Expert Commentary:

How Does Carbon Pricing Shape Coal-to-Gas Transition?

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Content

1. Introduction

So far, coal and natural gas have served as primary energy sources for power generation. In 2022, coal accounted for 36% and natural gas for 22% of power generation (1), with the remainder coming from hydropower (15%), renewables (12%), nuclear (9%), and other sources (6%).

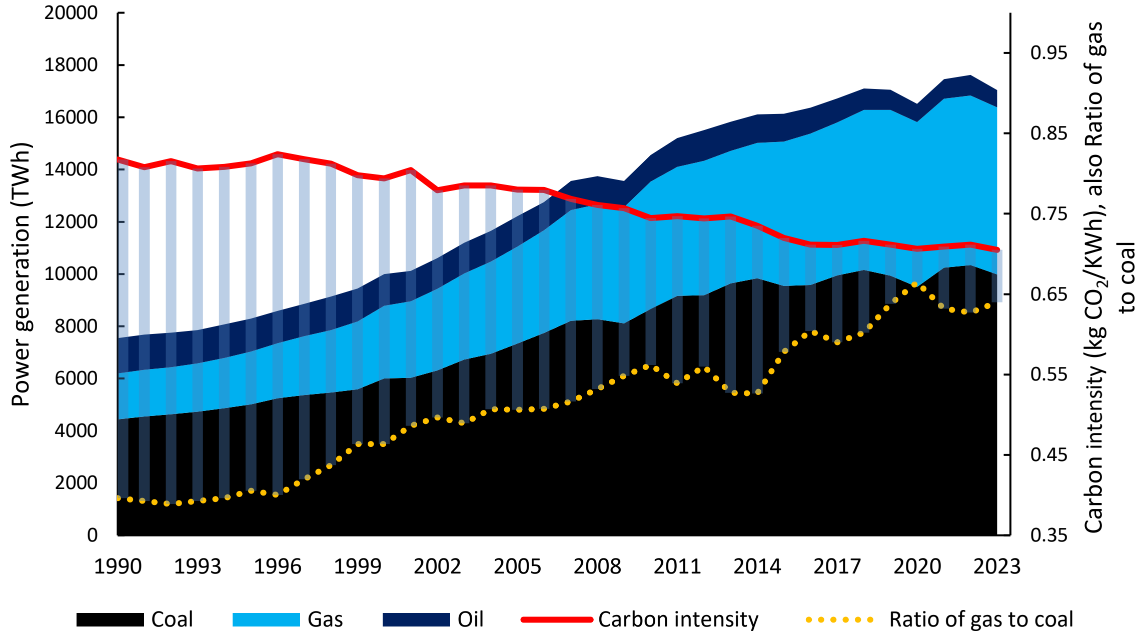
Given that coal power plants emit roughly double the amount of carbon emissions and significantly more other air pollutants such as PM and sulfur oxides compared to gas power plants, many countries have pursued coal-to-gas switching to meet CO_2 and air pollutants mitigation targets.

This perspective explores the potential of coal-to-gas switching as a pivotal strategy for emission reduction in the global power generation sector. Our primary objective is to analyse the impact of carbon pricing on the adoption of coal-to-gas switching and its implications across various regions worldwide. We aim to determine the optimal carbon price that would effectively incentivise coal-to-gas switching as a means of achieving emission reduction targets.

2. The crucial role of coal-to-gas switching in reducing emissions

Increasing the share of natural gas in fossil fuel-based power generation from 40% in 1990 to 64% in 2023 has notably decreased the emission intensity of power from 0.82 to 0.7 ($kgCO_2/kWh$), resulting in a cumulative saving of 27 gigatons of CO_2 during this period. Figure 1 illustrates the correlation between the increasing share of natural gas in power generation (yellow line) and the reduction in emission intensity (red line).

Figure 1: Fossil fuel-based power generation (TWh) on the left axis, its carbon intensity (kg CO2/kWh), and the ratio of gas to coal in power generation (%) on the right axis.



Source: GECF Secretariat

According to the IPCC's sixth assessment report, from 2010 to 2019, there was an annual decrease of 0.3% in global carbon intensity (CO_2 emissions from fossil fuel combustion and industrial processes per unit of primary energy). The report indicates that this decline was mainly due to the transition from coal to gas, restricted expansion of coal capacity, and increased adoption of renewable energy sources (2).

Renewables undoubtedly play a significant role in reducing emission intensity. However, their development isn't occurring at the necessary pace to effectively combat climate change. In recent years, a combination of reduced costs, accessible capital, and political endorsement has significantly accelerated the global shift towards renewable power. However, it's important to note that renewable energy only accounts for around 5% of global energy demand, while the world remained heavily reliant on fossil fuels to meet 80% of its energy needs.

On the other hand, the surge in renewable energy is meeting unexpected challenges. Disrupted supply chains and escalating interest rates are inflating costs. The existing transmission lines are proving inadequate to accommodate the proliferation of new and decentralised renewable energy projects. Building more transmission lines is expensive and complicated. Additionally, there is a growing concern regarding the limited access to critical minerals and metals, such as copper, lithium, cobalt, nickel, and aluminium, which are essential for solar and wind power generation. Given the capital-intensive nature of the production of these metals and the lengthy production lead times involved, establishing new capacities to meet the required levels of renewables for decarbonisation takes considerable time. Even upon the discovery of new metal sources, navigating legal and financial hurdles can prolong the process for years. Moreover, mining critical minerals for renewable energy is often tagged as a 'dirty' activity, leading to its exclusion from sustainable finance options and facing resistance at the local level.

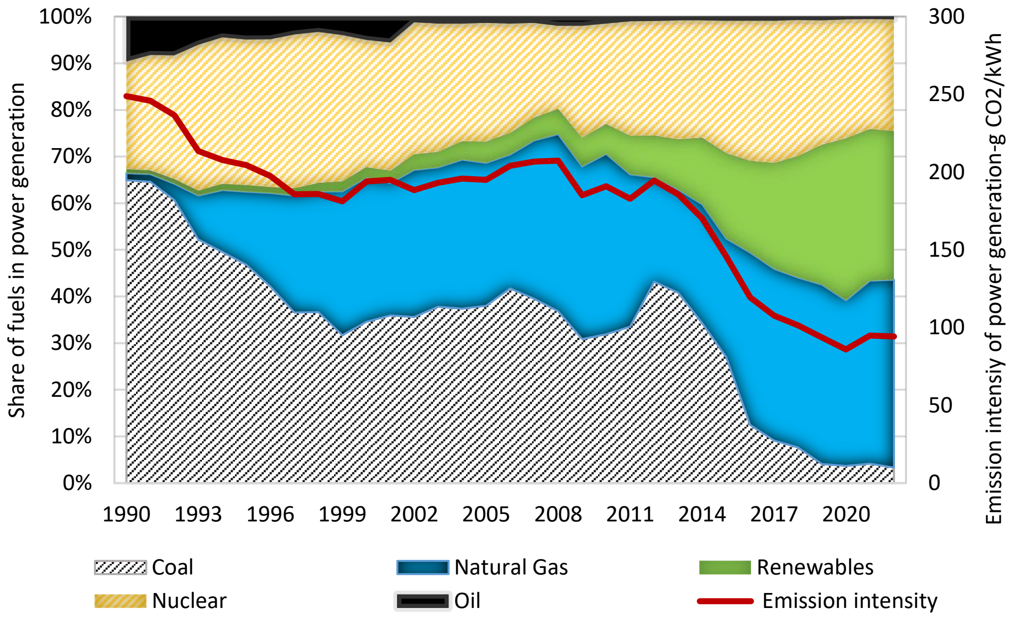
Furthermore, it's important to note that an exclusive focus on a single pathway to achieving climate targets might imperil the attainment of other sustainable development goals, limit funding for vital energy projects and threaten the essential public support for climate policies. Recent energy crises underscore that a disorderly transition to net zero, with an overemphasis on one solution, can pose challenges to energy affordability and result in a significant backlash against climate change policies. This could potentially undo previous achievements. Currently, many countries are considering revising their ambitious climate change plans due to social resistance (3).

