

Carbon Pricing in the Power Sector

Annex B – Case Studies



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ANNEX B: CASE STUDY SNAPSHOTS

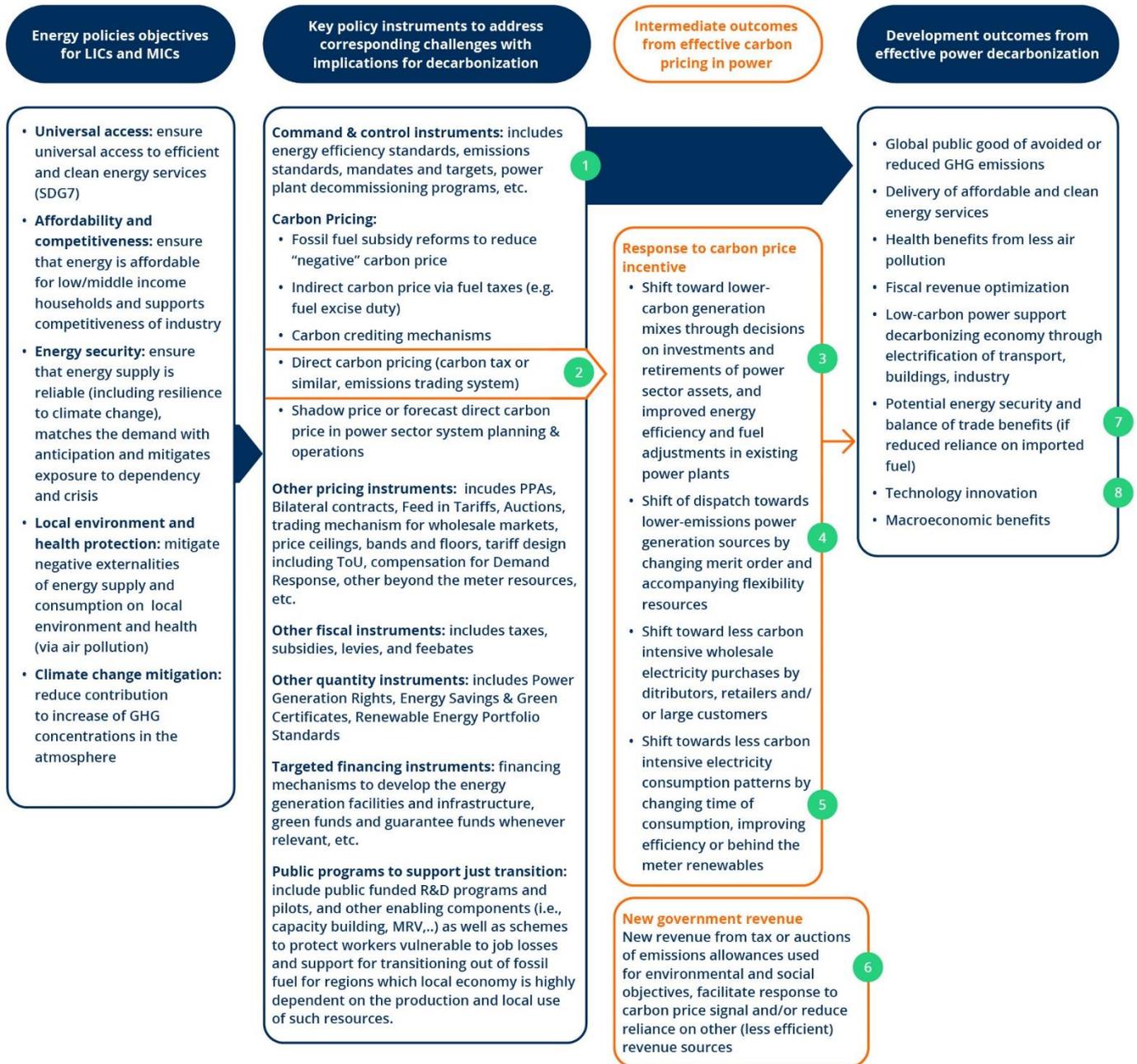
Case studies were developed to support the Pricing Carbon for Clean Electricity report led by the World Bank, the International Carbon Action Partnership (ICAP), and the International Energy Agency (IEA). The report aims to identify lessons from burgeoning experiences in high-, middle-, and low-income countries (HICs, MICs, and LICs) on the potential roles that two types of carbon pricing instruments (CPIs), carbon taxes and emissions trading systems (ETSs), can play in low-emissions development along different parts of the electric power sector value chain.

For the wider study, a theory of change was developed that situates carbon pricing within a broader package of policies aimed at transitioning MICs and LICs to a reliable, affordable, low-carbon electricity system. For reference, this is included in Figure A-1. The theory illustrates four expected intermediate outcomes of carbon pricing in the power sector, including (1) a shift in investments and retirements and a transition to a lower-carbon system; (2) prioritized dispatch of least-cost least-emissions power generation sources; (3) a shift toward more efficient consumption patterns; and (4) new fiscal revenues, reducing reliance on other sources. The theory also lists a series of assumptions that countries must fulfill to realize the expected intermediate outcomes of carbon pricing. Case studies have been chosen to validate or inform this theory of change and its assumptions across multiple LICs and MICs. In doing so, we provide the case studies to offer insights into the enabling conditions required for countries to achieve their desired outcomes from carbon pricing.

Four in-depth case studies, China, Colombia, Kazakhstan, and South Africa have been conducted to capture lessons learned from carbon pricing implementation in the power sector in LICs and MICs and their interrelation with other decarbonization policies. These were selected as case studies as they cover a broad range of power sector characteristics common in other LICs and MICs (e.g., state-owned monopoly power utility, high coal reliance, affordability, insecurity of supply, etc.), and cover both carbon taxes (South Africa and Colombia, which may soon have an ETS as well) and ETSs (China and Kazakhstan).

The case studies were developed based on reviews of relevant literature and policy documents as well as expert interviews with local power sector and carbon pricing experts. Interviews were conducted using semi-structured questionnaires, with questions designed to shed light on the different power sector structures and challenges in the focal countries and interrogate the impact that carbon pricing has had or is expected to have along the power sector value chain. World Bank experts and government and industry practitioners in each country have also contributed to these case studies. This document includes a full write-up of each case study.

Theory of change on the role of carbon pricing in the power sector in low- and middle-income countries



Critical assumptions:

1. Complementary actions selected are pursued in an appropriate sequence or in parallel to form a virtuous cycle that increases political appetite for enhanced ambition over time (World Bank, 2023c).
2. Interactions of carbon pricing with other policies are well managed, and the carbon price is strong and predictable enough to influence decision-making.
3. Carbon price is factored into the decisions around investments in new generation and retirement of existing power plants (explicit assumption for government agencies).
4. Electricity system is designed so that a direct carbon price is fully reflected in the “price offer” or “on-grid” tariff of a generator in the dispatch mechanism. Dispatch mechanism operates based on merit order.
5. Carbon cost is passed through to retail prices. The elasticity of demand determines the responsiveness of consumers to price signals.
6. Carbon pricing provides revenues to the government, which can be used to reduce more inefficient taxes.
7. Energy security can be improved by relying more on domestic sources of energy.
8. Technological innovation, such as the adoption of new storage technologies, is required to operate a future net-zero electricity system with high shares of variable renewable energy sources.

ANNEX B.1: CHINA CASE STUDY

China offers a representative example of how an ETS was implemented in the context of a formerly planned economy. The government has been prioritizing reliability over economic efficiency for its system. When the ETS was introduced, the system was highly reliant on coal generation and had an evolving, inflexible dispatch system adapted to it. At the same time, China had already made pledges with respect to greenhouse gases (GHGs) emission.

Country snapshot

While China had launched 7 provincial multi-sectoral pilots, the National ETS (NETS), launched in 2017, has been exclusively applied to the power sector, establishing carbon intensity benchmarks per technology. Under the current and near-term NETS design, emissions permit prices will play only a marginal role in deterring future investment in fossil fuel generating capacity and will likely have no impact on retirement decisions. It creates an incentive for improving the efficiency of plants operations. The current design does not incentivize fuel switching to lower- or zero-carbon power sources since shifting to lower carbon intensive fuel means having fewer allowances, zero in case of renewables. Smaller, older coal power plants receive higher carbon intensity benchmarks than larger more efficient ones. If a smaller plant has greater efficiency than its benchmark, it could profitably sell those permits to a larger plant, which was not the intended effect. Looking ahead, China's ETS will likely grow to cover sectors beyond electricity. One plausible change for the ETS is to adopt an absolute cap.

Besides the NETS, the electricity sector is the locus of many policies to decarbonize the economy, including clean electricity support (e.g. Renewable Energy Portfolio, Green Certificates, Green Power Market) and substitution policies, power plant energy efficiency requirements, and multiple power sector reforms that reduce implicit government support for coal-based electricity. In the end-use segment, policies supporting electrification are also an essential part of long-term decarbonization. Therefore, coordination between the NETS and these other policies is becoming increasingly important.

POWER SECTOR CHARACTERISTICS

China's power system is the largest in the world, with total capacity exceeding 2.9 terawatts (TW), in 2023, generating 1.2 TW (1,200 gigawatts, GW) from coal and over 1 TW from wind and solar photovoltaic (PV), contributing to an annual generation of over 850 petawatt-hours to meet the vast demand.

China's power sector policies have sought to achieve various objectives. These have included supply security, affordability, and macro-economic stability and, more recently, to lessen air pollution and climate change. Once controlled by the central government, in response to pressures to expand the sector, China's power supply became legally separate, highly concentrated grid companies and power producers (State Council, 1998, 2002). These companies mostly manage dispatch decisions and market mechanisms at the provincial level, and an evolving wholesale pricing system combines central planning and market competition within certain constraints. The primary stakeholders are grid companies; generation firms; and the firms in the upstream that provide consulting, manufacturing, and planning.

This section outlines the electricity sector's value flow. It details the industrial organization, governance, and operation issues along the industrial value chain from generation through transmission and distribution to final consumption. It highlights essential elements such as generation capacity, market dynamics, renewable energy integration, transmission, and consumer patterns, plus the reform agenda since 2015. It is now aiming to build a "new power system," which reformers regard as a way to better integrate renewable energy.

Electric power capacity

In China, both the national and local governments have roles for overseeing new investments in power generation. The regulations on shared responsibility are set for a specific time frame, although whether it will

be followed exactly remains unclear. Local governments (provincial and sub-provincial) directly permit most power generation projects, which have been undertaken by a few large state-owned enterprises (SOEs) and a wide range of smaller firms (NDRC, 2015), although the National Energy Administration (NEA) retains the authority to limit the total capacity by province (NEA, 2020b). Typically, larger or more sensitive projects such as nuclear power plants and hydropower plants still require central approval. Yet, overcapacity concerns exist in the coal power sector, for which there are central government guidelines for local governments on prioritizing closing inefficient plants (NEA, 2017). Retired coal power capacity may receive credits¹ that can be exchanged for the right to build newer replacement facilities (MIIT, 2014). It remains unclear whether new projects require capacity credits. Generation expansion is mainly conducted by SOEs at the central level - five major enterprises known informally as the “Big Five” (“五大”) and smaller ones (“四小”) - and a handful of large provincial energy companies.

The country has several tools increasing its move toward renewable energy. For example, a risk and early warning system has been established to halt new permitting of coal and renewable energy when capacity of either is deemed too large (NEA, 2020a, 2020c). Subject to a few exceptions such as if they provide both heat and power, new coal units must be larger than 600 megawatts (MW) (NDRC, 2021f). And regulations require retrofits for existing units that do not meet certain efficiency and emission performance standards (NDRC, 2021f). As well, a renewable portfolio standard (RPS) was adopted in 2021.

However, since COVID-19, China has been responding to increasing instability of its grid. Coal power still dominates China’s power generation, and the country experienced repeated power outages between 2020 and 2023 as well as broader sector and economic challenges. This led to weakening or disregarding of the measures in place to increase reliance on renewable sources. As well, in some provinces where renewable energy curtailment rates exceed desired levels new renewable capacity may be discouraged.

Lack of willingness to generate due to market distortions, rather than lack of physical capacity, constitutes the primary reason for recent electricity supply shortages and inadequate system capability. The causes of specific power outages are complex and vary, but since 2021 the mismatch between the high price of coal and the regulated cap on most electricity prices has been an overriding issue. New capacity additions will not address regional resource adequacy concerns in the absence of further market reforms, though some local grid stability concerns may still require new investments. Nevertheless, recent figures indicate the largest expansion in new coal power projects since 2015.² The magnitude of new projects in the pipeline of planning, under construction, or commissioning could be in the range of 50–200 GW in total.

Meanwhile, the growth of new energy sources, particularly wind and solar PV, continues to accelerate. The main cause is improved cost-effectiveness and other encouraging factors. By the end of 2023, it is estimated that 150 GW of new solar PV and 60 GW of new wind capacity was installed, with rooftop solar PV being particularly dynamic. Total installations have reached 1.05 TW. Combined with hydro and biomass, the overall renewable capacity has reached 1.2 TW, surpassing that of the previous dominating coal.

To address resource adequacy concerns and the declining profitability of coal power plants, China instituted a capacity compensation mechanism. Issued in November 2023 by China’s National Development and Reform Commission (NDRC) and NEA (NDRC and NEA, 2023), the mechanism compensates coal plants for their ability to produce electricity when needed. Depending on the province, the level ranges from 100 to 165 RMB per kilowatt hour (kWh) per year for 2024–2025. This support is designed to help coal plants gradually transition to a backup role for variable renewable energy. Considering the current coal overcapacity and the exclusion of non-coal generators that could potentially provide the same service at lower cost and emissions, the mechanism works as a subsidy for the entire coal fleet. Actual impacts on coal compliance performance and other generation technologies remain to be seen.

¹ This mechanism is also called generation rights trading (GRT).

² CREA - China permits two new coal power plants per week in 2022 – February 2023 - <https://energyandcleanair.org/publication/china-permits-two-new-coal-power-plants-per-week-in-2022/>.

Electricity generation and markets

Dispatch is coordinated by grid companies at the provincial, regional, and national level. Power producers sell electricity in a dual-track system through plans (pre-determined numbers of hours of generation per year for each power plant) and prices coordinated by the government as well as market-based mechanisms. Both market-based and plan-based electricity quantities form contracts that are generally binding on the grid company to meet over various time periods from days to a year.

Previously, China's pricing system was mostly based on a system of central benchmark tariffs. Since 2015, there has been a shift toward market-based price discovery through bilateral trading and centralized auctions. However, distortions exist, and recent years have seen some reversal of this trend due to the volatile energy market. Coal power plan-based transactions operate according to a benchmark on-grid price setting with some adjustments (NDRC, 2019), which allows partial pass-through of coal prices that are more liberalized and hence volatile. The NDRC determines nuclear and hydropower plant tariffs on a project-by-project basis according to cost-recovery principles with some variants in recent years (NDRC, 2013, 2014). Market-based mechanisms are primarily mid long term (MLT) contracts, which can be bilaterally negotiated or operated through centralized auctions (NDRC & NEA, 2016). Until October 2021, these markets had price caps set slightly above the benchmark of on-grid tariffs, which prevented the pass-through of increase into tariffs and could lead to an unwillingness to produce, which occurred in the 2021 power shortage. However, in October 2021, NDRC loosened the price cap to 20% above the benchmark level and removed the price limit on energy-intensive industries.³ Additionally, many markets are too heavily concentrated or lack proper designs to avoid the exercise of market power. Short-term markets such as day-ahead spot markets are currently being piloted with some notable growing pains integrating into the dual-track system. Markets for “peak regulation”—described in the “Renewable energy grid integration” section—are expanding more rapidly than spot markets. These create incentives for generators not to produce when renewable energy is plentiful. In 2023, the State Council issued a policy signal to accelerate the development of a spot market (State Council, 2023), but substantial progress has been limited.

Coal and gas power producers are also required to participate in the carbon emissions trading scheme. The ETS sets benchmark carbon intensity rates that generators must meet or pay penalties (MEE, 2021a). In the 2019–2020 compliance period, 2,225 plants or firm subsidiaries had to meet emissions standards.⁴ The scope and the standards were both refined in 2021–2022, and the allocation for this period was established ex post in 2023. Special financing tools, such as favorable loan interest rates, are being created to support carbon reduction efforts (BOPC, 2021).

Support to renewable energy-based generation

China has employed a number of tools to support renewable energy. Historically, utility- and commercial-scale solar and onshore wind historically benefited from fixed feed-in-tariffs. These are being phased out for new construction and replaced with the (lower-priced) coal benchmark on-grid tariff, competitive electricity markets, auctions, renewable portfolio standards, and voluntary “green certificate” markets (NDRC, 2021e). Minimum renewable energy purchase requirements that guaranteed a minimum capacity factor for renewable producers at standard benchmark tariffs, nominally to break even, and above which they should sell into markets were in place from 2016 to 2023 (NEA, 2019). After the abandonment of this approach of fragmenting the power market and creating a dedicated physical “green power market,” green certificates were adopted as the sole proof of renewable power’s “green attributes.”⁵

RPSs have faced challenges. Since 2021, RPSs have been implemented on the wholesale purchase side at the provincial level, which require grid companies and large users to meet a share of electricity purchased from renewable sources. NDRC and NEA issue annually an overall renewable energy obligation for each province (NDRC & NEA, 2021c). These face numerous issues related to counting and cross-provincial trading. Additional

³ [【关于进一步深化燃煤发电上网电价市场化改革的通知\(发改价格〔2021〕1439号\)】-国家发展和改革委员会 \(ndrc.gov.cn\)](https://www.ndrc.gov.cn/xxgk/jd/jd/202308/t20230803_1359098.html).

⁴ The full list of compliance firms is available here: <https://www.mee.gov.cn/xxgk2018/xxgk/xxgk03/202012/W020201230736907682380.pdf>.

⁵ https://www.ndrc.gov.cn/xxgk/jd/jd/202308/t20230803_1359098.html.

“green power trading” options exist coupled with green certificates, which enable the sale of attributes of green electricity for meeting either mandatory RPSs or voluntary green power purchase demand (NDRC, 2021a).

Renewable energy grid integration

Challenges integrating renewable energy into the grid have prompted large changes in institutions governing the management of power production in the last two decades. Ancillary services, such as providing reserve capacity from the power producers, are determined by the grid company and according to government policies should be compensated, either administratively or through ancillary service markets (NEA, 2021a). Reducing coal power output to prevent curtailment of renewable energy is compensated by generators through payments termed “peak regulation.” Peak regulation is technically considered an ancillary service in China. Though it is distinct from international conventions, they are increasingly coordinated through peak regulation markets in several regions (NEA, 2021a). However, such incentives for generators are difficult to align with the principle of marginal cost energy supply in spot markets. In addition, some responsibility for integration is shifted to renewable energy enterprises, with policies to require the development or the purchase of peak regulation capacity for extra renewable energy generation above certain thresholds (NDRC & NEA, 2021a). A recent official document issued by the State Council to guide the short-term market design acknowledged the lack of harmonization between peak regulation and spot markets (State Council, 2023).

