

Transitioning Away from Fossil Fuels: Insights to Drive Implementation

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Abstract: Since COP28, limited progress has been made in implementing the global commitment to transition away from fossil fuels. This article examines the challenges and opportunities in advancing this mandate in a just, orderly, and equitable manner. Drawing on Catavento's recent studies, it introduces a multidimensional framework to assess countries' capacity, highlights the dual energy and economic transitions, and emphasizes the need for parallel but differentiated tracks for oil and gas, and coal.

Keywords: transitioning away; energy transition; economic transition; COP30.

Transição de combustíveis fósseis: perspectivas para impulsionar a implementação

Resumo: Desde a COP28, a implementação do compromisso global de transição para longe dos combustíveis fósseis avançou de forma limitada. Este artigo analisa desafios e oportunidades para conduzir esse mandato de forma justa, ordenada e equitativa. Com base em estudos recentes da Catavento, apresenta uma abordagem multidimensional para avaliar a capacidade dos países, destaca as transições energética e econômica e enfatiza a necessidade de trilhas paralelas, porém diferenciadas, para petróleo e gás e para carvão.

Palavras-chave: transição de combustíveis fósseis; transição energética; transição econômica; COP30.

The 28th Conference of the Parties (COP28), convened in Dubai, United Arab Emirates (UAE), in 2023, marked a milestone for the global climate and energy agenda. At the Conference, 198 countries unanimously acknowledged that current efforts remained insufficient to align greenhouse gas (GHG) emissions with the long-term objectives of the Paris Agreement. In the same year, global GHG emissions surpassed 57 GtCO₂e, with the energy sector responsible for 68% of this total, reinforcing its central role and relevance in the global debate. In this context, the Parties agreed on a set of commitments designed to accelerate progress during this critical decade, with the aim of limiting the increase in global average temperatures to 1.5 °C above pre-industrial levels.

These commitments, articulated in paragraph 28 of the first Global Stocktake (GST), include: (a) doubling the global average annual rate of energy efficiency to 4% by 2030 (compared to 2% in 2022); (b) tripling renewable energy capacity to 11,500 gigawatts (GW) by 2030 (compared to 3,680 GW in 2022); (c) accelerating efforts towards the phase-down of unabated coal power; and (d) transitioning away from fossil fuels in a just, orderly, and equitable manner.

The achievement of these objectives implies a profound reconfiguration of energy systems worldwide. In 2024, fossil fuels accounted for 80% of the global supply of energy, reaching a record high of 519 exajoules (EJ). In contrast, projections suggest that, if the COP28 outcomes were to be fully implemented, fossil fuel demand would fall by 130 EJ to 375 EJ by 2030 (a 25% decline compared to 2022 levels). By the same year, oil and natural gas (O&G) consumption would

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decrease by approximately 20%, equivalent to 20 million barrels per day (mb/d) and 500 billion cubic meters (bcm), respectively, while coal consumption would drop by around 40%, or 2,500 million tons of coal equivalent (Mtce).

However, since COP28, the global energy and climate landscape has undergone significant shifts. Heightened geopolitical tensions and the weakening of multilateral governance have curtailed the willingness of States to cooperate on energy transition matters, redirecting attention towards energy security. Simultaneously, electricity demand has expanded more rapidly in both advanced and emerging economies, driven by structural shifts such as the electrification of transport and industry, rising demand for cooling, and the rapid growth of data centers. In 2024, global power demand increased by 4.3%, outpacing global energy demand and GDP growth of 2.2% and 3.2% in the same period, respectively.

In this context, notable advances have also been recorded. Investments in clean energy exceeded US\$ 2 trillion in 2024, representing more than twice the capital allocated to fossil fuels. Global renewable energy capacity is on track to achieve a 2.7-fold expansion by 2030, nearing the COP28 target. Energy efficiency, however, remains the critical laggard: in 2024, the global rate of improvement fell to approximately 1%, well below the required trajectory.

Although the mandate established at COP28 is unequivocal, current global trends indicate that progress is not advancing at the necessary pace. Bridging the gap between commitments and reality requires a clear understanding of the obstacles ahead, the stakes involved, and the concrete measures that can accelerate implementation. Against this backdrop, Catavento's recent studies seek to provide a robust diagnosis of the challenges and opportunities for countries in the transitioning away process, as well as key dimensions and indicators to support both Brazilian and international stakeholders in driving this commitment forward.

