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Macroeconomic Impacts of China’s Energy Transition

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Abstract

Solar and wind power account for a growing share of electricity generation in China and now dominate new capacity additions. As the power system transitions toward renewable generation, greater flexibility will be required to maintain system stability. This paper uses a computable general equilibrium model to assess the macroeconomic implications of this transition. Model results indicate a modest increase in electricity prices in the near-term, followed by sustained declines as renewable shares rise, particularly when variability is managed through battery storage rather than coal-fired backup generation. While the transition requires substantial adjustments in electricity supply and investment, it raises GDP in the long run and strengthens energy security. Battery-based flexibility outperforms continued reliance on coal across multiple dimensions, even when accounting for rising electricity demand from emerging technologies such as artificial intelligence. However, this transition pathway also increases the risk of stranded assets in the coal power sector.

Keywords: China, Energy Transition, Renewable Energy, CGE models

JEL Classification Numbers: O53, Q42, Q43, C68

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1 Introduction

China has experienced a rapid increase in energy use in the last 20 years, which has supported its high growth rates and industrialization. It has become the world's largest electricity producer, accounting for around one-third of global generation. At the same time, China has grown into a dominant role in the production of renewable energy technologies, contributing to a sharp decline in their costs. As a result, the expanding electricity supply in China has relied increasingly on renewable generation. In 2010, solar and wind power accounted for just over 1 percent of China's electricity generation but by 2024, their share increased to 18 percent, with total non-fossil energy sources reaching 38 percent.

Maintaining momentum toward clean electricity generation will be essential for global climate mitigation efforts, as China is the world's largest greenhouse gas (GHG) emitter, responsible for roughly one-quarter of global emissions.[1] Sustaining this progress, however, requires proactive policy measures. Firstly, with continued large-scale investment in renewable energy coupled with improved capital allocation efficiency. Secondly, complementary investments in enabling infrastructure–such as energy storage, modernized electricity grids, and enhanced system flexibility–will become increasingly important. Lastly, further policy reforms will be needed to facilitate the integration of renewable energy, including greater reliance on market-based pricing mechanisms and an expansion of the emissions trading system (ETS).

While China is on track to maintain investments in renewable energy and related infrastructure,[2] it remains important to assess the macroeconomic and energy security implications of the transition, particularly as it enters a new phase. Over the coming decade, renewable energy is expected to gradually replace coal as the backbone of electricity generation. Given the variability of solar and wind energy, this requires careful management. According to the IEA (2024a), in the current state of energy transition in China there is a need to build in a broad set of flexibility measures. These can be grouped into four key pillars: grid expansion, supply-side flexibility, demand-side flexibility, and energy storage. While China is already investing across all four dimensions, the scale, coordination, and regulatory framework of these investments will be critical to ensure system reliability at least cost. In this context, options such as improved inter-regional grid integration, diversified storage technologies, enhanced utilization of the existing power plant fleet, demand response, and the re-purposing of coal assets for flexibility can play an increasingly central role in supporting the low-carbon transition. At the same time, the significant technological advances and resulting cost declines in battery storage take on considerable importance, as they can substantially ease the system constraints arising from the intermittency of variable renewable energy (VRE) (cf. IRENA, 2026).

Beyond the growing need for system flexibility, China's energy transition also faces the challenge of rapidly expanding electricity demand. Although economic growth has slowed in recent years and is projected to remain more moderate than in the past, electricity demand is expected to double between 2025 and 2060 (ERI, 2024). This growth is driven by the electrification of transport, heating and selected industrial processes, as well as rising electricity consumption from artificial intelligence (AI) related data centers.

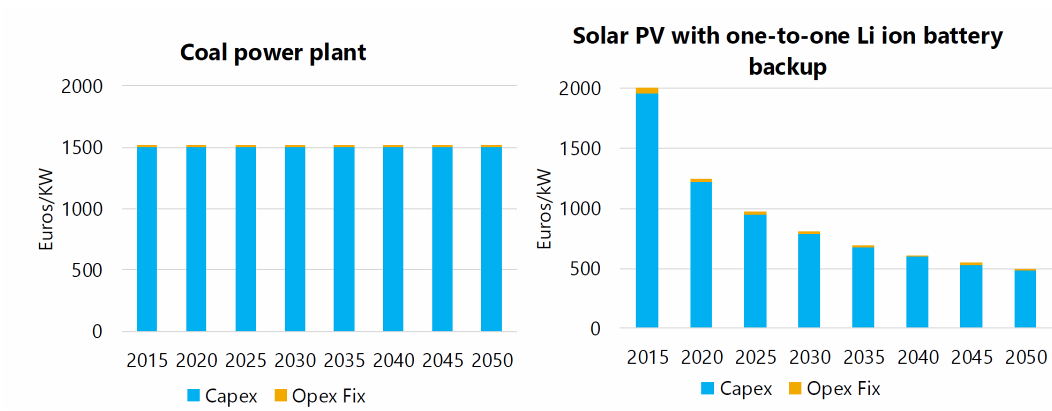
[1] However, China is not the largest cumulative emitter on a per-capita basis.

[2] See for example: https://english.www.gov.cn/policies/latestreleases/202508/25/content_WS68ac6afac6d0868f4e8f50fc.html

In this paper, we employ the IMF-ENV model (Chateau et al., 2025), a recursive dynamic global computable general equilibrium (CGE) model, to assess the macroeconomic impacts of renewable energy becoming the dominant energy source in China. We also examine how this energy transition interacts with alternative scenarios of electricity demand growth and the attainment of emission reduction targets. The analytical work using the IMF-ENV model is then complemented by a quantitative stranded assets analysis and a qualitative assessment of strategies for managing the phase-out of coal activities.

In the first step of the analysis we use the IMF-ENV model to evaluate macroeconomic outcomes for three energy transition scenarios. In the first of these scenarios, we evaluate the use of batteries as the main backup for VRE instead of coal power plants. As solar generation combined with battery storage has become less costly overall than coal-based generation and is expected to experience further cost reductions in the future (see Figure 1). This shift contributes to a decline in electricity prices and modest real GDP gains. Moreover, the deployment of batteries increases VRE output for a given level of installed capacity, thereby further raising electricity supply. With respect to energy security, our results indicate that the energy transition will substantially strengthen resilience by reducing both dependence on imported energy and the share of energy expenditure in GDP. The share of energy imports is projected to decline by 2.2 to 2.6 percentage points by 2040 from a baseline projected level of around 13.2 percent. At the same time, total energy expenditures as a share of GDP are expected to fall by between 1.7 and 2.0 percentage points from the baseline level of around 8.5 percent in 2040.

Figure 1: Global forecasts of technology costs



Source: Bogdanov et al. (2019). Note: The right-hand chart assumes that each unit of solar PV installation is backed up by one unit of battery energy storage.

The second set of energy transition scenarios considers higher electricity demand driven by AI-related data centers. In this case, we find that electricity price increases can be avoided if renewable energy is used for the additional capacity instead of coal. The third and last set of scenarios simulate alternative pathways for achieving China's official net-zero emissions target by 2060 through higher policy ambition. The results indicate that the ongoing shift toward renewable electricity generation constitutes an important step, but will not be sufficient on its own, as additional mitigation measures will be required after 2030. We find that implementing cost-effective, economy-wide policies –such as a comprehensive quantity-based emissions trading system– would make it possible to achieve the net-zero target at a relatively low GDP cost.

In the second step of our analysis, we assess the implications of the energy transition for stranded assets. Our results indicate that stranded coal capacity is projected to increase from 3 to 128 GW in 2030 to 61 to 236 GW by 2040, depending on future electricity demand and the degree of battery integration. Decisions regarding new coal investments are important: halting new construction could reduce stranded coal capacity in 2040 by as much as two-thirds. While large-scale battery adoption as backup may increase the risk of stranded assets in coal plants, rapid declines in renewable and storage costs could help offset these financial challenges, making it easier to absorb the system-wide impact of stranded assets. Although the overall financial impact of stranded coal power assets is manageable at the national level –given the relatively low exposure of China's banking sector– the consequences could be severe for specific regions with higher local exposures to coal power.

In the third step, we complement the quantitative analysis with a qualitative assessment of strategies for managing the large-scale replacement of coal with renewable energy. Given that China has more than twice as much coal capacity than the entire OECD, phasing out coal is a monumental task. However, we show that several countries have managed the transition without major social disruption and that China itself has made considerable progress. For example, coal sector employment has already declined by more than half since its peak in 2014. At the same time, China is pursuing a broad portfolio of technological options to enhance power system flexibility and accommodate a high share of variable renewable energy. The country is preparing to enter stage three (of six) of the IEA framework for integrating solar and wind power by investing in grid expansion, pumped hydro storage, battery systems, green hydrogen, and greater flexibility on both the demand and supply sides of the electricity system.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature, and Section 3 introduces the model and the counterfactual scenarios considered. Section 4 presents the simulation results, while Section 5 analyzes stranded assets. Section 6 discusses the specific challenges associated with phasing out coal and scaling up renewable energy. Section 7 concludes.

2 Literature review

Much of the literature on the energy transition in China has a strong technical focus. Zhang and Chen (2022), for example, estimate that reaching carbon neutrality will require a rapid increase in electrification, renewable energy and energy storage in the country. Wang et al. (2023b) identify the need for complementary infrastructure to support the deployment of solar and wind energy in China, including ultra-high-voltage transmission, energy storage, and power–load flexibility. With respect to transition outcomes, Gao et al. (2024) find that a shift toward cleaner energy reduces electricity costs for households, optimizes industrial structures, and decreases fossil fuel usage. The China Energy Transformation Outlook (ERI, 2024) systematically analyses the prospects for the transformation of energy production and consumption while exploring pathways and technological solutions for achieving net-zero carbon emissions under different scenarios. Our analysis draws on the report's electricity supply projections and the associated investment requirements, and complements it by providing a broader economic assessment, including the implications for electricity prices, GDP, GHG emissions, and energy security.

Regarding different technology scenarios, the literature typically analyses each technology separately.

Fan et al. (2023) estimate how the use of carbon capture and storage might decrease the need for investment and increase system resilience. Yu et al. (2024) evaluate the potential for different energy storage technologies. They find that various storage technologies can be expected to grow at rates of about 15 percent per year, with lithium-ion batteries emerging as the dominant technology by 2035. Regarding changes in electricity demand, Chen et al. (2025) evaluate the effect of AI on income distribution and energy consumption in China. They find that AI can be expected to widen the income gap and increase the consumption of non-renewable energy. We add to this literature by comparing scenarios for two types of flexibility options (coal power plants and batteries) and for increased energy use from AI, thus allowing to quantify the effects of technology adoption in a consistent framework.

Regarding energy security and stranded assets, the literature also has many dedicated research papers. Zhang et al. (2023) estimate that the continued construction of coal power plants could increase stranded coal assets from USD 55 billion to between three and seven times that amount, depending on the transition scenario. Similarly, Wu et al. (2024a) find that 6 percent of the total installed coal capacity in China is likely to be stranded if the country reaches carbon neutrality by 2060. Wang et al. (2024) confirm that a switch to renewable energy will improve China's energy security by making it less dependent on imported fossil fuels. We integrate this kind of analysis and quantify energy security and stranded assets in our macroeconomic framework.

Furthermore, achieving a net-zero pathway will require a significant strengthening of policy ambition. A commonly discussed market-based approach is the extension of the flagship policy –the Chinese ETS, which is currently limited to the power sector. Mu (2018) shows that the real GDP impact of reducing emissions decreases as the Chinese ETS broadens its sectoral and emissions coverage. An economy-wide ETS consistent with China's Nationally Determined Contribution (NDC) reduces real GDP by 2.1 percent relative to a no-policy baseline. In contrast, an ETS limited to eight energy-intensive sectors (accounting for 52 percent of CO_2 emissions in 2012) results in a substantially larger GDP loss of 10.5 percent while expanding coverage to include nine additional sectors (raising emissions coverage to 76 percent) lowers the GDP impact to 3.3 percent. Cao et al. (2019) analyze an emissions trading scheme covering the electricity and cement sectors combined with a hybrid policy that extends carbon pricing to non-ETS sectors. They find that achieving the same emissions reduction under the hybrid policy lowers both required carbon prices and welfare losses. While sector-specific decarbonization pathways have been examined (see for example, Jia and Lin, 2021), economy-wide analyses of China's net-zero transition remain relatively limited but are evolving rapidly. Cao et al. (2021) conduct a multi-model analysis using eight CGE models to simulate three carbon tax scenarios and assess the feasibility of China's emissions pathways toward its NDC and net-zero emissions targets. In most models, the NDC is achieved under the baseline scenario, and the results suggest that GDP costs remain modest even with carbon prices as high as 1,134 yuan (USD 160) per tonne of CO_2 by 2050. However, this carbon price level is insufficient to achieve the 2060 carbon neutrality target, highlighting the need for additional policies and technological options within the models.[3]

[3] Our model simulations in Section 4.3 indicate that the required implicit carbon price ranges from USD 50 to USD 275 per tonne of CO_2 by 2040, depending on the pathway chosen to achieve net-zero emissions by 2060.

