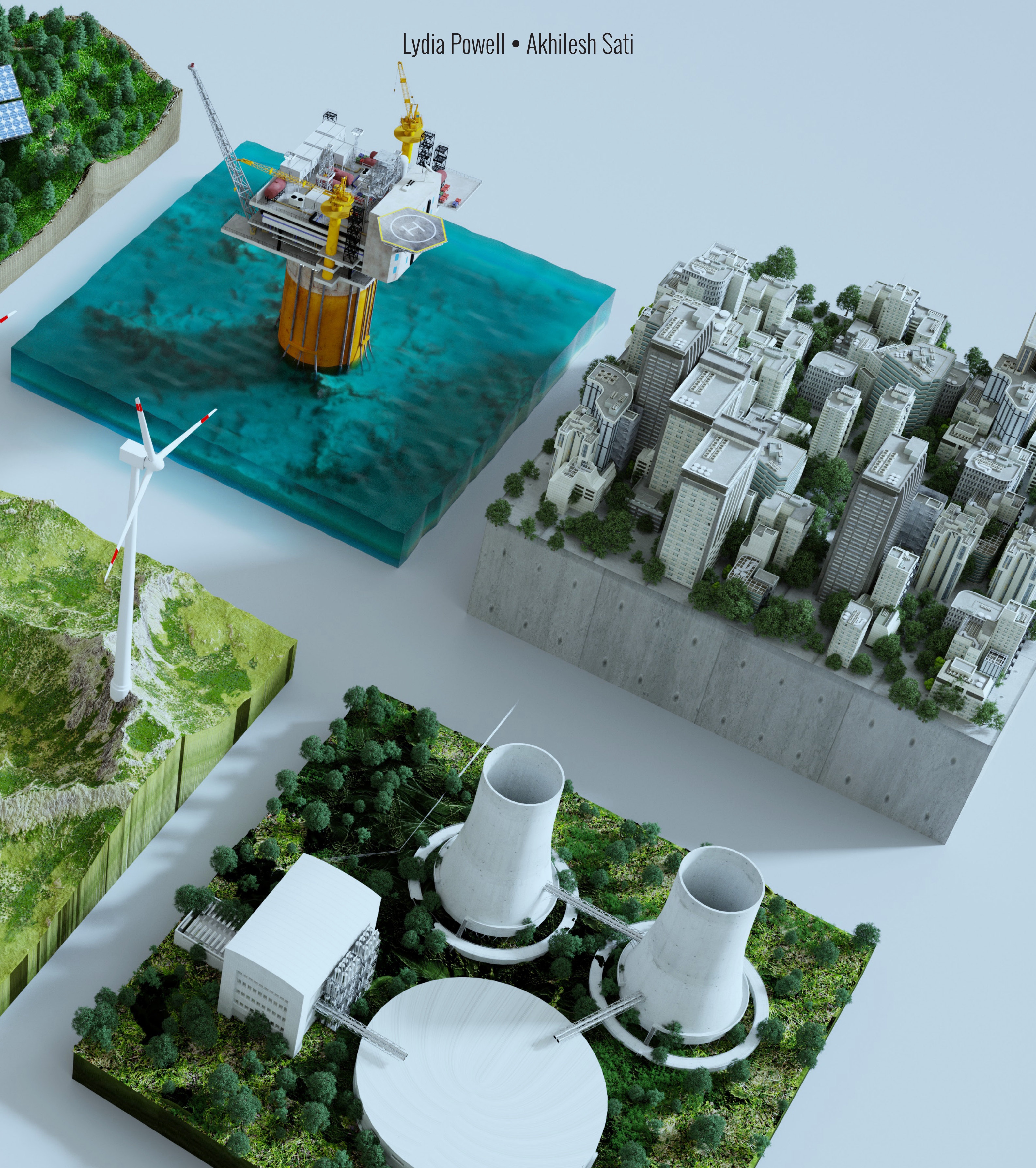
THE ENERGY TRANSITION AND CLIMATE CHANGE

Manifesto from the Global South

Lydia Powell • Akhilesh Sati



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Executive Summary

The belief that once science has established a limit to temperature increases, every nation will optimise activities to meet the goal is proving to be inaccurate. Since the Kyoto Protocol was signed in 1997, carbon emissions from energy use have increased from about 22 billion tonnes (BT) to over 35 BT in 2023, with significant but short-lived reductions recorded only during the financial crisis of 2007-08 and the COVID-19 pandemic in 2020-22. Reasons include the divergence in priorities of the Global North and the Global South, and the absence of scalable and abundant energy sources that simultaneously meet the strategic priories of affordability, security, and sustainability in the Global South.

In the last 150 years, the Global North has enjoyed the benefits of higher greenhouse gas (GHG) emissions, particularly carbon emissions, in the form of higher living standards with consequent higher per capita carbon emissions. Meanwhile, the Global South—victim of colonial exploitation and the resulting underdevelopment—is constrained in following the same path.

In 2023, the global average per-capita energy consumption was about 77 gigajoules (GJ), which is more than the minimum energy required for decent living. Out of about 90 countries and regions that include most of the world's population, about 33 countries have energy consumption below 77 GJ. The average per-capita energy consumption in the African continent is just 14 GJ. Roughly a seventh of the global population, mostly in the Global South, live without electricity or with inadequate and irregular supply of electricity, and about a third rely on traditional fuels such as firewood to cook their meals.

The energy choices of India and Brazil offer insights into how the domestic constraints and strategic priorities of a country influence and complicate the pace of the energy transition in the Global South. Fossil fuels accounted for 76.5 percent of power generation in 2023-24 in India while non-fossil fuels (including hydropower and nuclear) accounted for the remaining 23.5 percent. India's fuel choices for power generation reflect the pursuit of strategic goals of affordability, security, and sustainability: Coal offers affordability and security at the cost of sustainability; renewables offer sustainability at the cost of affordability and security; natural gas plays only a marginal role, though it can potentially offer some degree of sustainability because it compromises on the two critical domestic goals of affordability and security. Coal meets the domestic aspirations of energy access at the cost of global ambition for carbon reduction.

Brazil generated 91 percent of its electricity from clean sources in 2023, with hydropower dominating the mix at 60 percent. Brazil's per-capita carbon emissions are well below the global average. In 2023, it had the second lowest carbon intensity of electricity generation among the G20 countries. Brazil has already surpassed its target of reaching 84 percent renewable electricity by 2030. Though Brazil is known as a country with the cleanest basket of fuels for power generation with falling carbon emission levels, fossil-fuel production, mainly oil and natural gas production, accounted for most of the increase in domestic energy production in Brazil in the last decade.

The dominant fuel choice for power generation—coal in the case of India and hydropower in the case of Brazil—are driven by domestic resource endowment, an accident of geography that makes the respective fuel source the most affordable while ensuring energy security. For the Global South to leapfrog to cleaner energy sources, these sources have to be truly dependable, scalable, and affordable. In the Global North, strategies for reindustrialisation that justify trade barriers are conflated with strategies for carbon emission reduction, which decreases affordability and increases the carbon reduction burden on the Global South.

Coal is the dominant fuel for power generation in India and South Africa. South

Africa's experience in phasing out coal illustrates the complexities of the energy transition. In 2023, South Africa was the largest economy in sub-Saharan Africa in terms of GDP. In the same year, fossil fuels (mainly coal) accounted for over 82 percent of total power generation in the country, and non-fossil fuels accounted for the rest. While there are available fuel options to diversify South Africa's electricity mix, the affordability of electricity supply is a constraint on diversification.

At the United Nations Conference of the Parties in November 2021 (COP26), the G7-led Just Energy Transition Partnership (JETP), involving the governments of South Africa, the United Kingdom, the United States (US), the European Union, France and Germany, announced that they will provide an initial commitment of US$8.5 billion towards financing South Africa's decarbonisation efforts. Hailed as a revolutionary partnership agreement for decarbonisation in the Global South, a JETP was signed by South Africa, Indonesia, Vietnam and, later, Senegal, with 90 percent of the finance package allocated for electricity sector reforms through traditional development finance institutions of the Global North and the remaining 10 percent for core just-transition objectives.

The Renewable Energy Independent Power Producer Procurement Programme, which is part of the JETP, has attracted private-sector investments in renewable energy projects. However, the shutting down of South Africa's Komati Power Station, a 63-year-old 1,000-megawatt coal-based plant, as part of JETP proved to be far more challenging. Heralded as one of the largest global "repurposing" projects, US$497 million was offered to convert the Komati coal plant into a renewable energy generation site. When Komati was "repurposed", many people were left without work, which is devastating in a country where unemployment is high, at over 30 percent. The labour force in the coal sector prefers immediate rewards such as gainful employment over delayed gratification resulting from action on climate change—a phenomenon known in economics as 'temporal discounting'.

Overall, the Global South (including China) accounted for more than 84 percent of global coal consumption in 2023. In the Global South, 26 countries (excluding China, India, and Indonesia) invested in coal-based power generation capacity after signing the Paris Agreement. Of these, five invested in coal-based power generation capacity for the first time. The key factor that influenced the decision to invest in coal was affordability.

In India, electrification rates in road transport are impressive only in the two-wheeler (2W) and three-wheeler (3W) segments, which receive subsidies under a government programme to promote electrification. Though 2Ws have a share of over 70 percent in vehicle numbers, four-wheelers dominate fuel consumption. This means that decarbonisation of the 2W segment will have limited effects on fuel consumption patterns.

To accelerate the decarbonisation of road transport, India has revived its programme for blending ethanol with petrol with target dates for achieving ambitious blending rates. By 2025, the government aims to achieve ethanol blending of 20 percent. In 2024, around 98 percent of road transportation fuel came from fossil fuels and 2 percent from biofuels in India. The Global Biofuel Alliance proposed by India aims to establish a global partnership of national governments, agencies, industries and other stakeholders to advance sustainable biofuels technology deployment and expand sustainable biofuels market penetration.

Brazil is the world's second largest ethanol producer, behind the US, and the third largest biodiesel producer. One of the key challenges in India replicating Brazil's success in biofuel production and use is resource endowment, particularly land and water resources. India's arable land per capita is a third of that in Brazil and Brazil has 25 times India's per-capita renewable water resources. Unintended consequences of the ethanol blending programme in India, such as the import of corn and ethanol, illustrate that the goals of decreasing fuel imports, reducing carbon emissions and increasing farmer incomes cannot be achieved simultaneously. Even in Brazil, the production of biofuel crops, especially crops for the production of first-generation bioethanol and biodiesel, have had negative impacts on the environment, particularly through land-use change and deforestation.

According to the World Meteorological Organization, 2024 was the warmest ever recorded in human history, with the average global temperature in the year being 1.5°C above the pre-industrial baseline for the first time, breaching the threshold set by the Paris Agreement. Above-average temperatures have become the norm in the last decade, with exceptionally hot summers across the world. In this context, the lack of essential indoor cooling in most parts of the Global South, which is a dimension of energy poverty, is troubling.

According to the 'Cooling for All' initiative, at least 3.43 billion people still face cooling access challenges in 2021, including 1.09 billion rural and urban poor at high risk and 2.34 lower-middle income people at medium risk. Access to space cooling (air-conditioning or AC) in the Global South is a climate-change adaptation measure that requires as much attention as carbon mitigation measures because access to space cooling can save thousands of lives. There is concern that AC use will increase the demand for energy, which can increase peak electricity demand, increase carbon emissions if the electricity is generated by using fossil fuels, affect electricity systems' stability, and increase household spending on energy at the expense of other vital expenditure. According to estimates, a 1°C increase in temperature in the future will increase electricity consumption for space cooling by around 15 percent. India, which has more than 3,000 cooling degree days (CDDs) consumes just 70 kilowatt hours (kWh) for space cooling compared to 800 kWh in South Korea, which has only 750 CDDs. This disparity is mainly on account of low affordability of AC use in India.

Even if all theoretically possible efficiency gains are achieved, AC use is likely to remain the privilege of the affluent and aspiring classes. In India, the per-capita carbon emission of the lowest 50 percent of the population is 0.9 tonnes of CO_2 equivalent (tCO_2eq) and 1.2 tCO_2eq for the middle 40 percent compared to 9.6 tCO_2eq for the top 10 percent. AC use, which consumes more electricity than all other electrical equipment in a typical affluent household in India, accounts for a large share of the CO_2 emissions of the top 10 percent.

In theory, there is recognition that funds should be allocated for efficient cooling. The Kigali Cooling Efficiency Program recognises the need for financing for access to cooling, but this recognition remains limited, given that financing needs continue to be poorly defined and tracked globally.

For progressive outcomes, climate action needs to (i) reconcile with overarching aspirations in the Global South to catch up with the Global North economically and politically, (ii) acknowledge the significance of domestic energy resources for energy security and affordability, (iii) balance the Global North's obsessions of investment in mitigation action with the adaptation needs of the Global South, (iv) formulate technology and fuel agnostic strategies that pave the way for a low-carbon future, (v) assess country-level climate action on the basis of qualitative parameters that reflect the right to human wellbeing and (vi) reduce trade barriers on low-carbon technologies to increase affordability and accelerate energy transition in the Global South.

Introduction

Current scientific, economic and social discourses on global climate change warn that humanity is facing a challenge unlike any so far. Challenges posed by climate change are indeed unprecedented, but the narratives used to describe and address climate change constrain the political possibilities of responding to climate change. The divergent discourses on climate change are not so much arguments over scientific facts but rather a manifestation of the “responsibility” and “capability” divide between countries in the Global North and the Global South.

In the last 150 years, the Global North has enjoyed the benefits of higher greenhouse gas (GHG) emissions, particularly carbon emissions, in the form of higher living standards with consequent higher per capita carbon emissions.[1] The Global South, a victim of colonial exploitation and the resulting underdevelopment is, however, constrained in following the same path. The Global South and the

Global North face different realities, with different capacities, different resources, and different economic and political priorities. The heterogeneity of interests between the South and the North is exacerbated by the consensus-based process of multilateral negotiations coordinated by the United Nations (UN). The agreements signed since the first UN Conference of Parties (COP) in 1995 have not succeeded in limiting carbon emissions.[2] In the last three decades, all COP meetings, including the most recent one held in Baku in 2024, have involved the Global South holding the Global North responsible for historic carbon emissions and the Global North holding the Global South responsible for current and future carbon emissions.[3] This has slowed progress in addressing climate change. While the concept of “sustainable development” is accepted by both sides, the Global North prioritises the “sustainable” part while the Global South insists on development.[4] A “grand bargain” that would give acceptable meaning to the concept of sustainable development continues to be elusive.[5]

At the national level, the central role of energy in modern society for heating, agriculture, transportation, manufacturing, communication, information and knowledge production has introduced enormous interdependencies, uncertainties, circularities and multiple stakeholders with conflicting interests. The energy transition seeks to alter or redirect energy use, which has necessitated changes, often costly ones, across core systems of modern society. This has created a range of interests at the industrial and household levels that have been politically organised to prevent or slow down change.

