such as gas, nuclear and renewables. Global electricity demand has been increasing since 2000 and is projected to grow to 41235 TWh by 2040. Demand for electricity grew by an average of 3% per annum between 2000 and 2016, and it is expected to grow at an annual rate of 2.2% between 2017 and 2040.

Urbanization and the associated increase in residential energy demand, coupled with industrial expansion, particularly in developing economies such as China and India, are the main drivers propelling electricity demand. Figure 3.24 presents global electricity consumption over the historical and forecast periods.

Traditionally, coal-fired power generators have been used to produce electricity. Due to serious environmental concerns such as air quality particulate pollution which can result in ill health and premature deaths, and the high carbon intensity associated with coal combustion, many countries have revised their energy policies to replace coal with gas and renewables. Nonetheless, in 2016 coal remained the most preferred choice of fuel for power generation, with a steady market share of 38%. However, this trend is expected to decrease substantially over the outlook period due to air pollution concerns. Therefore, this report expects that coal's share in global electricity generation will drop by 11% in 2040, accounting for 27% of the global power electricity mix with a negative growth rate of 1.4% per annum.

Figure 3.24: Global electricity demand



Source: GECF Secretariat based on data from GECF GGM

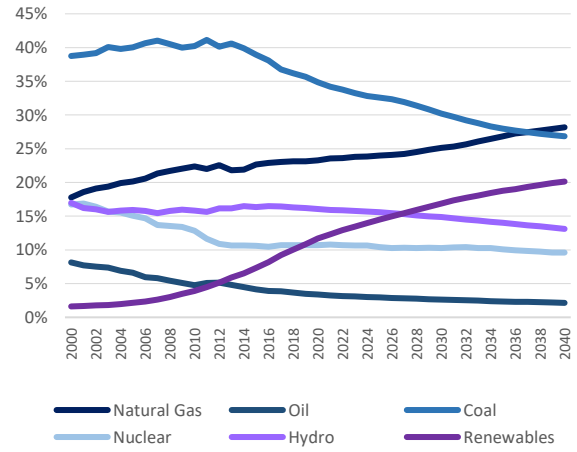
As natural gas is the logical substitute for coal for both economic and environmental reasons, its share in the power generation sector increased from 18% to 23% between 2000 and 2016, corresponding to an annual average growth rate of 1.6%. The share of gas in the electricity sector will continue to rise over the outlook period, reaching 28% in 2040, equating to an average growth rate of 0.9% per annum. This represents the largest market share of any fuel.

In 2016, the share of renewables in the global electricity mix was only 8%. However, due to significant reforms in energy policies, including technological advancements and governmental support in many countries, renewables will be the fastest growing fuels for electricity generation in 2040, accounting for a 20% share, and experiencing an annual average growth rate of 3.8%.

This report expects that over the outlook period, the share of nuclear in the global electricity mix will remain stagnant at 2016 levels of 10%. It might be worth noting that nuclear contributed 17% of the global electricity mix in 2000, but fell out of favour after the Fukushima accident in 2011 when countries decided to revise their energy policy in favour of gas and renewables.

Additionally, the share of hydro in the global power generation mix will drop from 17% in 2016 to 13% in 2040 (see Figure 3.25). Therefore, in 2040 about 57% of electricity generation will come from fossil fuels.

Figure 3.25: Global power generation mix (%)



Source: GECF Secretariat based on data from GECF GGM

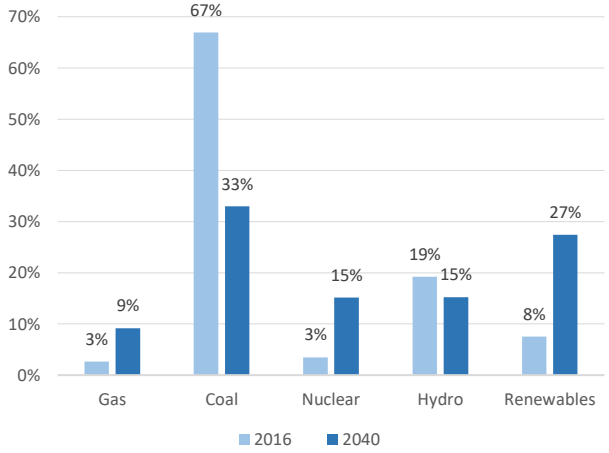
Regional electricity demand

Non-OECD Asia and North America (excluding Mexico) consumed 57% of global electricity demand in 2016, a figure which is forecast to rise to 60% by 2040. The GECF expects that non-OECD Asia will consume the most electricity, 19217 TWh in 2040, equating to an annual average growth rate of 3.2% between 2017 and 2040. This is, however, substantially below the 8% recorded over the 2000-2016 period.

Urbanization, higher living standards and a growing electric vehicle fleet will drive this boost in electricity demand and the main countries behind this increased demand are China and India.

Chinese electricity demand grew dramatically at an annual average growth rate of 10% between 2000 and 2016, and reached 6098 TWh in 2016. Yet even taking into account the slower future growth rate of 2.1%, China's electricity demand is expected to rise to 10037 TWh by 2040. The share of coal used in China's power sector will dramatically decrease, from 67% in 2016 to 33% in 2040. The country's 13th FYP highlights the government's intentions to reduce its future dependence on coal. Non-fossil fuels and gas will therefore gain a stronghold in electricity generation (Figure 3.26).

Figure 3.26: China's power generation mix in 2016 and 2040 (%)

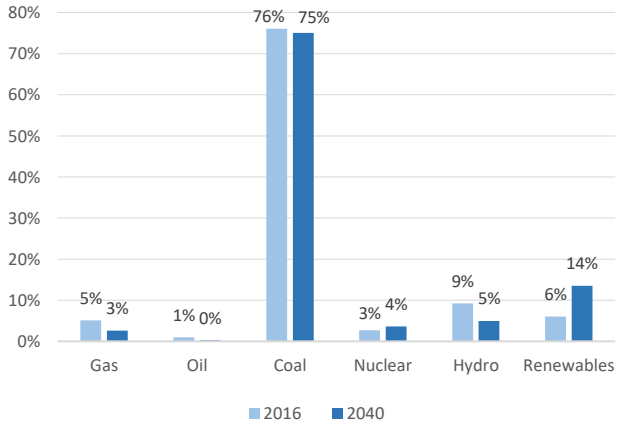


Source: GECF Secretariat based on data from GECF GGM

India is another key player in the non-OECD Asia region. Over the historical period (2000-2016) the average growth rate of electricity demand was 5.8% per annum, reaching 1417 TWh in 2016. Over the outlook period (2017-2040), it is projected that India's demand will continue to rise, peaking at 5163 TWh in 2040, corresponding to a growth rate of 5.5% per annum. Strong development in the industrial sector and improved electricity delivery to rural areas are the key drivers for such an increase.

Coal will remain the dominant fuel for electricity generation, with a market share of 75%. This percentage will drop by just 1% by 2040 from 2016 levels. However, as the country promotes renewables and cleaner coal consumption in power generation, the share of renewables will increase from 9% in 2016 to 14% in 2040 (Figure 3.27).

Figure 3.27: India's power generation mix in 2016 and 2040 (%)



Source: GECF Secretariat based on data from GECF GGM

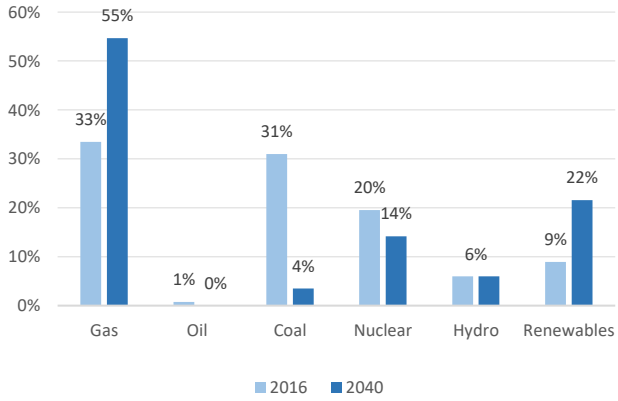
Compared to the non-OECD Asia region, North America's (excluding Mexico) electricity demand growth will be slower, reaching 5678 TWh by 2040 and corresponding to an average growth rate of 0.6% over the outlook period.

The US is the biggest electricity consumer in North America. Over the historical period, electricity demand in the US increased from 4060 TWh in 2000 to 4358 TWh in 2016 demonstrating a growth rate of 0.4% annually. Over the forecast period, the GECF expects that the slow growth of demand will continue until levels reach 4948 TWh in 2040 indicating 0.5% growth per annum. This is mainly due to a steady increase in population levels that affects domestic consumption. Moreover, replacing old equipment with newer and more efficient items specifically in outdoor and indoor lighting could also contribute to a slower growth rate. Additionally, the US economy is expected to move towards industries which are less energy intensive and which waste less electricity due to advanced technologies.

The US power generation mix over the historical period indicates that in 2000 coal was the dominant source of electricity production, with a share of 53%. However, the use of coal then started to decline, reaching a share of 31% in 2016. The dramatic decline of coal demand will continue over the outlook period, with it accounting for just 4% of the energy mix in 2040. Longer term policies such as cleaner power plants, the development of natural gas production (mainly shale gas) and tax reforms for renewables are among the top drivers of this steep decline.

In contrast, natural gas will maintain its market share over other types of fuel through to 2040. The share of gas in power generation will reach 55% in 2040 compared to 33% in 2016 and 16% in 2000. Shale gas exploration and development initiated in recent decades will decrease gas prices making it a favourable option for power generation. Following gas, renewables' share in electricity production will also increase over the outlook period. Environmental policies such as the Clean Power Plan (CPP) and Renewable Portfolio Standards are the main drivers which will encourage the use of renewables in electricity generation through to 2040 (see Figure 3.28).

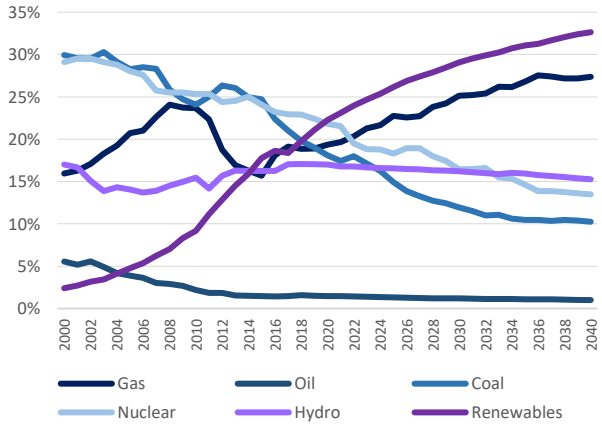
Figure 3.28: The US' power generation mix in 2016 and 2040 (%)



Source: GECF Secretariat based on data from GECF GGM

OECD Europe will become the third largest electricity consumer by 2040. Total consumption is expected to increase to 4432 TWh, growing at an average growth rate of 0.9% from 2017 onwards. Over the outlook period, the mix of electricity sources will change substantially due to energy efficiency reforms across the EU, driven mostly by environmental concerns and self-sufficiency policies. The market share of coal will decline from 22% in 2016 to 10% in 2040, and nuclear plants are expected to be decommissioned after the Fukushima accident and as a result, the share of nuclear energy used for electricity generation will drop from 23% in 2016 to 13% in 2040. Meanwhile gas and renewables will gain market share, increasing to 27% and 33% in 2040 respectively, from 18% and 19% in 2016. (Figure 3.29).

Figure 3.29: OECD-Europe power generation mix (%)

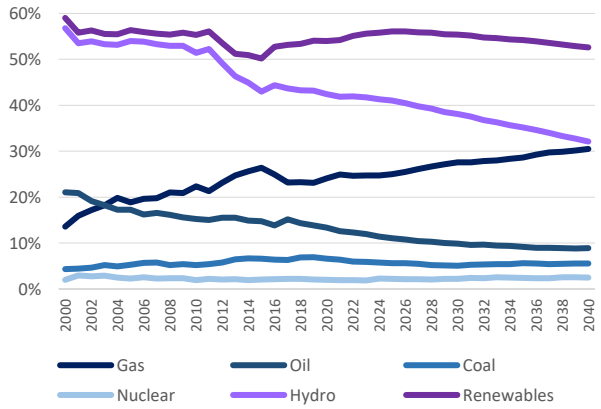


Source: GECF Secretariat based on data from GECF GGM

Latin America (including Mexico) is the next largest consumer of electricity worldwide during the outlook period, accounting for 3365 TWh in 2040

demonstrating a growth rate of 3.1% per annum. Many countries in the region e.g. Peru and Bolivia, are following development plans for urban and rural electrification, and strong regional economic growth can also explain the growth in demand for power over the forecast period (Figure 3.30).