Transmission, distribution, and storage

Grid companies are structured hierarchically into subsidiaries with up to five levels of organization: national, regional, provincial, city, and county (SPC, 2002). Grid companies and their subsidiaries have exclusive rights to invest in transmission and distribution networks in their jurisdictions and are regulated by the NEA and its local subsidiaries (NDRC & NEA, 2020). Recent reforms allow and encourage non-grid actors to own minor incremental distribution networks (NDRC and NEA, 2019). According to current guidelines, grid companies are allowed revenues for approved transmission lines according to a distinct regulated tariff charged per unit of electricity transmitted, which is updated every three years (NDRC, 2021b). Grid balancing resources such as pumped-hydro storage are deployed primarily by grid companies, though some guidelines exist to promote the participation of third parties through appropriate revenues (NDRC, 2021g). Battery storage is deployed by grid companies; large consumers install batteries on a voluntary basis, but renewable energy developers are mandated to install them (NEA, 2021b).

Electricity consumption

A transition in consumption is underway. According to government targets, all industrial and commercial users should eventually purchase their electricity entirely through market-based mechanisms, a process accelerated in 2021 (NDRC, 2021c). Access of consumers to markets can be either direct or through retail companies that aggregate consumers (NDRC & NEA, 2021b). For other consumers, regulated consumption prices include benchmark tariffs set by location and user type. Some localities have given preferential tariffs to attract energy-intensive industry, which are increasingly coming under scrutiny.

Two mechanisms govern consumption of electricity for most regulated consumers. “Orderly electricity consumption” rules determine how power is allocated in the case of shortages (NDRC, 2011). As well, time of use (ToU) tariffs, which specify different tiers of pricing based on the time of consumption, are implemented in China to help encourage more efficient consumption, with rates determined at the provincial and city levels (NDRC, 2021d). During 2022–2023, a ToU tariff was adopted across most provinces, although there is ongoing debate about its relative and absolute levels, especially when compared to the social marginal cost.⁶

CLIMATE POLICIES

Over the past 40 years, China’s development, powered largely by coal, has delivered unprecedented economic growth and development gains but also led to rapidly rising carbon emissions. China’s rapid economic ascendance since the 1970s has led to a nearly thirtyfold increase in per capita income but also resulted in carbon dioxide (CO₂) emissions growing more than tenfold over the same period. Although

⁶ Regulatory Assistance Project – August 2023 - <https://www.raponline.org/blog/realizing-tou-potential-consider-the-full-system-cost/>.

significant improvements in energy efficiency over the same period have led to weak decoupling, with energy intensity of GDP declining by two-thirds, energy demand continues to rise in increasingly urbanizing China and its economic structure with a high share of energy-intensive industries. China's rapid emissions growth has been driven primarily by coal.

As the world's largest coal producer and consumer, China relied on coal for nearly 60% of its total energy consumption in recent years, most of which was met by domestic production (4.07 billion tons in 2021).

Climate pledge to achieve net carbon neutrality by 2060

In September 2020, President Xi Jinping announced that China would aim to achieve net carbon neutrality by 2060. Combined with earlier commitments to peak carbon emissions by 2030—forming the “30/60” targets—and additional pledges to increase the share of non-fossil energy use and reduce the carbon intensity of economic growth, this establishes some bounds on China's expected emission trajectory. In order to limit global average temperature rise to less than 1.5–2°C, countries need to reach net neutrality around mid-century and achieve negative emissions in the latter half of the century (Rogelj et al., 2015). China's updated pledge together with other net zero commitments by major emitting countries under the Paris Agreement put the world broadly in line with this goal, though additional near-term ambition would increase its likelihood (Ou et al., 2021).

Peaking emissions and declining to zero over the span of four decades requires unprecedented changes across China's economy. It will be necessary to increase resource efficiency, reduce the use of unabated fossil fuels, and shift to non-fossil fuel energy sources. While the costs of solutions such as renewable energy and energy efficiency are declining, the scale of deployment will require significant investment and technology advancement as well as substantial policy changes to align activities in high-emitting sectors with decarbonization targets.

Carbon emission reduction has emerged as a primary policy goal, alongside other key objectives, principally energy security and air pollution control. Early efforts encouraged widespread expansion of energy sectors to meet growing economic needs. As China's energy intensity started to increase in the early 2000s and the threat of shortages loomed, energy efficiency policies were enacted to preserve energy security. Starting around 2013, severe air pollution in major cities led to restrictions on industrial development and retrofits of plants to achieve energy-saving and low-emissions targets.

Transitioning away from coal-based power generation

In China now, coal dominates energy and power sectors. Of total coal consumption, around 60% is used in power plants, combined heat and power plants, and district heating plants, and 60% of total electricity is generated from coal. Generation of electricity and heat represents 40–45% of national CO₂ emissions at present.⁷

China's transition from coal is both difficult and essential. In absolute terms, coal power capacity and generation have grown continuously over the past two decades. Coal-based generation capacity reached over 1,200 GW in 2023, eclipsing the total coal power capacity of the rest of the world. Most coal power plants are relatively young: 45% of the existing coal power plants are less than 10 years old, 82% less than 20 years, and the average capacity-weighted age is 13 years.⁸ However, due to the rapid development of non-fossil energy the share of coal-based electricity has been declining since the 2010s despite a rebound in 2022–2023. Hydropower, wind, solar PV, and nuclear now represent 35% of the power generation. Further progress is vital for China and the world to meet global mid-century climate targets. The power sector will undergo the most significant transformation first, leading the carbon reduction process.

⁷ Ember - Global Electricity Review 2023 – April 2023 - <https://ember-climate.org/insights/research/global-electricity-review-2023/>.

⁸ Remin University of China – Energy Foundation - Cost analysis and risk assessment of coal-fired plants in China – April 2022 -

[https://www.efchina.org/Attachments/Report/report-iceg-](https://www.efchina.org/Attachments/Report/report-iceg-20211020/%E4%B8%AD%E5%9B%BD%E7%85%A4%E7%94%B5%E6%88%90%E6%9C%AC%E4%B8%8E%E9%A3%8E%E9%99%A9%E5%88%86%E6%9E%90.pdf)

[20211020/%E4%B8%AD%E5%9B%BD%E7%85%A4%E7%94%B5%E6%88%90%E6%9C%AC%E4%B8%8E%E9%A3%8E%E9%99%A9%E5%88%86%E6%9E%90.pdf](https://www.efchina.org/Attachments/Report/report-iceg-20211020/%E4%B8%AD%E5%9B%BD%E7%85%A4%E7%94%B5%E6%88%90%E6%9C%AC%E4%B8%8E%E9%A3%8E%E9%99%A9%E5%88%86%E6%9E%90.pdf).

Insights from the modeling and scenarios work

Several studies show the pathway to change. These studies have simulated different pathways to accelerate the decarbonization of the energy sector toward the net zero carbon 2060 target, through structural transformation, improved energy efficiency, fuel switching, and electrification (IEA, 2012; World Bank, 2022).⁹ These analyses show GHG emissions reductions would derive from both substantial declines in total primary energy consumption and extensive electrification of energy demand and increase of the share of renewable energy sources.

The power sector is projected to drive emissions reduction in the next decade and will facilitate decarbonization at a later stage on energy end use. The World Bank's 2022 study indicates that the share of electricity in total final energy consumption in 2050 will increase to 53%, primarily due to fuel switching for heat generation for industry and buildings and electrification in transport.¹⁰ China would need to reduce coal power capacity to about 200 GW by 2050 (a reduction of more than 80% from 2021) and in the process face significant asset stranding risks to reduce the average coal capacity utilization rate from 48% in 2020 to about 10% by 2050, shifting the role of coal capacity from baseload serving to primarily peaking. About 40% of the remaining coal fleets is expected to be abated with carbon capture, utilization, and storage (CCUS) by 2050.

By 2030, the installed capacity of variable renewable energy, namely solar and wind, is projected to be about 1,700 GW under the Advanced Decarbonization Scenario. By 2050, renewable energy will be the major source of power generation, accounting for about 85% of total installed capacity and 75% of total electricity generation. To do so, China needs to add about 120 GW of solar and wind capacity every year by 2030, 1.5 times the annual average from 2016–2020 and 20% more than the capacity addition in 2021 (World Bank, 2022).

Scaling up investment in energy storage will also be needed. Such an investment will be necessary to make the grid flexible enough to integrate such a large share of variable renewable energy integration and grid flexibility will contribute to the reliability of the power supply. Estimates indicate the required energy storage capacity will reach 200 GW by 2030 and 1,300 GW by 2050 (World Bank, 2022).

Decarbonization policies influencing the power sector

The electricity sector is the locus of many policies to decarbonize the economy: clean electricity support and substitution policies, power plant energy efficiency requirements, the emissions trading scheme, and multiple power sector reforms that reduce implicit government support for coal-based electricity. In the end-use segment, electrification is an essential part of long-term decarbonization, which is being supported by policies to replace direct fossil fuel use with electricity (NDRC & NEA, 2022).

China issued two documents relevant to its climate policy and actions in 2023. Issued before the COP28 (Conference of the Parties) meeting in December 2023, the country's latest white paper (MEE, 2023a) outlines policies and strategies related to climate change, in particular for the power sector. The third national communication reports to the United Nations Framework Convention on Climate Change were submitted by China's government.¹¹

Additional targets are coming. China's upcoming Nationally Determined Contribution (NDC), anticipated in 2025, is expected to incorporate comprehensive climate targets (including possibly all GHGs and absolute emission caps) for 2030 and 2035, as guided by the top official document entitled "Opinions on Comprehensively Promoting the Construction of a Beautiful China."¹² This intent was further signaled and reinforced by the statement of then-special climate envoy of China, Xie Zhenhua, at COP28.¹³

STATE OF CARBON PRICING

⁹ "An Energy Sector Roadmap to Carbon Neutrality in China," IEA, 2021. "The China Climate Change and Development Report," World Bank, 2022.

¹⁰ The World Bank study was based on a modeling exercise in partnership with Tsinghua University, using TIMES, a bottom-up energy system linear programming-based optimization model for China's energy system. Results presented here refer to the Advanced Decarbonization Scenario, which shows a pathway of peaking emissions in 2025, reaching 1 gigaton of CO₂ equivalent of emissions in 2050 and net zero in 2060.

¹¹ https://unfccc.int/sites/default/files/resource/China_BUR3_Chinese.pdf and https://unfccc.int/sites/default/files/resource/China_NC4_Chinese.pdf.

¹² https://www.gov.cn/zhengce/202401/content_6925405.htm.

¹³ <https://mp.weixin.qq.com/s/tIOBZs4YtEsZO62wdQIOvQ>.

Evaluation of local ETS pilots

China's seven ETS pilots marked a significant step in China's environmental policy. Initiated in 2011 and operational between 2013 and 2016 across seven provinces and cities—Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Hubei, and Guangdong—each pilot had its unique design, reflecting the diverse economic and industrial characteristics of each region (Zhang et al., 2017). The power sector was a crucial component of these pilots, reflecting its substantial contribution to the total CO₂ emissions picture. The approach to covering this sector varied across the pilots, with some focusing on absolute caps and others on intensity-based targets. These pilots provided valuable insights for capacity building (Karplus, 2021). The regional pilots continue to operate in parallel to the National Emissions Trading Scheme (NETS) that was launched in 2017, covering the sectors and entities not included in the national system. As the coverage of the NETS expands, entities covered by regional systems are expected to be integrated into the national scheme (ICAP, n.d.)

The NETS has been exclusively applied to the power sector, establishing carbon intensity benchmarks at the plant and/or firm level. The scheme, which had a soft launch in 2017 and de facto inception in 2017, operates with a biennial allocation of carbon allowances. It has completed two cycles to date (MEE, 2023b).¹⁴ Its coverage has been limited so far to the fossil fuel-based power sector. Compliance obligations are set at the generation level and imposed at the subsidiary firm level, which could be an individual plant or an aggregate of plants. In practice, the NETS applies a mandate only on *coal-powered plants* since natural gas facilities, which are formally included in the system, are not required to surrender carbon credits for compliance (MEE, 2023b).

Emissions caps are based on the carbon intensity of the production, not on absolute emissions. The carbon intensity caps are based on technology, the more carbon-intensive technologies being allocated higher carbon-intensity caps.¹⁵ Free allowances are based on production output and administratively determined carbon-intensity benchmarks (see Table A-1). Plants performing better than (below) their carbon intensity benchmark receive more allowances than they need and can sell excess to those performing above their benchmark. This type of intensity-based ETS is also called a tradable performance standard (IEA, 2022). Such a design is compatible with growing demand, which would make absolute caps difficult and risky to set. However, as a consequence, renewable energy generators cannot participate except marginally through some limited use of carbon offsets.

Annual reports on the impact and future expectations of the NETS have indicated temporal price and volume patterns. This was true across both official (MEE, 2022) and non-official (IIGF/CUFE, 2023) sources. In 2021, the price was stable between RMB 40 and RMB 60 per ton of CO₂ (tCO₂) (around USD 5.5 to USD 8.5 per tCO₂) on most trading days, and the accumulated trading volume is 180 million tons (only 4% of the total emission, around 4.5 billion tons covered). Trading volumes decreased and carbon prices increased slightly, to around USD 8 to USD 10 per tCO₂, in 2022.

¹⁴ The working schedule lagged behind the two-year cycles, however. The allowance allocation in the 2021–2022 cycle was not finished until the middle of 2023 (MEE, 2023d).

¹⁵ Four carbon-intensity benchmarks are defined for four technology categories, as detailed in MEE, 2023b.

TABLE A-1

Technology-based intensity benchmarks for allowance allocation in China's NETS, 2022 level

Technology category	Technology criteria	Carbon intensity benchmark (gCO ₂ /kWh)
Unconventional coal-fired units	Circulating fluidized bed	930
Conventional coal-fired units at and below 300 MW	High-pressure Subcritical ≤ 300 MW Supercritical ≤ 300 MW	873
Conventional coal-fired units above 300 MW	Subcritical > 300 MW Supercritical > 300 MW Ultra-supercritical coal with CCUS	818
Gas-fired units*	Gas Gas with CCUS	390

Source: MEE, 2023b.

* Gas units currently have no obligation to surrender carbon credits under the NETS.

gCO₂/kWh = gigaton of carbon dioxide per kilowatt hour; MW = megawatts; CCUS = carbon capture, utilization, and storage.

The NETS has potentially problematic elements. It is designed in a way that incentivizes coal power plants that already perform better than their benchmark to expand production and sell excess allowances (Kuo, 2021). The design may lead to perverse incentives in which permits are transferred from less efficient to more efficient firms depending on the benchmark they are assigned. For example, a power plant below 300 MW receives a looser benchmark (979 gigawatt of carbon dioxide per kilowatt hour [gCO₂/kWh]) or 1,146 gCO₂/kWh depending on the technology), and, therefore, a larger allowance for a given production amount, than a plant above 300 MW (877 gCO₂/kWh). If the smaller plant had greater efficiency than its benchmark, it could profitably sell those permits to the larger plant, thereby leading to the equivalent of a negative carbon price (Goulder et al., 2022), (IEA, 2022d). The lax setting of the benchmark may also make quota compliance too easy (Yicai, 2021).

Furthermore, the current design does not incentivize fuel switching to lower- or zero-carbon power sources. Renewable energy generators do not receive permits and shifting to lower carbon intensive fuel means having fewer allowances. The establishment of the China Certified Emission Reductions (CCERs) offset market does facilitate some renewable energy producers to generate offsets and sell to compliance entities to meet a fraction (e.g., 5%) of their obligations. So far, four methodologies have been issued to qualify projects for generating CCERs, related to afforestation carbon sinks, grid-connected solar thermal power, grid-connected offshore wind power, and mangrove creation (Cenews, 2023), along with the guidelines for voluntary trading activities (MEE, 2023c).

There are issues with data quality due to issues with enforcement. High-quality data on emissions are key to the functioning of the market, as was stressed from the inception of the NETS (MEE, 2021b). However, instances of data falsification have been reported (Sina, 2021). Penalties for non-compliance are very limited compared to the cost of allowances.¹⁶ As a consequence, some firms have simply failed to procure and surrender enough emissions allowances to meet their target, indicating potential gaps in the enforcement authority and penalties for noncompliance.¹⁷

The RPS and ETS systems currently have little direct interaction in China. Renewable energy plants are not included in China's intensity benchmark ETS since their carbon intensity is zero and they cannot receive allowances. Moreover, the RPS cannot indirectly affect the price of an intensity benchmark-based ETS, since

¹⁶ The maximum fine for a company is only CNY 30,000 (USD 4,200).

the production and performance of the fossil fuel plants alone determine the total permit allocation. By contrast, in a more conventional absolute emissions-based cap-and-trade ETS, renewable energy supports would push in renewable energy, which would substitute for fossil fuel generation, thereby easing the compliance with the cap and reducing overall ETS prices (IEA, 2022).

Next steps for the market

After two years of operations, the institutional and regulatory framework has been established and many lessons have been learned. The guidelines for emissions accounting and reporting by regulated entities have been issued; the management rules for the registration, trading, and settlement of the NETS have been adopted; the roles and responsibilities for the enforcement of the compliance and the supervision of the trading have been established; and all of this framework has been operating relatively smoothly for now more than two years. Still, lead authorities in charge of the design and implementation of the NETS have acknowledged and identified a series of needs for further development and improvement (MEE, 2023g).¹⁸ Based on the assessment of the implementation of the NETS so far, authorities have expressed the intention to adjust the scope of the NETS, to align its design with the new “dual control” policy; to better coordinate with other policies and mechanisms of the power sector; to strengthen the legal and regulatory framework for measurement, reporting, and verification (MRV), compliance, and trading; as well as to review the allowances allocation method.

Looking ahead, China's ETS will likely grow to cover sectors beyond electricity. This expansion, as recent government statements note (MEE, 2023f), is set to bring in carbon-intensive industries, making the market more active by increasing the number of companies that buy and sell emission credits. However, the timeline has not yet been explicit and it may be adapted to consider the schedule of the European Union's carbon board adjustment mechanism (CBAM) implementation (China Energy Newspaper, 2023).

The next plausible change for the ETS is to adopt an absolute cap, which will alter the fundamental carbon allocation approach. Instead of the ETS focusing just on emission rates, there would be a hard limit on the total amount of emissions allowed, as highlighted on non-official channels (e.g., Duan, 2023). This cap would help China keep its overall carbon emissions in check and make it easier to measure progress against its climate goals. Moving from an energy cap to a dual control policy on carbon intensity and absolute emissions has been reiterated in early 2024 by China's top policy document, as previously mentioned. As indicated, this would require coordinating with the RPS system.

Data quality and capacity issues have not yet been resolved. Better data and more skilled people managing the system will make the ETS more relevant and influential as China moves toward its new NDC targets and the ultimate carbon neutrality target. The preparation for the reporting and verification of enterprise emission in key industries for the years 2023–2025 is an ongoing effort (MEE, 2023e; NDRC, 2022). In the wake of the 2018 governmental reorganization, key personnel were strategically reallocated from the NDRC to the Ministry of Ecology and Environment, enhancing the ministry's capacity to manage and oversee China's NETS.

