Role of Natural Gas in Meeting Sustainability and Climate Changes

July 2019

Comments and Questions regarding this report should be addressed to:

Sid-Ahmed Hamdani
Energy, Environment and Policy Analyst
Energy Economics and Forecasting Department
Gas Exporting Countries Forum
Tornado Tower, 47th-48th Floors. West Bay, Doha-Qatar
P.O.Box 23753
Tel: +974 440 484 22
Email: Sid-Ahmed.Hamdani@gecf.org
More information available on www.gecf.org

ABOUT THE GECF

The Gas Exporting Countries Forum (the GECF or the 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, Angola, 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.

Executive

Although climate change concerns play a key role in driving the future energy configurations, there is a need to consider more integrated framework to assess the sustainability of energy solutions: Assessing the sustainability of energy solutions is more than considering climate change and decarbonisation. It is, indeed, a combination of six identified energy-related criteria including energy access; availability and reliability; affordability and competitiveness; greenhouse gas mitigation; pollution mitigation; increased cooperation. These criteria reflect the link between energy and sustainability and represent the channels by which energy solutions contribute or not in supporting the Sustainable Development Goals.

Based on an integrated framework proposed in this report, natural gas can be a balanced and viable solution that contributes efficiently in achieving SDGs and supporting progress with climate objectives: Natural gas contributes in reducing carbon intensity and pollution effects resulting from energy-related activities; supports access to modern energy; improves availability and reliability of supply; provides competitive and affordable energy. Natural gas can also be a vector of increased cooperation and transfer of technologies between countries. Because of all these benefits, policies and measures that support natural gas can drive progress in the implementation of both the climate and sustainable development agendas.

Natural gas can significantly contribute in mitigating CO_2 emissions, which represent around 3⁄4 of the global energy-related greenhouse gases emissions: This contribution of natural gas can be achieved through switching and penetration against polluting and carbon intensive hydrocarbons; complementing renewables and acting as a reliable backup to their natural intermittency, and enabling improved energy efficiency for energy systems.

Natural gas has undeniable benefits in reducing emissions of hazardous pollutants, particularly Nitrogen Oxides (NOX) and Sulphur Dioxides (SO2) that are responsible of air quality degradation. Gas contributes by less than 7% to the global NOX emissions and 0.4% to the global SO2 emissions. Coal, however, represents around 2/3 of SO2 while oil is responsible of almost 70% of the NOX emissions.

Natural gas supports access to modern, affordable and reliable energy. ~~The abundance of natural gas, with proved reserves estimated at more than 193 trillion cubic meters, means that the world has plenty of gas to meet its energy requirements~~ The role of natural gas in improving energy access can take different forms including the supply of affordable gas-fired electricity; the expansion of gas networks to supply new areas; and the development of small scale LNG that makes gas accessible for small and niche markets. Globally, demand for small scale LNG could reach 100 million tonnes by 2030, through expansion of LNG for power, marine LNG and also LNG for trucks. The latter has the potential to reach around 40% of the small-scale LNG demand by 2030.

Natural gas is an available and reliable source of energy. The abundance of natural gas, with proved reserves estimated at more than 193 trillion cubic meters, means that the world has plenty of gas to meet its energy requirements for several decades. There is also a large untapped potential if we consider under- explored but promising areas such as Africa and the Arctic. The development of unconventional gas resources significantly extends this potential.

The availability and reliability of natural gas is also reflected in the ability of gas systems to ensure a continuous supply over the short-, medium- and long-term. This ability has improved significantly with the increas-

Summary

ing flexibility of gas supply chains, driven particularly by the expansion of LNG capacities. LNG supplements pipeline networks in order to provide diversified supply routes, and the recent emergence of floating and small-scale LNG facilities has contributed towards improving the availability of natural gas and its expansion into new and emerging markets.

Natural gas remains an affordable and competitive energy source in many markets and for various usages, especially when comparing to other energy alternatives such as oil products, electricity or even renewables in producing power.

Natural gas can be a vector for increased collaboration between various actors and stakeholders in different countries. There are different channels through which natural gas contributes in encouraging partnership for sustainable development including mobilization of finance; technology and expertise transfer; trade and improvement of institutional capacities and policymaking processes. Natural gas can drive cooperation between governments and institutions to share best practices and design policies that attract investors, improve efficiency of gas sectors and support the sustainable role of natural gas. The GECF is a case in point since the forum strives to develop a shared understanding of the gas market development and to support its Member Countries in adopting positions and undertaking measures that address the gas markets challenges and opportunities.

Natural gas faces the emerging methane emissions challenge. However, there are still large uncertainties regarding the contribution of gas- related activities to global methane emissions. The current available information on methane emissions is mainly based on estimates, which are often not accurate and difficult to verify. The challenge of measuring methane emitted from gas-related activities is also reflected in the huge number of potential sources of emissions worldwide. These uncertainties underpin the important need to improve knowledge, data availability, transparency and harmonization.

The oil and gas industry is deploying efforts to address methane emissions. This effort is not only driven by environmental and sustainability concerns, but also by economic reasons to capture more value from the saved methane; safety reasons to avoid accidents due to methane leaks; and the need to comply with regulatory restrictions.

Despite a large expected slowdown in the energy-related CO2 emissions, there is still a margin for further mitigation by increasing the penetration of natural gas. In the GECF Global Gas Outlook, the global energy-related CO2 emissions are forecasted to increase over the long-term, despite an expected deceleration compared to the historical trajectory.

The Outlook projects that the majority of energy-related CO2 emissions in 2040 will result from burning coal, which represents nearly 39% of the global total, followed by oil with 34%. The important role of carbon-intensive fuels, particularly coal, contributes in the mismatch between CO2 emissions in the reference case and in a scenario compatible with 2 Degree Celsius temperature increase targeted in the Paris Agreement. Promoting further penetration of natural gas in the energy mix, particularly against coal, can be a valuable and immediate solution to achieve more carbon mitigation and close the gap between the emissions trajectory in the reference case and pathways targeted by the Paris Agreement.

~~Some~~ Recommendations for GECF Member Countries

Based on this report, some key recommendations can be drawn for the GECF Member Countries:
Promote natural gas by considering its global sustainable benefits through an integrated energy-sustainability framework: The six criteria framework developed in this report and which figures out the link between energy and sustainability, can be helpful in arguing on the sustainable role of natural gas. This framework highlights that natural gas can support a balanced and integrated progress towards sustainable development when considering the various identified criteria.

Use different channels for dialogue and communication to promote the sustainable role of gas on different sustainability dimensions. There is an important need to enhance the voice of natural gas and display its economic, social and environmental advantages. In accordance with its mandate, the GECF secretariat can play an important role in this promotion through:

- Active participation at high-level meetings (e.g. G20, UNFCCC) to highlight the GECF integrated view on the role of gas in meeting sustainability challenges.
- Organizing events and workshops dedicated to the discussion of the environmental issues and challenges affecting natural gas as well as the opportunities that can be captured.
- Leveraging the GECF observer status at the UNFCCC to disseminate the GECF messages and insights on gas and sustainable development.

Develop a common and cooperative approach to deal with methane emissions: Despite large uncertainties on the role of gas-related activities in the global methane emissions, there is an important value in dealing with the issue. In this regard, the GECF gains to develop a common approach by:

- Establishing a partnership with a well-recognized ally that allow to build capabilities and share best practices with MCs.
- Looking for synergies between MCs by identifying concrete pilot projects on methane measurement and mitigation as well as the instruments that can be used to fund these projects.
- Supporting efforts to develop technologies that reduce GHGs emissions in the framework of the GECF Gas Research Institute.

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Introduction

Energy systems around the world are engaged in a transition process, which is reflected in profound structural changes in the ways energy is produced, supplied and consumed. These changes aim to achieve cleaner, safer and more sustainable energy supply and demand patterns, which contrast with the historical developments that have negatively impacted the environment and the equilibrium of ecosystems.

Increasing international commitments, including the 2030 United Nations Sustainable Development Agenda and the Paris Agreement, are important drivers behind this energy transition, as these global frameworks aim to address sustainability challenges and climate change concerns, mainly through enhanced policy actions.

The United Nations 2030 Sustainable Development Agenda has set sustainable development goals (SDGs) that need to be pursued by the global international community to enhance economic, social and environmental conditions, and support the development needs of current generations without compromising the needs of the future ones. Climate change is one of the main challenges harming sustainable development, and the Paris Agreement was a landmark global response to deal with this issue. The 24th Conference of Parties (COP 24), held in Poland last December, achieved a key progress by adopting a set of guidelines and detailed procedures supporting the Paris Agreement's implementation. However, COP24 underscored the urgent need to enhance climate actions and ambitions in order to accelerate the transition towards less carbon-intensive economies and meet the Agreement's "below 2°C" objective.

One major concern is how to achieve a delicate balance between enhanced climate actions under the Paris Agreement framework without harming the needs of economic and social progress in different countries. Adopting a carbon mitigation approach for energy sectors that does not integrate other priorities, such as employment, affordability and competitiveness, might lead to negative impacts on economic and social dimensions of sustainable development.

Countries have different specificities in terms of energy resources, demand dynamics, and development conditions, including access to technology and financial resources. Accordingly, there is no single energy-related response to climate challenges. Despite these differences, countries need to weigh the energy options that will allow them to efficiently balance and integrate the dimensions of sustainable development and to achieve progress for both the United Nations 2030 Agenda for Sustainable Development and the Paris Agreement. The GECF believes that natural gas can be an efficient energy option to deal with climate change and sustainability in an integrated and balanced ways, given the economic, social, technical and environmental benefits of natural gas.

The objective of this report is to contribute in the public debate on gas and sustainable development and show that the sustainability of energy solutions is more than climate change and decarbonization. It is, indeed, a combination of different energy-related criteria including energy access; availability and reliability; affordability and competitiveness; greenhouse gas mitigation; pollution mitigation; ~~increased~~ cooperation. These criteria reflect the link between energy and sustainability and represent the channels by which energy solutions or more generally energy systems contribute or not in supporting sustainable development.

These criteria are used to show that natural gas can be a viable solution for sustainability since it supports progress in consistent and balanced ways when considering all of them. The structure of this report is organized in two parts: the first examines the link between energy and the sustainable development goals (SDGs), develops an integrated framework of analysis of this link based on sustainability criteria for energy systems. This framework is used to outline why natural gas can be a viable and balanced energy solution that achieves progress toward climate objectives and the SDGs. The second part presents energy-related CO2 emissions forecasts and their main drivers according to the 2018 GECF Global Gas Outlook (GGO). This part also underscores the contribution of natural gas to mitigating CO2 emissions. This work is part of the continuous effort of

Secretariat to monitor the development of climate actions and initiatives,
assess their impact on energy and gas markets and highlight the attributes of natural gas that makes this energy source compatible with sustainable development. This report adds to a previously released report analysing the role of natural gas in the climate agenda, extends the analysis to include various sustainability dimensions, in addition to the climate- related one, and argues on the advantages of natural gas taking all these dimensions.
The GECF actively contributes to dialogue between energy stakeholders and has recently obtained the status of Observer to the United Nations Framework Convention on Climate Change (UNFCCC), which presents an important opportunity for large and thorough discussion of greenhouse gas (GHG) mitigation and sustainable development.

1

Sustainable Development and Climate Change

The Need for a Balanced Energy Solution

The adoption of the 2030 Sustainable Development Agenda in September 2015, followed three months later by adoption of the Paris Agreement, are key steps marking the increasing commitments of the international community towards sustainability. The two initiatives represent universal visions that support countries in identifying measures and policies aimed to improve economic, social and environmental conditions, at local, regional and global levels. However, whereas the Sustainable Agenda and its related SDGs reflect the integrated and holistic nature of sustainable development concept, including its different sustainability dimensions, the Paris Agreement specifically focuses on GHG emissions, with countries' National Determined Contributions as a main lever proposed by the Agreement to undertake strengthened mitigation and adaptation actions.

Countries' initiatives and actions, which are proposed in the context of the Sustainable Development Agenda and NDCs, require to consider consistent integration of the two frameworks, through well-designed policies and plans, especially those affecting the energy sector. Energy policies can be instrumental in promoting a balanced energy solution that support progress with climate change agenda without harming economic development and social progress.

1.1 Analysing the link between energy and sustainability in the context of Sustainable Development Agenda and the Paris Agreement

Implementing the 2030 Sustainable Agenda and Paris Agreement in efficient ways needs to understand the interdependencies and interactions between them. It requires also to find the ways that can consistently support both the SDGs as well as mitigation and adaptation actions proposed in countries' NDCs.

In analysing the interaction between the SDGs and the climate agenda, it is worth mentioning, first, that SDGs acknowledge the key role of combating climate change in sustainable development. SDGs refer to climate change in a climate- related goal (SDG 13), but also in other goals. For instance: SDG 1 (no poverty) states the need to reinforce adaptation of vulnerable population to climate events, while SDG 2 (zero hunger) highlights the link between sustainable processes for producing foods and their ability to adapt to the effects of climate change. Furthermore, SDG 11 (sustainable cities) recognize the role of urbanization and urban planning in reducing emissions of GHGs and various air pollutants.

Several overlaps do exist amid the 17 SDGs, and between the SDGs and Paris Agreement. One of the critical connections between the SDGs and the Paris Agreement is energy. Energy-related activities can be a source of greenhouse gases emissions, and then are specifically targeted by different NDCs. On the other side, energy is recognized as a key driver of sustainable development; and the sustainable agenda has dedicated an energy-related goal (SDG 7) that aims to improve access to clean and affordable energy.

It is possible to note that many countries' proposed NDCs refer to SDGs (NORTHROP 2016), but major part of the energy-related actions outlined in these NDCs, is driven by SDG 7 rather than by other sustainable goals. However, the link between energy and sustainability needs to be considered at a broader level; energy interacts with all the sustainable development dimensions and goals, it drives economic development and provides improved social conditions and welfare for people.

The GECF has identified six main criteria for energy-sustainability links that represent the channels by which energy could or could not contribute to achieving the SDGs. These criteria can be considered as main dimensions within each a set of sub-criteria or indicators can be defined. The six criteria include:

i) Reducing the intensity of carbon and other greenhouse gases: This intensity factor refers to the emission by unit of energy consumed. It can also refer to the emissions by unit of output (GDP for instance). The intensity factor is a key determinant of the level of GHGs emission from the energy-related activities.

ii) Mitigating pollution from energy-related activities and processes: It specifically refers to the emissions of air pollutants due to fuels' combustion; it also refers to other types of soil and water pollutions that result from the energy processes.

iii) Ensuring access to modern energy: This access enables to deal with energy poverty and to reduce reliance on traditional biomass, often procured and consumed in non-sustainable conditions.

iv) Improving availability and reliability of supply: It has to do with the ability to ensure on the short-, medium- and long-term a continuous physical supply of energy.

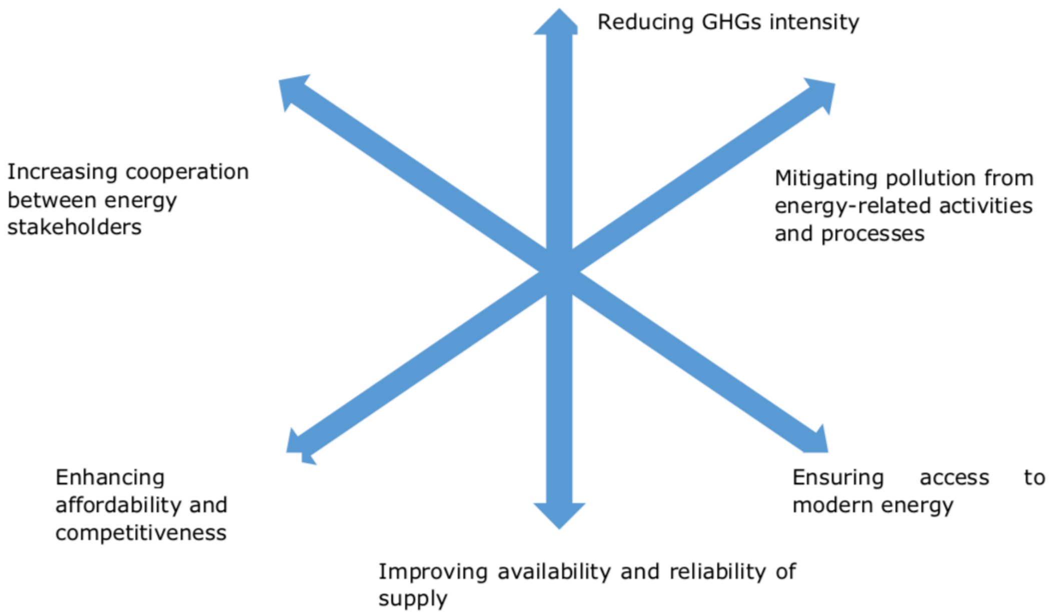
iv) Enhancing affordability and competitiveness of energy: It is underpinned by the cost of providing energy to populations and businesses.

iv) Attracting cooperation between energy stakeholders: This reflects the role of energy activities in supporting fruitful partnerships and cooperation between different energy actors and stakeholders.