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ABOUT CATAVENTO'S STUDIES

Catavento has developed two comprehensive reports on this topic. In December 2024, the study *Rethinking Transitioning Away from Oil and Gas in a Just, Orderly, and Equitable Manner* was released, introducing an innovative framework to assess the ability of countries to conduct the transition away from O&G across 11 major producers and consumers. In 2025, Catavento extended the scope of the analysis in a second study, *Transitioning Away from Fossil Fuels: A Broader perspective to Drive Implementation*, adding four countries to the previous O&G analysis, representing new energy and socioeconomic contexts, and conducting a coal sensitivity analysis.

The studies are based on two crucial points of departure. First, progress in supply and demand must proceed in tandem, as abrupt disruptions on the supply side risk generating price volatility, undermining energy access and affordability, and ultimately eroding societal support for the transition. Consequently, the scaling up of low-carbon alternatives across both energy production and consumption emerges as an indispensable condition for a just, orderly, and equitable transition away from fossil fuels.

Second, there is an urgent need for all countries to advance toward the implementation of the transitioning away commitment, as the costs of climate inaction exceed those of any potential transition pathway. In 2024 alone, global economic losses associated with extreme weather events surpassed US\$ 348 billion, 60% of which, approximately, were uninsured. This underscores the pressing socioeconomic imperative to accelerate action in order to mitigate future risks.

KEY INSIGHT #1—ADOPT A MULTIDIMENSIONAL APPROACH TO DETERMINE THE PACE OF EACH COUNTRY

Although all countries must move towards the implementation of the transitioning away commitment, it is equally important to acknowledge that they differ substantially in their ability to conduct the transition, which shapes both the pace and the pathway through which it may occur. Assessing this requires a multidimensional approach that considers not only energy-related aspects but also socioeconomic and climate factors. Catavento's work identified six dimensions to assess a country's capacity to transition away from fossil fuels, each of which captures a specific element of the challenge.

Fossil fuel relevance reflects the extent to which a country's economy is tied to fossil fuels in terms of production, contribution to Gross Domestic Product (GDP), exports, and exposure to stranded assets, providing a robust assessment of

structural vulnerabilities in the context of the energy transition. Nations with less diversified economies are particularly dependent on the sector to generate economic returns including fiscal revenues, trade balance, and employment. O&G remains the main driver of these returns, while coal plays a more regionalized role. For instance, in the UAE, which ranks as the world's 9th largest oil producer, oil rents equate to 16% of GDP and fossil fuels account for 49% of exports.

O&G competitiveness assesses the ability of a country to produce fossil fuels efficiently, considering both breakeven costs and emissions per barrel. Competitiveness stands out as a crucial factor in determining the capacity to navigate potential implications of the transition, including higher carbon costs and declining demand. Middle Eastern producers, led by Saudi Arabia and the UAE, are notable for cost-competitive and emissions-efficient production, while Norway stands out for its low-emissions production across both oil and natural gas.

Energy security obstacles refer to the barriers countries face in advancing the transition while ensuring a secure and accessible energy supply. Though most countries rely at least moderately on fossil fuels to meet current needs, those who are net exporters, present large per capita consumption levels, as well as growing demand trends, face significantly higher challenges. Conversely, there are countries that, while still dependent on fossil fuels to meet energy needs, face lower obstacles and a higher push to transition, whether due to lower per capita consumption or limited domestic production. In such cases, countries like India, Germany, and China have stronger incentives to develop domestic low-carbon alternatives at scale, as a means to enhance energy security.

Energy transition readiness measures a country's ability to replace fossil fuels with low-carbon solutions at scale and competitively, providing the same level of energy services. Key indicators include the cost of renewable electricity generation, integration into low-carbon value chains, and the capacity to finance the transition, reflected by GDP per capita and sovereign credit ratings. In many Emerging Markets and Developing Economies (EMDEs), including Brazil, the high

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cost of capital, which reflects a wide-range of macroeconomic and sector-related risks, is one of the most significant barriers to scaling clean energy investments, despite strong renewable competitiveness and potential for further integration into low-carbon value chains.