A questionnaire distributed by the Chinese Academy of Environmental Planning revealed high public expectations and concerns for the ETS (CAEP, 2023). Companies are interested in the ETS but face difficulties with tasks such as predicting carbon price trends, complex carbon emission accounting, and estimating their own profit and loss scenarios. They view the carbon market as a way to guide investments and technology toward greener practices, with carbon prices increasingly gradually over time due to various factors including government policies, market supply and demand, and availability of mitigation technologies.

¹⁸ A detailed diagnosis and program of research to improve and further develop the current ETS is presented by the Ministry of Ecology and Environment in the China Implementation Support Plan document proposed to the Partnership for Market Implementation of the World Bank.

FINDINGS ON THE EXPECTED IMPACT OF CARBON PRICING IN CHINA'S POWER SECTOR

The theory of change for this study detailed four intermediate outcomes that we expect effective carbon pricing will have in the power sector:

- a. **Investments and retirements** of power sector assets and broader infrastructure shift to lower-carbon systems over time.
- b. **Prioritized dispatch** of least-cost least-emissions power generation sources and accompanying flexibility resources.
- c. **Shift in electricity consumption patterns** in response to a carbon price.
- d. **New fiscal revenue** from tax or auction supplements and/or reduces reliance on other (less efficient) revenue sources.

This section outlines our findings on whether China's NETS, in its current form and if enhanced, would have these outcomes, based on our desk research. There is some degree of uncertainty, considering the evolving nature of the NETS design and the inherent need for an intensity-based ETS to regularly revise benchmarks in order to continue emissions reductions.

Investments and retirements

China's fossil fuel generation fleet, in particular coal-fired power, faces a nationwide overcapacity problem, with the coal fleet exceeding 1,200 GW even as utilization rates hover around 50%. Given salient energy security concerns, even more coal capacity has been permitted and is under construction in several provinces.¹⁹ **Under the current and near-term NETS design, emissions permit prices will play only a marginal role in deterring future investment in fossil fuel generating capacity and will likely have no impact on retirement decisions.**

By contrast, high fuel prices for coal and natural gas have a larger impact on investment and retirement decisions and point to an important interaction between NETS and broader, national-level energy pricing priorities. Following the energy crisis in fall 2021, in which coal prices doubled compared to the previous year and led to large-scale power outage events, NDRC has intervened in the coal market by increasing supply and establishing desired price windows. Prices remain higher than pre-crisis averages, though recent expansions in coal mining, coupled with a projected reduction in coal demand under environmental policies, could lead to falling coal prices. **If coal prices fall, then ETS prices could act as an important floor by establishing some minimum cost and externality pricing, which would place more pressure on the NETS to provide deterrents for future fossil investments.** The role of the NETS in investments and retirements would be enhanced if China were to move to an absolute emissions cap.

Prioritized dispatch

Coal plant fleet operators at both national and provincial levels are building carbon management capabilities, which include assessments of revenues or penalties deriving from the NETS. Due to the progressive expansion of electricity market reforms, currently around 60% of electricity in the country is sold through markets—predominantly MLT contracts.²⁰ **Operators consider carbon intensity and expected ETS allocations when signing MLT contracts, which affects generator dispatch.** However, as coal prices still remain at high levels compared to pre-crisis, these remain the main cause of profitability concerns by some coal generators when signing contracts and generating power. Thus, under high coal prices, the NETS will have limited impact on contract decisions of struggling plants. This is primarily because of the need to generate a minimum amount of power to survive and avoid shutdown. In such context, the carbon cost generated by the NETS, either positive or negative, can only have a marginal influence. Plants that are more efficient than the benchmark, on the other hand, will generate net revenues for the fleet operator, which may prefer to utilize these plants

¹⁹ Recent citation on current coal plant build plans.

²⁰ <http://finance.people.com.cn/n1/2024/0125/c1004-40166625.html>.

compared to its less efficient units. Therefore, internal decision-making of large, jointly managed fleets could influence the ways in which ETS prices affect dispatch.

Shift in electricity consumption patterns

With markets constituting 60% of total electricity sales, and with a target of 80% of large industrial electricity sales in 2024,²¹ ETS costs could be transferred to consumers, and thus potentially impact their consumption patterns, contingent on a few factors.

First, as MLT contracts are signed either monthly or annually, there must be reasonable future projections of allowance prices. Given the current practice of ex post benchmark revisions, it is difficult to imagine ETS prices being incorporated directly into power sales contracts.

Second, as with dispatch, the price of coal will have a large impact on the electricity contract price, which for most consumers is capped at 20% above the centrally set benchmark. With persistently high coal prices pushing contract prices to their maximum, there is little additional space to incorporate an additional ETS cost. A bonus for some more efficient coal generators that stand to gain revenues from the ETS is possible, but contracts will not necessarily reflect such a bonus if they result from ex post benchmark revisions.

Third, increased prices for electricity must translate to reduced consumption, which depends on the elasticity of demand by sector and specific retail price regulations, or the ability to shift demand to lower carbon-intensive hours. Small consumers may still face infrequently updated ToU tariffs, thereby muting any ETS price variation. Large, energy-intensive industries may be highly elastic to prices—and since the price cap has been removed for these users, the ETS could have a more significant impact on decisions by this class of consumers.

New government revenue

Today, none of China's NETS allowances are auctioned, which means governments are foregoing a potentially lucrative source of fiscal revenue. Fiscal revenues could serve multiple functions and as some local governments now face very acute fiscal pressures, NETS allowance auctions with local revenue sharing could help boost local economies. Chinese reports have long signaled a desire to establish allowance auctioning, though the process has been delayed because of concerns by the generation companies about a potential increase in inflation.

²¹ Citation for 80% industry target in 2024.

ANNEX B.2: COLOMBIA CASE STUDY

Colombia offers an interesting example of how a carbon tax has been implemented, but where coal and natural gas are currently exempt, such that the tax does not currently impact the Colombian power sector. There are plans to introduce coal into the carbon tax gradually, and to also introduce an ETS to provide a dual price signal. Once the carbon price truly applies to the power sector, it will offer an interesting example of a country introducing a carbon tax in a power sector already dominated by a high share of renewable hydropower (74% in 2021) with smaller shares of gas (15%) and coal (5%).

Country snapshot:

Colombia's carbon tax does not currently apply to the power sector. Natural gas is currently exempt, and although exemptions on coal have been lifted, the tax rate for 2024 is 0%. Thus, the intended effect to decarbonize this sector is limited. The carbon tax will apply to coal at a 25% rate starting in 2025, increasing gradually by 25% each year, reaching full application by 2028. Introduction of an ETS is also planned, providing a dual price signal. When the carbon tax is applied to coal, it is unclear whether it will cause natural gas generators to be dispatched more frequently. For this intended outcome to be observed the carbon tax needs to be high enough to make coal less competitive than gas, and the capacity mix needs to include more natural gas and renewables with storage. A carbon tax set high enough may achieve the intended effect of limiting investments in new coal power plants, supporting early retirement and creating additional incentives to invest in renewable generation.

POWER SECTOR CHARACTERISTICS

This section will explore the demand, supply, sector structure, and value chain and governance characteristics of Colombia's power sector to provide the context for the analysis on the impacts of the carbon tax.

Demand

Colombia has near-universal electricity access. In general, since 2001, the residential sector has been the largest consumer of electricity, and in 2020 97% of households had electricity (Ministry of Mines and Energy, 2021). Nonetheless, low-income households face challenges of affordability. Following the residential sector, industry and commercial/public service sectors are the largest consumers of electricity, with transport, agriculture, and other unspecified sources being lower-consuming sectors (Foster & Anshul, Rethinking Power Sector Reform in the Developing World, 2020a).

Colombia's electricity demand is growing (OECD, 2022). Estimates for 2021 indicated peak demand was 12 GW and the total annual electricity demand was 81.3 terawatt hours (TWh) (XM, 2016). Demand was then projected to grow by 2% annually during the period 2022–2036 (OECD, 2022), in line with a pattern of steady growth over the last 30 years (Foster & Anshul, 2020a).

Colombia has ambitious goals for increasing electrification of energy services. Currently 17% of energy services are electrified, and while some scenarios project electrification will only increase to 20% by 2050, the most ambitious projections would have 70% of services electrified. The added demand from this will require enormous capacity increases (Magnasco, 2023).

Supply

In 2022, Colombia generated 6615.5 gigawatt hours (GWh) of electricity. This was slightly higher than in previous years (6,403.5 and 6,451.5 in 2021 and 2020, respectively) (Foster & Anshul, 2020a). Table A-2 shows Colombia's supply split from 2020 (Foster & Anshul, 2020a).

TABLE A-2

Electricity generated by source in 2021

Supply source	Energy generated (GWh)	Percentage contribution
Hydro	60,496	73.8
Gas	12,257	15.0
Coal	4,046	4.9
Oil	2,892	3.5
Biofuels	1,933	2.4
Solar PV	323	0.40
Wind	60	0.1

Colombia's electricity mix is dominated by hydropower. In 2022, Colombia had 17.8 GW of installed generation capacity (OECD, 2022). Hydropower contributed 74% of this capacity in 2021, followed by natural gas (15%) and coal (5%) (Foster & Anshul, 2020a). The country's electricity mix has a relatively low emissions intensity of 182 gCO₂/kWh (Climate Transparency, 2020). Many regions in the country do not use coal for generation, although a small number—for example, La Guajira, Córdoba, and Norte de Santander—used coal exclusively for generation in 2017. There are plans in place to increase generation capacity for Cesar and Córdoba (OECD, 2021). Most of the country's electricity is produced and consumed domestically, reflecting its strong renewable and non-renewable energy resources. Colombia obtained 2% of its electricity from Ecuador in 2020 (Colombia, 2022). There are also transmission interconnections between Venezuela and Colombia, but the two countries have not traded electricity for years (IRENA & USAID, 2021).

Colombia's dependence on hydropower makes its power system vulnerable to weather and climate events. Low water levels in the hydro reservoirs related to climate events such as El Niño. The increasing rate of extreme hydrometeorological weather events, which, also creates volatility, stress, and unpredictable wholesale prices for Colombia's power system.

A flexibility assessment in 2018 did not identify issues or curtailment, loss of load, spillage, or inadequate reserves. However, drought years result in higher fossil fuel use as a less variable energy source, and thus higher emissions (IRENA, 2018). Colombia's long-term energy matrix plans include natural gas to ensure a reliable energy supply during such events. According to an electricity sector interviewee, gas is currently considered a transitional fuel, to be used until 100% renewable electricity generation can be achieved.

Plans to increase renewable energy are in place. Most of Colombia's renewable energy potential, an estimated 30 GW, 50 GW, and 32 GW, respectively, for onshore wind, offshore wind, and solar, is untapped (Vega & Munozcabre, 2023). However, recent investment in non-hydro generation has increased significantly with the amount of new generation connections to begin operations totaling over 12 GW for the period 2022–2027. If all these approved projects enter operation by 2027, solar and wind could contribute 37% of the country's total installed capacity (Vega & Munozcabre, 2023). Hydropower capacity has also expanded recently, with its largest plant, Ituango at 2.4 GW capacity, having begun operations in 2022, and due to be fully completed in 2024 (Hydro Review, 2022).

Nonetheless, challenges remain. Colombia's expansion of variable renewable energy is highly dependent on the capacity and locations of its transmission network, which is not sufficiently built out in rural areas where variable renewable energy has its largest potential. The areas of large renewable energy potential are concentrated in the northeast of the country, geographically far from where demand is concentrated (IRENA, 2018). A lack of transmission infrastructure limits the country's ability to take full advantage of its solar and wind generation potential, which is concentrated in these areas (Colombia, 2022). The transmission line that

would have transported the energy to users has been blocked following issues with environmental permitting, following social issues around land use along the line. Solar projects in particular are delayed in connecting to the grid (BloombergNEF, 2022). Delays in transmission infrastructure development have also delayed commissioning of already approved wind projects (Azzopardi, 2022).

POWER SECTOR STRUCTURE AND VALUE CHAIN

Upstream: Mining and extraction of fuels

President Gustavo Petro is committed to transitioning Colombia away from a fossil fuel-based economy. He has envisioned renewable energy as the country's future, and there is support in the cabinet on the need for climate action. Whether new fossil gas developments should be pursued for the medium term has generated some disagreement, however.

At the same time, Colombia is currently the largest coal producer in South America. As of 2019, Colombia had coal reserves of 5,985 million tons (Mt), with 80% found in the northeast of the country (IEA, 2023). It is the second largest producer of petroleum and other liquids after Brazil. As Colombia uses very little coal in its electricity mix, it exports most of its coal production. Coal is used for electricity generation to guarantee supply in years with scarce water availability (IEA, 2023).

Natural gas reserves are inadequate, leading to compensatory efforts. In 2022, gas reserves held approximately 80 billion cubic meters, equivalent to just over seven years of supply to a production ratio (IEA, 2023). Today the reserve is reported to be 7.2 years (IEA, 2023). Contracts for gas exploration have been provided in efforts to increase gas reserves over the medium term during the transition, although, in keeping with its status as a transition source, no further contracts for long-term gas exploration are expected (Zuluaga, 2023). Gas has been imported from Trinidad and Tobago since 2016, and no exports are made to prevent energy supply risks (IEA, 2023). Most gas produced in Colombia is used for electricity generation (EIA, 2022).

Crude oil reserves are also decreasing. Colombia's crude oil production has decreased from a peak of 1 million barrels per day during the period 2011–2015 to 767,000 barrels per day in 2021. Although Colombia is a net crude oil exporter, domestic refining capacity is not enough to meet demand, and therefore, Colombia imports most refined oil products (IEA, 2023).

Generation, Transmission, and Distribution

Colombia's electricity sector has been unbundled and liberalized since 1995. This was a response to the 1992 El Niño rationing crisis, and the transition included the introduction of wholesale and retail competition. Private sector companies now dominate in both the generation and retail markets. The sector is also highly concentrated, with 65% of generation concentrated in only four companies and 68% of retail concentrated in three companies (Correa-Giraldo, Garcia-Rendon, & Perez, 2021). Despite the sector being unbundled, vertically integrated companies across the market sectors generation, distribution, and retailing are also allowed (Correa-Giraldo, Garcia-Rendon, & Perez, 2021).

Both private and public sector companies operate in the transmission sector (IRENA & USAID, 2021). The high-voltage (500 kilovolts) transmission network is mainly owned and operated by the government-controlled ISA INTERCOLOMBIA S.A. E.S.B. (ISA).²² Another part of ISA, ISA 31, is one of the nine separate companies that own and operate sections of the lower voltage (230 kilovolts) transmission network. Colombia's independent system operator, XM, is a subsidiary of ISA. XM is responsible for the physical and commercial operations of the Colombian electricity market, the Colombian National Interconnected System through the National Dispatch Center, and for managing the wholesale energy market, the Mercado Eléctrico Mayorista.

Colombia participates in regional electricity sharing and plans to do so more in the future. The system has a connection with Ecuador that has a 10 GW exchange capacity. It also has a connection to Venezuela, but the quality is such that it is no longer used (Zuluaga, 2023). XM manages the short-term international electricity transactions (known by its Spanish acronym, TIE) with Ecuador and has responsibility for the interconnected

²² Ninety-nine percent of its shares are owned by Transco ISA, which itself is 62% owned by the government (IRENA & USAID, 2021).

operation with the Venezuelan electricity system (XM, 2023). The connection with Panama and Central America has been heavily delayed, reflecting both environmental concerns and concerns over the \$500 million cost. In 2023, Colombia and Panama both committed to revisit the interconnection, which is expected to improve energy security and increase lower-carbon electricity supply in the region (Bnamericas, 2023).

POWER SECTOR GOVERNANCE

The Ministry of Mines and Energy (MME), through the National Energy and Mining Planning Unit (UPME), oversees the policy and planning of the electricity sector (Min Energia, 2023). MME is responsible for formulating and adopting policies, plans, programs, projects, regulations, and guidelines according to government directives, to address what Colombia requires of its energy sector (US Department of Energy, 2003). Each year MME updates its National Generation and Transmission Expansion Plan (Plan de Expansión de Referencia Generación-Transmisión), which projects generation capacity and transmission project needs for the next 15 years (US Department of Energy, 2003). UPME is responsible for issuing connection permits for new generation capacity connecting to the grid (IRENA & USAID, 2021).

The independent Energy and Gas Regulation Commission (Comisión de Regulación de Energía y Gas; CREG) regulates electricity and gas. CREG is responsible for enforcing the adherence of participants to market rules. Regarding regulatory matters, CREG also receives support from the Technical System Operation Committee, which consists of generation, transmission, and distribution companies (IRENA & USAID, 2021).

Competition is enforced. CREG promotes competition by enforcing the limit of no one company being allowed to have more than 30% market share (Correa-Giraldo, Garcia-Rendon, & Perez, 2021), but the Superintendence of Residential Public Services has primary responsibility for enforcing competition laws (IRENA & USAID, 2021).

Renewable electricity plans and policies

Colombia is planning and incentivizing renewable energy capacity. The National Energy Plan 2050 and National Development Plan both acknowledge the importance of developing more renewables, especially non-hydro renewables (IRENA & USAID, 2021). The National Development Plan imposed a mandatory 10% purchase of renewable energy for retailers and distributors beginning in 2022 (IRENA & USAID, 2021). Tax incentives including accelerated depreciation, income tax deduction, VAT exemption for renewable energy equipment, energy efficiency, green hydrogen, and services and import tax exemption for renewable energy equipment are incentivizing investment in renewable energy (IRENA & USAID, 2021; Estevez, 2021). Generation for self-consumption is permitted alongside the selling of surplus energy back into the grid. Under a net metering scheme, systems up to 100 kilowatt peak can sell surplus electricity back into the grid (IRENA & USAID, 2021; Vega & Munozcabre, 2023). Investment into building renewable energy is coming from both domestic and international developers (IRENA & USAID, 2021).

Renewable energy auctions have had some success. There is a quota set on electricity retailers that 10% of their energy procured through power purchase agreements (PPAs) must be with renewable generators. To encourage investment in renewable energy (excluding large hydro), and to aid in meeting this quota, renewable energy auctions have been held to award PPAs to developers since 2019. These auctions have been successful in attracting international firms to build wind and solar generation in the country and over 3 GW of generation has been awarded through this process as of 2022 (Vega & Munozcabre, 2023). If employed in the future, systematic auctions could encourage a wider range of non-hydro renewable bidders, by providing strong investment signals to local and international investors (USAID, IRENA, 2021).

However, growth to date has been slow. According to an interviewee, licenses for 24 GW of capacity have recently been provided, but only 10% of these have been implemented (Luengo, 2023). The main factor preventing this implementation is transmission capacity. Such projects are designed to settle in high variable renewable energy potential and as a result, tend to be concentrated in regions with suitable conditions for generation. However, demand is concentrated around a few large cities, such that projects may have to compete for space in the transmission system. Additional issues around licensing are further delaying the

integration of these renewable projects. As well, looking ahead, the long-term continuity of renewable energy auctions in Colombia is uncertain.