The above-mentioned criteria can be helpful in assessing the sustainability of an energy solution (e.g. natural gas vs. coal) or more generally the sustainability of an energy system comprising both demand and supply chains. A sustainable energy system is the one that achieves progress in consistent and balanced ways when considering all these dimensions.

Figure 1.1 Identified criteria for energy–sustainability links

Source: GECF Secretariat



Energy–related criteria that supports SDG progress

The table below highlights some of the examples supporting the links between energy and SDGs through the different identified criteria.

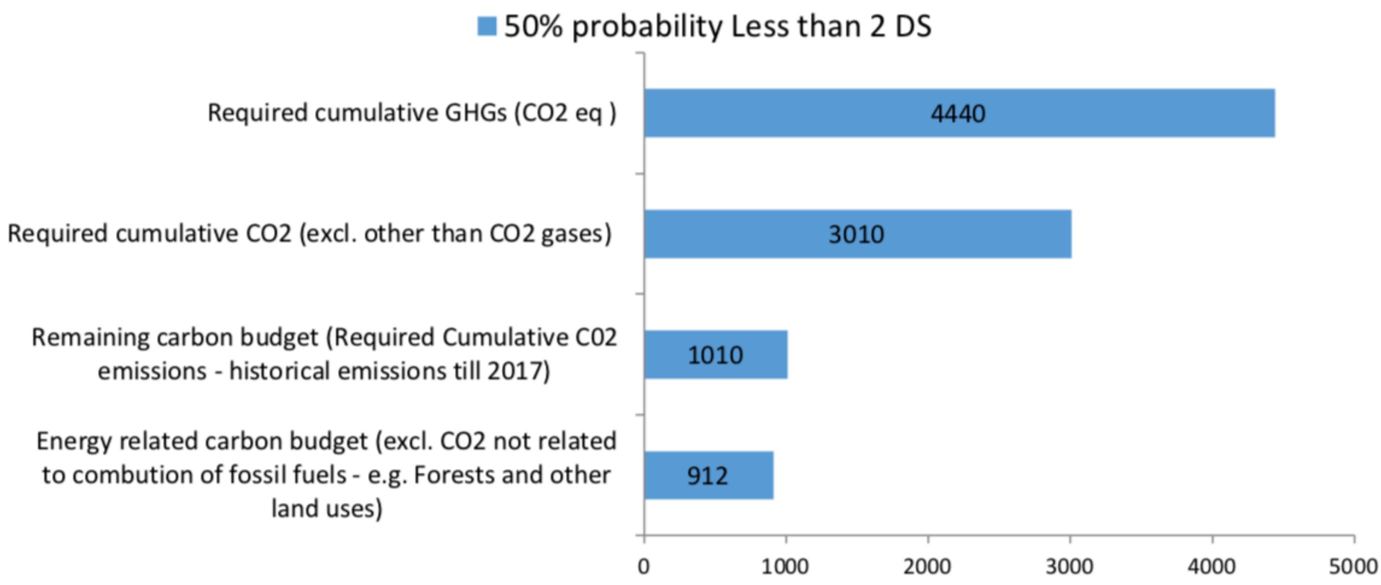
Criteria	Examples of the energy – SDGs link for the considered criteria
Reducing GHGs intensity	Mitigates the impacts of climate change through GHG reductions; reduces the frequency and magnitude of climate-related hazards (e.g. droughts, floods, sea level rise) (SDG 13). Mediates the negative impacts associated with climate change on terrestrial ecosystems (e.g. desertification, biodiversity loss, habitat degradation) (SDG 15).
Mitigating pollution from energy-related activities and processes	Improves access to clean air, soil, and water (SDGs 3, 15, 6 and 14). Improves living conditions, overall health and well-being, and economic activities that may be impaired by degraded human and ecosystem health (e.g. fisheries and agricultural systems) (SDGs 1, 2, 3, and 8).
Ensuring access to modern energy	Greatly contributes to the alleviation of poverty (SDG 1) through electrification; improves food security and agricultural productivity (SDG 2) through motorization. Supports inclusive and sustained growth through job creation and economic productivity (SDG 8). Improves indoor air quality and associated health risks through access to modern cooking infrastructure (SDG 3). Contributes to gender equality (SDG 5), as women and girls are often responsible for household management and may spend hours each day collecting biomass and fuel.
Improving availability and reliability of supply	Encourages the use and monetization of domestic resources for local development (SDG 8). Supports industrialization and infrastructural improvements for the benefit of local populations (SDG 9). Sustains energy-intensive utilities (e.g. water treatment, desalinization, and wastewater treatment) (SDG 6).
Enhancing affordability and competitiveness	Supports economic growth and social welfare (SDGs 1 and 8). Promotes competitive economies and industrialization (SDGs 8 and 9). Reduces inequality through affordable and universal energy access (SDG 10).
Increasing cooperation between energy stakeholders	Supports economic opportunities, energy infrastructure, technology transfer, and innovation (SDGs 8, 9, and 17). Improves institutional capacities, reinforces capacity building, and promotes international cooperation (SDGs 16 and 17).

Analysing the relationship between energy and the SDGs shows that undertaking energy-related actions to meet one SDG can significantly affect another SDG, often in a negative way. For instance: the use of motorization and fertilizers can increase the productivity of agriculture and contribute to reducing hunger and poverty, but at the same time, it will drive an increase in energy demand and GHG emissions. Furthermore, increasing the share of carbon free alternatives, such as renewables, will reduce the environmental impact but might lead to an increase in the cost of energy and therefore reduce its affordability. This overlapping demonstrates the overriding complexity behind defining the appropriate energy options that fit different SDGs, and this complexity has been further increased with the adoption of a very ambitious climate change agenda within the framework of the Paris Agreement which has put more pressure on traditional energy options and technologies.

It is worth mentioning that the objectives set out in the Paris Agreement require a dramatic transformation from the energy sector, whose GHG emissions represent nearly 75% of the global total. The fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5 report) estimates that, in order to achieve the 2°C target outlined in the Paris Agreement with a probability of 50%, cumulative atmospheric GHG emissions cannot exceed 4400 $GtCO_2$-eq throughout the century. Figure 1.2 demonstrates that, if other GHGs are excluded from consideration, the remaining share of CO_2 emissions is equivalent to 3010 $GtCO_2$. When historical CO_2 emissions are subtracted, a carbon allowance of approximately 1010 $GtCO_2$ remains if the Paris targets are to be achieved.

This carbon budget shrinks even further if only energy-related emissions are considered, totalling around 910 $GtCO_2$ between 2017 and 2100. This carbon allowance will be reached in less than three decades if current levels of energy-related CO_2 emissions (~33 $GtCO_2$ per annum) are maintained. Consequently, the energy sector needs to achieve marked reductions to comply with the ambitious 2°C Paris Agreement target.

Figure 1.2. Carbon stock calculations for the energy sector, considering historical emissions and Paris Agreement 2°C target ($GtCO_2$)



Source: Estimations based on data from the IPCC (AR5) report and the GECF Secretariat based on data from the GECF GGM

The Special Report on Global Warming of 1.5 °C (SR15) (IPCC, 2018) shows that more critical values need to be met for the remaining CO2 budget in order to achieve a lower temperature increase target of 1.5°C, which is the temperature required, according to the report, to significantly limit the global warming effect. The SR15 report estimates the remaining CO2 budget from the end of 2017 to 2100, with a 50% probability of occurrence, at 580 GtCO2 (the estimate uses the same methodology as the previous AR5 report, which is based on global mean surface air temperatures). This remaining CO2 budget increases to around 770 GtCO2 when using a methodology based on the global mean surface temperature (GMST) observed for the decade 2006-2015. This puts further pressure on the energy sector to reduce its emissions, while at the same time meeting sustainability requirements.

The strong link that energy forms between the 2030 Agenda and the Paris Agreement allocates responsibility to energy policies in supporting the alignment of the two frameworks. Energy policies establish priorities for the energy sector, affect preferences for particular energy resources, and define production, distribution, and consumption patterns. As such, energy policies can support progress towards achieving the SDGs and carbon mitigating actions outlined in countries' NDCs if they consider a portfolio of complementary and balanced measures that support sustainable energy solutions taking into account various sustainability dimensions as well as the specificities of different countries.

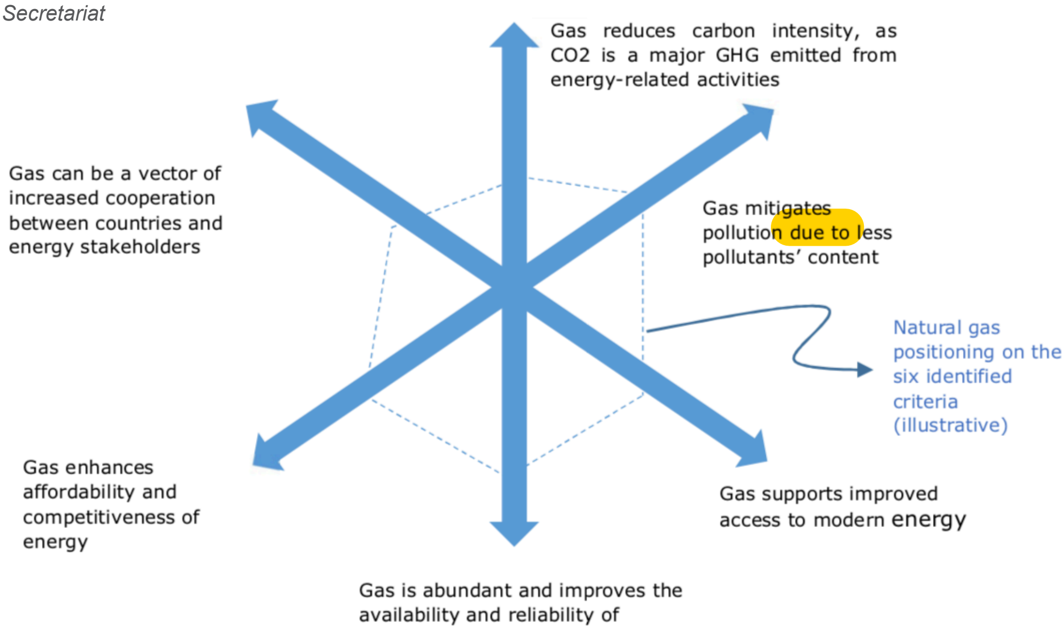
1.3 Promoting Natural Gas: A Balanced Solution to meet Sustainability and Climate Change

Natural gas can be a balanced and viable solution that achieves progress toward climate objectives and the SDGs. The technical, economic, social and environmental advantages of natural gas enable it to contribute efficiently towards achievement of the SDGs through several channels, including the six aforementioned criteria which are highlighted in Figure 1.3.

Natural gas contributes in reducing carbon intensity and pollution effects resulting from energy-related activities; supports access to modern energy; improves availability and reliability of supply; provides competitive and affordable energy. Natural gas can also be a vector of increased cooperation and transfer of technologies between countries. Because of all these benefits, policies and measures that support natural gas can drive progress in the implementation of both the climate and sustainable development agendas.

Figure 1.3. Natural gas-sustainability links (Illustrative)

Source: GECF Secretariat



Natural gas allows to achieve a balanced progress towards sustainable development when considering the identified criteria

The following paragraphs provide some analysis and evidence on the role of natural gas in mitigating CO_2 emissions and in progressing towards sustainable development, through the previously cited channels affecting SDGs.

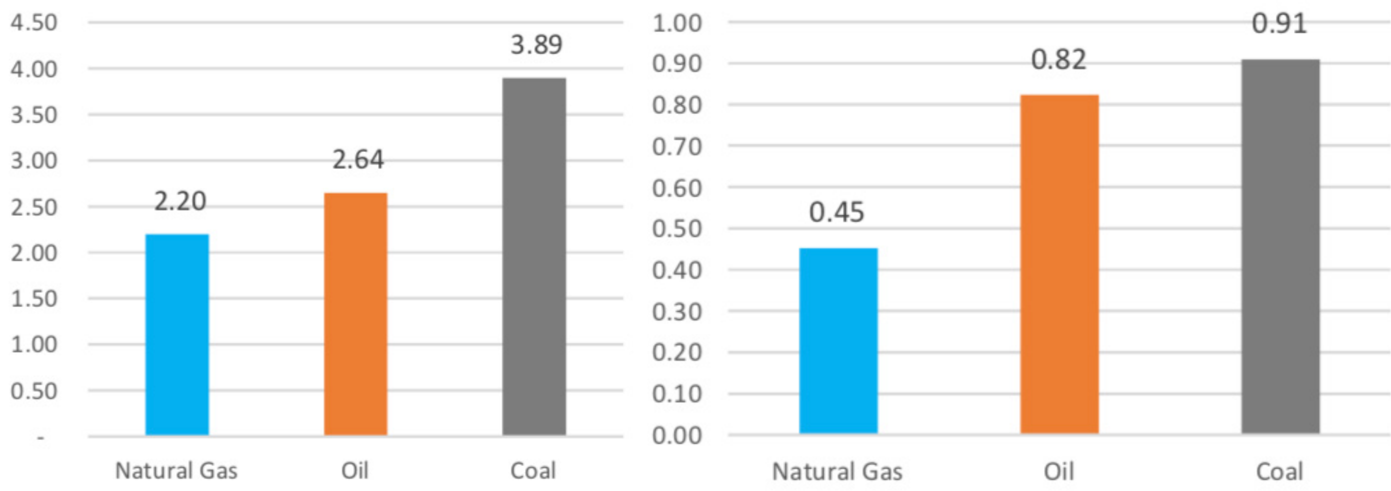
Gas reduces carbon intensity, as CO2 is the major GHG emitted from energy-related activities

CO_2 is the principal emitted GHG from the energy-related activities, representing around 3⁄4 of these emissions in 2017, followed by methane whose share is estimated at around 16%. Natural gas has a key role to play in the climate agenda, since it can significantly mitigate energy-related CO_2 emissions in three ways: i) through switching and penetration against polluting and carbon intensive fuels; ii) by complementing renewables and acting as a reliable backup to their natural intermittency, and iii) through improved energy efficiency.

- Switching and penetration of gas against carbon intensive fuels

Penetration of natural gas over more carbon-intensive hydrocarbons is one of the key contributors in mitigating CO_2 emissions. This penetration enables immediate reduction of emissions since the combustion of natural gas is estimated to produce, on the average, 20% less CO_2 than oil and 43% less than coal. In the power sector, the mitigation effect of using natural gas is even higher (figure 1.4), which is due to higher thermal efficiency of power plants. Based on the average thermal efficiency and fuels' carbon content, each produced Mwh is estimated to generate 50% less when using natural gas instead of coal and almost 55% less when using gas instead oil to produce power.

