WORLD ENERGY TRILEMMA 2024:

EVOLVING WITH RESILIENCE AND JUSTICE

ABOUT

WORLD ENERGY COUNCIL

The World Energy Council is the world's oldest independent and impartial community of energy leaders and practitioners. Through our Humanising Energy vision, we involve more people and communities in accelerating clean and just energy transitions in all world regions. Formed in 1923, the Council has convened diverse interests from across the full energy ecosystem for a century, and today has over 3,000 member organisations and a presence in nearly 100 countries. Our global network draws from governments, private and state corporations, academia and civil society, as well as current and future energy leaders. We effectively collaborate on impact programmes and inform local, regional and global energy agendas in support of our enduring mission: to promote the sustainable use and supply of energy for the benefit of all people.

Further details at www.worldenergy.org and on LinkedIn and X (formerly known as Twitter).

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WORLD ENERGY TRILEMMA INDEX 2024

The World Energy Council's definition of energy trilemma is based on three core dimensions: Energy Security, Energy Equity, and Environmental Sustainability of Energy Systems.

Balancing these three goals constitutes a 'Trilemma' and balanced systems enable prosperity and competitiveness of individual countries.

The World Energy Trilemma Index has been prepared annually since 2010 by the World Energy Council. It presents a comparative ranking of 126 countries' energy systems. It provides an assessment of a country's energy system performance, reflecting balance and robustness in the three Trilemma dimensions.

Access the complete Index results, national Trilemma profiles and the interactive Trilemma Index tool to find out more about countries' Trilemma performance and what it takes to build a sustainable energy system can be found at https://trilemma.worldenergy.org

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FOREWORD

For 100 years the World Energy Council has operated as an open and visionary, diverse and distributed energy leadership community. It is now developing into a deeply local and globally connected peer-to-peer platform, with thousands of organisations as members.

We share and shoulder a huge responsibility. Our enduring mission —to "promote the sustainable supply and use of energy for the greatest benefit of all people"— is best delivered by sharing stewardship for energy transitions throughout the world; using our convening power for the common good; connecting the 'dots' to close the 'gaps'; and collaborative change-maker capabilities that enable changes in energy systems for the benefit of all.

Nearly twenty years ago, our community created the World Energy Trilemma Framework in response to new demands for energy and sustainable development. The framework provides a practical, systems-based approach to guiding and tracking performance in managing the connected challenges of energy security, social equity, and environmental sustainability.

Our understanding of the connected challenges of energy transitions and sustainable development continues to evolve with global environmental sciences and complexity thinking, and, importantly, through an exchange of practical, grounded experiences in managing increasingly diverse energy systems. Here, diversity is used in the broadest sense—diverse societies, geographies, and technologies.

While the Trilemma Framework and approach have been continuously improved through use over the years, recent crises have led members to ask for a more fundamental evolution of all three dimensions, including a digital upgrade and an extension of the framework itself.

Multiple energy transition pathways are emerging in all regions of the world, but none are on track to avoid an overshoot of planetary boundaries or to provide clean, affordable, and reliable energy access to billions more people. We know there are big gaps in supply-side infrastructure and investment. And we know we need to do more to decarbonise energy demand and secure wider productive access and wiser uses of energy.

Our advice in reading this year's report is to look beyond the Global Index and the comparative ranking. Instead, let's discuss the importance of this flexible toolkit in addressing urgent and practical challenges of accelerating decarbonisation with justice and resilience.

Societies everywhere are facing the rapids of global energy transitions and the fog of a more crowded, fragmented, and polarised global energy leadership landscape.

Energy transition is not a straightforward swap of old for new technologies; it is a socially messy and transformational change process. A successfully managed global energy transition is unprecedented and cannot be completed all in one go nor by any single region, country, company or city, working alone. There is There is no one-size-fits-all net-zero pathway. Situations, starting points, and outlooks differ.

Energy transitions impact and are impacted by wider changes in man-made systems, such as industry, food, transport, and cities, and in the Earth's natural life support systems, such as climate, weather, oceans, and biodiversity.

While 2024 is expected to see solar and wind power exceed hydroelectric and nuclear in the global energy mix for the first time, not every energy use can be electrified by 2050, and trilemma trade-offs and synergies will continue to emerge and evolve as renewable electrification of the global energy mix increases.

We also know that what got us to 'here' won't get us all to 'there'!

The world has the technical know-how to get to net zero. What it lacks is the social know how—the 'how tos' and 'with whoms' of making faster, fairer, and more far-reaching energy transitions happen in all regions.

Guiding orderly, inclusive, and just global energy transition pathfinding is not easy but it is possible with the World Energy Trilemma approach.

Making faster, fairer, and more far-reaching energy transitions happen is essential. But these transitions are best achieved through 100s and 1000s of smaller steps and by involving billions more people and diverse communities in understanding their roles and choices. Many and new ways of aligning diverse needs and interests are essential and emerging.

An evolving and flexible World Energy Trilemma Framework is the best way to catalyse, connect, and scale new change-maker ecosystems, comprising countries, global value networks and supply chains, companies, cities, and regions.

Energy is too important to be a story of 'us' versus 'them'. It is the story of humanity that we can and must create together.

The World Energy Council does not exist to predict or control the future of energy but to co-create a better energy future for people and planet.

Please join us in retooling the Trilemma Framework and redesigning energy for 10 billion better lives and a healthy planet.

Angela Wilkinson
Secretary General & CEO
World Energy Council

EXECUTIVE SUMMARY

NOW IN ITS 15TH YEAR, THE WORLD ENERGY TRILEMMA FRAMEWORK IS RECOGNISED AS A VALUABLE TOOL TO NAVIGATE AND ACCELERATE ENERGY TRANSITIONS AROUND THE WORLD

Energy transitions entail profound whole-system changes that transcend the confines of traditional energy frameworks, moving beyond fuel substitution, electrification, decarbonisation of the global system and other technological advancements. Given the intricate interconnectedness of energy with other vital systems, such as industry, agriculture, and urban infrastructure, the transformative impacts of energy transitions extend well beyond the energy sector. Catalysing fairer, faster, and more far-reaching energy transitions requires that more people and diverse communities understand how the choices they make today help shape the energy systems of tomorrow.