Dispatch procedures

Colombia uses a merit order dispatch system. Centrally dispatched generators with greater than 20 MW capacity compete for the right to generate (Mastropietro, Rodilla, Rangel, & Batlle, 2020). For each hour of the following day, the market operator receives bids and offers. Plants greater than 20 MW must submit both availability and price while plants less than 20 MW only submit availability (Mastropietro, Rodilla, Rangel, & Batlle, 2020). The market operator uses a minimization algorithm subject to technical and economic constraints to determine the dispatch quantities for each plant and a spot price for each hour of the day (Mastropietro, Rodilla, Rangel, & Batlle, 2020). The spot price is the marginal price of the system plus any additional charges needed to compensate for operating losses incurred by thermal plants when dispatched at the marginal price (Perez, Carabali, & Benavides-Franco, 2022).

The market does not include a binding economic commitment. It is cleared ex post, such that dispatch and wholesale prices are determined based on the actual bids and offers at the time of dispatch, together with the activation of ancillary services. Prior to dispatch, Colombia has an indicative day-ahead market, in which the system operator (XM) “determines a nodal economic dispatch,” but there is no binding economic commitment (Mastropietro, Rodilla, Rangel, & Batlle, 2020). The price is fixed in the day-ahead market, with a minimum price at which generators must bid. This minimum price includes a reliability charge (carga de confiabilidad) cost, and some additional taxes and fees. There is an intra-day market, where generators can update their bids, based on changes to the availability of units, transmission lines, or generation forecasts (Zuluaga, 2023). The final revenue for participating generators is determined post-dispatch in a reconciliation process (Rudnick & Velásquez, 2019).

The current market design based on indicative day-ahead dispatch is not suitable for integrating large shares of variable renewable energy sources. If variable energy sources further penetrate the generation mix, hydropower plants will be increasingly unable to cope with variability, which would increase risks for market players as no economic signal is guiding dispatch decisions. Forecasts of renewable availability are much more accurate after the day-ahead market clearing. Binding commitments on the day-ahead market, in which variable renewable energy generators must meet unmet commitments by purchasing electricity on intra-day markets, would increase economic incentives for dispatchable capacity and storage as well as for renewable energy sources to improve forecasting methodologies. This would lead to more efficient dispatch of the energy mix (Mastropietro, Rodilla, Rangel, & Batlle, 2020). Dual or triple settlement markets could provide benefits to the efficient operation of the system, giving incentives to provide better forecasts, as deviations would result in financial consequences. This would require that short-term markets be designed and operate appropriately. Colombia’s regulatory institutions recognize the flaws in the current market design.

Tariff setting

End consumers obtain electricity through either the country’s regulated or non-regulated retail markets. The non-regulated market is only for customers with a monthly demand greater than 0.1 MW or 55 MWh. These customers are required to negotiate a contract with their retailer (IRENA & USAID, 2021); these customers make up less than a third of the market (Perez A. C., 2022). The regulated market charges tariffs in accordance with a formula set by the CREG, which sets a fixed-cost transmission cost and a method for calculating other components, which can vary over time. The CREG-regulated tariff methodologies are approved for a period of five years (IMF, 2019).

Colombia has generally achieved sufficient cost recovery in its tariffs. Currently tariffs allow for full cost recovery and account for the six components of the supply chain: generation, transmission, distribution, commercialization, losses, and restrictions (IMF, 2019). At times, tariffs have been set above cost recovery (104% between 2010 and 2017). However, drought years can significantly affect this due to the impact on hydropower costs (Huenteler et al., 2020, p. 14). Retail prices that customers see depend on their retailer and its wholesale contract and on their regional location and therefore, the resultant distribution charges, losses,

and constraints costs. Wholesale and distribution costs are the largest components of tariff prices (Correa-Giraldo, Garcia-Rendon, & Perez, 2021).

Subsidies to poor households address affordability. Colombia has the highest income inequality of any Organisation for Economic Co-operation and Development country and the second highest among Latin American countries (World Bank, 2021). Under the current system, 87% of residential customers receive varying levels of subsidy through a redistribution fund, the Fondo De Solidaridad Para Subsidios y Redistribución de Ingreso / Solidarity Fund for Subsidies and Income Distribution (Correa-Giraldo, Garcia-Rendon, & Perez, 2021). The level of subsidies households is eligible for is based on each municipality's strata allocation system, which is based on dwelling characteristics. Strata assignments have not been consistently updated across the country, and the subsidization system has faced criticism for poorly targeting the subsidy (IMF, 2019).

The subsidy is paid for through cross-subsidization with government supplementation. The wealthiest consumers pay a higher price for electricity, which covers most of the subsidies to poorer households (Luengo, 2023). Recently, the increase in number of subsidized households and thus the increase in subsidized consumption, combined with the low proportion of households that contribute to subsidies, has led to a higher required government transfer to address the loss of the redistribution fund (McRae & Wolak, 2020). Nonetheless, government supplementation amounted to 0.8% of government expenditure in 2019 (McRae & Wolak, 2020), and government involvement in the subsidy mechanism is viewed as exceptional.

A February 2023 takeover of the sector is likely to cause insecurity. In February 2023, President Gustavo Petro's administration responded to a sustained period of increasing tariff prices and inflation by temporarily taking over tariff setting. By casting aside, even temporarily, CREG's regulatory framework on tariff setting and indicating that tariffs may not consider costs for utilities, this move may undermine investor confidence. This in turn threatens the expansion of the electricity systems that will be necessary to meet Colombia's future demand (Fitch Ratings, 2023).

CLIMATE POLICIES

Colombia has committed to a net zero transition. Colombia's updated 2020 NDC for 2030 is set at 169.4 MtCO₂e, equivalent to a 51% reduction in emissions from a revised (no action) 2030 reference scenario. Twenty percent of this reduction is unconditional and the remaining 31% is conditional. The country will reach peak emissions by 2027 (Government of Colombia, 2020). Colombia's long-term strategy (LTS) includes a 2050 net zero GHG emissions target, which will require reducing emissions by approximately 90% compared to 2015 levels. The energy sector will be modernized and diversified under the LTS, with expansion supported by renewables. The plan is to manage the 10% of emissions that remain by proportionate domestic removals, through carbon capture and storage or land-based removals (Government of Colombia, 2020). The Climate Action Law (2021) enshrines the 2030 and 2050 emissions targets into law. The government has also committed not to enter into any new oil and gas exploration contracts and to ban fracking (Climate Action Tracker, 2023). Coordination on climate action occurs through the Intersectoral Commission on Climate Change (CICC) at the national level and through nine regional units at the sub-national level. In addition to other commitments, President Petro committed to establish a National Institute for Clean Energy in his election campaign, though this has not yet been achieved.

Three documents, the LTS, the national energy plan, and El Planes Integrales de Gestión del Cambio Climático Sectoriales (PIGCCS), lay out the future of the energy sector. To reach carbon neutrality by 2050, it will be necessary for Colombia to generate seven times the amount of electricity consumed in 2015. The LTS outlines three priorities for the future of the sector—clean, reliable, and affordable power generation; robust transmission and distribution; and regulatory modernization. Natural gas will remain in the long-term energy matrix to ensure a reliable energy supply (Government of Colombia, 2020). The LTS also describes the role of electricity in meeting the net zero target, stating that electricity must meet final energy demand wherever appropriate. It projects that by 2050 electricity will serve 40–70% of end uses, but the national energy plan envisages between 18% and 26% electrification of end uses by 2050 under cost-effective conditions

(Government of Colombia, 2020). The PIGCCS, which is the future climate plan for the energy sector, is aligned with the LTS. It would require the power sector to reduce emissions by 79% by 2050 compared to its baseline (Climate Action Tracker, 2023).

The government is committed to a just transition in the energy sector. The 2021 Climate Action Law acknowledged the need for a just transition as a pillar of a net zero transition, and President Petro's predecessor introduced processes to achieve a just transition, which have continued (Climate Action Tracker, 2023). Colombia also signed an agreement for a just energy transition focused partnership with Germany in June 2023 (New Climate Institute, 2024).

Challenges remain. Regional action faces several challenges, including resource constraints and low political or sectoral engagement, limiting the effectiveness of the CICC.

STATE OF CARBON PRICING

Colombia has had a carbon tax since 2016, but it has not impacted the price signals and incentives in the Colombian power sector as yet. El Impuesto Nacional al Carbono was introduced as part of a structural tax reform through Article 221 (Part IX) of Law 1819 of 2016. The tax is payable by all users within the distribution chain at the point of sale, but the sellers or importers are responsible for collecting and paying the tax to the national authority. The tax applies to the carbon content of liquid and gaseous fossil fuels, leaving solid fuels such as coal unaffected; to date it has applied to natural gas only when used in the petrochemical industry or refineries.

Immediate impact was negative. In 2022, the tax covered 23% of the country's total emissions, with a price set at Colombian pesos (COP) 18.830/tCO₂e (~USD 4.96 per ton) (World Bank, 2022). However, fossil fuel subsidies also applied to 16.7% of emissions, resulting in a lowered effective carbon price, which varies by sector and available subsidies (OECD, 2022). A tax reform bill passed in 2022 is designed to remedy this.

The reform will remove the exemption of coal from the existing carbon tax in 2025 in order to disincentivize the use of fossil fuels for electricity generation (EY Global, 2022). Enactment has been gradual. In 2023 and 2024, the tax applies at a 0% rate of the full price. From 2025 onward, the rate will increase by 25% each subsequent year, until the full tax rate applies to coal in 2028 (EY, 2022; IEA, 2023). This gradual increase was specifically chosen to avoid negative effects on electricity generation at a national level. The use of natural gas in electricity production will remain exempt from the carbon tax (OECD, 2019).

Offsets

Offsets neutralized the carbon tax through 2022. Companies were able to meet up to 100% of their carbon tax obligations through the use of domestic offsetting credits until 2022 (World Bank, 2022). In this way, they would demonstrate carbon neutrality. However, Law 2277 of 2022 states that this level may not exceed 50% (Government of Colombia, 2022).

The offsets have been substantial. By 2020, the carbon tax and offset mechanisms had led to the cancellation of 42.8 MtCO₂e of offsets, and COP 1.42 billion collected. More than 90% of the offsets have come from forestry projects. The market price of national carbon credits has been fluctuating somewhere between 80% and 95% of the tax price (IETA, Allcot, 2022). In analyzing the carbon tax impacts, World Bank's Partnership for Market Readiness (PMR) found that most of the offsets acquired for use toward tax compliance were bought by a small number of large companies from the fuel commercialization sector (74%) followed by aviation (11%) and oil exploration and exploitation (10%) (World Bank, PMR, 2020). At the end of 2021 the Colombian carbon market was boosted with a trading volume of 360 million tCO₂e in carbon credit, mainly due to corporate carbon neutrality goals and the Carbon Offsetting and Reduction Scheme for International Aviation mechanism (IETA, Allcot, 2022).

Emissions Trading System

Colombia is also considering implementing an ETS. The Climate Action Law (2018) describes the details of an ETS that, it states, should be implemented by 2030 (World Bank, 2022). The ETS is currently undergoing

development and review by the government, and a trial phase may begin in 2026 (Rodriguez G. A., 2023). The current proposal calls for directing auction allowances to the National Environment Fund, to be used for GHG reductions and mitigation projects (World Bank, 2022).

The goal of adding an ETS is to effectively increase the carbon price signal (Rodriguez G. A., 2023). A dual carbon price system, it is hoped, would cover a wider range of emissions sources, and thereby allow greater flexibility for agents to comply with emission reduction targets (Blanco, 2024).

PMR provided Colombia a set of design options for its ETS as part of its advice on carbon pricing within the formulation of the Climate Change Law. This included covering facilities in energy, industrial, waste, and fugitive emissions sectors to represent 45% of Colombia's emissions and setting an overall emissions limit at 122 MtCO₂ for these participating sectors in line with NDC commitments (World Bank, PMR, 2020). Regulated entities that would be covered by both a carbon tax and the ETS could potentially be allowed to use carbon tax payments as credits toward purchase of ETS allowances at auction to avoid double payment. A competitiveness assessment found that the mining industry, among others, was a priority for assessing carbon leakage. Work under the Partnership for Market Implementation program in Colombia will further implementation of the ETS.

Economy-wide impacts of the carbon tax

Colombia's carbon tax has affected demand of all fuels taxed except natural gas. This assessment is based on estimations of changes in demand attributable to the carbon tax between 2017 and 2020, based on the elasticities of demand and carbon tax levels for each of the fuels. The reason natural gas has not shown an effect is that its demand in the covered sectors is generally inelastic. Fuel oil demand fell the most (ranging from 3.5% in 2017 to 6.8% in 2020), followed by liquefied petroleum gas (LPG; 1.2%–1.3%), gasoline (0.6%–0.7%), jet fuel and kerosene (0.5%), diesel fuel (aceite combustible para motores; 0.4%–0.5%); all of these are attributable to the tax. In absolute terms consumption of gasoline declined the most due to the carbon tax (319,000–397,000 barrels per year), followed by diesel (228,000–281,000 barrels per year), LPG (81,000–97,000 barrels per year), fuel oil (73,000–77,000 barrels per year), and jet fuel and kerosene (60,000–72,000 barrels per year) (World Bank, 2020).

There are no additional measures in place or planned to address distributional impacts of the carbon tax to consumers or energy-intensive industries given affordability concerns. Some work is underway to consider the potential for ETS revenues to be used for this purpose. It is expected that the revenues will be diverted to the climate fund, and not for redistribution to address impacts (Goerner, 2023), but development of the ETS is in the early stages.

Fossil fuel subsidies

Fossil fuel subsidies are counteracting the incentives created by the carbon tax. Subsidies through tax exemptions apply to electricity, natural gas, and heat production; investment in assets for electricity and natural gas production; use of crude oil and gas; mining activities; use of crude oil in refining; and consumption of electricity. Subsidies through budgetary transfers apply to petroleum fuels in border regions; gas distribution; coal production; gas and electricity use by low-income groups; petroleum fuels in transport; and fossil fuel exploration (Gençsü I, 2022). The Colombian government has established plans to almost completely reduce fuel subsidies to zero, though not full elimination (World Bank, 2023).

FINDINGS ON THE EXPECTED IMPACT OF CARBON PRICING IN COLOMBIA'S POWER SECTOR

The theory of change for this study detailed five intermediate outcomes that effective carbon pricing will have in the power sector:

1. **Investments and retirements** of power sector assets and broader infrastructure shift to lower-carbon systems over time.

2. **Prioritized dispatch** of least-cost least-emissions power generation sources and accompanying flexibility resources.
3. **A shift in which consumers purchase less carbon intensive wholesale electricity.**
4. **A shift in electricity consumption patterns** in response to a carbon price due to the resulting higher cost of electricity.
5. **New government revenue** from tax or auction supplements and/or reduces reliance on other (less efficient) revenue sources.

This section outlines the current understanding of whether the carbon tax will have these expected outcomes detailed in the theory of change in Colombia, based on desk-based research and interview findings.

Investments and retirements

Power sector investment decisions in Colombia are market based. The carbon tax will not be relevant to electricity generation until 2025, when the tax will start to apply at a 25% rate, and the ETS is not yet in place. Coal makes up a small percentage of electricity generation (16.2% in 2020). However, it provides a significant source of baseload power in certain regions. **Interviewees expect, therefore, that carbon pricing will affect investment decisions in the coming years, especially if Colombia ultimately has a dual signal mechanism.** Once the carbon tax applies to coal, it may create a disincentive for generators to invest in new coal power plants by increasing the forecasted overall costs over the lifetime of the asset. It may also reduce the utilization rate of high-carbon assets, and therefore their expected revenue. As a result, it may create an incentive to retire existing coal plants early by increasing their operation costs. One interviewee explained that carbon tax is particularly likely to influence decisions on when to retire older power plants (Zuluaga, 2023).

As described in the next section on dispatch, one interviewee argued that at current rates, **the carbon tax was unlikely to lead to lower utilization of coal power plants, given that coal electricity is so much cheaper than gas power.** However, as the carbon tax rate increases and as alternative lower-carbon energy sources are built that reduce the utilization rate of coal plants, it is likely to create a disincentive to build new ones. Companies are therefore likely to invest in renewable generation instead. In the absence of any renewable specific auctions, renewables are required to compete in the wider market, against thermal generation (Rodriguez G. A., 2023). Most renewable generation is contracted via PPAs with fixed prices, but renewable generators may receive an uplift on higher wholesale prices induced by the carbon tax for that electricity that is sold on wholesale markets. The **higher potential revenues could increase the incentive to invest in new renewable capacity.** However, the transmission constraints that limit transport of renewable energy from source to consumers may limit this effect.

Prioritized dispatch

Given the carbon tax is not currently applied to coal and natural gas, it is not currently impacting dispatch decisions. It is expected that bids put forward by coal power plants in the wholesale market in the future will reflect the impact of the carbon price, and at that point **it may begin influencing dispatch decisions** (Zuluaga, 2023). Nonetheless, it is unclear whether applying the carbon tax to coal will cause natural gas generators to be dispatched more frequently.

The Colombian grid is mainly powered by hydropower. In wetter seasons and years, hydro generators tend to drive the wholesale price of electricity, as they tend to set their prices marginally lower than coal. In drier years, when more gas power is utilized due to lower hydropower output, gas generators tend to drive the wholesale price. Extreme weather events will also risk water availability, concentrating resources at certain times of the year which will affect or interrupt hydropower generation output (IEA, 2021).

One interviewee stated that it is unlikely because the carbon tax is unlikely to increase coal production costs such that it overcomes the higher price of gas at dispatch (Zuluaga, 2023). Currently the average price of coal is around 300 COP/MWh, and the average price for gas is around 500 COP/MWh (ANDEG, 2024). Assuming that generators' bids reflect the tax, the merit order dispatch will not prioritize gas instead of coal unless the impact of the carbon tax is greater than 200 COP difference. However, if storage

options/technologies improve in coming years, as seems likely, this may lower the cost of natural gas such that the difference is not as great, meaning the carbon tax impact will not need to be as significant.

Influence on wholesale purchases

When coal generators begin to pay the associated carbon tax with their fuel purchases, it is expected the cost of electricity traded through the wholesale spot market will increase (Blanco, 2024; ASOENERGIA, 2024). If the carbon tax is lower than the difference between coal and gas at dispatch, then the tax could create an uplift in prices, increasing the whole tariff price without switching the order of the dispatch, and therefore have no effect on emission reduction. Nonetheless, **increased inframarginal rents as result of the carbon price will benefit public- and private-sector hydro players**, increasing their revenue and making them more financially viable (ASOENERGIA, 2024).

An increasing spot market price could also impact prices negotiated through bilateral contracts and PPAs. These prices are sometimes agreed based on an expectation of the evolution of the spot price. Therefore, if spot prices are expected to increase with the addition of a carbon price, bilateral contracts could follow suit (Valencia, 2024). Some stakeholders think that a spot market will not influence long-term contracts as much as short-term contracts, and that in the longer term they will consider many other factors (ANDEG, 2024). This may mean **large energy consumers who negotiate with generators or retailers could be influenced toward purchasing energy from renewable generators with a more competitively priced PPA**. One consumer organization indicated that price was the most important aspect of the contract to be negotiated (ASOENERGIA, 2024).