3 Model description and scenarios

This section describes the methodology of the paper. Section 3.1 describes the model, IMF-ENV. This is followed by a description of the macroeconomic projections (Section 3.2), the baseline calibration (Section 3.3) and the counterfactual scenarios (Section 3.4).

3.1 The IMF-ENV model

IMF-ENV is a global recursive dynamic CGE model employed by the IMF Research Department. Full model documentation is provided in Chateau et al. (2025). It features a detailed description of energy production and consumption, and links GHG emissions to specific economic activities. This makes the model well suited to analyze macroeconomic and sector-specific effects of a variety of energy and climate mitigation policies at the national and global level. The model allows simulating mitigation policies such as carbon pricing and fossil fuel subsidies, energy demand and supply policies and regulations, improvements in energy efficiency and new green technologies, and how these affect GHG emissions, macroeconomic variables, sectoral output, employment and trade, among others. The core components of IMF-ENV –production, demand, trade, factor markets and inter-temporal linkages– are all relatively standard recursive dynamic multi-sector multi-region CGE model features.

The model is built using a neo-classical framework, which optimizes consumption and production decisions by households and firms. It follows the circular flow of the economy based on the activities of its key agents: firms, households, and markets. Firms purchase inputs (from other firms) and primary factors (from households) to produce goods and services. Households receive factor incomes and in turn demand the goods and services produced by firms. Markets determine equilibrium prices for factors, goods, and services. Finally, countries exchange goods and capital on international markets.

Factors of production are almost perfectly mobile across sectors (capital excluded) but not across countries. An important feature of IMF-ENV is that capital stocks have vintages such that firms' production and behavior are different in the short and long run. There are two capital vintages: new capital stock (i.e. net investment) is allocated without friction such that the return to new capital across sectors is the same for all sectors, on the opposite old (i.e. installed) capital is given and cannot be reallocated without high costs (i.e., a putty-clay specification). This allows for a more realistic adjustment of the capital stock in the short- and medium-run, as it increases the capital costs for expanding activities and reduces the productivity of capital that is tied to declining economic activities. Labor supply is determined by the working age population, labor participation and long-term unemployment rates. Labor adjusts endogenously to changes in real wages following a reduced-form wage supply curve that accounts for decisions on leisure and work (at both the intensive and extensive margin). The model also includes land and natural resources as production factors, which constrain the expansion of agricultural and mining activities.

Production follows a series of nested constant-elasticity-of-substitution (CES) functions to capture the different substitution possibilities across all inputs. Household demand is non-homothetic, which emphasizes subsistence (minimum) consumption levels of essential commodities (mainly food). International trade is modeled using the so-called Armington specification where demand for goods is differentiated by region of origin. This specification uses a full set of bilateral trade flows, prices and trade costs by commodity, which provides international linkages between regions, including supply chain features. The model is recursive dynamic: it is solved as a sequence of comparative static equilibria where the factors of production are exogenous for each time period and linked between time periods with accumulation expressions. Agents, however, are not forward looking and investment levels are driven by savings, which in turn is a combination of household savings, the government budget balance and the current account balance.

Within the neo-classical framework of the model, the primary transmission mechanism for policy shocks operates through changes in relative prices and the substitution possibilities within consumption, production, and trade. The extent of behavioral responses to these changes is determined by the relevant elasticities. For instance, implementing an energy tax would raise energy prices for both intermediate and final consumption, increasing the cost of energy-intensive goods and reducing overall energy demand. Consequently, the magnitude of both macroeconomic and sectoral effects is determined by the underlying economic structure of each country captured by the input–output tables, in combination with production, consumption, and trade elasticities and the degree of substitutability across affected inputs and goods.

The IMF-ENV model compares a business-as-usual (baseline) scenario with frozen trade, energy and climate policies with a policy counterfactual scenario that introduces new or alternate policies. The differences between both scenarios are used to estimate the impact of the policies on macroeconomic variables (e.g., GDP, sectoral production and employment, bilateral trade), energy variables (electricity generation mix, energy demand) and environmental outcomes (GHG emissions).

The IMF-ENV model is built primarily on a database of multi-regional input-output tables, combined with national accounts and bilateral trade flows. The central input of the model is the GTAP-Circular Economy (CE) database (version 11) with base year 2017.[4] This database contains country-specific input-output tables for 141 countries and 19 aggregate regions, and data for 88 commodities and 99 economic activities. For this project we use the G20 regional aggregation, which has 25 regions, 39 activities and 31 commodities. The specific regions, activities and commodities are presented in Tables 4 to 6 in the Appendix. The model runs until 2040. The database also represents world trade flows comprehensively for a given starting year. To allow detailed modeling of energy supply, the database includes eight electricity generation technologies: coal, natural gas, oil (diesel), hydro, nuclear, solar, wind and others (e.g., geothermal, biomass), as well as an electricity transmission and distribution activity. Finally, the database also includes all main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases.

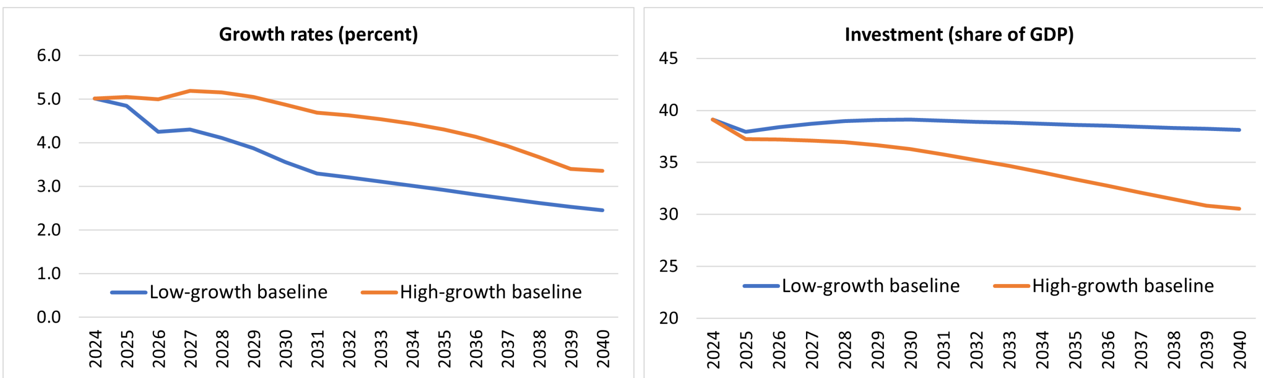
3.2 Macroeconomic framework assumptions

China's potential GDP growth is projected to decelerate over the medium and long term compared to historical rates. This decline reflects the structural constraints of a maturing economy, including diminishing returns to investment and lower productivity growth, and is compounded by rapid population

[4]The GTAP-CE database is an expansion of the GTAP-Power database Chepeliev (2023), which in turn is an expansion of the standard GTAP database (Aguiar et al., 2022). The GTAP-Power database, in contrast to the standard GTAP database, distinguishes 12 electricity generation activities. Furthermore, the GTAP-CE introduces an additional disaggregation of selected minerals and chemicals to the GTAP-Power database that align with the EU-CBAM products –e.g., fertilizers, cement, aluminum, copper, iron and steel.

aging. However, significant economic reforms could help mitigate the slowdown. Accordingly, our simulations calibrate two baseline scenarios for China's growth prospects until 2040, representing high and low growth pathways depending on whether future reforms are implemented. First, our low-growth baseline projections follow Muir et al. (2024), who estimate China's average growth rate at 3.8 percent from 2025 to 2030 and 2.8 percent from 2031 to 2040, without accounting for future structural reforms. Second, the high-growth baseline scenario is based on Cerdeiro et al. (2024), who model productivity-boosting structural reforms and a shift in China's growth strategy toward greater domestic consumption. This scenario projects potential average annual growth at around 4.3 percent between 2025 and 2040.[5] By 2040, the low- and high-growth scenarios predict growth rates close to 2 and 3 percent, respectively (Figure 2).

Figure 2: China, baseline scenarios, projections on growth and investment shares



Source: IMF Staff calculations based on Cerdeiro et al. (2024) and Muir et al. (2024).

In addition to the real GDP projections, we apply several assumptions regarding structural balances. China's high growth rates in the early 2000s were largely driven by increases in productivity following the WTO accession and rapid accumulation of capital on the supply-side. However, this strong growth was also accompanied by increasing imbalances, initially external (with very large current account surpluses), and later internal (with low consumption relative to investment), as described in (Zhang et al., 2018). Elevated investment levels in China have hastened the decline in aggregate productivity and potential growth, while also raising concerns about the sustainability of the investment-led growth model given high debt across the economy. On the demand side, Chinese households have historically maintained very high savings rates, largely due to precautionary saving behavior arising from gaps in social protection, increased employment uncertainty, and population aging (Zhang et al., 2018; IMF, 2022). These high savings rates are reflected in China's relatively high share of investment in GDP over time (Figure 2).

To project total investment, the general government balance, and the current account balance (CAB), we rely on the IMF's World Economic Outlook (WEO) data from October 2025, which covers the period from 2025 to 2030. Beyond 2030, we introduce scenario-specific assumptions. In the low-growth baseline scenario, total investment is projected to remain steady at approximately 38 percent of GDP, in line with Muir et al. (2024). Conversely, the high-growth baseline scenario, based on Cerdeiro et al. (2024), envisions a shift toward greater private consumption, with investment shares gradually decreasing to

[5] The low-growth baseline projections are close to the OECD's SSP2 scenario (Dellink et al., 2017) and NGFS growth projections (NGFS, 2024), while the high-growth baseline projections are similar to the China Energy Transformation Outlook Report (ERI, 2024) and the World Bank's Country Climate Development Report (World Bank, 2022).

around 30 percent of GDP by 2040. For the baseline government and current account balances, we adopt the standard neoclassical macro closure assumption by holding their absolute levels constant after 2030. As a result, their shares relative to GDP decline gradually through 2040. This assumption is consistent with the intended rise in private consumption, while abstracting from long-term changes in fiscal policies and foreign capital flows that are not directly related to the energy transition.

3.3 Baseline scenario calibration

Macroeconomic variables are calibrated based on the growth assumptions detailed in Section 3.2. Hence, we assume two distinct growth paths with different assumptions on the shares of investments to GDP, but relatively similar assumptions for the calibration of the government balance and CAB. In addition, we assume that total labor supply evolves in line with projections of working age population that are consistent with the "Middle of the Road" Shared Socioeconomic Pathway (SSP2) of Dellink et al. (2017).

An important feature of our modeling exercise is that we calibrate total electricity supply and its composition by power source using projections from energy models. Specifically, the baseline electricity supply projections are sourced from the current policy scenario from the NGFS Phase V GCAM model simulations (NGFS, 2024).[6] For the counterfactual scenarios we use the projections of electricity supply from the China Energy Transformation Outlook Report (ERI, 2024), hereafter referred to as the CETO report, which account for the expansion of renewable generation and the increase in electricity demand driven by greater electrification of the economy.[7]

In both our baseline and counterfactual scenarios, we assume that solar electricity generation costs steadily decline by 3 percent annually, while wind generation costs also decrease but at a slower rate of 2 percent per year.[8] These reductions lead to lower production costs for both power sources, which in turn influence electricity prices in proportion to the share of solar and wind in the overall generation mix.

Figure 3 depicts total electricity supply and its composition in 2023, along with their changes over time under both the baseline and counterfactual (BCNS) scenarios.[9] Under the baseline (high-growth) scenario, total electricity supply increases steadily, reaching a level 73 percent higher in 2040 than in 2023. This growth is driven primarily by the expansion of solar and wind generation, alongside a moderate decline in coal's share.

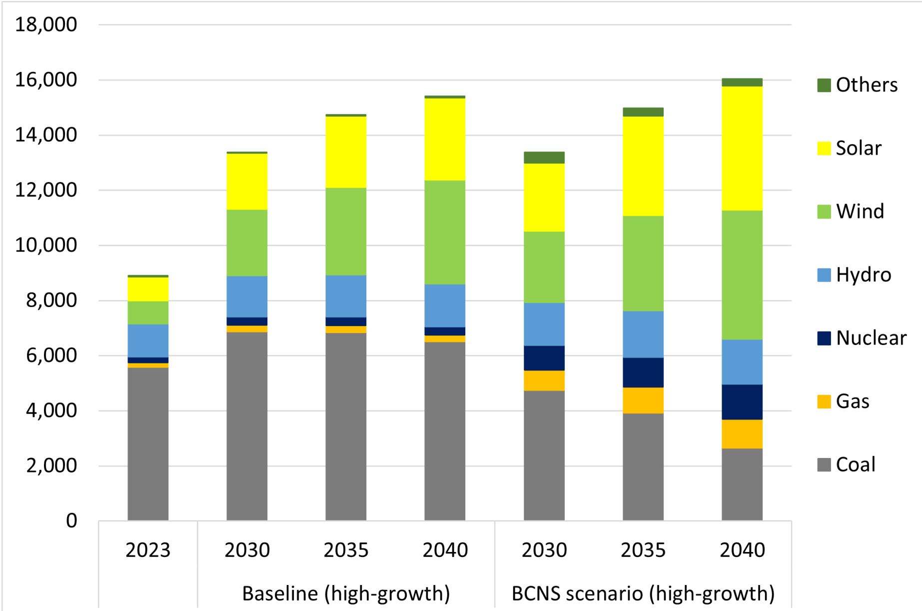
[6] All electricity supply projections are calibrated to align with each of the growth paths we employ.