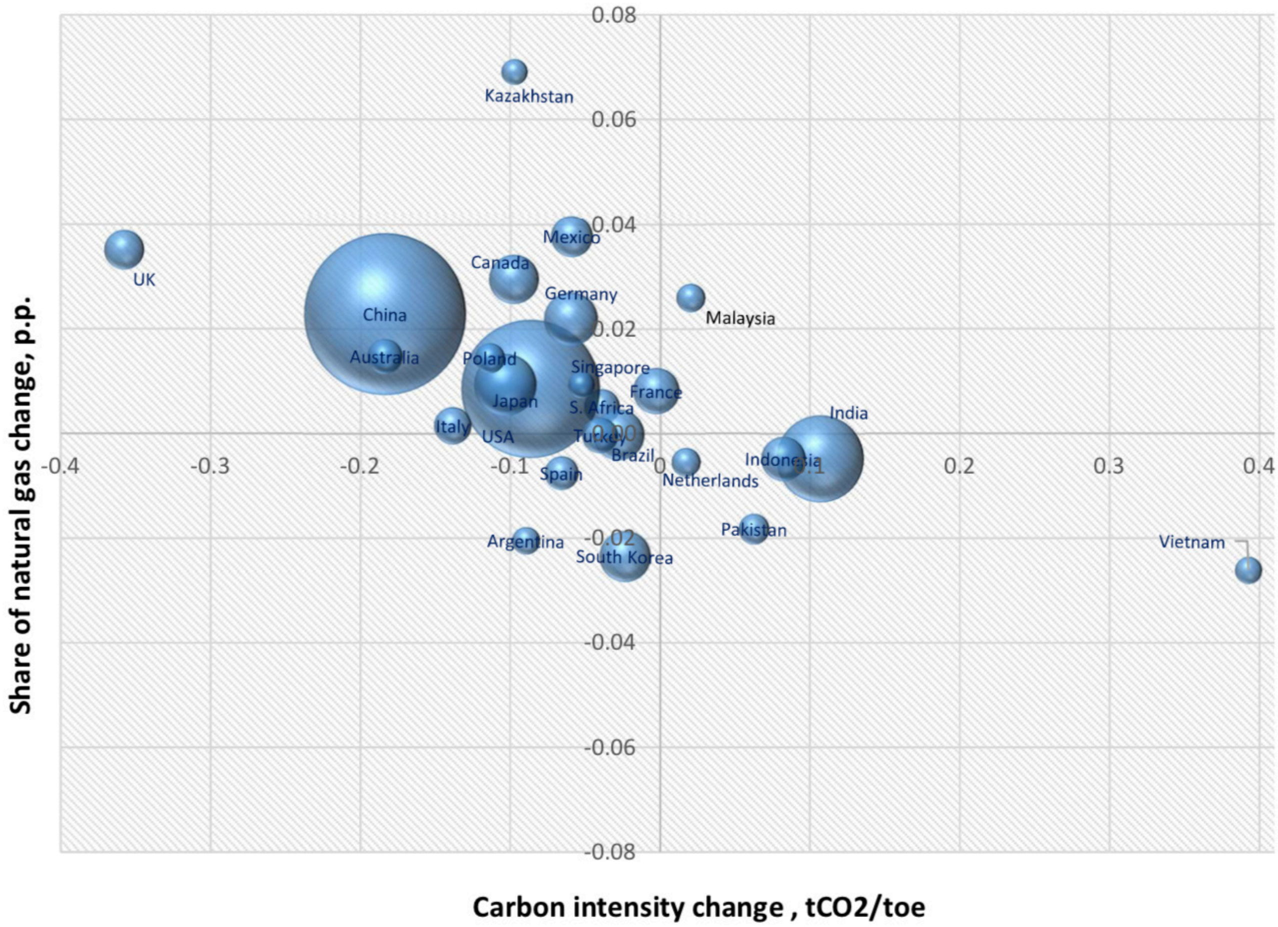
Figure 1.4. Average CO2 Emissions by primary fuel consumed in 2017 (tCO2 /toe), and Average CO2 Emission factors of gas, oil, and coal based electricity (tCO2 /MWh)



Source: GECF Secretariat based on data from the GECF GGM

The recent evolutions showed clear evidence that natural gas progress in the energy mix has played a key role in carbon mitigation for several countries. Figure 1.5 plots for some key consuming countries the variation of natural gas shares between 2012 and 2017, and the change of carbon intensities

Figure 1.5. Change of gas shares and carbon intensities between 2012 and 2017



Note: The size of the bubbles represents the country's share in global primary energy consumption Source: GECF Secretariat based on data from the GECF GGM

The chart depicts a concentration at the upper left side, meaning that a large part of the selected countries has observed a decreasing carbon intensity associated to increasing gas penetration. China, the US and the UK are key examples that highlight this recent trend.

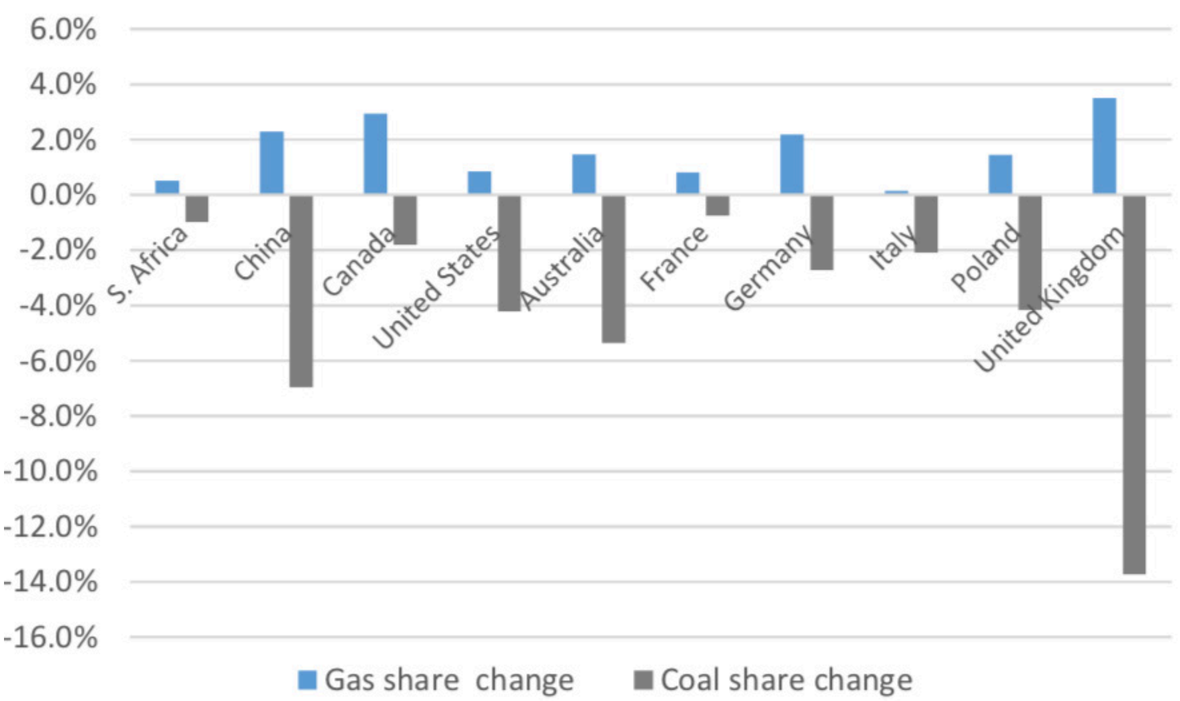
For China, the carbon intensity decreased from 3.22TCO2/toe in 2012 to 3.04tCO2/Toe in 2017, and this decline is associated to an increase in the share of natural gas from 4.4 to 6%. This penetration of gas has occurred at the expense of coal whose share shrunk from 67% in 2012 to 62% in 2017. Although it is not the only factor, coal to gas switching played a substantial role in reducing the Chinese carbon intensity. The substitution of gas to coal is also an important driver of the recent carbon intensity reduction in the UK and the US. This substitution drove a decrease of total CO2 emissions, between 2012 and 2017, by 3.5% for the US and 18.2% for UK.

The key carbon mitigating role of gas penetration against coal is highlighted in figure 1.6, showing that almost all countries observing a decrease of their carbon intensity and increase of gas shares over the 2012-2017 period (i.e. countries positioned at the left upper side in figure 1.5), have in the same time decrease the share of coal.

Conversely, a number of countries that reduced the share of natural gas to the benefit of coal like India, Vietnam, Pakistan and Indonesia have seen a substantial increase in their carbon intensity, although some of these countries (e.g. India) have made a significant progress in other carbon mitigation options such as renewables. Coal share progress in the four above-mentioned counties has specifically occurred in power generation driven by the competitiveness of coal in this sector, and also by the decreasing availability of domestic gas, as it is the case in Vietnam. Malaysia has observed an increase in the share of natural gas and a relative stagnation of coal share. This has raised its carbon intensity slightly, by around 0.02 tCO2/toe. The figure could be improved if natural gas achieves more penetration at the expense of coal.

The other category of countries highlighted in figure 1.5 is those that achieved a decrease of their carbon intensity despite a reduction of gas share in their energy mix. The increase of nuclear was a key driver for Argentina and South Korea, while a recovery of hydropower generation in Spain and Turkey supported their intensity reduction between 2012 and 2017.

Figure 1.6. Penetration of gas against coal (Shares in primary energy mix)



Source: GECF Secretariat based on data from the GECF GGM

– Complementarity between natural gas and renewables

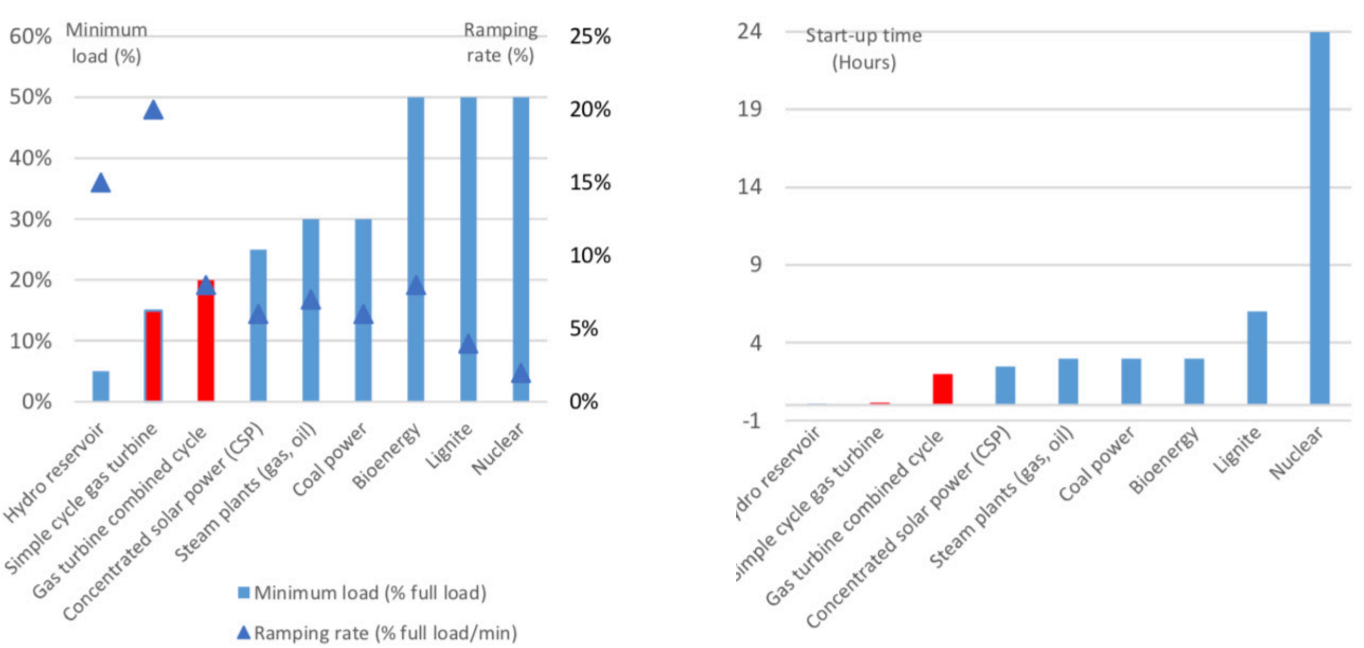
Natural gas and renewables can be valuable partners, particularly in the power generation sector, where gas-fired power plants can provide the required flexibility of power systems to accommodate increasing shares of renewables. Natural gas can ensure cost efficient back-up to intermittent renewables and contribute in maintaining the stability of power grids by responding rapidly to the variability of their electricity production.

Figure 1.7 depicts three parameters that determine the flexibility of power plants: the average minimum load (i.e. minimum operating threshold before shutdown); ramping rate (i.e. pace of variation of the generated electricity) and the start-up time. It is possible to note that the simple cycle gas turbine and combined cycle gas turbine have higher ramping rates and lower minimum loads compared to other power generation technologies including those based on coal, biomass and nuclear. Gas power plants also provide low start-up time. Although the simple cycle gas turbine offers the best flexibility features, several modern combined cycles have the possibility to run either on combined or simple gas cycles, given them the possibility to adjust to the required flexibility of power systems.

The flexibility advantage of gas-fired power plants is also reinforced by the increasing flexibility and reliability of the gas supply chains that allows adjusting procurement of gas to the fluctuations of fuels' needs.

The flexibility of gas supply chains has recently been improved with increasing gas storage capacities, LNG and pipeline operational flexibility (i.e. pipeline line- pack). The complementarity between gas and renewables can also be reflected in the possibility to develop renewables and gas hybrid systems for heating or producing power (e.g. solar gas hybrid power plants). There is also the potential to use gas infrastructure for synthetic gas and hydrogen produced from excess renewables production.
Given all the advantages supporting the complementarity between gas and renewables, gas can be instrumental in enabling renewables' progress and developing efficient and less carbon-intensive energy systems.

Figure 1.7. Average minimum load and ramping rate (%) (Left side), and hot start-up time (hours) (Right side) for various power generation technologies



Source: Agora energiewende (2017)

- Role of gas in improving energy efficiency

There is a range of energy-performant technologies based on natural gas, which can support improvements of energy efficiency at competitive costs. These technologies might include gas-fired power plants such as CCGT, which can reach more than 60% thermal efficiency, gas boilers, or also cogeneration technologies that allow a combined production of power and heat.

In the power sector, the penetration of gas-fired power plants, particularly CCGT, at the expense of coal plants has substantially contributed to improvements in average thermal efficiency. Figure 1.8 depicts that the share of gas in power generation reached 23% in 2017, increasing from 20% share in 2007. Over the same period, the share of coal in the generated power decreased from 41% to 38%. This evolution of coal and gas shares in power generation supported an improvement in the average thermal efficiency from 38% in 2007 to 40% in 2040.

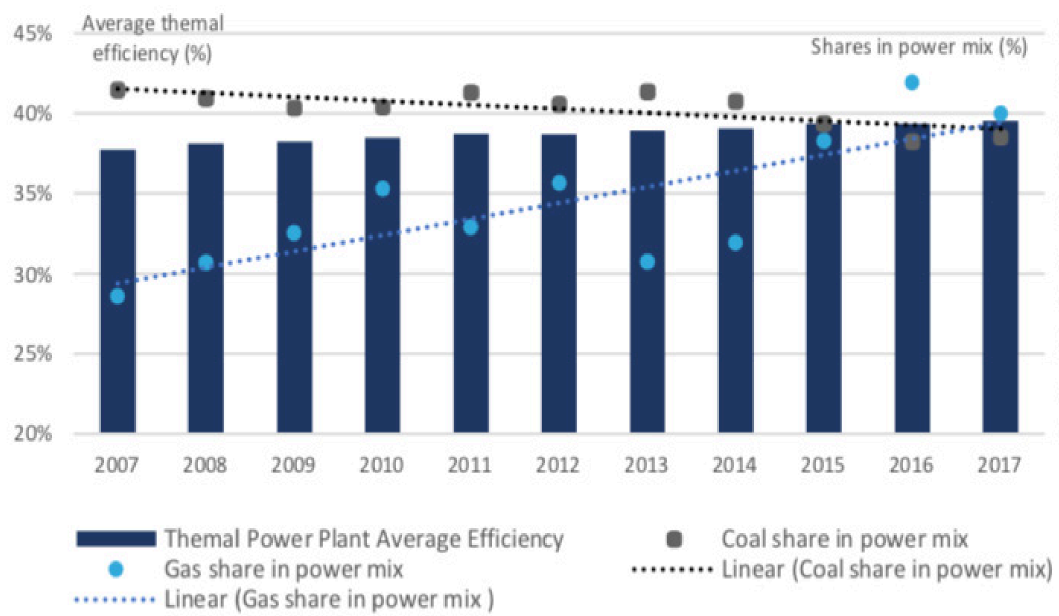
Improvements of energy efficiency enables less consumption of primary energy sources and correlatively leads to less CO_2 emissions for the same amount of output.