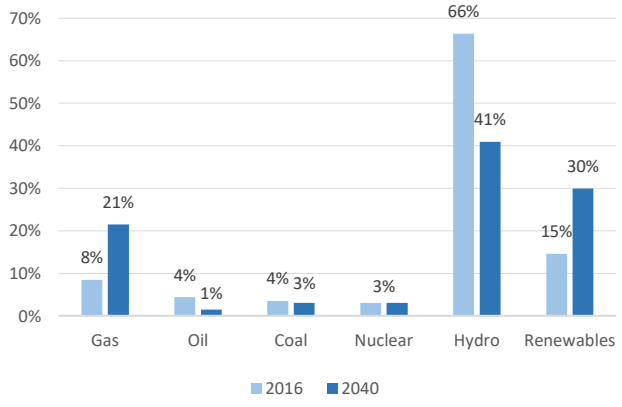
Figure 3.30: Latin America power generation mix (%)



Source: GECF Secretariat based on data from GECF GGM

Brazil is the main contributor to electricity demand in the region. The country's electricity consumption will accelerate during the outlook period, with an annual average growth rate of 3.3%, reaching 1364 TWh by 2040. This is mainly attributed to the country's prospective economic growth and an increase in population.

Figure 3.31: Brazil's power generation mix in 2016 and 2040 (%)



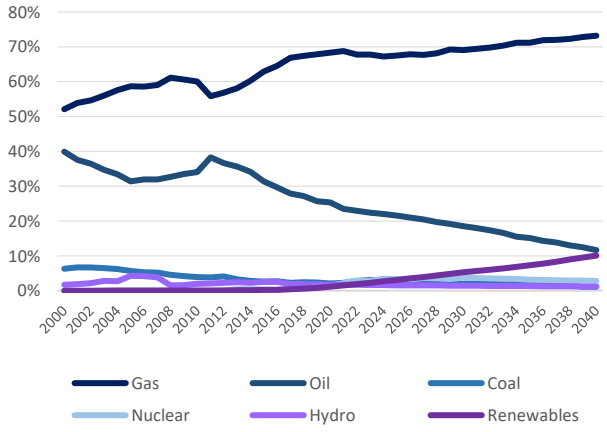
Source: GECF Secretariat based on data from GECF GGM

Historically, as illustrated in Figure 3.31, hydro has been the main source of power generation in Brazil, accounting for a 66% share in 2016. The GECF expects that the use of hydro will continue to decline over the projection period attaining a 41% share of power generation mix by 2040, as climatic conditions result in less rainfall in the future. To meet the increasing demand for electricity, Brazil will shift to renewables and gas with a generation share of 30% and 21% by 2040, respectively. This implies that gas will see the strongest increase in growth for power sector consumption, with a 3.9% growth rate per annum over the outlook period, while renewables growth rate will be 3% over the same period.

Middle Eastern electricity demand grew substantially over the historical period from 472 TWh in 2000 to 1132 TWh in 2016 indicating an average growth rate of 5.6% per annum. Population increases, economic growth, and improvements in the level of living standards due to higher urbanization have been the main drivers for increased electricity demand. Over the outlook period, the GECF expects that demand for electricity will double reaching 2419 TWh by 2040 demonstrating a growth rate of 3.2% per annum (Figure 3.32).

Natural gas will play a key role in the Middle East countries' generation mix. Over the outlook period, natural gas will ultimately achieve a share of 73% in the generation mix. However, consistent with other regions across the world, these countries are also planning to develop renewables usage to offset the finite nature of fossil fuels. It is expected that by 2040, renewables will constitute a share of 10% of the region's generation mix. This compares to oil's share, which will drop substantially from 30% in 2016 to 12% in 2040.

Figure 3.32: The Middle East's power generation mix (%)

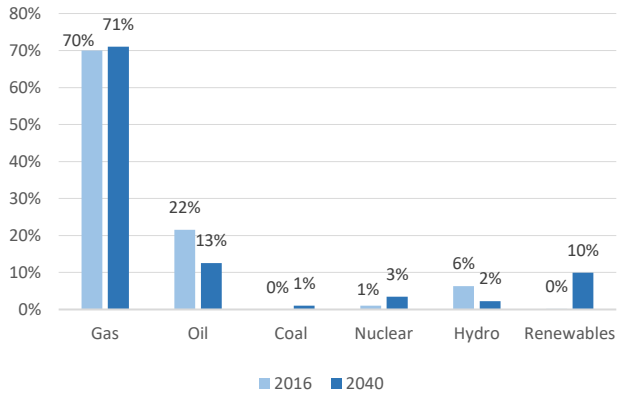


Source: GECF Secretariat based on data from GECF GGM

As the main regional contributor, Iran's electricity demand grew 137% between 2000 and 2016, rising from 121 TWh to 286 TWh. It is expected that by 2040,

demand will continue to grow, reaching 664 TWh. Gas generated more electricity than other fuels in 2016, accounting for 70% of Iran's electricity generation, while oil contributed 22%, and hydro only 6%. Iran is interconnected with Afghanistan, Armenia, Azerbaijan, Iraq, Pakistan, Turkey, and Turkmenistan, and is a net electricity exporter (Figure 3.33).

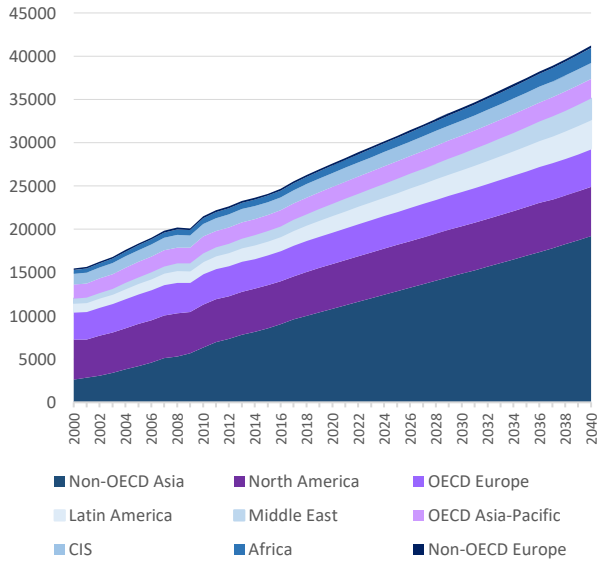
Figure 3.33: Iran's power generation mix in 2016 and 2040 (%)



Source: GECF Secretariat based on data from GECF GGM

OECD Asia-Pacific (2253 TWh), CIS (1869 TWh), Africa (1712 TWh), and non-OECD Europe (291 TWh) are the next largest electricity consumers over the outlook period. These regions will experience growth rates of 0.8%, 0.9%, 3.4% and 1.4% per annum respectively. Figure 3.34 illustrates regional electricity demand over the historical and forecast period.

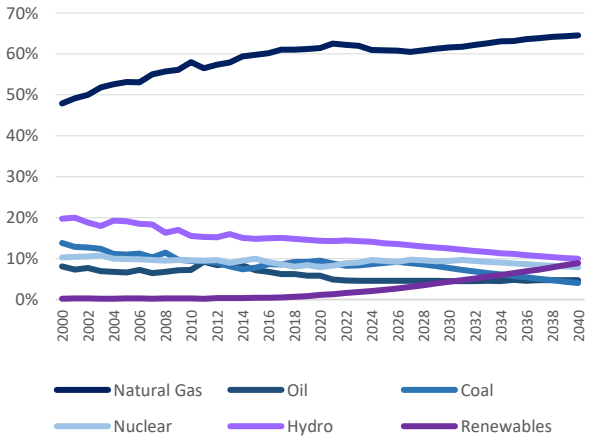
Figure 3.34: Regional electricity demand (TWh)



Source: GECF Secretariat based on data from GECF GGM

Over the historical period, demand for electricity in the GECF Member countries was boosted from 1261 TWh in 2000 to 1937 TWh in 2016 demonstrating an annual average growth rate of 2.7%. Over the forecast period, it is expected that electricity consumption will increase to 3402 TWh, indicating a growth rate of 2.4% by 2040. Increased urbanization, economic development and population increases which stoke demand in the domestic sectors are the key drivers for such an increase (Figure 3.35).

Figure 3.35: GECF Members' electricity demand (%)



Source: GECF Secretariat based on data from GECF GGM

Almost one-third of demand can be attributed to Russia's electricity consumption. In 2040, Russia will require 1237 TWh of electricity due to its economic growth. However, its growth rate (0.7%) will be slower than those of other GECF Members such as Iran.

As a result of the Russian government's environmental policy, coal-fired power plants will increasingly be replaced by natural-gas fired plants resulting in coal having a declining share in the country's generation mix, down from 16% in 2016 to 5% by 2040. Natural gas will dominate the country's generation mix, reaching 62% in 2040. Russia's abundant reserves of natural gas enables the country to reap more economic and environmental benefits from the use of the fuel. Nuclear (16%), hydro (15%), and renewables (2%), are the next largest contributors to Russia's power generation mix.

CHAPTER 4: SUPPLY AND TRADE

Key assumptions and findings:

- Global gas production capacity will increase by an average of 2% per annum over the Outlook period.
- The GECF countries are expected to increase their total production capacity by 1.5% per annum over the Outlook period, to more than 2.5 tcm in 2040.
- Unconventional capacity is expected to increase by 4% per annum to around 2000 bcm in 2040 resulting in more than 30% of total gas production capacity coming from unconventional sources in 2040. The GECF countries are expected to account for 7% of total unconventional capacity by 2040, which is anticipated to accelerate in the mid-2020s.
- The average growth rate of global production between 2016 and 2040 is expected to be approximately 1.8% (1.9% average annual growth up to 2022).
- Despite conventional production (including YTF) increasing from around 3000 bcm in 2016 to more than 3600 bcm in 2040, the share of conventional gas in the global energy mix will fall from 81% to 67% by 2040; this implies that one third of total production in 2040 will be extracted from unconventional resources, compared to the current share of only 18%.
- By 2040, 29% of total gas demand will be met by gas imports through pipeline or LNG, a percentage which is approximately equal to the current situation.
- Pipeline trade will expand over the Outlook period by a CAAGR of around 1.6% to reach more than 830 bcm per year in 2040.
- The LNG market will grow significantly, particularly in the medium-term. The share of LNG trade as a proportion of total gas trade is anticipated to rise to 44.8% over the Outlook period
- The future for LNG export growth is very promising with a forecast average annual growth rate of 2.8%. The volume of LNG trade will increase by around 240 MTPA (324 bcm) to reach the level of 498.5 MTPA (673 bcm) by 2040
- The share of LNG trade held by the GECF countries drops from 59% in 2016 to 47% by 2020, but will recover to around 52% by 2025 and then settle at 50% by 2040.

Gas resource base

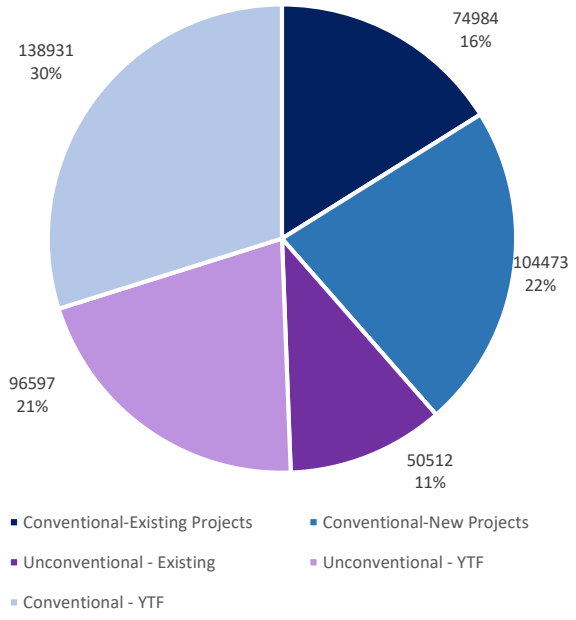
Many assessments have been made of the existing volume of global natural gas resources, all of which provide divergent figures based on conflicting definitions and methods. This variation has led to reporting discrepancies regarding the volume of proven reserves and undiscovered resources. Nevertheless, all of these reports acknowledge that natural gas resources are abundant and, unlike coal, widely distributed amongst the world regions.

The GECF GGM contains a comprehensive database on gas resources, including liquids such as LPG and condensate. This detailed technical information is used in modelling, as it imposes significant impacts on the economy of extraction and production.

The world possesses an ample amount of natural gas, totalling 465 tcm. Almost 180 tcm are identified as proven conventional reserves; these are split into two categories, existing and new projects, for classification purposes. Undiscovered conventional resources (YTF) total 139 tcm and unconventional resources (including discovered and YTF) total 147 tcm. Figure 4.1 shows the share of remaining recoverable natural gas resources

(excluding C2+) by type, split by proven reserves and YTF resources.

Figure 4.1: Natural gas resources by type (bcm)



Source: GECF Secretariat based on data from GECF GGM

Figure 4.1 also illustrates that more than half (51%) of total natural gas resources remain undiscovered. These volumes will play a large role in satisfying gas demand over the Outlook horizon. Indeed, new discoveries of conventional and unconventional gas resources will become a vital issue for the future of the gas industry.

The current resource to production ratio is about 130 years for the entire resource base, including existing projects, new projects, YTF, and unconventional. This ratio is only around 60 years for proven reserves which include existing projects, new projects, and unconventional reserves. With this rate of production, and without new discoveries, the current volume of gas reserves will be extracted in just 60 years' time.

In 2016, GECF Countries held almost 67% of proven gas reserves and accounted for more than half of undiscovered unconventional resources. Assuming that global demand for natural gas continues to grow, their market position will strengthen as these conventional reserves and unconventional resources are developed. The advancement of exploration and extraction technologies should result in increased volumes and market share of unconventional gas reserves.

