THE IMPACT OF CLIMATE CHANGE ON THE GLOBAL ENERGY & GAS MARKET

GECF GLOBAL GAS OUTLOOK 2040

GECF

GAS EXPORTING COUNTRIES FORUM

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West Bay Towers view, Doha - Qatar

Gas Exporting Countries Forum

The Gas Exporting Countries Forum (GECF) is an international, governmental organization, established in 2001. It became a full-fledged organization in 2008 with its permanent secretariat based in Doha, Qatar.

The GECF provides the framework for exchanging experience and information among Member Countries. The GECF is a gathering of the world's leading gas producers whose objective is to increase the level of co-ordination and to strengthen collaboration among Member Countries.

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 co-ordination in gas-related matters.

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. Azerbaijan, Iraq, Kazakhstan, the Netherlands, Norway, Oman and Peru have the status of Observer Members.

Reference to environment and global warming in GECF Global Gas Outlook

GECF Global Gas Outlook refers to the environmental and global warming issues as main drivers of the future developments of energy markets, and more particularly of natural gas markets, especially in a context characterized by adoption and ratification of the Paris Agreement. GECF Global Gas Outlook examines the main policy orientations and directions aiming to mitigate greenhouse gas emissions in the framework of this agreement; the Outlook develops a reference case, based on Post Paris Agreement policy assumptions, and taking into account the challenges and uncertainties faced by these policies in different countries and regions.

COP21 as a turning point in energy policy developments

The agreement of COP 21 reached in Paris in December 2015 was a turning point because it involved almost all the countries emitting GHGs, including the most reluctant ones in relation to climate change policies. These countries agreed to mitigate their GHG emissions in order to keep the global warming below 2° C,compared to the pre-industrial period, with continued efforts to reach a more stringent target of less than 1.5 °C. The Intended Nationally Determined Contributions (INDCs) submitted by several countries are a central mechanism in the COP 21 Agreement, reflecting the new bottom up approach, which is adopted to deal with climate change. Countries declared their Intended Nationally Determined Contributions (INDCs) and committed themselves to voluntary targets to reduce their emissions.

Main COP 21 agreement outcome is the requirement of ratification of at least 55 countries representing 55% of global GHG emissions, to be enforced as an international agreement with legal effect. The ratification, indeed, is a country internal approval process formalizing the official endorsement and joining of this country to the Paris Agreement.

The ratification of China, the United States (US), the European Union (EU), and India as most important polluting areas in the world, representing nearly 55% of GHGs emissions, gave a great impetus to the agreement and allowed it to reach the two required thresholds to be enforced as international law. The policy development in these four areas in line with their climate commitments, will drive the post-COP 21 era, and will lead to great effect on the evolution of gas markets, since these areas are the most important energy- and gas-consuming markets in the world and contribute significantly in determining the future dynamics and prospects of these markets.

In the table 1, we present the main objectives highlighted in the submitted INDCs and also in other plans and announcements related to energy and climate change policies of China, the US, the EU and India.

[1] Representing 42% of global primary energy demand and 52% of global gas demand in 2015

Table 1: Main energy and climate change policies' targets

Countries	Renewable Energy	Non-Renewables	Efficiency	GHGs mitigation
United States	Doubling non-Hydro renewables in Power Generation (around 10% by 2020)		Doubling the productivity of energy (2010-2030)*	GHGs: 26-28% reduction (2025/2005 level);
China	Non-Fossil in energy mix: 15% (2020), 20% (2030). Power Generation Capacities (2020): 200 GW of wind power, 100 GW of solar PV, 30 GW of bioenergy.**	Peaking coal consumption at 4.1- 4.2 G. Tec.** 10% of gas in Primary Energy Mix (2020) Nuclear: 58 GW (2020)**		Lower CO2 emissions per unit of GDP by 60% to 65% (2030/2005 level) Peaking of carbon dioxide emissions around 2030
European Union	REN: 20% (2020); 27% (2030) – Renewable in transport 10% (2020))***		Efficiency increase: 20%(2020); 27% and potentially 30% (2030)***	GHGs: 20% reduction (2020/1990 level); 40% reduction (2030/1990 level) ***
India	40% of N. Fossil in power generation installed capacity by 2030 Power generation capacity (2022): 100 GW of solar PV, 60 GW of wind power, 10 GW of bioenergy, 5 GW of small hydro	Reducing the share of coal in primary energy below 65% by 2017 Nuclear: 63 GW installed capacity by the year 2032	Avoid a capacity addition by nearly 20GW and achieve fuel saving by around 23 M. Tce per year	Reduce the emissions intensity of GDP by 33 to 35% (2030 / 2005 level)

*Sources: INDC; * President Obama Climate Plan (13); ** China Energy development plan 2014-2020 (14); *** EU Energy Strategy (for 2020 and 2030) (15)*

View on Post Paris Agreement policy developments in the GECF Outlook

Despite the objectives and measures announced by countries in the framework of their energy policies and submitted INDCs, many uncertainties and challenges still exist which can lead to mismatches between the policies' ambitions and the real outcomes of the implemented measures. Among the main uncertainties and challenges are political issues and support for climate ambitions, lobbying and resistance to change, security of supply priorities, growing energy needs to sustain economic and social developments, funding issues and affordability of energy supply, economic viability of green projects, non-binding and conditional commitments in the framework of the COP21 agreement, and the efficiency and level of implementation of the detailed agreement mechanisms.

The Outlook takes account of the main climate and energy policy highlights and directions in various energy policy domains, including renewable and non-renewable energy, energy efficiency and the mitigation of GHG emissions. The main focus is on the four key countries and regions (China, the US, the EU and India) whose climate commitments and related policy developments will affect significantly the prospects for global gas markets.