[7] This study uses two energy models –China's End-Use Energy Demand Analysis Model (ERI-LEAP) and the Electricity and District Heating Optimisation Model (ERI-EDO); and an integrated assessment model (IAM): the Energy Transformation Socio-Economic Impact Assessment Model (CETPA). Throughout our study We use their Baseline Carbon Neutrality Scenario (BCNS).

[8] These cost reductions are based on Bogdanov et al. (2019).

[9] In the low-growth baseline and counterfactual scenarios (not shown), total electricity supply is approximately 9 percent lower than in the high-growth scenarios. Nonetheless, the shifts in electricity generation composition in the low-growth scenarios closely resemble those shown in Figure 3.

Figure 3: Projections on electricity supply by source for the baseline and policy high-growth scenarios (in TWh)



Source: IMF Staff calculations based on NGFS (2024) and ERI (2024).

3.4 Counterfactual scenarios

All counterfactual scenarios are grounded in projections from the CETO report, encompassing electricity capacity and generation (supply), the electricity mix (the proportion of each power source in total generation), the rate of electrification in the transport and industrial sectors, and the required infrastructure investments as a share of GDP— including grid expansion and renewable energy projects, electric vehicles (EV) charging infrastructure, and firm-level investments to enhance electrification in industrial processes, among others. Consequently, unlike the baseline scenario, the counterfactual scenarios reflect the anticipated energy transition marked by a major shift in the supply mix, with a sharp reduction in coal generation and large-scale growth in solar and wind capacity (see Figure 3). These scenarios also foresee a slightly larger increase in total electricity generation, driven by higher electrification demand, reaching 80 percent above 2023 levels by 2040, but do not include higher electricity demand from AI-related data centers.

For all counterfactual scenarios, we use the electricity supply projections from the main (BCNS) scenario in CETO as the baseline. This scenario assumes a transition toward VRE, strong GDP growth, coal remaining the main backup source, and no additional electricity demand from AI. It is important to note that the electricity supply and generation mix produced by CETO's detailed energy models satisfies technical feasibility constraints and system balancing requirements. As shown in Figure 3, this BCNS scenario includes an even larger expansion of solar and wind generation relative to the baseline scenario, accompanied by increases in nuclear and gas generation and a more pronounced decline in coal generation.[10] We then scale down electricity supply to align with our lower GDP growth assumptions

[10]The nuclear expansion reflects only conventional nuclear technologies. Should advanced nuclear technologies reach commercial viability, they would offer an additional low-carbon complement to solar and wind generation.

in each respective scenario. In addition, consistent with CETO, we model two key assumptions. First, we assume that all household vehicles are electric by 2035, sharply reducing the share of refined oil in household energy demand. Combined with further household reductions in coal and natural gas use for heating and cooking, electricity demand is expected to account for approximately 97 percent of total household energy demand by 2040. Second, we model increasing electrification of industry and commercial transportation such that by 2040 electricity represents 50 percent of intermediate energy demand in manufacturing and doubles in commercial transportation (from the current value of around 14 percent to 28 percent).

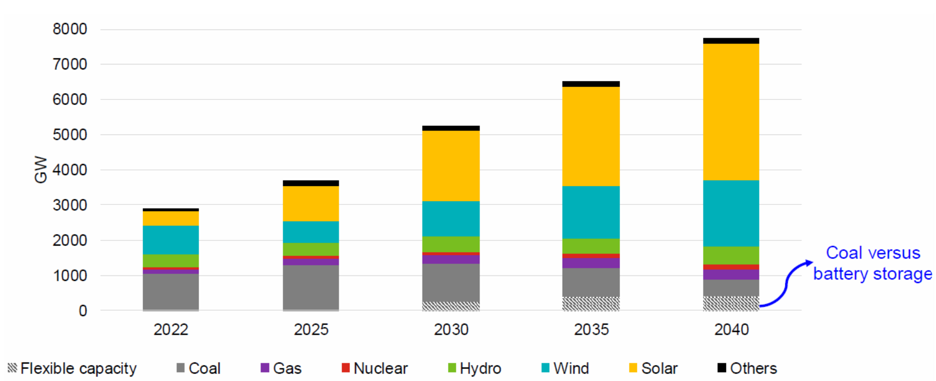
Moreover, in the counterfactual scenarios we assume that the energy transition is driven by cost reductions in renewable generation resulting from technological change, without the introduction of additional policies beyond those implicitly included in the BCNS scenario of CETO. Accordingly, these scenarios incorporate existing policies, including the current intensity-based ETS in the electricity sector and its planned expansion in 2025 to cover cement, aluminum, iron, and steel industries

Finally, the baseline projections for total GHG emissions are calibrated using the "current policies" scenario from the NGFS Phase V GCAM model simulations (NGFS, 2024). In all our counterfactual scenarios, GHG emissions are determined endogenously by the model.

3.4.1 Energy transition scenarios under different back-up technology assumptions

This first set of scenarios is modeled to quantify the impacts of choosing different flexibility options for backing-up variable renewable energy sources. These scenarios are structured along two dimensions. The first captures alternative economic growth paths (low and high growth), based on our macroeconomic assumptions. The second reflects the choice of primary backup technology for VRE, namely coal or batteries. Figure 4 presents historical and projected generation capacity by source, where flexible capacity denotes the portion of total backup capacity that can be supplied either by coal or battery storage. While this constitutes a relatively small portion of total capacity, it can lead to distinct electricity price and macroeconomic impacts.

Figure 4: China, projections on electricity generation capacity by source in GW



Source: IMF Staff calculations based on ERI (2024).

These combinations yield four initial scenarios (see Table 1). The CETO report assumes that VRE backup is provided primarily by coal, and to a lesser extent by hydropower, nuclear, and natural gas.[11] Accordingly the scenario in which VRE is mainly backed up by coal follows the estimations from CETO, where by 2040 VRE represents 57 percent of total electricity generation, with 422 GW of installed coal capacity used for backup. When batteries are the main backup technology we assume that no coal capacity for backup is required.[12] Moreover, batteries serve a dual function: they act as a storage option and can also indirectly increase solar generation by storing excess electricity and releasing it during periods of high demand. As a result, a larger share of solar generation can be utilized, effectively enhancing the contribution of installed VRE capacity. Based on estimations from He et al. (2020), we assume that using batteries as the main backup technology raises the share of solar in total electricity supply by six percentage points, resulting in VRE representing 63 percent of total generation in 2040.

We also rely primarily on the CETO report as the main source for estimating the additional investment requirements associated with the energy transition.[13] For the scenarios where VRE is backed up by coal, we use the CETO report estimates that the additional yearly investment needs amount to an average 2.3 percent of GDP. When VRE is backed up mainly by batteries, we estimate that average annual investment requirements fall to 2.1 percent of GDP. Our estimated reductions in the investment costs are explained by the assumption that coal generation costs are expected to remain constant while solar generation and battery costs continue to decline over time (see Figure 1).

Battery backup is modeled by increasing renewable generation (reflecting batteries' dual function), deducting the investments needed for installing batteries from the total annual investment costs, and assuming no excess coal capacity requirements for VRE backup.[14] As a result, electricity supply and generation mix remain equal across scenarios, ensuring adequate system balancing and flexibility for increased VRE.

[11] Note that the CETO report projects that backup support from new storage technologies, including batteries, will become significant only after 2040. Rather, it assumes that by 2060, hydrogen and e-fuels will be the primary sources of flexibility for balancing the electricity system.

[12] Other backup options, such as hydro and nuclear, remain active, with their output levels identical in both scenarios.

[13] Note that higher electricity generation in the model entails increased capital investment, which is endogenously determined based on the initial cost structure of the electricity sector. We then compare these endogenous investment requirements with the higher total investment needs projected by CETO. The difference between the two is then exogenously imposed in the policy simulations. The investment differences primarily stem from higher costs related to upgrading the grid infrastructure for electricity transmission and distribution.

[14] This last assumption is examined in our stranded assets analysis in Section 5.

Table 1: Scenario matrix

	VRE backed up by coal by 2040 57% of total generation is VRE 422 GW of coal capacity for backup 2.3% of GDP invested on green energy	**VRE backed up by batteries by 2040** 63% of total generation is VRE 0 GW of coal capacity for backup 2.1% of GDP invested on green energy
Low GDP growth rates From 5% in 2025 to 2% in 2040	LowGr_Coal	LowGr_Battery
High GDP growth rates From 5% in 2025 to 3% in 2040	HighGr_Coal	HighGr_Battery
AI data centers (with high growth) 3.5% increase in electricity demand	AI_Coal	AI_Battery
Net Zero pathway (with high growth) Based on NGFS pathway		NZ_NGFS
Net Zero pathway (with high growth) Emissions peak in 2025		NZ-peak2025
Net Zero pathway (with high growth) Emissions peak in 2027		NZ-peak2027

3.4.2 Scenarios with increased electricity demand from AI

The second set of scenarios quantifies the economic effects of rising electricity demand driven by the continued expansion of the energy-intensive data centers that support the development and deployment of AI. To quantify this shock we draw on Bogmans et al. (2026), who estimate that electricity demand from data center expansion associated with AI in China will grow by about 10 percent annually, reaching roughly 3.5 percent of total electricity supply by 2040.[15] Using this information, we add two additional scenarios to our matrix: AI_Coal and AI_Battery. Both scenarios assume that electricity demand increases by 3.5 percent because of higher demand from AI-related data centers and the high GDP growth assumptions.[16] The main difference lies in the source of additional generation: AI_Coal assumes that the additional required electricity supply is provided fully by coal generation, whereas AI_Battery assumes it is fully provided by solar combined with battery storage.[17]

It should be noted that these AI-related scenarios do not account for any additional growth effects generated by AI itself. Although such effects are likely to be positive and potentially significant, they remain highly uncertain, both at the macroeconomic level and in terms of sectoral dynamics and their

[15] Note that in their modeling framework, this demand shock is implemented by increasing electricity demand from data centers through higher productivity in the IT sector. In contrast, we model the additional electricity demand by increasing total electricity supply in China rather than sector-specific IT demand, therefore, working under the assumption that leads to some differences in the results as explained below.

[16] As AI is a relatively novel technology, large uncertainties remain on its development trajectory and adoption. Therefore, projections on AI-related electricity demand remain uncertain. Our shock on China's projected data-center electricity consumption in 2030 falls within, but toward the lower bound of, the IEA's forecast range of 260–470 TWh (IEA, 2024b).

[17] In addition, these two scenarios keep the assumptions associated with VRE backed by coal and by batteries, respectively.

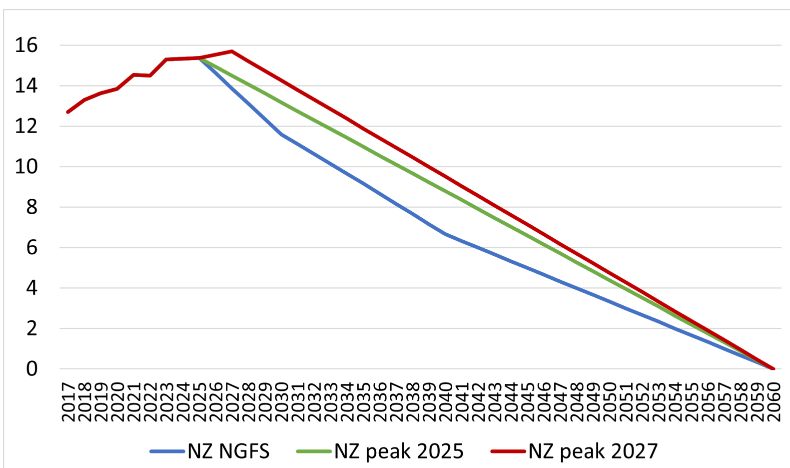
implications for overall electricity demand. Our AI-related scenarios therefore only assess the expected electricity demand arising from the expansion of AI-related data centers.

3.4.3 Scenarios targeting a net zero emissions pathway

The third set of scenarios examines various net-zero emission pathways. Under its earlier Paris Agreement commitments, China pledged to peak emissions before 2030 and achieve net-zero emissions by 2060 (ERI, 2024). In the most recent 2035 NDC commitments, China pledged to reducing economy-wide net GHG by 7 to 10 percent from peak levels by 2035. In both cases, the timing of the emissions peak directly shapes the net-zero emission trajectory.