Natural gas production outlook

The GECF's production outlook is based on calculations from over 4300 producing fields and discoveries, including their supply costs and their physical characteristics. In other words, production capacity profiles are defined for each production entity, aggregated into tranches, and by supply node at a country level. This capacity profile is applied to the supply model, generating results that suggest how much initial capacity will be developed over a specific future time period.

The production profile represents the maximum capacity that a given production entity can produce over time. It is based on: the volume of remaining recoverable gas reserves found in the base year (2016); historical production figures; the production start date; and the composition of the gas field. Through modelling iterations that cover both obligated flows and free trade, based on projected demand assumptions, the volume of production from each entity can be forecast.

The GECF GGM can separately forecast gas production and production capacity. In addition to market drivers, the results of the capacity projection model are used as inputs for production forecasts. Production capacity will depend largely on reservoir profiles, policies, and development plans. Although production volume is mostly determined by market dynamics, in turn, market projections significantly affect policies and decisions regarding development plans. This section will outline these feedback mechanisms within the GECF GGM by first addressing production capacity projections, followed by an analysis of the model's production forecast with its associated demand projections.

Production capacity projections

Demand for natural gas is rising due to its affordability, abundance, and its impact on emissions reductions. These numerous benefits have encouraged gas-producing countries to expand their production capabilities, facilitating the penetration of natural gas in energy consuming sectors.

The latest GECF GGM projections indicate that global gas production capacity will increase by an average of 2% per annum over the Outlook period (Figure 4.2). The largest average annual growth in production capacity

will be seen in Africa and non-OECD Asia, which will see compound annual growth rates of 3.4% and 4.7%, respectively.

As Figure 4.2 illustrates, capacity growth can be seen in most regions in terms of absolute volume, with the exception of OECD Europe. However, due to the lower starting point for production capacity in non-OECD Asia and Africa, the growth rate for these two regions is more significant.

Among non-OECD Asian countries, China and, to a lesser extent, India are the most important contributors to capacity expansion. China is the most significant contributor, with an average annual growth rate of 5.6% between 2016 and 2040.

In Africa, the most important contributors to capacity expansion are Angola, Algeria, Egypt, Libya, Mozambique, Nigeria, and Tanzania. In Angola, an average annual growth rate of 10.6% is forecast, albeit from a lower base than either Algeria or Nigeria.

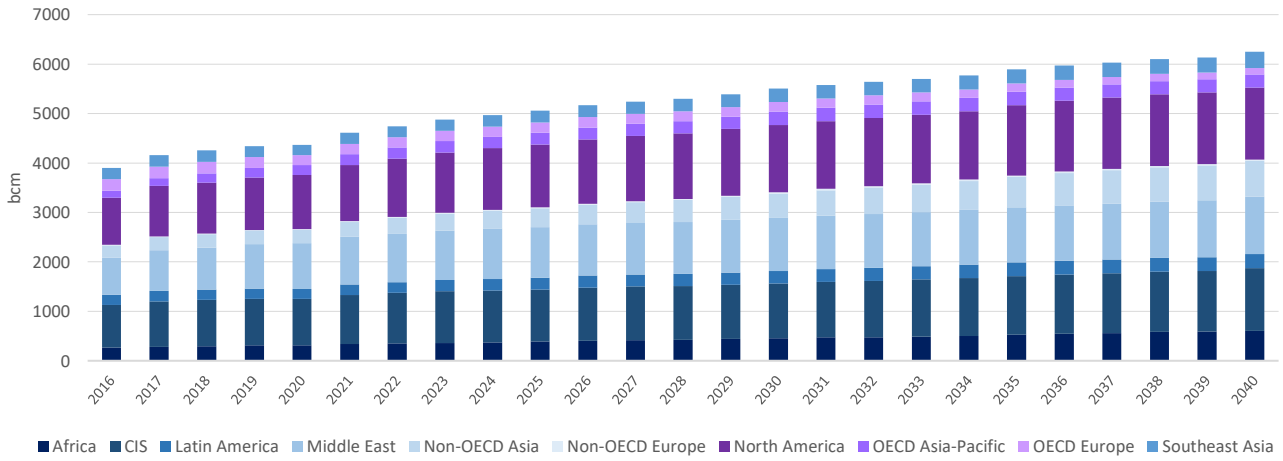
Angola is the second largest producer of oil in Africa, and most of its gas production is in the form of associated gas. Only 10% of Angola's gross gas production is currently brought to market, with the remaining 90% being flared or reinjected. In 2016, only 1.7 bcm (out of 12 bcm of gross production) was brought to market. The country plans to control this huge amount of flared gas and to develop its gas resources. The GECF forecasts that Angola's production capacity will increase to over 37 bcm by 2040. Most of this capacity will come in the form of associated gas, with the remainder coming from non-associated reserves, such as those in Garoupa and Katambi.

As far as Egypt is concerned, the first two fields developed along its West Nile Delta projects, Taurus and Libra, started to produce gas in May 2017. The project includes five gas fields under development, which are estimated to hold approximately 140 bcm of reserves. The Giza, Fayoum and Raven fields are also under development in the West Nile Delta and are expected to start production in 2019. If the development of the Zohr and West Nile Delta projects is also included, substantial production capacity expansion is anticipated in Egypt over the medium-term. Furthermore, significant capacity volumes will be added over the longer-term through undiscovered resources (YTF).

Algeria has also been making great efforts to increase its production capacity in recent years, by developing large projects such as Timimoun, Touat, North Reggane, and Ahnet. These ventures are anticipated to add more than 16 bcm of new capacity by the end of 2018. In addition, there are ongoing projects that address enhanced recovery in existing fields.

Nigeria is investing in the expansion of two gas-gathering facilities that will reduce gas flaring. Additionally, five new projects, grouped under the name of Gbarain – Ubie Phase 2, are expected to add more than 17 bcm of capacity by 2022. Therefore, associated gas will continue to contribute significantly to total gas capacity in Nigeria over the Outlook period.

Figure 4.2: Natural gas production capacities by region



Source: GECF Secretariat based on data from GECF GGM

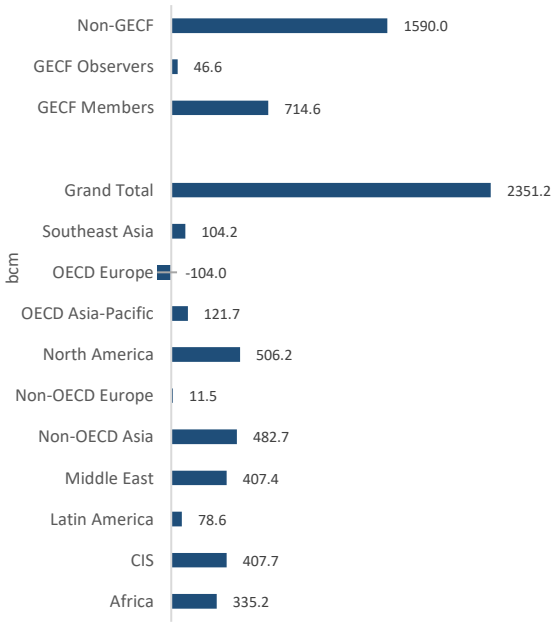
Production capacity in other regions is expected to increase at the following average annual growth rates: OECD Asia-Pacific (2.6%), North America (1.8%), the Middle East (1.8%), Southeast Asia (1.6%), the CIS (1.6%), and Latin America (1.4%). The only region expected to see a net capacity decline is OECD Europe (-2.4%), due to the natural depletion of existing domestic reserves that are not expected to be compensated by adding capacities from remaining natural gas resources (see Table 4.1).

The Middle East will witness significant capacity expansion, mostly driven by Iran, Qatar, Oman, and Iraq. Russia will also add significant volumes to reach a total of more than 900 bcm by 2040. This growth comes from a variety of projects from both conventional and unconventional resources.

Figure 4.3 provides a clear picture of incremental production capacity in terms of absolute volumes. North America, non-OECD Asia, the Middle East, the CIS, and Africa will increase their production potential and, correspondingly, will contribute the most to market growth. The geographical distribution of this incremental expansion suggests that pipeline gas will still be considered the most convenient form of trade, besides LNG, due to shorter distances between demand nodes.

Europe, Central America and new emerging markets in Asia benefit from this regional distribution, as they meet part of their gas needs through pipeline flows from neighbouring producers.

Figure 4.3: Natural gas incremental production capacities by region (2016-2040)



Source: GECF Secretariat based on data from GECF GGM

The GECF countries are expected to increase their total capacity by an average of 1.5% per year over the Outlook period, to more than 2.5 tcm in 2040 (Figure 4.4). Most of this increase in terms of absolute volume will come from Russia, Iran, Qatar, Egypt, Nigeria, and Algeria. Taking average annual growth rates for the GECF Countries into account, Azerbaijan (5.5%), Libya (4.4%), and Iraq (4.4%) will contribute significantly to production capacity growth rate.

Table 4.1: Natural gas production capacity by region **bcm**

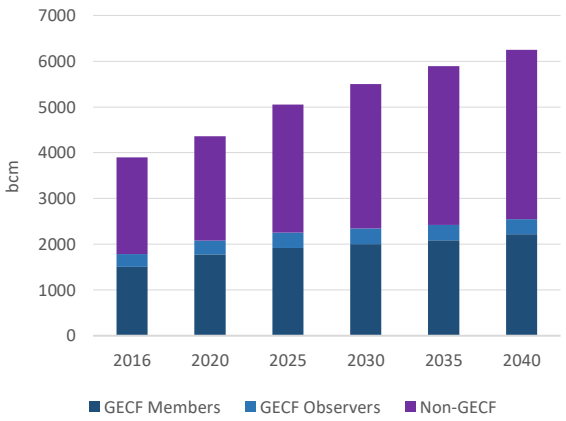
	Africa	CIS	Latin America	Middle East	Non-OECD Asia	Non-OECD Europe	North America	OECD Asia-Pacific	OECD Europe	Southeast Asia	Grand Total
2016	270.3	860.3	206.8	751.٢	244.١	12.5	950.8	145.3	235.7	222.٤	3898.1
2020	312.1	941.0	201.7	926.6	268.9	11.4	1093.9	201.1	202.6	203.7	4362.9
2025	391.5	1047.9	237.5	1026.6	380.1	19.6	1271.5	235.4	208.7	236.8	5055.6
2030	453.3	1110.9	251.0	1074.3	487.9	27.9	1361.2	270.8	193.3	272.8	5503.3
2035	527.0	1184.1	276.2	1113.7	617.1	29.2	1422.1	271.9	164.5	286.9	5892.7
2040	605.2	1268.0	285.5	1158.6	726.8	24.0	1457.0	266.7	131.0	326.5	6249.2
CAAGR (2016-2014)	3.4%	1.6%	1.4%	1.8%	4.7%	2.8%	1.8%	2.6%	-2.4%	1.6%	2.0%

Source: GECF Secretariat based on data from GECF GGM

Figure 4.4 also illustrates that, in addition to the GECF Members, developments in non-GECF production capacity are also promising. These results suggest a common tendency amongst countries with natural gas reserves to develop their resources for the benefit of meeting both internal demand and international trade, especially in the post-Paris Agreement era. A case in point is China, which has announced ambitious goals to reduce air pollution by increasing its share of natural gas in energy consuming sectors, part of which will be met with domestic supply.

Due to the depletion of productive reservoirs, production capacity of existing fields (under production) is expected to decline over the Outlook horizon (Figure 4.5). The total capacity of conventional existing fields will decline by 4% annually, to 1300 bcm in 2040, a 61% decrease from 2016. New capacity will grow by 15% per annum, but even this significant growth will not be adequate to satisfy global gas demand to 2040 and unconventional and YTF resources will be needed, according to the latest GECF GGM results.