Renewable energy policies

Policies that promote renewable energy have significantly contributed to renewable energy's expansion in the global energy mix, particularly solar and wind power. Without policy support and government intervention, renewable energy would not have been able to make such progress because of its technical and economic characteristics (high costs, low energy content, need of large areas for project deployment, intermittency and difficulties associated with the integration in the power systems). Therefore, government intervention has been a key driver in the development of renewables, even in the liberalized energy markets where other policies advocate free competition between energy sources. This intervention has sometimes led to major dysfunctions such as those observed in the European power markets[2], and it has also brought some legal issues with competition and trade rules such as those observed in the American State Level Renewable Portfolio Standards. [1]

Many countries have considered ambitious targets for renewables, particularly in power generation, where several mechanisms and support schemes are used to achieve these targets, such as subsidies (mainly in the form of feed-in tariffs or tax exemptions); the application of priority schemes for electricity supply, renewable electricity supply standards and purchase obligations, or the establishment of renewable investment funds.

In the Outlook, renewable policies continue to drive renewable progress in the primary energy mix, mainly in power generation. However, it is expected that many of the renewable supporting schemes will be affected by constraints, mainly those related to funding large amount of subsidies, and integrating a large share of intermittent renewables.

China and India, which have been the main drivers of the recent renewable development, have considered many instruments to boost renewables in their primary energy mix, but have to deal with several difficulties to sustain this over the long term. These difficulties include funds securing , and the ability of power systems to integrate a large share of intermittent renewables. The two countries have experienced many renewable curtailments linked to infrastructure congestion and grid access difficulties ([2][3], as well as mismatches between central and provincial level policies, and the fragmented structure of the internal power markets. There have also been difficulties in implementing electricity price reforms to ensure the attractiveness for renewable projects. India, in particular, has proposed a reform of its complex power sector allowing for more efficient regulation, greater access to grids for renewable power, and more attractive electricity prices, but the country has also experienced many difficulties related to the existing institutional barriers and lack of policy coordination between various entities in charge of the energy sector. These difficulties can be expected to continue.

For the EU, renewable subsidies, particularly the feed-in tariffs as the main support mechanism, are expected to be revised, mainly because of budget constraints and dysfunction observed in power markets integrating large share of renewables. Some member states are applying more competitive and market-based mechanisms in defining the level of renewable support (such as competitive auctioning, renewable certificates and feed-in premiums) [4]. These instruments aim to integrate renewables more effectively in power systems, mainly by exposing renewable suppliers to market conditions and to the system balancing needs. However, the extension of these mechanisms, as recommended by the Environmental and Energy State Aid Guidelines of the European Commission and discussed in the framework of the New Renewable Directive [5], and their effect on renewable development, remain uncertain.

As the Indian and EU examples show, the main challenge for the renewable power generation support schemes is the adaptation of policies from renewable development to their large-scale integration.

Renewable promotion policies were particularly oriented towards the power generation sector. However, there are also certain renewable incentives and supporting mechanisms in other sectors, such as transportation, especially in the form of standards encouraging bio-fuels (e.g., the Renewable Fuel Standards in USA), but the competition between energy and food production has significantly challenged these policies. The Outlook presents a cautious view in terms of renewable penetration in the transportation sector.

[2] Observed dysfunctioning in liberalized power markets: Unfair competition between renewables benefitting from subsidies and priority schemes, and thermal sources; a significant drop in electricity wholesale reference prices, which led to a significant reduction of margins of the non-subsidized thermal power plants; a significant drop in operating rates of gas power plants, leading to closure and difficulties to provide back up to intermittent renewables; a disconnection between the high electricity prices applied to end users (owing to cost of subsidies) and wholesale electricity prices.

Natural Gas policies

The role of gas will be broadly affected by policies which will be implemented in line with the countries' post-COP21 commitments to reduce the carbon intensity of their economies. It is worth noting that the two main visions have emerged in the debate dealing with the transition to low-carbon economies. One vision that only promotes renewable energy and nuclear power, downplaying the technical, economic, and environmental advantages of natural gas, and another vision, which may be considered more pragmatic, that considers gas as a fuel that will play a key role in a sustainable and competitive transition of the energy system.

The first vision has significantly influenced energy policies, with many countries considering initiatives that are clearly unfavorable to natural gas and which feed large uncertainties regarding the gas end-use energy markets. Alongside this, gas market liberalization policies have brought uncertainties for the gas exporters. These uncertainties have arisen particularly through the challenging of traditional gas trade models, which have been based on two principles that proved to be successful in the development of gas markets: i) long-term and stable partnerships and ii) indexation on reliable oil price references, reported in traded markets with good liquidity. For instance, the energy reforms and liberalization process under implementation in Europe have been slow and many concerns exist about the efficiency and reliability of some mechanisms adopted in the framework of this policy. In addition, the final configuration of the European gas market remains an uncertainty for gas suppliers, mainly because of the lack of harmonization in rules and functioning of European member states' gas markets and of the predominance of national choices at the expense of a regional strategy.

On the other hand, the policies that aim to support gas infrastructure development, network integration and upstream projects, associated with other mechanisms to stimulate gas demand, have been key drivers of gas demand growth. These policies have allowed a remarkable growth of gas in countries like China and the US. For the US, it is estimated that the increase in gas consumption between 2010 and 2015 and its substitution for coal, have resulted in avoided emissions of around 160 Mt CO2.[3] However, a debate is challenging the current US policy, supporting gas exports and infrastructure developments. At the end of September 2016 US senators asked the Department of Energy to slow down gas export approvals until an assessment of its impact on the internal gas market has been conducted. The outcome of this debate and its translation in energy policy, particularly after the presidential election, could affect significantly the development of US gas supply and prices and consequently the demand of gas in the US.

China and India provide very significant gas growth potential, but gas development in both countries is conditioned by infrastructure development and by the level of domestic gas prices, (which remain largely subsidized)[4], compared to the price of other energy alternatives, coal in particular. India and China have launched gas and power sector reforms that aim to promote competition and market price mechanisms in these two sectors. However, these reforms face many constraints and issues, mainly those related to the rigidity of market structures and concentration of market power.