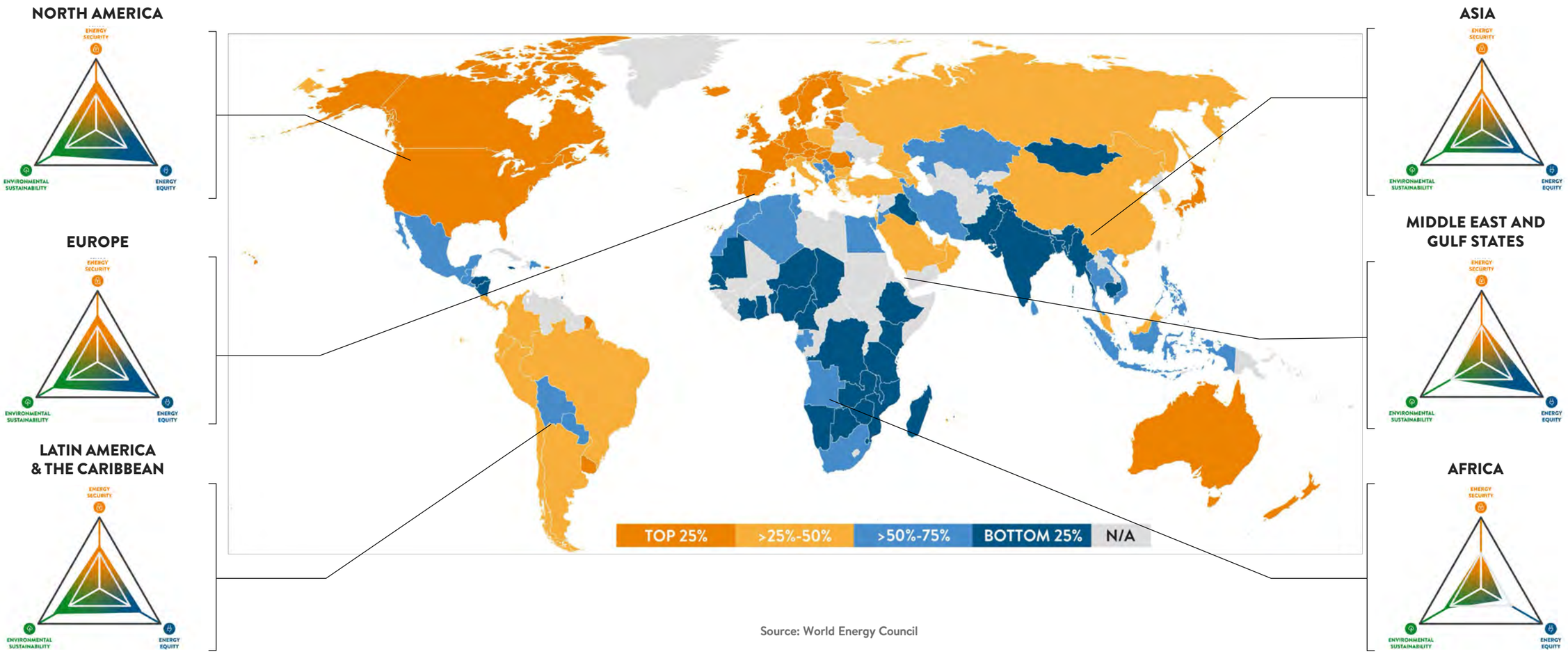
As energy transitions unfold within the broader context of systemic shifts across a spectrum of interdependent systems, they signify a fundamental reorientation of our relationship with energy. This reorientation necessitates significant changes in organisational structures and operations of the energy system.

Now in its 15th edition, The World Energy Council's World Energy Trilemma Report 2024 places significant emphasis on signals from interviews with experts in the community. These experts have used the Trilemma Framework to discuss the implications of post-pandemic recovery and the war against Ukraine within specific regions across the world, with special emphasis on the management of trade-offs among the World Energy Trilemma dimensions of energy security, equity, and sustainability. These regional reports identify both challenges and opportunities as well as the effects of recent crises on energy systems throughout the world and the strategic responses to these crises.

A NEW KIND OF DEMAND-DRIVEN ENERGY SHOCK

While the overall Index scores continue to show European countries among the top performers, the interviews highlight the challenges faced and responses sought to the first consumer-led demand-driven energy shock following the invasion of Ukraine. The bombing of the Nord Stream pipelines, alongside growing geopolitical tensions, starkly exposed Europe's vulnerability due to its heavy reliance on Russian gas, prompting a critical reassessment of energy sources and triggering the demand-driven energy shock. Apart from Hungary, which resisted fully cutting ties with Russia, a majority of European nations decided not to import Russian gas. Other countries stepped up to export more gas or reroute deliveries of LNG to make up for the shortfall, managing to ease the stress on energy security. But while the security dimension of the energy Trilemma was addressed in the short term, there were significant repercussions on energy equity, due to soaring energy prices, as well as on environmental sustainability, due to an increased use of traditional energy sources, including coal.

These impacts on equity and sustainability were experienced in regions across the world, much beyond Europe. While Europe was able to manage the short-term, demand-driven energy shock following the cutting off of Russian supplies, the long-term consequences, coupled with its green only policies, pose a number of risks, including loss of competitiveness, rising input costs, and loss of technological advantage, potentially leading to deindustrialization.