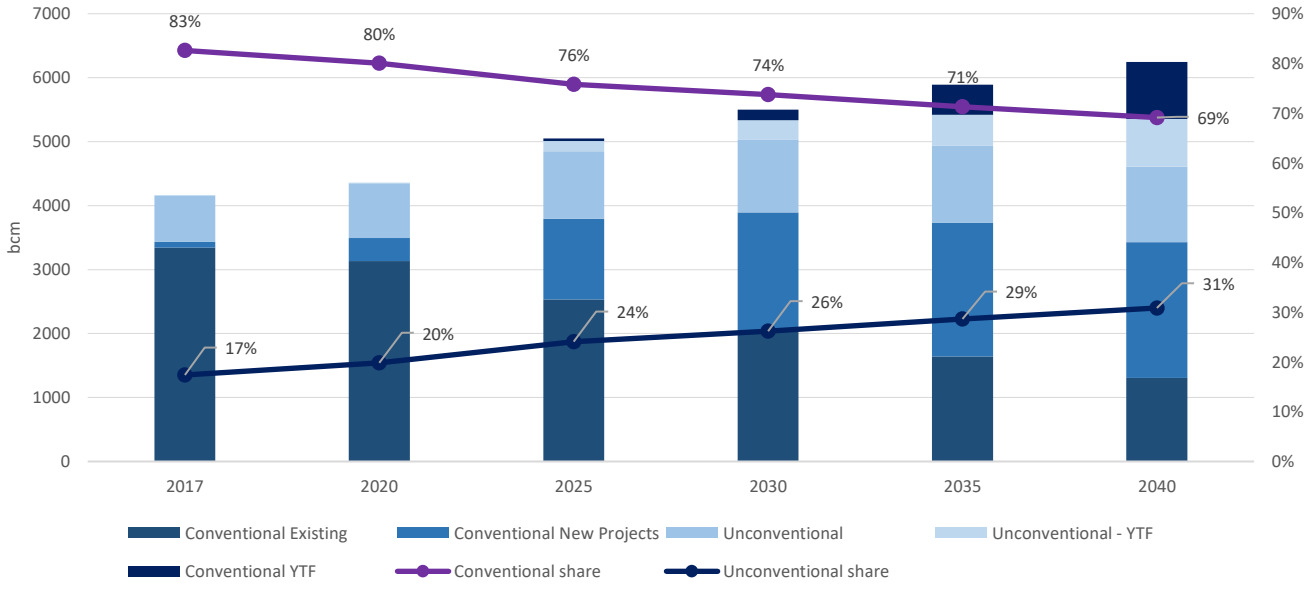
Figure 4.4: Production capacities of GECF Countries and non-GECF countries



Source: GECF Secretariat based on data from GECF GGM

The prospect for unconventional resources (including YTF) is very promising. Unconventional capacity is expected to increase by 4% per annum, from approximately 700 bcm in 2016 to slightly less than 2000 bcm in 2040. As seen in Figure 4.5, more than 30% of total gas production capacity will come from unconventional sources in 2040, compared to 17% in 2017. We can also see that unconventional YTF resources are expected to contribute considerably to total unconventional capacity, totalling 40% in 2040.

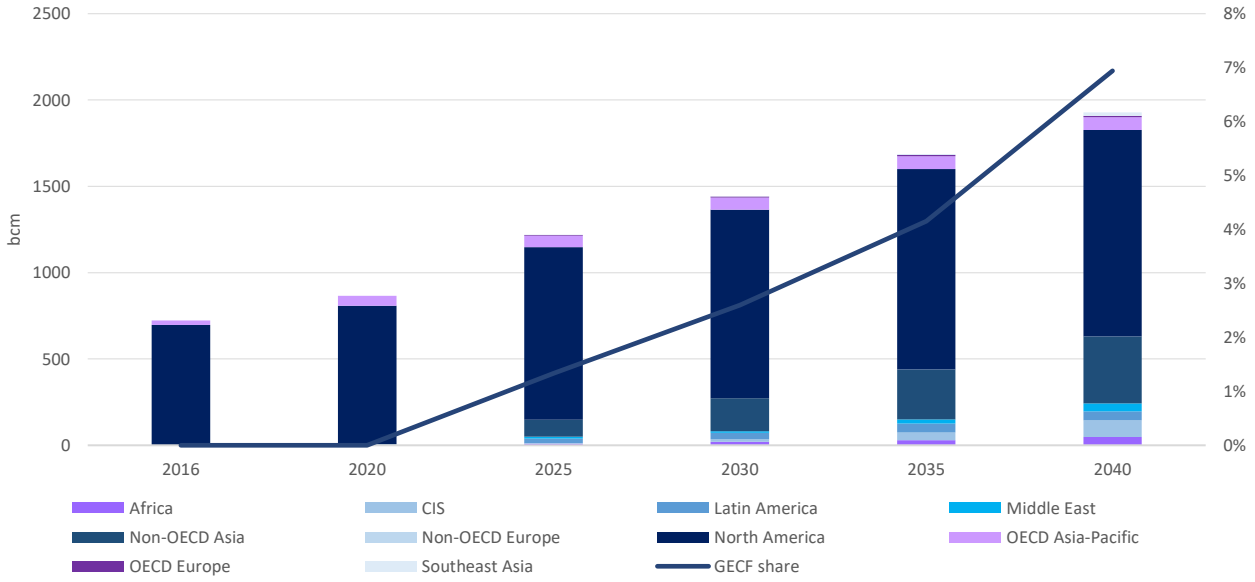
Figure 4.5: Natural gas production capacities by resource type



Source: GECF Secretariat based on data from GECF GGM

Figure 4.6 illustrates regional contributions to the development of unconventional resources and the share of the GECF countries. North America will dominate unconventional capacity of production and is anticipated to contribute 60% to total capacity in 2040. This capacity is significantly lower than the current share of 95% for that region, indicating market competition from new producers, specifically Australia. China and Argentina will also increase capacity through the development of unconventional resources. The GECF countries are projected to contribute to unconventional production after 2023, led by Algeria, and latterly Russia (most likely CBM), and to a lesser extent Bolivia and the UAE. Therefore, as Figure 4.6 illustrates, the share of the GECF countries' unconventional production capacities will increase over the Outlook period. GECF Members are anticipated to account for 7% of total unconventional capacity by 2040, after an anticipated increase in the mid-2020s.

Figure 4.6: Annual unconventional gas production capacity by region (2017–2040)



Source: GECF Secretariat based on data from GECF GGM

Global marketed gas production

The GGM used in this Outlook assesses the optimal level of production, based on capacities and trade models (obligated trade and free trade) that reflect the call for constrained and contracted gas, as well as the call for free natural gas. All signed contracts are applied to the model, as well as production potentials and market circumstances. Consequently, results can be achieved for all categories and all fields. In this section, the aggregate volumes of projected production will be discussed by region, to simplify the results. The definition of marketed production excludes flared gas, recycled gas, and production/transportation losses before the point of sale.

Global marketed production has been increasing since 1990 at an annual average growth rate of 2.5% through 2016. In the coming years, the average global production growth rate (from 2016 to 2040) is expected to be approximately 1.8% (1.9% average annual growth up to 2022), as it adjusts to the developments and prospects of global gas demand and associated uncertainties. Thus, global gas production is expected to increase by almost 50% to 5400 bcm by 2040, compared to current output of approximately 3500 bcm. Cumulative production (2016-2040) is almost 110 tcm, representing about a quarter (23%) of total remaining resources in 2016.

Slightly less than half (49.3%) of natural gas production currently comes from the CIS and North America, specifically the US, Russia and, to a lesser extent, Canada, Turkmenistan, Kazakhstan, Uzbekistan and Azerbaijan. Almost all of these countries will increase their gas production over the Outlook period. The aggregate share of the CIS and North American regions will, however, decline to 45% by 2040, compared to

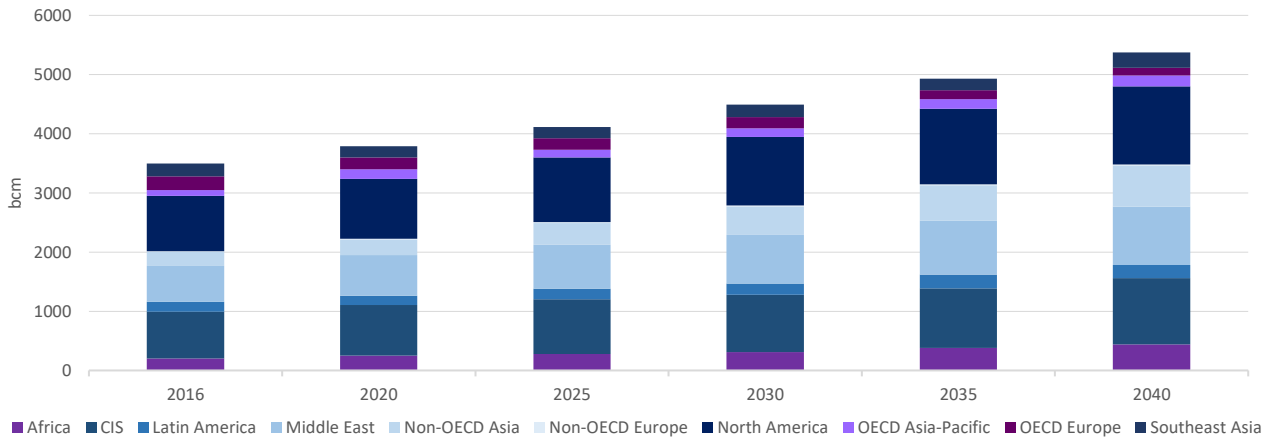
1990, when the two regions represented more than two-thirds of global gas production. This reflects the fact that the number of producers is gradually increasing and spurring more market competition. The Middle East and non-OECD Asia (including Southeast Asia) have emerged as important players since 1990, both in terms of market share and total output. These two regions have seen an annual output increase of almost 500 bcm and 300 bcm (from 1990 to 2016) and their market shares have increased to 17% and 13%, respectively.

Africa and Latin America have also seen significant increases in annual output, and they are expected to play a bigger role in global gas supply in the future. OECD Asia-Pacific, especially Australia, has seen gas production increase threefold since 1990. Meanwhile, European gas production seems to have peaked in the last decade and is now in constant decline.

Figure 4.7 provides projections of regional gas market production over the outlook period. The market share of each region is illustrated in Figure 4.8.

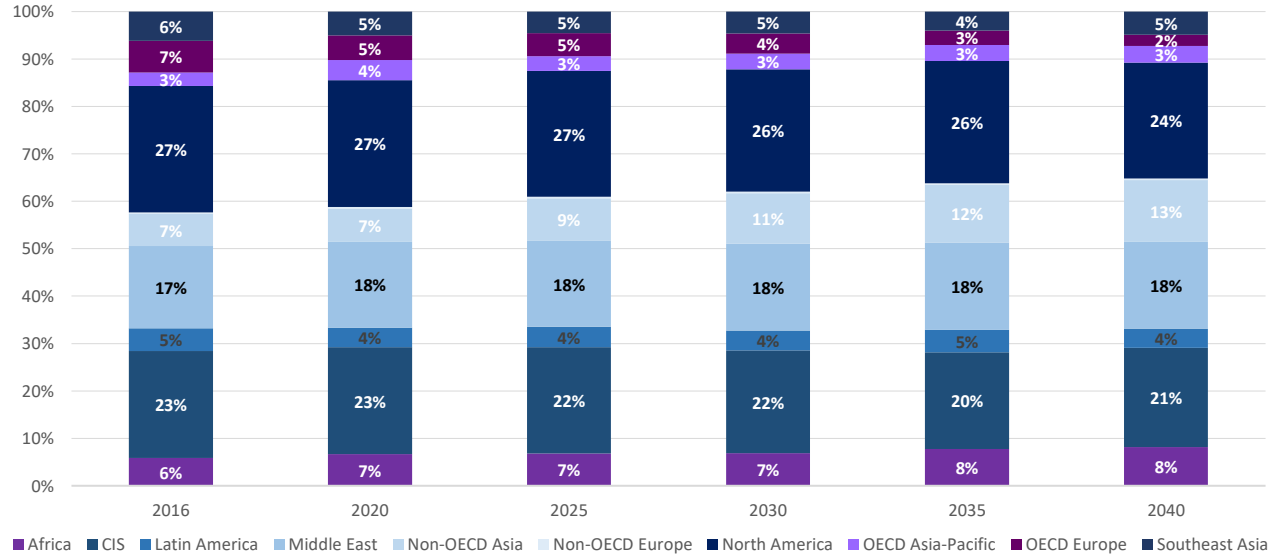
North America and the CIS will remain the largest natural gas producers over the forecast period. However, their global gas production shares will decrease by 2040 to 24% and 21% respectively. These trends will continue despite an absolute increase in output of more than 43% and 42%, respectively, compared to current levels.

Figure 4.7: Natural gas production by region



Source: GECF Secretariat based on data from GECF GGM

Figure 4.8: Share of natural gas production by region



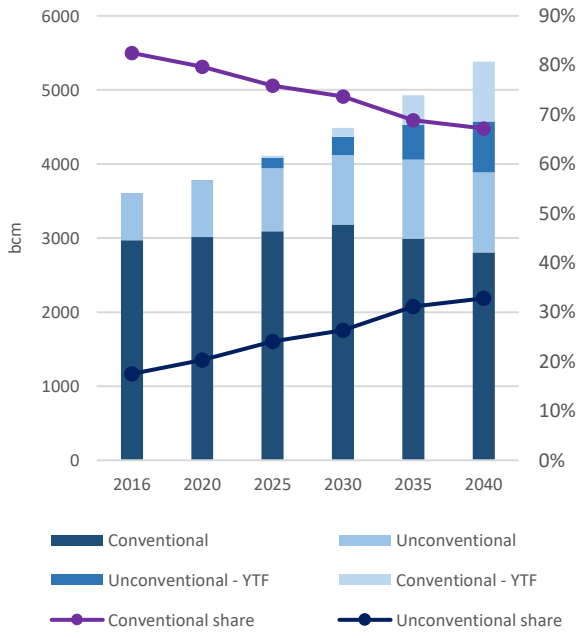
Source: GECF Secretariat based on data from GECF GGM

The Middle East and non-OECD Asia (excluding Southeast Asia) gain further market shares, accounting for 18% and 13% of the global output in 2040 respectively, with annual output increasing by almost 2.0% and 4.6% between 2016 and 2040. Africa will hold the fifth largest market share after non-OECD Asia. Its output is expected to more than double by 2040 from current levels, from 205 bcm to around 440 bcm. Africa will record an annual average growth rate of 3.2%, making it the second fastest growing region after non-OECD Asia. Latin America as a region will grow more moderately by around 1.2% annually, with some Latin American countries (Brazil, Bolivia, and Venezuela) recording more impressive growth.