Total GHG emissions from China have been steadily increasing over time, but have recently stabilized around 15 Gigatonnes of CO_2-equivalent (GtCO2eq).[18] However, it remains uncertain whether emissions have already peaked in China, leaving open multiple possible pathways to achieve net zero by 2060. Since the peak year represents an upper bound, we consider three scenarios with alternative assumptions about the timing of emissions peaking (Figure 5). The first scenario, NZ-NGFS, follows the NGFS Phase V net-zero emissions pathway for China, in which emissions peak in 2025 and then decline rapidly in early years before moderating over time (NGFS, 2024). We construct two additional pathways –NZ-peak 2025 and NZ-peak 2027– in which emissions peak at those respective years and then decline linearly until 2060.

Figure 5: China, total GHG emission pathways for different scenarios (GtCO2eq)



Source: IMF Staff calculations based on the IMF Macroeconomic Climate Indicators Dashboard and NGFS (2024).

Achieving these pathways will require a sharp reversal in current emission trends. Even under continued progress in renewable energy deployment, additional mitigation measures will be needed to align with a net-zero consistent pathway by 2040. To meet these deeper emission reductions, we model three additional counterfactual scenarios. All scenarios build on the high-growth baseline with VRE supported by battery storage (see Table 1). Furthermore, to curb GHG outside the electricity sector, we simulate a quantity-based emissions trading system (QB-ETS) in each scenario.[19] Through this mechanism, the model endogenously determines the implicit carbon price for non-electricity emissions under the QB-ETS

[18]Based on historical data from the IMF Macroeconomic Climate Indicators Dashboard (https://climatedata.imf.org/).
[19]This reform of the existing ETS aligns with prior IMF recommendations (cf. IMF, 2024).

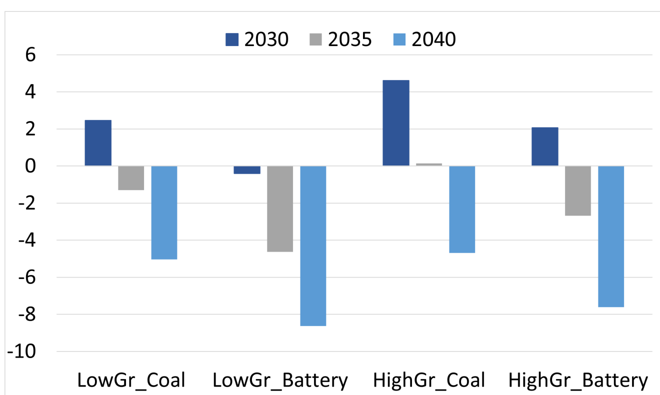
that aligns with the overall emissions target, taking into account emission reductions already achieved in the electricity sector via the anticipated energy transition.[20]

4 Results

4.1 Impacts of the energy transition

Regardless of the GDP growth assumptions, expanding electricity supply (see Figure 3 and Figure 4) requires additional investment in the power sector relative to the baseline. Given the model's vintage capital structure, these investments take time to translate into new capacity. As a result, electricity demand initially rises faster than supply, generating short-term upward pressure on prices for all scenarios except in the low-growth battery backup scenario (LowGr_Battery). As shown in Figure 6, when coal is used to back up variable renewables, short-term electricity prices increase by 2.5 to 4.5 percent relative to the baseline. By contrast, when battery storage complements variable renewables, the short-term price response is more muted, with price effects ranging from -0.4 to 2.1 percent by 2030. This pressure unwinds over the medium to long term as new electricity supply becomes available, eventually leading to electricity prices falling below the baseline ranging from -4.7 to -5 percent with coal backup and -7.6 to -8.6 percent with battery backup by 2040. The electricity price pressures are weaker under battery-based backup technologies than under coal, reflecting the virtuous channel that is assumed in the model whereby greater battery deployment enables higher renewable generation.

Figure 6: Domestic electricity prices (percent change relative to baseline)

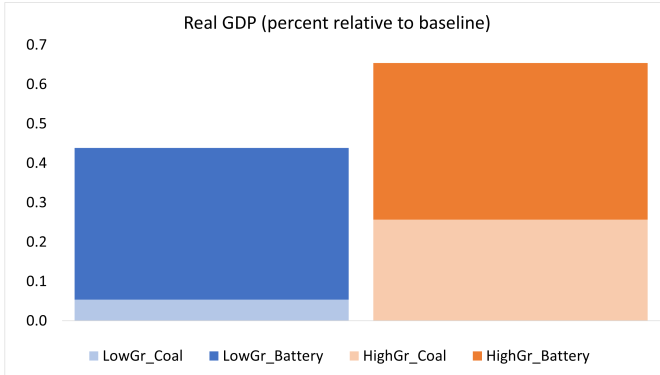


Source: IMF Staff calculations using the IMF-ENV model.

Overall, GDP increases relative to baseline values, across all energy transition scenarios by 2040 (Figure 7), regardless of the choice of backup technologies, although the gains are larger in scenarios where batteries are used as backup rather than coal. While these gains are modest –ranging from 0.05 percent to 0.65 percent of GDP in 2040– they are nonetheless meaningful given the scale of the energy transformation they deliver.

[20]We also assume that China is the only country implementing these additional policies toward net-zero, while other countries maintain their current policy pathways.

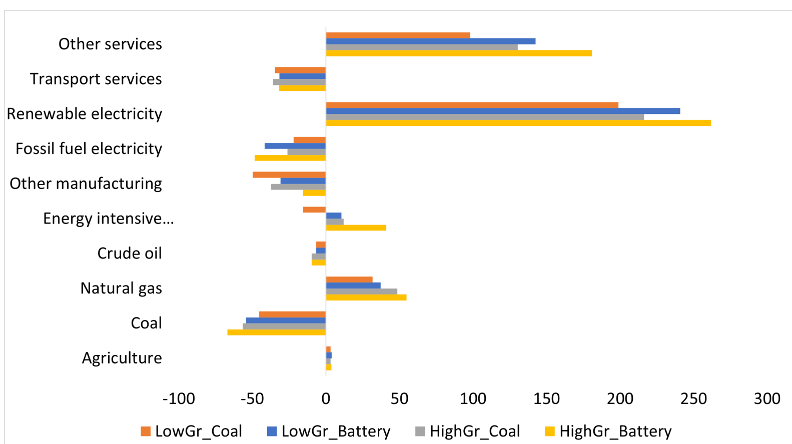
Figure 7: Real GDP changes in 2040 (percent change relative to baseline values)



Source: IMF Staff calculations using the IMF-ENV model.

Expanding electricity supply, at lower prices, raises aggregate economy-wide value added and induces a reallocation across sectors. Within electricity generation, declining production costs for renewable technologies increase the value-added contribution of variable renewables, more than offsetting losses in fossil-based generation (Figure 8). These shifts are accompanied by second-round effects upstream, most notably a decline in value added in coal mining reflecting lower fossil fuel demand. Over the longer term, lower electricity prices and higher assumed electrification rates reallocate value added toward energy-intensive manufacturing sectors in most scenarios. By contrast, value added in fuel-intensive transport declines, reflecting reduced demand for fossil fuels and substitution toward electrified alternatives as relative energy prices adjust.

Figure 8: Change in sectoral value added (2040, absolute differences in billion RMB relative to baseline values)



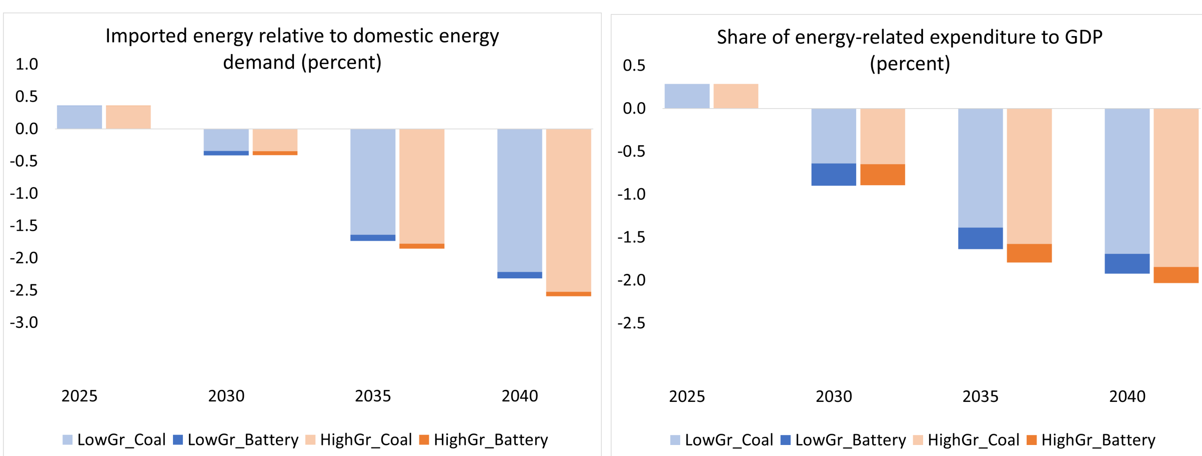
Source: IMF Staff calculations using the IMF-ENV model.

From the demand side, the long-term positive GDP impact is driven by higher private consumption and investments. Private consumers benefit from higher real income due to lower electricity prices, which boost consumption. Figure 8 shows that the increase in demand for services is particularly strong, reflecting its higher income demand elasticity.

As China transitions toward higher shares of renewable energy by 2040, key energy security indicators strengthen. This reflects changes in domestic electricity production prices and rising electrification, which shift energy demand away from fossil fuels and affect trade flows. These indicators include the share of imported energy in domestic energy demand and the share of total energy related expenditure in GDP. The former captures energy import dependence, while the latter reflects the overall energy intensity of the economy and the sensitivity of economic activity to energy price shocks. China imported about 14 percent of its total energy consumption in 2024. Under the baseline scenarios, this share declines modestly to about 13 percent by 2040 under the high growth scenario and to about 13.4 percent under the low growth scenario. Over the same period, total energy expenditures as a share of GDP fall from about 11.4 percent in 2024 to around 8.0 percent under the high growth scenario and 8.9 percent under the low growth scenario by 2040. This decline in energy expenditures is driven by a combination of lower electricity prices, a higher share of electricity in total energy demand due to increased electrification of the economy, and a corresponding reduction in demand for imported fossil fuels.

Model simulations show that China's energy transition improves energy security along both dimensions over the long run under both growth scenarios (Figure 9). In the early years of the transition, however, these indicators temporarily deteriorate as the energy system adjusts and investment requirements increase. Over time, as renewable capacity expands and the electricity generation mix shifts toward lower cost solar and wind technologies, the indicators improve. By 2040, energy import dependence declines by about 2.2 to 2.5 percent in the coal backup case, with an additional reduction of around 0.1 percentage point when battery storage is included relative to the baseline. At the same time, energy related expenditure as a share of GDP falls by about 1.7 to 1.8 percent with coal backup, with a further decline of about 0.2 percentage point in the battery storage scenario. The reduction in both indicators is somewhat larger under the high growth scenario than under the low growth scenario.

Figure 9: Indicators of energy security



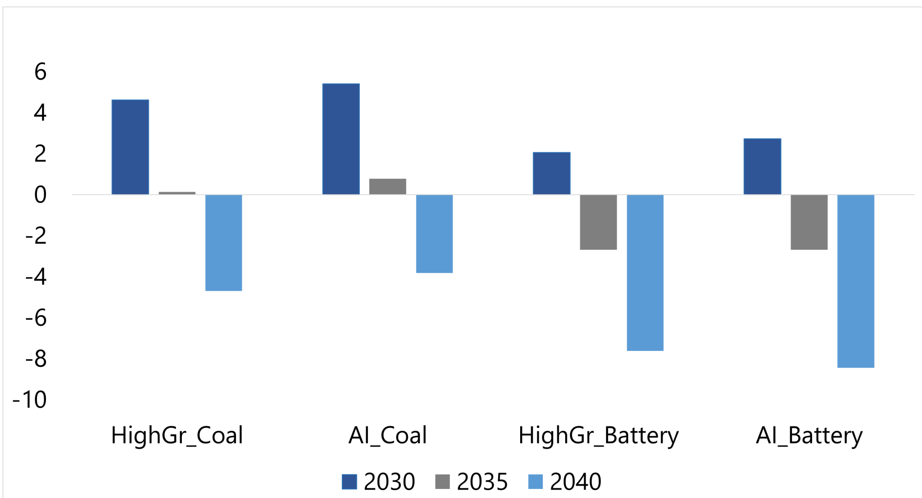
Source: IMF Staff calculations using the IMF-ENV model.