Source: World Energy Council

NORTH AMERICA

POWERING THE FUTURE: NORTH AMERICA'S TRILEMMA MANAGEMENT PLAN UNVEILED

North America is addressing its energy trilemma by focusing on infrastructure resilience, community-driven energy equity, and environmental sustainability. The transition towards clean energy is propelled by policies like the Inflation Reduction Act, although challenges such as investment in transmission infrastructure and market vulnerabilities persist. The continent's energy future hinges on balancing affordability, reliability, and sustainability, emphasising the importance of innovative policies and technologies, consumer engagement, and efforts to strengthen the grid against climate-induced disruptions.

EUROPE

NAVIGATING UNCERTAINTY TO MAINTAIN AFFORDABILITY AND TO ENSURE THE RESILIENCE OF ENERGY SYSTEMS IN RESPONSE TO GEOPOLITICAL SHOCKS

Europe is currently reassessing its energy strategy with a new focus on security in relation to affordability and sustainability. In contrast to a continuing reliance on gas, the rapid move towards diversification, particularly in renewables, reveals the tensions between immediate energy needs and long-term environmental goals. Price surges have prompted significant state intervention and electricity market reforms to protect consumers. Europe's challenge lies in balancing renewable integration, grid variability, and technological independence amidst geopolitical and energy sovereignty concerns, while steering towards resilient, self-reliant, and equitable energy systems.

LATIN AMERICA & THE CARIBBEAN (LAC)

FINDING A SOCIO-POLITICALLY APPROPRIATE PATH TOWARDS A RESILIENT AND SUSTAINABLE ENERGY FUTURE

Latin America and the Caribbean face complex energy futures, balancing security, equity, and sustainability amidst climate and political shifts. Subsidies play a crucial role in maintaining affordability, yet disparities and the cost of decarbonization continue to pose significant challenges. The region's reliance on hydro energy underscores the urgency for diverse and sustainable energy sources in the face of rising climate threats. The journey towards a resilient and sustainable energy future is marked by efforts to balance economic disparities, preserve biodiversity, and foster public-private partnerships amidst global energy shifts and the critical need for structural changes.

ASIA

ENSURING CONTINUITY OF ECONOMIC GROWTH WHILE MANAGING A SUSTAINABLE AND FAR-REACHING TRANSITION

Asia's energy transition is marked by robust demand driven by economic growth amidst climate threats and challenges to infrastructure resilience. Striving for energy independence, the region is exploring renewables while grappling with coal dependency. Efforts towards universal electricity access continue in a context of subsidies and other market complexities. Sustainability ambitions are visible in commitments to renewable expansion and electric vehicle adoption, yet balancing economic growth with clean energy transitions poses financing challenges. Asia's path is a multifaceted quest for resilience, clean energy, and sustainable growth, supported by regional cooperation and private investment.

MIDDLE EAST AND GULF STATES (MEGS)

PLACING ENERGY TRANSITION AT THE CENTRE OF AMBITIOUS ECONOMIC DIVERSIFICATION PLANS

The Middle East and Gulf States are at a crossroads, transitioning from traditional oil and gas dominance, critical to maintaining global energy security, to renewable and nuclear energy amidst geopolitical shifts. Already scoring high on energy equity, the region is investing in diverse energy sources and global initiatives to ensure continued access. Ambitious renewable targets and strategic investments mark a move towards sustainability, yet balancing economic diversification with challenges like governance and climate change is increasingly important. The region's journey towards balancing its energy trilemma involves navigating complexities to achieve sustainability and security goals amidst regional tensions.

AFRICA

SECURING RISING DEMAND DESPITE CONTINUOUS CHALLENGES

Africa is confronting a critical phase in its energy development, characterised by rising demand, security challenges, and a transition towards cleaner energy. Despite infrastructure and investment limitations, efforts towards renewable energy adoption and regional integration are gaining momentum. The continent faces a delicate balancing challenge between advancing energy equity, particularly in rural areas, and navigating environmental sustainability amidst increasing renewable investments and oil explorations. Africa's energy landscape is further complicated by geopolitical dynamics, highlighting the importance of upskilling, private sector financing, and institutional leadership for a sustainable future.

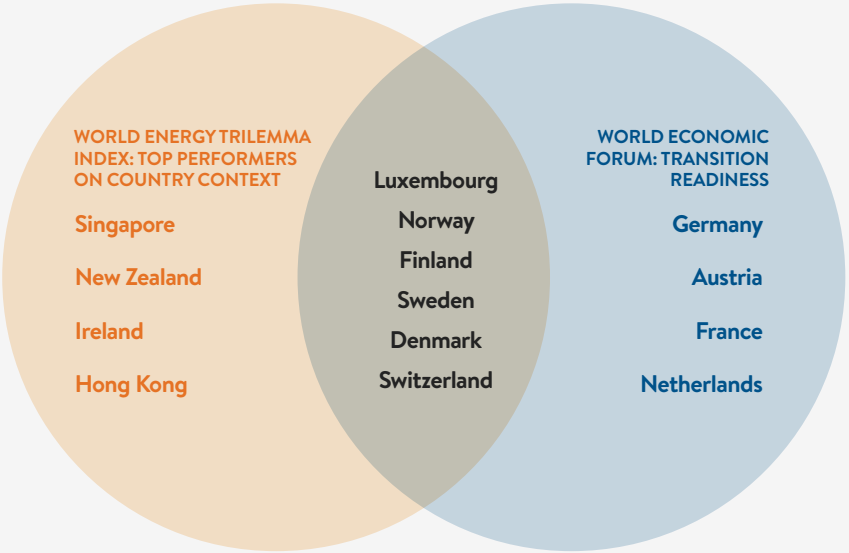
Top-performing countries in the World Energy Trilemma Index consistently emerge as leaders across Sustainable Development Goals (SDG) rankings and the World Economic Forum's (WEF) Energy Transition Index. This underscores their robust performances in energy sustainability, alignment with sustainable development goals, and readiness for energy transition. Nordic countries stand out for their consistent performance across all indices, highlighting their comprehensive approaches to energy sustainability and strong policy frameworks. The high scores of the Nordic countries also reflect their dedication to addressing broader socio-economic and environmental challenges.