As pointed out by David Victor, the assumptions that (i) once science has established a limit to temperature increases, every nation will optimise activities to meet the goal, (ii) negotiating multilateral targets for carbon reduction will solve the problem and (iii) once low-carbon technologies are developed, every nation will adopt them, are proving to be inaccurate.[6]

This report highlights the complexities of the energy transition with specific examples from the Global South and offers a manifesto for climate action that highlights challenges and priorities of the Global South. India, a sufficiently large representative sample of the Global South, is used as the primary context of analysis. Without discounting the diversity among nations within the Global South, the convergence and divergence in the energy choices of India, Brazil and South Africa in specific contexts and the drivers behind the choices are explored to extract insights.

Rationale

Inadequate Outcomes

Since the Kyoto Protocol was signed in 1997, carbon emissions from energy use have increased from about 22 billion tonnes (BT) to over 35 BT in 2023, with significant but short-lived reductions recorded only during the financial crisis of 2007-08 and the COVID-19 pandemic in 2020-22.[7] The share of fossil fuels in global primary energy consumption has fallen from about 87 percent in 2003 to about 82 percent in 2023—a much slower rate of reduction than what is required to keep average temperature increases below 2°C.[8] According to the Carbon Action Tracker, governments' 2030 Paris Agreement targets will lead to 2.5°C warming by the end of the century because of weak existing targets for carbon reduction.[9] Probabilistic estimates of temperature increases by the end of the century suggest that, even if all countries meet their promises under the Paris Agreement and continue to reduce emissions at the same rate thereafter, it is unlikely that warming would stay under 2°C.[10] The study concludes that, to have a 90-percent probability of staying below 2°C of warming, the annual rate of decline in emissions would need to more than quadruple.[11]

Compromise on Interests of the Global South

The current approach is contextually insensitive to interests of the Global South. In 2023, the Global North, representing about 1.3 billion people or 16 percent of the global population, emitted a disproportionate share of carbon emissions at about 12.5 BT of carbon dioxide, which is about 33 percent of total global carbon emissions.[12] The Global North also dominates the discourse on climate change, which is pivoted in scientific research but is designed to discard and stigmatise alternative framings. Multilateral climate negotiation platforms strive for universal agreements based on the dominant narrative, ignoring diverse national interests and capacities. For example, negotiating positions at COP29 in Baku in 2024 continued to focus on the divergence between the two blocs.[13] The Just Transition Work Programme (JTWP) at Baku concluded with no substantive decision on advancing the JTWP because of the differences between the Global North and the Global South.[14] Key members of the Global North, including the United States (US), European Union (EU), and the United Kingdom (UK) wanted to delete the text that affirmed "that countries have different starting points and national priorities and that just transition pathways must be nationally determined, in the context of equity and the principle of CBDR-RC (common but differentiated responsibilities-respective capabilities) in the light of different national circumstances embedded in the UN framework convention on climate change (UNFCCC)."[15] In the discussion over development at COP29, the US proposed to delete the reference to the "right to development" and the "right to a clean, healthy and sustainable environment."[16] The Global North expects the Global South to merely survive, not prosper.

On finance, the US$300 billion per year to be mobilised by the Global North failed to represent real "progression beyond previous efforts" (of US$100 billion per year if inflation is taken into account).[17] The Global South wanted the issue of unilateral trade measures such as the Carbon Border Adjustment Mechanism (CBAM) of the EU to be discussed at COP29 as it violated provisions of equity embedded in the climate-negotiating framework while the Global North said that the proper forum is the World Trade Organisation (WTO).[18] Trade barriers such as CBAM will transfer the burden of decarbonisation to the Global South, delaying rather than accelerating the global energy transition.

Exploiting Guilt and Fear

The Global North has been responsible for 92 percent of the excess carbon emissions since 1850, which constitutes the stock of carbon in the atmosphere and is the cause of current loss and damage from drought, floods and other natural disasters attributed to climate change.[19] The Global South, which experiences most of the consequences of natural disasters,[20] assigns historic responsibility to the Global North and seeks financial compensation for loss and damage. The North has responded by pointing out that current and future flow of carbon emissions is mostly from the Global South.[21] In 2023, carbon emissions increased by 6 percent in China, which accounted for over 31 percent of global carbon emissions, the largest in the world. India, labelled the third largest carbon emitter, accounted for over 7 percent of global carbon emissions, and carbon emissions from the country increased by 9 percent in 2023.[22] However, the increase in emissions from the Global South is primarily due to quantity (number of people) and not quality (high consumption). The appropriate metric that captures this fact is per-capita right to atmospheric space.

Dominant analytic frames attribute all natural disasters to climate change. This has diverted attention from place-based (affluent and less affluent geographies) vulnerabilities, their socio-political causes and existing fragilities and inequalities. While blaming all crises on climate change may highlight the urgency for action, members of the public may prefer to hold the government accountable for inadequate investments in flood or drought prevention and precarious living conditions.[23] The framing of climate change as the root cause of nearly all problems creates the possibility for other nations to impose their own ideals for society, nature and a better world on countries that may adopt a different path to achieve the same goals. Narratives that exploit guilt and fear to persuade countries to act have been ineffective so far. If climate change is an existential threat, the logical response would be a unified, equitable narrative.

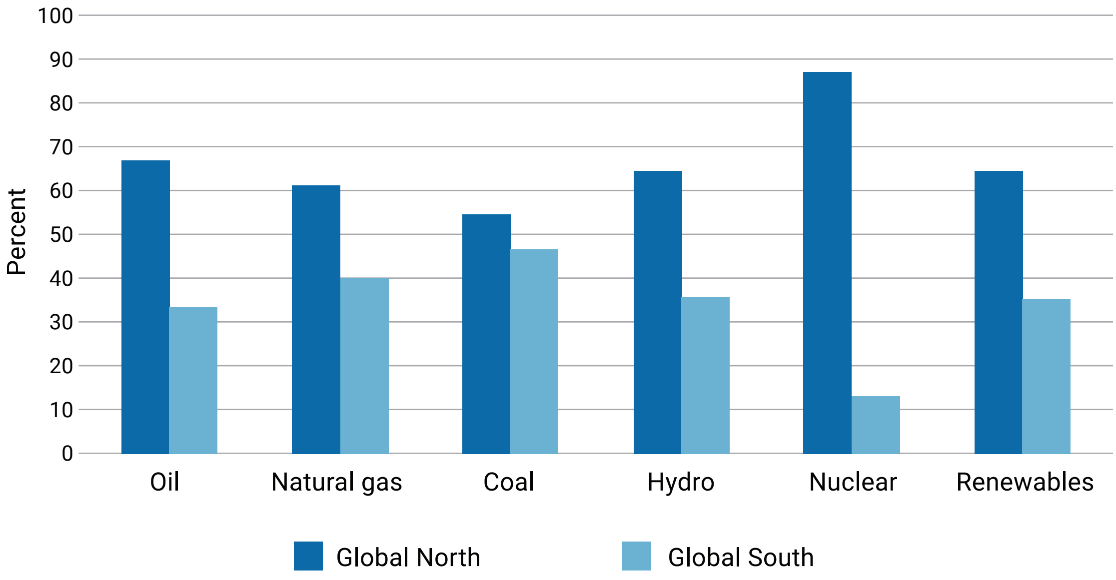
Global North and Global South: Stylised Facts

This report uses the World Bank (WB) classification of countries into income groups based on 2023 gross national income (GNI) per capita, calculated using the WB Atlas method.[a] All WB member countries, totalling 189, and all other economies with populations of more than 30,000 are included in the classification.[24] Under this classification, economies with GNI per capita of US$1,145 or less are low-income countries; economies with GNI per capita of US$1,146-$4,515 are lower middle-income countries; economies with an income of US$4,516-14,005 are upper middle-income countries; and economies with GNI per capita above US$14,005 are high-income countries.[25]

a In calculating GNI per capita in US$ for operational and analytical purposes, the WB uses the Atlas conversion factor instead of market exchange rates. The purpose of using the Atlas conversion factor is to reduce the impact of exchange-rate fluctuations in cross-country comparisons of national incomes. The Atlas conversion factor for a given year is the average of a country's exchange rate for that year and the two preceding years, adjusted for the difference between the rate of inflation in the country and international inflation. The objective of the adjustment is to reduce short-term changes to the exchange rate caused by inflation.

For the sake of simplicity, all countries with GNI per capita less than US$14,005 are treated as the Global South and countries with income above US$14,005 as the Global North.[26] As scholars on geopolitics have noted, the Global South is not an organised "collectivity" but an analytical framework grounded in geopolitics above all else.[27] In climate change negotiating platforms, the geopolitical context is important in bargains over the responsibility for causing climate change and the capability to address climate change.

Figure 1: Energy Consumption Share by Fuel (1980)

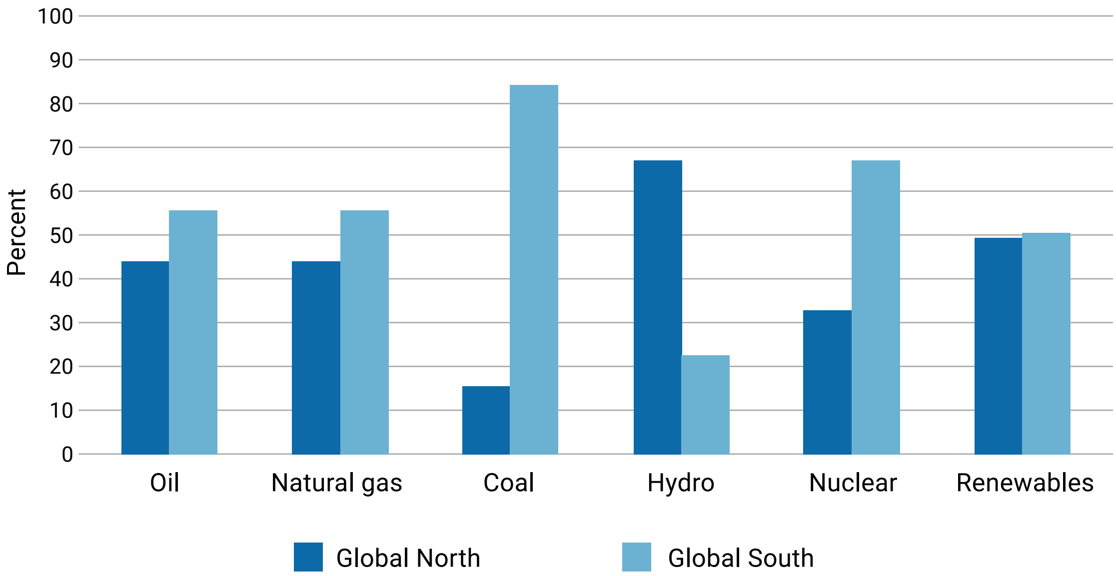


Source: Statistical Review of World Energy 2024[28]

As per the categorisation of countries based on GNI per capita, 85 are high-income countries, 26 are low-income countries, 51 are lower middle-income countries (including India) and 54 are upper middle-income countries (including China, Brazil and South Africa). The Global North (high-income countries) had just over 16 percent of the global population but accounted for over 60 percent of global Gross Domestic Product (GDP) in 2022.[29] Only 1 percent of its population was under extreme poverty, and it accounted for about 33 percent of global carbon emissions. The Global South accounted for over 84 percent of the population, nearly 40 percent of global GDP, 99 percent of persons under extreme poverty and over 67 percent of global carbon emissions.[30] The Global South is highly diverse in terms of incomes, capabilities, economic composition, and energy profiles. The GNI ranges from about few hundred dollars per capita to over US$14,000 per capita. This is also true for the Global North, with GNI varying from US$14,000 to over US$100,000 per capita. Carbon emissions from the Global South are highly concentrated in India and China, which together account for over 35 percent of the global population. The top 10 highest polluting countries in the Global South account for over 78 percent of the group's emissions while 120 countries account for just 22 percent of all of the Global South's emissions.[31] Many of these lower-income nations are more vulnerable to the effects of climate change, such as flooding, drought, intense heat and disease. By default, the Global South holds the veto on climate action as it is the majority in terms of population and accounts for a large share of the current flow of carbon emissions. For success over climate action, the interests of the Global South must be given higher priority.

In terms of population, India is more than 23 times the size of South Africa and close to seven times the size of Brazil.[32] In terms of GDP, India is nine times the size of South Africa and just under twice the size of Brazil. However, the per-capita GNI of South Africa is three times larger than that of India and that of Brazil is four times that of India.

Figure 2: Energy Consumption Share by Fuel (2023)



Source: Statistical Review of World Energy 2024[33]

In 2023, the global average per capita energy consumption was about 77 gigajoules (GJ). On average 77 GJ is more than the minimum energy required for decent living.[34] Out of about 90 countries and regions that cover most of the world's population, about 33 countries have energy consumption below 77 GJ.[35] The average per-capita energy consumption in the African continent is just 14 GJ.[36] Roughly a seventh of the global population, mostly in the Global South, live without electricity[37] or with inadequate and irregular supply of electricity and about one-third rely on traditional fuels such as firewood to cook their meals.[38] The majority in the Global North consume several times the energy needed for comfortable living.[39] For example, average per-capita energy consumption in the Organisation of Economic Co-operation and Development (OECD) countries that are part of the Global North is about 166 GJ, compared to about 58 GJ in non-OECD countries that belong to the Global South.[40] While Brazil and South Africa have per-capita energy consumption above the non-OECD average, India's per-capita energy consumption is less than half of the non-OECD average.

Space heating during cold winters and industrial energy use contributes to increase in per-capita energy use in the Global North. Most of those in the Global South experience intense heat in the summer, but a majority of the households cannot afford space-cooling devices such as air conditioners.[41] Leaders in the Global South want to accelerate energy access and energy consumption for economic growth, better quality of life and for political accountability. Energy security is also of equal if not greater priority as it underwrites national security. The decarbonisation of energy supply is important for the Global South, but energy for economic growth and national security are also priorities.[42]

In the Global South, there is near-complete agreement over the desirability of high mass consumption, technological dynamism and rising levels of GDP to catch up with the Global North. Belief in economic progress is so pervasive that it has become, in effect, a solution for poverty alleviation, social inclusion and, ironically, environmental sustainability. Extremes in the political spectrum, whether right or left, are predicated on the notion that whatever the shape of the future, it will be realised through continued economic growth. For political leaders in the Global South, "not growing" is not an option because millions with unmet aspirations is a greater threat to national security than climate change in the medium term.