OECD Europe is expected to be the only region where output declines, with it estimated to fall annually by an average of 2.5%, to approximately 127 bcm in 2040. This decline is attributed to waning reserves and low rates of replacement, especially in Norway and the Netherlands.

In spite of increasing conventional production (including YTF), from around 3000 bcm in 2016 to more than 3600 bcm in 2040, the share of conventional gas falls from 81% to 67% by 2040 (Figure 4.9). This shows the increasing role of unconventional resources, which will contribute one-third to total production over the outlook period.

Figure 4.9: Natural gas production by field type



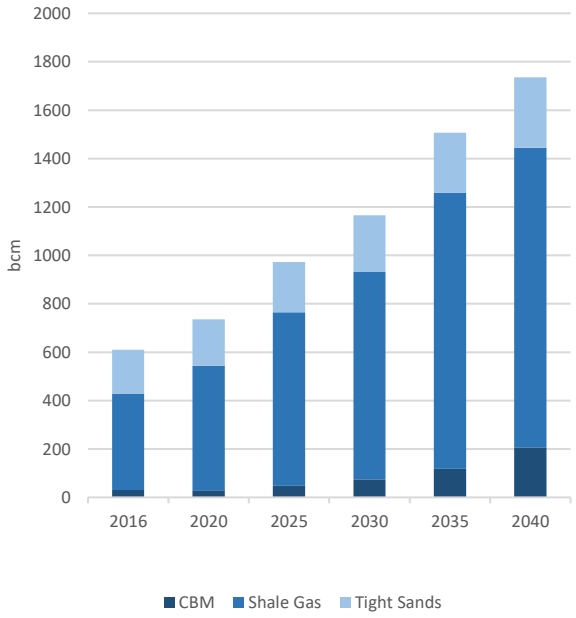
Source: GECF Secretariat based on data from GECF GGM

Technology plays a significant role in this development, in favour of unconventional resources. A considerable decline in unconventional production costs allows these resources to be competitive, even in low price environments. The most important contributors to the ramp-up of unconventional production are the US, Russia, Canada, Algeria, Argentina, and Australia.

Among unconventional resources, shale gas will continue to dominate production. By the end of 2040, more than 1.2 tcm of shale gas is anticipated to be produced annually, mostly from the US and China, and to a lesser extent from Algeria, Russia and Saudi Arabia.

The second most important unconventional resource is tight gas produced in the US and Canada. China, Russia, the US and Australia will be the most important producers of CBM and will cause a surge in production over the forecast period (Figure 4.10).

Figure 4.10: Unconventional gas production by type



Source: GECF Secretariat based on data from GECF GGM

Table 4.2: Natural gas production by region											bcm
	Africa	CIS	Latin America	Middle East	Non-OECD Asia	Non-OECD Europe	North America	OECD Asia-Pacific	OECD Europe	Southeast Asia	Grand Total
2016	205.4	789.3	166.4	607.9	236.5	11.6	932.8	110.2	233.0	216.3	3497.3
2020	252.7	853.4	157.7	685.5	266.5	11.4	1112.6	160.6	196.9	191.0	3788.2
2025	280.5	922.4	176.3	745.3	368.5	14.7	1092.7	127.5	197.9	188.1	4114.1
2030	309.6	971.3	187.9	823.3	479.9	15.3	1157.0	149.7	189.9	207.2	4491.2
2035	383.6	1004.8	233.8	908.6	600.7	15.9	1272.8	165.4	149.9	179.2	4493.6
2040	438.1	1124.3	221.3	982.9	699.1	16.9	1325.4	187.1	127.4	262.3	5384.8
CAAGR (2017-2014)	3.2%	1.5%	1.2%	2.0%	4.6%	1.6%	1.5%	2.7%	-2.5%	0.8%	1.8%

Source: GECF Secretariat based on data from GECF GGM

Global gas trade outlook

This section will examine global LNG and pipeline trade over the Outlook period, from the perspective of both importers and exporters.

The GECF GGM contains two trade models: free trade and obligated trade. The obligated trade model takes all contracted volumes of natural gas into account, including both LNG and pipeline; results from this model show how these contracted volumes can be achieved over the forecast period. The remaining capacity will be optimized and allocated for trade by running the free trade model; results from this model take all technical, financial and market circumstances into consideration.

In this Outlook, trade volume is defined as the volume of gas produced in one country and consumed in another. The figures that are reported do not include flows that pass through a country via pipeline or that are re-exported. Some reports estimate that around 730 bcm of natural gas was transported via pipelines in 2016 and that figure includes flows passing through intermediate countries. This transit volume accrues to neither the producer nor the consumer and is not added to the total volume of trade in this report. In terms of global LNG trade, re-exported volumes are excluded from total trade figures due to the methodology employed in the GECF GGM.

In this Outlook, trade is quantified in net terms, rather than gross terms. Given this approach, we can more accurately see the export potential for countries and regions, based on: their production capacity development; internal demand trends; the geographical situation; and benefits arising from the trade itself. In the present Outlook, trade figures are presented on a regional basis. These figures do not only show inter-regional trade, but also cover all volumes of gas produced in one country and consumed in another - either within the same region or in another. For example, when we say that pipeline exports in OECD Europe will decline, this means that countries in OECD Europe will export less gas to all countries within or outside this region.

Figure 4.11 shows how net global demand for natural gas develops over the Outlook horizon, and how it can be met by indigenous supply and imports. In 2017, around 1000 bcm, or approximately 29% of total consumption, will be met by imports in the form of LNG or pipeline gas. This share is projected to remain constant through to 2040, when total consumption will be around 5400 bcm and total trade will equal 1500 bcm. Therefore, 500 bcm of more natural gas will be traded by the end of the period, compared to current levels.

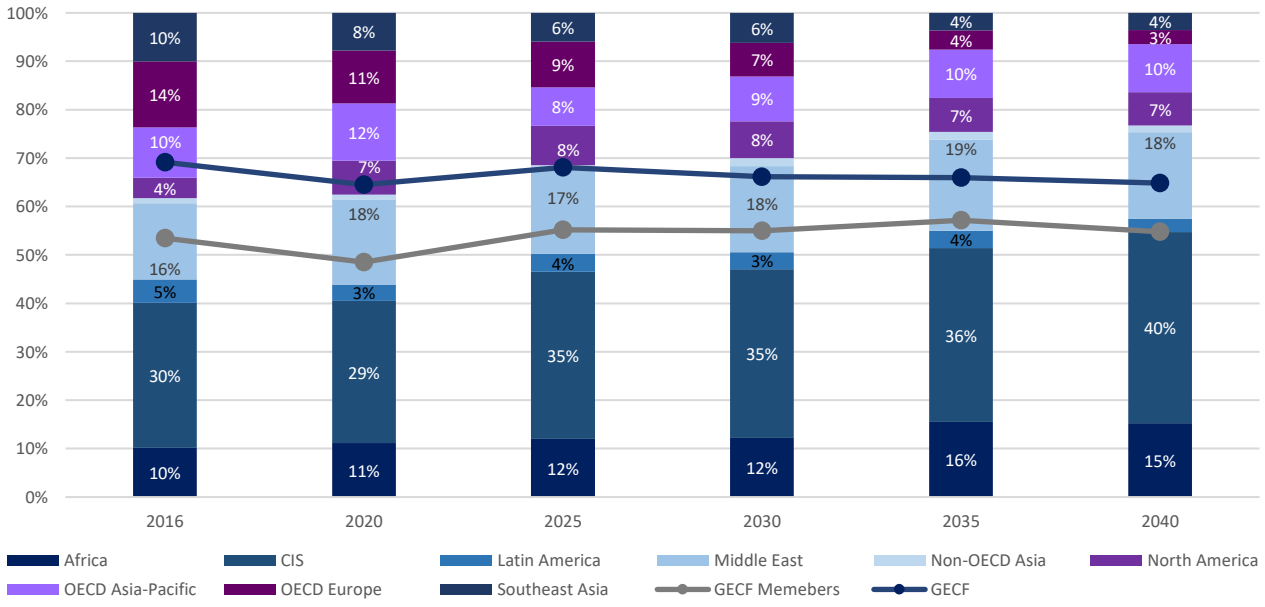
Figure 4.11 Composition of global gas demand

Source: GECF Secretariat based on data from GECF GGM

The regional shares of global gas exports are presented in Figure 4.12, demonstrating that the CIS will be the largest exporter over the entire Outlook horizon. Russia, Turkmenistan, Azerbaijan, and Uzbekistan are the most important contributors to this expansion.

Total exports from Russia will increased by more than 200 bcm, an average annual growth rate of 2.5% through to 2040. Azerbaijan and Turkmenistan will see annual growth rates of 9.1% and 3.5% respectively, increasing their annual export volumes by a respective 48 bcm and 84 bcm by 2040. The expansion of pipeline infrastructure from the CIS to Europe and Asia contributes to these promising figures, especially pipeline expansion to China and expansion of LNG liquefaction in Russia.

Figure 4.12: Regional market share of global gas exports

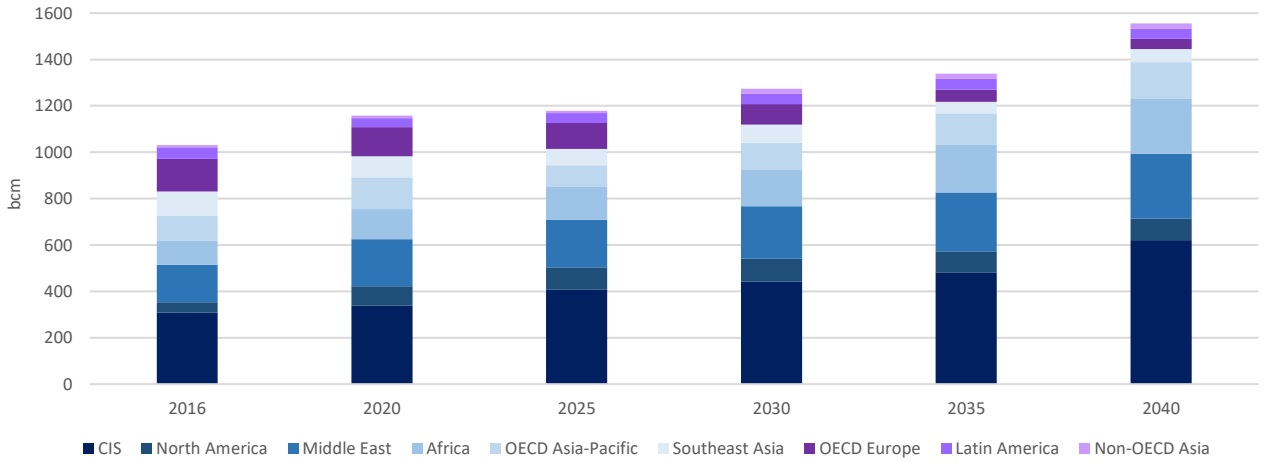


Source: GECF Secretariat based on data from GECF GGM

Figure 4.13 provides information on the absolute value of gas exports from different regions. North America, Africa and the Middle East are projected to more than double their total exports, by 7%, 15% and 18%, respectively. Their combined shares total 40%, equal to that of the CIS region (40%). The remaining 20% share is exported by non-OECD Asia, Southeast Asia, Latin America, and OECD Europe. OECD Europe and Southeast Asia will lose share due to depleting gas fields and consequent production declines. In addition, increasing domestic demand in Southeast Asia will push gas production towards domestic consuming sectors. The Netherlands, Norway, Malaysia, and Indonesia will also export less natural gas, mostly due to weakening production.

The GECF Countries maintain their role in the global gas trade over the Outlook horizon. In the medium-term, a slight decline can be observed in the market share of the GECF Countries in terms of total export volume, which can be attributed to the export boom in Australia and the US. However, the GECF's share will recover to around 68% by the mid-2020s and will settle at 65% in 2040. This means that, in 2040, 65% of natural gas consumed in countries who are not gas-producers, will be the output of the GECF Countries.