Figure 1: Comparing country ranks on the World Energy Trilemma Index, Sustainable Development Goals, WEF Energy Transition Index

COUNTRY		SUSTAINABLE DEVELOPMENT GOALS	WORLD ECONOMIC FORUM
Denmark	1	3	2
Sweden	1	2	1
Finland	2	1	4
Switzerland	3	15	5
Canada	4	26	19
Austria	5	5	8
France	6	6	7
Germany	7	4	11
Estonia	7	10	10
United Kingdom	8	11	13
Norway	8	7	3

Both the World Energy Trilemma Index and the World Economic Forum's Energy Transition Index evaluate the strength of an enabling environment for energy transitions. While specific indicators may differ, both indices aim to assess a country's ability to design and implement effective policy frameworks to support an orderly, just, and inclusive transition. European countries predominantly feature in the top ranks of both the World Energy Council Trilemma Index and the World Economic Forum's assessment of transition readiness. The Council's World Energy Trilemma Index includes Singapore and New Zealand among the top performers as well.

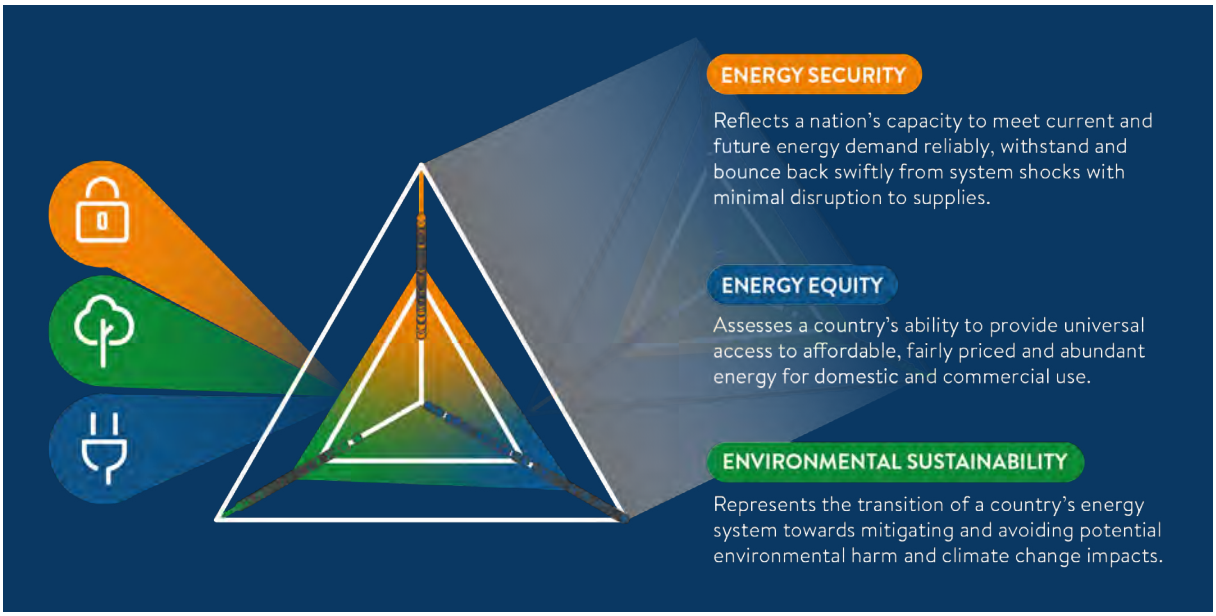
Figure 2: Comparing the World Energy Trilemma Index and the WEF's Energy Transition Index



THE WORLD ENERGY TRILEMMA FRAMEWORK

As people navigate through the complex and interdependent structures and operations of diverse energy systems, the World Energy Trilemma Framework serves as a navigation tool, with the World Energy Trilemma Index as the metric of progress. While the Trilemma itself—energy security, equity, and sustainability—helps to guide energy leaders in the management of competing demands, the Trilemma Index tracks and measures integrated energy system performance in 120 countries.

Figure 3: World Energy Trilemma



In addition to reporting the Trilemma Index results, **The World Energy Trilemma Report 2024** includes an overview of the evolving energy system context and what new developments in that context might be significant for each of the Trilemma dimensions. Regional chapters offer highlights describing the diverse ways of managing the Trilemma in response to recent multiple crises. This year the report also captures selected uses of the Trilemma through case studies of how it is driving transformative initiatives in Barranquilla, Colombia, the Baltics, New Zealand, and India.

"Given today's combined challenges of climate change, securing reliable supplies of energy, and providing that energy to businesses and households in a just and fair way, there has never been another time when the ***World Energy Trilemma*** *framework has been more useful in helping countries devise balanced and effective energy policies."*

— Philip Lowe

Image from BBC Humanising Energy

HUMANISING ENERGY

"Humanising Energy" is the World Energy Council's visionary action-orientated leadership agenda for making energy transitions happen across the world. Energy transitions away from fossil fuels involve complex coordination challenges. Governments, corporations, and civil society must manage an evolving energy Trilemma of security, affordability and environmental sustainability throughout the process of innovating change and with increasing attention to resilience and justice. With the rise of unprecedented events and increasing uncertainty, moving humanity beyond net zero and into a safe operating space requires human creativity and collaboration.

The Council believes the best way to do this is by humanising energy—involving more people and diverse communities in understanding their roles and choices and remaining realistically hopeful about making progress by enabling 100s and 1000s of smaller steps along multiple, diverse pathways. This agenda emphasises the need for societal transformations beyond decarbonization. Simply reducing carbon emissions will not address the complexities of global energy challenges.

Image from the World Energy Council's Humanising Energy Series featuring Climeworks (Finland) produced by BBC StoryWorks.