In the Outlook, policy supports to gas infrastructure development (LNG in particular), and to network integration and upstream projects[5], along with other measures promoting demand for efficient energy uses and technologies, drive the progression of gas in the primary energy mix. Gas is also promoted as a back-up to intermittent renewable energy.
Furthermore, policies encouraging natural gas in transportation are reinforced in many countries, with tightening regulations on fuel quality, and they also support the development of distribution networks and natural gas vehicles. The implementation of the International Maritime Convention on the Prevention of Pollution (MARPOL), establishing emission standards for shipping, supports strongly the progress of gas in LNG bunkering.

Coal policies

Coal, the biggest emitter of greenhouse gases (GHG), faces two opposing forces influencing its role in the primary energy mix. On the one hand, there are the positive drivers linked to its price advantage and its wide availability in major consuming regions, and on the other hand, there are the negative drivers which result from the need to reduce pollution and GHG emissions according to countries' climate commitments. These opposing forces sometimes translate into contradictory energy policies. Some countries continue to grant subsidies and supports to coal in order to preserve economic activities and employment in local mining areas, and also to ensure their security of supply, while at the same time setting ambitious targets to reduce emissions.

However, the overall direction of the energy policies is to set air pollutant emission standards for the coal consuming sectors, particularly heavy industries and power generation. This has potentially important effects on coal demand. Among the main existing policy instruments, of note are the EU large combustion plant directive (LCPD), the emissions' standards considered in various clean air plans, and also the controversial US standards proposed by the Federal Environment Protection Agency (EPA) in 2015 in the framework of its Clean Power Plan.[6]

China's announcements to cap coal consumption at 4.1-4.2 MT by 2020, and to freeze approval for new coal mines and new coal power plants in many Chinese provinces, show a clear signal of Chinese willingness to reduce the role of this fuel in its primary mix. India, however, still considers coal has a key role in its economy. But even here, the country is supporting the development of more efficient technologies, and has adopted appropriate policy initiatives, such as the mandated use of highly efficient supercritical technology for new coal power plants or the taxation of coal (Coal Cess) to fund the development of clean technologies.

In the Outlook, coal consumption is mainly constrained by air pollution emission standards, carbon taxes, and mandated cap measures in the key markets. These policies will particularly support the phasing out of less efficient coal-based technologies, and the installation of more efficient ones.

[3] The gas demand increase is equivalent to nearly 70% of the coal decrease during the same period. Our estimation considers the CO2 emissions avoided by using gas instead of coal for this amount of gas increase between 2010 and 2015.

[4] For instance, in India, difficulties in sustaining gas subsidies and gas allocation policy have already led to decrease gas supply, particularly for power generation, where many gas power plants, though recently commissioned, have seen low operating rates.

[5] Including investment support mechanisms and bilateral and multilateral cooperation for project development.

[6] This plan received strong opposition from the American Congress and in February 2016 the Supreme Court issued a "Stay Order" suspending the implementation of the CPP..

Nuclear policies

Nuclear policy in many countries is still unclear. Indeed, the Fukushima incident has led many countries to shut down nuclear power plants (particularly the oldest ones), to freeze approval for new nuclear plants, to reconsider the development plans and some countries have even considered progressive phasing out of nuclear power. But to date, Germany appears to be the only country that shows a strong ambition of a complete phase out of its nuclear capacity by 2022. The United Kingdom, however, has recently announced its support for nuclear as a main driver of its transition to a low-carbon economy, and the recent approval of the Hinkley Point C EPR Project shows a concrete move in this direction. Even Japan, the home of Fukushima, is considering a progressive restarting of its nuclear power plants after their closure for more than four years.

The Fukushima effect seems to be waning. Some indicators show that overall energy policies are supporting nuclear power as a main lever of GHG emission reduction and diversification of the energy mix, particularly in countries with large and growing energy needs like China and India. These two countries have announced objectives to double their nuclear installed capacities (China by 2020, with an objective to reach 58 GW) or to increase it tenfold (India by 2032, with an objective to reach 63 GW). Many policy measures and initiatives are considered in line with this pro-nuclear vision, including the strengthening of safety measures, promoting research and development to expand their own nuclear technologies (such as thorium-based technologies) and to adopt last generation nuclear reactors. The two countries are also leveraging cooperation and partnership to develop their nuclear industry, mainly by offering growth opportunities in a difficult global context for the nuclear industry.

In the traditional nuclear countries, stronger safety and control checks continue to be the main drivers of nuclear policy, particularly in a context where security and safety are used as arguments to promote nuclear technology exports to countries interested in developing nuclear power. A case in point is the the EU, which highlighted recently its willingness to preserve the dominance of Europe in the nuclear industry, by supporting the development of safe and innovative nuclear technologies (including new generation small size nuclear reactors) that can be promoted for export. However, nuclear policy in Europe is mainly driven by Member States' choices and visions, and many uncertainties remain regarding the evolution of nuclear power in these countries. The main challenge for many European countries is the decommissioning of the old nuclear installations. At the end of 2015, there are 89 nuclear power reactors permanently shut down in Europe which need to be safely decommissioned and dismantled [6].

For the Outlook, the overall direction of energy policy is in support of nuclear energy, by focusing in particular on strengthening safety checks and controls. This would make it possible for a large share of existing nuclear fleet to continue operating, with extended lifetimes in many countries. However, the development of new nuclear power plants, especially in emerging nuclear countries, will face serious difficulties and challenges related to technology transfer, high project development costs, resistance from the local population, and constraints on fuel supply and skilled labor. These can lead to mismatches between announced objectives and actual projects.