Figure 4.13: Total gas exports by region



Source: GECF Secretariat based on data from GECF GGM

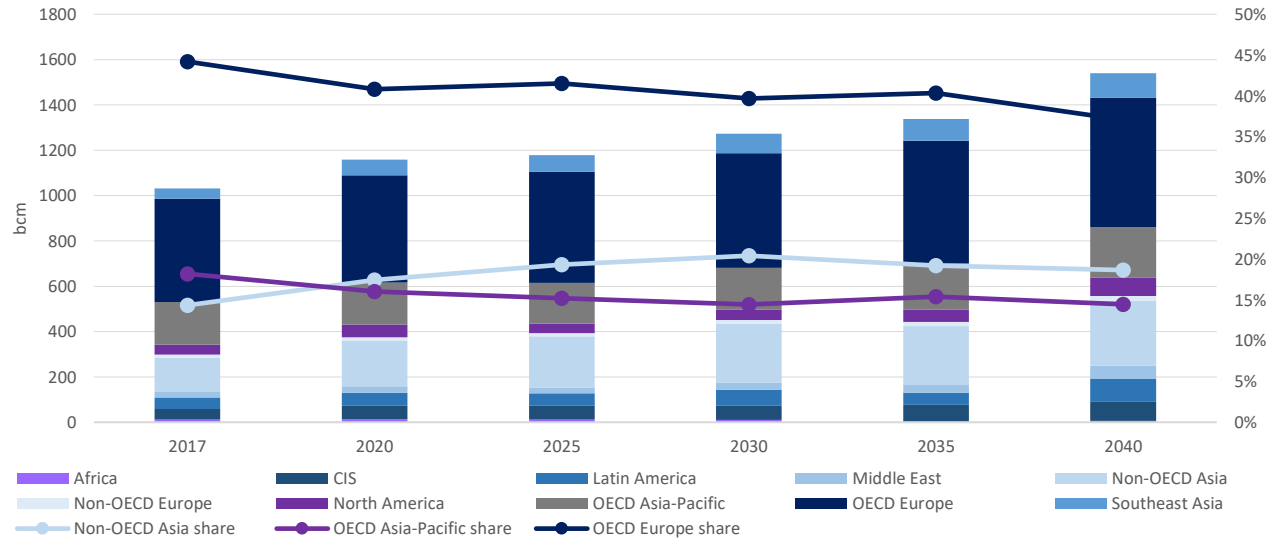
From the demand side, we can see that OECD Europe will remain the biggest importer of natural gas. By 2040, OECD Europe will import around 120 bcm of gas above current levels (both via pipeline and LNG). Its market share will, however, fall from around 45% in 2016 to less than 37% in 2040. The primary reason behind this declining market share in total gas imports, despite significant growth in their absolute value, is the emergence of new markets in other regions of the world, especially Southeast Asia and non-OECD Asia. Moreover, increases in European gas demand will be limited by the deployment of renewables, efficiency improvements, and energy conservation measures, among other reasons.

New emerging markets in Southeast Asia (e.g. Philippines, Thailand, Singapore, and Vietnam) will more than double total imports to the region, to around 105 bcm annually over the Outlook period.

In non-OECD Asia, increasing demand for natural gas is driven primarily by China, India, and (to a lesser extent) by Pakistan, Bangladesh, Hong Kong, and Chinese Taipei.

This huge increase in demand will elevate non-OECD Asia to the position of second largest importing region after OECD Europe. Non-OECD Asia will overtake OECD Asia-Pacific in terms of market share by around 2020. This can be attributed to stagnating demand in South Korea and decreasing demand in Japan (Figure 4.14).

Figure 4.14: Total natural gas imports by region

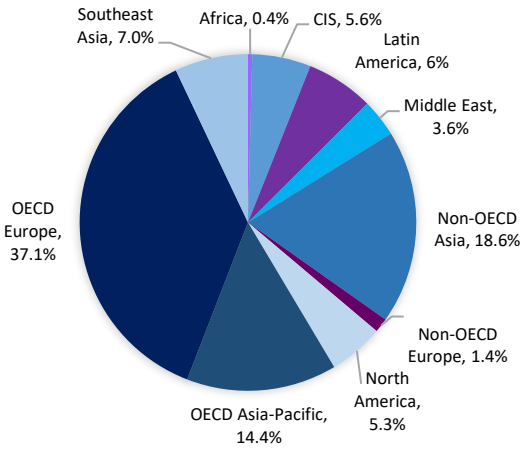


Source: GECF Secretariat based on data from GECF GGM

More than 78% of total gas imports in 2040 will be accounted for by Europe and Asia, with only 11% of imported gas flows heading to countries in North America and Latin America (see Figure 4.15). In the Middle East, an increase from current volumes will be observed, from 26 bcm today to around 50 bcm by 2040. This will increase the region's import share from 2.7% in 2017 to 3.6% in 2040. Jordan, Bahrain and Kuwait are the predominant countries behind this increase.

Africa will have the smallest natural gas import market over the Outlook period. Because of recent and expected developments in Egypt, such as the aforementioned Zohr Field and projects in the West Nile Delta, the country will once again become an exporter and its gas imports will consequently decline. This is one of the factors behind Africa's forecast reduced import share.

Figure 4.15: Regional shares of natural gas imports in 2040



Source: GECF Secretariat based on data from GECF GGM

Pipeline trade outlook

Pipelines will remain the dominant vehicle for natural gas trade over the outlook period, with usage increasing by a CAAGR of around 1.6% to more than 830 bcm per year by 2040.

Pipeline trade volumes are very dependent on bilateral long-term negotiations. In most countries, pipeline infrastructure is owned by state-run companies, and geopolitical issues can have a significant impact on the development of infrastructure and contractual negotiations concerning investments in pipeline trade.

Figure 4.16 presents the total volume of pipeline trade by region. Currently, the share held by the CIS of total pipeline exports is 50%. In other words, half of the gas received through pipelines and consumed in a country other than where it was produced, is output from the CIS region. This share will grow to 69% by 2040. Developing pipeline infrastructure from the CIS region to two important demand nodes (Europe and China/India) is the main reason for this increase.

As far as the medium-term is concerned, some significant pipeline projects in the aforementioned regions will become operational in about four years: the Nord Stream 2, the Southern Gas Corridor (SCPX, TANAP and TAP), the fourth line of the Asia-China gas pipeline D, the Turkish Stream and the Power of Siberia. Lower production costs and increasing demand from these regions will drive the expansion of pipeline trade in the long-term.

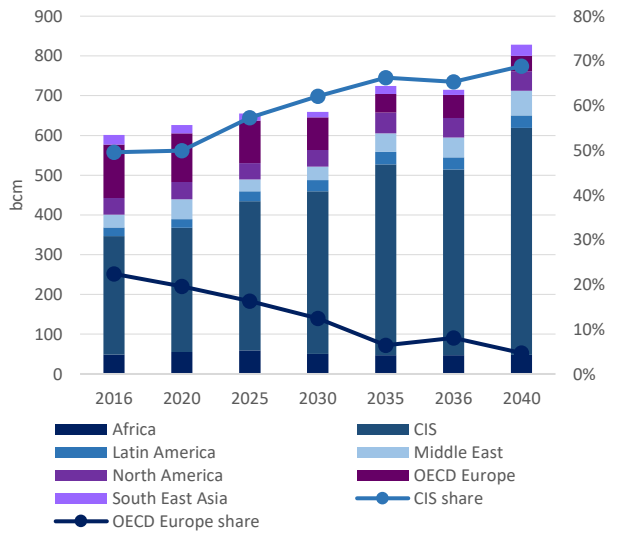
European countries will see declining pipeline exports, as evident in Figure 4.16. This is mostly attributed to production declines in European gas fields, particularly Norway and the Netherlands. European pipeline exports will fall by 5.2% annually over the forecast period, with export volumes declining to less than 40 bcm by 2040. This represents a 70% decrease from current levels.

Latin America will see a slight increase in pipeline exports, driven by Bolivia, and in line with North American trends. Both regions will increase their pipeline exports by around 20 bcm over the forecast period. Pipeline infrastructure in North America will develop considerably, but most of this development will take place within the US and Canada. The US will begin to import less gas from Canada, due to developments in its internal pipeline network that make it possible to meet internal demand with domestic supply.

The Middle East is another region that will witness growth in pipeline exports, by a rate of 2.8% per annum over the Outlook period, reaching more than 60 bcm in 2040. This expansion will benefit GECF countries, such as Iran, Iraq, and Qatar.

Total pipeline exports from GECF Members will increase over the Outlook period, while GECF Observers' pipeline exports will decline.

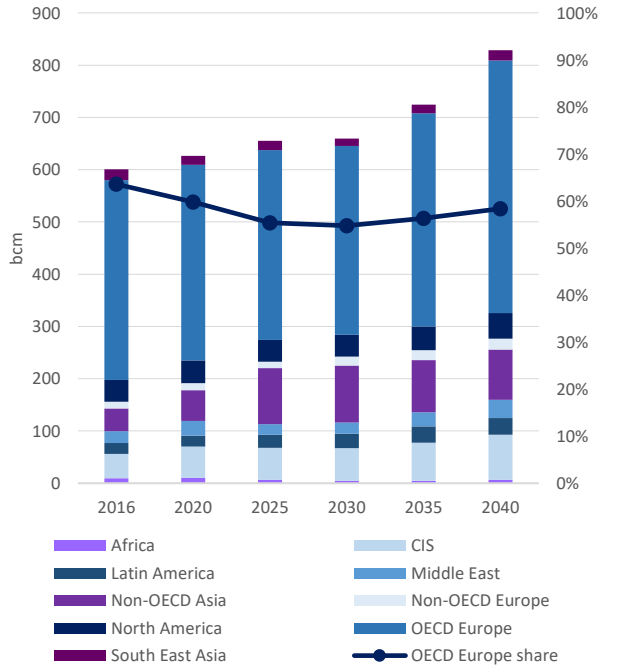
Figure 4.16: Pipeline gas exports by region



Source: GECF Secretariat based on data from GECF GGM

Among importing regions, OECD Europe is the largest destination for pipeline gas and it will retain this position over the Outlook period (see Figure 4.17). However, the region's share will decline from more than 65% in 2016 to 58% in 2040. This decline stems from the fact that other regions are emerging, accounting for significant market shares of pipeline exports. Furthermore, increasing volumes of LNG are being introduced to meet European demand. (This issue will be discussed in more detail in the following section.)

Figure 4.17: Pipeline gas imports by region



Source: GECF Secretariat based on data from GECF GGM

LNG trade outlook

The LNG market has undergone a marked transformation in recent years, with a significant expansion of LNG infrastructure in Australia and the US. This growth will be followed by a few years of stagnation in the absence of new and sufficient final investment decisions, as well as volatility while the market finds its equilibrium.

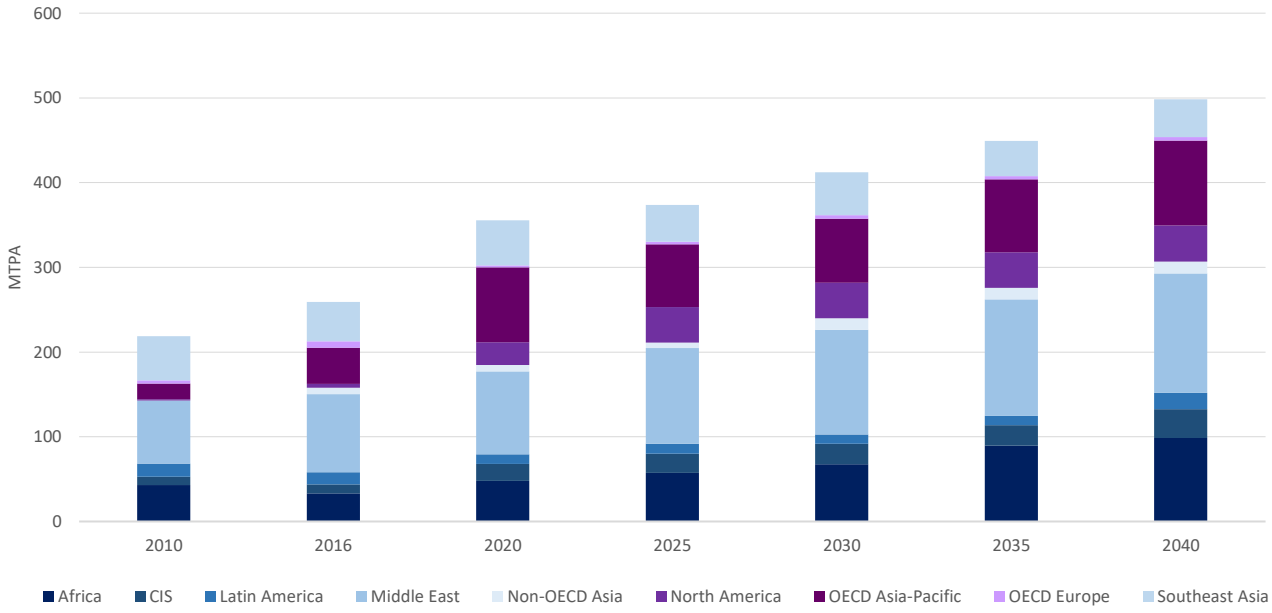
Figure 4.١٨ illustrates historical trends and forecast LNG volumes traded by exporting regions. After 2012, when LNG flows declined due to the economic recession, LNG market volumes started to increase at an accelerated pace. This is forecast to continue, with the largest increases in LNG trading volumes taking place between 2016 and 2020 - the period known as the 'LNG Boom'. The largest contributors to this increase are Australia and the US. As can be seen in Figure 4.١٨, the outlook for LNG export growth is very promising, with an average annual growth rate of 2.8%. The volume of LNG trade will increase by around 240 million tonnes per annum (MTPA) (324 bcm), reaching 498.5 MTPA in 2040.

In the medium-term, it can be seen that LNG trade soars to 356 MTPA by 2020— approximately 100 MTPA more than seen in 2016, when trade totalled 258 MTPA. Most of this boom will come from additional capacity in Australia and the US.