Emissions profile captures historical and current contributions to global GHG emissions, reflecting the principle of Common but Differentiated Responsibilities (CDBR) established under the Paris Agreement. Industrialized economies such as the United States (US), China, Russia, and historically Germany are among the largest contributors to global emissions and therefore face stronger expectations to accelerate reductions given their weight on the global carbon budget. In contrast, many EMDEs, having been responsible for relatively less cumulative emissions, may retain greater flexibility in determining their energy pathways, including the potential use of fossil fuels, as they pursue economic development and seek to meet growing energy needs.

Institutional and social resilience assesses the ability of countries to navigate the complex economic and energy shifts associated with the transition. Nations with high-energy access, capable institutions, robust planning capacities, and resilient societies should manage to steer the transition in a more stable manner, while protecting vulnerable populations and ensuring economic stability. This is particularly evident in advanced economies, including the US, Canada, Norway, and Germany.

KEY INSIGHT #2—ADVANCE ON TWO SIMULTANEOUS TRANSITIONS: ECONOMIC AND ENERGY

Beyond providing a deeper understanding of the complexities involved in transitioning away from fossil fuels, the multidimensional analysis illustrates the existence of two simultaneous transitions: energy and economic. The energy transition refers to the transformation of carbon-intensive energy systems into lower-emission alternatives, while the economic transition focuses on identifying new sources of growth, fiscal revenues, and exports.

Although the energy transition has gained broad global recognition and a more mature diagnosis, progress on the economic transition remains limited, reflecting the absence of clear economic alternatives to the fossil fuel industry. This gap is critical in the context of transitioning away, as it shapes both the pace and the capacity of countries to move in this direction. In this context, Catavento's study points to several potential avenues to support and enable this transition, which will be highlighted in the following segment.

Energy transition

Technologies are already available to deliver at scale, affordably and reliably, the energy services currently provided by fossil fuels. Approximately 40% of the world's energy supply are directed to electricity generation, with fossil fuels accounting for around 59% of this total. Final energy consumption, in turn, is concentrated in three main sectors: industry (39%), buildings (28%) and transportation (27%). Among these sectors, a varied reliance on fossil fuels is observed, which meet roughly 63% of consumption in industry, 36% in buildings and 94% in transport. In parallel, a wide range of low-carbon technologies, at different stages of maturity and competitiveness, can be deployed across these segments to substitute fossil fuels use.

Renewables, led by wind and solar, are the primary technologies driving power sector decarbonization. In 2024, 91% of newly commissioned utility-scale renewables projects delivered electricity at a lower cost than fossil fuel alternatives, with wind and solar ranking as the cheapest sources in most major markets on a levelized cost of electricity (LCOE) basis. Complementing their expansion, battery storage has seen rapid deployment, mainly alongside wind and solar to mitigate intermittency, enabled by a 93% LCOE reduction since 2010.

Electrification stands out as the most consequential lever to reduce fossil fuel consumption across all three end-use sectors, whenever its application is possible. The greatest progress has been in light transport, where electric vehicles (EVs) are expected to represent 25% of global automobile sales in 2025, and over 50% in China, the world's largest market. Additionally, heat pumps and other electricity-based technologies play a central role in the buildings and light industry sectors, enabling households and businesses to access efficient and affordable services, especially in fossil fuel-importing countries subject to fluctuations in international prices.

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Nonetheless, there are several sectors that still lack viable electrification alternatives due to economic or technical constraints, particularly heavy transport and hard-to-abate industries, including steel, cement, and petrochemicals. In these cases, while low-carbon solutions exist, which include sustainable fuels (e.g.: low-carbon hydrogen, advanced biofuels) and carbon capture, utilization and storage (CCUS), they remain significantly more expensive than their fossil fuels counterparts, which hinders large-scale adoption.

The challenge now lies less in identifying solutions than in overcoming the barriers to their implementation. Countries must establish conditions for a decarbonized energy system to compete with fossil-based systems in a reliable and affordable manner. For mature technologies, this involves adapting electricity markets to accommodate the growing share of renewables, promoting energy storage solutions, and upgrading grid infrastructure. Public policies that encourage the adoption of electrification technologies, such as energy efficiency standards, also play a crucial role. In the case of heavy transport and hard-to-abate industries, targeted public support remains essential to accelerate cost reductions, drive technological breakthroughs, and stimulate demand for low-carbon solutions.