Amid these challenges, natural gas, acknowledged as the cleanest fossil fuel, holds significant potential for reducing energy-related emissions. In particular, transitioning from coal to gas presents a readily achievable opportunity for quick wins in emissions reduction. Therefore, supporting policy measures for coal-to-gas switching can be a strategic decision, given the demonstrated effectiveness and utility of such transitions in history.

3. Case studies from the UK, Germany, and the United States

To scrutinise the significance of coal-to-gas switching for emission reduction, let's explore the divergent strategies pursued by two countries: the UK and Germany. The first country adopts a policy to utilise all possible low-carbon fuels for decarbonisation, while the second country places an overemphasis on renewables. Certainly, numerous factors influence the decision-making process of policymakers in these two countries, shaping their respective approaches, including the availability and affordability of each fuel. However, our focus here is not on the intricacies of those factors but rather on assessing the impact of these approaches on emission reduction. By analysing the outcomes of these divergent strategies, we aim to gain insights into their effectiveness in addressing the pressing issue of emissions reduction.

Figure 2: Share of fuels in power generation in the UK (left axis) and CO_2 emission intensity of power generation (right axis)



Source: GECF Secretariat

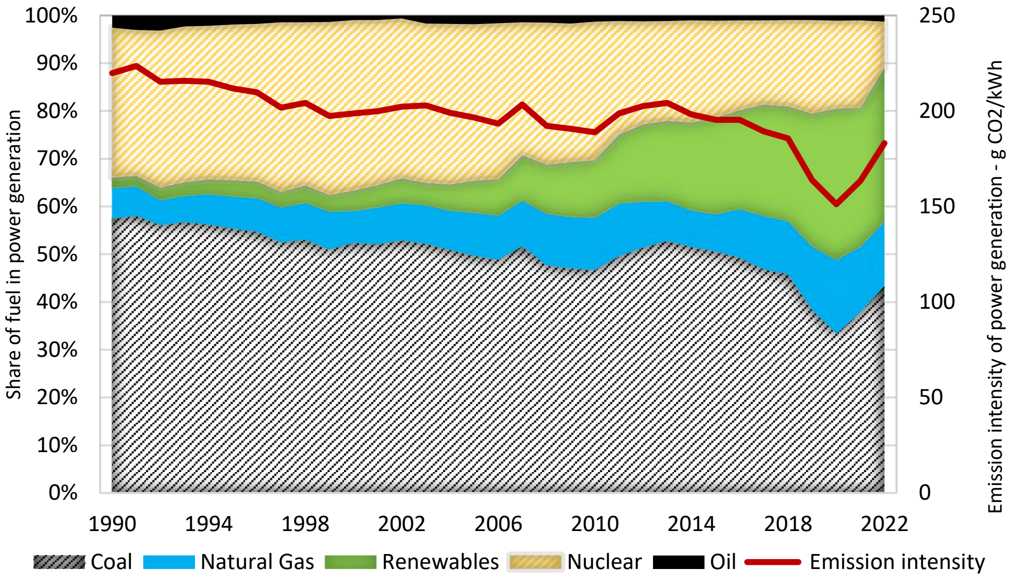
Power generation in the UK has significantly transitioned from coal to a combination of natural gas and renewables since the 1990s. Figure 2 illustrates the shift in the share of fuels in the UK's power generation and the corresponding trend in emission intensity (the red line).

It is evident from Figure 2 that the UK has pursued a policy of utilising a combination of low-carbon fuels to decarbonise its power generation, with natural gas playing a critical role in this endeavour. Initially, the UK focused on transitioning from coal to gas as the low-hanging fruit and subsequently developed renewables without reducing the share of natural gas.

Figure 2 clearly illustrates two distinct steep declines in coal consumption, followed by corresponding declines in emission intensity. The first transition occurred from 1991 to 1999, and the second from 2012 to 2016. During the first period, coal was supplanted by natural gas and nuclear power, and its share has declined from 65% to 33%. The second transition happened from 2012 to 2016; this time, natural gas and renewables played the primary role in substitution and decreased the share of coal to 10%. In aggregate, the combination of fuel switching and coal plant retirements in the UK led to a decrease in coal generation share from 65% in 1990 to 2.3% in 2022. As a result, emission intensity decreased from 248 to 94 gCO_2/kWh, reflecting a 62% reduction.

However, the rapid uptake of natural gas in the UK was not replicated in Germany or elsewhere in Europe. Despite Germany's reputation as a renewable energy champion, thanks to its substantial investments in wind and solar power, the country has experienced limited success in decarbonising its power sector, with emissions decreasing by only 17% since 1990, compared to the UK's reduction of 62%. Figure 3 illustrates that Germany's sluggish progress is primarily attributed to its ongoing reliance on lignite and hard coal, which account for over 40% of its electricity supply.