REDESIGNING AND EVOLVING THE WORLD ENERGY COUNCIL TRILEMMA INDEX

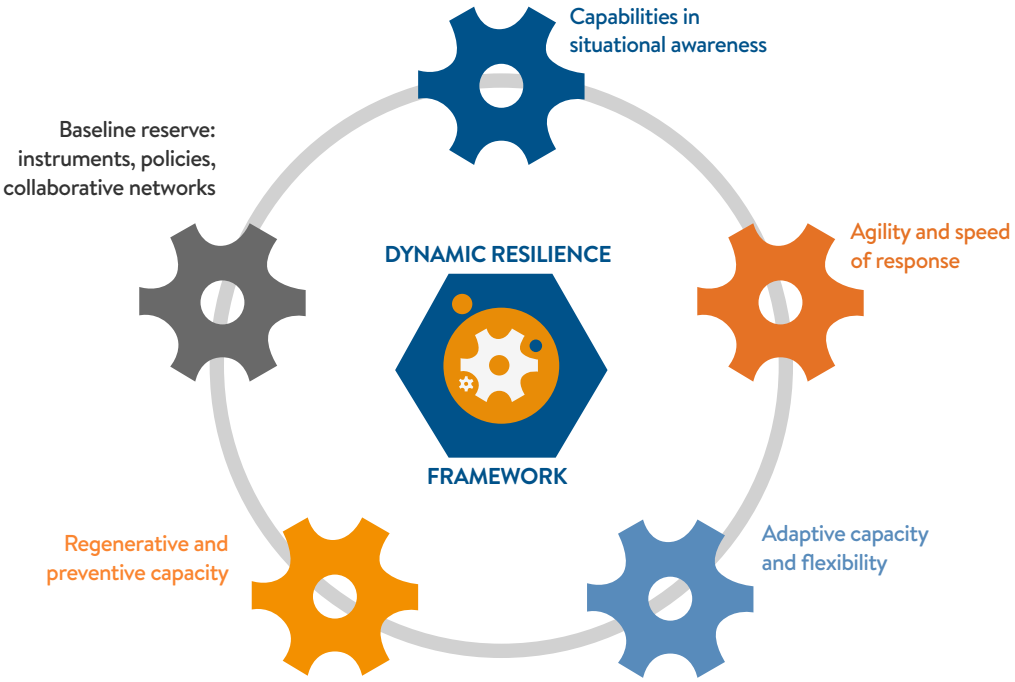
Many countries, organisations, and institutions use the World Energy Council Trilemma Framework to inform their energy policies, strategies, and investment decisions. To reflect evolving trends, priorities, and emerging challenges, the Council and its world energy community of leaders and practitioners are committed not only to helping generate regular updates of the Trilemma Index but also to helping refine the Index itself to ensure its ongoing usability as a policy assessment and policy pathfinding tool that supports energy transitions in different contexts.

"With humanity under 'Code Red' - multiple planetary boundaries exceeded and the growing chance of surpassing the 1.5-degree target set under the Paris agreement, all before the end of this decade - the ***World Energy Trilemma*** *and World Energy Scenarios are more relevant than ever. These critical tools along with the Council's unique energy community allow us to address not only the 'why' and 'what' of this energy transition, but also the 'how to' and 'with whom'."*

— Rafael Cayuela Valencia

In 2020 the World Energy Council explored a new concept of energy security – "dynamic resilience." Dynamic resilience is an integrated approach to risk management that includes adapting to climate change, dealing with physical and digital threats to infrastructure, diversifying energy supply, and coordinating energy systems across barriers. It has assumed even greater urgency now, given recent geopolitical crises, a pandemic, and severe disruptions in the global energy system.

Figure 4: Dynamic Resilience Framework



CHAPTER

DIMENSIONS

JUMP TO

ENERGY SECURITY

ENERGY EQUITY

ENVIRONMENTAL SUSTAINABILITY

Image from the World Energy Council's Humanising Energy Series featuring Fluence, Keeping the lights on produced by BBC StoryWorks.

ENERGY SECURITY

Figure 5: Top improvers in 2023 against their 2000 score

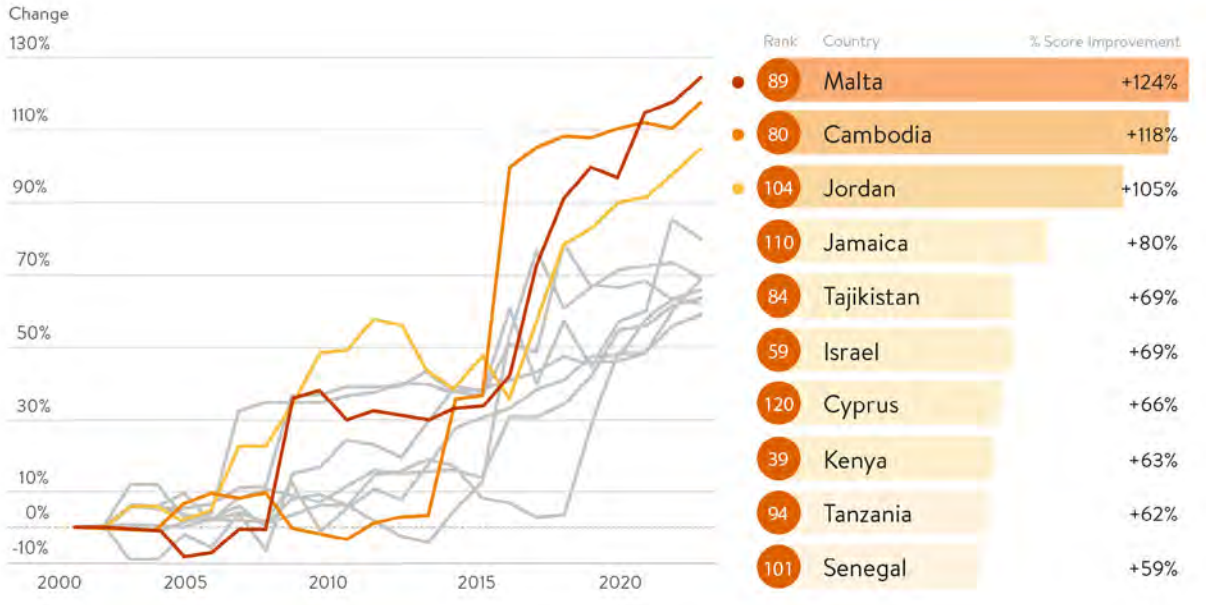
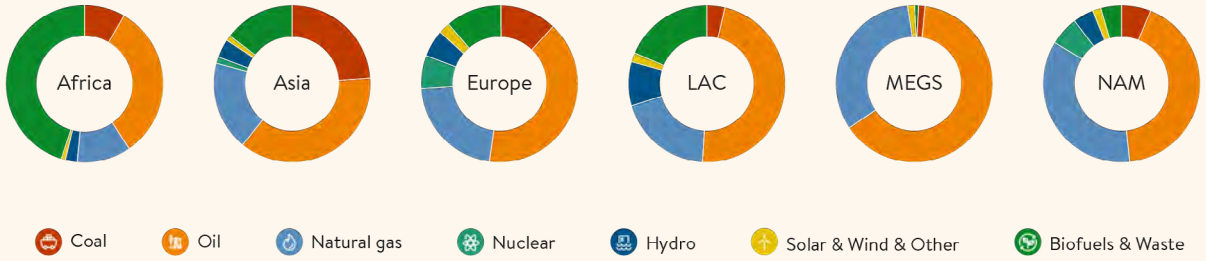