Energy efficiency enabled by natural gas technologies is one of the key features underpinning the role of gas in mitigating CO_2 emissions.

Gas mitigates pollution due to less pollutants' content

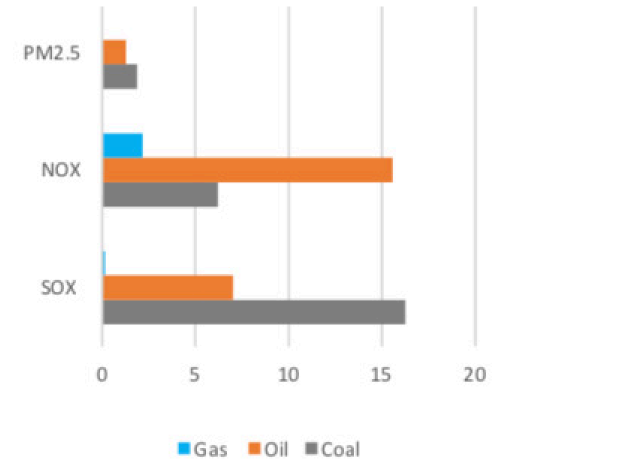
The degradation of air quality and local pollution have been largely driven by the increased emissions of harmful pollutants such as sulphur oxides (SO_X, particularly sulphur dioxide, SO_2), nitrogen oxides (NO_X) and fine particulate matters ($PM_{2.5}$). Natural gas can substantially reduce the effect of these pollutants compared to other hydrocarbons. Based on the average pollutants emission factors (figure 1.9), it respectively emits 99% and 98% less SO_2 than coal and oil. Natural gas is also responsible for 65% less NO_X emissions than coal and 85% less than oil, and is almost not emitting particulate matters.

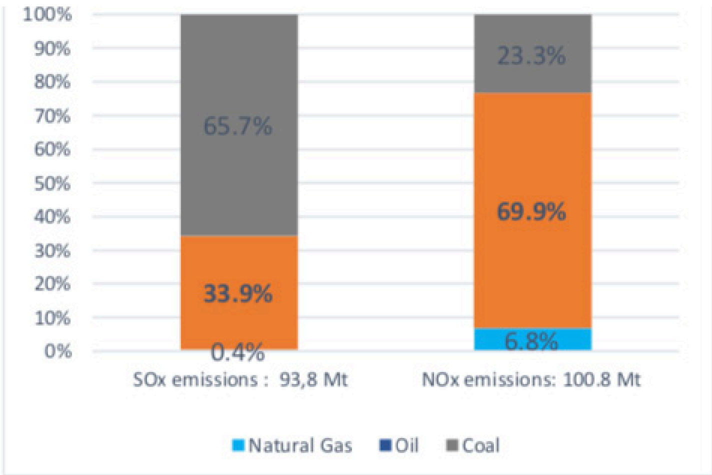
Figure 1.8. Average thermal power plant efficiency in relation to gas and coal shares in power mix (2007-2017)



Source: GECF Secretariat based on data from the GECF GGM

Figure 1.9. SO2, NOX, and PM2.5 emission factors for gas, oil and coal (kg/toe), and Global SO2 and NOX emission shares by fuel (%)





Source: GECF Secretariat based on data from the GECF GGM

Given these lower emission factors, natural gas has contributed with around 0.4% of the global emitted SO2, estimated at 100 million tonnes in 2017. It was responsible for less than 7% of NOX emissions which amounted at around 94 million tonnes. Conversely, coal represented two-thirds of the global SO2 while oil emitted nearly 70% of the NOX in 2017.

As highlighted in a recent IGU survey, support to natural gas significantly improved urban air quality in several cities around the world. In Beijing, a city that suffers from significant air quality issues stemming from pollution and smog, the concentration of particulate matters reached 86µg/m3 in 2014. This is nine times the limit of safety suggested by the World Health Organization (WHO). Since 2014, the Chinese government and local authorities adopted aggressive policy measures to phase out coal-fired boilers, shut down coal-fired power plants, and support natural gas for heating and power production. These actions allowed with the city to reduce particulate matter by more than 1/3 (IGU, 2018a).

Gas supports improved access to modern energy

Natural gas can support access to modern, affordable and reliable energy. The improved access based on natural gas can take different forms including the supply of affordable gas-fired electricity; the expansion of gas networks to supply new areas; and the development of small scale LNG that makes gas accessible for small and niche markets. Furthermore, the development of gas activities in countries with low energy access, particularly in sub-Saharan Africa can provide revenues for these countries and enable them to develop infrastructure that support improved access to energy.

It is estimated that around 1.1 billion people have no access to electricity in the world; most of them are located in sub-Saharan Africa and South East Asia (IEA 2017). Developing gas-fired power plants can strongly improve the access to affordable and reliable electricity in these regions. In sub-Saharan Africa, electricity generated from natural gas expanded from 4% in 2000 to more than 10% in 2017. It is estimated that this progress has enabled more than 50 million people in the region to gain access to electricity. The share of natural gas in sub- Saharan African power generation is expected to more than double, reaching around 20% by 2040 according to the GECF Outlook (GECF 2018a). Several countries with relatively low access to electricity such as Mozambique, Tanzania and Angola encourage the usage of gas in power generation as a lever to improve access and reduce energy poverty. Improving the domestic usage of gas, especially in power generation is often planned as part of an extended gas/LNG export plan that enables these countries to both increase their revenues and support energy access.

The expansion and integration of gas networks has the potential to increase the grid coverage in various regions, and to support access to clean energy, particularly for heating and cooking.

Several emerging and developing countries have initiated programs to expand gas networks to reach isolated areas. Algeria improved the penetration of gas (58% of Algerian households have access to gas in 2017, increasing from 30% share in 2000). This progress has been driven by the strong government effort to support economic development and alleviate poverty, including energy poverty, especially in rural areas and in the southern part of the country.

Russia was able to improve access to natural gas from 53% in 2005 to 67% in 2016 through the extension of its network. Russia has a plan to reinforce its domestic gas network and ensure access to gas in new areas in eastern Siberia. In Sub-Saharan Africa, the development of gas network and their integration support improving access to new discovered or existing gas reserves, and enable these economies to create new industries and business opportunities, and improve their population welfare. A case in point is Nigeria where the reinforcement and extension of gas network enabled access to affordable gas resources for its different regions, and supported monetization of natural gas whose a non- negligible share is flared. The potential development of gas network in Mozambique and its monetization on internal market (industry and power generation) and through exports, including through pipeline to South Africa (Mozambique is already exporting around 4 bcm to South Africa), is also another example showing the role of gas network extension in alleviating energy poverty and providing revenues for African countries.

The development of small-scale LNG in niche markets provides a great opportunity to improve energy accessibility in remote areas. Indonesia has been able to provide energy to its islands through small LNG. Spain has been able to improve the penetration of natural gas in some areas not supplied by pipelines through LNG trucking. Furthermore, the deployment of distributed systems such as off- grid or decentralized gas based solutions has also the potential to play a key role in providing access to energy for all. Globally, demand for small scale LNG could reach 100 Mt by 2030, through expansion of LNG for power, marine LNG and LNG for trucks. The latter can reach more than 40% of the small-scale LNG demand by 2030.

Gas is abundant and improves the availability and reliability of supply

Natural gas is an available and reliable source of energy. The abundance of natural gas, with proved reserves estimated at more than 193 trillion cubic meters, means that the world has plenty of gas to meet its energy requirements for several decades. There is also a large untapped potential if we consider under-explored but promising areas such as Africa and the Arctic, and the development of unconventional gas resources significantly extends this potential.

The gas industry has made large efforts to make the exploration and development of gas resources more efficient, and it has been able to reduce both the costs and the environmental impact of gas-related activities ~~significantly~~. The GECF countries have made a lot progress in this regard and they continue to undertake large investments in order to reinforce their gas production capacities despite challenging market conditions.

The availability and reliability of natural gas is also reflected in the ability of gas systems to ensure a continuous supply over the short-, medium- and long-term. This ability has improved significantly with the increasing flexibility of gas supply chains, driven particularly by the expansion of LNG capacities. LNG supplements pipeline networks in order to provide diversified supply routes, and the recent emergence of floating and small-scale LNG facilities has contributed towards improving the availability of natural gas and its expansion into new and emerging markets.

Moreover, the development of storage capacities, both in the form of underground reservoirs for long-term storage and pipeline line-pack and LNG for shorter-term storage, is another indicator of the increasing flexibility of gas supply chains. Countries such as China are striving to improve their storage capacity ~~significantly~~ in order to better manage seasonal demand and supply imbalances. China has released a plan to double its gas storage capacity from 7.4 bcm in 2016 to around 14.8 bcm by 2020.

Despite all these advantages, ensuring sustained availability and security of gas supply over the long-term needs large investments and this is strongly affected by security of gas demand. The gas industry remains capital-intensive and requires security of demand and visibility on revenues in order to ensure economic viability and secure funding. Security of demand can be improved through transparent policy actions in consumer markets, which recognize the important role of natural gas in achieving sustainable development.

Gas enhances affordability and competitiveness of energy

Natural gas remains an affordable and competitive energy source in many markets and for various usages, especially when comparing to other energy alternatives such as oil products, electricity or even renewables in producing power. The integration of environmental externalities through the pricing of pollution and carbon emissions can further reinforce the competitive advantage of natural gas, particularly against coal.

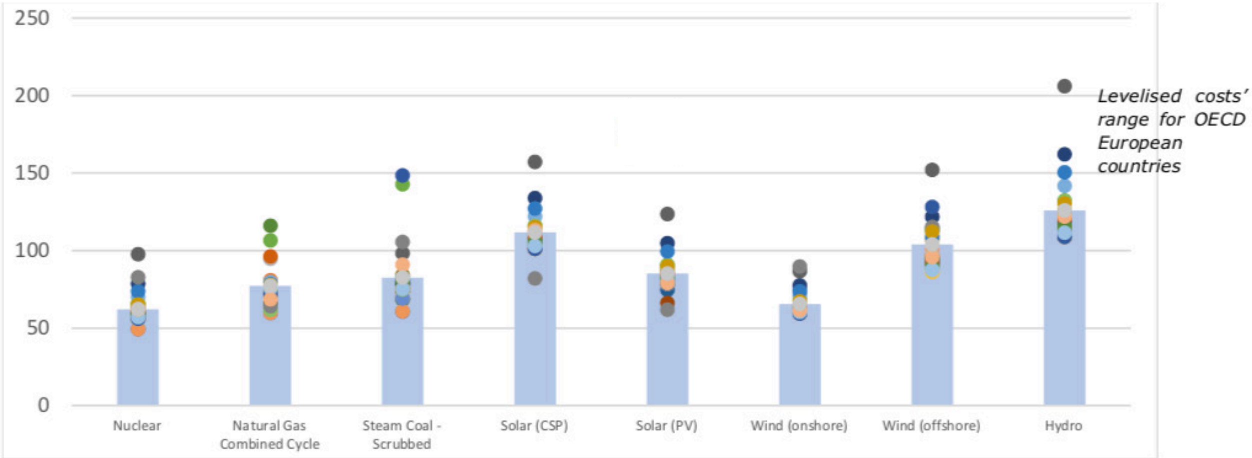
There are many drivers that support the affordability and competitiveness of natural gas including: its abundance and large availability; expanded gas infrastructure and networks in different markets; energy efficiency of the gas based technologies (e.g. Combined Cycle Gas Turbine -CCGT); possible synergies with other processes such as the combined production of power and heat; low carbon penalties and pollution costs. Furthermore, it is much less costly to transport the same amount of energy in the form of natural gas than in the form of electricity and this add another advantage to natural gas over electricity.

In power generation, one key indicator of the competitiveness of natural gas is the long-term levelised cost of producing power by using CCGTs. Based on the estimation of these costs in OECD Europe in 2017 (Figure 1.10), CCGT remains competitive compared to solar, offshore wind and nuclear, with a cost estimated at around 78$/MWh. The consideration of higher carbon prices compared to previous estimations contributes in making the cost of CCGT even more competitive than coal-fired power plants in OECD Europe (e.g. The 2020 average carbon price from the EU ETS is estimated at around $20/tCO2, which is doubling the level of our previous estimation in GECF (2018).

In the case of onshore wind, the estimated levelised cost (66$/MWh) is relatively less than CCGT. However, this cost estimation needs to be taken carefully since it does not incorporate the hidden costs of integrating wind in power systems, which include the costs of strengthening the electricity networks and the costs of back up to accommodate the variability of renewables.

It is worth noting that the average levelised costs (Figure 1.10) aim to give an overall picture in OECD Europe, but there are some differences at countries' level. For instance, countries in southern Europe, such as Spain and Italy, have lower than average solar PV costs (estimated at around 70$/MWh for Spain and 75$/MWh for Italy), which is mainly due to larger exposition to sunlight in these countries. For natural gas combined cycles, countries such as Latvia and Estonia are estimated to have the lowest levelised costs due particularly to lower gas prices applied for power generators compared to other western European countries.

Figure 1.10. Average levelised costs by type of power plants in OECD Europe ($/MWh)



Source: GECF Secretariat based on data from the GECF GGM

European

Gas can be a vector of increased cooperation between countries and energy stakeholders

Partnership and cooperation play a significant role in achieving sustainable development, by enabling efficient and effective implementation of sustainable actions and initiatives. The role of partnership has particularly been highlighted in the 2030 Sustainable Development Agenda under the SDG 17 (i.e. Partnership for Sustainable Development Goals).

Natural gas can be a vector for increased collaboration between various actors and stakeholders in different countries. There are different channels through which natural gas contributes in encouraging partnership for sustainable development.

Mobilization of finance: Natural gas can attract investors and partners to mobilize the large financial resources, needed for developing capital-intensive gas supply chains. There is evidence that the discovery of gas resources and the decision of governments to proceed with their monetization raise partners' interest in the country and increase the financial inflows. These financial inflows can be provided by different types of partners, including energy companies and financial actors, and are usually driven by large profit expectations and potential added- value stemming from developing gas-based projects.

Technology and expertise transfer: Natural gas can also be an important driver of technology and expertise transfer in the gas industry. Indeed, the complexity of gas projects and the need of their implementation in efficient way to improve their economic viability, make technology and expertise as a key factor of success. This requirement puts partnership with experienced gas actors, and technology and expertise providers at the heart of the gas developments. Countries endowed with gas resources often consider partnership as a strategic priority. They particularly support technology and expertise transfer by encouraging foreign partnership with local actors of the gas industry.

The GECF recognizes the important role of technology cooperation and knowledge sharing for its gas-exporting members. In this regard, cooperation is a core value at the forum and the recent establishment of GECF Gas Research Institute, as a plat form of technical cooperation and innovation, is one important step to confirm the role of partnership in building sustainable gas industry.

Trade: the gas trade contributes in sustainable development, particularly by providing revenues for gas exporters, and supporting access to competitive and clean energy sources for the gas importers. Gas trade can therefore achieve mutual benefits for both producing and consuming countries and allows reinforcing the economic link and relationships between various actors in these countries.

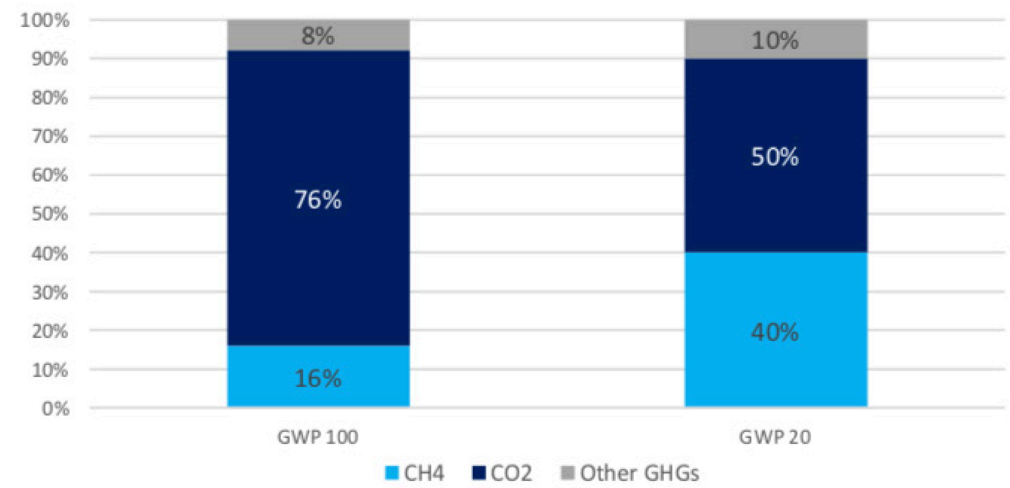
Gas trade has significantly progressed in the recent years, particularly with the development of LNG that allowed the emergence of new production and demand centres and diversification of routes. This LNG progress significantly reinforced the positive role of gas in enhancing partnership and cooperation.