Figure 4.١٩ provides historical and forecast regional shares of LNG exports. It shows that the US will experience a gain of 8% of total LNG exports through to 2020 and 11% through to 2022, compared with 2% in 2016. The share of OECD Asia-Pacific grew from 12% in 2015 to 17% in 2016; it is projected to reach 25% by 2020.

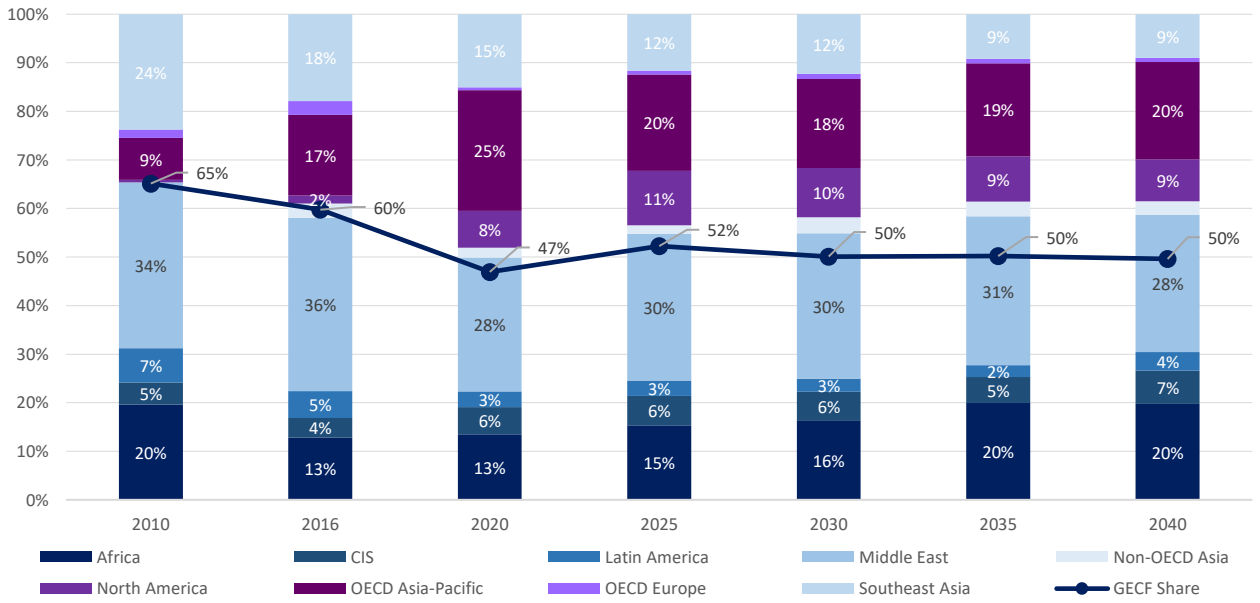
Africa will also considerably expand its LNG capacity and LNG flows. Exports from Africa will grow by 4.6% annually, to reach more than 90 MTPA by 2040. Egypt, Equatorial Guinea, Algeria, Nigeria, Cameroon, Angola, and Mozambique are the most important contributors to this growth. The expansion of LNG capacity in the US and Australia over the last three years has caused Africa's market share to decrease from 17% to 13%. Over the Outlook period, Africa will recover its position in LNG trade to account for more than 20% of the market.

Figure 4.1٨: LNG export by region



Source: GECF Secretariat based on data from GECF GGM

Figure 4.١٩: LNG export share by region



Source: GECF Secretariat based on data from GECF GGM

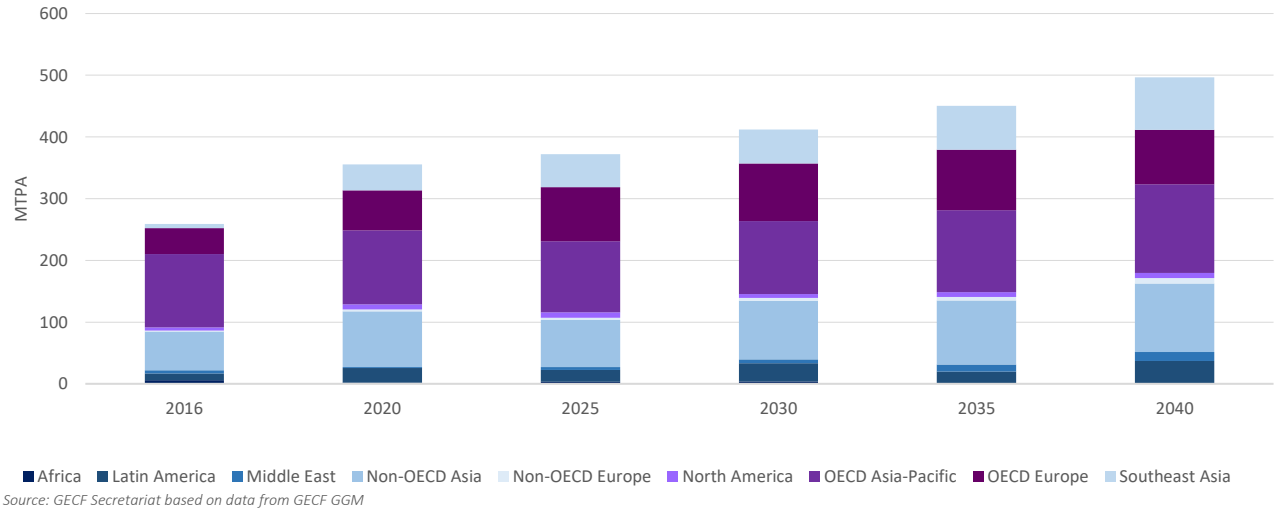
In the early 2010s, the Middle East was the biggest LNG exporter globally, with more than one-third of the region's LNG volumes being exported from Qatar, Oman, the UAE, and Yemen. However, capacity expansion in other regions has eroded its share of the market. It is forecasted that, by the end of 2020, only 28% of total LNG exports will come from the Middle East. However, there is optimism over developments which will increase absolute levels of exports in the region: de-bottlenecking of existing capacity and capacity additions announced in Qatar by 30%; recovering LNG capacity in Yemen; and the entrance of Iran into the LNG export market. The developments in Qatar and Iran will increase the region's share of LNG exports to more than 30% by 2025.

The share of the GECF countries will drop from 59% in 2016 to 47% in 2020, recovering to around 52% by 2025 and reaching 50% by 2040. Figure 4.٢٠ show

forecast LNG flows to all importing regions in absolute volumes and market shares, respectively.

From the demand side, OECD Asia-Pacific will remain the biggest LNG importing region, led by Japan and South Korea. It is anticipated that it will import around 144 MTPA of LNG by 2040, around 25 MTPA above current values. This regional share will level-off to 29% by the end of the forecast period.

Figure 4.٢٠: LNG import by region

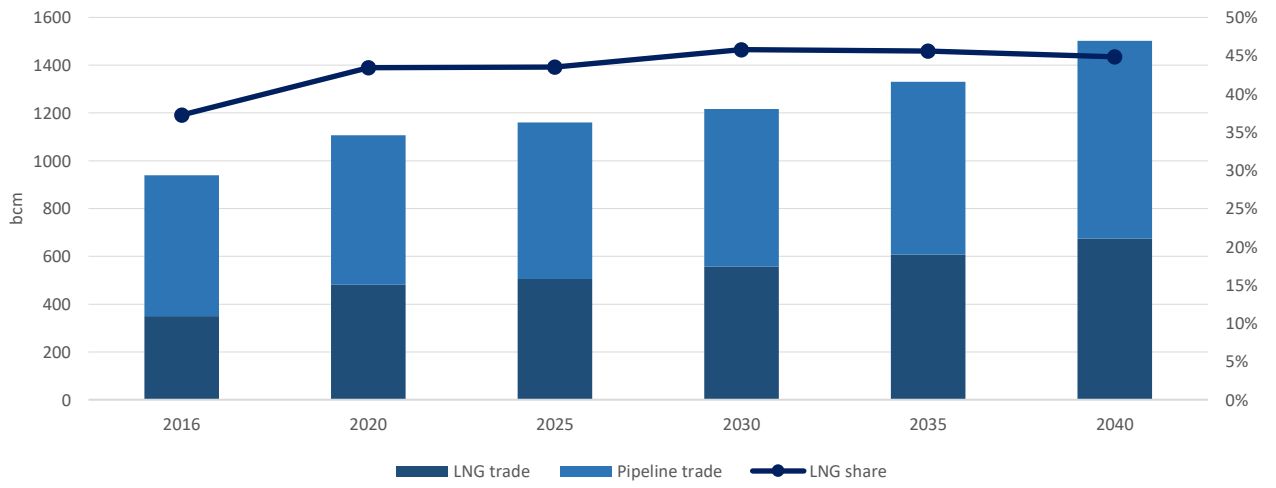


Source: GECF Secretariat based on data from GECF GGM

Emerging LNG import markets (e.g. Philippines, Thailand, and Vietnam) will allow Southeast Asia to gain market share, to around 17% of total LNG imports by 2040, compared with less than 8% currently.

The share of LNG in total natural gas trade will increase. In the medium-term, LNG's share will soar from the current value of 37% to around 45%. With the commissioning of new pipelines, the share of LNG will then remain fairly constant until 2030, remaining around 45% (see Figure 4.٢١).

Figure 4.٢١: Natural gas trade combination by type



Source: GECF Secretariat based on data from GECF GGM

ANNEX I: REGIONAL GROUPINGS

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

Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam,

Commonwealth of Independent States (CIS): Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

Latin America: Argentina, Bolivia, Brazil, Central America (Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Honduras), Chile, Colombia, Ecuador, Other Caribbean (Aruba, British Virgin Islands, Saint Vincent and the Grenadines, Saint Pierre and Miquelon, Suriname, Antigua and Barbuda, Bermuda, Jamaica, Belize, Barbados, Grenada, Cuba, Dominican Republic, Cayman Islands, Saint Lucia, Saint Kitts and Nevis, Dominica, Falkland Islands, Bahamas, Montserrat Antilles, Guadeloupe, Martinique, Guyana, Haiti), Paraguay, Peru, Puerto Rico, Trinidad and Tobago, Uruguay, Venezuela

Middle East: Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates (UAE), Yemen

Middle East and North Africa (MENA): Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates (UAE), Yemen, Algeria, Egypt, Libya, Morocco, Tunisia

Non-OECD Asia: Bangladesh, China, Hong Kong, India, Nepal, Other Asia (Maldives, Vanuatu, Laos, Afghanistan, Mongolia, Bhutan, Macau, Fiji, Cook Islands, North Korea, Tonga, Samoa, New Caledonia, East Timor, Kiribati, Solomon Islands, Papua New Guinea, French Polynesia), Pakistan, Sri Lanka, Taiwan

Non-OECD Europe: Albania, Bosnia, Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Macedonia, Malta, Romania, Serbia and Montenegro

North America: Canada, United States, Mexico

OECD Asia-Pacific: Australia, Japan, New Zealand, South Korea

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, United Kingdom

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam

Sub-Saharan Africa (SSA): Angola, Central Africa (Democratic Republic of Congo, Gabon, Cameron, Congo), Eastern Africa (Eritrea, Sao Tome and Principe, Sierra Leone, Mauritania, Seychelles, Lesotho, Liberia, Somalia, Cape Verde, Sudan, Central African Republic, Kenya, Djibouti, Chad, Burkina Faso, Burundi, Gambia, Niger, Rwanda, Mali, Guinea- Bissau, Ethiopia, Guinea, Uganda, Mauritius, Madagascar, Malawi, South Sudan, Comoros, Swaziland, Reunion, Tanzania), Equatorial Guinea, Nigeria, South Africa, Southern Africa (Mozambique, Namibia, Zimbabwe, Botswana, Zambia), Western Africa (Senegal, Cote d'Ivoire, Ghana, Togo, Benin)

GECF Members: Algeria, Bolivia, Egypt, Equatorial Guinea, Libya, Islamic Republic of Iran, Nigeria, Qatar, Russia, Trinidad and Tobago, UAE, Venezuela

GECF Observer Members: Azerbaijan, Iraq, Kazakhstan, Netherlands, Norway, Oman, Peru

European Union: Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

ANNEX II: DEFINITIONS

Agriculture: Includes all energy used on farms, in forestry, and for fishing.

Biofuels: Liquid fuels derived from biomass or waste feedstocks and including ethanol and biodiesel.

Biomass and Waste: Renewable organic materials, such as wood, agricultural crops or wastes, and municipal wastes, especially when used as a source of fuel or energy. Biomass can be burned directly or processed into biofuels such as ethanol and methane.

Bunkers: Includes both international marine bunkers and international aviation bunkers.

Coal: Includes demand for both primary coal (including lignite, coking, and steam coal) and derived fuels (including patent fuel, brown coal briquettes, coke oven coke, gas coke, gas-works gas, coke-oven gas, blast-furnace gas, and oxygen steel furnace gas). Peat is also included.