The national interest concerns of the Global South are portrayed as proxies for the interests of the elite as the benefits of economic growth are expected to be largely appropriated by the middle class and the elite.[43] There is merit in this argument; South Africa has the highest Gini coefficient (63) in WB rankings,[44] with Brazil following closely behind (52). However, as long as nations remain the primary target for policy action, the focus on national interests by the Global South cannot be contested. Climate-change policy is fundamentally constructed through the twin lenses of national security and national economic strategy, the 'nation' being the master discourse that legitimises other discourses. In this light, the current climate-change negotiating framework in multilateral platforms that seeks to facilitate the production of global public goods such as carbon mitigation without accommodating national interests is unlikely to result in cooperative outcomes.

Box 1: Convergence of Energy Consumption in the Future

Carbon mitigation pathways identified in the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (2021-23) acknowledge the need for equity between countries and regions but the report makes little effort to operationalise the same.[45] By its own admission, the IPCC scenarios focus on cost effectiveness rather than equity outcomes.[46] According to the IPCC scenarios, there will be no convergence in per-capita energy consumption between the Global North and South even after 2100. The North American region is projected to have the highest per-capita energy consumption in 2050 across scenarios;[47] it is projected to consume about six to eight times more energy than Sub-Saharan Africa and about five times more energy than South Asia in 2050.[48] In the scenarios, higher energy consumption in the Global North is supported by the continued use of fossil fuels even in 2050, notwithstanding their declared net-zero targets.[49] Fossil fuel consumption is, in fact, restricted much more severely in most of the Global South.[50] The IPCC scenarios disregard both the historical responsibility of the Global North for carbon emissions as well as the future energy needs of the Global South to meet basic human needs. Africa, despite its very low contribution to historic emissions, is projected to bear a disproportionately high burden of climate-change mitigation.[51] Current figures show that the world's wealthiest 5 percent of individuals use more energy than the poorest half of the global population combined.[52] High rates of energy use pose a problem because this makes it difficult to decarbonise the energy system fast enough to stay within carbon budgets. There is an urgent need to develop scenarios that represent convergence to levels of energy that are sufficient for human well-being and compatible with rapid decarbonisation.

India's Energy Choices

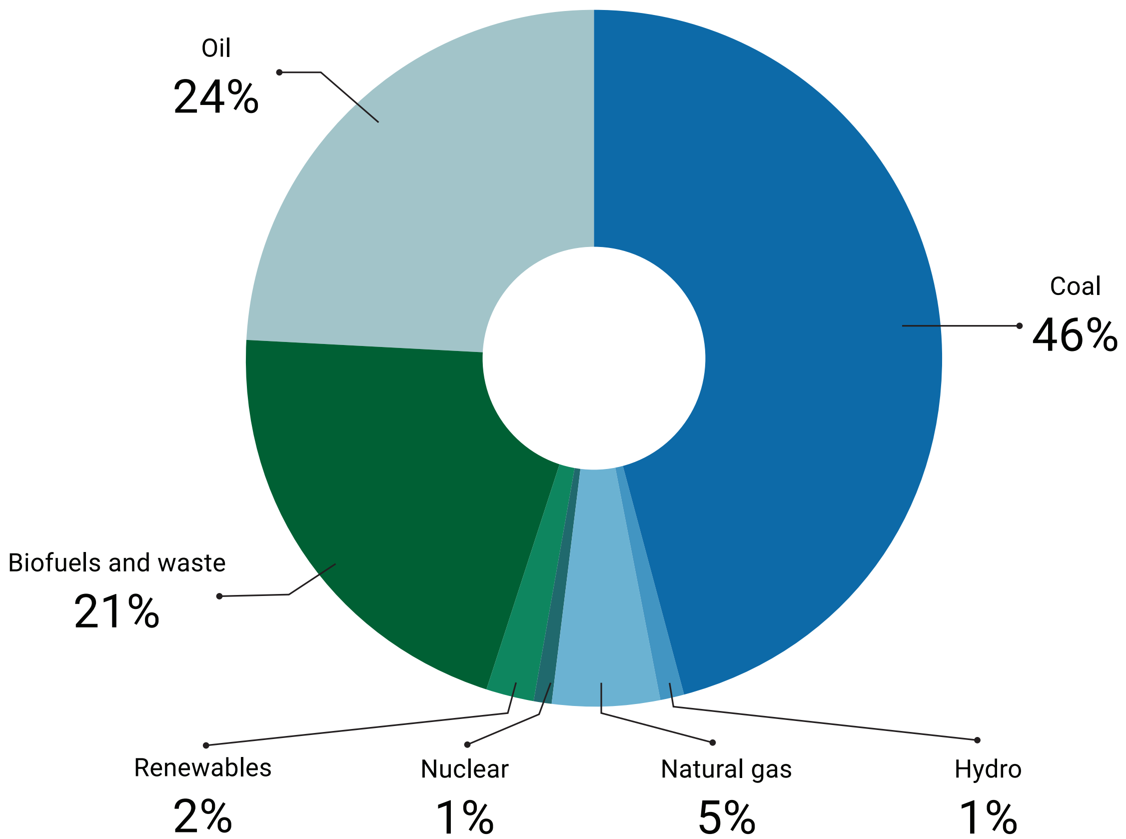
Primary Energy Basket

In 2023, India's primary energy consumption was almost nine times larger than that of South Africa and just under three times that of Brazil; however, South Africa had the largest per-capita energy consumption, followed by Brazil and India.[53] In terms of carbon emissions, India's total emissions were more than five times that of South Africa and Brazil, but in terms of per-capita emissions, India had the lowest level of emissions, well below world average.[54] Brazil had low per-capita carbon emissions comparable to India because of the high share of hydropower and biofuels even though Brazil's per-capita energy consumption was three times that of India in 2023. South Africa's per-capita carbon emissions were more than three times that of India even though its energy consumption was only about a ninth of India's in 2023. Coal was the dominant fuel in South Africa and India followed by oil and renewable energy. Oil accounted for the largest share in Brazil's primary energy basket while hydropower and biofuels had the second and third largest contributions in 2023. Drivers behind the energy choices of India, Brazil and South Africa offer insights into the divergence in their respective energy choices and the convergence in the drivers behind those choices.[55]

In the last two decades (2003-23) India's GDP grew at an annual average of 6.7 percent.[56] Growth in commercial energy (excluding biomass) consumption reflected the growth in GDP, with an annual average growth rate of about 5 percent in the last two decades (2003-23).[57] In 2003-23, India's carbon emissions from energy use rose by an annual average of 5 percent, notwithstanding the fact that low-carbon renewable energy (RE) consumption grew at least three times faster than fossil and faster than non-fossil energy sources such as nuclear and hydropower.[58]

Despite above-average growth in GDP and energy consumption in the last two decades, India's per capita energy consumption of about 27.3 gigajoules (GJ) in 2023 was below world average of 77 GJ and below the non-OECD average of 58.5 GJ per capita.[59] It was also below the bare minimum consumption of the about 40 GJ per capita required to achieve a Human Development Index (HDI) of above 0.7 (compared to developed countries, which have HDI > 0.9).[60] India was labelled the third largest emitter of carbon after China and the US in 2023 on the basis of current territorial emissions but was the only country among the top emitters to have per-capita energy consumption significantly lower than average world consumption of primary energy.

Figure 3: India's Primary Energy Basket (2022)



Source: International Energy Agency[61]

The contradiction between high carbon emissions at the national level and low energy consumption and carbon emissions at the per-capita level constitutes the unique energy policy challenge of India and most of the rest of the Global South: the Global South needs more affordable energy but with less carbon (sustainability). India’s choice of fuels for power captures this dilemma as none of the fuels (fossil and non-fossil fuels) meet the three critical metrics of affordability, security and sustainability.

Coal dominated India’s primary and secondary (electricity generation) energy basket in 2022.[62] In 2022, coal accounted for 45.8 percent of India’s primary energy supply of 42.5 exajoules (EJ), oil accounted for about 23.9 percent, unprocessed biomass and biofuels 20.7 percent, natural gas 5 percent, hydropower 1.4 percent, renewable energy 1.7 percent and nuclear energy accounted for 1.1 percent.[63]

In 2022, industry accounted for over 40 percent of energy consumption in India, followed by the residential sector, which accounted for over 25 percent of energy consumption.[64] The transport sector accounted for roughly 17 percent of energy consumption, while agriculture and forestry accounted for about 5 percent of energy consumption. Commercial and public services accounted for about 3 percent of energy consumption, and unspecified and non-energy use accounted for the remaining 9 percent of energy consumption.[65] Industrial energy consumption exceeded residential energy consumption only in 2009, and in 2022, industrial energy consumption was almost 2.5 times that of the residential sector. Coal was the largest source of industrial energy, with a share of 63 percent in 2022.[66] Electricity had a share of about 19 percent, while oil had a share of 18 percent.[67] The share of natural gas in industrial energy use was less than 1 percent.[68] Residential and other building energy use was dominated by biomass (firewood, animal dung and waste), which accounted for about 59 percent, followed by electricity and oil with a share of about 19 percent each.[69] Natural gas accounted for less than 1 percent of residential energy use. Biofuels accounted for 3 percent of transportation fuels and electricity about 2 percent. Oil products accounted for over 92 percent of energy used by the transport sector, while natural gas accounted for about 3 percent in 2022.[70]

Power Generation

As of October 2024, coal accounted for about 48 percent of power generation capacity while renewables (e.g., solar, wind) accounted for about 34.4 percent in India.[71] Hydropower accounted for about 10.3 percent of power generation capacity, natural gas about 5.5 percent and nuclear power the remaining 1.8 percent. Overall, fossil fuels accounted for about 53.5 percent of installed capacity for power generation while non-fossil fuels (including hydro and nuclear power) accounted for 46.5 percent. In terms of power generation, coal accounted for over 74 percent in 2023-24, followed by renewables, which accounted for 13 percent of generation.[72] Hydropower generation accounted for about 7.7 percent, followed by nuclear with 2.7 percent and natural gas with 1.8 percent.

Overall, fossil fuels accounted for 76.5 percent of power generation in 2023-24 in India while non-fossil fuels (including hydro and nuclear power) accounted for the remaining 23.5 percent.[73]

The share of fuels in power generation in India was close to the share of fuels used to generate power globally in the case of hydropower and renewables, while it deviated significantly in the case of coal, natural gas and nuclear power. Globally, coal accounted for 35 percent of power generation in 2023 compared to India's 75 percent.[74] Globally, natural gas accounted for over 22 percent[75] of power generation, the second largest after coal, whereas in India, it was a minuscule 1.8 percent in 2023-24—the smallest share among fuels for power generation.[76] Globally, nuclear power accounted for over 9 percent[77] of power generation, while in India, it accounted for just 2.7 percent in 2023-24.[78] India has increased power generation from non-fossil fuels by 40 percent in the past five years, but from a low base; the use of unabated fossil fuels in the power sector has also increased significantly.[79] The share of electricity in final consumption rose in India from 11 percent in 2000 to 18 percent in 2023.[80]

India's share of coal use in power generation (>75 percent)[81] is much larger than the 17 percent share in OECD countries (i.e., countries from the affluent Global North) and larger than the 45 percent share in non-OECD countries.[82] In the case of natural gas, India's share (<2 percent)[83] is much smaller than that of the OECD countries, which is over 30 percent, where it is the largest source of power generation. India's share of natural gas in power generation is also much lower than the 17.5 percent share of non-OECD countries.[84]

Key strategic goals of affordability, security and sustainability explain the divergence in the energy profile of India compared to the rest of the world. While from a long-term perspective, India needs the solar and renewables option; from a medium-term perspective, the development of ultra-super critical (USC) and super critical (SC) coal-based power-generation technology, along with natural gas and nuclear energy, can provide significant benefits in terms of carbon reduction. The adoption of USC and SC technology for coal-based power plants can save as much coal as would be saved by the installation of 10 times the solar power capacity.[b] Mitigation success, which is currently measured narrowly in terms of the capacity addition of solar

[b] A USC coal-based power plant has an efficiency of 46 percent compared to 34 percent for a sub-critical plant and 40 percent for an SC plant. Thus, with a USC or SC plant, the savings in coal consumption and reduction in CO2 emissions can be substantial. A 10,000 MW power plant will generate 60 billion kWh of electricity per year at around 70 percent load factor. It has a specific heat of 1,870 kcal/kwh compared to 2,530 kcal/kwh for a sub-critical plant. Thus, every unit generated with USC will save 0.165 kg [(2,530-1,870)/4,000] coal of 4000 kcal/kg; and 60 billion kWh will save 9.9 million tonnes of coal per year. When a sub-critical coal plant is substituted with solar plants, for every kwh generated, 0.63 kg of coal (2,530/4,000) is saved. Thus, 15.6 billion kWh (1,000*9.9/0.63) will have to be generated by solar plants to save the equivalent 9.9 million tonnes of coal. Since a solar plant generates 1500 kWh per KW of installed capacity, the matching installed capacity needed will be nearly 100,000 MW (15.6*1,000/15,000).

and wind energy installations,[85] needs to be substituted with a technology and a fuel-agnostic approach that measures the reduction in carbon emissions.[86]

The Drivers of Fuel Choices

The use of coal as the fuel for power generation in India maximises affordability and security. The emphasis on coal as a fuel for power generation began in the 1970s as part of India's response to the increase in crude oil prices.[87] In the 1980s, the strategy of "self-reliance" that called for the use of domestic coal, along with hydropower and nuclear energy to reduce the economy's exposure to crude oil prices, drove an increase in the demand for coal.[88]

Price controls on Indian coal initiated during the World Wars prevailed despite the exponential increase in production driven by government investments. The Global North encouraged investments in coal production and consumption in the Global South to limit its own consumption of oil as the 1960s and 1970s were dominated by the fear of oil scarcity and high oil prices.[89] State ownership promoted employment in the coal sector, which, in turn, sustained labour-intensive mining. Price controls and low labour costs made coal the most affordable source of power generation in India.[90] This enabled the government to offer millions of poor consumers with access to electricity in the 1980s and 1990s.[91] Coal-based power plants spread across the country as state governments demanded "self-reliance" and employment opportunities at the state level.[92] This led to coal transport by rail across the country. High tariffs on coal transport by rail became an attractive source of revenue for the railways, which also enabled cross-subsidies for passenger rail tariff, which was (and remains) politically attractive.[93]