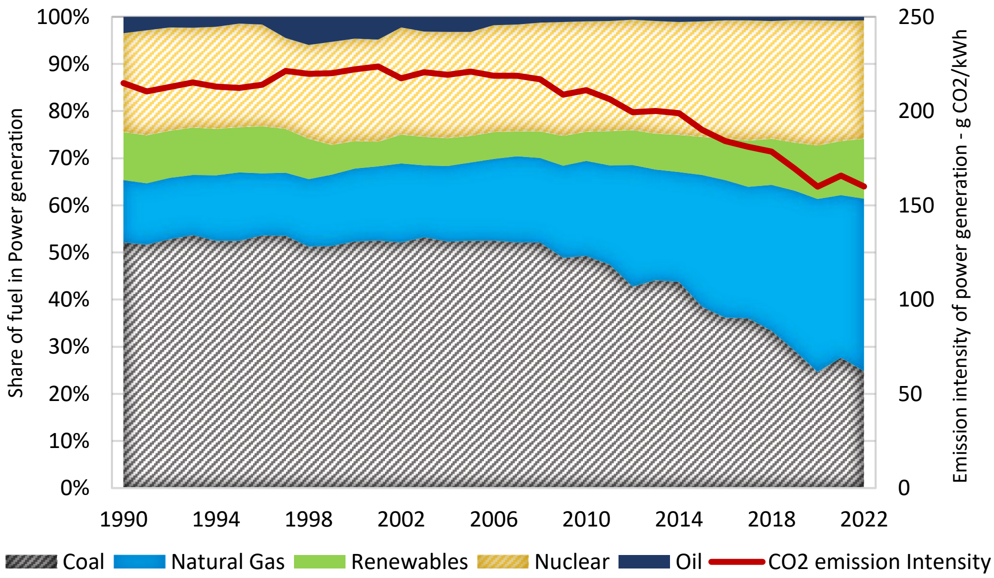
Figure 3: Share of fuels in power generation in Germany (left axis) and CO_2 emission intensity of power generation (right axis)



Source: GECF Secretariat

Another example is the role that natural gas has played so far in the decarbonisation of the United States power sector. The United States' transition away from coal and lignite was propelled by the increase in shale gas production from 2009. The share of gas has increased from 13% in 1990 to 37% in 2022, resulting in a 26% reduction in the US average carbon intensity of electricity (see Figure 4), which is 9% more than Germany's reduction. Although this reduction is smaller than what occurred in the UK due to the lesser development of renewables, considering the significant amount of power generation in the United States, it has led to considerable CO_2 savings since 2009. Actually, the transition to natural gas has been the primary factor driving emission reductions in the United States thus far.

Figure 4: Share of fuels in power generation in the United States (left axis) and CO_2 emission intensity of power generation (right axis)



Source: GECF Secretariat

At the 28th session of the UN Climate Conference (COP28, December 2023), a decision was made to accelerate efforts to reduce unabated coal power. Furthermore, the conference's Global Stock Take outcome recognised the significance of "transitional fuels" in facilitating the energy transition while ensuring energy security. It was widely interpreted that the term "transitional fuels" primarily pertains to natural gas.

Now, countries are invited to align their NDCs with these decisions and address them in terms of their national policies by COP30 in 2025. For instance, during the recent meeting of their corresponding ministers in April 2024, G7 countries made a new commitment to phase out coal power generation. They collectively agreed to discontinue the use of coal power generation in their energy systems "during the first half of the 2030s." Additionally, in their final communique, ministers mentioned that "publicly supported investments in the gas sector can be appropriate as a temporary response, subject to clearly defined national circumstances." Among G7 countries, Germany seems to face a more formidable challenge in achieving this target. While most members of the Group are already planning to phase out coal before 2035, Germany has legislated a final target to exit coal by 2038 at the latest.

4. Opportunity for emission reduction through coal-to-gas switching

Annual energy-related greenhouse gas emissions increased by 1.1% to a record 39.3 $GtCO_2eq$ per year in 2022, with emissions from coal contributing 58% of the increase. While the global shift towards renewable energy, carbon removal technologies, and nuclear power represents a crucial phase in addressing climate change, the role of natural gas remains distinct in this context.

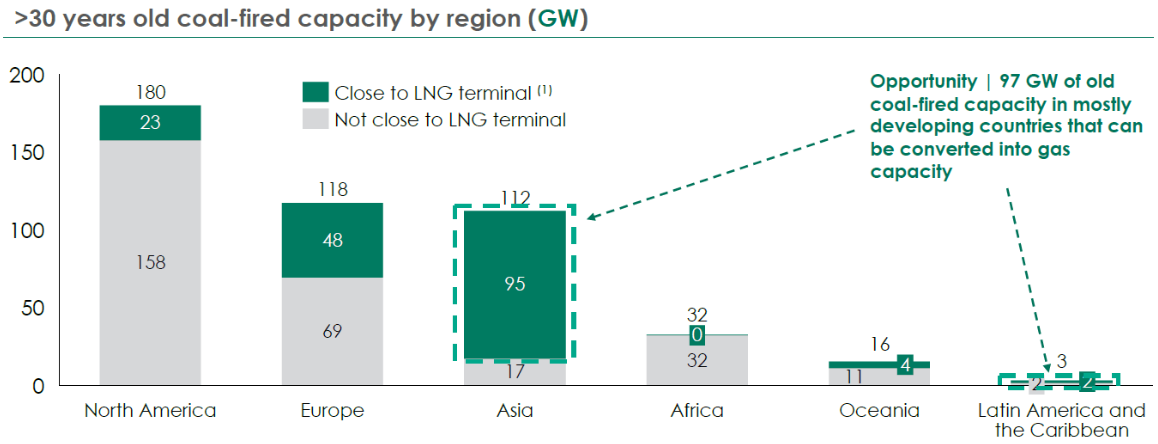
Natural gas is poised to play a critical role in diminishing the emissions gap through increased share in the energy mix. The carbon intensity of natural gas is nearly half that of coal and 20% less than that of oil. This lower carbon intensity positions natural gas as a viable option for immediate and cost-effective emission reductions, especially through direct substitution in sectors such as power generation, industry, and transport.

As an example, there is presently an estimated global coal-fired generation capacity of 2000 GW, contributing to over 10 $GtCO_2e$ emissions annually. Replacing this capacity with gas-fired thermal power plants would result in a reduction of approximately 5.5 $GtCO_2$ emissions. Furthermore, due to the superior energy efficiency of gas-fired power plants compared to coal-fired ones, this substitution would lead to improved energy efficiency and better control over primary energy demand. However, the extent to which this switching could proceed depends on various factors.

The availability and accessibility of natural gas, both domestically and through imports, can be a significant influencing factor. The presence of the necessary infrastructure, including regasification terminals, pipelines and power plants, also can facilitate this transition. In its 2019 report titled "The Role of Gas in Today's Energy Transitions," the International Energy Agency (IEA), after underscoring the significance of coal-to-gas switching as a prompt strategy for reducing emissions, highlights the potential for swift emissions reductions when existing infrastructure can be utilised to deliver equivalent energy services with lower emissions (4). The report estimated the potential to decrease up to 1.2 G ton CO_2 emissions in the power sector by transitioning from coal to existing gas-fired plants, contingent upon favourable relative prices and regulatory frameworks. Such action, according to the report's calculations, would result in a 10% reduction in global power sector emissions and a 4% decrease in total energy-related CO_2 emissions.

The other opportunity lies in replacing outdated coal power plants with gas-fired ones wherever feasible. According to a study by the Global Carbon Council, there are 171 gigawatts (GW) of coal-fired capacity over 30 years old, conveniently positioned near liquefied natural gas (LNG) terminals. Around 100 GW of this capacity is found in developing nations.