Figure 6: Primary Energy Supply illustrates differing regional energy contexts for Security



Source: World Energy Council, IEA

When the World Energy Trilemma framework was first devised some 15 years ago, energy security was focused on concerns about supply-side shocks, access to scarce resources, strategic reserves, energy efficiency, and exposure to commodity prices. The concept of energy security now extends to a variety of new challenges, including the prospect of demand-driven energy shocks, exemplified by Europe's decision to move away from Russian gas imports in response to Russia's invasion of Ukraine. The new world of 'disruption-as-usual' includes extreme weather events and issues beyond traditional oil and gas dependencies, such as data and technologies, critical minerals and metals, and new kinds of asymmetric threats to both physical and digital infrastructures.

EFFECTS OF WAR

The Russia-Ukraine war, which began in February 2022, OPEC+ production cuts, and other global incidents have rigorously tested energy security strategies across the globe. In response, countries in Latin America, Africa, and Asia have ramped up their domestic oil, gas, and coal production to mitigate geopolitical and market pressures. However, this approach, while enhancing supply security in the short-term, diverges from the global momentum towards environmental sustainability and the shift to cleaner energy forms.

Following the Ukraine invasion, European nations, heavily reliant on Russian oil and gas, responded by using less gas, securing extra supply at higher prices, temporarily increasing coal-fueled power generation, introducing binding EU-wide targets to fill gas storage, and bringing online record amounts of renewable energy, as well as introducing obligatory energy-saving measures. While the spike in energy prices led to a cost-of-living crisis in many parts of Europe and other parts of the world, Europe's interconnected electricity markets ensured secure electricity supplies. A combination of demand-side measures, along with actions to quickly secure liquefied natural gas (LNG) supplies, resulted in Europe securing 95% gas storage by Q4 2022.

The need for long-term resilience in energy systems, which must adapt to cyber threats and other risks, highlights the importance of comprehensive security measures beyond mere physical infrastructure protection. Cooperation, information exchange, and solidarity among nations, especially among Baltic and Nordic countries, are necessary to enhance energy security in response to potential cyberattacks and other digital risks.

PIVOT TO DYNAMIC ENERGY RESILIENCE

The understanding about what constitutes energy security is undergoing a profound change. Simple ideas of adequate supply are giving way to a focus on resilience. Amidst the challenges posed by extreme weather events, the diversification of energy supplies, and emerging threats to both physical and digital infrastructure, the adaptation of energy systems to withstand disruptions and the capacity for demand-side management are both crucial to energy security. In addition, to avoid the catastrophic global overshoot of 1.5-degree Celsius, attention is being focused on carbon removal, climate repair, and innovative strategies for building adaptive infrastructure. Japan, for example, has responded to devastating typhoons by revising electricity grid standards. Latin America is turning attention to the vulnerability of its hydroelectric power to erratic rainfall and droughts. Concerted efforts to future-proof energy infrastructure against climate-induced disruptions reflect a broader understanding that resilience is not just about responding to immediate threats but also about anticipating and mitigating future challenges, ensuring that energy systems can sustainably support societal needs in an era marked by climate uncertainty.

NEW NEEDS FOR ENERGY SYSTEM RELIABILITY

The Ukraine war has intensified the focus on gas storage, while the surge in renewable energy adoption necessitates expanded storage capacity to synchronize generation with demand, both in the short term and for seasonal shifts. This intricate balancing act requires grid investment and digitilisation as well as new measurements and indicators of system stability. The integration of diverse energy sources, which requires large-scale, adaptable, and integrated energy storage, underscores the significance of policies promoting advanced grid infrastructure and smart technologies to safeguard system stability. Electricity market reforms, while seen primarily as responses to the need for energy equity, are also introducing time-based tariffs to support the balancing act for grid reliability.

Figure 7: Changes between 2000 and 2021 in the diversity of electricity generation of the security top performers

Source: World Energy Council, IEA

SUPPLY CHAIN VULNERABILITIES

Many new energy technologies, including renewables, energy storage, and electric vehicles, require critical minerals that are highly concentrated in only a few countries. While Western powers own the access to the technologies (IP, manufacturing facilities, expertise), the global south, especially Africa, owns the access to critical minerals, and China controls a significant portion of the rare earth elements market and processing capacities. A more diversified control might mitigate against geopolitical risks in the context of US-China competition —risks already seen as a consequence of the global pandemic and the Ukraine crisis, with the trade sanctions that followed. In the future, such crises, as well as trade disputes or social and environmental issues within producing countries, could pose challenges to energy security, and potentially to energy transitions.