In the 1990s, power generators competed for privileged access to state-controlled resources rather than competing to provide electricity to optimise the policy goals of increasing affordability and decreasing pollution.[94] Despite the implementation of policies to open up power generation to the private sector in the early 2000s[95] and the policy to commercialise coal mining in the 2010s, the overall environment of coal production, supply and consumption has not changed radically in the 2020s.[96] Perversely, taxes and levies imposed on the coal sector, supposedly to penalise pollution from coal production and use, are now an important source of revenue for governments at the state and central levels;[97] the coal sector accounted for 10 percent and 2 percent of energy sector revenues to the central and state governments, respectively, in 2021.[98] The quantum of taxes and levies on coal grew faster than the growth of coal production. From 2014 to 2021, coal production grew by just over 9.5 percent, while coal-sector revenues grew by over 25 percent.[99]

The parameters of affordability and security that make coal attractive when compared to natural gas also make it less attractive for power generation in India. The metric of carbon reduction, where natural gas scores over other fossil fuels, is accorded lower value than security and affordability, which explains why the share of natural gas in power generation in India is much lower than most countries. Natural gas emerged as a fuel for power generation only in the early 2000s, when prospects for domestic natural gas production were optimistic.[100] This optimism was based partly on the enthusiastic projections for domestic gas production and partly on the expectation that natural gas, having the lowest emissions of carbon among fossil fuels, will displace coal in power generation and oil in transportation.[101]

The first assumption proved to be false, which meant gas use for power generation had to be sustained through imports in the form of Liquefied Natural Gas (LNG). High-cost imported gas reduced the affordability of power, which led to the second assumption—that gas would displace coal—also being proved to be false. In 2010, the share of natural gas in India's primary commercial energy basket was 9.4 percent, which fell to 5.7 percent by 2023 as volumes of domestic gas production declined.[102] In 2012, natural gas accounted for roughly 10 percent of gross electricity generation, which fell to less than 2 percent in 2023.[103] In 2023-24, India produced just over 31 billion cubic metres (BCM) of natural gas while it consumed over 67 BCM of gas, with over 54 percent of consumption met with imports.[104]

In contrast to natural gas, reducing CO_2 emissions is the most important metric that makes renewable energy (RE) sources attractive as fuels for power generation. Towards the goal of maximising carbon reduction, the government is not only implementing enabling policies[105] for private investment but also executing programmes underwritten by generous subsidy support for RE power generation.[106] Although intermittent RE requires the support of back-up generation or back-up battery storage, these costs are socialised to improve the affordability of RE power. The cost of stranded assets in conventional power generation and the increase in system level costs to integrate RE power are also socialised, which improve the score of RE as affordable power.[107] In 2003-23, RE power generation grew at an annual average of over 20 percent.[108] Though the annual average growth slowed to 15.3 percent in 2013-23 compared to 26.5 percent in 2003-13, RE power generation has retained a double-digit growth rate annually.[109]

India's fuel choices for power generation reflect the pursuit of strategic goals of affordability, security and sustainability: Coal offers affordability and security at the cost of sustainability; renewables offer sustainability at the cost of affordability and security; natural gas plays only a marginal role though it can potentially offer some degree of sustainability because it compromises on the two critical domestic goals of affordability and security. For effective energy transition, alternatives have to be truly dependable, scalable and affordable.[c]

[c] In the communication sector, people in the Global South leapfrogged to mobile communication devices, bypassing traditional wired communication devices without the aid of subsidies because mobile communication devices were scalable, affordable and dependable.

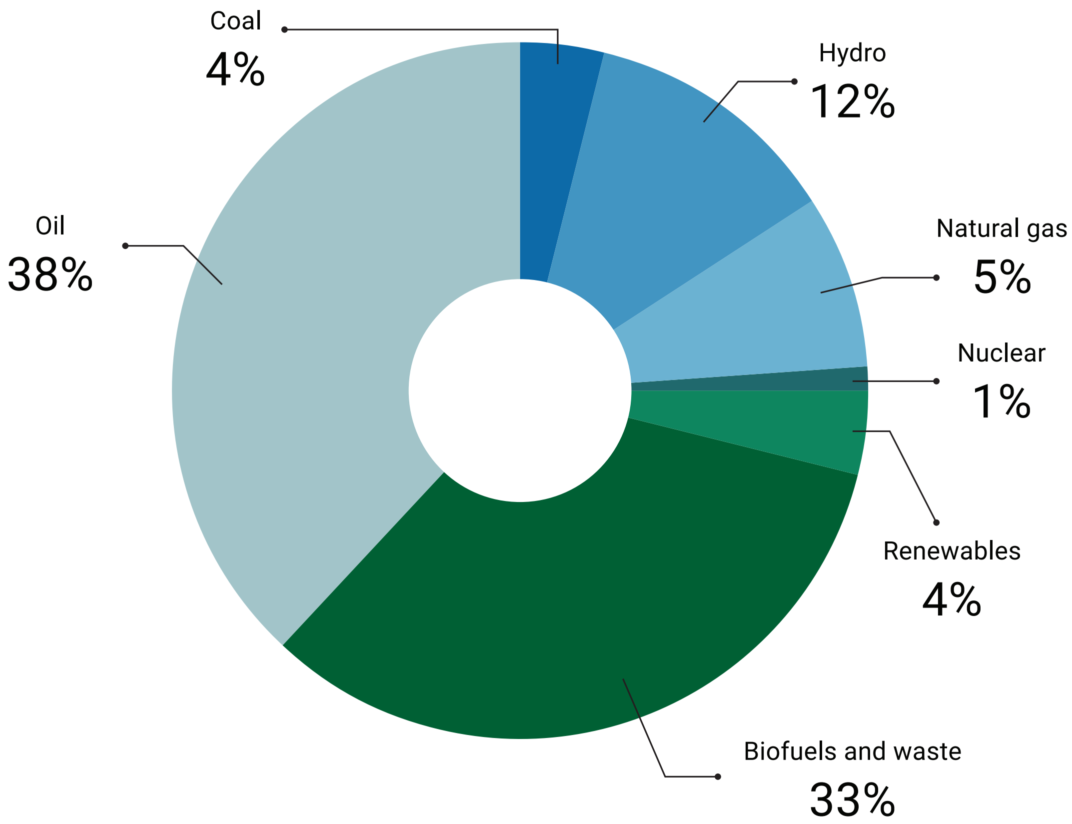
Fuel Choices for Power Generation: Brazil and India

The primary energy and secondary energy baskets of Brazil and India cannot be more different but key drivers behind the energy choices of both countries are similar. Brazil is an upper middle-income country in the Global South and the largest economy in Latin America and the Caribbean.[110] Brazil's energy mix is diverse compared to that of India and South Africa. Energy consumption in Brazil had an average annual growth rate of 0.5 percent between 2011 and 2021, compared to 3.3 percent between 2000 and 2010, driven by Brazil's real GDP per-capita growth.[111] Total primary energy demand has doubled in Brazil since 1990, led by strong growth in electricity consumption and in demand for transport fuels, driven by robust economic growth and a burgeoning middle class.[112]

In 2023, oil accounted for 36 percent of Brazil's primary energy supply, followed by biofuels, which accounted for 33 percent.[113] Hydropower accounted for 11 percent, followed by natural gas at 8 percent. Coal and renewables accounted for about 4.4 percent each, while nuclear energy accounted for about 1.2 percent of primary energy supply.[114] Overall, fossil fuels accounted for about 40 percent of Brazil's primary energy basket while non-fossil fuels (including biofuels, nuclear, hydropower, solar and wind) accounted for the rest.

In contrast, India's primary energy basket is dominated by coal and fossil fuels, which accounted for over 74 percent (excluding biomass) of India's energy supply in 2022. However, the key factor in the dominant energy choices in Brazil and India is domestic resource endowment, which underwrites both energy security and affordability.

Figure 4: Brazil's Primary Energy Basket (2022)



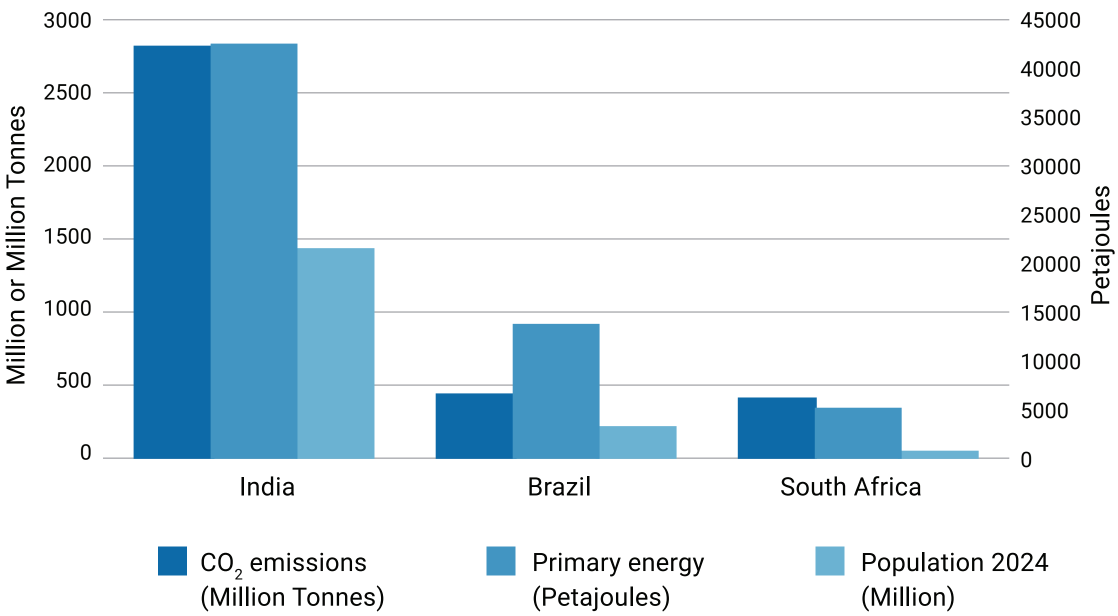
Source: International Energy Agency[115]

Brazil generated 91 percent of its electricity from clean sources in 2023, with hydropower dominating the mix at 60 percent. Brazil is the world's third-largest hydropower producer, behind China and Canada.[116] Wind and solar accounted for 21 percent of power generation—a substantial 4 percent increase from the 17 percent in 2022, up from just 5.8 percent in 2016 well above the global average of 13 percent.[117] Wind generation is favourable in Brazil because wind blows in the dry period, which affects hydropower generation. However, natural-gas-based power is used when both hydropower and RE fall below expectations.[118] Brazil's nuclear power plants also provide a consistent source of baseload electricity, which contributes to overall energy security and grid stability. The distribution of electricity in Brazil is nearly universal; 99 percent of the population has access to some form of electricity.[119]

Brazil's per-capita carbon emissions are well below the global average.[120] In 2023, it had the second lowest carbon intensity of electricity generation among the G20 countries. Brazil has already surpassed its target of reaching 84 percent renewable electricity by 2030.[121] Hydropower, which has been the backbone of Brazil's power sector, stopped growing in the early 2010s, leading to a short-lived foray into gas power to meet electricity demand growth. In 2014, non-fossil-based power generation (hydropower and RE) fell to 74 percent, and non-fossil-based generation had to be stepped up to meet the 26 percent demand, with natural gas alone contributing 17 percent.[122] This resulted in a 20-fold increase in natural gas power generation compared to 2000. An increase in the use of fossil fuels for power generation led to a surge in Brazil’s power-sector emissions,[123] which peaked in 2014 at 114 million tonnes of CO2 ($MtCO_2$).

Since then, Brazil has increased investments in RE and biofuels.[124] Brazil increased non-fossil fuel-based power generation capacity through auction-based renewable procurement power purchase agreements (PPAs), where contracts typically last 15-30 years.[125] These auctions served as an avenue for private project developers to compete for contracts to sell electricity to distribution companies, and the framework included contracts to reduce risk for investors.[126] To encourage the development of solar and wind power, the Brazilian government implemented tax breaks, financing programs, and net metering regulations.[127] Brazil also introduced supportive policies at the supply and demand ends to encourage investments in renewable energy.[128]

Figure 5: Aggregate Energy and Emissions Profile: Brazil, India and South Africa

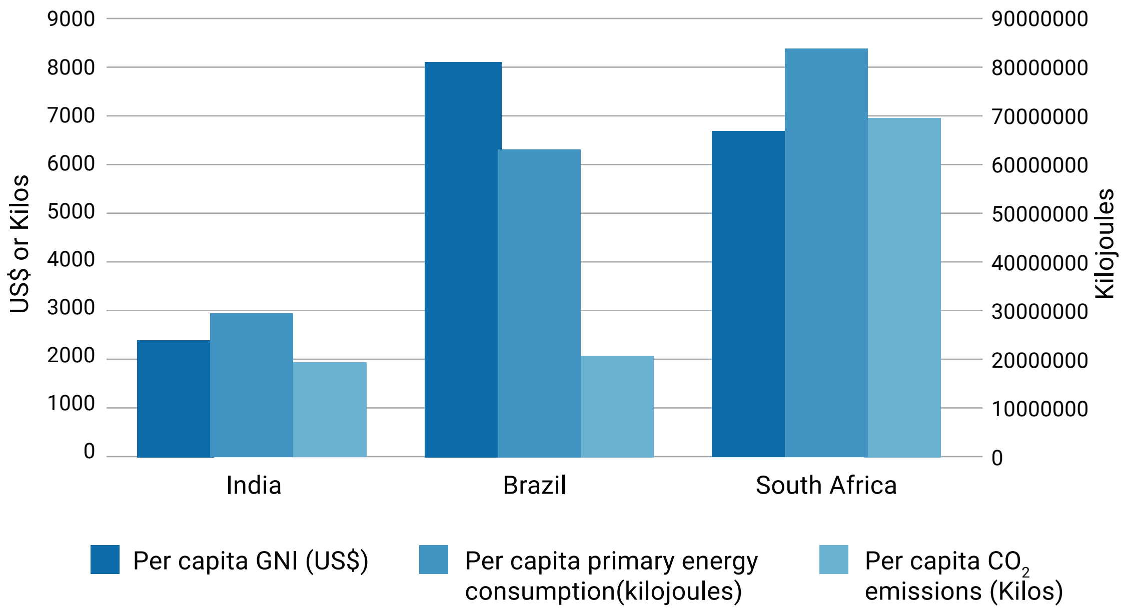


Source: Statistical Review of World Energy 2024[129]; UN Population Division[130]