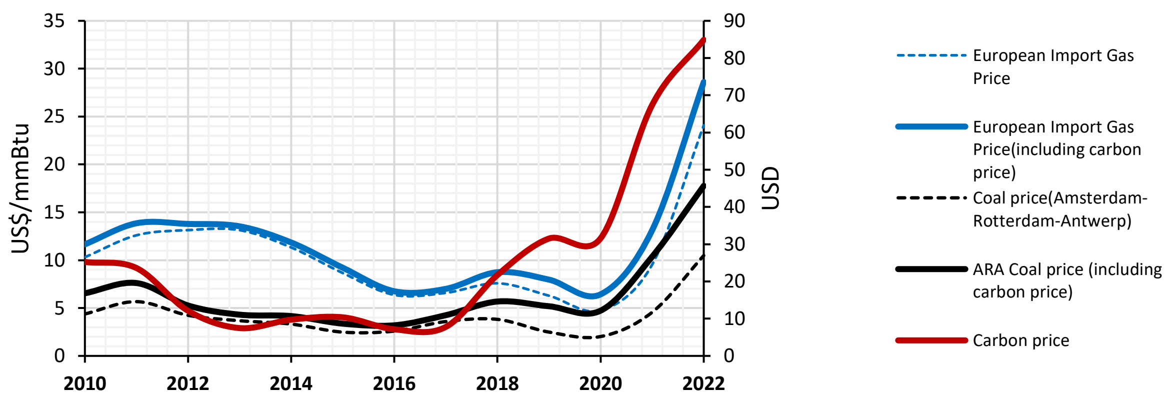
Figure 5: Coal-to-Gas Switching Opportunity by Region, based on aged coal-fired capacity near LNG terminals



Source: GCC

Nonetheless, market dynamics are the primary drivers behind the transition from coal to gas, whether through utilising existing infrastructure or allocating new capacity to natural gas over coal. Relative prices of coal and natural gas can strongly influence the attractiveness of gas-fired power generation compared to coal. If natural gas becomes more economically viable than coal, it can incentivise the transition. Furthermore, various environmental policies aim to influence market dynamics by offering subsidies, incentives and implementing carbon pricing mechanisms to encourage the adoption of low-emission fuels. Establishing and nurturing carbon markets, for example, stands out as one effective strategy embraced by many countries in this pursuit. Consequently, the interplay between the prices of coal, natural gas, and carbon emissions now stands as the primary force shaping the market dynamics driving the transition from coal to gas. Figure 6 depicts the trend of coal and gas prices in Europe over the past decade, both with and without the inclusion of carbon emission costs.

Figure 6: Coal and gas price trends in Europe with (solid lines) and without emission cost (dotted lines) alongside carbon price



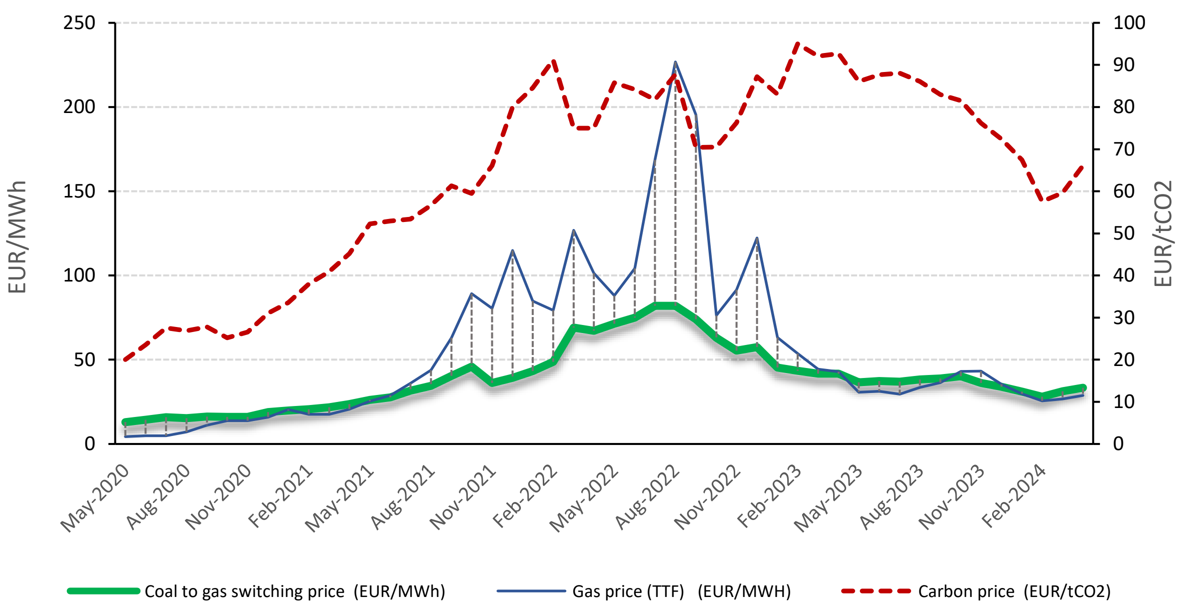
Source: GECF Secretariat

5. Coal to gas switching price

When a region has ample capacity for both coal and gas-fired power plants, the primary factor influencing coal-to-gas switching is the price of coal, gas and emission. This can be shown by the coal-to-gas switching price. This metric signifies the price of gas at which gas-fired generation becomes more competitive than coal-fired generation, factoring in operating costs, efficiencies, fuel expenses, and carbon pricing. When the price of gas falls below this threshold, gas becomes the economically preferable fuel for power generation, and conversely, when it rises above, coal gains the advantage. Figure 7 displays the trend of coal-to-gas switching prices, natural gas prices, and carbon prices in Europe over the last three years. Given that coal power plants emit approximately double the amount of carbon emissions compared to gas power plants, they inherently face a higher carbon cost. Consequently, a combination of lower gas prices relative to coal prices and increased carbon prices acts as a catalyst for coal-to-gas switching in power generation, promoting a transition towards cleaner and more environmentally sustainable power generation.

Based on Figure 6, gas has often been more expensive than coal over the past decade. However, gas-fired power plants boast higher efficiency compared to coal-powered ones and emit less CO_2. Consequently, when considering these factors in economic calculations, the transition from gas to coal has proven to be more cost-effective over the last three years, except for the energy crisis in 2022 (Figure 7). Amidst the energy crisis, natural gas relinquished its competitive edge against coal, resulting in a resurgence in coal demand. The heightened reliance on coal had detrimental environmental repercussions, undermining global endeavours to curtail greenhouse gas emissions. This underscores the significance of sufficient investment in the natural gas value chain. Shortages of natural gas played a pivotal role in the 2022 crisis, mainly attributable to years of underinvestment in natural gas supplies, a situation exacerbated by geopolitical tensions in Eastern Europe.