Energy efficiency policies

Policies promoting energy efficiency are recognized as an important lever for sustainable development and they are central to many of the submitted INDCs. The main mechanisms that are taken into account to improve energy efficiency are: the establishment of energy performance standards in different sectors; the labelling of appliances and equipment; incentives and support for investments in energy efficient technologies; and also the introduction of market mechanisms and price signals (subsidy reduction) to encourage rational energy consumption. Mandatory energy performance standards for appliances and equipment, and also for buildings (building codes) are the main policy drivers for improving energy efficiency in the Outlook, in the buildings, industry and transport sectors. These standards will encourage the phasing out of obsolete and less efficient technologies and processes, and stimulate technical progress that enables compliance with these standards (for example, the development of smart energy systems). However, a conservative view regarding further strengthening of these mechanisms is assumed, given that there are often difficulties in implementing standards and resistance to changes, such as those observed in the US, where EPA proposals to enhance energy performance standards have been controversial and received opposition, particularly from the US Congress. [7].

Other cases, in some instances voluntary mechanisms, to promote energy efficiency, such as those related to energy rating and labeling schemes (for instance the Energy Star program in the US, which has been expanded to other countries) will be likely to play a role in improving energy efficiency, reinforced by any increase in end-use energy prices driven by the impact of renewable costs, and the reduction of energy subsidies in many countries.

Policies promoting structural industrial shifts in emerging countries will also be influential in reducing energy intensity, especially for China and India, where ambitious plans have been announced to achieve a transition toward more efficient and sustainable development models. The two countries are also undertaking ambitious energy efficiency policies to curb their growing energy demand. The industrial sector is drawing particular attention from policy-makers, given the importance of heavy and energy-intensive industries, as well as the great potential of improving energy efficiency in this sector.

On the other hand, the establishment of financing supports for the development and deployment of clean and energy efficient technologies will also contribute significantly in the improvement of energy efficiency, especially in the end-use sectors, which can provide less costly improvement options [8]. Many funds have been established to promote this, such as the EU's European Energy Efficiency Fund (EEEF) or the Energy Efficiency Financial Institutions Group (EEFIG)). Gas-based technologies and processes are well placed to get such supports given the energy performance and cost efficiency they can provide.

Other GHGs mitigation measures

Policies which aim to reduce GHG emissions will be a broad combination of measures and instruments, including renewable energy, non-renewable energy, and energy efficiency policies. There are also some instruments that are more specifically related to the mitigation of GHG emissions, such as carbon taxation, carbon markets, air pollution standards, and supporting mechanisms for the development of carbon capture and storage, and carbon sinks (reforestation).

Policy instruments aiming to strengthen emission standards for air pollutants and to improve air quality will also serve as major policy driver to reduce GHG emissions, especially in power generation, industry, and transport. Although emission standards can sometimes overlap with energy performance standards,[7] they can also lead to different choices to comply with the standards. Indeed, emissions standards can encourage more fuel switching towards cleaner sources of energy such as renewables or gas in power generation or electricity in transportation. For example, the American CPP emission standards will mainly affect coal power plants, since more efficient gas-based power plants generally meet the proposed targets, and thus encourage fuel switching to gas) [9].

Other specific GHG mitigation policy instruments involve putting a price on carbon, either directly via carbon taxes or indirectly through emission trading systems (creating a carbon market). Some studies [10] consider under carbon price assessment other specific taxes that are applied to the use of fossil fuels, which are not explicitly named carbon taxes, but can be considered as an air pollution penalty or a lever to rationalize consumption of fossil fuel. Often a combination of a carbon market and such specific taxes exist in the same country.

In the Outlook, carbon taxes are assumed to become more widespread, notably in China and India, which have mentioned in their respective INDCs that consideration will be given to taxes as a policy instrument to reduce GHGs. However, the extent of this tax increase may be relatively limited in comparison with the impact from the expected reduction of subsidies on fossil fuels.

For the EU, the carbon and other specific taxes applied in the EU's Member States are mainly oriented towards sectors not covered by the EU Emission Trading Scheme (ETS), such as transport and buildings. These taxes, and other policies, will be applied differently in Member States according to their GHG emissions reduction targets. It should be noted that the EU has recently set up binding emission targets for Member States as part of its "Effort Sharing" mechanism, where the aim is to reduce GHGs emission by 30% by 2030 comparing to 1990 level, in sectors not covered by the EU ETS [11]

Carbon pricing through emission trading systems, announced by some countries as one of the important measures to reduce emissions, are likely to continue to experience some difficulties in developing market relevant reference prices for carbon. Indeed, the European carbon market, which is by far the largest such market in the world, has seen a major dysfunctioning owing to the persistent imbalances between supply and demand of emission allowances. The European Commission has proposed to reform this market as part of its EU ETS Phase III (2013-2020) and Phase IV (2020-2030), including back loading[8] of emissions allowances, the establishment of auctioning as a default allocation method instead of free allocation to exempt firms and sectors, the progressive reduction of emissions limits, and the establishment of a "Market Stability Reserve" scheme. These measures are intended to have an effect on prices over the long term.

Separately, the UK, which introduced a carbon price floors in 2013 on the EU ETS references price, is expected to maintain this floor over the long term, indicating a clear willingness to send a signal to the markets to reduce CO2 emissions.

The Outlook takes account of the launching of other emission trading markets in the world, especially the Chinese national market in 2017, which will be an extension of the pilot project that has already been initiated in seven provinces and cities.

The US CO2 market remains driven by regional and state level initiatives, such as the Regional Greenhouse Gas Initiative (RGGI) in the eastern part of the country and the cap and trade program in California. The establishment of a national carbon market will see some difficulties, especially after the failure of a more comprehensive regulation governing CO2 markets to receive legislative approval. [9]

[7] Refer to Paragraph 2.3.3.