In 2023, Brazil's power-sector emissions were 38 percent below 2014 levels, at 70 $MtCO_2$. This represented an average decline of 6.7 percent per year.[131] Capacity additions in wind and solar since 2014 are behind the reduction in CO_2 emissions in Brazil from a peak of 0.56 tCO_2 per capita in 2014 to 0.33 tCO_2 per capita in 2023.[132] Between 2011 and 2021, CO_2 emissions in Brazil increased on average at an annual rate of 0.9 percent compared to 1.8 percent between 2000 and 2010.[133]

Despite the success in solar and wind capacity additions, the high share of non-fossil-fuel-based energy in Brazil is dependent on its robust hydroelectric base.[134] The share of hydropower has fluctuated from year to year over the past decade amid varying weather conditions, accounting for 60 percent of Brazil's electricity in 2023 compared to 63 percent on average since 2013.[135] Continued expansion of hydropower is increasingly constrained by the remoteness and environmental sensitivity of a large part of the remaining resource.[136]

Figure 6: Per-Capita Energy and Emissions Profile: Brazil, India and South Africa



Source: Per-capita primary energy and carbon emissions calculated using Statistical Review of World Energy 2024[137] and UN Population Division data[138]; Per capita GNI from World Bank database[139]

Oil accounts for the largest share of primary energy in Brazil.[140] Since 2006, vast offshore oil reserves have been discovered deep beneath a layer of salt known as the pre-salt layer off the coast of Brazil, significantly boosting the country's crude oil production. These oil and gas discoveries have confirmed Brazil's status as one of the world's foremost oil and gas provinces.[141] Production from the deepwater pre-salt fields has gained momentum in recent years, offsetting declining output from mature fields elsewhere.[142] Successful developments in deepwater oil production has turned Brazil into a net oil exporter.[143] As of 2023, Brazil ranked among the top 10 global oil producers.[144]

Though Brazil is known as a country with the cleanest basket of fuels for power generation with falling carbon emission levels, fossil fuel production, mainly oil and natural gas production, accounted for most of the increase in domestic energy production in Brazil in the last decade.[145] Brazil is the largest producer of petroleum and other liquids in South America and the ninth largest producer in the world.[146] Brazil's natural gas and LNG market is expanding because of rising domestic consumption, infrastructure development and market reforms. Brazil's natural gas supply is made up of domestic production, Bolivian imports and LNG cargoes.[147] Most of Brazil's natural gas output is reinjected rather than sold on the domestic market.[148] The reinjection of gas is used to improve oil recovery. Natural gas is used in industries such as petrochemicals, fertilisers, steel, ceramics and food processing for process heating, power generation and as feedstock.[149] As of 2020, the industrial sector consumed most of Brazil's natural gas (67 percent of total natural gas consumption).[150] Residential and commercial demand accounted for a minor portion of total gas demand, representing a 5 percent share of natural gas consumption in 2020.[151] Most of the demand is concentrated in the country's southeastern region, where the pipeline distribution system is more developed.[152]

Brazil's natural gas market faces some challenges, including the far distances between offshore natural gas fields and the coast as well as limited natural gas pipeline infrastructure.[153] A large portion of Brazil's territory does not yet have access to the pipeline grid, which is mainly concentrated in coastal states, where most of the demand is located.[154] Brazil has increased the number of natural gas-fired power plants in the last decade.[155] As in the case of India, natural gas is more expensive than hydropower as source of power generation in Brazil.[156] For the Brazilian government, the affordability of electricity for households is priority, which makes hydropower the preferred choice for power generation.

In periods of drought, when hydropower generation falls and the intermittency of renewables becomes a problem, private-sector-owned natural gas plants make up for the gap in supply.[157] The increase in gas use in electricity generation has served as a dispatchable backup that has prevented the growth of more polluting sources such as coal and oil. As in the case of India, internal regional gas consumption disparities in Brazil are not solely due to economic inequality but also from the lack of access to gas pipelines in urban peripheral areas and inadequate midstream infrastructure for gas distribution.[158]

Brazil is the second largest biofuels producer, accounting for about a fifth of global production and consumption.[159] Biomass-based power generation in Brazil is inextricably linked to the production of biofuels, particularly sugarcane-based ethanol. The sugarcane feedstock used to produce ethanol also produces large amounts of biomass residues, such as bagasse, which are then used to generate electricity. This integration of the biofuels and biomass power sectors helps to make resources more sustainable and efficient.[160] As biomass is less competitive than wind and solar generation, the share of biomass and waste electricity generation among non-hydroelectric renewables has declined in the last decade.[161]

The dominant fuel choice for power generation, coal in the case of India and hydropower in the case of Brazil, are driven by domestic resource endowment, which is an accident of geography that makes the respective fuel source the most affordable and ensures energy security. Both India and Brazil are major investors in renewable energy, but the dominant domestic resource endowment leads to different labels attributed to the two countries. While coal resources have led to India being called a "coal addict",[162] abundant hydropower resources have made Brazil a "trailblazer"[163] in carbon reduction. Nevertheless, both Brazil and India are struggling with contradictions between economic growth and carbon reduction, like most of the rest of the world.

In 2023, Brazil was the ninth largest economy in the world (measured in current US$),[164] the 30th largest emitter of carbon and the seventh largest crude oil producer.[165] Brazil is simultaneously pursuing investments in fossil and non-fossil fuels for two seemingly contradictory goals: While one aims to protect the planet from degradation, with specific national targets as required by multilateral treaties, the other aims for continued global economic growth to achieve human development objectives. The underlying assumption is that efficiency improvements will reconcile the tension between growth and ecological sustainability.

However, studies have shown that global growth of 3 percent per year will make it empirically unfeasible to achieve any reductions in aggregate global resource use and rapid reductions in carbon emissions to stay within the carbon budget for 2°C.[166] The proposed solution is to introduce quantified objectives for resource use per capita with substantial resource-use reductions in the Global North. Although the call for reduction in resource use is bound to meet strong resistance from the Global North, Brazil, as the host of COP30 in 2025 as well as being a trailblazer in the production and use of non-fossil-fuel-based energy, could initiate a dialogue that is grounded in the complexities and trade-offs in the energy transition and call for solutions that are more feasible and equitable.

Three decades ago, Brazil offered revolutionary alternative measures to quantify the responsibility and capability of countries in the context of climate change.[167] The country could now reintroduce alternative frameworks to quantify responsibility and capability for climate action (see Box 2).

Box 2: Brazil's Equitable Framework for Quantifying Climate Responsibility[168]

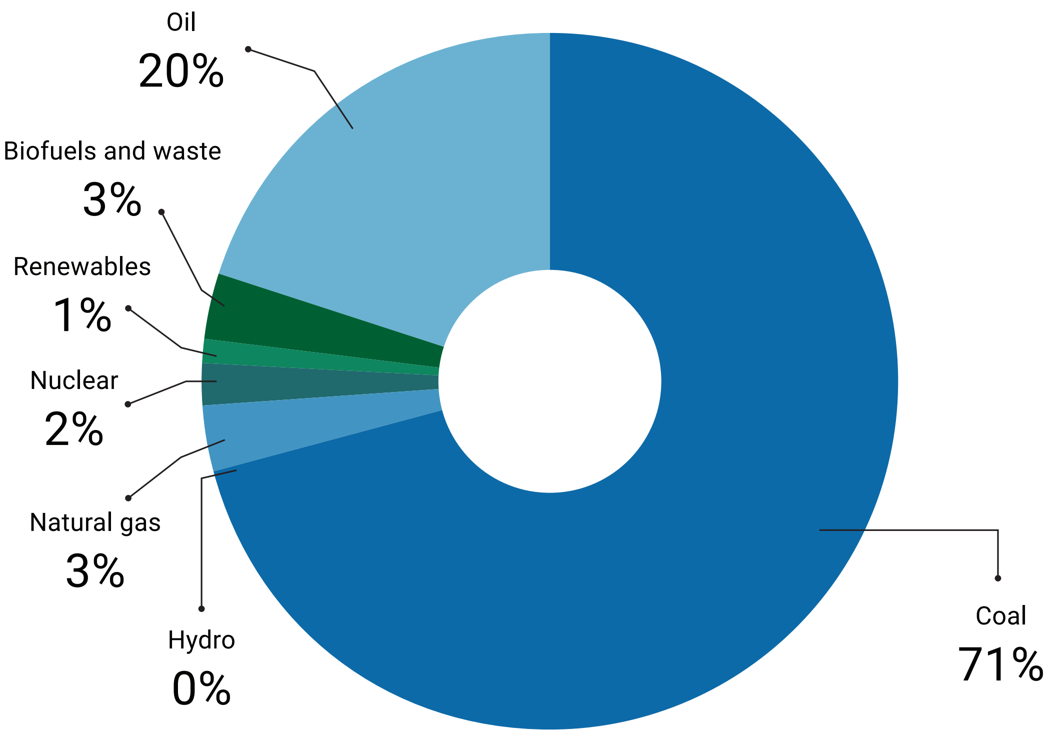
In the run-up to the Kyoto Protocol, proposals were invited from all Parties on how to shape quantified emission limitation and reduction objectives for Annex I Parties (Global North). Brazil presented an innovative and equitable framework for quantifying climate responsibility in 1997. The proposal sought to base emission-reduction requirements on an industrialised country's relative responsibility for the global temperature rise (about 0.6°C higher than pre-industrial levels at that time). The Brazilian proposal called on the Global North as a bloc to reduce their GHG emissions 30 percent below 1990 levels by the year 2020. The proposal's most innovative feature was the method used to distribute emission-reduction burdens among countries—according to each country's relative responsibility for the global temperature increase. The proposal incorporated flexibility into targets by allowing individual targets to be negotiated among rich countries. In other words, the Global North would be bound by the collective target and could trade individual targets among themselves. Another important element of the proposal was the Clean Development Fund (CDF), a punitive and financial mechanism to be managed by the Global Environment Facility. Failure on the part of industrialised countries to achieve their required reductions would result in a fine payable to the CDF. The value attributed to the fine was set at US$10 per tonne of carbon emissions exceeding the target. The distributive criterion for the fund corresponded to the Brazilian proposal's rationale of proportionality: Developing countries could apply for funds according to their relative contributions to atmospheric warming. The funds would finance GHG abatement projects, and up to 10 percent would be used for adaptation projects. The primary objective of the proposed fund was to promote climate protection, including through the transfer of clean technologies, and allowing for the participation of developing countries. The COP in Kyoto did not adopt the Brazilian proposal. The Global North considered the methodology for estimating past emissions to be biased in favour of the Global South and insisted on negotiating targets in a bottom-up, pledge-based fashion. The CDF was also rejected because it was seen as a punitive instrument entailing financial penalties, making it an unlikely instrument in an international treaty.

Enabling Just Transitions: South Africa and India

South Africa was the largest economy in Sub-Saharan Africa in 2023 in terms of GDP.[169] Coal accounted for over 70 percent of South Africa's primary energy supply in 2022, while oil accounted for about 20 percent.[170] Of the remaining 10 percent, biomass and biofuels accounted for about 3 percent, natural gas and nuclear accounted for about 2 percent each and renewables for about 1.4 percent.[171]

In 2023, coal accounted for over 82 percent of total power generation, renewables accounted for 8 percent, nuclear power about 4 percent, oil and other sources accounted for about 2 percent each, hydropower accounted for less than 1 percent while natural gas did not play a role in power generation.[172] South Africa also has a sophisticated synthetic fuels industry and produces liquid fuels from its gas-to-liquids (GTL) plants.[173]

Figure 7: South Africa: Primary Energy Basket (2022)



Source: International Energy Agency[174]

Although South Africa has a high level of access to electricity relative to other Sub-Saharan African countries, its electric power sector experiences frequent power outages because of insufficient investment in electricity infrastructure.[175] South Africa is seeking to diversify its power generation mix by attracting investments in renewable energy sources, but coal is expected to remain the main fuel source to meet its energy needs in the near future.[176] Hydropower accounted for a small share of South Africa’s total electric capacity and generation. South Africa is a relatively dry country, but the rivers in the eastern part of the country are used for hydroelectric power generation. Most of South Africa’s hydroelectric power generation comes from four hydroelectric pumped storage plants.[177]

While there are available fuel options to diversify South Africa’s electricity mix, the affordability of electricity supply is a constraint on diversification. In a poll conducted by the Department of Energy in 2021, three-quarters of South Africans stated that the priority for the government energy policy should be to keep electricity prices low, and economic considerations outweighed other priorities by a considerable margin. Regarding the future fuel mix, nearly a third of respondents agreed with the following statement: “It does not matter which source, as long as it is the cheapest”.[178] Though the structure of consumption and spending on electricity is skewed towards higher income groups, with the richest 20 percent of the population accounting for more than half of the total electricity consumption, affordability is a constraint on fuel choices for power generation.[179]

According to a study, South Africa is less likely to find the volumes of gas needed to considerably lessen its reliance on coal for power generation.[180] With the options currently available, particularly the potential for gas imports from Mozambique, gas-fired power is not anticipated to play a larger role in South Africa’s power industry in the future, especially because of the affordability constraint.[181] However, South Africa is seeking to expand its natural gas pipeline network through the Africa Renaissance Pipeline (ARP), a US$8 billion, 2,599-kilometre pipeline with a capacity of 17.9 BCM per year.[182] South Africa currently does not have any LNG terminals, but the government is looking to develop LNG infrastructure to diversify natural gas import sources and increase natural gas consumption.[183]

The primary concerns in the energy sector in South Africa include power outages (load shedding), differences over the course of policy and political threats. South Africa’s largest coal-based power generator accounts for approximately 95 percent of the electricity used in the country and 45 percent of the electricity used in Africa.[184] About 45 percent of all consumers in South Africa receive electricity directly from the dominant utility, and the remaining 55 percent receive electricity through redistributors (including municipalities).[185] The monopoly generator is a vertically integrated, state-owned power company, which is among the top 20 utilities globally in terms of generation capacity.[186] South Africa has announced plans to unbundle its dominant vertically integrated utility into three separate entities responsible for generation, transmission and distribution to address the high debt levels under the Just Energy Transition project.[187]

South Africa's energy transition is critically dependent on its economic development and future energy demand. Unlike coal-dependent countries in the Global North, such as Germany and Italy, which have committed to phase out coal but have declining population trends and low economic growth rates, South Africa's population is growing and so is the aspiration for a better quality of life, which increases the demand for energy.[188] Considering techno-economic factors such as existing coal reserves, the influence of the mining sector on GDP and the employment generated by the coal mining sector, shutting down South Africa's operating coal capacity in the next two decades is unlikely to be straightforward.[189] This is also true in other coal-dependent countries in the Global South such as India, Indonesia and Vietnam (outside of China, which consumed more than 56 percent of global coal consumption in 2023), which, together with South Africa, accounted for more than 19 percent of global coal consumption in 2023.[190] Overall, the Global South (including China) accounted for over 84 percent of global coal consumption in 2023.[191] In the Global South, 26 countries (excluding China, India and Indonesia) invested in coal-based power generation capacity after signing the Paris Agreement.[192] Of these, five invested in coal-based power generation capacity for the first time.[193] The key factor that influenced the decision to invest in coal was affordability.[194] These countries would have invested in cleaner energy sources if they were scalable, affordable and their supply was secure (independent of geopolitical influences).