Figure 7: The trend of coal-to-gas switching prices, natural gas prices, and carbon prices in Europe over the last three years



Source: GECF Secretariat, based on data from Refinitiv Eikon

6. Role of carbon price on coal to gas switching

As previously stated, in the UK, the significant decrease in coal generation was driven by the impact of transitioning from coal to natural gas generation, notably from 2012 to 2016. This shift played a crucial role in halving power sector emissions, a trend not observed in Germany or elsewhere in Europe. To provide context, Britain's transition from coal to gas in 2016 exceeded the combined efforts of all other European countries (5). However, substantial emissions reductions only began in 2013, coinciding with the decreasing share of coal as carbon prices started to rise (6).

Commencing in 2005, British power plants became subject to the EU Emissions Trading Scheme (ETS). Yet, the scheme failed to yield sufficiently robust carbon prices to drive sustained investments in low-carbon technologies. Consequently, in 2013, Britain implemented the Carbon Price Support (CPS) policy. This policy mandated power-sector emitters to pay an additional fee, referred to as a top-up, to maintain a Carbon Price Floor (CPF) set by policymakers. The objective was to furnish generators with the assurance of a more stable, albeit higher, price for CO_2 compared to what was available solely through the EU-wide market. Initially, the CPF was slated to increment annually until 2020 (reaching £30/tCO_2). However, the Government imposed a cap on the CPS component, limiting it to a maximum of £18/tCO_2 from 2016 to 2021. Although this move might imply a reduction in ambition due to financial constraints, it should be juxtaposed with an EU-ETS price of approximately €5/tCO_2 throughout 2016.

To identify the carbon price that incentivises the transition from coal to gas, we'll utilise a straightforward equation (7). The coal-to-gas switching price should motivate companies to decrease GHG emissions in a financially viable manner. Therefore, this price begins by determining the marginal cost (MC) of each fuel without factoring in carbon costs.

$$\text{MC} = \frac{FC}{\eta}$$

Here, FC represents the fuel cost, and η denotes the power plant's efficiency. We presume that the power plant's efficiency is an average value, meaning the marginal cost is primarily influenced by the fuel cost alone. Subsequently, if we introduce a carbon cost, such as a carbon tax or allowance price, the equation adjusts to accommodate this additional expense:

$$\text{MC} = \frac{FC}{\eta} + \frac{EF}{\eta}\ EC$$

Where EF represents the emission factor, which depends on the type of fuel and the quantity burned, while EC denotes the emission cost. Fuel switching occurs when power generation from an alternative fuel becomes more economical. To determine the minimum cost required for a switch, we equate the marginal cost of coal to that of gas, effectively solving for the emission cost within this equation.

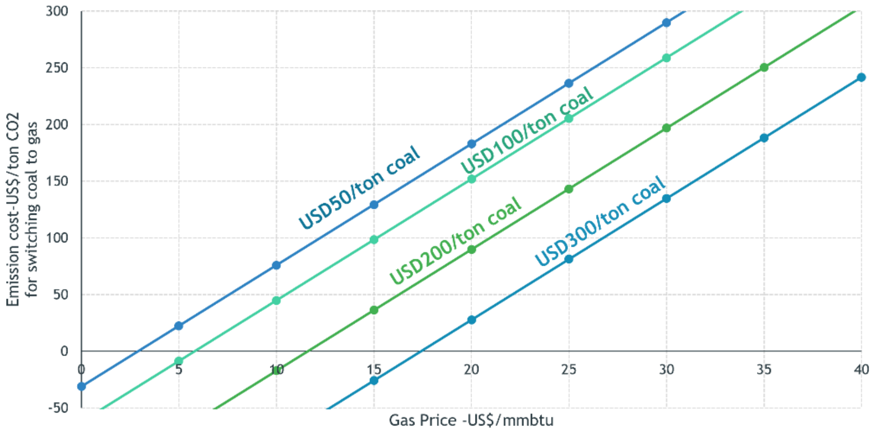
$$\text{EC}_{\text{switch}} = \frac{\eta_{coal} FC_{gas} - \eta_{gas} FC_{coal}}{\eta_{gas} EF_{coal} - \eta_{coal} EF_{gas}}$$

Hence, when the emission cost falls below this threshold, generating electricity from coal becomes more economical than from natural gas, and vice versa. Using these equations, we generated the plot presented in Figure 8, illustrating the carbon price levels at which coal-to-gas switching is incentivised for different gas and coal prices.

A typical coal plant operates with an efficiency of 32% to 33%. There are two main types of natural gas power plants: simple cycle and combined cycle. The efficiency of a simple cycle natural gas power plant typically ranges from 33% to 43%. Conversely, a combined cycle power plant can achieve efficiencies exceeding 60% by utilising the hot exhaust gases to drive a secondary turbine, thereby generating additional electricity. In Figure 8, an average efficiency of 32% for coal plants and an average efficiency of 44% for gas power plants has been used to generate the graph (8). On average, coal emits around 0.114 tons of CO_2 per mmbtu, and natural gas emits around 0.0585 tons of CO_2 per mmbtu when burned for electricity generation.

Following a period of heightened volatility and a series of record-breaking price surges in 2022, global natural gas prices have predominantly been trending downward in 2023. The average natural gas price at the United States Henry Hub (HH) was USD 2.57/mmbtu, the average Title Transfer Facility (TTF) price, serving as the benchmark for Europe, was USD 12.9/mmbtu and as for the Asian market, the annual average NEA spot LNG price reached to USD 13.47/mmbtu in 2023. The GGO 2023 anticipates that elevated gas prices to persist until the mid-202s, then to rebalance around 2026-2027. Accordingly, it is expected that the average long-term price for natural gas in Europe is set to stabilise at around USD 9/ mmbtu, while in Asia, the long-term price is anticipated to settle at

Figure 8: The interplay among carbon, gas, and coal prices



Source: GECF Secretariat

approximately USD 10/mmbtu. Meanwhile, the Henry Hub, serving as a benchmark, is projected to maintain an average long-term natural gas price of around USD 4/mmbtu throughout the forecasted period. With these natural gas prices in mind, Figure 8 indicates that if carbon is priced between USD 25 to $75 per ton, natural gas can effectively compete with coal priced from USD 50 to USD 100 per ton.