[8] Back loading is a short term measure aiming to reduce the surplus of emission allowances on the market. It consists of postponing the supply of 900 million emission allowances until 2019, initially planned to be released between 2014 and 2016

[9] A cap and trade market regulation has been proposed in the framework of the American Clean Energy and Security Act of 2009, which has received opposition from the Senate

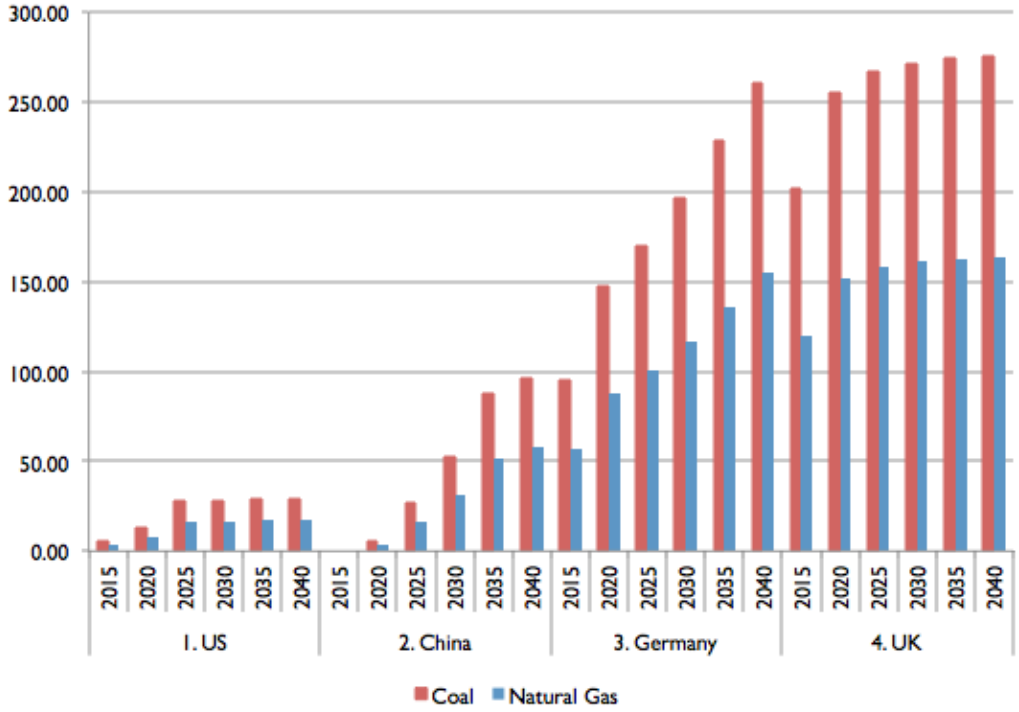
Carbon price perspectives in GECF Outlook

Carbon can be priced in various ways including carbon taxes, price references from emissions trading systems (CO2 markets), or a combination of both. Carbon prices allow internalisation of the external cost of climate change by increasing fuel costs for producers and consumers, making low-carbon fuels attractive at the expense of high carbon ones.

In the GECF Outlook, carbon prices are integrated in the prices of fuels used in different sectors, by estimating a "Carbon equivalent price", which includes both carbon tax and CO2 markets' reference prices. The Carbon equivalent price reflects the carbon content of the fuel and the emissions associated with its usage in different sectors.

Figure 1 highlights GECF carbon equivalent price forecasts for natural gas and coal which are applied mainly in power generation and industry, in China, US, UK and Germany. GECF considers two European countries, UK and Germany, since they are developing different approaches to carbon pricing. Specifically, in 2013 the UK introduced a carbon price floor to the CO2 market reference prices, while Germany continues to rely only on the EU Emission Trading System (EU ETS) reference prices.

Figure 1: Perspectives of carbon equivalent prices for coal and gas in US, China, UK and Germany (USD/Tonne CO_2)



Sources: GECF Secretariat based on data from GECF GGM

The UK and Germany display the highest levels of carbon equivalent prices over the long term, which reflects more aggressive carbon pricing policies than in the US and China. However, higher equivalent carbon prices are forecast for China than US particularly after 2025, due to tax increase in China and also to an increasing CO2 market reference price.

Despite differences in the carbon equivalent price levels for the four countries considered above, note that the pricing of CO2 will be translated in higher prices for coal relative to gas, particularly for European countries. The gap between oil and gas carbon equivalent prices in UK and Germany, can reach more than USD 100 per ton by 2030. This gap is expected to constrain coal-based power plants and industries.

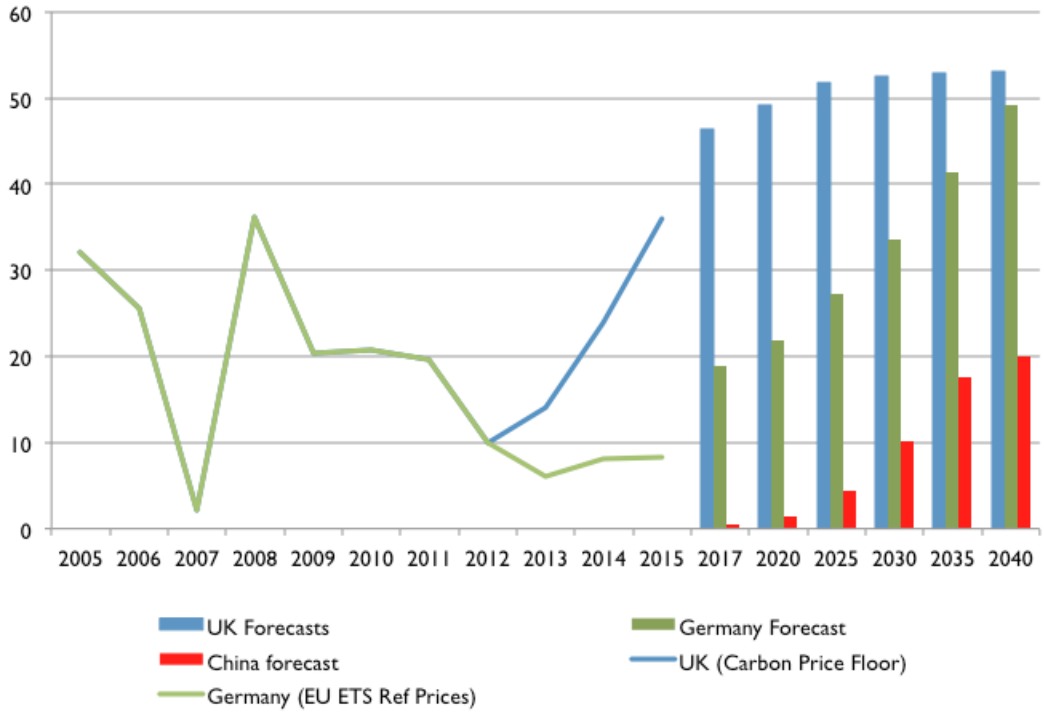
For China, the gap between gas and coal carbon equivalent prices would increase slightly to reach around USD 40 per tonne by 2040. This also reflects the policy to reduce the role of coal in the Chinese economy. US has the lowest carbon price gap in the Outlook (around USD 11 per tonne by 2030).