4.2 Effects from increased electricity demand from AI

Simulations show that additional demand from new sources like AI-related energy use, leads to higher pressures on electricity prices in the long-term. To assess the price effect, we compare the scenarios with added AI demand (AI_Coal and AI_Battery) to their corresponding scenarios without the additional AI demand (HighGr_Coal and HighGr_Battery, respectively). Figure 10 shows that when electricity demand increases due to AI and coal is used as the backup technology, the electricity price increase is about one percentage point higher relative to scenarios without additional AI-related demand (5.5 percent vs. 4.6 percent). Although prices decline by 2040, the reduction is lower when there is additional demand for AI-related purpose (–3.8 percent instead of –4.7 percent).

When batteries provide the main source of backup capacity and solar PV is deployed to meet the additional electricity demand associated with AI use (AI_Battery), electricity prices in 2030 increase by an additional 0.6 percentage points relative to the case without extra AI demand (2.7 percent compared with 2.1 percent in HighGr_Battery). By 2040, however, electricity price reductions become larger under higher AI demand (–8.4 percent versus –7.6 percent), reflecting the assumption that batteries facilitate a larger share of variable renewable energy in the power system and thereby increases the share of low-cost generation in total supply.[21]

Figure 10: Electricity prices (percent change relative to baseline)



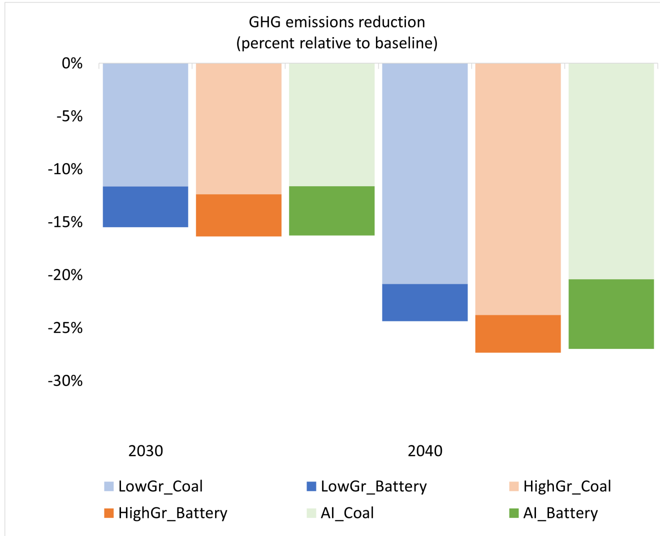
Source: IMF Staff calculations using the IMF-ENV model.

Because the medium- and long-term reductions in electricity prices from the green transition are slightly dampened when increased AI-related electricity demand is included, the associated positive effects on GDP and energy security indicators are also lower. Nevertheless, the overall effects remain positive.

Finally, all energy transition pathways reduce GHG emissions, with larger net reductions when coal is not used to back up variable renewables (Figure 11). When coal provides backup, total GHG emissions fall by about 12 percent by 2030 and 20–24 percent by 2040. In contrast, pathways relying on battery storage deliver larger reductions, at around 15–16 percent by 2030 and 24–27 percent by 2040.

[21] Hence, this reflects both a demand shock and a supply-composition effect.

Figure 11: GHG emissions reduction (percent change relative to baseline)

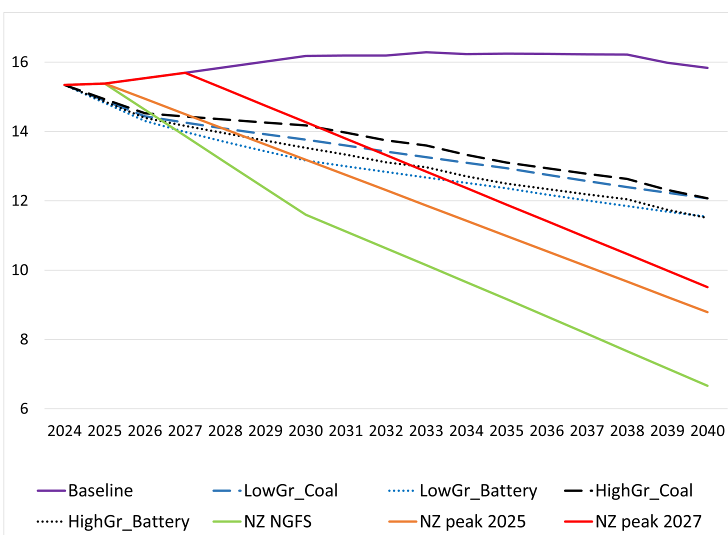


Source: IMF staff calculations using the IMF-ENV model.

4.3 Results when targeting net zero emission pathways

The push for increased renewable generation and electrification of the Chinese economy modeled above results in significant reductions in total GHG emissions. However, these reductions still fall short of net-zero pathway requirements. As shown in Figure 12, while our energy transition scenarios achieve medium-term emission cuts aligned with pathways peaking between 2025 and 2027, they are insufficient to meet Net-Zero targets in the long run. By 2040, a substantial gap remains between our energy transition scenarios and all net-zero pathways, with the gap even wider under the NGFS net-zero pathway (NZ NGFS), which front-loads emission reductions. This underscores the necessity for additional mitigation measures beyond the deep transformation of the electricity sector.

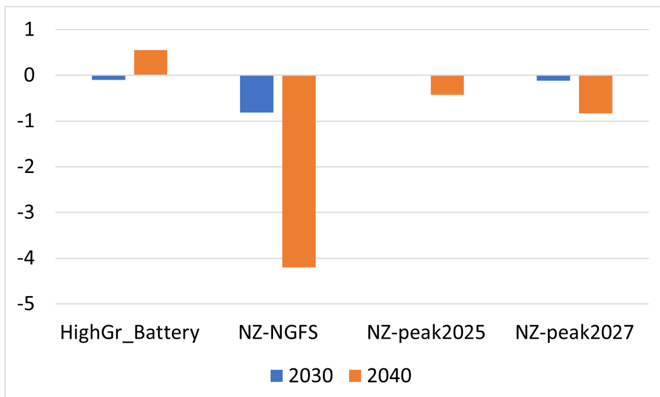
Figure 12: Total GHG emissions (GtCO2eq)



Source: IMF staff calculations using the IMF-ENV model.

To close this emission gap, we model and expanded quantity-based ETS in non-electricity activities to reach the emission targets for each of our net zero scenario. Although there are numerous policies that can achieve the same objective, carbon pricing is regarded as one of the most efficient policies. Accordingly, we find that GDP costs are relatively modest, but conditional on how ambitious the emission reductions are (Figure 13). The ambitious NGFS net-zero pathway requires sharp emission reductions early on, implying that the implicit ETS carbon price must rise to about USD 275 per tonne of CO_2 by 2040. In the absence of alternative green technologies, such a high carbon price requires reductions in economic activity in non-electricity sectors to curb emissions. As a result, GDP costs are largest under this pathway, exceeding 4 percent of real GDP by 2040 relative to the baseline. Nevertheless, given that the Chinese economy is projected to grow at an average rate of around 4 percent over this period, these costs remain relatively modest.

Figure 13: Real GDP changes in 2030 and 2040 (percent change relative to baseline values)



Source: IMF staff calculations using the IMF-ENV model.

By contrast, the remaining net-zero pathways—NZ-peak2025 and NZ-peak2027—entail much lower emission reduction requirements by 2040. Accordingly, the implicit ETS carbon price required by 2040 is substantially lower, at USD 56 and USD 78, respectively. These price levels are broadly comparable to current prices in the European Union's ETS. As a result, the associated GDP impacts are considerably smaller, remaining well below 1 percent of GDP in 2040 relative to the baseline. Hence, if China follows an emissions reduction pathway that begins in the coming years and linearly reaches net zero by 2060, the ongoing energy transition makes a substantial contribution toward achieving this target at relatively low GDP cost.

To sum up our simulation results, we find that compared to coal as a backup technology, batteries offer more flexible grid storage and lead to a greater reduction in electricity prices in the long term. Energy security improves as electricity supply increasingly relies on renewable generation, and finally, this green energy transition, with increased renewable generation and electrification of transport and industries, can substantially contribute toward China's 2060 net zero target at relatively low GDP costs. Nevertheless, more reliance on batteries will also increase the size of stranded assets within the coal power sector and we analyze this issue in the following section.

5 Stranded assets analysis

In this section we estimate the magnitude of stranded assets in the coal power sector resulting from the energy transition. The starting point of the analysis is to estimate the coal capacity requirements for each of our main scenarios. Our primary data source is the energy sector projections reported in the CETO report (ERI, 2024). Using two energy system models, the report projects a modest increase in coal capacity between 2025 and 2030, reaching approximately 1.3 TW, followed by a gradual decline to about 0.9 TW by 2040 under their main BCNS scenario. This development is driven by the rapid expansion of solar and wind power, which is expected to gradually displace coal capacity during the 2030s.

These CETO projections correspond to our scenario with high growth and VRE backed up by coal (HighGr_Coal). To estimate the coal capacity requirements in our other scenarios, we use our coal generation projections (in TWh), which adjust overall generation for lower GDP growth assumptions and increased AI-related electricity demand. We assume a capacity factor of 0.55 for coal-fired power plants,[22] which allows us to estimate excess, or backup, capacity—defined as capacity exceeding generation requirements and associated with backup electricity provision. We further assume that the use of batteries as the primary backup technology for variable renewable energy reduces the need for coal-based backup capacity by 50 percent in 2030, 75 percent in 2035, and fully replaces it by 2040. The final coal capacity requirements for each scenario are reported in Table 2. The results indicate that between 2030 and 2040, coal capacity is projected to decline by about one-third in scenarios where coal is the primary backup source for VRE, and by more than half in scenarios where batteries become the main backup source by 2040.

Table 2: Coal capacity projections by scenario (installed capacity in GW)

Scenario	**2030**	**2035**	**2040**	**% change (2040 vs 2030)**
LowGr_Coal	1,264	1,142	814	-35.6%
LowGr_Battery	1,011	758	430	-57.5%
HighGr_Coal	1,336	1,226	894	-33.1%
HighGr_Battery	1,068	814	473	-55.7%
AI_Coal	1,354	1,255	926	-31.6%
AI_Battery	1,068	814	473	-55.7%

IMF Staff calculations using ERI (2024).

Building on the estimated coal capacity requirements, we assess the potential stranded capacities in China's coal power sector. Chinese coal plants have the highest emissions lock-in among global energy infrastructure,[23] placing them at considerable risk of becoming stranded assets as decarbonization accelerates (Tong et al., 2019). Our analysis starts from a baseline that includes all coal power plants that were operational or under construction as of June 2025. We then compare projected coal capacity across different scenarios with the capacity that would remain available if all plants operated throughout their

[22] The capacity factor measures the share of actual electricity generation relative to the maximum possible generation if a plant operated at full capacity continuously over a given period. Coal plants typically operate with capacity factors between 0.6 and 0.8. In China, however, this figure has declined steadily from about 0.7 in the early 2000s to 0.53 in 2022, as coal units increasingly serve as backup rather than baseload generation. See for example: https://www.spglobal.com/energy/en/research-analytics/chinas-record-coal-capacity-approvals-in-2022-carbon-targets.

[23] Emissions lock-in refers to the long-term persistence of greenhouse gas emissions resulting from existing long-lived, carbon-intensive infrastructure and systems, which make the transition to low-carbon alternatives more difficult and costly.

intended lifetimes. Whenever projected capacity exceeds expected demand, we simulate plant retirements by sequentially retiring the oldest units first, following the methodology of Edwards et al. (2022). Stranded capacity for each plant is calculated as the product of its installed capacity and the share of its expected operating lifetime lost as a result of early retirement. We assume an average coal plant lifetime of 40 years and complement this with sensitivity analyses using alternative lifetime assumptions.

China's large coal fleet faces stranded asset risk as renewable energy adoption accelerates. Stranded assets could emerge as soon as 2030, and the risk intensifies with more extensive renewable deployment. In the HighGr_Coal scenario, around 6 GW of coal capacity is projected to be prematurely retired by 2030, rising to 68 GW by 2040 (see Table 3). For context, committed capacity –including operating and under-construction coal power plants– amounted to 1,397 GW as of June 2025. Accordingly, stranded assets in 2040 account for about 5 percent of committed capacity in 2025 in scenarios where coal serves as the main backup source. However, this share roughly triples when batteries are the primary backup technology.

Table 3: Stranded coal power capacity by scenario

	Stranded capacity: in GW			**Stranded capacity: share of committed capacity in 2025**		
Scenario:	**2030**	**2035**	**2040**	**2030**	**2035**	**2040**
LowGr_Coal	25	43	90	2%	3%	6%
LowGr_Battery	128	179	236	9%	13%	17%
HighGr_Coal	6	20	68	0%	1%	5%
HighGr_Battery	103	155	216	7%	11%	15%
AI_Coal	3	13	61	0%	1%	4%
AI_Battery	103	155	216	7%	11%	15%

Source: IMF Staff calculations. Note: Committed capacity includes both operating and under-construction capacity. As of June 2025, it amounted to 1,397 GW.