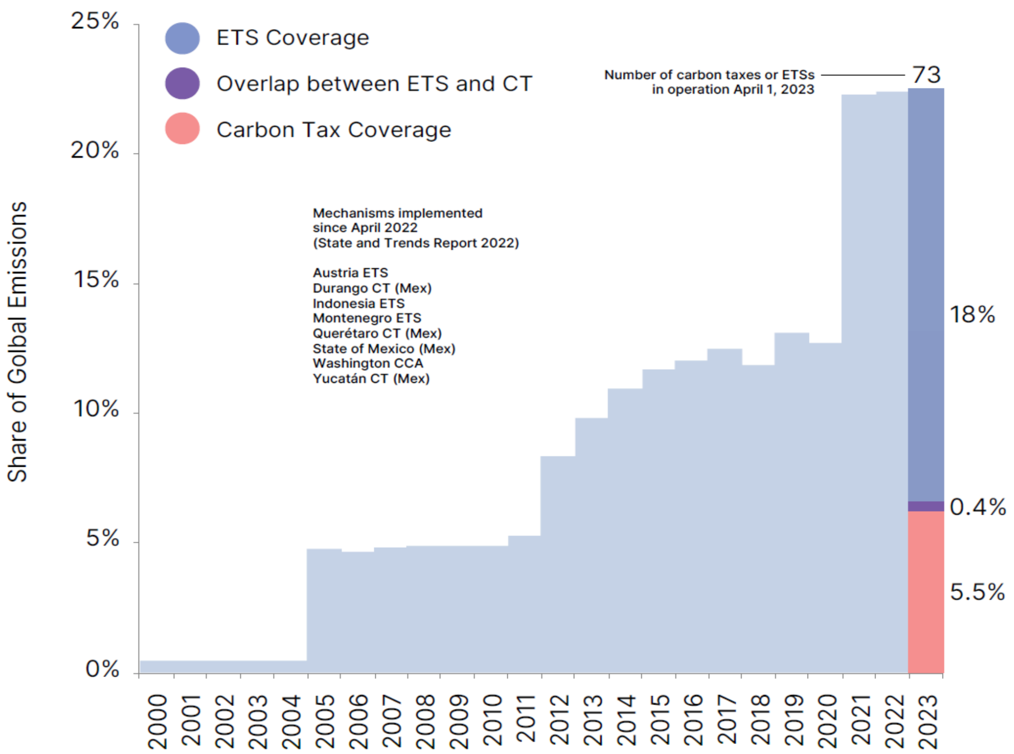
It's important to note that this analysis pertains specifically to coal-to-gas switching in areas where there is ample capacity for both coal and gas-fired power plants. To determine the necessary carbon price for directing new capacity for power generation to gas-fired plants instead of coal, we must consider additional factors. Some aspects to consider include the availability and abundance of domestic sources of each fuel, as they directly impact the feasibility and cost-effectiveness of the transition while ensuring energy security. Moreover, the presence of critical infrastructure such as extraction and refinery facilities, regasification terminals, pipelines, and power plants significantly influences the allocation of new capacity to gas-fired plants rather than coal. It's important to note that this aspect falls outside the scope of this study.

7. Advancements in carbon pricing

Over the last decade, carbon pricing has seen substantial evolution. As of April 2023, there has been a remarkable increase in the number of carbon taxes and Emission Trading Systems (ETSs) worldwide, with a total of 73 such mechanisms currently in operation. According to the World Bank, 49 countries have already implemented carbon-pricing schemes, and an additional 23 nations are actively considering their adoption (9). Notably, Indonesia, Japan, and Vietnam have recently joined the carbon market landscape by initiating their carbon pricing initiatives.

As depicted in Figure 9, a substantial 23% of global emissions, equivalent to a staggering 11.8 gigatons of CO_2 equivalent, are now subject to existing carbon taxes or emission trading schemes. To put this into perspective, out of the total 51.6 gigatons of CO_2 equivalent emitted in 2023, over one-fifth of it is now under the purview of these measures. This represents a tremendous leap from the mere 5% coverage we observed back in 2010 (9).

Figure 9: Carbon pricing coverage of global emissions



Source: The World Bank

It is important to note that the vast majority of these carbon pricing mechanisms are concentrated in high-income countries, primarily in Europe and North America. In fact, every country within the European Economic Area and North America has at least some portion of its emissions covered by one of these mechanisms; however, Emerging economies are showing growing interest in adopting carbon credit instruments.

The spread of carbon pricing is unfolding through three primary channels. First, governments are establishing new markets and levies. For instance, Japan initiated a voluntary national market for carbon offsets in April 2023, intending to complement an existing regional cap-and-trade policy in Tokyo. Indonesia's carbon trading mechanism commenced trading in September 2023. Malaysia is currently conducting a study on carbon pricing instruments, slated for completion in 2024, paving the way for the implementation of either a carbon tax or an ETS. India has unveiled the design elements of the India Carbon Market, encompassing both compliance and voluntary carbon pricing. Meanwhile, Vietnam is in the process of developing an emissions-trading scheme scheduled to be operational by 2028. Egypt is gearing up to inaugurate the pilot phase of its compliance carbon market in 2024, while Turkey aims to initiate an ETS with a pilot phase commencing in 2025. Moreover, New York State has released additional program design details for its cap-and-invest system. Additionally, several other countries, including Brunei Darussalam, Thailand, and the Democratic Republic of Congo, have expressed their intentions to implement carbon pricing measures.

Second, countries that already have established markets are beefing up their policies. The regulators completed program reforms for the EU ETS, the UK ETS and the Australian Safeguard Mechanism. Many other regimes are reviewing their carbon programs. They could further push up carbon prices in 2024, including but not limited to North American programs like the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative (WCI), and the expected sectoral coverage expansion of China's national ETS.

Also, some carbon pricing regimes extend to more sectors to drive decarbonisation in other parts of the economic activities. More countries are targeting transport and fossil fuel upstream sectors for mandatory carbon pricing obligations. Maritime transport emissions will be covered by the EU ETS in 2024. The EU's ETS II will become operational in 2027, covering fuel combustion in buildings, road transport and additional sectors. The UK ETS looks to cover domestic maritime transport from 2026. The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) enters its first phase in 2024. Canada revealed a regulatory framework for an oil and gas sector cap-and-trade system. Vented carbon dioxide from the upstream oil and gas sector will be covered by the UK ETS in 2025.

The final way that carbon markets are spreading is via cross-border schemes. The EU's programme is by far the most advanced. In CBAM's pilot phase, importers of aluminium, cement, electricity, fertiliser, hydrogen, iron and steel will need to report "embodied emissions" (those generated through production and transport). Then, from 2026, importers will have to pay a levy equivalent to the difference between the carbon cost of these emissions in the EU's scheme and any carbon price paid by the exporter in their domestic market. Free permits for sectors will also be phased out, and the housing and transport industries will be brought into the market. (scop 1 and 2)

The EU CBAM set a precedent for other countries. The UK announced the implementation of the UK CBAM starting in 2027. There are other similar mechanisms under discussion. Australia is also taking a step further, considering policy options in a consultation launched in November 2023, including an Australia CBAM. The United States proposed the Foreign Pollution Fee Act. With financial obligations under the EU CBAM starting in 2026 and more countries adopting similar mechanisms, trade partners could be exposed to revenue leakage. So, it is expected that other countries will implement a carbon border tax or raise their domestic carbon prices.

However, Article 6 of the Paris Agreement, designed to establish the rules for international emissions trading, has not yet become operational. The implementation of Article 6, specifically Article 6.4, is expected to establish a new framework for a global carbon market, creating additional demand for credits, with eligibility rules to be determined by the UN.