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Economic transition

In the context of the economic transition, it is important to acknowledge the fossil fuel industry's relevance for many countries, in terms of fiscal revenues, trade balance, and jobs. Between 2018 and 2022, the O&G sector generated more than US\$ 17 trillion in revenues, nearly half of which was directed to governments. At present, the renewable energy and clean technology sectors cannot generate fiscal revenues at levels comparable to those derived from the fossil fuel industry. In 2024, for example, gasoline and diesel tax revenues reached approximately US\$ 560 billion, compared to US\$ 2.5 billion from electricity taxes.

Fossil fuels accounted for 8% of total merchandise exports globally in 2024, equivalent to nearly US\$ 1.9 trillion. Dependence on fossil fuels for export revenues

remains significant, even in relatively diversified producers such as the US (15%) and Brazil (16%) and exceeding 80% in less diversified economies such as Nigeria and Saudi Arabia. At the same time, of the 67.5 million people employed in the global energy sector, 48% (32.5 million) work in fossil fuels. While clean energy jobs are projected to comprise an increasing share of energy employment, many of the new positions are unlikely to emerge in current fossil fuel-producing regions, potentially leaving some countries or regions at risk of being left behind.

The first critical avenue to tackle the economic transition is to promote economic diversification, particularly in countries heavily reliant on O&G revenues. To achieve this, several strategies can be pursued. For example, the industry's revenues can be partially directed toward new sources of economic growth and the development of low-carbon value chains. These resources can also be invested in clean energy research, development, and innovation (RD&I), as well as reskilling efforts, enhancing competitiveness in emerging energy systems. Effective allocation of these revenues requires strengthened institutional capacity and improved transparency. It is equally important to foster an attractive business environment to mobilize private investment, especially in countries where public funding is constrained.

The second critical avenue is to level the playing field between fossil fuels and low-carbon alternatives, in particular when it comes to price signals. This includes a comprehensive reform of inefficient fossil fuel subsidies. In 2023, global fossil fuel subsidies amounted to US\$ 616 billion, predominantly aimed at lowering consumer prices. However, evidence shows that these subsidies often fail to address existing inequalities and can distort market signals. Expanding carbon pricing mechanisms is another crucial strategy. Such mechanisms are essential tools to internalize the negative externalities of fossil fuels, promote more efficient resource allocation towards low-carbon technologies, and generate revenues that can offset fiscal impacts arising from the gradual transitioning away of fossil fuel activities.

The third avenue is promoting market-based mechanisms that reward low-carbon products. In this case, improving and harmonizing carbon accounting standards is critical. This requires robust international cooperation towards the alignment of criteria and, in turn, enabling the comparability of low-carbon attributes across products, as well as the assessment of their green premium. Further initiatives include mechanisms that match supply with demand for low-carbon products, including labeling schemes, buyers' coalitions, and other market-based incentives.

Finally, the fourth avenue is reducing the burden of fossil fuel import expenditures. Currently, more than 75% of the world's population lives in fossil fuel-importing countries, while a quarter resides in countries spending over 5% of GDP

on fossil fuel imports. In this context, promoting domestic low-carbon alternatives and energy diversification, where feasible and competitive, can strengthen energy security, reduce exposure to volatile import bills, improve energy access and affordability, enhance economic competitiveness, and free up fiscal space.

KEY INSIGHT #03—ADOPT PARALLEL BUT DIFFERENTIATED TRACKS FOR O&G AND COAL

The third key conclusion is that the debate on transitioning away from fossil fuels should advance along two distinct, but parallel, tracks: O&G and coal. While demand for all three fossil fuels must decline to meet the COP28 commitments, the dynamics of reducing coal consumption differ substantially from those of O&G, as coal demand is far more concentrated, both geographically and by sector.

The Asia-Pacific region stands out as the largest consumer and producer of coal. In 2024, 82% of global coal consumption occurred there, led by China (56%), India (14%) and Indonesia (3%). Similarly, coal supply, which is largely oriented towards domestic consumption, is also concentrated in these countries, with more than 80% of global coal production located in Asia-Pacific. By comparison, 72% of global oil production are concentrated among the top ten producers, whereas for coal, 71% are concentrated in just three countries—China (52%), India (10%), and Indonesia (9%). As a result, coal is the least traded of the three fossil fuels, with only 20% of total production directed toward international markets, compared to 40% for crude oil.