Improving institutional capacities and policymaking processes: Natural gas can also drive cooperation between governments and institutions to share best practices and design policies that attract investors, improve efficiency of gas sectors and support the sustainable role of natural gas. One case in point of this inter-governmental cooperation around the gas industry is the establishment of the GECF. The forum strives to develop a shared understanding of the gas market development and to support its Member countries in adopting positions and undertaking measures that address the challenges and capture the potential opportunities on the markets.

1.4 Methane Emissions Challenge: uncertainties on the role of gas-related activities but efforts deployed to deal with the issue

In a context characterized by increasing pressure to reduce GHGs, methane emission has emerged as one of the major challenges affecting different sectors [27] generating methane, particularly the agriculture and the hydrocarbon industry. Methane is a potent GHG with a high effect on global warming. However, this effect is still a matter of debate, and questions continue to be raised about its contribution compared to other GHGs, especially CO_2.
One of the key metrics used to assess the global warming effect is the GWP (Global Warming Potential). GWP defines the radiative forcing impact of a specific GHG in comparison to CO_2, and then determines the relative contribution of this gas to climate change. There are different estimations of methane's GWP depending on the timeframe over which the cumulative radiative forcing effect is considered. For instance, if the estimation is based on a 20-year timeframe, the GWP of methane is 80 times more than CO_2 (GWP20). This potential drops to around 28 if the calculation is based on a 100-year timeframe (GWP100).

Figure 1.11. Methane and CO2 shares in GHGs emissions depending on GWP calculation method



Source: IGU 2018b

The selected timeframe for GWP estimation can significantly change methane contribution to global GHGs emissions (expressed in CO2-equivalent). As depicted in Figure 1.11, the share of methane in global GHG emissions can increase from 16% to around 40%, when using GWP20 instead of GWP100.

Action against global warming, which is a long-term issue, needs to consider appropriate efforts and initiatives that are able to address the effects of both methane and CO2 over a long-term timeframe. These two gases together represent more than 90% of GHGs emissions in the atmosphere.
Methane is a short-lived GHG and disappears from the atmosphere after approximately 12 years (compared to around 100 years for CO2). This means that each new molecule of methane emitted in the atmosphere is compensated by the disappearance of another molecule emitted 12 years earlier.

If GWP20 is chosen to evaluate the contribution of methane to global warming, it will exaggerate its effect, since this methodology of calculation neglects all the impacts that might occur more than 20 years after the methane is emitted. The GWP20 would have larger focus on short-lived GHGs and might favour the initiatives that support methane mitigation over that of CO2 (IGU, 2018b).

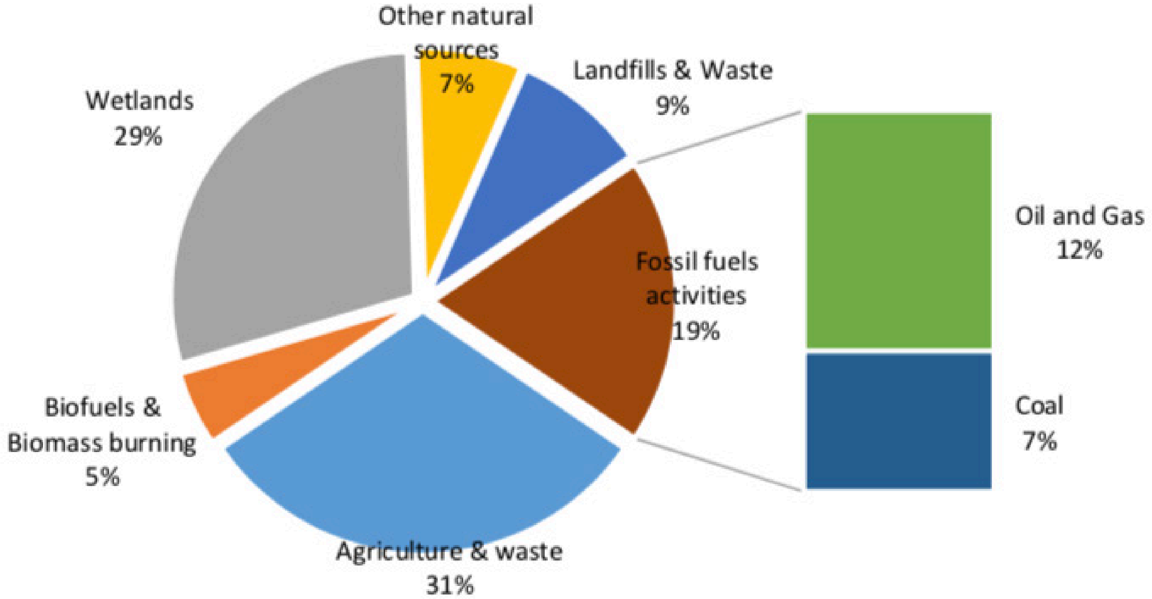
Consequently, the use of GWP100 could be more appropriate in guiding policy actions and initiatives, which reflect a more balanced approach for combating the long-term effect of global warming.

Methane emissions and natural gas activities

Recent data available from the Global Carbon Project (GCP) estimates that total CH4 emissions from all sources averaged between 540 and 568 million tonnes from 2003 to 2012. Anthropogenic sources including fossil fuels activities, biofuels and biomass burning, agriculture and waste accounted for approximately 60% of this figure. Agriculture and waste are the largest contributors with around 32% of the methane emissions. Various studies reported that the rise in atmospheric CH4 levels observed over the past ten years is not the result of increased gas production (OIES 2017), but is most likely the result of increased agricultural activities (Saunois et al. 2016). A study by the National Oceanic and Atmospheric Administration (NASA) showed that recent increases in methane emissions is largely coming from biological sources including swamp gas, rice fields and flatulence of cattle (Nisbet, E. G et al. 2016)

Fossil fuel emissions (including oil and gas, and coal) account for 19% of global methane emissions. Coal mining accounts for more than one third of the CH4 emissions related to fossil fuel activities. This underscores the need to reduce the contribution of coal in the energy mix, in order to diminish both the emissions of CO2 in the coal combustion phase and of methane along the coal supply chain.

Figure 1.12. Total average methane emissions by source, 2003-2012



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

There is significant uncertainty about the direct input of the natural gas supply chain to total fossil fuel-related CH4 emissions. This uncertainty is reflected in the fact that a wide divergence in measurements exist between countries, and according to the methodology employed (bottom-up versus top-down).

The challenge of measuring methane emitted from gas-related activities is also reflected in the huge number of potential sources of emissions worldwide. These might include intentional leakage and venting due for instance to the unavailability of processing facilities, and unintentional or 'fugitive' methane as well as methane emitted from incomplete combustion.

The current available information on methane emissions is mainly based on estimates, which are often not accurate and difficult to verify. Furthermore, a large number of studies on methane use data from the US. There is, therefore, an important need to improve data availability, transparency and harmonization, especially outside the US. Despite these challenges and realities, the oil and gas industry is deploying efforts to address emissions of methane and also of CO2, especially CO2 resulting from flaring activities. This methane mitigation effort is not only driven by environmental concerns but also by: i) economic reasons to capture more value by saving natural gas; ii) safety reasons to avoid accidents due to methane leaks; and also iii) the need to comply with methane emissions regulatory restrictions (e.g. Russia has adopted standards to reduce methane emissions).

The gas industry is part of several initiatives that aim to deal with the methane issue. For instance, the UNECE Group of experts on natural gas, which gather representatives from different actors and stakeholders in the industry including from the GECF countries, works on the ways and best practices enabling improvements of methane data transparency and reduction of methane leakages from the gas-related activities. The UNECE has also declared 2020 the 'Year of Methane'.

Other initiatives, such as the Global Methane Initiative, the Oil and Gas Climate Initiative and the Climate Clean Air Coalition[1] , are also involving actors in the energy sector which are interested in deploying actions to mitigate methane from gas activities.
Thirteen of the largest oil and gas companies in the world (including BP, Shell, ENI, Equinor, CNPC and Aramco) have pledged $1.3 billion, through the Oil and Gas Climate Initiative (OGCI), in order to scale up the development of climate-friendly technologies and solutions, including the ones that target reduction of methane leakage. This initiative includes even the US companies (i.e. Chevron, ExxonMobil and Occidental Petroleum) marking their willingness to pursue efforts to reduce the methane impact, and this despite the recent attempt of the Trump Administration to roll back methane emissions standards for the upstream activities. Adding to that, several oil and gas companies have set voluntary objectives to reduce methane from their gas-related activities. The companies which are part of the OGCI agreed on a collective target to reduce methane intensity (i.e. share of methane to the hydrocarbon production) from their operations from 0.35% in 2017 to below 0.25% by 2025 (GIE-MACROGAS, 2019). In line with this objective, Shell and BP have set ambitions to reach below 0.2% methane intensity, while the Norwegian Equinor wants to achieve a near zero methane emissions.

It is also worth mentioning that major oil and gas companies including BP, Shell, Eni, ExxonMobil, Repsol, Total as well as companies from GECF countries such as Gazprom and Qatar Petroleum, have recently signed a "guiding principles" document[2] on reducing the methane emissions across the gas value chain. These principals particularly include improvements in the accuracy of data and collection methods and increased transparency and reporting standards.

Implementation of the above-mentioned initiatives has allowed non-negligible progress of the gas industry in dealing with methane concern. This progress is noticed in various areas including: i) Identification of methane emissions sources across the various segments of the gas value chain; iii) Application of the Best Available Technique (BAT) and principals to reduce emissions; iv) Development of reporting methods aimed to increase transparency and comparability of the data and v) Measurement and quantification of methane, despite the still need for further improvements in the measurement methodologies (GIE-MACROGAS, 2019).

2

Energy-Related CO_2 Emissions and their Drivers

After highlighting the sustainable advantages of natural gas, this part aims to show the GECF Global Gas Outlook forecasts of the energy-related CO2 emissions in the reference case and their main drivers. It specifically underlines the contribution of natural gas in shaping the emissions future trajectory and its carbon mitigation potential.

2.1 Recent evolutions

During the 2000s, economic progress and increased energy demand of emerging countries, China and India in particular, drove the rapid growth of the energy-related emissions. However, this global momentum has been affected by the 2007 economic crisis that led to substantial emissions reduction in various markets, especially in Europe and the US. The relative recovery of global economy after 2008 has not been associated with a strong resumption of CO2 emissions. The latter have indeed observed a slowdown and plateaued since 2014.

Power generation and industry have been key contributors in the observed stagnating trajectory of emissions, particularly between 2014 and 2016. This stagnation is the result of the energy efficiency improvements, the deceleration of industrial activities in countries like China and penetration of the less carbon- intensive fuels, especially natural gas against coal.

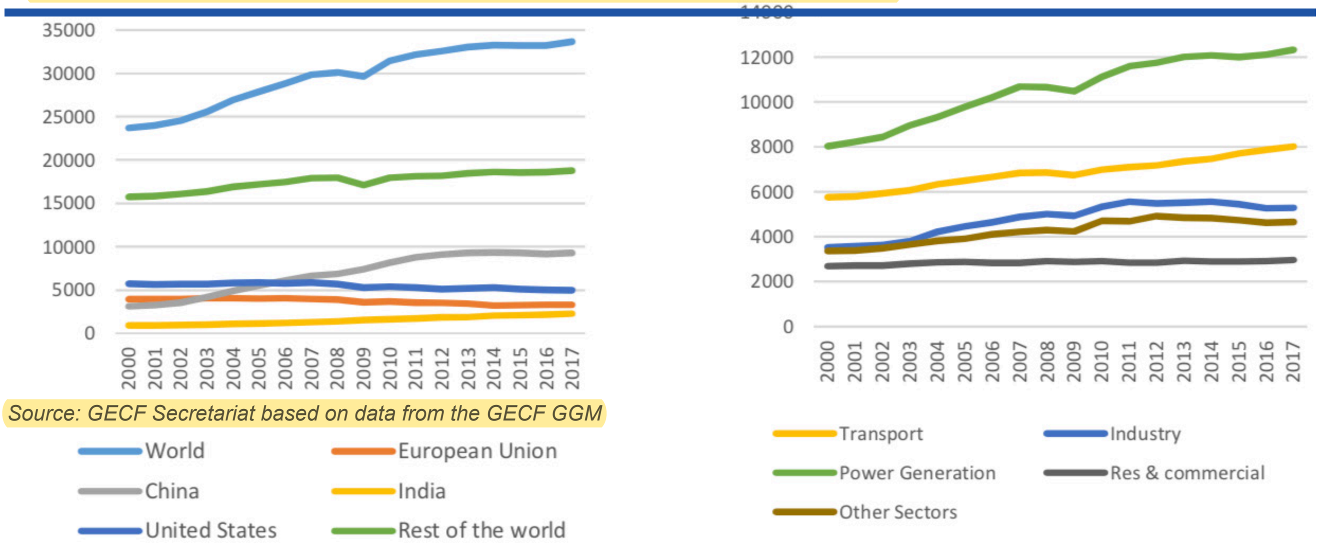
After three consecutive years of stabilization, the CO2 emissions resumed with growth after 2016 and observed a 1.4% increase in 2017 reaching around 33.7 GtCO2. The EU, China and India were key drivers of this growth, adding together 58% of the 456 MtoCO2 globally added between 2016 and 2017. Rising industrial activity and growth of coal demand contributed in this emission progress. China, for instance, increased its coal demand after a declining trend observed since 2014, and this increase was supported by Chinese strengthened measures aimed to mitigate local pollution and reduce over-capacities in some coal-based activities including power generation and steel industry.

It is worth noting that the residential and commercial sectors have the lower contribution in global CO2 emissions, representing together around 10% of emissions in 2017. This is mainly due to the dominance of electricity and natural gas in these sectors' energy consumption. Nevertheless, the residential sector has driven an increase of emissions after 2014, which is supported by an increased demand on oil-based products (especially LPG), following the oil price decline.

The oil price decrease in 2014 has also stimulated oil demand in the transport sector as well as its CO2 emissions. This sector observed a relatively steady growth averaging at around 2% over the 2000-2017 period.

2 The Guiding Principles on Reducing Methane Emissions across the Natural Gas Value Chain were developed in collaboration with the Columbia University, the Environmental Defence Fund, the International Energy Agency, the International Gas Union, the Oil and Gas Climate Initiative, the Climate Investment Funds, the Rocky Mountain Institute, the Sustainable Gas Institute, the Energy and Resources Institute, the University of Texas at Austin, and UN Environment.

Figure 2.1. CO2 emissions by key markets, and by sectors (MtCO2)



Source: GECF Secretariat based on data from the GECF GGM

2.2 CO2 Emissions Forecasts and Drivers

Trends at the global level

Global energy-related CO2 emissions are anticipated to observe a significant slowdown over the long-term in comparison with the historical pathway. Emissions will grow by 0.6% annually over the 2017-2040 period decelerating from an observed annual growth of more than 1.2% during the last decade. Emissions are projected to reach around 38.2 GtCO2 in 2040.