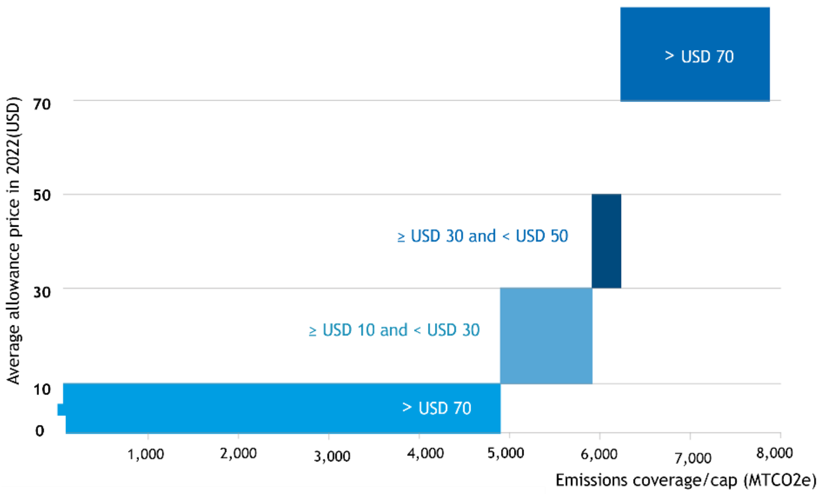
Despite the proliferation of carbon markets globally, a critical examination reveals that many of these markets fall short of achieving their intended impact and are plagued by prices that are too low to induce substantial changes in behaviour.

Figure 9 depicts the price evolution in selected Emission Trading Systems (ETSs) over the last five years, and Figure 10, referenced from the ICAP Status Report 2023, illustrates the range of allowance prices in 2022 within ETSs in force, along with the corresponding volume of emissions covered by them at those price levels. The majority of emissions covered by ETSs occurred in systems where average prices were below USD 10 in 2022. Approximately one-sixth of ETS-covered emissions were in systems where average prices ranged between USD 10 and USD 50. There were no systems where prices fell within the range of USD 50 to USD 70, whereas the EU, Swiss, and UK ETSs recorded average prices surpassing USD 70. Over one-fifth of ETS-covered emissions occurred in systems where the average allowance price in 2022 exceeded USD 70 (10).

Figure 9: Price evolution in selected ETSs from 2018 to 2023

Source: The World bank

Figure 10: The range of allowance prices in 2022 within ETSs in force and the associated volume of covered emissions.



Source: the ICAP Status Report 2023

Driven by domestic climate commitments and partly influenced by carbon border taxes, an increasing number of countries are accelerating their efforts to enhance carbon prices. For example, Singapore recently amended its carbon pricing legislation to raise the nation's carbon tax starting in 2026, from USD 4-19 in 2024 to USD 38-60 per ton in 2030. Similarly, Canada is advancing its plan to elevate its federal baseline, aiming to surpass USD 127 per ton by 2030. South Africa plans to raise its national carbon tax to at least USD 30 by 2030. In the EU, the annual decline rate for the EU ETS cap will double to 4.4% from 2028 as part of the "Fit for 55" package.

To effectively limit global warming to below 2°C, carbon prices must increase to a range of USD50/tCO_2 to USD100/tCO_2 by 2030. Adjusting for inflation, this equates to USD61 to USD122 by 2030 in 2023 USD (9). However, according to Figure 8, to incentivise the transition from coal to gas, a price range between USD25 to USD75, depending on the region, would work efficiently.

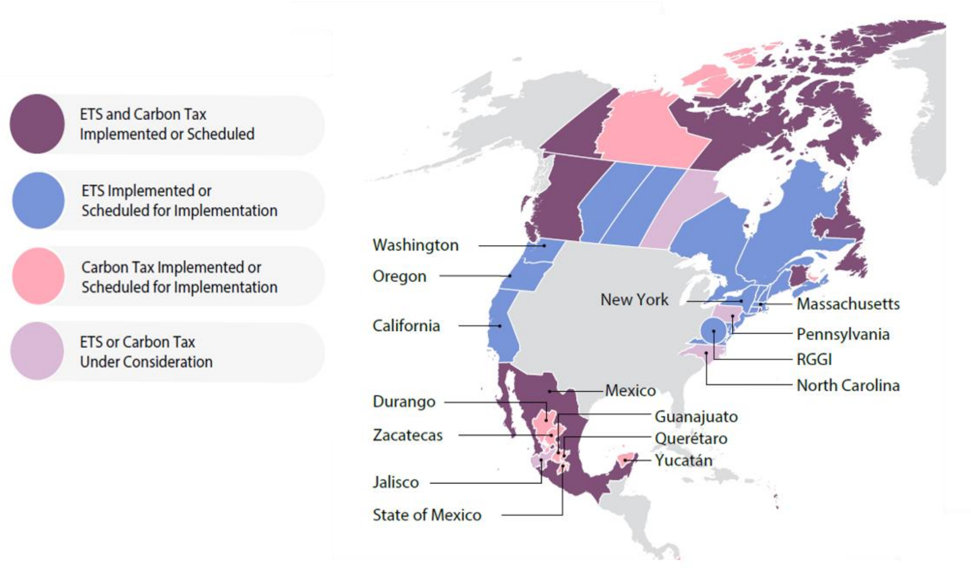
8. Concluding remarks

Coal and natural gas are primary sources of global power generation. Given coal's high emissions, transitioning to gas can significantly lower GHG emissions and other air pollutants. It is a low-hanging fruit for achieving emission reduction and air quality improvement goals. While renewables undoubtedly can play a significant role in reducing GHG emission intensity, their development is not occurring at the necessary pace to effectively combat climate change within the narrow timeframe required to meet the temperature goal set out in the Paris Agreement. Moreover, an exclusive focus on renewables as the sole pathway to achieving climate targets may jeopardise the achievement of other sustainable development goals, limit funding for essential energy projects, and undermine public support for climate policies. Coal-to-gas switching offers a practical approach to emission reduction, as demonstrated by the UK's transition compared to other coal-reliant countries such as Germany, which has chosen to prioritise investments in renewables.

The degree of coal-to-gas switching in the power generation sector depends on various factors, including the availability and accessibility of natural gas, as well as the presence of essential infrastructure such as regasification terminals, pipelines, and power plants. Significantly, there are 171 gigawatts of coal-fired capacity worldwide that are over 30 years old strategically situated near LNG terminals. This advantageous proximity could facilitate their replacement with gas-fired power plants. However, in regions where there is sufficient capacity for both coal and gas-fired power plants, market dynamics play a pivotal role. Factors such as the relative prices of coal and natural gas, as well as environmental policies, particularly carbon pricing mechanisms, are key drivers in this transition.

In North America, where the projected coal price is expected to be around USD40/ton by 2050, combined with the forecasted natural gas price of approximately USD4/mmbtu at the Henry Hub, coal-to-gas switching is already economically favourable. With such competitive gas prices, a modest carbon price in the range of USD25/tonCO_2 could further incentivise the transition from coal to gas in the power generation sector. Figure 11 depicts a map illustrating the carbon pricing mechanisms in this region. In Canada, the carbon price has hovered around USD 50 /ton CO_2, with plans to raise it to USD 127 /ton CO_2 by 2030. Contrastingly, the United States lacks a nationwide carbon pricing mechanism, and carbon prices in local markets have historically remained below USD 20 per ton of CO_2.