In the long term, if wholesale markets do not affect long-term contracts, this could increase demand for long-term renewable PPAs. However, any coal generators in Colombia already choose not to actively participate in procurement through PPAs as their prices are not competitive compared to renewable generators. **Those coal generators that do still engage in PPAs could opt to participate more in the spot market instead.**

If wholesale electricity prices rise with the addition of the carbon tax, carbon leakage may occur through interconnections with neighboring countries. Consequently, **there is a risk that untaxed electricity generated by neighboring countries will be prioritized over domestic generation subject to a carbon tax**. Colombia would be very unlikely to implement a carbon board adjustment mechanism at the border with Ecuador, as the connection is key to providing energy security during periods of El Niño (Herrera, 2024).

Shift in electricity consumption patterns

As the carbon tax does not currently apply to the power sector, there are no expected shifts in electricity consumption patterns from the current design of the carbon tax. The carbon price signal is low, accounting for 1.4% of the final price of fossil fuels (Rodríguez G. A., 2023). Once the tax begins to apply to coal, the carbon tax is expected to be passed on to consumers through retail tariffs (Luengo, 2023). **No limits on the cost pass-through are expected.** One study found the carbon tax would add 2% onto the cost of retail tariffs (Zuluaga, 2023). It is expected that the market will continue to pay into the tier-based cross-subsidy system with the current distribution levels, and that the government will not provide extra funding to address any finance gaps (Luengo, 2023). While an increase in retail tariffs would create a price signal to consume electricity more efficiently, one interviewee felt that this was unlikely as electricity demand in Colombia is relatively inelastic (Zuluaga, 2023).

Time-of-use tariffs are used for unregulated consumers in industry sectors. It is expected that a carbon price could be factored into these ToU tariffs as a method of demand side management (Luengo, 2023). One interviewee thought that ToU tariffs may also apply to regulated markets in the future, but that this may take up to five or six years to put in place (Zuluaga, 2023). One interviewee anticipated that ToU tariffs will be able to reflect the impact on wholesale prices caused by the carbon tax, reflecting the variation in the carbon content of electricity at different times of day (Zuluaga, 2023). Night-time tariffs may become marginally more expensive due to the lack of solar generation. However, the factors influencing price are much broader than just the carbon tax. **The variability in demand between night and day will likely outweigh the influence of the carbon price on ToU tariffs.**

New government revenue

The generation of revenues was only a secondary, rather than a primary objective from introducing a carbon tax. The relatively low carbon price set and use of offsets for 100% of compliance (allowing covered entities to purchase offset credits that cost less than the tax) have helped to address concerns around economic impacts but mean the tax provides little government revenue (ADB, 2022). After 2022, entities were only able to use offsets towards 50% of compliance. This may have encouraged further decarbonization efforts rather than compensating for emissions-using offsets, which would lower GHG emissions but prevent an increase in carbon tax revenues.

The reforms to apply the carbon tax to coal from 2025 could increase carbon tax revenues by 30%, according to estimates made by the National Administrative Department of Statistics using 2017 national coal production numbers (The Earth Institute, Colombia University, 2019). According to the Ministry of the Economy's original projections, revenues from Colombia's carbon tax would provide approximately USD 200 million to the country per year. However, the Colombian revenue service reported that the tax generated only USD 158 million in 2017, and USD 79 million by September of 2018 (The Earth Institute, Colombia University, 2019). **Carbon tax revenue is expected to reach 0.03% of GDP by 2025, increasing to 0.1% by 2030** (World Bank, 2023).

Between 2017 and 2022, revenue from Colombia's carbon tax was allocated for specific uses, but administered through a separate fund, El Fondo para la Vida y Biodiversidad. In the first three years, 30% of the carbon tax revenue was used for environmental measures, including payments for environmental services. Seventy percent went to the Peace Fund, which is in line with the Final Agreement of Peace. Starting in 2020, this split of revenue use changed to a fifty-fifty split between environmental and Peace Fund projects. In 2023, it is now closer to **80% of tax revenue being used for environmental projects, which includes supporting NDC measures** (Rodriguez G. A., 2023). The remaining 20% of the funds would be used for the management of illicit crops.

Box A-1. Summary of findings for Colombia's carbon tax

The carbon tax has not previously applied to the power sector (due to coal and natural gas exemptions). Thus, its effect on this sector is limited. However, coal will be subject to the carbon tax at a 25% rate from 2025, and an ETS is in development that will provide a dual price signal.

The Colombian grid is dominated by a high share of renewable hydropower with smaller shares of gas and coal. Coal provides a significant source of baseload power in certain regions. In wetter seasons and years, hydro generators tend to drive the wholesale price of electricity, because these generators tend to set their prices marginally lower than coal, and the more expensive gas generators are not dispatched as frequently. In drier periods, with reduced hydropower output, more gas power is utilized, and gas generators tend to drive the wholesale price. When the carbon tax is applied to coal, it is unclear whether it will cause natural gas generators to be dispatched more frequently. For this intended outcome to be observed, the carbon tax needs to be high enough to make coal less competitive than gas, and the capacity mix needs to include more natural gas and renewables with storage.

A carbon tax set high enough may achieve the intended effect of limiting investments in new coal power plants, supporting early retirement and creating additional incentives to invest in renewable generation (in the absence of any renewable specific auctions, renewables are required to compete in the wider market, against thermal generation).

The carbon tax is expected to be passed on to consumers through retail tariffs. Although no limits are expected on the cost pass-through (and no additional financial aid is planned), the effect of higher retail tariffs on more efficient energy consumption may be limited by the relatively inelastic electricity demand in Colombia.

ANNEX B.3: KAZAKHSTAN CASE STUDY

Kazakhstan offers an example of how an ETS has been implemented in a coal- and gas-dominated electricity system, with a recent change from a liberalized wholesale market to a single-buyer model. Before the implementation of the single buyer, 90% of wholesale electricity was traded through bilateral contracts circumventing dispatch decisions based on price signals. Lessons can be drawn from Kazakhstan's experience for other LICs and MICs that aim to apply a carbon price in the power sector.

Country snapshot:

The Kazakhstan ETS does not provide the full benefits expected of an ETS. Its benchmarks have been set at a high level, resulting in an overallocation of allowances that has reduced the trading price. Separate benchmarks have been set for gas and coal, reducing the incentive for fuel switching. The wholesale price caps require generators to absorb costs instead of passing them on to consumers. Kazakhstan introduced the single-buyer model in July 2023, which policy makers hope will introduce merit order dispatch. Further market reform can ensure the ETS allowance price achieves the desirable outcomes of implementing an ETS, including providing appropriate investment incentives by reducing price caps, encouraging merit order dispatch and time-of-use retail pricing.

POWER SECTOR CHARACTERISTICS

This section will explore the demand, supply, power sector structure and value chain and governance arrangements in Kazakhstan to provide context for the subsequent analysis of the impacts of the ETS.

Demand

Kazakhstan's electrical demand is growing and it is highly seasonally variable. Kazakhstan's electricity demand is expected to have an average annual growth rate of 2.7% between 2021 and 2035 (IEA, 2022c, p. 73). In 2022, electricity demand was 112 TWh (Ember, 2023) and peak demand was 15.9 GW in January 2022 (Prime Minister of the Republic of Kazakhstan, 2022). Kazakhstan experiences large temperature variations, from 40 degrees Celsius in the summer to -40 degrees Celsius in the winter (EBRD & CIF, n.d.), and this impacts the seasonal variation in electricity demand. In most regions of the country, people rely on heat for more than six months, much of which is not delivered through electricity.

In 2020, Kazakhstan's electricity access rate was 100%, and the breakdown in usage has remained largely steady since 2001 (IRENA, 2022b). The largest sectoral consumer of electricity is the industrial sector (63%). This was followed by the residential sector (20%), and commercial and public services (11%). The remainder goes to transport, agriculture, and other non-specified sources (IEA, 2023). About 60% of households' energy demand comes from heating and most cities have district heating systems with co-generation or heat-only boilers. In some rural areas, coal or natural gas is also used to provide heat in the winter (IEA, n.d.).

Supply

Coal power dominates Kazakhstan's electricity mix. The country has 207 power plants with total installed capacity of 24.5 GW, of which available capacity is 20.7 GW and 7.9 GW comes from plants that have been in operational use at least 25 years (KEGOC, 2023b). In 2022, installed coal power capacity represented 13.6 GW. Coal generated 60% of electricity, followed by natural gas (29%), hydro (8%), wind (2%), and solar (1%; Ember, 2023). The country's older plants are declining. Six companies account for 80% of the generation capacity: Kazakhmys, Kazakhstan Utilities Systems, CAEPCO, Zhambyl GRES, ERG, Samruk Energy. These companies also own 75% of capacity from plants in operation more than 40 years (KPMG & Acelerex, 2023, p. 12). A limited availability of high-quality coal has led to plants shifting to lower-quality coal over time. Low-quality coal, open storage, and inadequate coal processing influence plant performance and accelerate the aging process (KPMG & Acelerex, 2023, pp. 10-25). The government is working toward expanding gas use to reduce reliance on coal

(IEA, 2022c). Significant progress has been made in developing the gas network in recent years, but only about 50% of the population live in areas that have access to natural gas. Kazakhstan's gas reserves are in the country's western region, but there are no pipelines from the west to the northeastern region, where many people live (GLG, 2021).

The location of Kazakhstan's power plants, which is far from the load centers, causes transmission losses. The coal power plants are near the coal mines in the north of the country. The south of the country is not endowed with fossil fuels and must import electricity from the north or from neighboring countries. The western part of the country is isolated and had an energy deficit in 2022 (KPMG & Acelerex, 2023, p. 14). Transmission and distribution losses were estimated to be 7 TWh in 2012 (EBRD & CIF, n.d.).

Currently, there are limited flexible generators in the system. A number of generators are combined heat and power (CHP) plants that are critical to delivering heat to customers (KPMG & Acelerex, 2023, p. 38). Without a corresponding electrification of heating, a shift to renewables will not by default provide heat to these customers. Half of the country's hydropower plants are regulated by irrigation schedules for the agriculture sector. All coal power plants operate as baseload. According to the International Energy Agency, the power system relies on the Russian power system to cover imbalances and maintain frequency stability (IEA, 2022c, p. 13). It is unclear whether coal power plants, given their design, could begin to operate more flexibly as more variable renewable generation is added to the grid. The lack of flexible generators could be an inhibiting factor to integrating high levels of variable renewables. Kazakhstan introduced a capacity market in 2019, which may help to create incentives to build and maintain more flexible forms of generation.

Kazakhstan has a large potential for renewable energy. About half of the country's territory has average wind speeds of four to six meters per second, and its topography is well suited to develop wind energy (EBRD & CIF, n.d.). The Asian Development Bank's estimate of the country's hydrological resource potential is 170 TWh per year (ADB, n.d., p. 2). However, low generation tariffs, laws on specially protected natural areas, and restrictions on use of land protected as the "lands of the forest fund" have constrained development (Perzadayeva, Ospangali, & Alimzhanov, 2022). Developing new hydropower plants could provide more flexible generation required by the grid in response to increased intermittent renewables.

Various measures are in place to increase renewable energy development. Kazakhstan introduced renewable capacity auctions in 2018 to accelerate its progress toward renewable energy targets. A 15-year feed-in tariff introduced in 2013 was changed to support renewable capacity auctions in 2018 to capitalize on falling prices. Their renewable auction program procured over 1 GW of capacity during the first two years, 2018 and 2019 (USAID, n.d.). In June 2023, it was reported that TotalEnergies had signed a PPA for a 1 GW Mirny onshore wind park, the largest wind project in Kazakhstan (Recharge, 2023). The Mirny project is considered a front-runner project and will be combined with a 600 MWh battery energy storage system. The electricity generation will be sold to the single buyer of electricity established recently, to supply to the national grid.

POWER SECTOR STRUCTURE AND VALUE CHAIN

Upstream: mining and extraction of fuels

Fossil fuel extraction is significant. Kazakhstan is the 10th largest producer of coal in the world, accounting for 1% of global production (Mining Technology, 2023), and it sits on Central Asia's largest recoverable coal reserves, which are relatively inexpensive to mine. (Russia is the largest importer of Kazakh coal.) Coal prices are not regulated, and coal used for electricity production is sold based on prices negotiated directly between sellers and buyers. Kazakhstan is involved in various stages of the nuclear fuel cycle. It ranks number one in uranium mining and has the second largest identified recoverable resource of uranium in the world. It is also the largest oil producer in Central Asia and a major gas producer. However, a third of its gas production is reinjected to enhance extraction of oil (IEA, 2022c).

Generation, transmission, and distribution

Kazakhstan is part of the Central Asian Power System. Its system is synchronously linked to the electricity grids in Kyrgyz Republic, Uzbekistan, and the Russian Federation (ADB, n.d.). Kazakhstan is part of establishing the Eurasian Economic Union (EAEU) Common Electricity Market with Russia, Belarus, Armenia, and Kyrgyzstan, expected to be launched in 2025. Kazakhstan has 21 regional distribution companies and 45 retail companies (IEA, n.d.). The state-owned national transmission company is the Kazakhstan Electricity Grid Operating Company (KEGOC), which has been operating since 1996. It is responsible for “central dispatch, control, system security, and international connections” (ADB, n.d., pp. 1–2). KEGOC estimates a deficit of 5.2 TWh of existing and planned generation capacity and an increase in the deficit of balancing power from 0.9 GW to 1.11 GW from 2022 to 2028 (KPMG & Acelerex, 2023, p. 63).

Reliability has improved significantly. Kazakhstan went through an investment boom in its power sector during the years 2009–2014. As a result, the hours of outages dropped more than 70%, from 3,200 hours a year to 900 (ADB, n.d.). In 2021, its network reliability worked without problems achieved 98.60% reliability, suggesting the system experienced 123 hours of reduced network reliability (KEGOC, 2021).

Auctions have been in place since 2017. The government replaced feed-in tariffs with auctions to procure new renewable generation capacity. As part of the renewable capacity procurement auctions, successful bidders are offered 15-year PPAs. A guaranteed single buyer buys electricity from renewable energy generators under a 15-year PPA and sells it to conventional generators, which sell this electricity together with their own generation to large consumers and retail companies (ADB, n.d., pp. 2-3). For auctions held after January 1, 2021, the contract length of PPAs issued under the renewable auctions has increased to 20 years.

The country’s electricity sector has a wholesale market, but it has been small. The market was introduced in 2001. As part of the market design, wholesale electricity could be purchased through bilateral contracts, or traded in the centralized wholesale market for short-term, mid-term, and long-term contracts. The design also set a maximum for prices, set by the Ministry of Energy. Until recently, most of the electricity was sold through bilateral contracts (90%), with the remaining electricity sold in a centralized market operated by the market operator KOREM. The past few years have seen shrinkage in share of power traded on the market, with a corresponding rise in less transparent bilateral contracts. The main reason appears to be price caps, which are set too low to stimulate interest. KOREM notes that the ministry’s tariff policy does not allow for profits (IEA, 2022c, p. 85; KOREM, 2020), and retail companies have reported that the low prices are causing financial losses and requiring them to underpay employees. Some plants have reported they are unable to raise capital for refurbishment as a result of low prices (KPMG & Acelerex, 2023, pp. 33-57).

Restructuring of the wholesale market is underway. On July 1, 2023, the power sector structure was changed to a single-buyer model. The hope is that this will make merit order dispatch more feasible and that the model will attract investments because it will create more transparency. LLP Financial Settlement Center for Renewable Energy Sources Support (FSC), an organization under the Ministry of Energy, will be the single buyer of electricity (RFC, 2023). The state-owned national transmission company once owned FSC, but it was transferred to the government of Kazakhstan in 2022. The implications of making FSC the single buyer for existing bilateral contracts, pricing, and dispatch decisions remain unclear.

Generators have non-discriminatory access to the electricity markets. Private sector companies provide most electricity generation; five companies provided 68% in 2019 (IEA, 2022c, p. 74). The distribution segment was unbundled in 2004, by splitting the role of distribution and retail and allowing stand-alone energy supply organizations to operate in the retail market (ADB, n.d.). The retail market has been competitive, with about 45 companies participating (IEA, n.d.). However, as of 2024, only suppliers of last resort will continue to operate as retailers, and they will be bundled with the regional distribution company in their area.

Decarbonization will be costly and it is uncertain. The Kazakh government is considering the possible phase-out or significant reduction of coal-fired generation by 2050 (IEA, 2022c). However, 2022 energy balance projections include plans for 1.5 GW of new coal-fired capacity before 2035. Between 2023 and 2040, investment costs for generation and storage in the power sector to support the required decarbonization

needed to reach carbon neutrality even by 2060 are predicted to be as high as USD 39 billion (World Bank, 2022).

POWER SECTOR GOVERNANCE

Power sector planning

Kazakhstan is developing a draft Concept for Electricity Sector Development that would cover the years up until 2035. The concept is part of a written announcement by the Official Information Source of the Prime Minister of the Republic of Kazakhstan. The Ministry of Energy, which oversees the nation's power sector policy (IEA, 2022c), approved an action plan on February 24, 2024, which includes the commissioning of 26 GW of new generating capacity. By 2035, variable renewables will make up 24.4% of the installed capacity, 10.8% will come from hydro power, gas will make up 25.8%, coal will constitute 34.3%, and nuclear power will provide 4.7% of total capacity (Official Information Source of the Prime Minister of the Republic of Kazakhstan, 2024).

Kazakhstan is actively facilitating an expansion of renewable energy capacity. Auctions have been introduced for renewable energy procurement, beginning with a series of 20 auctions based on the plots of land appropriate for renewable energy in 2018. These included nine auctions for larger renewable projects and 11 for smaller ones (USAID, n.d.). In 2019, it introduced site-specific auctions, ensuring bidders have access to land and grid connection prior to bidding. As well, laws and by-laws outline support for renewable energy and energy efficiency (Government of Kazakhstan, 2023). The country adopted the Concept on the Transition to a Green Economy in 2013, which sets emissions in the power sector in 2012 as baseline to which the country should return (Ministry of Justice of the Republic of Kazakhstan, 2013). Substantially expanding domestic gas use is part of the plan to phase out coal use. This has been financed through gas exports to Russia and China. Increased domestic gas use may be difficult to subsidize as more gas is diverted from the export market to the domestic market (IEA, 2022c, p. 32).

Dispatch procedures

Dispatch has changed recently. The National Dispatch Centre of the System Operator is a branch of KEGOC and is in charge of the centralized operational dispatch control. As part of its power sector reform in 1996, Kazakhstan introduced a wholesale market with Pool Market Rules and a merit-order dispatch system based on half-hourly pricing (USAID, 1996). In this centralized market, KOREM has run online auctions for day-ahead and intra-day trades for generators and supply organizations. There is also a real-time balancing market and a market for system and ancillary services. Prior to the recent adoption of the single-buyer model, 90% of electricity was traded through bilateral agreements between generators and energy supply organizations. This circumvented the dispatch system based on auctioning and hourly pricing. Thus, generators entered long-term bilateral contracts based on pre-agreed prices rather than market-based hourly auction pricing.