In addition, our carbon equivalent price projections highlight different growth dynamics in the UK and Germany, driven by the projected dynamics in the CO2 market reference prices which can be observed in figure 2.

The chart highlights the current divergence between the UK's CO2 reference price (including a floor price), and the EU ETS reference price used by Germany. The persistent low EU ETS prices have been noted, owing to an excess of emissions' allowances in the market, despite the adoption by EU of the short term "back-loading" measure in 2014 to rebalance the market.

The EU ETS Phase III and Phase IV reforms are expected to have a longer-term effect, leading to an increase of the EU ETS reference prices and a convergence between these prices and the UK CO2 floor price, as highlighted in the chart.

Figure 2: Perspectives of CO_2 market reference prices (USD/ Total CO_2)



Sources: GECF Secretariat based on data from GECF GGM

Nevertheless, for China, where a national CO2 market is planned to start in 2017, CO2 reference prices are expected to be at low levels, before progressing slowly to reach USD 10 per tone CO2 in 2030 and USD 20 per tonne CO2 in 2040. Relatively low levels of Chinese carbon price are expected to prevail in the first stage of the CO2 market, mainly because of the likely excess of emission allowances compared to demand, which is affected by the recent economic cooling and the expected structural change (more service sector penetration in the Chinese economy).

The US carbon market is a subnational market with mainly two regional initiatives, the RGGI and the Cap and Trade system in California. Other regional or state level initiatives could be launched, but the development of a US national carbon market remains uncertain and will be conditioned by the evolution of other climate change and carbon regulation, and its implementation the future of the proposed US Clean Power Plan, presently suspended by the Supreme Court, is central to this.

The GECF Outlook considers a national average carbon price for the USUS (including carbon tax and CO2 market reference prices). It is estimated that this carbon price to be around USD 1.5 per tonne CO2 in 2016, increasing to USD 3.25 per tonne CO2 by 2020 and stabilizing at around USD 7-8 per tonne CO2 by 2025-2030. This price of carbon in the US reflects a relatively conservative view, but this remains a great uncertainty, especially with regard to the energy policy choices that will take place in future administrations, including whether or not the Clean Power Plan can be implemented after the 2016 Presidential elections.

Beyond the four countries considered above, there are other national carbon pricing instruments (carbon taxes and emission trading schemes) are under consideration or scheduled to be implemented. Australia, Brazil, Canada, Chile, Japan, Mexico, Turkey, New Zealand, Ukraine, South Korea, and South Africa are some examples. However, many uncertainties exist with regards to the progress of these carbon instruments, particularly regarding carbon market development and the effectiveness with which they signal relevant investment decisions.

Outlook assumptions consider, in addition to the EU and China, that other countries will implement national carbon markets over the period to 2040, including Australia, Canada, Hong Kong, South Korea,[10] Mexico, and Turkey. However, the year of implementation will vary by country. While China and Hong Kong expect to establish national markets by 2017, the others are expected to join by 2020.

10 According to Enerdata, in January 2015, South Korea started a carbon emission market imposing caps on emissions for 525 large companies; however, industry participants are slowly adopting emission trading, prompting the government to review its GHG emission target for 2020.

Energy related CO_2 emissions

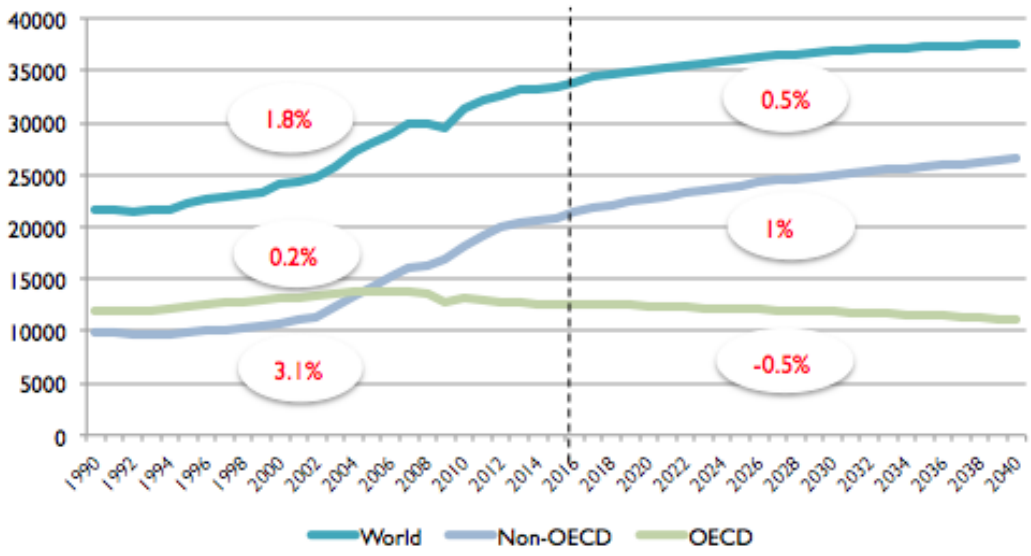
Considering the view on Post Paris Agreement policies development, GECF forecasts the energy related CO2 emissions by factoring the main policy assumption in GECF Global Gas Model. Global carbon emissions associated with fossil fuels consumption increased on an average of 1.8% per year between 1990 and 2015. Non-OECD emissions rose by 3.1% annually, and OECD emissions were up by 0.2% per annum. Meanwhile, in 2015, 80% of energy-related CO2 emissions were emitted by oil and coal, while gas accounted for the rest.