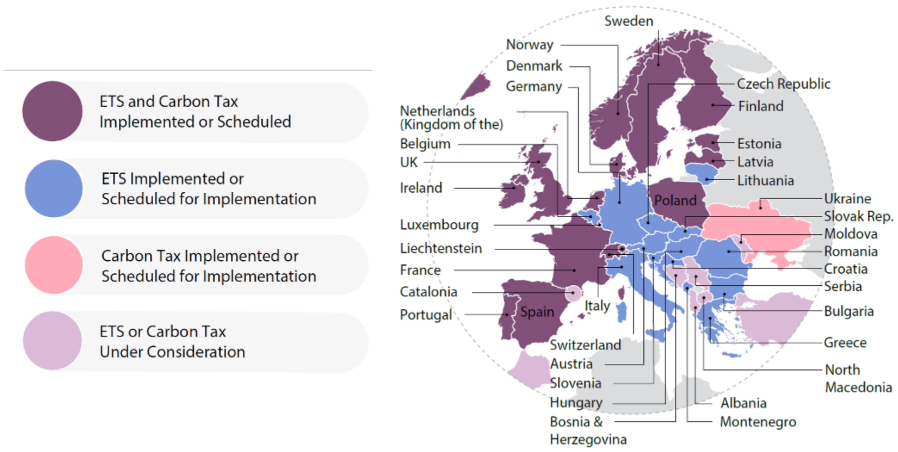
Figure 11: Map of carbon taxes and ETSs in North America,2023



Source: The World Bank

All European countries currently operate under a carbon pricing mechanism. The majority of Europe is covered by the EU Emissions Trading System (ETS), which was established in 2005 and has since matured into a well-developed framework (see Figure 12). Europe boasts relatively high carbon prices, averaging around USD90 per ton of CO_2. Projections suggest that coal prices are anticipated to reach approximately USD50 per ton by 2050, while long-term natural gas prices are forecasted to stabilise at around USD9 per million British thermal units (MMBtu). The high carbon prices, combined with the moderate coal prices and competitive natural gas prices, suggest that the current carbon pricing levels are already providing a strong incentive for coal-to-gas switching in the power generation sector.

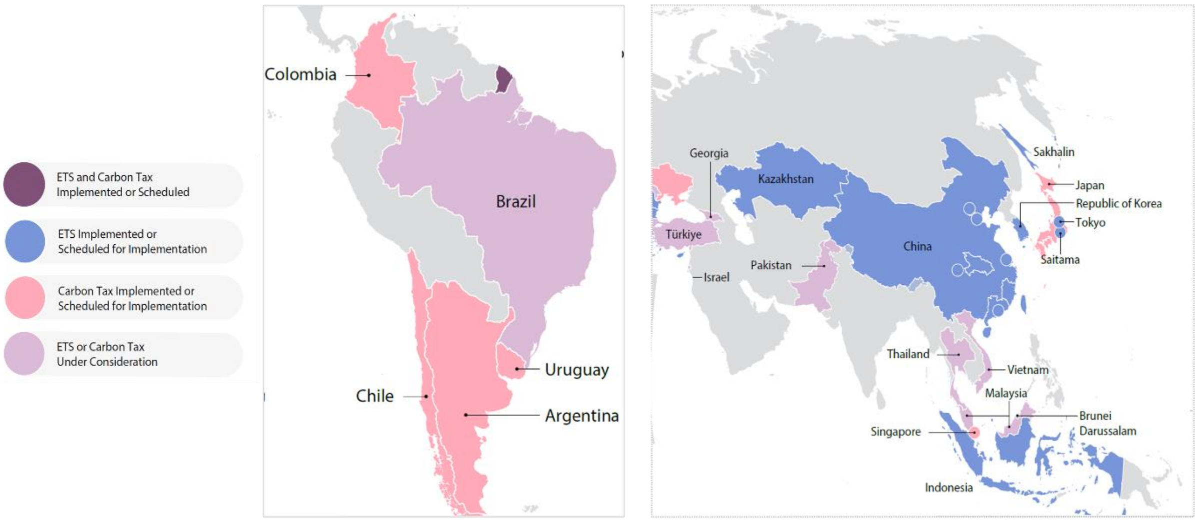
Figure 12: Map of carbon taxes and ETSs in Europe,2023



Source: The World Bank

In East Asia and Latin America, where the projected coal prices are expected to be higher, around USD80/ton and USD55/ton, respectively, by 2050, and the long-term natural gas prices are expected to settle at approximately USD10/mmbtu, a higher carbon price may be necessary to drive coal-to-gas switching. Given the higher coal prices in these regions, along with competitive natural gas prices, carbon prices in the range of USD50 to USd75 ton CO_2 could provide the required impetus for power generators to favour gas over coal, facilitating accelerated transitions. However, these regions lack robust carbon pricing mechanisms, making it difficult to create the necessary economic incentives for transitioning from coal to gas in the power generation sector. Carbon prices in this region mostly remained under USD 10 per ton of CO_2 in 2023. Without effective carbon pricing mechanisms, power generators in East Asia and Latin America may not have sufficient motivation to invest in cleaner natural gas technologies over coal. Even with the higher projected coal prices, the absence of adequate carbon pricing limits the competitiveness of natural gas as an alternative.

Figure 13: Map of carbon taxes and ETSs in Asia (right) and Latin America (left),2023



Source: The World Bank

In Africa, the narrative takes a different turn. The region grapples with significant challenges, including limited civil infrastructure and underdeveloped industrial and supply chain ecosystems. Approximately 600 million people in Africa lack access to electricity, and in sub-Saharan Africa alone, 900 million people still lack access to clean cooking facilities. These deficiencies in the energy sector both exacerbate the issue and stem from the prevailing situation. Furthermore, Africa is often labelled as the most vulnerable continent to the impacts of climate change despite bearing no historical responsibility for it and contributing only a mere 3% to global greenhouse gas emissions.

Africa, blessed with a youthful population and abundant natural resources, faces the urgent priority of socio-economic development amidst energy poverty. Leveraging the continent's considerable conventional natural gas reserves, estimated at around 45 billion cubic meters, presents an opportunity to address current issues of pollution and greenhouse gas emissions while optimising resources and supporting renewable energies, which Africa is naturally rich in. This approach could drive sustainable development in Africa for decades to come, extending beyond the current United Nations development agenda and the SDG 2030 targets. Additionally, increased use of natural gas could alleviate pressure on forestry resources by reducing the need for logging and charcoal production.

However, realising the potential of gas reserves requires substantial investments in exploration, development, infrastructure, and human capacity building. Thoughtful management of energy transition policies across the continent can foster lasting synergies between energy and climate objectives, paving the way for more sustainable development for all.

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