Tariff setting

Sector regulation is fragmented and it lacks independence from the government. The Ministry of Energy sets tariffs at the power plant level, whereas the Ministry of National Economy sets them for the rest of the power sector value chain. The Ministry of National Economy's Committee for the Regulation of Natural Monopolies and Protection of Competition sets retail tariffs and tariff methodologies. It also sets tariffs for regulated dispatching, balancing, and transmission services, and approves retail tariffs for distribution companies (IEA, 2022c, p. 79). The Ministry of Industry and Construction regulates the heating supply pipes.

Kazakhstan has some of the lowest retail electricity tariffs in the world. Electricity tariffs are subsidized and set around 3.2 US cents/kWh for households and 5.5 US cents/kWh for business. This costs the government about 3% of GDP (IEA, 2022c, p. 130). These subsidies translate to artificially low retail tariffs that are not cost reflective and do not provide incentives for consumers to save energy. Energy subsidies in Kazakhstan are equivalent to USD 228 per capita per year (World Bank, 2022, p. 40). However, Kazakhstan currently has no ToU tariff.

CLIMATE POLICIES

Kazakhstan's updated NDC requires it to take meaningful action (World Bank, 2022). The country has an unconditional commitment to reduce emissions by 15% by the end of 2030 relative to 1990 as a base year and a conditional commitment to reduce emissions by 25% by the end of 2030 relative to 1990.

Over the last decade, Kazakhstan has produced several climate strategies for decarbonization. The 2012 “Strategy Kazakhstan 2050” outlined by President Nursultan Nazarbayev included a commitment to using alternative and renewable sources for at least 50% of energy consumption by 2050 (Nazarbayev, 2012). The 2013 Concept for the Transition to a Green Economy confirmed this commitment in policy and outlined a 15% reduction in carbon dioxide emissions in electricity production by 2030, and a 40% reduction by 2050. An action plan was developed in 2020 to achieve these goals (IEA, 2022). The National Development Plan of the Republic of Kazakhstan through 2025 further supports implementation of the commitments named in the 2013 document.

Kazakhstan's Eighth National Communication in 2022 contained additional commitments. These include (i) reducing the share of coal in power generation to 40% by 2030, (ii) commissioning a nuclear power plant with the intention that it produce 1.5 GW nuclear power in 2030 and 2 GW by 2050, and (iii) introducing a carbon tax on GHG emissions from sectors not covered by quotas (Government of Kazakhstan, 2023). Concepts for development of the fuel and energy complex and the electricity sector between 2023 and 2029 from the Eighth National Communication include upgrades for existing capacity and commissioning new generating capacities, which will provide an additional 11.7 GW of energy, as well as increasing the share of electricity from renewable sources in the total energy generation to 12.5% (Government of Kazakhstan, 2023).

Kazakhstan recently adopted “The Strategy for Achieving Carbon Neutrality of the Republic of Kazakhstan Until 2060,” which outlines the likely technology pathways across sectors to decarbonize the economy (Government of Kazakhstan, 2023; World Bank, 2022). It contains proposals for the decommissioning of coal power plants that have been in operation more than 30 years and the introduction of carbon capture and storage technologies for those units that will continue to operate after 2035 (Government of Kazakhstan, 2023). This means more than half of existing coal power plants are expected to close in the next decade (Kazakhstan Communal Services, 2023).

STATE OF CARBON PRICING

Kazakhstan implemented an ETS in 2013, which is now in its fifth phase. The ETS works in multiple sectors and applies to facilities emitting more than 20,000 tCO₂/year and has covered the power sector since Phase 1. Emissions from 218 installations in the power sector, centralized heating, extracting industries, and manufacturing are covered, encompassing 47% of national emissions (ICAP, 2022). The relatively broad base of the ETS enables obligated parties to purchase emission allowances from other sectors, which theoretically incentivizes emission reductions to occur in the most cost-effective manner.

Allowances are currently allocated for free based on emissions intensity benchmarks (previously this allocation approach was mixed with grandfathering). The reported benchmarks can be found on a government website.²³ The benchmarks, which form an overall cap on emissions, are allocated based on an entity's previous year's output. In the power sector, there are two benchmarks, one for coal (0.985 tCO₂/MWh) and one for other fuels (0.621 tCO₂/MWh). In the current phase (2022–2025), the allowances are allocated based on the average output in 2017–2019 multiplied by the benchmark emission factor and adjusted down by a linear reduction factor of 1.5% each year. Hence, the number of allowances is expected to decrease from 166 million in 2022 to 158 million in 2025, with a reserve of around 11 million (Adilet, 2022). This was again updated in January 2024.

²³ List of benchmarks in regulated sectors of the economy: <https://adilet.zan.kz/rus/docs/V2100023621#z18>.

High benchmarks have created an oversupply of allowances. Should an entity require more allowances to cover its emissions it must trade in the secondary market for allowances. However, the price of emission allowances has remained low due to the oversupply, roughly KZT 563 (~USD 1.22).

Volumes of emission allowances that are traded on secondary markets have also remained low. Only 0.8% and 1.3% of total allocated emissions were traded, in 2014 and 2015. This can be attributed to many factors—the cap was set too high; firms received additional carbon allowances if they increased their capacity; violation penalties were commonly waived; the MRV system used by many firms did not comply with international standards; the national offset market was poorly developed; and there was no market maker to improve liquidity (Howie & Atakhanova, 2022). Price volatility was high during this time, with prices ranging from USD 0.06 and USD 4.54 in 2014 and USD 0.05 to USD 8.10 in 2015 (Howie & Atakhanova, 2022).

Article 286 of Kazakhstan’s Environmental Code addresses carbon budgets. These budgets determine the maximum permissible volume of greenhouse gases under the ETS and outside the ETS. Plans are in place to reduce these budgets by 1.5% per year between 2021 and 2025 and by 2.5% per year between 2026 and 2030. An interviewee explained that a cross-over is expected in 2024 or 2025 where the emissions cap is reduced and the level of free allocation will not cover entity emissions. Industry stakeholders note that this is likely to create a deficit for ETS allowances. This will push up the allowance price and increase the cost to fossil fuel generators emitting CO₂. If there is additional lower-carbon generation available on the grid, coal power plants may be outbid in the spot market, and thus have reduced operating hours. In the longer term, a higher allowance price may provide an exit signal to help with an orderly exit of coal generators.

Previous national allocation plans have not decreased emission allowance allocations at the rate previously expected. An interviewed expert explained that the following uncertainty in the direction of allocations and prices means that obligated parties are not factoring the carbon price into long-term planning.

Forecasts of emission allowance prices are highly uncertain. However, the World Bank’s Country and Climate Development Report (CCDR) for Kazakhstan detailed a scenario where the ETS would achieve half of Kazakhstan’s NDC target with a carbon price of USD 20 by 2030.

Box A-2. Support from the Partnership for Market Readiness and Partnership for Market Implementation programs

The World Bank’s Partnership for Market Readiness (PMR) program worked to strengthen Kazakhstan’s ETS by verifying the functionality of the national carbon registry and established an electronic GHG reporting platform. PMR also supported the process of developing the ETS cap under the National Allocation Plan (2021) by providing macroeconomic modeling, with further proposed caps for 2022–2030. PMR also developed a decade-long road map of technical measures necessary for reaching Kazakhstan’s NDC (Marteau, 2021).

The World Bank’s follow-on program, the Partnership for Market Implementation, aims to further strengthen the ETS and expand carbon pricing to contribute to the NDC aims. Strengthening the ETS will involve a reduction of the allowance cap; improved benchmark values; auction support; an expanded offset market; and improved MRV processes. Carbon pricing expansion activities will assess the introduction of carbon pricing to additional sectors, including methane. Just transition and distributional impacts will be analyzed under the program (Agabekov, 2022).

FINDINGS ON THE EXPECTED IMPACT OF CARBON PRICING IN KAZAKHSTAN’S POWER SECTOR

The theory of change for this study detailed five intermediate outcomes that effective carbon pricing will have in the power sector:

1. **Investments and retirements** of power sector assets and broader infrastructure shift to lower-carbon systems over time.

2. **Prioritized dispatch** of least-cost least-emissions power generation sources and accompanying flexibility resources.
3. **A shift in which final consumers purchase less carbon intensive wholesale electricity.**
4. **Shift in electricity consumption patterns** in response to a carbon price.
5. **New government revenue** from tax or auction supplements and/or reduces reliance on other (less efficient) revenue sources.

This section outlines the findings on whether Kazakhstan's ETS will have these expected outcomes, based on expert interviews and desk-based research.

Investments and retirements

Kazakhstan's ETS, as currently structured, provides limited incentive to shift investments and retirements in a transition to lower carbon generation. The overallocation of emission allowances has suppressed the carbon price. While the price is expected to increase going forward as the cap is reduced, there is little indication that government or private actors have begun factoring these price increases into tariffs, PPAs, or plans. The planned energy balance up to 2035 gives no indication that the cost curves in the modeling reflect carbon pricing. Instead, the energy balance modeling exercise uses the NDC emission reduction targets as an underlying assumption. The forecast energy balance is re-approved each year, so subsequent revisions will incorporate new policies and developments.

Beyond the suppressed carbon price, **the principle of one product, one benchmark is currently not in force in the power sector.** Instead, different benchmarks are applied to coal and gas power, meaning that coal generators receive more emission allowances. Kazenergy (2019) argued that the ETS benchmark emissions intensity for coal-based electricity was set very high at 0.985 tCO₂/MWh, which provides little incentive for coal-fired power plants to reduce their GHG emissions. The benchmark for electricity generated from fuel oil and natural gas is set at 0.621 tCO₂/MWh. With these two benchmarks, there is only an incentive to reduce the emissions on the margin, and not to shift to lower-carbon forms of generation, such as from coal to gas (IEA, 2022). **Incentives for cleaner power production could be strengthened by giving all power suppliers the same benchmark,** much as they are in other parts of the world and in other sectors in Kazakhstan, could provide a strong incentive to transition away from emissions-intensive generation.

Generators currently must bear the cost of purchasing emission allowances as they cannot pass it on to consumers via wholesale tariffs. Generators expressed concerns that low wholesale price caps already result in important repairs and maintenance being delayed or canceled, which could **reduce the availability of the plant and accelerate its path to early closedown.** A higher carbon price, without a corresponding increase in alternative lower-carbon forms of generation, could exacerbate this effect.

Stakeholders express concern that a carbon price will retire coal power plants that are required to ensure uninterrupted power supply. Kazakhstan already struggles with adequate capacity, and policies that will shut down generation capacity is a concern for the security of supply. All energy-intensive entities would bear the cost. **Investments in new low-carbon generation capacity, such as hydropower, nuclear, variable renewables, and/or storage, could mitigate these problems.** An expansion of the country's gas network may also enable new natural gas generation plants in parts of the country that currently do not have them.

The ETS could provide the needed incentives. Long-term PPAs secured through renewable energy auctions primarily drive investment in new renewable energy installations. Renewables currently do not receive an uplift from a higher electricity wholesale price caused by a carbon price due to the fixed price set in their PPAs. Nevertheless, an interviewed expert explained that **having an effective ETS that could create an incentive to shift away from coal would be highly complementary to the auctions driving uptake of renewables.** A policy framework that aimed to achieve decarbonization of the power sector by only focusing on driving renewables would risk causing the more expensive forms of thermal generation to exit first in the energy transition. These tend to be natural gas. The ETS could create incentives for the highest-emitting forms of generation to exit first.

Prioritized dispatch

Kazakhstan's ETS allowance price is currently not expected to change the cost at which generators are ordered in the dispatch process, as fossil fuel generators currently cannot pass on the carbon cost in their wholesale tariffs. For the ETS to lead to prioritized dispatch of least-cost least-emissions power generation sources, **wholesale tariffs will need to factor in the ETS allowance price to change the merit order of generators.**

Before Kazakhstan introduced the single buyer model in July 2023, 90% of electricity was traded through bilateral agreements between generators and ESOs based on pre-agreed prices, which meant that a dispatch system based on auctioning and hourly pricing did not apply. With the new single buyer model, FSC will purchase the electricity from generators. **It is unclear whether the single buyer model will enable merit order dispatch**, in which power plants with a lower marginal cost (such as variable renewables) are prioritized over more expensive forms of generation when they are available. This could be the basis for change; if a carbon price is passed through in wholesale generation tariffs and there is a robust ETS allowance price, fossil generators could be less competitive in a merit order system.

This scenario, however, would require sufficient capacity and system flexibility to regularly prioritize dispatching more efficient forms of generation. Currently, Kazakhstan is supply constrained. **Given the challenges of energy security, there is a potential risk that a reduced cap will increase the cost of generation, but not lead to emission reductions**, because the power plants will need to be dispatched regardless of costs to meet demand. Fossil fuel generators would have a role to play in providing ancillary and balancing services.

Influence on wholesale purchases

Prior to the single-buyer model, retail companies and large consumers were able to purchase electricity through long-term PPA contracts, which were subject to specific price caps for each technology that limited the competitiveness of each. Under the single-buyer model, independent bilateral contracts have been largely impossible since July 2023. While a group of affiliated companies can generate electricity for their own consumption if permitted by the government, most retailers and large consumers have to go through the single buyer to purchase electricity. Without consumer choice, **the ETS allowance price will not contribute to incentivizing retailers and large consumers to sign renewable energy PPAs** with private generation companies.

Shift in electricity consumption patterns

As noted in the CCDR report (World Bank, 2022), Kazakhstan has regulated retail tariffs at around USD 0.032/kWh per households and USD 0.055/kWh for businesses. The fact that tariffs are not fully cost reflective suggests the price signal for efficient consumption is weak, with or without the carbon price. **If the allowance price is not passed through to end tariffs, it will not provide an added incentive to reduce electricity consumption or invest in energy efficiency measures.** Kazakhstan also does not have ToU tariffs, and thus a higher carbon price could not create an incentive for consumers to reduce consumption during the most carbon-intensive generation hours, even if the carbon price were passed through. The International Monetary Fund developed a scenario where Kazakhstan increased the carbon price to USD 25/ton to encourage significant emissions reductions. In this scenario, impact on energy prices showed increases of 10.7% and up to 187% respectively for LPG and coal when used as energy sources (IMF, 2022).

In any case, thus far Kazakhstan's ETS program has explicitly prohibited carbon cost pass-through (of both CO₂ allowance costs and abatement costs). An interviewed expert explained that **if there is an increase in the carbon price, the power plants will likely need to ask the government to increase tariffs**, which could trigger a chain of different tariff restructuring steps down the value chain to distribution companies and end consumers.

It is unclear whether the political economy in Kazakhstan is conducive to reflecting the carbon price in consumer tariffs. In 2022, price rises for gas led to unprecedented protests and the subsequent rollback of government energy policy reforms, highlighting the political challenges for a carbon price in the country

(Carbon Pulse, 2022). Government officials have warned that the need to improve infrastructure will trigger further increased electricity tariff prices this year. Prices are expected to increase up to 30% but will depend on the condition of infrastructure in the region (Kumenov, 2023). What kind of political challenges this will cause remains to be seen.

New government revenue

Since 2021, all allocation of emissions allowances in the power sector were freely allocated based on benchmarks, so no revenue was generated. Existing legislation allows for primary market auctioning. The NDC Roadmap and CCDR include plans for introducing auctioning of emission allowances. Auctioning would now start in 2026 and reach 10% of allowances by 2030. The Ministry of Energy is considering using the revenue to create a decarbonization fund, but no decisions have been made.

Box A-3. Summary of findings for Kazakhstan's ETS

The Kazakhstan ETS is currently not designed in an optimal way to induce a price signal that can shift investments and dispatch towards lower carbon sources. Its benchmarks have been set at a high level, which has resulted in an overallocation of allowances that has reduced the trading price. Separate benchmarks have been set for gas and coal, reducing the incentive for fuel switching. A geographically limited gas network is another barrier to fuel switching. The wholesale tariff caps reduce generators' ability to pass on costs to consumers, and instead require them to absorb costs. Consequently, the ETS allowance price has been prohibited from passing through to retail tariffs. The inability of generators to pass through carbon costs creates risks to the security of supply. Kazakhstan struggles with a shortage of capacity in the network during peak times. As a result, the ETS allowance price can increase without changing dispatch procedure. Kazakhstan introduced a single buyer in July 2023, which it is hoped will improve the system operator's ability to dispatch according to merit order. Further market reform would ensure the ETS allowance price achieves the desirable outcomes of implementing an ETS, including providing appropriate investment incentives by removing price caps and encouraging merit order dispatch and time-of-use retail pricing.

ANNEX B.4: SOUTH AFRICA CASE STUDY

South Africa offers an example of how a carbon tax was implemented in a context of high stakeholder opposition, an electricity system struggling with achieving sufficient security of supply, high reliance on coal, the state-owned monopoly power utility Eskom (which is expected to be unbundled), and concerns about the distributional impacts of the carbon tax, with a high share of the population living under the line of poverty. Lessons can be drawn from South Africa's experience for other LICs and MICs that aim to apply a carbon price in the power sector.

Country snapshot:

The South African carbon tax has not had its intended effect in the power sector due to its exemptions for generators. As exemptions are removed in the future, the carbon tax is expected to provide a price signal that could in theory shift investments and dispatch toward lower carbon assets. Eskom is currently working toward unbundling its generation, transmission, and distribution segments and updating policy documents that are likely to affect how the dispatch and tariff-setting methodology works in the future, including how the carbon price signal is passed through the value chain. Further market reform can ensure the carbon tax elicits the desirable outcomes of implementing a carbon tax.

POWER SECTOR CHARACTERISTICS

This section will explore the demand, supply, and governance characteristics of South Africa's power sector to provide the context for the analysis on the impacts of the carbon tax.

Demand

South Africa's electricity demand is expected to grow steadily. In 2022, South Africa had a peak electricity system demand of 34.6 GW and an annual electricity system demand (domestic and export) of 227 TWh (Pierce & Roux, 2023). Demand is expected to grow by 1–2% per year through 2050 (Department of Mineral Resources and Energy, 2019, p. 28).

The industrial sector dominates consumption of electricity in South Africa. The largest sectoral consumer of electricity in 2020 was the industrial sector (consuming around 50% of the total electricity), followed by the residential sector (25%) and the commercial and public services sectors (19%). This has been the general trend since 1998, with transport, agriculture, and other non-specified sources being lower electricity-consuming sectors (IEA, South Africa, 2022e).