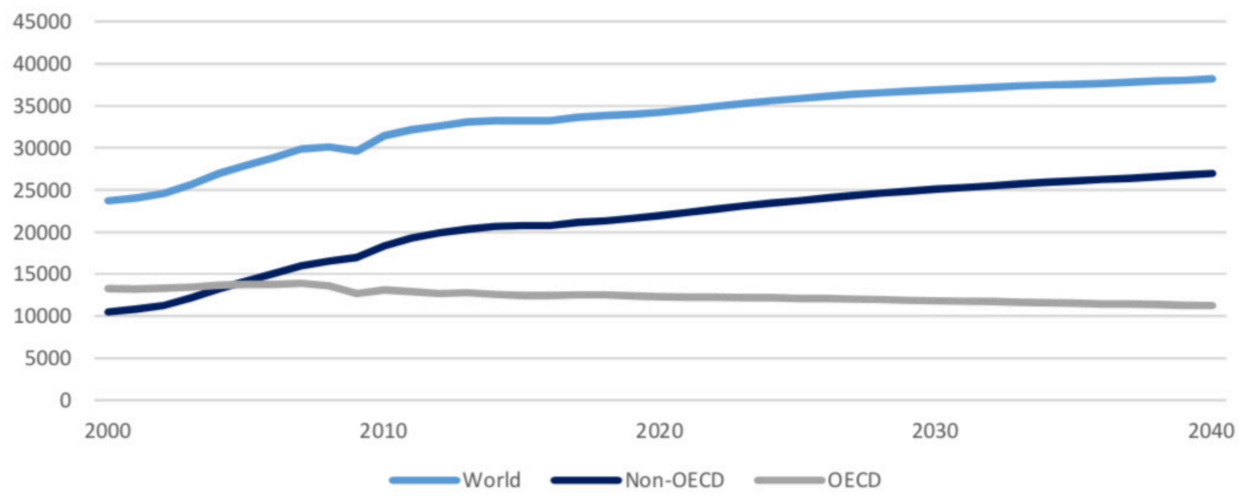
The future emission prospects for OECD and non-OECD regions are projected to exhibit two opposing trajectories. The non-OECD economies will drive emission growth over the long-term offsetting the expected decline of emissions in the OECD regions (CAGR 2017-2040: 1.1% for OECD vs. -0.5% for non-OECD). Nevertheless, this growth is set to decelerate substantially in comparison to the past trends, due to large deployed mitigation efforts as part of non-OECD countries' engagement in the framework of the Paris Agreement.

In order to appreciate the main drivers that affect global emission prospects, and highlight the differences between OECD and non-OECD economies, Kaya decomposition methodology is applied on the future emissions. This methodology deconstructs emissions into four factors: population; average revenue (or GDP per capital); energy consumption per GDP (or energy intensity) and CO2 emission by unit of energy consumed (i.e. carbon content of the energy mix or carbon intensity).

This decomposition shows that population and GDP per capita will be key drivers of CO2 emissions at global level. GDP per capita is even anticipated to observe an acceleration when comparing to the past trends with an expected average annual growth of 1.4% between 2017 and 2040. However, the increase of economy and demography is projected to be attenuated by a substantial decrease of energy intensity and, to less extent, of the carbon content of energy mix (or carbon intensity). As highlighted in figure 2.3, global carbon intensity, which observed a relatively stable trajectory, is projected to decrease by around 0.5% annually over the 2017-2040 period, supported by the penetration of clean and less carbon intensive fuels.

The kaya decomposition underlines the differences between the factors driving emissions in OECD and non-OECD regions. Non-OECD economies are set to observe an important increase of their population and revenues per capita, whose upside effect on emissions largely outpaces the mitigating effect of decreasing energy and carbon intensities. Conversely, the strong declining trends of energy intensity and

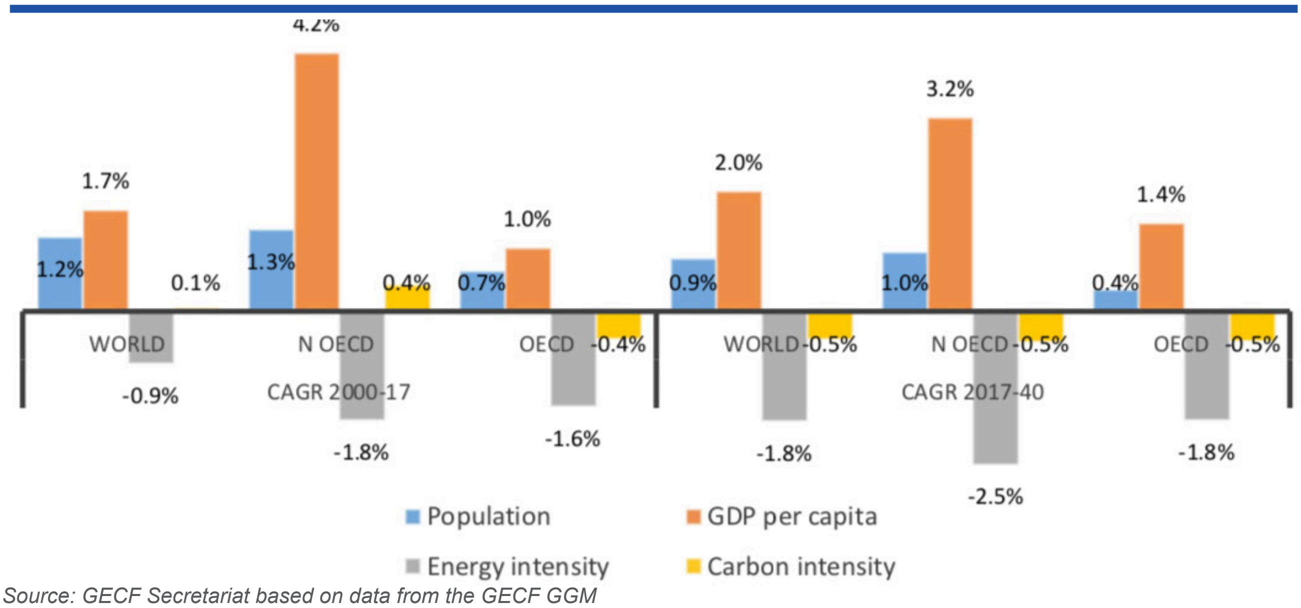
Figure 2.2. Energy-related CO2 emissions (MtCO2)



Source: GECF Secretariat based on data from the GECF GGM

carbon intensity anticipated for most of the OECD economies, will support the emissions decline in the region offsetting the upside effect of growing population and economies.

Figure 2.3. Average annual growth rates of the CO2 emission drivers (Kaya decomposition) (%)

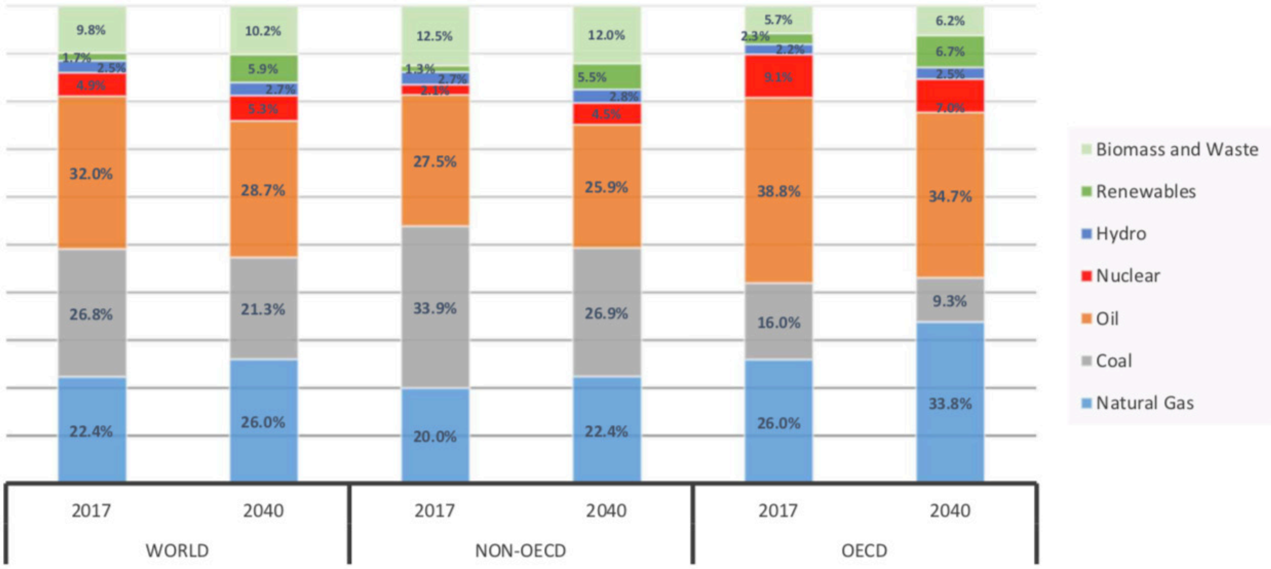


Source: GECF Secretariat based on data from the GECF GGM

One key point is that energy intensity of GDP is projected to observe a faster decline in non-OECD regions compared to OECD, (CAGR 2017-2040 for non- OECD: -2.5% vs. OECD: - 1.8%). This is due to the higher existing potential to enhance energy efficiency and also to achieve a structural change in non-OECD economies by rising the role of less energy-intensive industries and sectors (e.g. the service sector).

The effort of both OECD and non-OECD economies to support clean energy sources, including renewables and natural gas, will translate in decreasing carbon content of their energy mix. However, despite this effort, the level of penetration of clean energy sources is expected to highlight some key differences between the two regions.

Figure 2.4. Primary energy demand by energy sources (%)



Source: GECF Secretariat based on data from the GECF GGM

In non-OECD, although coal is expected to lose significant market shares to the benefit of natural gas and renewables, it will remain a major source of energy, accounting for around 27% of the primary energy demand (Figure 2.4). Renewables and nuclear progress will play a key role in reducing the carbon intensity of the non-OECD region.

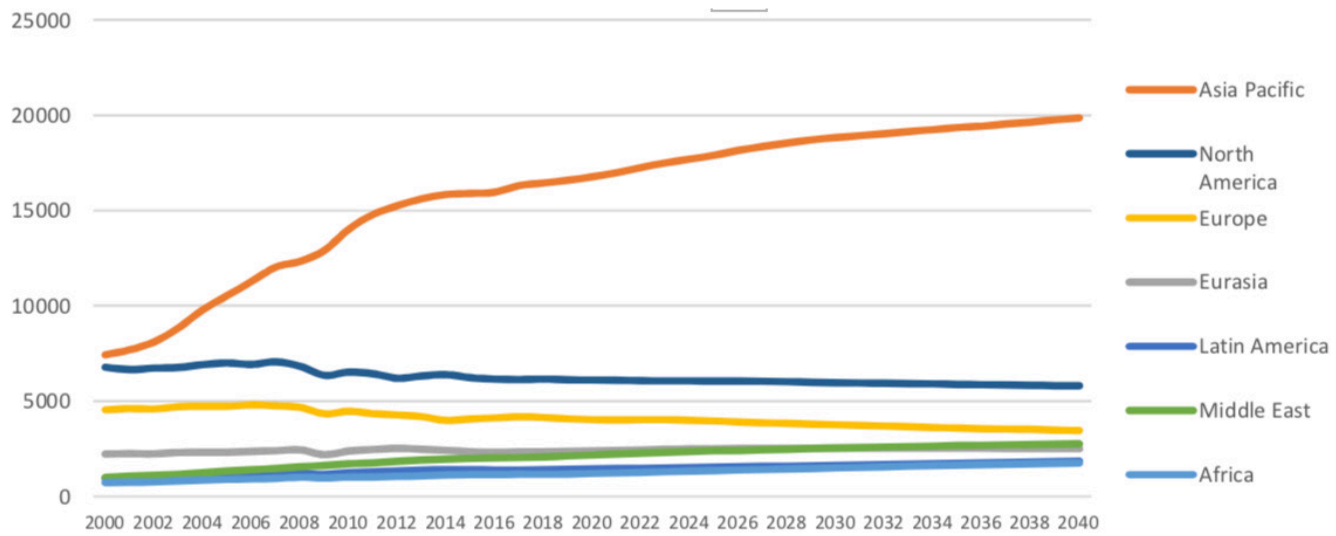
Conversely, in the OECD, coal is projected to decline intensively and to represent less than 10% of the primary energy mix in 2040 (down from 16% in 2017). The penetration of natural gas (34% share in 2040 compared to 26% in 2017) and renewables (7% in 2040 compared to 2% in 2017), at the expense of coal and oil, will contribute significantly in reducing the carbon intensity in the OECD region, though the decrease of nuclear share will play an upside effect on this intensity.

At global level, oil and coal consumption will continue to dominate the global primary energy mix, together representing 50% share by 2040. In the non-OECD region, Oil and coal are anticipated to cover 53% of the primary energy demand in 2040. Accordingly, there is a non-negligible margin to increase the penetration of natural gas and achieve more carbon mitigation in non-OECD countries.

Trends at the regional level

According to the GECF Global Gas Outlook projections, Asia Pacific is expected to confirm its leading role in terms of CO2 emissions widening the gap with other regions such as North America and Europe. Asia Pacific is projected to grow annually by almost 1% over the 2017-2040 period, and this will mark a substantial slowdown compared to the past trends (CAGR 2000-2017: 4.7%). The Middle East and Africa are anticipated, however, to exhibit the highest emission growth rates between 2017 and 2040, that contributes in increasing the contribution of these two regions in the global energy-related emissions from 9% to almost 12% by 2040.

Figure 2.5. CO_2 emissions by regions in the Outlook ($MtCO_2$), and annual growth rate (%)



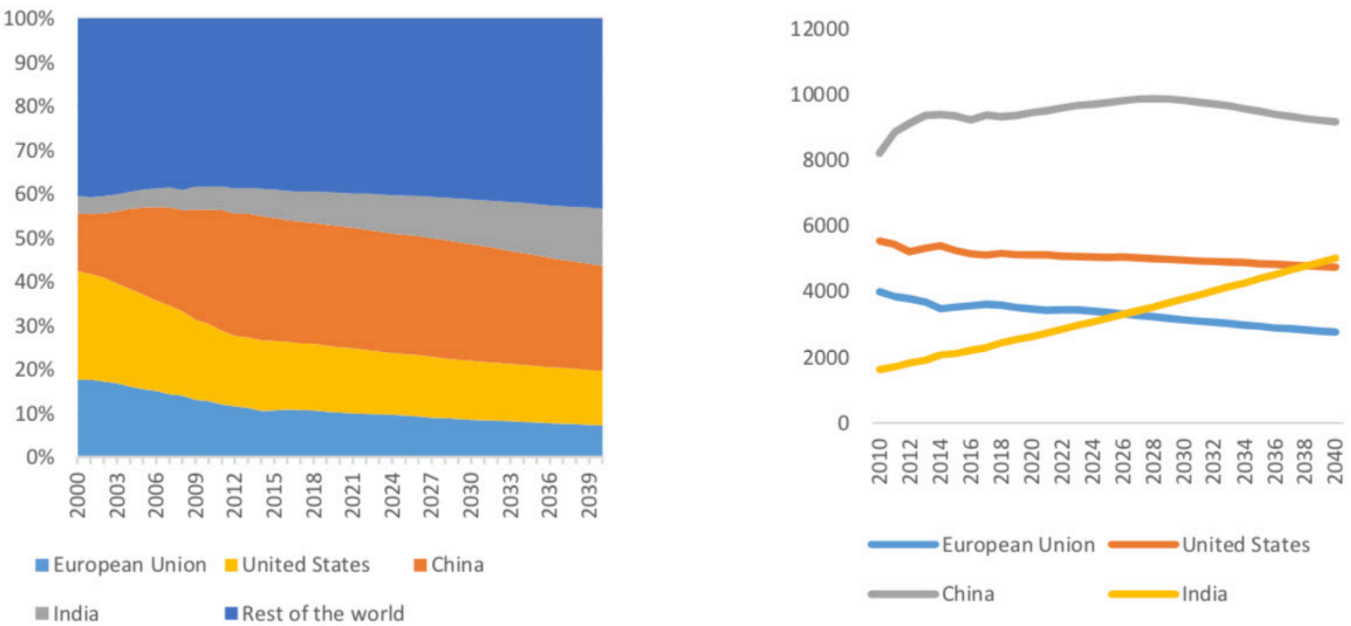
Source: GECF Secretariat based on data from the GECF GGM

On the other side, Europe will see the fastest decline of CO_2 emissions, with an average annual decrease estimated at 0.7% over the forecast period. The emission decline in Europe is supported by the implementation of reinforced climate and environmental measures under the auspices of the EU policy. North America is also anticipated to observe a non-negligible drop in its emissions (CAGR 2017-2040: -0.2%). The US contributes a lot in this declining trend, particularly by implementing initiatives at non-federal level (e.g. states jurisdictions, cities and businesses). Furthermore, market forces, which are reflected in the competitiveness of natural gas and renewables. will play an important role in supporting the penetration of these energy sources and in driving US carbon mitigation.