The magnitude of stranded assets is closely tied to future investment decisions. Policies on new coal power plants are a key determinant: continued construction creates assets that risk either locking in emissions or becoming stranded. As of June 2025, over 200 GW of new coal capacity is under construction, with an additional 100 GW permitted.[24] However, avoiding new coal investments could significantly reduce stranded assets—halting new construction could cut stranded capacities in 2040 by two-thirds in the HighGr_Coal scenario, from 68 GW to just 22 GW. Previous research also indicates that new coal plants are unlikely to recoup their investment costs if China maintains its climate targets (Clissold, 2023).

Future electricity demand is another critical factor affecting coal asset utilization and the extent of stranding. If demand grows rapidly, coal plants will have more opportunities to operate, reducing the risk of stranded assets. Conversely, stagnant demand can exacerbate overcapacity and increase stranded assets.

[24] The recent expansion of coal-fired power capacity has been driven primarily by energy security concerns, particularly following power shortages in the early 2020s. However, existing studies suggest that these outages were largely attributable to inflexible grid management rather than a lack of generation capacity. In particular, limited system flexibility has been identified as a key factor behind power shortages across several provinces in 2022 (Shen et al., 2024; Qin and Myllyvirta, 2025). Section 6.2 discusses policy options to enhance grid flexibility and ensure a more reliable power supply.

Considering economic growth and AI adoption, installed capacity projections range from 1,264–1,354 GW in 2030 and 814–926 GW in 2040 (see Table 2). This could translate to 3–25 GW of stranded capacity in 2030 and 61–90 GW in 2040 (see Table 3).

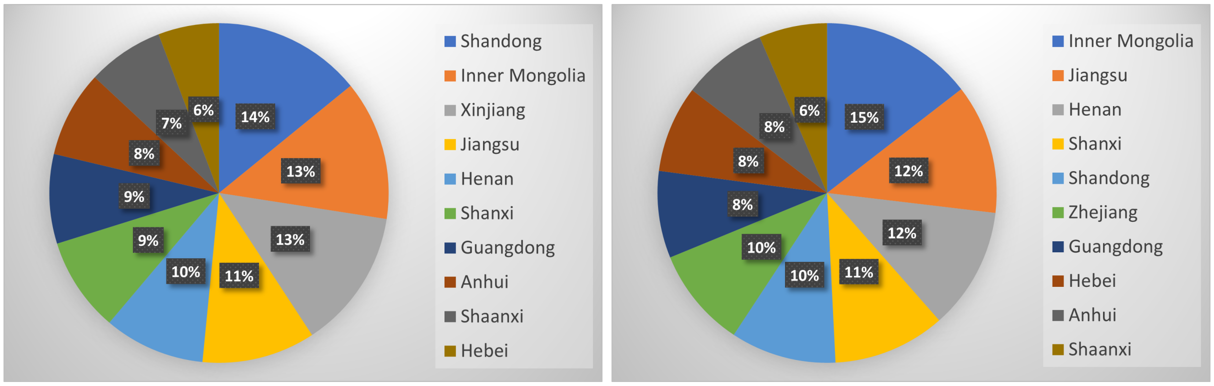
Technological advancements could also significantly affect stranded capacity. If wind, solar, and battery costs decrease faster than anticipated, these technologies could out-compete coal –even for balancing and peak loads– thereby accelerating coal's phase-out. With extensive battery storage, coal capacity is projected to drop to 473 GW by 2040 (HighGr_Battery), and further to 430 GW if economic growth slows (LowGr_Battery). This would increase stranded capacity to 216 GW in HighGr_Battery and AI_Battery,[25] and up to 236 GW in LowGr_Battery, representing 17 percent of currently operating and under-construction coal capacity. However, rapid cost reductions in renewables and storage could lower total system costs, making it easier to financially absorb stranded assets.

The average lifetime of Chinese coal plants is also a key variable. Currently, these plants are relatively young, averaging 15 years in operation, compared to a global average of 46 years and even longer in some advanced economies (Cui et al., 2019). Studies use either physical or economic lifetimes to estimate stranded assets, ranging from a 30-year design life (Wang et al., 2026) to a 50-year physical life (Edwards et al., 2022). Our sensitivity analysis, using 30- and 50-year lifespans, captures both investment losses and forgone earnings. In the HighGr_Coal scenario, there are no investment losses at a 30-year lifetime, but stranded capacity could reach 16 GW in 2030 and 147 GW in 2040 if a 50-year lifetime is assumed.

Potential stranded capacity varies significantly by province, reflecting differences in local coal power structures and investment patterns. Across scenarios, the top ten provinces consistently account for about two-thirds of total stranded capacity, with only minor shifts in rankings. Nine of these provinces remain at the highest risk under both LowGr_Battery and HighGr_Coal scenarios, underscoring persistent regional vulnerabilities (see Figure 14). This concentration is partly attributable to the expansion of China's transmission infrastructure—for instance, the development of ultra-high-voltage transmission lines such as the "West Inner Mongolia–Northern Shanxi–Southern Tianjin" route has spurred considerable new coal power installations in provinces like Inner Mongolia and Shanxi. As a result, these provinces face greater stranded asset risks compared to others. An exception is Xinjiang: while it has a relatively low risk of stranded capacity in the HighGr_Coal scenario, it emerges as one of the highest-risk provinces in the LowGr_Battery scenario. This shift is primarily due to changes in total required installed capacity and the associated increase in stranded assets and Xinjiang's younger coal fleet. With an average plant age of just 10 years (versus the national average of 15 years), Xinjiang is more susceptible to premature retirements and, consequently, higher stranded asset risk under certain scenarios.

[25] Higher level of stranding in the HighGr_Battery scenario reflects the greater displacement of coal capacity under this scenario relative to others.

Figure 14: Stranded Capacity in 2040 across Scenarios (Top 10 Provinces), for LowGr_Battery scenario (left chart) and HighGr_Coal scenario (right chart)



Source: IMF staff calculations.

The financial system impact of coal power stranded assets is manageable at the national level but could be severe locally. China's banking sector can absorb coal asset losses in aggregate, as total bank exposure to coal power is less than 1 percent of total loans (Spencer et al., 2017; Wang et al., 2022). However, certain provinces and regional banks face significantly higher exposure. In regions such as Ningxia, Xinjiang, and Inner Mongolia, coal power represents a larger share of local investment.

The risk of substantial stranded assets has already been highlighted by the World Bank (2022). However, it is important to place these potential losses in perspective. Comparing a sustainable scenario with a business-as-usual scenario, Mercure et al. (2018) find that stranded assets in 2035 amount to less than 0.5 percent of GDP in China and are more than offset by significantly higher GDP in the sustainable scenario, driven by China's leadership in green technologies.

6 Managing the energy transition

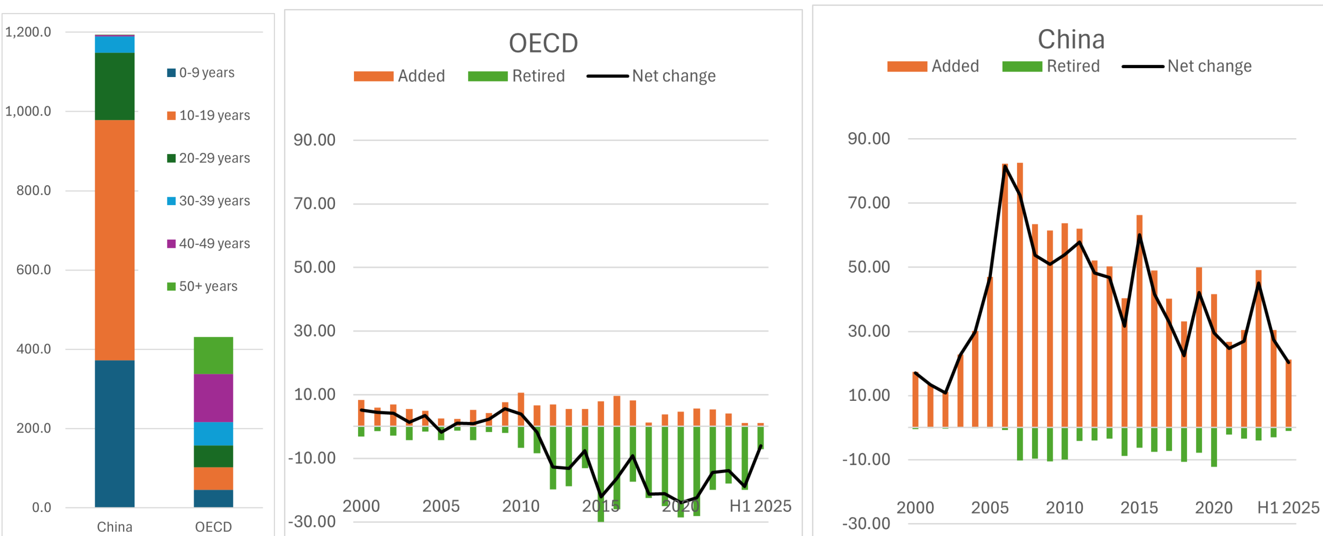
Replacing coal with low-carbon electricity generation requires careful management with complementary policy support. For China, the energy transition involves phasing out coal use and increasing the use of low-carbon energy sources. Both sides of this transition require complementary policies to avoid economic disruptions. Phasing out coal means that the sector will reduce employment. The first part of this section explores how workers can be supported and how employment opportunities can be created. Increasing the use of solar and wind power requires long-term planning to ensure grid stability. The second part of this section identifies flexibility options to ensure that electricity remains reliable.

6.1 Phasing out coal

China has constructed massive coal capacity between 2005 and 2025, which makes it much more difficult to phase out coal than in the OECD, where most capacity was constructed before 2005 (left panel of Figure 15). Historically, coal power plants have been operated for about 50 years (Cui et al., 2019). Phasing out coal power plants that have operated for a much shorter time is likely to imply financial losses, making them stranded assets. The entire operating coal fleet in OECD countries in 2025 had a capacity of 431 GW. The capacity of coal power plants constructed in China between 2005 and 2025 is

979 GW. At the same time, the OECD has gradually phased out significant capacity in recent years with only minimal additions (central panel of Figure 15), while the reverse applies to China (right panel of Figure 15). Phasing out coal can be achieved in the OECD simply by continuing the trends observed since 2010. In China, a complete reversal of the strategy in recent years is required.

Figure 15: Coal capacity in the OECD and China



Source: Global Energy Monitor
Note: The first panel shows the age distribution of operating coal capacity in GW in the OECD and China. The second and third panel show added and retired coal capacity in the OECD and China.

The transition out of coal employment in China, by contrast, has made large progress. Most of the employment in the coal sector is in coal mining (Hamilton et al., 2022). Employment in coal mining has decreased from the peak of 5.3 million in 2014 to 2.5 million in 2024 (CEIC, 2025), mainly due to automation (Paredes and Fleming-Muñoz, 2021). This means that in terms of employment, half of the coal phaseout has already been achieved. Lessons learned from this experience can guide the completion of the transition. Challenges remain, however. Coal employment is concentrated in a few provinces in the north of the country (Hamilton et al., 2022). Renewable energy projects are estimated to replace 25 percent of the jobs lost in the coal industry (Niu et al., 2024), but many of these jobs require long-distance relocation (Wu et al., 2024b).

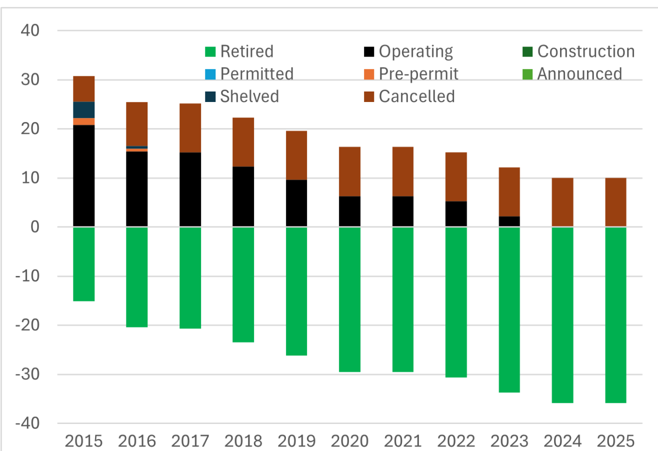
The government can address the employment challenge through targeted measures. Even in an ambitious decarbonization 2°C scenario, the phaseout of coal in China would take until the 2040s. This gradual decrease means that a considerable share of workers will transition to retirement. As discussed above, another share will find employment in renewable energy. Additional options are discussed by (Niu et al., 2024). For instance, retraining programs can improve the skill match between workers and new industries. In addition, the government can direct new investment to coal regions. This can take the form of re-purposing abandoned coal mines into energy storage facilities or using the grid connectors of coal power plants to connect renewable energy capacity.