Meanwhile, power and industry concentrate the largest share of coal use, with the power sector representing around 65% of total demand. Although renewable power generation is cheaper than coal-fired electricity in most major markets, coal demand remains strongly influenced by domestic dynamics and priorities, particularly energy security. This is especially evident in countries experiencing rising electricity consumption, where infrastructure constraints limit the large-scale deployment of renewables.

Industry accounts for roughly 30% of global coal demand, with steel and cement production responsible for over 70% of this share. These sectors face significant challenges in accelerating the adoption of alternative production methods. In steelmaking, for example, coal-based blast furnace–basic oxygen furnace (BF-BOF) technology represents 68% of global production capacity, with the economic lifetime of these assets typically lasting for 40 years. While around 60% of global steel production facilities are expected to face major investment decisions this decade, low-carbon alternatives carry a levelized cost of production

50% to 100% higher than conventional methods, undermining competitiveness and potentially locking-in coal-based infrastructure.

By contrast, O&G consumption is more geographically dispersed and cross-sectoral, with highly globalized markets shaped by international trade and investment flows. This makes the transition away from O&G a multilateral challenge, requiring coordination across countries and sectors, as well as systemic shifts across energy systems in both supply and demand. Addressing O&G and coal together under a single framework risks obscuring their distinct socioeconomic, geopolitical, and energy implications. A dual-track approach, therefore, is more effective, allowing for localized and sector-specific strategies for coal while managing the global complexities O&G.

COUNTRY CLUSTERS

Taking these key insights into consideration, it was possible to identify three clusters among the 15 countries analyzed, according to their overall capacity to transition away from fossil fuels.

The first cluster is well-positioned to navigate both the energy and economic transitions. They are characterized by high economic diversification, despite some vulnerability to stranded assets and significant fossil fuel dependence. These countries face persistent energy security challenges yet demonstrate high transition readiness supported by strong macroeconomic fundamentals and robust capabilities to conduct the transition in an orderly manner. These nations are also some of the largest current and historical emitters, having already taken their share of the carbon budget. Examples of these countries among the sample would be the US, China and Germany.

The second cluster may demonstrate strong capacity in certain categories but remains vulnerable in the economic and energy transitions. These countries have a higher reliance on fossil revenues and a more limited economic diversification, though they generally maintain relatively competitive O&G production profiles. Energy security obstacles vary between major producers and net-importers, yet uneven renewable competitiveness, a secondary role in low-carbon value chains and weaker macroeconomic conditions constrain their transition readiness. Overall, while these countries display a more diverse profile with notable opportunities, they also face significant challenges across the analyzed dimensions, limiting their ability to navigate either the energy or economic transition. Examples consist of Canada, Brazil, Norway, Russia, Argentina, the UAE, India, and Indonesia.

The third cluster is less equipped to pursue both the energy and economic transitions. These countries are characterized by heavy economic exposure to fossil fuels, driven by their limited economic diversification and strong reliance on exports and revenues, notably from O&G. They generally have a lower readiness to switch to a low-carbon energy system, due to weaker investment conditions and low value chain participation, coupled with a strongly fossil fuel-oriented energy mix and more vulnerable institutional and social landscapes. In the sample, these include Saudi Arabia, Nigeria, Angola, and Iraq.

CONCLUSION

The theoretical framework proposed by Catavento's studies on transitioning away from fossil fuels seeks to stimulate international and multilateral debate, ensuring the most effective mobilization of all countries toward this transition. The studies identify five fundamental elements that must be addressed to advance global ambition in a just, orderly, and equitable manner. First, supply and demand must progress in tandem. Second, all countries must advance, albeit along different pathways. Third, assessing these pathways requires a multidimensional framework. Fourth, two simultaneous transitions—energy and economic—must be managed. And fifth, O&G and coal should be addressed in parallel but along separate tracks.

Although underscoring the complexities of the task ahead, this approach reaffirms the possible pathways that should be assessed through a combination of shared common goals and domestic viabilities. Adapting the course of an established system requires courage and audacity, while also a degree of reality. There is no better place to aim for progress than COP30. 🚩

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