CO_2 emissions forecasts in the biggest carbon-emitting markets

The larger part of CO_2 emissions is concentrated in four areas: China, India, the EU and the US, which together represent 60% of the global emissions. Despite that this share is set to decrease to nearly 58%, by 2040, these areas remain the biggest CO_2 emitters. The increasing contribution of China and India is expected to offset the declining shares of the US and the EU.

Figure 2.6. CO_2 emission shares (%), and emissions forecasts for the biggest carbon- emitting markets ($MtCO_2$)



Source: GECF Secretariat based on data from the GECF GGM

India

India emissions are set to observe one of highest growth globally with an estimated average rate of 3.4% over the 2017-2040 period. This growth is driven by the progress of population and economy, and the still expected dependence on coal, especially in power generation. Nevertheless, the country strives to mitigate its CO_2 emissions by promoting the uptake of renewables and natural gas, and also by reducing its energy intensity. India has a 2030 target to achieve a reduction of the GHG emission intensity of GDP by 33-35% over its 2005 level (Indian NDC 2015).

Based on policy assessments of India and GDP forecasts, the GECF Outlook anticipates that India will overpass its emission target and achieve more than 38% reduction of GHG intensity by 2030. Indian energy-related CO_2 emissions are estimated at nearly 3.8 $GtCO_2$ in 2030, which is less than the level of emissions which is compatible with the government target (assessed at around 4 -4.1 $GtCO_2$). The latter assessment considers the Indian GHG intensity target, forecasts of GDP and the contribution of energy-related CO_2 emissions in the total GHGs.

Despite that India is on track to meet its NDC's emissions target, the GECF assessment shows that the country has the potential to enhance its ambition and achieve better carbon mitigation results, if the government deals with the several barriers that hinder the development of a gas-based economy and reduction of its energy intensity, particularly in power and industrial sectors.

China

The energy-related CO_2 emissions in China are set to observe a peak between 2025 and 2030, and to decrease after that achieving 9.1 $GtCO_2$ by 2040. China stated a target to reduce its CO_2 emission intensity of GDP by 60-65% in 2030 compared to 2005. The GECF Outlook forecasts that emission intensity will shrink by around 68% in 2030 over to 2005 level, which means that the country is set to over-pass its NDC target.

However, some recent developments in the Chinese policies such as the reduction of renewables subsidies, especially for solar PV, and the loosening of restrictions on coal put a large uncertainty on the future emission trajectory. The government decided to strongly attenuate the development of large-scale and distributed solar PV projects (Baker 2018; GIZ 2018), and permitted the construction of coal power plants in some provinces experiencing tension between electricity demand and supply (Hao 2018). The GECF outlook revised upward its emissions projections for China in 2018 compared to 2017 to factor the potential effect of these policies.

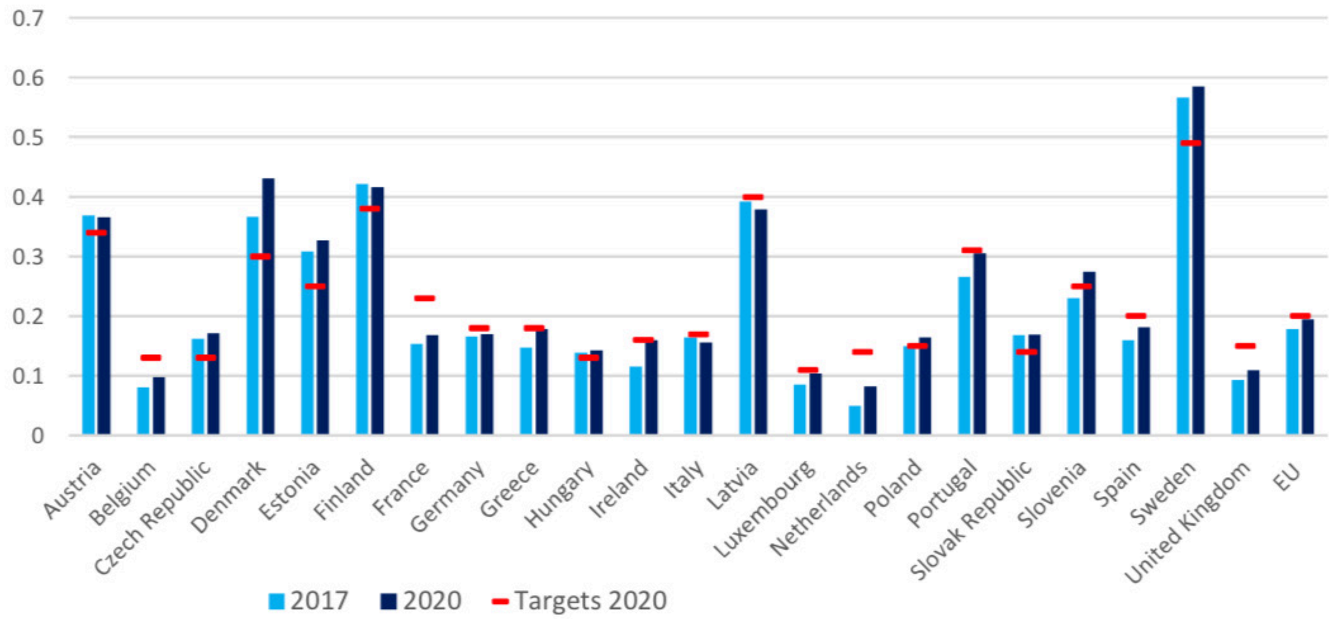
For renewables, China considers shifting its policy from subsidy-based to more market-based schemes in order to increase the cost efficiency of variable renewables development. The government also ambitions to support the integration of renewables in the networks and reduce the discrepancy between the progress of installed capacities and ability of power systems to evacuate the produced electricity. This discrepancy has contributed in large waste and curtailment of renewables.

European Union

The Outlook projects a strong decline of energy-related CO_2 emissions in the EU, driven by efforts to reduce coal, increase renewables and improve energy efficiency. These emissions are expected to reach 3.1 $GtCO_2$ by 2030 and 2.7 $GtCO_2$ by 2040. These forecasts are more ambitious than the 2017 Outlook edition, reflecting recent policy developments and higher carbon prices. However, they are still not sufficient to reach the EU 2030 GHGs emissions target (e.g. 40% reduction compared to 1990). The energy-related CO_2 emissions that are compatible with this target are estimated at 2.7 $GtCO_2$. That means the EU target is expected to be reached ten years later. Disparities between national policies and ongoing reliance on coal in some European countries will contribute to hinder the achievement of EU targets.

One key area where the disparities between Member States can be reflected is in the deployment of renewables and the level of ambition of renewable targets (Erbach 2016; CEER 2017). The latter can be noted in the 2020 targets set in the National Renewable Energy Action Plans, as depicted in figure 2.7 The Outlook assumes that Member States in northern Europe, and several countries in the eastern part of the EU, especially those that have large hydro potential, such as Romania, Austria and Bulgaria will over-achieve their 2020 targets. However, other countries such as Germany, the Netherlands, France and the UK are expected to miss their 2020 targets. The UK and France, in particular, need to intensify their efforts in order to catch up with other countries.
The collective effort of EU Member States is expected to allow the EU to get close to its 2020 renewables target (20%), and to achieve a renewables share of around 25% by 2030, thereby missing the ambitious stated target for this horizon (i.e. 32% of renewable share in the final energy demand).

Figure 2.7. EU Member States renewable shares, and targets according to National Renewable Energy Action Plans



Source: GECF Secretariat based on data from the GECF GGM

United States

Energy related CO2 emissions in the US are expected to reach around 5 GtCO2 by 2025 and 4.7 GtCO2 by 2040, shrinking from 5.1 GtCO2 in 2017. Despite downward trends, these projections reflect a mismatch between the emissions trajectory in the reference case and the NDC's emissions target. The US NDC targets at least 26% GHG reduction in 2025 compared to 2005 levels. In line with this target, CO2 emitted from the energy-related activities is estimated to represent around 4.4 GtCO2 by 2025.CO2 mitigation in the US is mainly driven by the expected penetration of natural gas at the expense of coal and the uptake of renewables. These two drivers are supported by availability of affordable natural gas, decreasing costs of renewables as well as state - based policies aimed at restricting CO2 emissions.

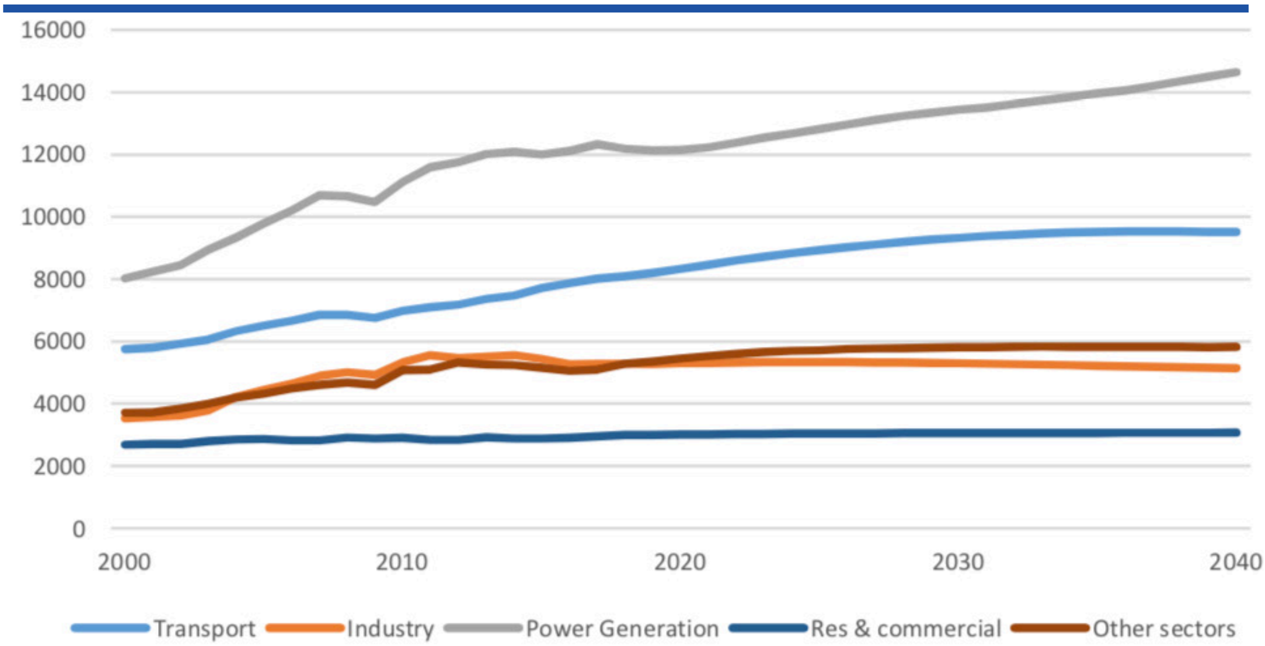
Nevertheless, the main challenge for the US is related to implementation of the Trump administration proposed policies aimed at downgrading the US environmental commitments and actions, and the extent to which several opposing forces to these policies (e.g. state-level policies and non-state actions including cities, environmental groups and businesses) would offset their potential upside effect on emissions. One case in point is the attempt of the Trump administration to revive a declining coal industry, especially by repealing the Clean Power Plan (CPP). The latter aims to reduce emissions from the power generation sector by proposing strengthened standards targeting coal-fired power plants.

Trends by sectors

The 2018 GECF Outlook forecasts that power generation and transport will be the main drivers of CO2 emissions over the long-term; these sectors are expected to grow annually by around 0.8% and 0.7% respectively, over the 2017-2040 period. Power generation will continue to drive emissions to support the huge needs of baseload generation, particularly in emerging and developing Asian economies, where coal will continue to play a key role. The emissions from coal-fired power plants are still forecasted to grow between 2017 and 2040 worldwide by around 11%, and by 38% in Asia Pacific region.

The emissions from the transport sector are projected to stabilize after 2035, due to improvements in vehicle energy performance, as well as the penetration of hybrid, electric and gas-powered vehicles. The share of electric vehicles will reach around 14.6% by 2040, increasing from 1.2% in 2017. Other sectors, including refineries, will increase their CO2 emissions but these emissions are expected to stabilize after 2030. The expected slowdown of oil products' demand affects significantly the refining activity and contribute in stabilizing the emissions of this sector.

Figure 2.8. CO2 emissions by sector (MtCO2)



Source: GECF Secretariat based on data from the GECF GGM

The industrial sector would observe a stagnation of its emissions and a slight decrease after 2030. These trends are driven by the strong decrease in industrial energy intensity and the reduction of coal to the detriment of natural gas in the industrial energy mix. The energy intensity of the industrial sector (expressed in energy consumed by industrial GDP) would decrease by more than 40% between 2017 and 2040.

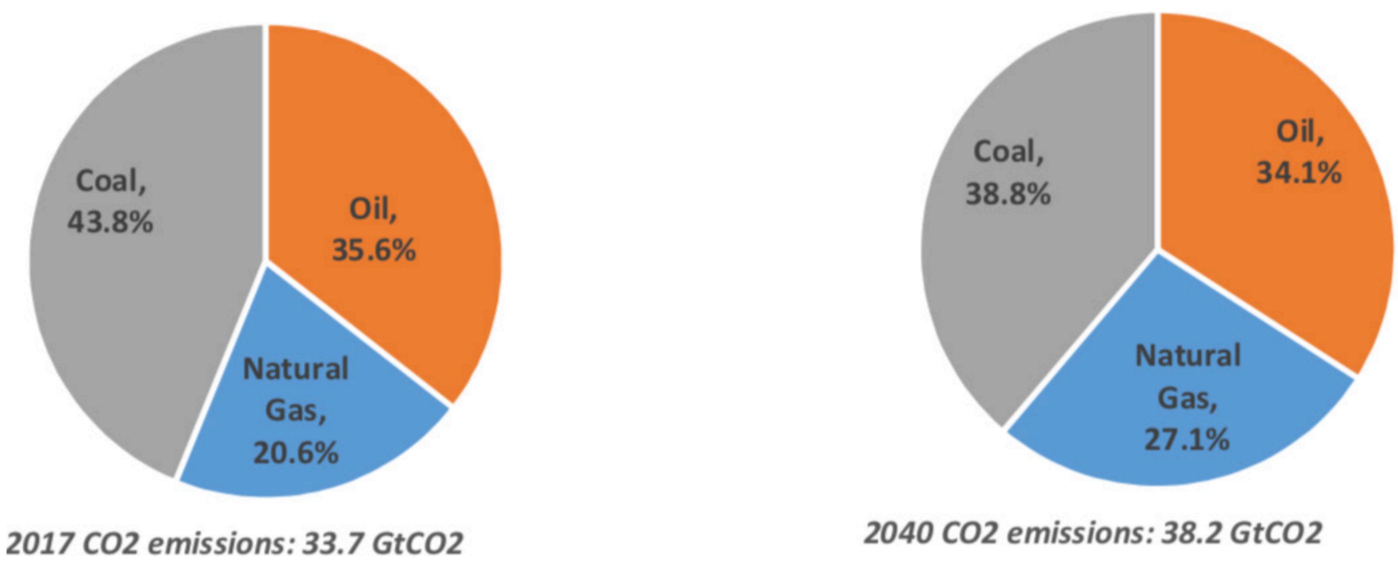
On the same period, the coal demand in the industry would decline by 18% while the gas demand is projected to increase by more 32%. Improvement of energy efficiency, especially for the electric usage and penetration of natural gas against coal and oil products, especially in the non-OECD economies contribute also in mitigating the emission of residential and commercial sectors at global level. These emissions are forecasted to increase slightly by around 4% between 2017 and 2040.