In the GECF Outlook, world energy-related CO2 emissions rise from 33.4 GtCO2 in 2015 to 37.6 GtCO2 in 2040 (Figure 3). Emissions by 2040 are thus 13% above the level witnessed in 2015.

In contrast, global carbon emissions are expected to increase more slowly compared with the past 25 years at an average of 0.5%, by 2040, reflecting lower energy demand growth and the deployment of higher efficiency measures.

The OECD region is expected to reduce its 2015 emissions level by 12% over the outlook period. However, this decline is not enough to offset the enormous growth in non-OECD emissions. By 2040, the non-OECD emissions jump by 27% from the current level. The non-OECD countries would then be responsible for 70% of energy-related CO2 emissions in 2040, despite the fact that per capita emissions in non-OECD countries would still be less than half those of OECD countries.

Figure 3: CO_2 emissions in the GECF Global Gas *Outlook* (Mt)

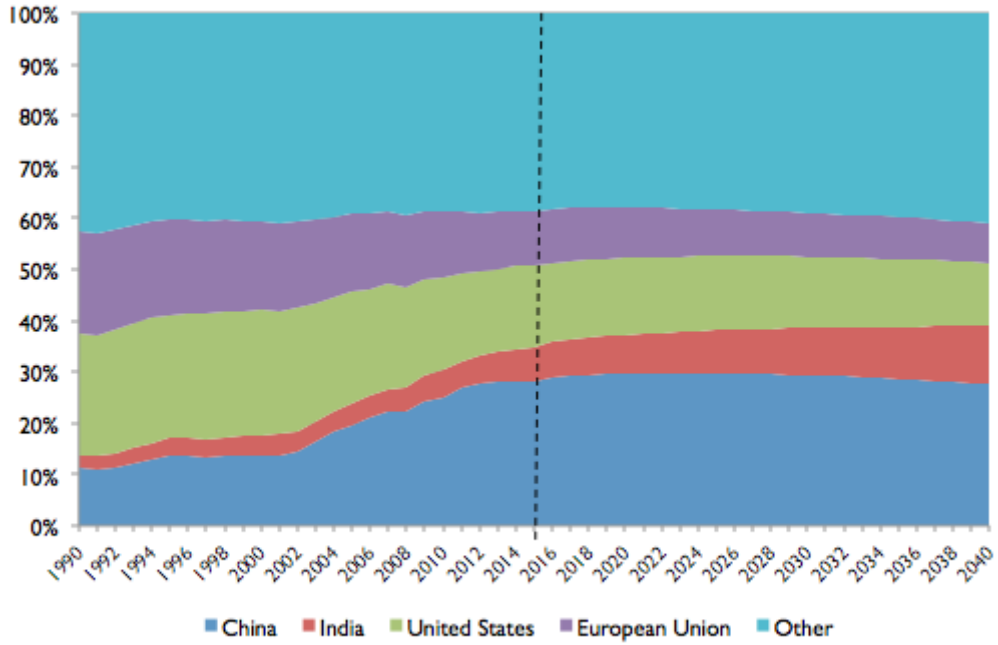


Sources: GECF Secretariat based on data from GECF GGM

In 2015, CO2 emissions were primarily linked to China (28%), followed by the US (16%), EU (11%) and India (7%). Over the projection period by 2040, carbon dioxide emissions are forecast to rise in China and India. However, China is successful in decelerating CO2 emissions growth considerably and, as a result China's CO2 emissions are set to increase by only 10%. India, on the other hand, will see an increase of 90% in its emission during the projection period. In contrast, EU and US are expected to prove successful in reducing their emissions, by 12% and 19% respectively, reflecting the continuing decarbonization policies as well as higher penetration of clean fuels, including renewables and gas in their fuel mix. China, India, and the US accounted for over half of carbon emissions in 2015 (Figure 4). Through 2040, the share of these three countries rises by 0.6 percentage point and reaches to 51.4%, indicating that a reduction in EU and US emissions is not sufficient to offset the increase in Indian and Chinese CO2 emissions.
Carbon emissions in China are expected to peak in 2020 and to start to decline thereafter. However, Chinese emissions still stand at a higher level than 2015 by the end of outlook period.

Carbon emissions in EU countries have been declining by an average of 0.8% over the past 25 years since 1990. During the outlook period, we expect a downward trend will continue at the same pace, mainly under the impetus of stronger efficiency measures and further deployment of clean fuels. US carbon emissions are also expected to drop by 0.5% per year between 2015 and 2040. However, India's carbon emissions increase strongly by an average of 2.6% per year.. Despite such significant growth, India's CO2 emissions per capita still remain well below the global average throughout the projection period.