Access and affordability are prominent issues in South Africa. The Sub-Saharan Africa electricity access rate in 2020 was 48%, while South Africa's 86% was thus strong for the region, it was below the global average of 91% (INEP, 2023; IEA, IRENA, UNSD, World Bank, WHO, 2022). The integrated national electrification program provides capital subsidies to municipalities to provide electricity connection to the remaining backlog of permanently occupied residential dwellings.²⁴ However, energy poverty was estimated to be 43% in 2021, meaning household's basic energy needs cannot be met in full (TIPS, 2021)

Supply

South Africa has a carbon-intensive electricity mix dominated by coal power plants. In 2022, generation capacity was 54 GW. Coal still dominates the energy mix (80%), followed by hydro (6%) and nuclear (5%) (Pierce & Roux, 2023). The dominance of coal in South Africa's electricity mix resulted in an emissions intensity of 716 gCO₂/kWh in 2021 (Our World in Data, 2022). Most of the electricity is produced and consumed domestically; the country has strong domestic coal reserves. However, 4% of electricity is imported from Lesotho, Mozambique, Zambia, and Zimbabwe, and 5% is exported to Botswana, Eswatini, Lesotho, Mozambique,

²⁴ DMRE - [191023ELECTRIFICATION.pptx \(live.com\)](#).

Namibia, Zambia, and Zimbabwe (Ratshomo, 2021). Many of the country's coal power plants cannot be operated flexibly. Newer or retrofitted coal power plants can operate at minimum operating levels of 10–20%, but older plants have minimum operating levels of 60% or higher.

The electricity system also struggles with an inadequate capacity margin. Eskom's coal power plants have been poorly maintained and load shedding and rolling blackouts are common. As a result of decommissioning and maintenance of aging coal infrastructure and Eskom's financial limitations, insufficient electricity supply has been an issue for the last 20 years and has worsened recently (Hanto et al., 2022). In 2022, power cuts occurred on more than 200 days with outages of six to eight hours a day for most households (Enerdata, 2023). Five percent of forecasted annual demand (equivalent to 8 TWh) was lost through load shedding (IEA, 2023). There were periods in 2023 when Eskom's coal power plants had an overall capacity factor of only 45%.²⁵

Distributed generation is growing in South Africa at an accelerated rate. The government announced an increase in the generation license exemption from 1 MW to 100 MW for embedded generation in 2021, then removed all generation license requirements for development in 2023. Businesses and private households are increasingly interested in generating their own electricity to lessen reliance on Eskom, and the utility's estimates indicate that rooftop solar PV increased from 0.9 GW in March 2022 to 4.4 GW in June 2023 (Eskom, 2023). Eskom is planning a net-billing and/or feed-in tariff to unlock supply from commercial and household rooftop solar generators in an attempt to increase generation capacity. It is also implementing a new Virtual Wheeling Platform, where power can be wheeled from private renewable energy generators to multiple off-takers via PPAs (CDH, 2023).

Increased solar PV may worsen overall conditions and complicate the impact of a carbon tax. Solar PV and storage technologies can alleviate some of the impact of load shedding and blackouts on households and businesses, but credit-constrained households cannot afford such measures and the independence of the wealthiest electricity consumers can distort the cost sharing of future grid reinforcement projects. A carbon tax that passes through to the retail electricity tariff could further incentivize investment in solar PV, as well, making higher-income household more self-reliant, meaning lower-income households that cannot afford this upfront cost will need to pay for the higher tariffs caused by a carbon tax cost pass-through, and associated cost recovery from existing coal plants. Low-income households could consequently bear a larger burden of paying for additional grid reinforcements. As a result of an influx of new generation being connected at the distribution level, distributors are also currently struggling to manage local network congestion.

Other measures to address capacity face obstacles. South Africa is actively trying to increase and diversify the size, scale, and nature of its generation fleet. However, Eskom's financial situation limits its own investments into new capacity. For example, Eskom has permission to build a 3 GW CCGT power plant in Richards Bay using LNG.²⁶ However, because the National Treasury has given Eskom debt relief, the utility cannot borrow any more money. This means Eskom has the permission to build the plant but not the funds to do so. An LNG terminal would also need to be built in Richards Bay to import LNG, such that additional infrastructure would be needed to realize the CCGT power plant.

Independent power producers (IPPs) are challenging the dominance of Eskom's generation share, but stumbling blocks have arise here as well. South Africa put the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) in place in 2011, and it has begun to meet its goal of encouraging investments in large-scale renewable energy (Hanto et al., 2022). The REIPPPP is a competitive open tender scheme for power sector investors to bid for a PPA and access to the transmission grid for their generation project. Initially bidders submitted quantity at any price, but, based on input by the National Treasury, subsequently both capacity and price were submitted to ensure the auction functioned competitively. Investment in renewables has occurred at increasingly cost-competitive prices as a result of the program. However, in the most recent bidding round, most of the allocated capacity was not awarded due to grid constraints (Department of Mineral Resources & Energy, 2022). Furthermore, many of the successful bidders

²⁵ [Eskom's coal-fired power stations in deep trouble – Daily Investor.](#)

²⁶ [South Africa: Eskom's new gas power station gets green light | Club of Mozambique.](#)

have not started construction due to bidding prices that are “too low to be viable,” together with the impacts of inflation and increasing interest rates that have weakened South Africa’s rand and led to increased raw material costs (Kruger, 2023). Since grid upgrades can be very lengthy (due to regulatory barriers, long processing times, etc.) and costly to implement, in the present circumstances the lack of grid capacity is a major hurdle to the acceleration of renewable energy expansion in the country.

There are signs that renewable energy will be cheaper than coal in the future, but no certainty. New solar and wind projects are considered cheaper to invest in than new coal power plants in South Africa, and it is becoming clear that the operations and maintenance cost components of existing coal power plants have been underestimated. Air quality minimum emissions standards for combustion installations that will require existing coal power plants to make a significant investment have been phasing in since 2015 (CREA, 2023). These factors will increase the cost of operating existing coal power plants and make renewables more competitive on a relative basis. Investments in renewables can provide important additional generation capacity to the system. However, ultimately renewable energy may not be less expensive than existing coal.

POWER SECTOR STRUCTURE AND VALUE CHAIN

Upstream: mining and extraction of fuels

Allocating coal contracts in South Africa has become politicized. South Africa is currently the most coal-dependent country in the Group of 20 (World Bank, 2022d), and coal has played significant political and economic roles in the country for a long time. Eskom and the coal mining industry have strong ties, as the two contracting models that Eskom and coal mining companies have used reflect. The first was a model where Eskom provided the capital financing to coal mines in return for off-take guarantees. The second was a fixed-price model where “coal sold to Eskom was subsidized from exports, with low coal costs passed through Eskom to benefit electricity users” (Burton, Lott, & Rennkamp, 2018).

Generation, transmission, and distribution

Vertical integration and government ownership are barriers to change. Eskom currently owns and operates the generation, transmission, and distribution segments of the power sector. While IPPs can sell generation through PPAs to Eskom as the single buyer, IPPs only account for around 5% of total generation (ITA, 2023). Eskom also functions as the transmission system operator and while municipalities provide about 40% of distribution in the country, Eskom provides the remaining 60% (Baker & Phillips, 2019). Some apprehension has been observed from the government toward introducing private sector participation in the generation segment. It is reported that an Eskom-led coalition to oppose wind and solar power, making the case for nuclear power as the only solution, has “fought increasingly hard” (Hochstetler, 2020, p. 32). Historically, Eskom leadership has been heavily implicated in state capture. A new Eskom-dedicated State Capture Task Team is executing a plan to address this as well as “serious crimes related to Eskom’s operations” (ESI, 2023). Eskom’s transmission grid is already constrained in many places, limiting where new generation capacity can connect. This is due to a chronic underinvestment in Eskom’s transmission grid (DailyInvestor, 2023). A visual map of [Eskom’s Generation Connection Capacity Assessment for 2024](#) shows the resulting limitations.

Unbundling has begun, however. To address the challenges faced by the power sector described in the next section, the government has initiated the process of unbundling Eskom into separate business entities of generation, transmission, and distribution. It is intended that this will improve the currently limited competition and transparency in the sector (Grange, 2019). The transmission segment was legally separated into the National Transmission Company South Africa (NTCSA) in December 2021 but it remains under Eskom ownership. NTCSA will “sell energy and capacity to Eskom Distribution on an aggregated wholesale energy tariff structure that is calculated based on the regulatory revenue decision for Eskom Generation” (Enerdata, 2021).” Further unbundling of Eskom is expected, such that it ultimately only will control generation.

POWER SECTOR GOVERNANCE

South Africa faces significant challenges in the governance and regulation of its power sector. Each year, the content and effectiveness of power sector regulation across Sub-Saharan Africa is assessed and benchmarked in the Electricity Regulatory Index for Africa (ERI), which is run by the African Development Bank. The ERI report computes a total score calculated by averaging two sub-indices, namely the Regulatory Governance Index and the Regulatory Substance Index. In 2022, the top three performing countries were Uganda, Egypt, and Senegal, which scored 0.846, 0.785, and 0.710 out of 1.000 respectively; South Africa's regulatory sector had a total ERI score of 0.55, which ranked it 21st out of 43 countries. This low score reflects good scores on most criteria in both indexes but poor scores on independence and economic regulation for tariff setting (African Development Bank, 2022).

Power sector planning

A series of iterations of the Integrated Resource Plan (IRP) guides the Department of Mineral Resources and Energy (DMRE) in overseeing power sector planning. The IRP is “an electricity infrastructure development plan based on least-cost electricity supply and balance, taking into account security and the environment” (Department of Mineral Resources and Energy, 2019, p. 8). Updated periodically, the IRPs are based on supply and demand projections, and Eskom develops their Transmission Network Plans based on the IRP. The IRP has not included the value of ancillary services that certain technologies can offer.

The strategy for increasing generation capacity through 2030 has been outlined but not fully implemented. The analysis used to develop this strategy, developed in IRP 2019, indicates wind and solar energy are the least expensive technologies. The plan calls for a scale-up of renewable energy through adding 18 GW of new wind and solar PV, 2 GW of storage, and 3 GW of gas thermal in addition to the decommissioning of around 12 GW of outdated and inefficient coal-fired power plants. Although the IRP 2019 has already been approved, its execution is taking longer than expected.

DMRE published the IRP2023 for public comments on January 4, 2024. The IRP 2023 emphasizes the significant role of coal and calls for “a consideration for investments in more efficient and cleaner coal technologies” (DMRE, 2024). Given the unsolved financial and operational issues facing Eskom, uncertainty around the successful implementation of the IRP continues to be high. Further details on South Africa's plans for decarbonizing the electricity system are provided in the Climate Policies section.

Dispatch procedures

The [Scheduling and Dispatch Rules](#) of the South African Grid Code dictate dispatch procedures. This code stipulates that the system operator should “Schedule and Dispatch generation and demand-side resources to least cost whilst maintaining the prescribed system security” (Nersa, 2015, p. 10). As part of the day-ahead scheduling, the system operator forecasts hourly demand for the next day. Dispatchable thermal generators submit their hourly availability and incremental cost curves capturing the incremental costs of increasing generation above its minimum generation point. The dispatch algorithm will first determine an unconstrained dispatch schedule, which minimizes “the total cost of generation required to meet the expected demand, constrained by the reserve requirements and technical capabilities of dispatchable generators” (p. 23). Following this, the constrained schedule dispatch algorithm determines a dispatch schedule that also factors in “transmission networks constraints” (p. 23).

Tariff setting

Nersa sets end-use electricity tariffs. Municipal tariff structures vary significantly across municipalities and, in most cases, are set using a benchmarking approach. Both direct and cross subsidies are used to reduce the price of electricity for residential customers; however, the application of these are inconsistent across municipalities. Subject to separate legal frameworks, both Eskom and municipalities can adjust their tariffs annually with regulatory approval.

Low tariffs and access concerns have driven reliance on fossil fuel subsidies (World Bank, 2022d, p. 12). The government has offered basic electricity policy for free²⁷ since 2003, which provides free electricity to grid-connected households up to 50 kWh per month. It is administrated through the municipalities in South Africa, and the municipalities compensate Eskom for the electricity provided for free (South African Government, 2024). However, Nersa allowed Eskom to increase its tariffs by 19% for the year 2023–2024, complicating efforts to provide affordable electricity to South Africans beyond the 50 kWh threshold (Enerdata, 2023).

Eskom's end-use tariffs have been one cause of its financial difficulties. They are set through the Multi-Year Price Determination process, outlined in Nersa's (2021) Pricing Review methodology (Nersa, 2021). The process employs a revenue-based tariff methodology to forecast "utility costs across the entire value chain" lumped together in order to set an average price, and is not cost reflective (Nersa, 2021, p. 7). It does not factor in the impact of pricing on the energy consumed (price elasticity of demand), and thus a higher average price leads to lower consumption, which reduces Eskom's revenue. This type of "averaging" has been identified as a problem "which results in inefficiencies, cross subsidies and socialization of costs" (Nersa, 2021, p. 8). Allowed revenues are calculated according to regulatory formulas. The generation formula covers generation operational expenditure, depreciation, efficient energy primary costs (inclusive of non-Eskom generation), transmission charges pass-through, risk management adjustments, and returns on generation assets and working capital. The primary energy costs include the fuel usage cost.

Eskom's financial difficulties reflect the need to raise tariffs. Currently, tariffs are not sufficient to cover Eskom's costs of operation in addition to servicing its high levels of debt resulting from financial losses in the past few years (Eskom, 2022). Eskom's debt has accumulated to an unsustainable level, such that it cannot invest in the network and maintain assets to sufficient standards, which has an effect on service reliability and quality. These financial challenges are a primary driver of efforts currently underway to unbundle Eskom into separate business entities. Nersa's recent pricing review calls for activity-based costing (ABC): explicitly stating the separate cost components for "generation, transmission, distribution, trading and other services" (p. 8) when submitting costs to Nersa for approval. Switching from a revenue-based approach to a "cost to serve" approach is more likely to address the problems in the system. **South Africa's 2022 Electricity Pricing Policy Review provides some important insights into the future of the tariff-setting system** (DMRE, 2022). For example, it states that tariffs "should be designed from cost reflective principles" and calls for both "cost reflectivity and transparency" (p. 72). It also suggests that time-of-use pricing should become more prominent in South Africa's system (p. 87). This latter suggestion, as described in the "State of Carbon Pricing" section, may affect the impact of carbon pricing.

CLIMATE POLICIES

The concept of a low-carbon transition is gaining ground in South Africa. The government recently placed climate change within its wider development strategy, and it has made changes in legal and institutional frameworks to address this (World Bank, 2022d). As part of its new development strategy, outlined in the National Development Plan, Vision 2030, the government defined its climate ambitions that include net zero emissions and a just transition. The Climate Change Bill passed in the South African Parliament in October 2023 includes wide-ranging points that would support low-carbon development. It includes the implementation of sectoral emissions targets and carbon budgets. Carbon budgets will require entities to prepare a GHG mitigation plan to meet the required budget (Government of South Africa, 2022). The Presidential Climate Commission is a new advisory body instituted to facilitate South Africa's just transition to a low-carbon economy and climate-resilient society by 2050 (World Bank, 2022d).

South Africa's international commitments align with the shift to prioritizing low-carbon energy. The first NDC committed to a "peak, plateau and decline" trajectory, in a range between 398 and 614 MtCO₂e between 2025 and 2030. The updated NDC shows significant progression for targets within the same period. South Africa's updated NDC emission targets are set at 398–510 MtCO₂e in 2025 and 350–420 MtCO₂e by 2030,

indicating a peaking before the end of the decade. It states that the long-term decarbonization of the South African economy will begin in the 2020s, focusing in the electricity sector, followed by a deeper transition in the 2030s. Actions from the power sector that are required to meet these targets include the implementation of the power sector investment plan (through IRP 2019) and the carbon tax (Government of South Africa, 2021).

South Africa’s Just Energy Transition Investment Plan corresponds with the NDC and LTS. In conjunction with international support, it aims to mobilize USD 8.5 billion to support the achievement of South Africa’s low-carbon development. Specific actions relevant to the power sector include:

- Leading a just transition that protects vulnerable workers and communities, especially coal miners, women, and youth, affected by the move away from coal.
- Managing Eskom’s debt successfully and sustainably.
- Defining the role of the private sector and creating an enabling environment through policy reform in the electricity sector, such as unbundling and improved revenue collection.
- Establishing local value chains (including micro, small, and medium enterprises).
- Providing opportunities for technological innovation and private investment to drive the creation of green and quality jobs (Government of South Africa, 2022b).

Nonetheless the dominance of coal presents a challenge. Fossil fuels have been supported by policies and direct and indirect government subsidies for many years, and special interest groups, especially trade unions, linked to coal are very powerful (Hanto et al., 2022). South Africa’s electricity is currently mostly provided by a number of large coal plants located in the Mpumalanga province, where most of the country’s coal resources are to be found (Government of South Africa, 2021), and challenges are expected in addressing the economic and social consequences resulting from this transition in coal-producing areas. Despite the government’s strong commitment to reaching net zero emissions a clear and nationally owned net zero commitment with a costed implementation plan has not been adopted (World Bank, 2022d). If fully implemented, South Africa’s current policies would result in emissions reductions only in line with the global goal of holding global warming at, but not well below, 2°C (Climate Action Tracker, n.d.).

STATE OF CARBON PRICING

South Africa began a journey toward a carbon tax in 2010. A carbon tax was chosen over an ETS due to the oligopolistic structure of the energy sector in South Africa. It was thought that the small number of industry players would mean that economic efficiency gains would be minimal with an ETS, that the lack of market players and diverse abatement costs would limit opportunities for trading, resulting in inappropriate trading prices (National Treasury, Republic of South Africa, 2010, p. 6). However, the carbon tax faced multiple postponements, revisions, and an elaborate and a long public consultation process. Stakeholders expressed concern that the carbon tax would raise electricity prices, increase operational costs, cause unemployment and job losses, and fail to increase renewable. Concerns were also raised about the horizontal coordination between the National Treasury and the Department of Environmental Affairs, and the coherence of the tax with existing policies. Finally, some stakeholders were concerned about the destination of revenue raised by the tax. The South African government responded to these concerns, through media statements, further workshops, and changing the tax design itself. Ultimately the South African government introduced the tax into legislation in 2019. Phase 1 of the carbon tax began when the law was implemented, on June 1, 2019; Phase 2 was originally set to begin on January 1, 2023, but in the 2022 budget speech, the treasury extended the first phase through to December 31, 2025 (KPMG, 2022).²⁸ The second phase is scheduled to be from January 1, 2026 to 2030.

²⁸ The minister of finance announced the act, the Carbon Tax Act No 15 of 2019, in the country’s 2019 budget, and the act was gazetted on May 23, 2019 (Gazette No. 42483), together with the Customs and Excise Amendment Act No. 13 of 2019 (Gazette No. 42480).

During Phase 1 the carbon tax has limited application. It applies only to Scope 1 emitters (direct emissions). Stationary and some non-stationary GHG sources with a thermal design capacity of 10 MW or more must pay taxes on their direct emissions. The tax applies to industry, buildings, and transport sectors (except public transport) irrespective of the fossil fuel used. Entities that produce emissions from the following are liable to the tax, subject in some cases to a capacity threshold:

- electricity generation and fuel combustion,
- industrial processes (cement, iron and steel, glass, ceramics),
- fugitive emissions (e.g., methane emissions from mining),
- direct (Scope 1) stationary emissions, and
- direct (Scope 1) non-stationary emissions. The carbon tax is applied in addition to existing taxes already levied on fuels.