Trends by fuels

The major part of energy-related CO_2 emissions in 2040 is expected to result from the combustion of coal, representing around 39% of emissions by 2040. Oil will be the second source of emissions with 34% share at the same horizon. For natural gas, despite the anticipated growth for its consumption, it will have the smallest impact on global emissions.

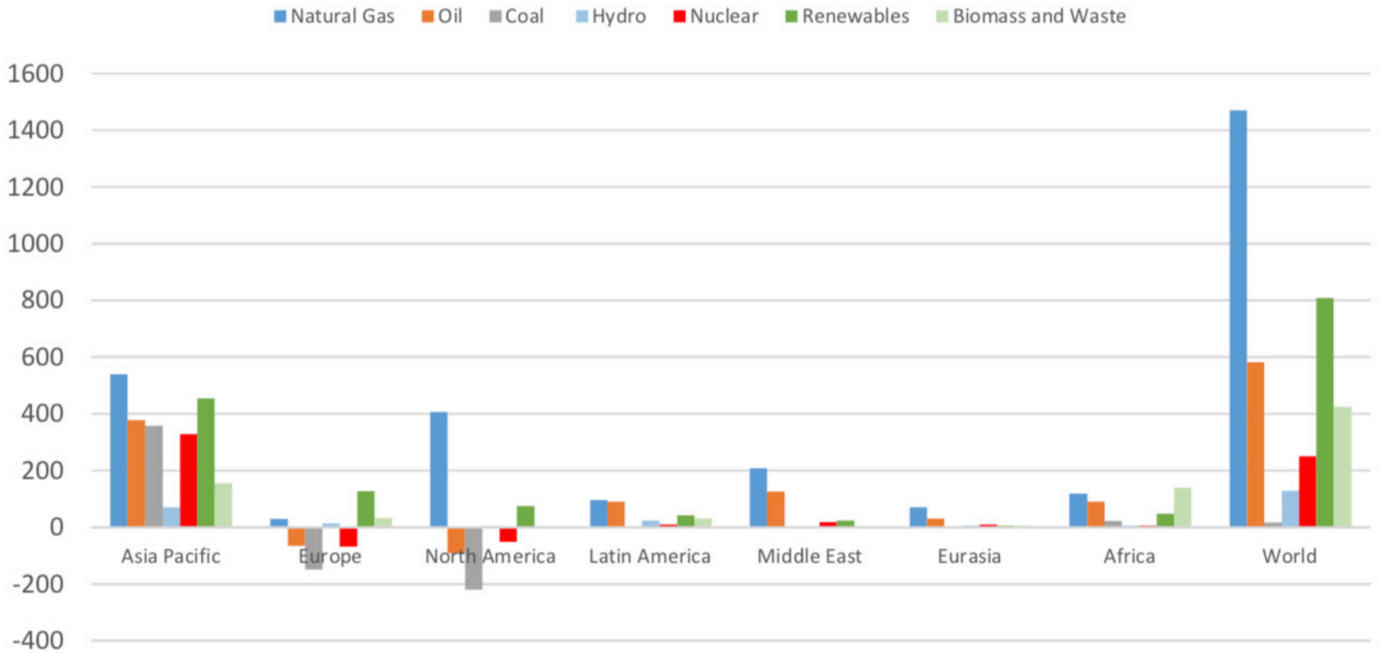
The long-term contribution of coal, oil and gas in the global emissions is driven by the prospects of energy consumption and energy mixes in different regions. As highlighted in figure 2.12, incremental demand of coal between 2017 and 2040 is expected to remain positive in the GECF Outlook with global demand reaching around 3800 Mtoe in 2040 (compared to 2780 Mtoe in 2017). Indeed, the strong increase of coal demand in Asia-Pacific will compensate the anticipated decline in Europe and North America.

Figure 2.9. CO_2 emissions by hydrocarbon source (%)



Source: GECF Secretariat based on data from the GECF GGM

Figure 2.10. Incremental demand by region and energy source between 2017 and 2040 (Mtoe)



Source: GECF Secretariat based on data from the GECF GGM

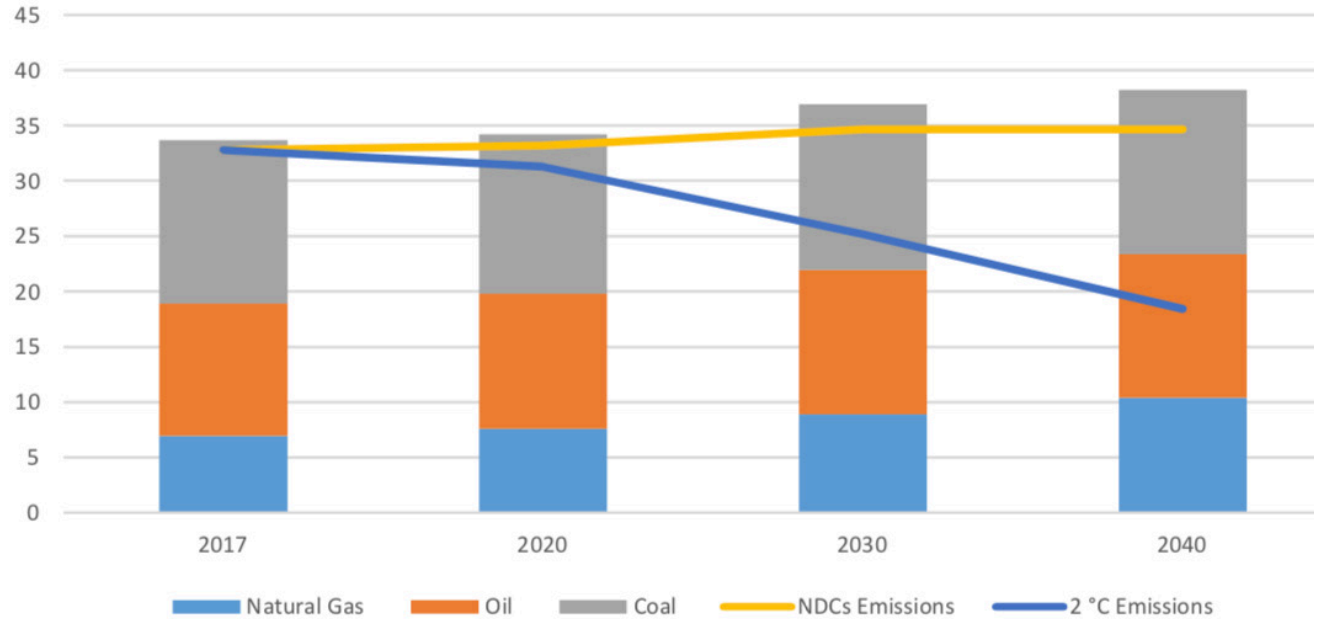
Coal policies play a central role in driving these forecasts. Indeed, the global coal policy orientation is to limit the environmental impact resulting from coal-related emissions. This will occur either through the phasing out of coal or by adopting measures, particularly in emerging countries, which improve energy efficiency and support pollutant emissions' reduction from coal-based technologies. However, the Outlook also considers that many countries, especially in Asia and Eastern Europe, continue to rely on coal as an abundant, cheap and often domestically produced alternative.

Oil demand will also observe a significant increase, supported by the emerging and developing countries in Asia, Africa and the Middle East. The growth of economies and population in these regions as well as rising urbanization are the major drivers of this global oil demand increase, estimated at around 580 Mtoe between 2017 and 2040. Natural gas and renewables (excluding hydro and biomass) are forecasted to observe the largest demand escalation in major regional markets. The global incremental demand between 2017 and 2040 is estimated at around 1470 Mtoe for gas and 810 Mtoe for renewables. These demand growths will allow natural gas and renewables to reach respectively 4633 Mtoe and 1047 Mtoe by 2040. Asia-Pacific will drive this future progress of natural gas and renewables, and the region is anticipated to represent nearly 37% of the global incremental demand of natural gas and 56% for renewables between 2017 and 2040.

Natural gas and renewables, including solar and wind, are anticipated to benefit from favourable policy supports aimed to reduce the environmental impacts of energy consumption. Gas is also promoted in power generation as a flexible option to balance the variable electricity that will result from the expected large penetration of intermittent solar and wind.

Despite this non-negligible progress of natural gas and renewables, the important role of the carbon intensive fuels, particularly coal, contributes in the forecasted mismatch between CO2 emissions in the reference case and in NDCs and 2 °C scenarios. NDCs scenario reflects an emission trajectory which is compatible with countries' pledges in their NDCs, while 2 °C scenario considers the required emission to meet the temperature increase target set in the Paris Agreement.

Figure 2.11. CO_2 emissions forecasts in the GECF reference case, aggregate NDCs and 2 °C scenario ($GtCO_2$)

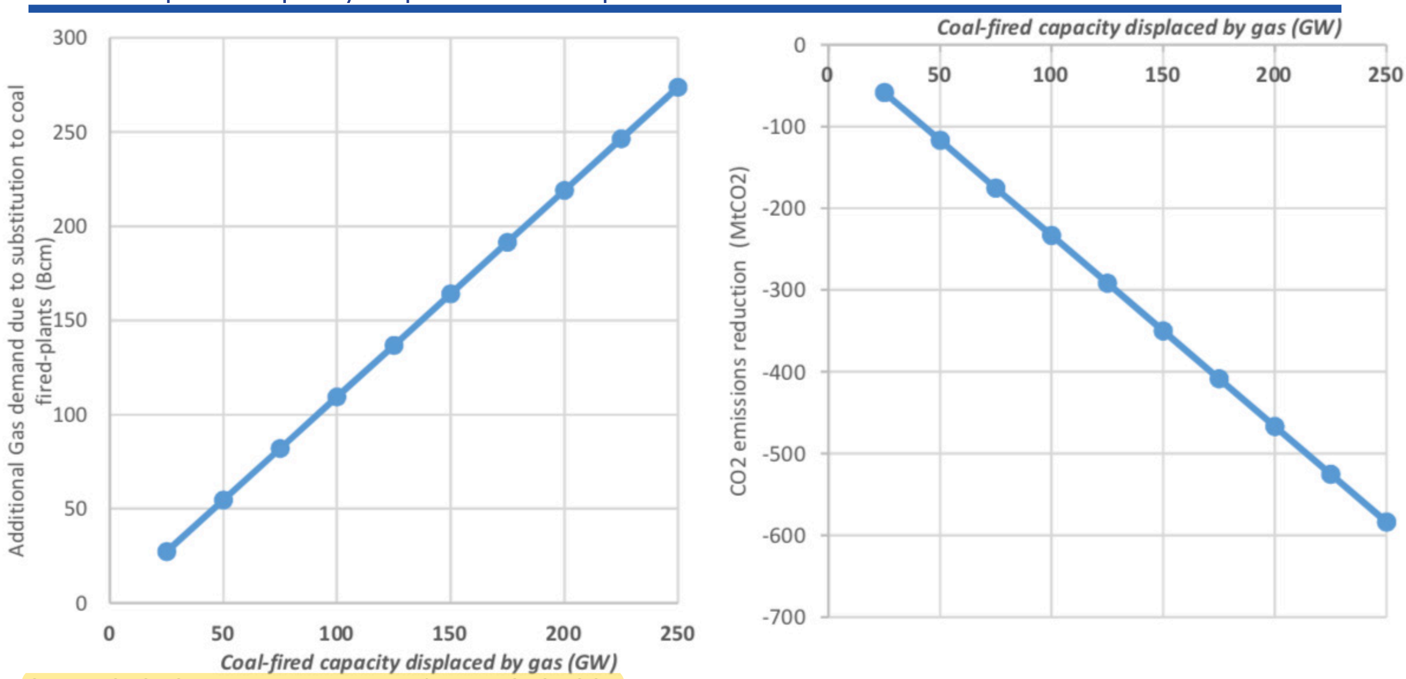


Source: GECF Secretariat based on data from the GECF GGM

The emission gap compared to reference case is estimated at around 3.6 $GtCO_2$ for the NDC scenario and at more than 19 $GtCO_2$ for 2 °C scenario by 2040, and this reveals the great effort required to achieve the Paris Agreement objectives. Natural gas as the less carbon intensive fossil fuel can play a key role in reducing this gap. As depicted in figure 2.14, there is a non-negligible potential to further reduce the emissions from coal by increasing its substitution by natural gas. The penetration of natural gas against coal can be particularly achieved in the power and industrial sectors, in the emerging and developing regions that will concentrate the major part of global coal demand over the long-term.

In the power sector, figure 2.12 outlines the potential of emissions reduction compared to 2040-forecasted level when substituting coal-based power generation by natural gas. It can be noted that displacing 100 GW of coal-fired capacity will add more than 110 bcm of gas consumed in power generation and reduce the emissions by around 235 $MtCO_2$ emissions. Taking the forecasted global coal-

Figure 2.12. Additional gas consumption (left) and CO_2 emission reduction (right) resulting from coal-fired power capacity displacement compared to 2040 forecasted levels



Source: GECF Secretariat based on data from the GECF GGM

fired capacity by 2040, estimated at 2132 GW, and if the production of 10% of this capacity is displaced through gas to coal substitution, it will result in an additional gas consumption of around 245 bcm, and emissions reduction of almost 500 $MtCO_2$ by 2040. This level of abated emissions represents nearly 6% of the total expected emissions of China by 2040. It is clear that more penetration of natural gas in the power sector against coal will lead to large CO_2 abatement.

CONCLUSION

Implementing the 2030 Sustainable Agenda and Paris Agreement in efficient ways needs to understand the interdependencies and interactions between these two agendas. It requires also to find the ways that can consistently support both the Sustainable Development Goals (SDGs) as well as mitigation and adaptation actions, mainly those proposed in countries' National Determined Contributions (NDCs).

Energy is a critical point of intersection between the SDGs and the Paris Agreement and is a main driver of sustainability including its economic, social and environmental dimensions. The GECF has identified six main criteria for energy- sustainability links that represent the channels by which energy could or could not contribute to achieving SDGs. These include: i) ensuring access to modern energy, ii) improving availability, reliability and security of supply, iii) enhancing affordability and competitiveness, iv) reducing carbon intensity, v) mitigating pollution from energy-related activities and processes, vi) increasing co-operation between energy stakeholders.

Based on these criteria, natural gas is a balanced and viable solution that contributes efficiently in the achievement of the SDGs and supports progress with climate objectives. Natural gas contributes in reducing carbon intensity and pollution resulting from energy-related activities, supports access to modern energy, improves availability and reliability of supply, and provides competitive and affordable energy. Natural gas can also be a vector of increased co-operation and technology transfer between energy stakeholders. Because of all these benefits, policies and measures that support natural gas can drive progress in the implementation of the climate and sustainable development agendas.

Nevertheless, natural gas faces the emerging methane emissions challenge. It is worth noting that there are still large uncertainties regarding the contribution of gas-related activities to global methane emissions. These uncertainties underpin the important need to improve knowledge, data availability, transparency and harmonization. The oil and gas industry is deploying efforts to address methane emissions. This effort is not only driven by environmental and sustainability concerns, but also by: i) economic reasons to capture more value from the saved methane; ii) safety reasons to avoid accidents due to methane leaks; and iii) the need to comply with regulatory restrictions.

In the 2018 GECF Global Gas Outlook, the global energy-related CO_2 emissions are forecasted to increase over the long-term, despite an expected deceleration compared to the historical trajectory. The Outlook estimates the average annual growth rate at 0.6% between 2017 and 2040, bringing the level of emissions to around 38.2 $GtCO_2$ in 2040. Non-OECD economies are expected to continue driving the growth and to compensate for the projected emissions decline in OECD economies.

The Outlook projects that the majority of energy-related CO_2 emissions in 2040 will result from burning coal, which represents nearly 39% of the global total, followed by oil with 34%. The important role of carbon intensive fuels, particularly coal, contributes in the mismatch between CO_2 emissions in the reference case and in a scenario compatible with 2 degree Celsius temperature increase targeted in the Paris Agreement. Promoting further penetration of natural gas in the energy mix, particularly against coal, can be a valuable solution to achieve more carbon mitigation and close the gap between the emissions trajectory in the reference case and the pathways targeted by the Paris Agreement.

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