Figure 4: Energy-related CO_2 emissions in the GECF Global Gas *Outlook*

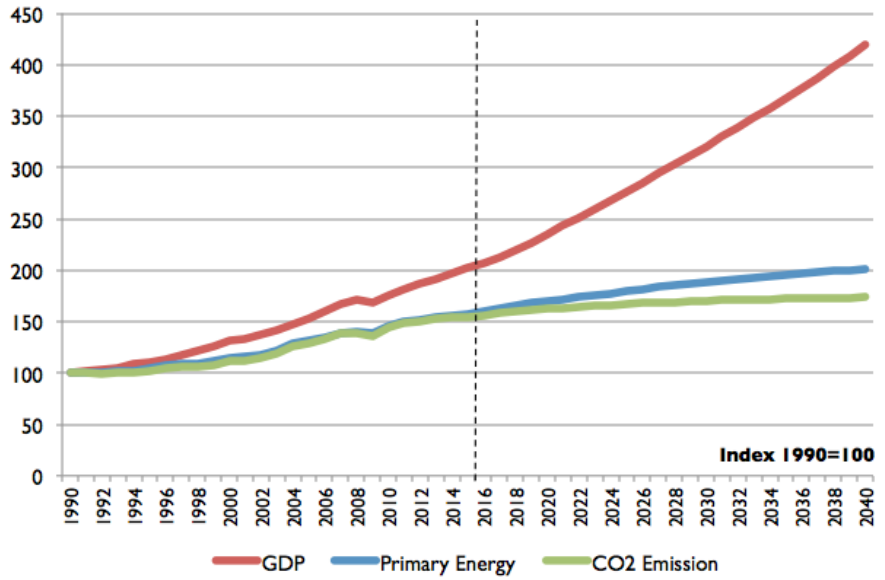


Sources: GECF Secretariat based on data from GECF GGM

GECF countries contributed to 12% of the global CO2 emissions in 2015. In the Outlook, the total CO2 emissions from the GECF countries are set to increase by 15% for the period from 2015 to 2040. Nevertheless, the GECF contribution to global CO2 emission is expected to remain stable, showing only a marginal increase by the end of the period to reach 12.3%.

Globally, implementing better energy efficiency measures and shifting the economic structure of the developing countries from high energy-intensity sectors to the low energy-intensity service sectors is expected to result in lower global energy intensity per capita and per GDP, and therefore GDP and energy consumption are set to decouple over the outlook period. Furthermore, increasing the penetration of clean fuels, including gas and renewables in countries energy mix, will also widen the gap between carbon dioxide emissions and total primary consumption (Figure 5).

Figure 5: Global CO_2 emissions, GDP, and energy consumption



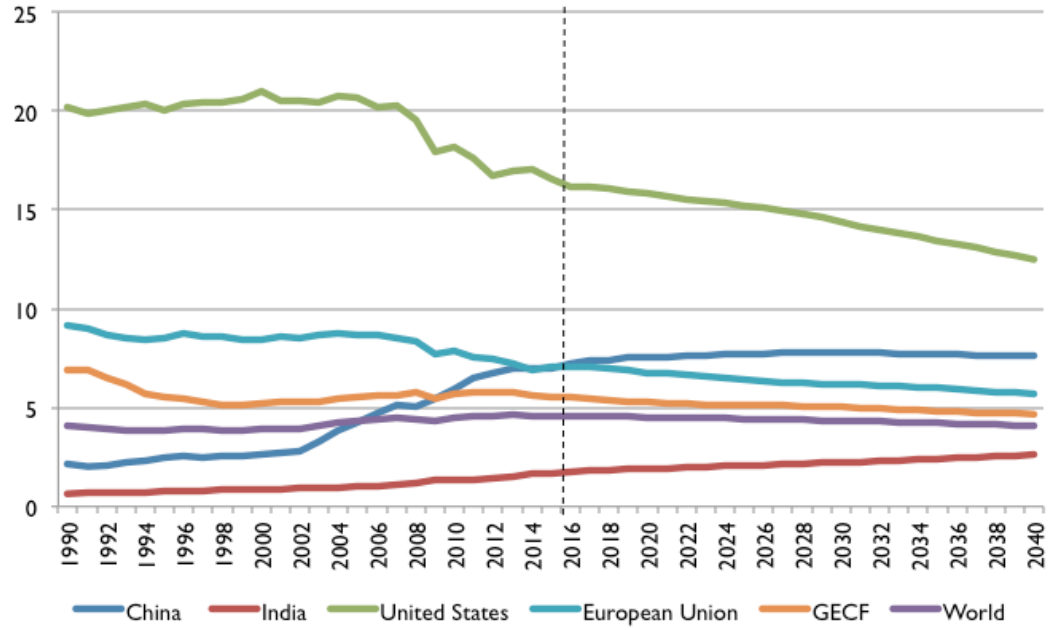
Sources: GECF Secretariat based on data from GECF GGM

In the Outlook, the global average energy-related CO2 per capita emissions is set to decline gradually over the projection period (Figure 6). From 1990 to 2015, CO2 per capita emissions increased by an average of 0.4% per year. Over the next 25 years, a different pattern will be observed and CO2 per capita emissions are expected to fall at a similar rate to that witnessed over the past 25 years; approach 4.1 tonnes per person. Chinese CO2 per capita emissions already passed the world average in 2005, is expected to pass the EU in 2016, and then to peak around 2030 at 7.7 tonnes CO2 per person.

The EU CO2 per capita emissions keep declining, while still being above the global average by the end of the outlook period. Per capita emissions from US are projected to decline dramatically from 20 tonnes CO2 per person per capita in 1990 to 16.5 in 2015, and then are expected further reduction by 2040 to reach to 12.4 tonnes per person.

India has one of the lowest CO2 per capita emissions and expected to remain so across the projection period. However, in terms of increment in emissions, India will be the far largest CO2 emitter with over 2Gt additional CO2 emissions between 2015 and 2040. GECF CO2 per capita emissions stood at 5.5 tonnes per person in 2015. At this point, it is still 1 tonne per person higher than global average. By 2040, the gap between the GECF and global average CO2 per capita is expected to narrow and drop by half to reach 0.5 tonne per person above the global average.

Figure 6: Energy-related CO_2 emissions per capita by region (Tonnes)



Sources: GECF Secretariat based on data from GECF GGM

Despite the fact that in the GECF Outlook gas is the fastest growing fossil fuel, and renewables are growing strongly, still it is not enough to keep the climate pathway in line with scientific recommendations, and existing political agreements to limit the concentration of GHGs in the atmosphere to around 450 parts per million. This indicates that more penetration of gas and renewables is required to control total carbon dioxide emissions sufficiently to meet climate protection targets.

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