In the Global North, most of the carbon reduction achieved was from switching from coal to natural gas for power generation, which was driven by high carbon prices and low gas prices.[195] Coal to gas switching is unaffordable in most countries in the Global South because of the volatility in the price of imported LNG. In addition, the Global South does not have functioning carbon markets that can price out coal. To address the challenge, affordable clean energy technologies that can match or exceed the affordability of coal must be developed and made available across the world. Towards this goal, barriers to trade in clean energy technologies must be eliminated. Most of the increase in renewable-energy capacity additions in the Global South can be attributed to affordable but imported technologies. In the Global North, strategies for reindustrialisation that justify trade barriers are conflated with strategies for carbon emission reduction, which is increasing the carbon reduction burden on the Global South.

Just Energy Transition Partnership

At COP26 in November 2021, the G7-led Just Energy Transition Partnerships (JETPs), involving the governments of South Africa, the UK, the US, the EU, France and Germany, announced that they will provide an initial commitment of US$8.5 billion towards financing South Africa's decarbonisation efforts.[196] Hailed as a revolutionary partnership agreement for decarbonisation in the Global South, JETPs were signed by South Africa, Indonesia, Vietnam and later by Senegal. The partnership sought to unbundle the monopoly power utility, transition away from the reliance on coal-generated energy and move towards privately generated renewables, build an electric vehicle industry and develop a green hydrogen sector that exports to Europe.[197] Ninety percent of the finance package was allocated for electricity-sector reforms through traditional development finance institutions of the Global North, and the remaining 10 percent was for core just-transition objectives.[198] The initial commitment of the JETP aimed to mobilise private-sector financing through various mechanisms such as grants, concessional loans and other risk-sharing instruments.[199] The partnership aimed to support South Africa in reducing its use of coal and reducing its emissions by 1 billion tonnes (BT) to 1.5 BT over 20 years.[200]

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), a part of the JETP has been successful in attracting private sector investment in renewable energy projects.[201] As of January 2024, the REIPPPP has procured approximately 6.4 GW of renewable energy from 112 independent power producers (IPPs) over seven bidding auction windows. The South African government is seeking investors to develop an additional 5 GW of new capacity from solar and wind sources.[202]

Non-hydropower renewables are expected to increase by 8.7 GW by 2032 in South Africa.[203] As in the case of India, solar energy is expected to drive renewable capacity addition because the government has relaxed the standards for local content in solar modules to speed up the implementation of solar projects. Capacity derived from non-hydropower renewable energy sources have been the fastest growing segment in the electric power sector over the past decade.[204] This is one of the interventions of JETP that has produced intended results. However, the shutting down of South Africa's Komati Power Station, a 63-year-old 1000 MW coal-based plant as part of JETP has proved to be far more challenging.

In October 2022, South Africa's government shut down Komati, in line with its JETP plans. Heralded as one of the largest global "repurposing" projects away from fossil fuels, US$497 million was offered to convert the Komati plant into a renewable energy generation site powered by 150 MW of solar, 70 MW of wind and 150 MW of battery storage.[205] The town was entirely built around the power plant and, at one point, provided jobs to an estimated two-thirds of the residents. Yet, when Komati was "repurposed", many were left without work, which is devastating in a country where unemployment is high at over 30 percent.[206] It also created resentment in the community, reflected in comments such as that the repurposing project had been created to "plant poverty in the area", that it was an example of an "unjust energy transition" and that it created an "atom bomb" scenario of social discord".[207]

The Komati debacle, along with the series of blackouts, wiped billions of dollars from the country's GDP and condemned growth to less than 1 percent annually, which led the South African government to extend the life of other coal power stations.[208] Three plants that were to be mothballed have had their retirement dates extended to 2030.[209]

Uncertainty over the fate of coal-sector workers and efforts to reduce state control over energy assets through privatisation have translated into domestic political opposition to JETP.[210] The message that South Africa has sent to the Global North is that it does not want to be the guinea pig for the Global North in the global energy transition. South Africa has stated that it will decarbonise at a pace and scale that is affordable to its economy and society.[211]

Among other fears over the JETP that could stall rather than facilitate the energy transition are: (i) reduction in the ability of the state to respond to energy shortages, (ii) green indebtedness and (iii) green austerity.[212] Acting too fast risked damage to huge sections of South Africa's economy before the country built alternative energy and industrial capabilities.

Analysis of the JETP highlights that it was predicated on the conventional loan-based financing system that was anything but revolutionary.[213] The key hurdle is the contradiction between addressing climate change and restraining ambitions of climate justice within neoliberal orthodoxies. Members of the International Partners Group (IPG) of financiers, all from the Global North, promote the vision of a fairer and cleaner world exploiting optimism bias, whereby experts overstate the likelihood of good things happening.[214] Academic work notes that the blended finance model that underpins JETP calls for using domestic public funds to subsidise the private sector to the benefit of international green energy corporations.[215] Labelled "green structural adjustment" by some scholars,[216] the JETP model of climate finance could be used to compel the economies of the Global South to serve the interests of private companies, mostly from the Global North.[217] Despite the positive connotation of the term "climate finance", scholars argue that it can replicate unequal, neocolonial dynamics through green structural adjustment.[218]

The original concept of a just transition in the 1970s was that workers in sectors labelled toxic should not be asked to pay a disproportionate tax, in the form of unemployment, to achieve the goals of environmental protection.[219] In more recent times, the idea of a just transition has been politicised.[220] Scholars conclude that the Global South has to forgo policy autonomy due to global climate change pressures and have quantified the extent to which the burden of long-term coal phase-out responsibilities will fall unequally on countries in the Global South, foremost among them China and India.[221] Tensions between local democratic sovereignty and global energy justice often amplify the Global North's leverage of the energy choices and strategies of the Global South.[222] Policies that could meet climate mitigation and energy access goals without exploiting international inequalities in ways that risk undermining justice are desirable but so far not designed.

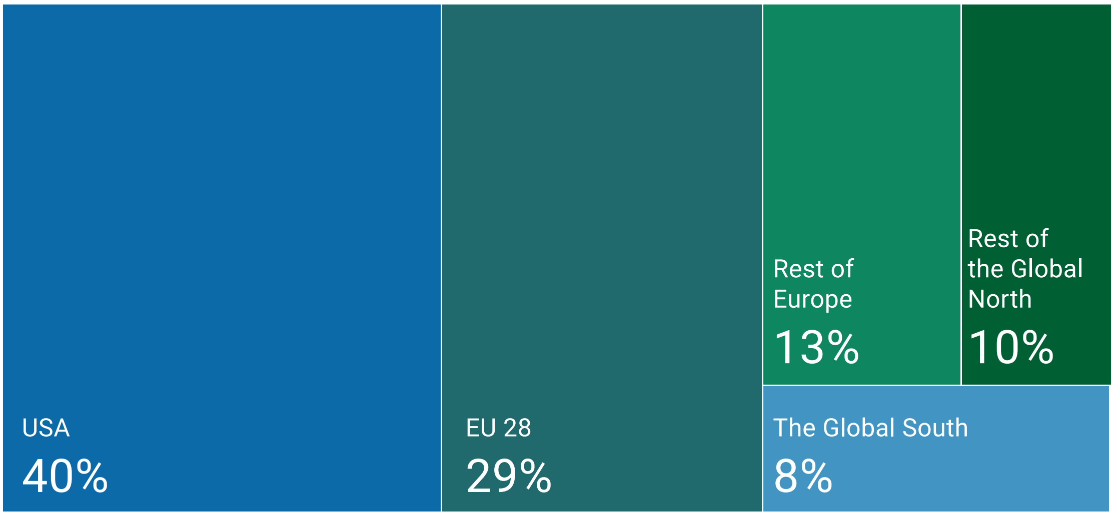
Scholars have concluded that the current 1.5°C-compatible low-carbon pathways for coal phase-out exceed "even the most optimistic interpretations of real-world ambitions."[223] To meet the 1.5°C limit, China, India and South Africa would need to phase out coal twice as fast as historically observed "for any power technology in any country, relative to system."[224] South Africa would need to reduce its share of coal generation at a rate of approximately 30 percent each decade to meet the 1.5°C limit.[225]

According to the Global Energy Monitor, South Africa employs over 67,000 people in its coal sector, and India is estimated to employ over 330,000 people with formal jobs and more than four times the number (over 1.3 million) in informal jobs in the coal sector.[226] Millions more are employed in the upstream and downstream coal value chain in both countries. Most of those employed in coal mining are unskilled or semi-skilled workers and are unlikely to transition to gainful employment in other segments when coal is phased out. Like their counterparts in the Komati power plant in South Africa, many coal workers in India are likely to return to the agriculture sector, settle for menial labour in urban areas or become destitutes, as shown by the history of industrial transitions. It may be argued that, coal workers, constituting less than 0.0005 percent of the total population (including China), cannot hold up action on the existential threat of climate change. However, for the labour force in the coal sector, immediate rewards such as gainful employment are preferable over delayed gratification such as would be yielded from action on climate change—a concept known in economics as 'temporal discounting'.[227] As time-discounted benefits of carbon reduction will be visible only in decades, immediate action such as phasing out coal will pose an immense political and economic challenge, especially in democracies such as India and South Africa.

Countries of the Global South typically have high debt burdens. This limits fiscal space to fund necessary system strengthening and fossil phase-out investments. Institutional and regulatory weaknesses and poor creditworthiness of counterparties raise risk-adjusted return expectations of investors, making bankable renewable projects scarce.

For instance, India's annual average energy transition outlay is estimated to be about 10 percent of the country's GDP. However, India's combined investment outlay on education, health, water and housing fall well short of 10 percent.[228] With available technologies, the capital cost for replacing a conventional fossil-based power plant with renewables is five to six times higher for the same level of energy service (dispatchable round the clock).[229] Even conventional electricity costs are up to 25 percent more in India (and most of the rest of the Global South) due to lack of competition, inadequate transmission and distribution and inadequate load management capacity.[230] These constraints translate to higher equipment costs, higher cost of capital and higher operating costs due to larger system losses and lower system flexibility. India’s most recent economic survey, released in February 2025 explicitly states that “there is no valid economic rationale for shutting down coal plants in India, leaving huge investments underutilised and stranded and without a dependable alternative in place”.[231]

Figure 8: Responsibility for Excess Carbon Emissions by Country/Region



Source: Jason Hickel[232]

Box 3: Entitlement to a Fair Share of the Atmosphere[233]

Negotiations and agreements under the UNFCCC are focused on current territorial emissions. According to a study on entitlement to atmospheric space, under territorial framing, China's responsibility is more than double that of the US, and India comes in just behind the EU. In the context of climate change, what matters is stocks of CO_2 in the atmosphere, not annual flows. The study argues that responsibility must be measured in terms of each country's contribution to cumulative historical emissions. This is fair as the countries that contributed to cumulative CO_2 emissions benefited from burning fossil fuels in the form of wealth generation and high living standards.

If the principle that the atmosphere is a shared and finite resource and that all people are entitled to an equal share of it is applied, the share of responsibility of each country changes substantially, as highlighted in the study. Under this regime, national responsibility for climate damages is estimated as the extent to which nations have exceeded their fair share of a given safe global emissions budget. Such an approach assigns national responsibility for emissions in excess of the global budget in a manner that takes account of both scale and population. Countries that have exceeded their fair share would then be said to owe a climate debt to countries that have remained within their fair share.

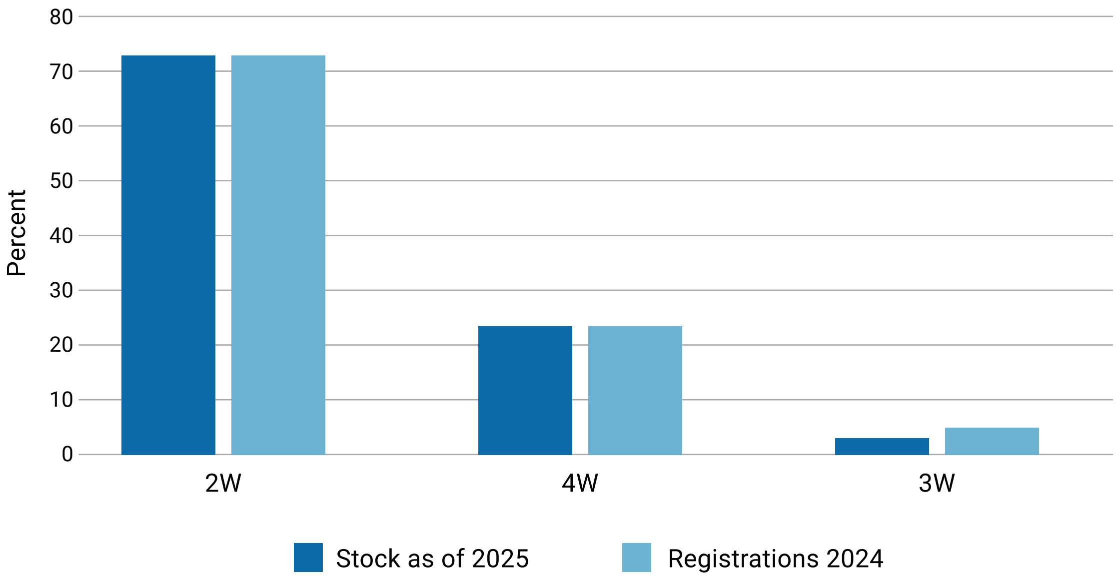
In the study, fair shares are defined with reference to 350 parts per million (ppm) atmospheric CO_2, and 1850 is used as the base year for calculating cumulative historical emissions based on consumption-based emissions. The results show that the US, which had an allocated share of 41.5 gigatonnes of carbon-dioxide ($GtCO_2$) had cumulatively used 420.4 $GtCO_2$ of the available carbon budget with an overshoot or debt of 378.9 $GtCO_2$ or 40 percent of total overshoot emissions. India, which had an allocated share of 133.4$GtCO_2$, had cumulatively used 43.2 GtCO2 of the available carbon budget with an undershoot of 90.2 $GtCO_2$ or 34 percent of total undershoot emissions. The US and EU28 together were responsible for 69 percent of the overshoot, and the G8 countries (the US, EU28, Russia, Japan and Canada) were responsible for 85 percent of the overshoot. Annex I countries were responsible for 90 percent of the overshoot and the Global North as a whole was responsible for 92 percent of the overshoot. The study observed that interpreting responsibility for climate change consistent with the principles of planetary boundaries and equal access to atmospheric commons provides just guidance for determining liability for damages related to climate change.