As possible inspiration for the coal phaseout in China, we consider four European countries –Czech

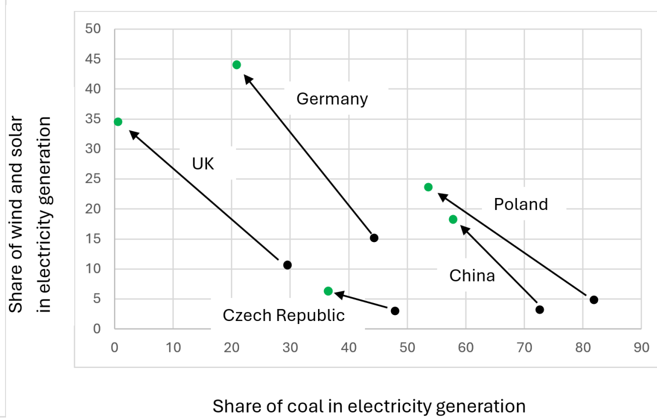
Republic, Germany, Poland and the UK– which have achieved a substantial reduction in their reliance on coal for electricity generation. Of these countries, Poland and the Czech Republic are at an earlier stage of the coal phaseout, and are managing the coal phase-out through a range of policies focused on supporting former coal workers. Poland has, in fact, overtaken China in the race to reduce reliance on coal (right panel of Figure 16). Both countries strongly rely on retraining workers and creating new employment. The Czech Republic focuses its effort for the employment transition on the three most affected regions (Ministry of the Environment, 2022). Programs include the establishment of new industries, education of workers and the improvement of welfare, for example through the restoration of the areas affected by mining. Poland uses a similar approach (Śniegocki et al., 2022). The Polish government provides severance payments and encourage early retirement for coal workers. In addition, miners can receive subsidies for starting new companies, affected areas are supported as special economic zones and the public sector invests in former coal regions.

Figure 16: The coal phaseout internationally

(a) Coal phaseout in the United Kingdom (GW)



(b) The energy transition between 2014 and 2024 for selected countries



Source: Global Energy Monitor and Ember
Note: The black dot represents the energy mix in 2014 and the green dot in 2024 for each country.

The governments of the UK and Germany focused less on the coal sector and more on supporting the development of new economic activity. In both the UK and Germany, the coal industry had already been in decline for decades and much of the coal employment had been lost due to automation and more competitive coal mining regions abroad. This allowed both countries to phase out coal in electricity generation rapidly once the cost for renewable energy fell significantly. The right panel of Figure 16 shows that both countries reduced the share of coal dramatically within ten years. The left panel of Figure 16 zooms in on the transition in the UK, which shows that the country switched off the last remaining 20 GW year by year until reaching zero in 2024. In the UK, the employment reduction in the coal sector was addressed mainly by diversified companies that reassigned coal workers internally. The strategy of the German government rested on three pillars (Oei et al., 2020). Support for worker retraining and early retirement was complemented by investments in modern energy and transportation infrastructure. Furthermore, the government aimed at improving the quality of life in coal mining regions to attract private investment. This included establishing and promoting education and research facilities, and enhancing the cultural, recreational, and environmental quality.

6.2 Phasing in flexibility

As coal is phased out, the electricity system needs to increase flexibility options to maintain stability. Solar and wind energy are variable, so the Chinese electricity system needs to complement its increasing share of these technologies with options that are available when these two energy sources are not producing (Wang et al., 2023b). The IEA (2024a) proposes conceptualizing the integration of solar and wind energy into the electricity system in six phases. China will move from phase 2 to the border between phases 3 and 4 by 2030.[26] Phases 2 and 3 require a range of measures to be taken, which we group into four flexibility options: grid extension, supply flexibility, demand flexibility and energy storage. China is already investing in all of those building blocks, but now needs to ensure that the investments match the required scale and that regulation is updated to enhance flexibility.

A larger and more advanced electricity grid enables the pooling of electricity supply across wide geographical areas. A key principle for stabilizing power systems with high shares of variable renewable energy is to connect regions with different solar and wind generation profiles, allowing electricity to flow from areas with abundant generation to those with higher demand. In China, offshore wind provides an important complement to solar power generation (Guo et al., 2025). The country possesses vast desert regions in the west, where solar resources are abundant and reliable and land-use constraints are relatively limited, while the largest wind power potential is concentrated in the north and northwestern regions.

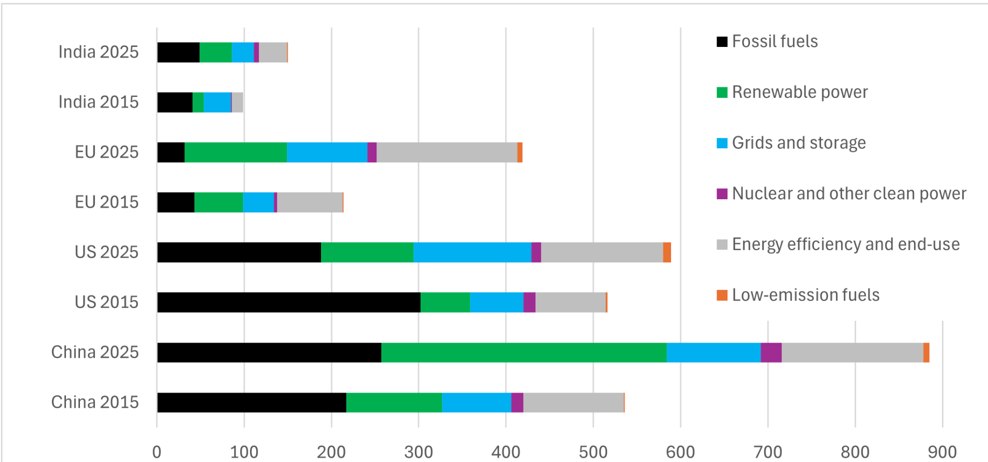
Although transmitting electricity over long distances entails some transmission losses, these can be significantly reduced through the use of ultra-high-voltage (UHV) transmission lines, a technology in which China is already investing extensively (Wang et al., 2023a). At the same time, China is expanding its smart grid infrastructure, which improves system flexibility by enabling, among other things, bidirectional use of transmission lines. Relative to the United States and the European Union, a larger share of China's electricity network has already been upgraded to smart grid technology (Sospiro et al., 2021). Reflecting these efforts, estimated investment in China's electricity grid reached USD 121 billion in 2025, compared with USD 69 billion in 2015.

China's energy storage strategy spans batteries, pumped hydropower, and green hydrogen –a diversification that reflects the distinct advantages each technology offers for balancing electricity supply and demand. Among these, battery storage has emerged as the leading option for managing VRE intermittency, driven by rapid technological progress and steep cost reductions. IRENA (2026) projects that battery systems co-located with solar and wind could deliver reliable, round-the-clock electricity at costs increasingly competitive with conventional generation, and China's investment trajectory underscores this commitment: battery investment reached USD 20 billion in 2025, up from near zero a decade earlier (IEA, 2025). Moreover, long-duration storage alternatives are well positioned to complement batteries by bridging the multi-day and seasonal supply gaps that short-duration systems cannot cost-effectively address. Pumped hydropower –where surplus electricity pumps water into an elevated reservoir for later release

[26] Phase 2 requires enhancing flexibility with existing resources, for example, by using existing storage for managing variability. Phase 3 requires tweaking existing rules and assets to extract flexibility, for example, by steering the location of VRE deployment. Phase 4 requires creating new systems to extract further flexibility, for example, by developing diurnal cycle storage.

through turbines– remains the lowest-cost storage option, though its geographical potential is inherently limited. China is nonetheless expanding it systematically, with installed capacity expected to reach 120 GW by 2030 (Guo et al., 2025). Green hydrogen, produced via electrolysis using excess renewable electricity and subsequently converted back to power in adapted gas-fired plants, is considerably more expensive but uniquely suited to smoothing seasonal imbalances –such as those arising from the strong diurnal and seasonal variability of solar generation. China is also advancing innovative approaches such as compressed air energy storage (Wang and Xue, 2025), further broadening its technological portfolio and reinforcing its position at the frontier of long-duration storage development.

Figure 17: Energy investment across regions and sectors in USD billion, 2015 and 2025



Source: IEA (2025).

Improving supply flexibility will increasingly rely on optimizing the use of the existing power plant fleet. Electricity systems have an inherent flexibility that allows compensating for a small amount of solar and wind variability. This results from the ability of fossil fuel power plants and hydropower plants to adjust output on demand. China is, for example, building new hydropower capacity, like the 60 GW Medog Hydropower Station. However, suitable locations for hydropower are limited. China also gradually expanded natural gas power plant capacity over the last 20 years, but given that it is an importer of natural gas, this strategy is limited by concerns for energy security. The government aims to reduce the use of coal to limit local air pollution and GHG emissions. Nuclear energy serves as a baseload and is not flexible enough to respond to fluctuations in other energy sources. As the share of solar and wind energy increases, more can be done to make the most of the existing capacity. The IEA recommends, for example, reducing dispatch intervals, that is, enabling power plants to respond faster to changes in demand. Power plants can also be retrofitted to become more responsive.

Demand flexibility requires substantial technological and regulatory development, but China has already made meaningful progress in this area. If demand is partially responsive to supply, additional investments in the other three options can be reduced. At the household level, demand flexibility can mean charging EVs when solar generation is abundant, for example. At the industrial level it can involve timing energy intensive processes to align with electricity supply. It requires access to relevant information in real time and the ability to optimally steer equipment based on the information. Given these demands on digitization and automation, it has become feasible only recently. However, China is very active in using this potential. For example, the Chinese government is promoting integration between EV charging infrastructure and the power system (Wei et al., 2025). This means that households go beyond flexible demand and provide energy storage (through their car batteries). At the same time, the National Development and Reform Commission is setting targets for industries to increase demand flexibility (Liu et al., 2023).

Coal power plants can also be repurposed to enhance power system flexibility. China's commitment to reducing emissions and achieving carbon neutrality by 2060 will require the gradual phase-out of all coal-fired power plants (see Figure 17). However, many of these plants are expected to be retired before reaching the end of their economic lifetimes. One approach to utilize some of the remaining capacity is to retrofit the power plants so that biomass and coal can be co-fired and to combine this with carbon capture and storage (CCS) (Sun et al., 2025). In combination, such power plants could be carbon neutral, or at least have significantly lower emissions than conventional coal power plants. If only biomass is used or if plants are converted to use green hydrogen, they could be carbon neutral even without CCS (He et al., 2023). However, both biomass and green hydrogen face limitations. The availability of biomass is constrained (Nie et al., 2022) and green hydrogen is more expensive than natural gas for the foreseeable future (Ueckerdt et al., 2024). As a result, such conversions are likely to be viable only in a few strategic locations, where they could be pivotal to ensure grid flexibility. Beyond re-purposing entire power plants, it might be possible to reuse at least the grid inter-connector for renewable energy capacity, synchronous condensers (devices that enhance voltage stability) or batteries (Jindal and Shrimali, 2022).

7 Conclusion

This paper illustrates that replacing coal with renewable energy as the primary source of electricity generation poses a major challenge but also offers a significant opportunity for China. Most obviously, the country must sustain rapid, efficient investment in renewable energy. Second, a large amount of complementary infrastructure will be required, as the share of VRE continues to rise. We find that batteries outperform coal power plants in this role, as they allow for lower electricity prices and faster growth, even when accounting for additional electricity demand from AI-related data centers. Less visible challenges include the social costs of phasing out coal and the risk of stranded assets. The transition away from coal will have significant impacts on coal-producing regions, making worker retraining and compensation mechanisms necessary. Moreover, our results indicate that the risk of stranded assets in the coal sector may be substantial and highly concentrated in specific Chinese provinces.

At the same time, green technologies continue to advance –driven in large part by Chinese innovation– creating substantial opportunities. First, the transition to renewable energy is expected to decrease electricity prices in the mid- to long term. This opens the possibility of accelerating economic growth. Beyond these direct economic benefits, additional gains arise. In particular, the energy transition is projected to significantly reduce China's dependence on imported fossil fuels, thereby strengthening energy security. In addition, if AI-related developments increase electricity demand from data centers, accelerated investment in renewable energy offers a straightforward option to meet this demand and thus support the development of new economic opportunities. Finally, our results indicate that the energy transition represents an important step toward China's goal of achieving net-zero emissions by 2060 and that, with additional policy measures, this objective can be reached at relatively modest economic cost.