Entities that engage in activities that produce direct GHG emissions are required to report them. The 2017 National Greenhouse Gas Emission Reporting Regulations established this requirement; as of May 2022 370 firms were licensed. Reporting occurs via the South African National Greenhouse Gas Emissions Reporting System, which is under the management of the Department of Forestry, Fisheries and Environment (DFFE). DFFE provides entities with a confirmation letter that is included in tax filings with the South African Revenue Service (SARS). Entities obtain a single license for the combination of all of their emissions facilities from a customs and excise branch, and they file form DA180 and supporting documents to SARS (South African Revenue Service, 2020). The carbon tax return must be submitted, and the tax liability must be paid by July of the following year for any emissions in the current year (January–December).²⁹ It is not clear what level of compliance SARS has achieved, and it has no enforcement mechanism. However, among licensees, 85.4% of firms were paying their tax obligation as of 2020.

The carbon tax has increased steadily. The carbon tax had an initial price of ZAR 120/tCO₂e for 2019. Until 2022, the rate increased annually by the amount of consumer price inflation plus 2% annually, to ZAR 159/tCO₂e, and it will increase more steeply from 2023 onward (PWC, 2022).³⁰ In the 2022 budget, the government proposed the following carbon tax rates:

1. From January 2023 to December 2029, the rate will increase by inflation—or a minimum of USD 1.00, meaning the tax should be at least USD 20/tCO₂e by 2026.
2. From January 2030, the carbon tax rate should be at least USD 30/tCO₂e.
3. From January 2050, the carbon tax rate should be at least USD 120/tCO₂e.

More change is likely coming. To give effect to the proposed carbon tax rate changes for the period 2023 to 2030, the National Treasury published the draft 2022 Taxation Laws Amendment Bill (TLAB) for public comment and stakeholder consultation in July 2022. The draft bill has been submitted to the Parliament for consideration. Following public hearings held by the Standing Committee on Finance in September 2022, the proposed USD-based carbon tax rates have been changed to the rand equivalent using the average rand-dollar exchange rate for the period August 2021 to July 2022. The draft TLAB has been amended to include the specific carbon tax rates for the period 2023 to 2030. The Select Committee on Finance considered the draft bill and the minister of finance addressed it during his medium-term budget policy statement on October 26, 2022.

²⁹ [South Africa – Corporate – Other taxes \(pwc.com\)](https://www.pwc.com/southafrica/corporate/other-taxes).

³⁰ The carbon tax rates for 2019, 2020, 2021, and 2022 were ZAR 120/ tCO₂e, ZAR 127/tCO₂e (USD 7/tCO₂e), ZAR 134/tCO₂e, and ZAR 144/ tCO₂e, respectively. In the 2023 Budget Review, the National Treasury confirmed the new carbon tax pricing mechanism would introduce the following rates: 2023: ZAR 159/tCO₂e; 2024: ZAR 190/tCO₂e; 2025: ZAR 236/tCO₂e; 2026: ZAR 308/tCO₂e; 2027: ZAR 347/tCO₂e; 2028: ZAR 385/tCO₂e; 2029: ZAR 424/ tCO₂e; and 2030: ZAR 462/tCO₂e.

Tax free exemptions

The carbon tax incorporates a range of allowances and exemptions designed to address industry concerns as well as socioeconomic concerns. Tax-free emission allowances range from 60% to 95%. Reflecting concerns about the impact of the tax on the competitiveness of industries, the overall tax-free allowance was increased to 95% and a trade exposure allowance was developed. The tax design was also developed to incorporate tax-free allowances for fugitive and process emissions, as a response to concerns to measuring challenges. As well, a carbon offset scheme was introduced to provide flexibility for taxed entities. And, finally, the environmental levy on conventional generators (fossil fuels and nuclear power), which is in place until the end of 2025, can be offset from the carbon tax liability of a fossil fuel generator to avoid double taxation.

Revenue neutrality

In line with its design, the carbon tax is revenue neutral and neutral on the price of electricity. In 2020, the tax revenue from the carbon tax was ZAR 650,000; in 2021 it was ZAR 1.4 million. It grew to an estimated ZAR 1.7 million in 2023 and ZAR 1.8 million in 2024. However, the Energy Efficiency Savings Tax Incentive (Section 12L under the Income Tax Act, which was implemented in 2013) can be claimed by companies to reduce their tax liability. Electricity generators are also allowed to reduce their carbon tax liability by offsetting any payment of the electricity generation levy and the costs of additional purchases of renewable energy (whether or not the project is under the REIPPPP), which renders the carbon tax neutral on the price of electricity. These measures aim to cushion poor and low-income households and energy-intensive users from higher energy prices in the first phase of the carbon tax. Both of these measures help to avoid regressive impacts of the carbon tax, and both have been extended through 2025. Some of the revenue of the carbon tax is proposed to be used and recycled for the REIPPPP program through soft earmarking and to reduce the electricity levy that would be applicable to these REIPPPP projects as well.

Carbon offset allowances

Carbon offsets can be used to reduce liable entities' tax obligation by 5-10% depending on the industry. Offsets projects and credits that are approved, listed, and retired under the Carbon Offset Administration System platform managed by the Department of Mineral Resources and Energy are eligible. The South African Carbon Tax Offset system currently operates through a "gatekeeping" model, whereby projects in South Africa developed under the Clean Development Mechanism, the Verified Carbon Standard, and the Gold Standard are potentially eligible. For an offset to be eligible, it must come from emissions reductions achieved within South Africa and come from a sector not covered by the tax (i.e., waste, agriculture, forestry, other land use, or public transportation). The government anticipated an increased supply for carbon tax offsets, because of the REIPPPP scheme incentivizing generators to develop renewables that subsequently could be used as offsets. To compensate for this reduction in demand, the government decided that REIPPPP projects could not be used as carbon tax offsets. Through this exclusion the government ensured that the overlap between the carbon tax and the renewable energy support scheme would be minimal. However, this measure also received critique for not delivering the most cost-efficient method for emission reductions.

The government is also considering developing its own crediting mechanism. In January 2022, the DMRE released for public comment a draft framework to develop domestic carbon offset standards. The draft sets out the requirements and criteria for selection, evaluation, and approval of domestic standards.

Other emission allowances

Phase 1 offers additional emissions allowances. These include a basic tax-free allowance of 60% for all activities, a 10% process and fugitive emissions allowance, a maximum 10% allowance for companies that use carbon offsets to reduce their tax liability, a performance allowance of up to 5% for companies that reduce the emissions intensity of their activities, a 5% carbon budget allowance for complying with the reporting requirements, and a maximum 10% allowance for trade exposed sectors. In Budget 2022, it was announced that the basic tax-free allowance will gradually phase away beginning January 1, 2026, after stakeholder consultations.

The carbon tax in the power sector

South Africa has developed a complex system of thresholds and exemptions to address the plethora of concerns about costs to the sectors covered, and the different impacts of these costs. The power sector is no exception.

The carbon tax is applied at the generation stage of the power sector value chain. Net generation is taxed rather than gross generation. Fossil fuel electricity generators can offset the carbon tax by subtracting the renewable energy premium and the electricity levy. The former is a premium paid for purchasing renewable energy under the Renewable Energy Independent Power Producer tariff. It is limited to Eskom and other electricity generators that also purchase electricity (National Treasury, 2021). The latter (also known as the environmental levy) is placed on fossil fuel generators at 3.5 ZAR cents/kWh.

In Phase 1, the carbon tax is expected to be approximately offset by the renewable energy premium and electricity levy. Although the electricity levy will remain constant while the carbon tax increases yearly, the size of the renewable energy premium payments will overwhelm this dynamic so that the combination of the electricity levy and the renewable energy premium is expected to completely offset the carbon tax. Carbon offsets must be purchased, which means that Eskom incurs a cost when using the 10% offset allowance. The carbon offsets have a price cap such that it cannot be higher than the tax. As well, the combined renewable energy premium and electricity levy cannot offset more than the total value of the carbon tax, which ensures there is no effective negative carbon tax. Nersa allows Eskom to pass through their prudent expenditure. Eskom therefore must demonstrate that they minimize their effective tax burden to be allowed to pass the cost through in tariffs.

Schedule 2 of the Carbon Tax Act sets out the various tax-free allowances. Electricity and heat production comes under Intergovernmental Panel on Climate Change code 1A1a. More details are set out in Eskom's (2021) Generation Licensee document. Eskom can offset emissions associated with 1A1a by the electricity levy and renewable energy premium. However, since 2023, Eskom can no longer offset emissions associated with domestic aviation (1A3a) (associated with helicopters assessing monitoring transmission lines) and use of electrical equipment (2G1b) (any leaks for gas-insulated switch gears).

To meet the updated NDC mitigation goal, the National Treasury proposes to increase the pace at which the carbon tax rate goes up. The goal is to provide policy certainty to tax liable companies on the carbon price over the short, medium, and long term to guide their planning and future investment decisions. In the short term, the significant tax-free emissions allowances (60–95%) were included in the tax design to result in a net tax rate of between ZAR 6 and ZAR 48/tCO₂e (0.3 USD to 2.5 USD), to provide current significant emitters time to transition their operations to cleaner technologies through investments in energy efficiency, renewables, and other low-carbon measures (South African Revenue Service, 2020). Critics have said that the carbon tax does not give a strong price signal to discourage fossil fuel investments in favor of renewables, and more ambitious regulations should be put in place to support decarbonization (Hanto et al., 2022).

FINDINGS ON THE EXPECTED IMPACT OF CARBON PRICING IN SOUTH AFRICA'S POWER SECTOR

The theory of change for this study detailed five intermediate outcomes effective carbon pricing will have in the power sector:

1. **Investments and retirements** of power sector assets and broader infrastructure shift to lower-carbon systems over time.
2. **Prioritized dispatch** of least-cost least-emissions power generation sources and accompanying flexibility resources.
3. **A shift toward less carbon intensive wholesale electricity purchased by final consumers.**
4. **A shift in electricity consumption patterns** in response to a carbon price (higher cost than no carbon price).

5. **New government revenue** from tax or auction supplements and/or reduced reliance on other (less efficient) revenue sources.

This section outlines the findings on whether South Africa's carbon tax will have these expected outcomes, based on expert interviews and desk-based research.

Investments and retirements

The carbon tax is currently fully offset by the electricity levy and renewable energy premiums and is thus not expected to have had any impact on investments and retirements. However, the announcement of the carbon tax projected to 2030 can provide a price signal. Thus, the impact on investments is expected to change in successive phases, **favoring investments in renewables in the long term**. How natural gas fits into this is unclear; it is viewed as a potential transition fuel that would provide flexible generation with significantly lower emissions than coal. However, South Africa currently pays more for natural gas, which it imports, than for domestic coal. Whether a higher carbon price in the future will offset these costs will depend on the relative fuel prices and the carbon price at the time.

The [IRP 2010](#) included a carbon peaking limit, which was based on the outcome of an annual African National Congress (ANC) policy meeting. This forced a change in the IRP toward nuclear based on the economics at the time. However, the [IRP 2019](#) was prepared a year in advance. At that time uncertainties regarding its implementation and details of the carbon tax remained and thus the plan does not address it. Nonetheless, Eskom cannot ignore the projected carbon tax through 2030 in its modelling, which the National Treasury has measured. **New generation technologies are expected to be either nuclear, gas, or renewables and storage**. Indeed, it is expected that when IRP 2023 releases sometime this year, it will not include plans for any new coal power plants and the carbon tax is being factored into the modeling to some degree.

As South Africa does currently not have a wholesale market with marginal pricing, a carbon tax does not increase the absolute revenues of renewables as their unit revenues are currently fixed based on their PPA with the National Transmission Company (Eskom). Nonetheless it makes renewables more competitive relative to fossil fuel generators that are now more expensive to operate. The carbon tax does impact the relative costs as fossil fuel generators could lose their competitiveness as the carbon tax increases. While the electricity levy and renewable energy premium in Phase 1 of the carbon tax is currently offsetting this impact, **Eskom may manage its portfolio differently and increase investments in renewable energy in anticipation of later phases**. However, further stimulation of renewable energy capacity relies on sufficient transmission network to transport large amounts of variable renewables across the country, and transmission grid expansions typically take years to build.

Eskom has raised the concern that tariffs are still not cost reflective even as they have increased significantly in the last few years. Nersa is reluctant to increase tariff allowances, given affordability concerns for consumers. **If the electricity levy and renewable energy premiums can no longer offset the carbon tax after 2025, Eskom's ability to invest in maintaining its fleet of coal power plants will be compromised**. Coal power plants that are approaching their end of useful life are expected to be retired regardless of the carbon tax, and it is unclear whether the carbon tax will accelerate this process.

Prioritized dispatch

The generators the carbon tax is expected to affect are dispatchable thermal generators such as coal power plants and open cycle gas turbine plants using diesel or kerosene. The carbon tax will impact the cost of generating through the incremental cost curve thermal generators submit to the system operator, as outlined in the first section of this case study. The generators are therefore expected to include the full cost of the carbon tax when submitting the cost curves to the system operator. **Given the dispatch algorithm minimizes total costs subject to technical constraints, the most carbon-intensive technologies (i.e., inefficient coal power plants) will be dispatched only in three instances:** (1) when their total cost is lower or equal to the most expensive generator being dispatched, (2) when the power plant is required to solve a system constraint, or (3) when the system operator calls on it in real time.

Capacity constraints and resulting load shedding will drive the impact of the carbon tax on prioritized dispatch of least-cost least-emissions power generation sources in the short to medium term. If the system has spare capacity, high-carbon generators are likely to receive fewer operating hours, because of the carbon tax. However, due to the acute capacity gap, **changes to short-term dispatch decisions are expected to be limited**, as there are limited options to switch in the short term from coal to a lower-carbon option. All firm capacity is needed to minimize outage events and maintain system stability (Nersa, 2015).

Any future impact that the carbon price has on the operating hours of coal plants will likely be greater in the case of older facilities than new ones. The newest coal power plants, those furthest from retirement, tend to be the least variable cost coal plants. For example, Medupi is one of the most efficient (in terms of emissions) and lower-cost coal plants, as it has a coal mine in very close proximity, and thus has fuel costs that are lower than those of other older coal mines.

Influence on wholesale purchases

A carbon price can incentivize retailers and large consumers to purchase lower carbon generation through long-term PPAs. With the increases to, and ultimately the removal of, the license threshold for new capacity sold through bilateral contracts to end-consumers, large industrial users have a choice between purchasing electricity from Eskom or purchasing it directly from IPPs through bilateral contracts. If the price of the PPA (including wheeling charges) is cheaper than the expected long-term cost of purchasing from Eskom, then it would be in large consumers' interest to purchase directly from IPPs. If the carbon price makes renewable generators more competitive than fossil fuel IPPs, there may be an increased demand for renewable PPAs with wheeling.

However, there are a few reasons why the carbon tax's incentive to shift purchases toward less carbon intensive wholesale electricity is limited. In the current phase of the carbon tax, fossil fuel generators can offset the carbon tax liability by the electricity levy, thus reducing the impact of the carbon price signal. In Eskom's case, a combination of the electricity levy and the renewable energy premiums completely offsets the carbon tax. Currently Eskom Transmission sells to Eskom Distribution, which again sells to municipalities, large consumers, and some retail customers. Eskom Distribution does not currently buy directly from IPPs. Instead, IPPs sell to the Single Buyer Office of Eskom Transmission. Hence, Eskom Distribution and the municipalities cannot buy from IPPs without a generation license, and generation licenses are only allocated in line with the IRP, which effectively determines the electricity mix that Eskom Distribution and municipalities can purchase from. **Hence, the carbon price will currently not impact the purchasing decisions that distribution companies have in South Africa.**

Shift in electricity consumption patterns

While in the short term the carbon tax has a neutral effect on electricity prices, it may increase prices in the long term and thereby incentivize a reduction in energy consumption. As around 88% of generation is from coal, the higher carbon tax is expected to increase end user tariffs in the future, and consumers may adjust consumption patterns in response. **If the carbon tax is passed through using time-of-use tariffs, it may create an added incentive for consumers to shift their consumption patterns to a time of day where the carbon intensity is lower and hourly electricity prices are cheaper.** As the buildout of rooftop solar PV and battery storage increases, time-of-use pricing together with net metering policies can encourage further uptake in renewables, where households and businesses increasingly defect from the grid. The interaction between the carbon tax and buildout of distributed energy resources should be further investigated.

However, it is unclear how the carbon tax will be passed through the value chain to consumers in a context of historical electricity tariff subsidies. Nersa is currently approving tariffs that are not cost reflective. **A carbon tax could make achieving cost reflectivity harder if Nersa does not allow full pass-through to retail tariffs.** Thus, a carbon tax could add to Eskom's current financial difficulties.

If electricity tariffs do increase as a result of a higher carbon tax, **there may be distributional impacts**. Low-income households in South Africa spend up to 27% of their income on energy, in contrast to the country average of 14%, and will have difficulty affording more (World Bank, 2022d).

New government revenue

The carbon tax raised 1.6 billion rand (USD 84 million) in 2022, making up less than 0.2% of total tax revenue collected in South Africa.³¹ This amount currently goes directly into the general government budget, and thus far the National Treasury has resisted pressure to commit to allocating these funds to energy and climate goals. However, **there is also new pressure from communities and nongovernmental organizations in favor of funding climate adaptation projects**, which may continue to increase.

Box A-4. Summary of findings for South Africa's carbon tax

The South African carbon tax does not currently impact price signals in the power sector due to its exemptions on fossil fuel generators. This is due to the environmental levy and renewable energy premiums offset any impact the carbon tax would have in the power sector. As exemptions are removed in the future, the carbon tax is expected to provide a price signal that could in theory shift investments and dispatch toward lower-carbon assets. However, the role of the carbon tax in the power sector is unclear given Eskom currently has no plans to invest in future coal power plants, as solar and onshore wind power are considered cheaper to build than new coal. Eskom has received permission to build a 3 GW CCGT power station, but not the funds to do so. There is a concern that the carbon tax will only increase the cost of electricity to consumers while South Africa struggles with capacity shortages and load shedding. During periods of supply deficit, all available power plants will need to be dispatched to meet demand, and the carbon cost is therefore likely to be passed through the value chain. Concerns about the distributional effects of the carbon tax on retail tariffs are also acute, given high poverty levels in South Africa. Eskom is currently working toward unbundling its generation, transmission, and distribution segments and updating policy documents that are likely to affect how the dispatch and tariff-setting methodology works in the future, including how the carbon price signal is passed through the value chain. Further market reform can ensure the carbon tax elicits the desirable outcomes of implementing a carbon tax.

³¹ [South Africa's carbon tax: Changes and implications for taxpayers \(deloitte.com\)](https://www.deloitte.com/southafrica/insights/publications/south-africa-carbon-tax-changes-and-implications-for-taxpayers).

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