Decarbonising Road Transport: The Case of Biofuels

India's Vehicle Stock

In 2024, there was a stock of over 389 million registered vehicles on the Indian roads. Of this, about 73 percent were two-wheelers (2Ws), 24 percent were four-wheelers (4Ws) and about 3 percent were three-wheelers (3Ws).[234] Electric vehicle (EV) stock of about two million accounted for about 1 percent of the total vehicle stock in India. In the global context, India's EV stock, including 2/3Ws, was about 0.5 percent. India overtook China in 2023 to become the biggest market for electric 3Ws.[235] India continues to have a high share of EV 2/3Ws with lead-acid batteries in sales, despite government efforts to ban this technology in low-speed EVs and encourage a transition towards lithium-ion (Li-ion) technology, motivated by poor environmental credentials for lead-acid battery recycling.[236] Due to their low upfront purchase price, lead-acid battery-powered electric 3Ws remain a widespread public transport option across India.[237] Estimates of their market share range from 55-98 percent.[238]

Figure 9: India Vehicle Stock and Registrations: Share by Type

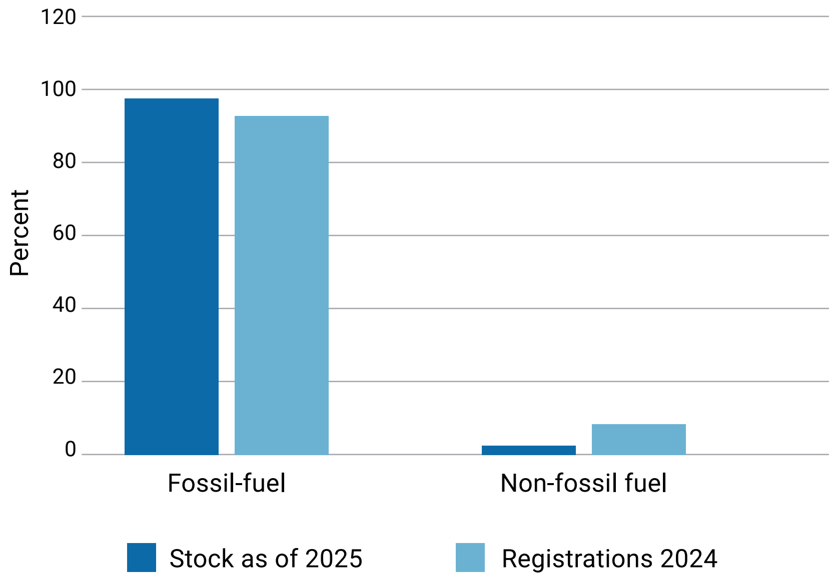


Source: Vahan Database[239]

The share of 2W registrations fell from 76 percent of total vehicle registrations in 2020 to about 72 percent in 2024 while the share of 4W registrations increased from 20 percent of total vehicle registrations in 2020 to 23 percent in 2024.[240] The share of 3W registrations doubled from 2 percent of total registrations in 2020 to about 5 percent in 2024.[241]

In 2020, vehicles powered by fossil fuels (petrol, diesel, Liquefied Petroleum Gas [LPG], compressed natural gas [CNG] and LNG) accounted for over 98 percent of vehicle registrations; in 2024, the share of fossil fuel-based vehicle registrations fell to 92 percent.[242] In the same period, the share of EV (battery-operated, fully electric and other types) registrations increased from less than 1 percent to about 8 percent, and the share of hybrid vehicles and alternative fuel (ethanol and methanol) vehicles increased from less than 1 percent to over 2 percent.[243] Electrification rates are impressive only in the 2W and 3W segments that receive subsidies under a government programme to promote electrification.[244] Though 2Ws have a high share of vehicle numbers, 4Ws dominate fuel consumption. This means that the decarbonisation of the 2W segment will have a limited effect on fuel consumption patterns.[245]

Figure 10: India Vehicle Stock and Registrations: Share by Fuel Type



Source: Vahan Database[246]

To accelerate the decarbonisation of road transport, India has revived its programme for blending ethanol with petrol with target dates for achieving ambitious blending rates. The goals of this program include increasing energy security, improving farmer incomes and reducing carbon emissions from road transport. The case of biofuels in Brazil, a global pioneer in biofuels production and deployment, is illuminating in this regard.

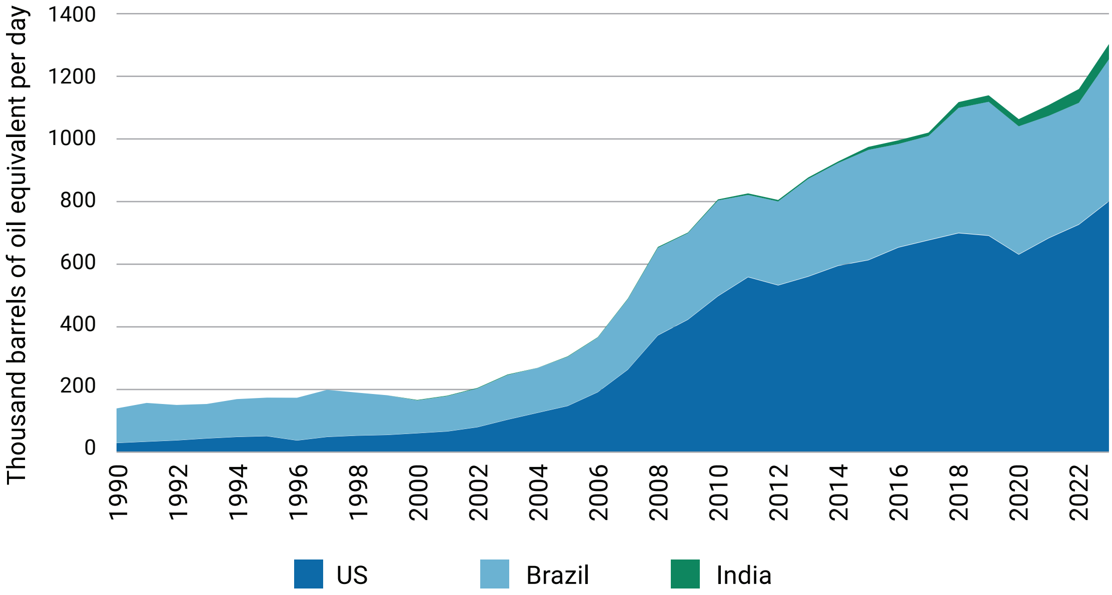
Role of Biofuels: Brazil and India

The Global Biofuel Alliance (GBA) proposed by India aims to establish a global partnership between national governments, agencies, industries and other stakeholders to advance sustainable biofuels technology deployment and expand sustainable biofuels market penetration.[247]

India has had programs for blending ethanol with petrol for over two decades. The most recent push for biofuels was initiated with the biofuels roadmap released by NITI Aayog (the in-house think tank of the Government of India) and the Indian Ministry of Petroleum & Natural Gas (MOPNG) in 2021.[248] The report recommended (i) advancing the target for 20 percent ethanol blending in petrol by five years to 2025 and (ii) the use of food crops such as maize (corn), sugarcane and surplus rice as a biofuel feedstock.[249] The government aims to strengthen India's energy security, enable local entrepreneurs and farmers to participate in the energy economy and reduce tailpipe emissions of vehicles.[250]

An indicative target of 20 percent ethanol blending in petrol was set for 2030.[251] In the Ethanol Supply Year (ESY), which runs from November to October, the blending of ethanol with petrol stood at 380 million litres, with a blending percentage of 1.53 percent in ESY 2013-14.[252] In the ESY 2023-24, the blending percentage surpassed 13 percent, with approximately 5.45 billion litres (BL) of ethanol blended. By 2025, the government aims to achieve 20-percent ethanol blending.[253] In 2024, around 98 percent of road transportation fuel came from fossil fuels and 2 percent from biofuels in India (through blending).[254]

Figure 11: Biofuel Production: US, Brazil and India



Source: Statistical Review of World Energy 2024[255]

According to the Government of India, in the decade 2014-2024, savings of over US$12 billion in foreign exchange, a reduction of CO2 emissions by 54.4 million tonnes and a substitution of 18.1 million tonnes of crude oil was achieved through ethanol blending.[256] The government also stated that US$16 billion was disbursed to ethanol distillers and US$10 billion to farmers growing feedstock for ethanol production. The government anticipates demand for 10.16 BL of ethanol to achieve the target of 20-percent ethanol blending by 2025.[257]

The ethanol blending programme also recorded some compromises in its goal of increasing energy security by reducing imports in 2024.[258] Above-average monsoon rains and the surplus production of sugarcane and other foodgrain in previous years gave rise to optimism over an increase in ethanol production in 2024.[259] However, sugarcane and rice production increases did not materialise and food grain surpluses dwindled in 2024. Sugar production decreased by about 8 percent due to late rainfall and pest infestations in major sugarcane-producing regions.[260]

Similarly, rice production was also 2 percent lower than the previous year due to water stress. The availability of these two major feedstocks decreased by approximately 20 percent in 2023 compared to 2022.[261] The result was that India, which was traditionally a net exporter of corn, became a net importer in 2024, with the import of a record 1 MT of corn, mainly from Myanmar and Ukraine, which grow non-genetically modified (GM) corn.[262] In 2024, India imported 600 million litres of ethanol, almost 50 percent more than imports in 2023, to meet its medical, industrial and beverage demand.[263]

The ethanol blending programme also makes substantial demands on public funds.[264] The price of ethanol in India is higher than in countries like the US (corn-based) and Brazil (sugarcane-based), which are much larger producers of ethanol.[265] This is because India's regulated price of feedstock (e.g., sugarcane, corn) is maintained at a higher level to support farmers.[266] The Minimum Support Price (MSP) for corn increased from INR 13,650/tonne (t) to INR 19,620/t in 2022-23—a 43 percent increase.[267] In the same period, corn production costs increased by about 25 percent. In January 2024, the government raised the procurement price of corn-based ethanol by 29 percent, bringing it to INR 71.86 (about US$0.86)/litre.[268] The price of corn-based ethanol in the US in 2024 was approximately US$0.74/litre.[269] Generous MSPs facilitate an increase in corn production and higher income for domestic corn farmers.[270]

The unintended consequences, such as the import of corn and ethanol, illustrate that decreasing fuel imports, reducing carbon emissions and increasing farmer incomes cannot be achieved simultaneously. Among many reasons is that increasing production of fuel crops (sugarcane and corn) in India, where arable land and water are limited, involves a trade-off between food and fuel.

The goals of Brazil's biofuels have evolved with time. In 1933, the Brazilian government offered incentives to use surplus sugarcane for ethanol production to address the challenge of sugarcane overproduction.[271] In 1975, Brazil reoriented ethanol production to reduce the country's reliance on foreign fossil fuels by blending ethanol with petrol.[272] Ethanol blending mandates began with the ProAlcohol programme, and the blending mandate has since progressively increased to the current 27 percent (volume basis).[273] This forced the adoption of flex-fuel vehicles in Brazil that can switch between any petrol-ethanol blend, from 100 percent petrol to 100 percent ethanol.[274] Flex-fuel vehicles comprise nearly 90 percent of Brazil's light-duty vehicle fleet today, allowing Brazilian consumers to choose higher ethanol blends when ethanol prices are advantageous.[275] Since the 2000s, the goal of the biofuel blending programmes in Brazil has shifted to sustainability and the reduction of carbon emissions. Combustion of ethanol produces water and CO_2, but full-cycle emissions can be 50-70 percent lower than fossil-fuel combustion. However, full-cycle emission levels critically depend on the energy used for the cultivation and irrigation of feedstock such as sugarcane or corn.[276] In India, the use of fertilisers derived from fossil fuels and the use of diesel pumps or electric pumps that draw electricity from a predominantly coal-based grid may substantially reduce net carbon emission reduction benefits.[277]

Sugarcane is the primary feedstock for ethanol production in Brazil, followed by corn. In addition to ethanol, Brazil has a large biodiesel industry, the world's third-largest market for biodiesel after the US and Indonesia.[278] Brazil's biodiesel program began in 2005, with the National Programme for the Production and Use of Biodiesel (PNPB), which manages mandatory minimum biodiesel blend rates with the current rate set at 14 percent, which will increase in March 2025 to 15 percent.[279] About 69 percent of the biodiesel production in 2023 originated from soybean oil, and 16 percent is made from used cooking oil.[280] Today, Brazil is the world's second-largest ethanol producer, behind the US, as well as the third-largest biodiesel producer.[281]

Brazil has also ventured into second-generation ethanol (cellulosic ethanol) production from non-food biomass like sugarcane bagasse, a byproduct of traditional ethanol and sugar manufacturing, that can reduce the conflict over land for fuel or food production but can also increase productivity yielding 50 percent more fuel for the same surface.[282]

One of the key challenges in India replicating Brazil's success in biofuel production and use is resource endowment, particularly land and water resources. Arable land available per capita in India was 0.1 hectares (ha) per capita in 2021, while it is 0.3 ha per capita in Brazil.[283] Renewable freshwater resources per capita were about 1035 cubic metres (m^3) in India in 2021 compared to 26,552 m^3 per capita in Brazil, which is more than 25 times that of India.[284] Brazil has more than five times the global average in renewable freshwater resources, while India has only one-fifth of the world average. India is the second-largest producer of sugarcane.[285] Freshwater resource availability is an important factor in the cultivation of sugarcane, the dominant feedstock for ethanol production in India. Generally, sugarcane crops require 300-500 millimetres (mm) of rainfall/water for their growth and 1,500-2,500 mm of rainfall/water to complete the growth cycle. Sugarcane has one of the longest growing periods, and its growth can come to an untimely halt if there is a water shortage.[286] One kilogram of sugarcane production requires 1500-3000 litres of water.[287]

Even in Brazil, the production of biofuel crops, especially crops for the production of first-generation bioethanol and biodiesel, has negatively impacted the environment, particularly through land use change and deforestation.[288] Brazil's use of biofuels has been challenged in recent years by rising costs and issues linked to land use protection.[289]

In the case of first-generation biofuel crops that can be used directly as food, biofuel production can especially affect food security through two principal pathways.[290] First, they compete for the same natural resources used to support food production. Second, they may compete with traditional agricultural commodities and affect food security outcomes.[291] Feedstock production implies the use of water and land resources that could be available for additional food production.[292]

Estimates suggest that biofuel that fills a regular car tank could feed one person for one year[293] and that about 200 million people could be fed with crops (in terms of calories) used for bioethanol production globally and 70-80 million people with the caloric content of total biodiesel production.[294] First-generation biofuels are at the core of the food-energy-land-water nexus because of the destination of edible crops as fuel for energy production rather than food for reducing malnutrition.[295] The increasing demand for ethanol implies a consequent increase in demand for crops such as corn in the United States and sugarcane in Brazil, causing concerns over land use change.[296] Land use change is the largest source of GHG emissions in Brazil.[297]

The key message from Brazil's and India's biofuel programmes is that decarbonising road transport using first-generation biofuels involves trade-offs that may substantially reduce the net benefit of blending, especially in the context of carbon emission reduction.