ENERGY DEMAND MANAGEMENT: A KEY TO SECURITY

Energy demand management is recognized as an essential component of energy security, reflecting a shift towards more active consumer participation in energy markets, particularly through dynamic pricing and flexibility contributions. During the first winter of the Ukraine war, citizens and businesses in Europe decreased energy demand, demonstrating collective resilience in the face of energy challenges and signaling that demand management can be part of security measures.

Many factors are likely to transform regional demand profiles—for example, the rise of digital technologies and associated cooling demands, fuel-switching in hard-to-abate sectors like steel production, more prosumers, and ambitious national hydrogen strategies in in high-income, resource-rich countries such as the UAE and the Kingdom of Saudi Arabia. Consumers with photovoltaic systems (PVs), solar energy capabilities, electric vehicles, or heat pumps should be able to contribute actively to future energy markets, which should enable dynamic pricing as well as the opportunity to sell excess energy back to the grid.

THE IMPORTANCE OF A DIVERSIFIED ENERGY SUPPLY

A rethinking of energy security is underway as the world energy system transitions away from a dominant dependency on fossil fuels to a more diversified energy mix and increasingly diverse and more decentralized new power systems. The rise of renewables in the energy mix demands new levels of interconnection and flexibility to meet the challenges related to wind and solar variability. Strategic planning is needed, as well as investment in digital grid infrastructure with the computational power to manage variabilities in both supply and demand. By effectively sharing regional assets, countries can benefit from each other's generation capacities to improve reliability and resilience. Rwanda, for example, is attempting to increase regional interconnectivity. And under the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP), Singapore is importing up to 100MW of hydropower from Lao PDR through Thailand and Malaysia electrical grids.

PEAK FOSSIL FUELS IN ELECTRICITY GENERATION?

By contrast, many resource-rich countries often exhibit low diversity in their electricity generation mix, primarily relying on hydrocarbons. This reliance is evident in the Gulf Cooperation Council (GCC) countries, where hydrocarbons have historically dominated the energy landscape. However, countries like the UAE are actively reducing their fossil fuel dependency by incorporating nuclear and solar capacities, resulting in a significant decrease from 97% to 89% reliance on hydrocarbons. Similarly, Saudi Arabia has set ambitious targets, aiming for 50% renewable energy by 2030. These developments suggest a potential peak in the role of fossil fuels in electricity generation, especially as low-cost producers typically transition last. However, it's important to note that such trends can be influenced by volatile global conditions, which may challenge or even reverse progress.

ENERGY SECURITY AND THE SOCIAL LICENSE TO OPERATE

Energy security is strongly connected to both energy equity and environmental sustainability in the context of the social license to operate In Africa, transitioning from the coal sector has led to an upskilling of the work force. In Latin America, some communities have objected to transmission lines as well as oil and gas exploration and extraction. In Europe, while there is more support for climate-change action, a 'NIMBY' response – 'Not in my backyard!'— often creates barriers to implementation.

Denmark's approach to wind energy development is often cited as a successful model for navigating social license challenges. The policy framework encourages community-owned wind turbines by providing financial incentives for local ownership. This has resulted in high levels of public support for wind energy, as communities directly benefit from the projects through job creation, local investment, and reduced energy costs.

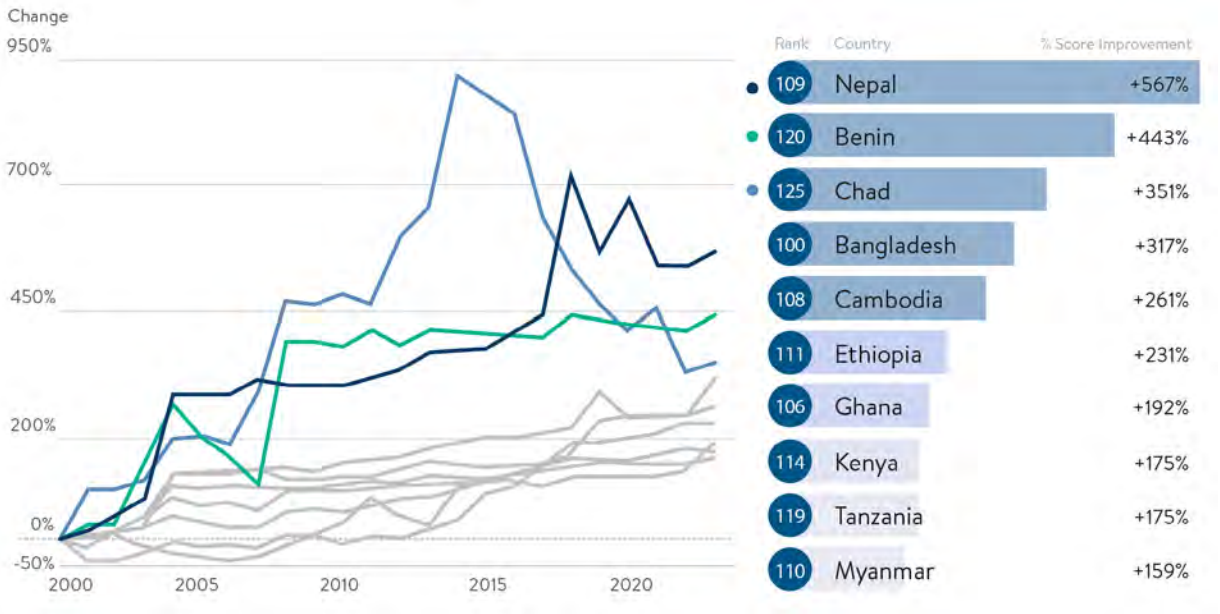
*"Beyond past perceptions of clean energy as a panacea for energy security and environmental challenges, there is now a widespread recognition that the issues of energy security, affordability, and environmental sustainability are enduring, complex, and interconnected – regardless of the global energy composition. Tools like the **World Energy Trilemma Framework** equip us to navigate these competing priorities with foresight and balance."*

— Landon Derentz

These examples emphasize that targets for renewable energy capacity or emissions reductions will not, by themselves, guarantee progress on the sustainability dimension of the trilemma. There is, after all, a human dimension within which the World Energy Trilemma operates.