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A Additional tables

Table 4: Concordance for commodities (i) between IMF-ENV and the GTAP database

1	All Crops (cro)	Paddy Rice (pdr), Wheat (wht), Cereal grains nec (gro), Vegetables, fruits, nuts (v_f), Oil Seeds (osd), Sugar cane, sugar beet (c_b), Plant-based fibers (pfb), Crops nec (ocr)
2	Livestock (lvs)	Bovine cattle, sheep and goats, horses (ctl), Animal products nec (oap), Raw milk (rmk), Wool, silk-worm cocoons (wol)
3	Forestry (frs)	Forestry (frs)
4	Fisheries (fsh)	Fishing (fsh)
5	Coal extraction (coa)	Coal (coa)
6	Crude Oil extraction (oil)	Oil (oil)
7	Natural gas (gas)	Gas (gas), Gas manufacture, distribution (gdt)
8	Other extraction (OMN)	Non-metallic minerals mining (nmn), Mining of iron ores (mio), Mining of aluminum ores (mao), Mining of copper ores (mcu), Mining of other ores (moo)
9	Food Products (fdp)	Bovine meat products (cmt), Meat products nec (omt), Vegetable oils and fats (vol), Dairy products (mil), Processed rice (pcr), Sugar (sgr), Food products nec (ofd), Beverages and tobacco products (b_t)
10	Textiles (txt)	Textiles (tex), Wearing apparel (wap), Leather products (lea)
11	Paper products & publishing (ppp)	Paper products, publishing (ppp)
12	Petroleum and coal products (p_c)	Petroleum, coal products (p_c)
13	Chemical products, excl. fertilizers (crp)	Other chemicals (xch)
14	Fertilizers (fer)	Nitrogen fertilizer (nfr), Phosphorus fertilizer (pfr), Potassium fertilizer (kfr)
15	Non-metallic minerals, excl. cement (nmm)	Other mineral products (nmx)
16	Cement (cem)	Cement (cem)
17	Iron and Steel (i_s)	Iron and steel - primary (isp), Iron and steel - secondary (iss), Recycling - iron and steel (ris), Iron and steel casting (isc)
18	Non-ferrous metals, excl. aluminum (nfm)	Copper - primary (cpp), Copper - secondary (cps), Recycling - copper (rcp), Other metals - primary (mpp), Other metals - secondary (mps), Recycling - other metals (rom), Non-ferrous metals casting (nfc)
19	Aluminum (alu)	Aluminum - primary (app), Aluminum - secondary (aps), Recycling - aluminum (ral)
20	Fabricated metal products (fmp)	Metal products (fmp)
21	Electronic equipment (ele)	Computer, electronic and optical products (ele)
22	Transport Equipment (mvh)	Motor vehicles and parts (mvh), Transport equipment nec (otn)
23	Other manufacturing activities (oma)	Wood products (lum), Basic pharmaceutical products (bph), Rubber and plastic products (rpp), Electrical equipment (eeq), Machinery and equipment nec (ome), Manufactures nec (omf)
24	Electricity (ELY)	Coal power baseload (CoalBL), Coal-based CCS (colccs), Oil power baseload (OilBL), Oil power peakload (OilP), Gas power baseload (GasBL), Gas power peakload (GasP), Gas-based CCS (gasccs), Nuclear power (NuclearBL), Advanced nuclear (advnuc), Hydro power baseload (HydroBL), Hydro power peakload (HydroP), Wind power (WindBL), Solar power (SolarP), Other baseload includes biofuels, waste, geothermal, and tidal technologies (OtherBL), Electricity transmission and distribution (TnD)
25	Water services (wts)	Water (wtr)
26	Construction (cns)	Construction (cns)
27	Land transport (otp)	Transport nec (otp)
28	Water Transport (wtp)	Water transport (wtp)
29	Air Transport (atp)	Air transport (atp)
30	Other Business services (osc)	Trade (trd), Accommodation, food and service activities (afs), Warehousing and support activities (whs), Communication (cmn), Financial services nec (ofi), Insurance (ins), Real estate activities (rsa), Business services nec (obs), Recreation and other services (ros), Dwellings (dwe)
31	Other collective services (osg)	Public administration and defense (osg), Education (edu), Human health and social work activities (hht)

Notes: nec = not elsewhere classified. Commodities 1 to 4 correspond to agriculture, 5 to 8 to mining, 9 to 23 to manufacturing, and 24 to 31 to services.

Table 5: Concordance for activities (a) between IMF-ENV and the GTAP-CE database (version 11c)

1	All Crops (cro)	Paddy Rice (pdr), Wheat (wht), Cereal grains nec (gro), Vegetables, fruits, nuts (v_f), Oil Seeds (osd), Sugar cane, sugar beet (c_b), Plant-based fibers (pfb), Crops nec (ocr)
2	Livestock (lvs)	Bovine cattle, sheep and goats, horses (ctl), Animal products nec (oap), Raw milk (rmk), Wool, silk-worm cocoons (wol)
3	Forestry (frs)	Forestry (frs)
4	Fisheries (fsh)	Fishing (fsh)
5	Coal extraction (coa)	Coal (coa)
6	Crude Oil extraction (oil)	Oil (oil)
7	Natural gas (gas)	Gas (gas), Gas manufacture, distribution (gdt)
8	Other extraction activities (OMN)	Non-metallic minerals mining (nmn), Mining of iron ores (mio), Mining of aluminum ores (mao), Mining of copper ores (mcu), Mining of other ores (moo)
9	Food Products (fdp)	Bovine meat products (cmt), Meat products nec (omt), Vegetable oils and fats (vol), Dairy products (mil), Processed rice (pcr), Sugar (sgr), Food products nec (ofd), Beverages and tobacco products (b_t)
10	Textiles (txt)	Textiles (tex), Wearing apparel (wap), Leather products (lea)
11	Paper products & publishing (ppp)	Paper products, publishing (ppp)
12	Petroleum and coal products (p_c)	Petroleum, coal products (p_c)
13	Chemical products, excl. fertilizers (crp)	Other chemicals (xch)
14	Fertilizers (fer)	Nitrogen fertilizer (nfr), Phosphorus fertilizer (pfr), Potassium fertilizer (kfr)
15	Non-metallic minerals, excl. cement (nmm)	Other mineral products (nmx)
16	Cement (cem)	Cement (cem)
17	Iron and Steel (i_s)	Iron and steel - primary (isp), Iron and steel - secondary (iss), Recycling - iron and steel (ris), Iron and steel casting (isc)
18	Non-ferrous metals, excl. aluminum (nfm)	Copper - primary (cpp), Copper - secondary (cps), Recycling - copper (rcp), Other metals - primary (mpp), Other metals - secondary (mps), Recycling - other metals (rom), Non-ferrous metals casting (nfc)
19	Aluminum (alu)	Aluminum - primary (app), Aluminum - secondary (aps), Recycling - aluminum (ral)
20	Fabricated metal products (fmp)	Metal products (fmp)
21	Electronic equipment (ele)	Computer, electronic and optical products (ele)
22	Transport Equipment (mvh)	Motor vehicles and parts (mvh), Transport equipment nec (otn)
23	Other manufacturing activities (oma)	Wood products (lum), Basic pharmaceutical products (bph), Rubber and plastic products (rpp), Electrical equipment (eeq), Machinery and equipment nec (ome), Manufactures nec (omf)
24	Coal powered electricity (clp)	Coal power baseload (CoalBL), Coal-based CCS (colccs)
25	Oil powered electricity (olp)	Oil power baseload (OilBL), Oil power peakload (OilP)
26	Gas Powered electricity (gsp)	Gas power baseload (GasBL), Gas power peakload (GasP), Gas-based CCS (gasccs)
27	Nuclear power (nuc)	Nuclear power (NuclearBL), Advanced nuclear (advnuc)
28	Hydro power (hyd)	Hydro power baseload (HydroBL), Hydro power peakload (HydroP)
29	Wind power (wnd)	Wind power (WindBL)
30	Solar power (sol)	Solar power (SolarP)
31	Other power (xel)	Other baseload includes biofuels, waste, geothermal, and tidal technologies (OtherBL)
32	Electricity transmission and distribution (etd)	Electricity transmission and distribution (TnD)
33	Water services (wts)	Water (wtr)
34	Construction (cns)	Construction (cns)
35	Land transport (otp)	Transport nec (otp)
36	Water Transport (wtp)	Water transport (wtp)
37	Air Transport (atp)	Air transport (atp)
38	Other Business services (osc)	Trade (trd), Accommodation, food and service activities (afs), Warehousing and support activities (whs), Communication (cmn), Financial services nec (ofi), Insurance (ins), Real estate activities (rsa), Business services nec (obs), Recreation and other services (ros), Dwellings (dwe)
39	Other collective services (osg)	Public administration and defense (osg), Education (edu), Human health and social work activities (hht)

Notes: nec = not elsewhere classified. Activities 1 to 4 correspond to agriculture, 5 to 8 to mining, 9 to 23 to manufacturing, and 24 to 39 to services.

Table 6: Regional concordance between IMF-ENV and the GTAP database

1	Argentina (Argentina)	Argentina (ARG)
2	Australia (AUS)	Australia (AUS)
3	Brazil (BRA)	Brazil (BRA)
4	Canada (CAN)	Canada (CAN)
5	China (CHN)	China (CHN)
6	France (FRA)	France (FRA)
7	Germany (DEU)	Germany (DEU)
8	India (IND)	India (IND)
9	Indonesia (IDN)	Indonesia (IDN)
10	Italy (ITA)	Italy (ITA)
11	Japan (JPN)	Japan (JPN)
12	Korea (Korea)	Republic of Korea (KOR)
13	Mexico (MEX)	Mexico (MEX)
14	Russia (RUS)	Russian Federation (RUS)
15	Saudi Arabia (SAU)	Saudi Arabia (SAU)
16	South Africa (ZAF)	South Africa (ZAF)
17	Türkiye (TUR)	Türkiye (TUR)
18	United Kingdom (GBR)	United Kingdom (GBR)
19	United States (USA)	United States of America (USA)
20	Rest of EU & EFTA (REU)	Austria (AUT), Belgium (BEL), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), Greece (GRC), Hungary (HUN), Ireland (IRL), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Poland (POL), Portugal (PRT), Slovakia (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Switzerland (CHE), Norway (NOR), Rest of EFTA (XEF), Bulgaria (BGR), Croatia (HRV), Romania (ROU)
21	Other Middle East countries (ROP)	Bahrain (BHR), Iraq (IRQ), Islamic Republic of Iran (IRN), Israel (ISR), Jordan (JOR), Kuwait (KWT), Lebanon (LBN), Oman (OMN), Palestineian Territory (PSE), Qatar (QAT), Syrian Arab Republic (SYR), United Arab Emirates (ARE), Rest of Western Asia (XWS)
22	Other Asian countries & New Zealand (ODA)	Hong Kong SAR (HKG), Mongolia (MNG), Taiwan Province of China (TWN), Rest of East Asia (XEA), Brunei Darussalam (BRN), Cambodia (KHM), Lao PDR (LAO), Malaysia (MYS), Philippines (PHL), Singapore (SGP), Thailand (THA), Viet Nam (VNM), Rest of Southeast Asia (XSE), Afghanistan (AFG), Bangladesh (BGD), Nepal (NPL), Pakistan (PAK), Sri Lanka (LKA), Rest of South Asia (XSA), New Zealand (NZL), Rest of Oceania (XOC)
23	Other African countries (OAF)	Algeria (DZA), Egypt (EGY), Morocco (MAR), Tunisia (TUN), Rest of North Africa (XNF), Benin (BEN), Burkina Faso (BFA), Cameroon (CMR), Côte d'Ivoire (CIV), Ghana (GHA), Guinea (GIN), Mali (MLI), Niger (NER), Nigeria (NGA), Senegal (SEN), Togo (TGO), Rest of Western Africa (XWF), Central African Republic (CAF), Chad (TCD), Congo (COG), Democratic Republic of the Congo (COD), Equatorial Guinea (GNQ), Gabon (GAB), Rest of South and Central Africa (XAC), Comoros (COM), Ethiopia (ETH), Kenya (KEN), Madagascar (MDG), Malawi (MWI), Mauritius (MUS), Mozambique (MOZ), Rwanda (RWA), Sudan (SDN), United Republic of Tanzania (TZA), Uganda (UGA), Zambia (ZMB), Zimbabwe (ZWE), Rest of Eastern Africa (XEC), Botswana (BWA), Eswatini (SWZ), Namibia (NAM), Rest of South African Customs Union (XSC)
24	Other East European and Eurasian countries (OEA)	Albania (ALB), Belarus (BLR), Serbia (SRB), Ukraine (UKR), Rest of Eastern Europe (XEE), Rest of Europe (XER), Armenia (ARM), Azerbaijan (AZE), Georgia (GEO), Kazakhstan (KAZ), Kyrgyzstan (KGZ), Tajikistan (TJK), Uzbekistan (UZB), Rest of Former Soviet Union (XSU)
25	Other Latin American countries (OLA)	Rest of North America (XNA), Costa Rica (CRI), Guatemala (GTM), Honduras (HND), Nicaragua (NIC), Panama (PAN), El Salvador (SLV), Rest of Central America (XCA), Dominican Republic (DOM), Haiti (HTI), Jamaica (JAM), Puerto Rico (PRI), Trinidad and Tobago (TTO), Rest of Caribbean (XCB), Bolivia (BOL), Chile (CHL), Colombia (COL), Ecuador (ECU), Paraguay (PRY), Peru (PER), Uruguay (URY), Venezuela (VEN), Rest of South America (XSM), Rest of the World (XTW)

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