Closing the Cooling Gap

Background

According to the WMO, 2024 was the warmest ever recorded in human history, and the average global temperature for the year exceeded 1.5°C above the pre-industrial baseline for the first time, breaching the threshold set by the Paris Agreement.[298] Technically, the Paris Agreement target of limiting warming to below 1.5°C is calculated using a 20-year average, so a single year above the threshold does not signal a formal breach of the target.[299] However, above-average temperatures have become the norm in the last decade with exceptionally hot summers worldwide. In this context, the lack of essential indoor cooling in most parts of the Global South, a dimension of energy poverty, is troubling.[300] Though the adoption of household AC typically increases with rising incomes in the Global South, most of the desperately poor who need air conditioning do not have it and are not likely to have it in the future.[301] Access to cooling is an adaptation measure for the Global South that can save lives.[302] There is an immediate need to finance access to cooling for poor households.

By most estimates, the energy gap between the rich and the poor is unlikely to be closed by 2030, though Sustainable Development Goal 7 (SDG7) calls for universal access to electricity. Scholars point out that the energy poverty gap is even broader than indicated by the SDG7 electricity access indicator when the need for space cooling is also considered.[303] Assessment of the extent of the population lacking access to residential cooling (the cooling gap) is estimated to be between 1.8 and 4.1 billion in the Global South.[304] The 'Cooling for All' initiative observes that at least 3.43 billion people still face cooling access challenges in 2021,[305] including 1.09 billion rural and urban poor at high risk and 2.34 lower-middle income people at medium risk. Access to space cooling (AC) in the Global South is a climate-change adaptation measure that requires as much attention as carbon mitigation measures because thousands die of heat stress in the Global South.[306]

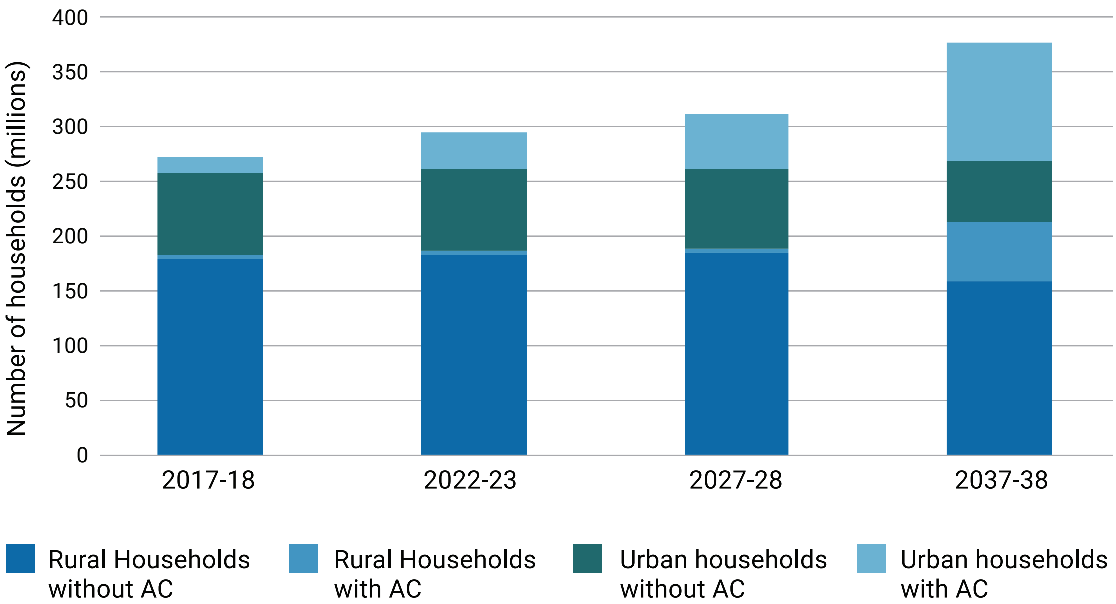
Cooling Gap: Global North and South

The cooling gap distribution is uneven across the Global South.[307] The regions with the highest share of population affected by the cooling gap include Sub-Saharan Africa, South Asia and South-East Asia, both because of lower income levels and hotter climate conditions in these regions.[308] In these regions, ACs are considered a luxury due to their high initial costs and high running costs.[309] AC is assigned to the top tier of electricity access in the World Bank's multitier framework, implying that it is exclusive.[310] Only 8 percent of the 2.8 billion people living in the hottest regions of the world have access to AC, which makes access to cooling an equity issue.[311] Adoption of AC is a climate-change adaptation response that confers potentially large health benefits to people. However, there is concern that AC use will increase the demand for energy, which can increase peak electricity demand, increase carbon emission if the electricity is generated using fossil fuels, affect electricity systems stability and increase household spending on energy at the expense of other vital expenditures.[312] Cooling appliances account for nearly 20 percent of global electricity use by buildings.[313] In turn, the operations of the building sector represent 30 percent of global final energy consumption and cause 26 percent of global energy sector CO_2 emissions.[314] About two-thirds of the 1.6 billion AC units installed globally are in residential buildings, accounting for about half of the total 1,200 terawatts (TW) of installed cooling capacity.[315]

According to a study, by the end of the century, under a scenario of continued high emission growth, death rates due to heat stress are expected to increase by 106.7 per 100,000 in low-income countries but to fall by 25.2 per 100,000 in high-income countries as a result of their significant spending to prevent more deaths.[316] Heat stress is also unevenly distributed within countries, disproportionately affecting low-income and disadvantaged groups.[317] In India, studies found an average temperature difference of 7.6°C between formal and informal housing, where lower-income and marginalised people are more likely to live.[318] The population-weighted heat-stress exposure is 100 percent for India compared to China, where the exposure is less than 20 percent.[319] According to estimates, a 1°C increase in temperature will increase electricity consumption for space cooling by around 15 percent.[320] The total minimum energy requirements to close the cooling gap with AC and fans have been estimated at 786 TWh/year for the entire Global South, corresponding to about 14 percent of global residential electricity consumption.[321]

Many parts of the world experienced record-high temperatures in the last few years, and the global average number of cooling degree days (CDDs, the number of degrees that a day's average temperature is above 18°to 21°C) in 2020 was 15 percent higher than in 2000.[322]

Figure 12: AC Use in Households in India: Current and Future



Source: MOEF&CC (2018)[323]

Out of the 35 percent of the world's population living in countries where the average daily temperature is above 25°C, only 10 percent own an AC unit.[324] India, which has more than 3,000 CDDs, consumes just 70 kWh for space cooling compared to 800 kWh in South Korea, which has only 750 CDDs.[325] This disparity is mainly because of the low affordability of AC use in India. Currently, less than 10 percent of Indian households own ACs, but demand is growing rapidly.[326] Studies show that the correlation between wealth and AC use is stronger than the correlation between climate and AC use.[327]

Efficient Cooling

Most detailed analyses of space cooling needs conclude that technology is the answer for improving the efficiency of AC systems to substantially reduce electricity consumption and, consequently, GHG emissions.[328] Providing AC systems with higher energy efficiency could lead to 16 percent reduction in electricity requirements, while better building shell insulation could entail 34 percent reductions.[329] While reducing energy needs, enhanced building quality could also improve indoor thermal comfort and limit the need for active cooling systems.

The average efficiency of ACs in India is relatively low, given the cost-sensitive nature of the Indian market.[330] Many of the suggestions from expert organisations propose stringent efficiency standards for ACs and incentives for the purchase of efficient ACs.[331] Better building design, increased renewables integration and smart controls are other measures suggested to reduce space cooling energy use and emissions and limit the power capacity additions required to meet peak electricity demand.[332]

Other interventions recommended include increasing minimum energy performance standards closer to those of best-in-class ACs, which are typically twice as efficient as the market norm.[333] Government procurement agencies and large private-sector buyers (like real estate developers) leveraging their buying power through advanced market commitments and bulk procurement programs for super-efficient ACs is a workable solution.[334]

Simple financing solutions are observed to encourage people to buy more efficient ACs. Financial solutions include distribution companies (DISCOMs) offering ‘on-bill’ financing, which would allow consumers to pay for energy-efficient appliances on their electricity bills and in instalments, enabling them to realise cash savings from the very first day.[335]

Even if all theoretically possible efficiency gains are achieved, AC use will likely remain the privilege of the affluent and aspiring classes. In India, the per-capita carbon emissions of the lowest 50 percent of the population is 0.9 tCO_2eq and 1.2 tCO_2eq for the middle 40 percent, compared to 9.6 tCO_2eq for the top 10 percent.[336] AC use that consumes more electricity than all other electrical equipment in a typical affluent household in India accounts for a large share of the CO_2 emissions of the top 10 percent.[337] This means that the poor and middle-class households that make negligible contributions to CO_2 emissions (from ACs and other energy-intensive devices) are likely to suffer most from heat stress. There is an opportunity for the Global North to fund access to cooling in the Global South through targeted programmes mediated by the government and non-governmental organisations.

Paying for Efficient Cooling

In theory, there is recognition that funds should be allocated for efficient cooling. The Kigali Cooling Efficiency Programme (K-CEP) recognises financing needs for access to cooling. Still, this recognition remains limited given that financing needs continue to be poorly defined and tracked globally.[338] The Green Climate Fund (GCF) also calls for half its funding to be dedicated to adaptation, with half of that funding going to the poorest countries in the Global South, where access to cooling is a key adaptation measure.[339] However, the GCF's approach to adaptation has several shortcomings, including a complex application process, difficulty reaching local communities, a lack of risk appetite for innovative projects, inadequate transparency in funding allocation and concerns about the effectiveness of its project selection process, often resulting in delays in delivering crucial adaptation funds to those most in need.[340] Studies point out that the "simplified approval process" launched to facilitate access to finance takes years to complete and requires information that is impossible to find in the Global South.[341]

China's clean energy technologies exported to the rest of the world is produced from cheap coal-based power. The greater the demand for clean energy technologies, the greater is China's coal use. In this context, it makes greater sense for India (along with the rest of the Global South) to focus a lot more on adaptation (such as providing access to cooling) rather than on carbon emission mitigation.[342]

Recommendations and Conclusion

The dominant framing of the energy transition from the Global North, both popular and academic, oversimplifies the challenge and carries with it some degree of value judgement. The great diversity between the North and the South cannot be discounted in any analysis, and alternative framings reveal important truths. The overview of specific trade-offs in the energy transition efforts of India, Brazil, and South Africa shows that the path towards decarbonisation is economically challenging, socially problematic, technologically intractable, and politically complex. Interventions for the energy transition proposed by the Global North cannot be accepted uncritically because they ignore diverse histories and national contexts in the Global South. The interventions proposed by the Global North were designed for post-industrial economies with stagnant or declining populations and slow economic growth rates where energy consumption growth has peaked or plateaued. Economies in the Global South are growing, and their populations are increasing with concomitant growth in energy demand. The Global South is not likely to abandon its aspirations for better living standards so that countries in the Global North can continue living in cleaner environments and cooler climates.

- For productive outcomes on the energy transition, the energy transition effort needs to reconcile with the overarching aspiration in the Global South to catch up with the global north economically and politically.

The friction between energy transition and energy security is clearly evident in the actions of the Global North in response to the conflict over Ukraine. These actions reveal the limitations of transitioning to renewable energy sources while also protecting energy security and affordability.

- To ensure energy security, energy transition policies must acknowledge the significance of domestic energy resources for energy security and affordability.

With decreasing global financial commitments to support mitigation action in the Global South, countries in the South must increasingly prioritise adaptation measures to safeguard the benefits of rapid economic growth against climate-induced setbacks.

- The path towards decarbonisation needs to balance the Global North's obsession with investment in mitigation action with the Global South's adaptation needs, starting immediately with funds for space cooling among poor households.

As technologies and fuels for carbon emission reduction evolve, policies tied to specific technologies and fuels can become redundant. Policies that are independent of technologies and fuels will offer flexibility, adaptability and future-proof investments.

- Policy must prioritise technology and fuel-agnostic strategies that pave the way for a low-carbon future, minimising stranded costs and optimising benefits.

Approaches to climate response that invoke guilt and fear need to be replaced with more optimistic approaches that focus on the hope of a better future guaranteed by the individual right to a standard of living adequate for health and well-being.

- Country-level climate action needs to be based on qualitative parameters that reflect the right to human wellbeing at the individual level rather than territorial levels that are skewed against large countries.

The Global North is re-industrialising at the cost of decarbonisation. Trade and non-trade barriers of the Global North exceed those of the Global South, which is fragmenting markets and increasing the cost of the energy transition.

- To accelerate the energy transition, trade and non-trade barriers on low-carbon technologies must be reduced to increase affordability and accelerate the energy transition in the Global South.

About the Authors

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Endnotes

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