Contracts for Difference: A mechanism of hedging the price of electricity for renewables between renewable generators and counter parties (for instance Low Carbon Contracts Company in the UK). It allows the generators to receive a pre-agreed level for the duration of contracts (the strike price). Under this mechanism, when the market price for electricity generated (the reference price) is below the strike price agreed in the contract, compensation is paid by the counter party. On the other side, when the reference price is above the strike price, the renewable generator pays the counterpart.

Cost tranche: A set of production entities grouped according to a defined cost range.

Curtailment: According to National Renewable Energy Laboratory, curtailment is a reduction in the output of a generator of variable renewable energy from what it could otherwise produce given available resources like wind or sunlight. Variable renewable energy curtailment is usually used as a way to reduce the production of energy that cannot be delivered due to lack of power system flexibility.

Distributed energy system: they include systems which generate and deliver energy services (Power, cooking, or heating services) in an independent way from centralised systems. For renewable power, they include particularly off grid renewable generators such as home solar panels.

Domestic: The domestic sector includes energy used in the residential, commercial and agricultural sectors. Domestic energy use includes space heating and cooling, water heating, lighting, appliances, and cooking equipment.

Electricity generation: Defined as the total amount of electricity generated by power only or combined heat and power plants including generation required for own-use. This is also referred to as gross generation.

Energy sector: Covers the use of energy by non-energy sector and the energy losses in converting primary energy into a form that can be used in the final consumption sectors. It includes losses by gas works, petroleum refineries, blast furnaces, coke ovens, coal and gas transformation, and liquefaction. It also includes energy used in the distribution network. Transfers and statistical differences are also included in this category.

Existing gas production facilities: Those that are in production as of 2015.

Feed-in premium: a renewable policy support mechanism which offers a compensation based on markets conditions. In this mechanism, electricity from renewable energy sources is sold on the electricity spot market and renewable producers receive a premium on top of the market price of their electricity production. No premium is paid if market prices are higher than the reference tariff level.

Feed-in tariff: a renewable policy support mechanism which offers a fixed compensation to renewable energy producers, providing price certainty and long-term contracts that help finance renewable energy investments. The level of compensation is based on the cost of generation of each technology.

Feedstock: Use of energy as feedstock in petrochemical industry.

First forecast year: First year of the start of the forecasts in the current version of the Model. It is updated year on year, depending on the availability of the whole set of corresponding required input data and the granularity of the model's architecture and structures.

Gas exports (upstream volumes): Gas volumes shipped by a gas exporting country to an importing country including all the losses (pipelines, liquefaction, shipping, and regasification).

Gas imports (end use volumes): Net gas volumes delivered by an exporting country to an importing country, not including the losses during the shipment.

Gas: Demand for natural gas, both associated and non-associated with petroleum deposits, but excludes natural gas liquids, the gas used in enhanced oil recovery, and gas works gas. (Also referred to as natural gas).

Heat energy: Obtained from the combustion of fuels, nuclear reactors, geothermal reservoirs, the capture of sunlight, exothermic chemical processes, and heat pumps which can extract it from ambient air and liquids. It may be used for heating or cooling, or converted into mechanical energy for transport vehicles or electricity generation. Commercial heat sold is reported under total final consumption with the fuel inputs allocated under power generation.

Heat generation: Refers to fuel use in heat plants and combined heat and power c (CHP) plants.

Heat Plants: Heat plants, refers to plants (including heat pumps and electric boilers) designed to produce heat.

Hydropower: The energy content of the electricity produced in hydropower plants.

Industry: Includes fuel used within the manufacturing and construction industries. Key industry sectors include iron and steel, chemical and petrochemical, nonferrous metals, nonmetallic minerals, and other manufacturing.

International aviation bunkers: Includes the deliveries of aviation fuels to aircraft for international aviation. The domestic/international split is determined based on departure and landing locations and not by the nationality of the airline.

International marine bunkers: Covers those quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined because of the port of departure and port of arrival, and not by the flag or nationality of the ship.

Natural gas liquids: Liquid or liquefied hydrocarbons produced in the manufacture, purification, and stabilization of natural gas. These are those portions of natural gas which are recovered as liquids in separators, field facilities, or gas processing plants. Natural gas liquids include but are not limited to, ethane (when it is removed from the natural gas stream), propane, butane, pentane, natural gasoline, and condensates.

Natural gas production capacity: The potential volumes of natural gas ready to be produced by developed wells and processing units associated with a production entity.

Natural gas production: Marketed production including domestic sales, exports and in some cases natural gas used for enhanced oil recovery in oil fields.

Natural Gas Proven Reserves: Refers to existing reserves, new projects, and unconventional (existing) gas resources.

Natural Gas Resources: According to SPE (Society of Petroleum Engineers) classification in the Petroleum Resources Management System (PRMS), natural gas resources are categorized by five field types including: Existing; New projects; Unconventional existing; Unconventional YTF; and Conventional YTF (sometimes noted YTF only).

New project gas production: Fields that have been discovered but have yet to be developed or are in development.

Non-energy use: Fuels used for non-energy products excluding use as feedstock in petrochemical plants. Examples of non-energy products include gas works, cooking ovens, lubricants, paraffin waxes, asphalt, bitumen, coal tars, and oils as timber preservatives.

Nuclear: Refers to the primary energy equivalent of the electricity produced by a nuclear plant, assuming an average conversion efficiency of 33%.

Oil: includes demand for crude oil both conventional and unconventional and petroleum products include refinery gas, ethane, LPG, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil naphtha, and other oil products (white spirit, lubricants, bitumen, paraffin, waxes, and petroleum coke) and natural gas liquids but excludes biofuels and synthetic oil based products.

Petrochemical Feedstocks: The petrochemical industry includes cracking and reforming processes for the purpose of producing ethylene, propylene, butylene, synthesis gas, aromatics, butadiene and other hydrocarbon-based raw materials in processes such as steam cracking, aromatics plants, and steam reforming.

Power generation: Refers to fuel use in electricity plants and combined heat and power (CHP) plants.

Production entity: A gas field, or group of gas fields located in the same zone, or gas geological prospects from which marketed natural gas production is expected to be available and economically viable.

Production signature: A curve that models the rate at which the remaining recoverable gas reserves will be produced, without damaging the corresponding reservoir.

Renewables: Includes bioenergy (biomass and waste), geothermal, hydropower, solar photovoltaics (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy for electricity and heat generation.

Residential: Energy used by households including space heating and cooling, water heating, lighting, appliances, electronic devices, and cooking equipment.

Total final consumption: the sum of consumption by the different end-use sectors. TFC is broken down into energy demand in the following sectors: industry, transport, domestic (including residential, commercial and agriculture), and feedstock uses.

Total primary energy demand: Represents domestic demand only and is broken down into power generation, heat generation, refinery, energy sector, non-energy sector, and total final consumption.

Transport: Fuels and electricity used in the transport of goods or persons within the national territory irrespective of the economic sector within which the activity occurs. This includes fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Fuel delivered to international marine and aviation bunkers is presented only at the global level and is excluded from the transport sector at a domestic level

Unconventional gas production: Fields that are associated with gas resources that are from either coal bed methane, tight shale, or other resources that require special development techniques.

Yet-to-Find (YTF): refers to the theoretical volume of undiscovered gas reserves, calculated based on the probability of finding reserves in certain geological areas. YTF also assumes that technological advancements will make it economically feasible to extract the gas in the future.

Nationally Determined Contributions (NDCs): are the Intended Nationally Determined Contributions (INDCs) after their ratification by Individual governments. They include the countries' GHG mitigation and adaptation pledges submitted to the UNFCCC in the framework of the Paris Agreement. In This outlook we use indifferently NDCs and INDCs

National Solar Mission: The National Solar Mission initiated in 2010 is a major initiative of the Government of India to promote solar power. It involves Indian States, research institutions and industries. The government of India has also launched other missions to support environmental agenda, such as the National Smart Grid Mission and National Electric Mobility Mission

ANNEX III: ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
AV	autonomous vehicle
b/d	barrels per day
bcm	billion cubic metres
BEV	battery electric vehicles
bn	billion
BREFs	Best Available Techniques reference documents
BRICS	Brazil, Russia, India, China and South Africa
BTU	British Thermal Unit
CAAGR	compound average annual growth rate
CBM	coalbed methane
CCS	carbon capture and storage
CEA	Indian Central Electricity Authority
CEP	Clean Energy for all Europeans
CH_4	methane
CHP	combined heat and power
CIS	Commonwealth of Independent States
CNG	compressed natural gas
CO_2	carbon dioxide
COP	Conference of Parties
CPP	Clean Power Plan
CPS	carbon price support
EAU	emission allocation unit
EB	Executive Board (GECF)
EC	European Commission
EIA	Energy Information Administration (US)
EOR	enhanced oil recovery
EPA	US Environmental Protection Agency
ETS	emissions trading system
EU	European Union
EV	electric vehicle
FITs	feed-in tariffs
FYP	Five Year Plan
GCP	Global Carbon Project
GDP	gross domestic product
GECF	Gas Exporting Countries Forum
GGM	Global Gas Model
GHG	greenhouse gas

Gtoe	giga tonne of oil equivalent
GW	gigawatts
IEA	International Energy Agency
IED	Industrial Emissions Directive
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
KBPD	thousand barrels per day
km	kilometre
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MARPOL	International Maritime Convention on the Prevention of Pollution
MENA	Middle East and North Africa
MEPS	mandatory energy performance standards
MER	market exchange rates
mmBtu or mBtu	Million British Thermal Unit
MT	Million tonnes
Mtoe	Million tonnes of oil equivalent
MTPA	Million tons per annum
NDCs	Nationally Determined Contributions
NPS	New Policies Scenario
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PHEV	Plug-in hybrid electric vehicles
PPP	purchasing power parity
PV	photovoltaic
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
Tcm	trillion cubic meter
TEC	Technical and Economic Council
TWh	terawatt hours
UCV	unconventional
UN	United Nations
US	United States
USD	United States Dollar
WTI	West Texas Intermediate
YTF	yet-to-find
ZEVs	zero-emission vehicles

ANNEX IV: TABLES OF APPROXIMATE CONVERSION FACTORS

Crude oil*	To convert:				
	tonnes (metric)	kilolitres	barrels	US gallons	tonnes/year
From	Multiply by:				
Tonnes (metric)	1	1.169	7.70	307.86	-
Kilolitres	0.8581	1	6.2898	264.17	-
Barrels	0.1364	0.159	1	42	-
US gallons	0.00325	0.0038	0.0238	1	-
Barrels/day	-	-	-	-	49.8
*Based on the worldwide average gravity					

Oil equivalent conversion factors	From thousand tonnes of oil equivalent (ktoe)
to	Multiply by
Terawatt hours (energy) (Twhe)	0.01163
Million British thermal units (MM Btu)	39.70
Petajoules (PJ)	0.04187
Million barrels (mbbl) of crude oil	0.00770
Billion cubic meters (bcm) of natural gas	0.00117
Million cubic meters (mcm) of natural gas	1.16959
Billion cubic feet (Bcf) of natural gas	0.04130
Million cubic feet (mcf) of natural gas	41.30370
Million tonnes of coal equivalent (6,000 kcal/kg) (mtce)	0.00167

Products	To convert:			
	Barrels to tonnes	Tonnes to barrels	Kilolitres to tonnes	Tonnes to kilolitres
From	Multiply by			
LPG	0.086	11.6	0.542	1.844
Gasoline	0.118	8.5	0.740	1.351
Kerosene	0.128	7.8	0.806	1.240
Gas oil/diesel	0.133	7.5	0.839	1.192
Residual fuel oil	0.149	6.7	0.939	1.065
Product basket	0.125	8	0.786	1.272

Units

1 metric tonne = 2204.62 lb = 1.1023 short tons

1 kilolitre = 6.2898 barrels

1 kilolitre = 1 cubic metre

1 kilocalorie (kcal) = 4.187 kJ = 3.968 Btu

1 kilojoule (kJ) = 0.239 kcal = 0.948 Btu

1 British thermal unit (Btu) = 0.252 kcal = 1.055 kJ

1 kilowatt-hour (kWh) = 860 kcal = 3600 kJ = 3412 Btu

Natural gas and LNG	To convert:					
	billion cubic metres NG	billion cubic feet NG	million tonnes oil equivalent	million tonnes LNG	trillion British thermal units	million barrels oil equivalent
From	---------- Multiply by ----------					
1 billion cubic metres NG	1	35.3	0.9	0.74	35.7	6.6
1 billion cubic feet NG	0.028	1	0.025	0.021	1.01	0.19
1 million tonnes oil equivalent	1.11	39.2	1	0.82	39.7	7.33
1 million tonnes LNG	1.36	48.0	1.22	1	48.6	8.97
1 trillion British thermal units	0.028	0.99	0.025	0.021	1	0.18
1 million barrels oil equivalent	0.15	5.35	0.14	0.11	5.41	1

Calorific equivalents	One tonne of oil equivalent equals approximately :
Heat units	10 million kilocalories , 42 gigajoules , 39.70 million Btu
Solid fuels	1.5 tonnes of hard coal 3 tonnes of lignite
Electricity	12 mega watt-hours

1 tonne of ethanol = 0.57 tonne of oil

1 tonne of biodiesel = 0.88 tonne of oil

1 barrel of ethanol = 0.57 barrel of oil

1 barrel of biodiesel = 0.88 barrel of oil

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