ENERGY EQUITY

Figure 8: Top improvers in 2023 against their 2000 score



Source: World Energy Council, IEA

When the World Energy Trilemma framework was first devised some 15 years ago, energy equity spanned a variety of issues beyond access to affordable energy services, including measures related to education, health and safety, and equality. These measures were later reduced to a focus on the accessibility and affordability of energy supply across the population. Even with this narrower focus, equity goes beyond ensuring access to affordable energy; it demands a nuanced consideration of the interplay between cost, price, and value, and the financial and societal impacts of changes in any of these dimensions—as well as the increased short-term costs of the shift to renewable energy.

SUBSIDIES: RESPONDING TO RISING ENERGY COSTS

The energy price shocks of the post-COVID era and the war in Ukraine have brought energy affordability to the forefront of public consciousness. In response, governments worldwide, particularly those with the financial capacity, have implemented emergency subsidy reforms and similar measures to shield individuals, businesses, and other consumers from the worst repercussions of these energy price spikes with spillover effects through inflation across all aspects of human life.

MANAGING THE COSTS OF ENERGY TRANSITIONS

A focus on the Levelized Cost of Electricity (LCOE) of energy technologies has shifted to a consideration of the overall system costs. At the same time, the price to consumers is often affected by inadequately structured markets or relies on subsidies that obscure price signals that reflect scarcity or supply problems. Along with the expansion of metrics, there is also a broadening of what equitable energy means, from access and affordability to the essential role energy plays in driving economic opportunities and overall benefits. Effectively managing the total costs of energy transition to society involves considering the need for connecting cost, price, and value. This additional complexity underscores the importance of addressing financial aspects and societal impacts in the pursuit of global energy equity.

WHO PAYS FOR ENERGY TRANSITIONS?

The narrative around equitable transitions differs depending on whether it's being told by the developing or developed world. The equitable transition for the developing world continues to include low-carbon fuels such as gas, while the developed world stresses, for example, green hydrogen. The current Ukraine crisis has reinforced the role of natural gas as a reliable transition fuel for Europe. The picture for natural gas is very different in the US, where security at cheap prices seems very likely in the medium-term. Africa continues developing oil and gas resources 'guilt free' to meet their growing demand equitably while pursuing the pathway for low-carbon fossil fuels through industry efficiency, openness to exploring carbon capture and underground storage (CCUS), and the development of forestry plantations as effective sinks for carbon dioxide emissions. But the use of fossil fuel revenues to fund the transition, as seen within the Gulf states, has led to backlash, despite demonstrable projects for CCUS and low-carbon production strategies being on track.

> *"In the United States, electricity consumption for video gaming is greater than that of the entire Nigerian economy, a nation with a population that's expected to surpass that of the U.S. within 20 years. Stark energy inequality like this creates untenable disparities in both current economic opportunities and future job creation. The **World Energy Trilemma** approach allows us to balance competing priorities of security and sustainability."*
>
> — ***Todd Moss***

Whether gas is included or not in the list of transitional fuels begs the question of who pays for energy transitions? Some attention was called to this issue through the pledges towards climate finance that were made at COP28 in the UAE.

CONSTRUCTING SUCCESSFUL ENERGY MARKETS—THE COST OF CAPITAL AND THE ROLE OF TRANSPARENCY

The cost of capital (interest rate for loans and return on investment for investors) is critical for the viability of any energy project, but especially for renewable generation, which has lower capacity factors and financial returns despite the downward trend of technology investment costs. Geopolitical crises, the regional political environment, and the often unclear regulatory contexts increase uncertainty about total project costs and discourage investment.

An often-overlooked driver of affordable clean energy solutions is the positive impact of transparency in contractual agreements. In Germany or Texas, for example, if one were to embark on establishing a wind farm, the market dynamics, including the pricing and contractual terms, are transparent and accessible to the public. This openness not only ensures fair competition but also enables regulators, market actors, and the general public to scrutinize the details of power purchase agreements, including taxes, pricing structures, and other vital project parameters.

However, this transparency is not universal, especially in emerging markets. A significant issue that has not received ample attention is the lack of openness in many markets regarding the terms and conditions of power purchase agreements. In some cases, the very existence of these contracts is shrouded in secrecy. This lack of transparency in contract details carries profound implications.

Drawing lessons from other sectors, particularly the oil and gas industry, where the Extractive Industries Transparency Initiative has successfully fostered transparency norms, it becomes evident that transparency is not just an ethical requirement but also a practical necessity. Similarly, sovereign debt is now subjected to disclosure requirements, in recognition of the public's right to know and the potential impacts on national finances. Therefore, in the realm of clean energy, advocating for contract disclosure norms becomes a crucial element in fostering good governance, ensuring competitive procurement, and ultimately driving down costs.

ENERGY TRANSMISSION—A CHALLENGE FOR EQUITY

Transmission is not just a security issue but creates a bottleneck for equitable energy transitions. New transmission infrastructure needed to connect the sources of generation to consumption centres remains under-financed. The US Inflation Reduction Act (IRA), for example, does not include transmission—a barrier to fulfilling the goals of the legislation. Regional collaborations, like those in Asia and Latin America, can be a solution for covering the cost of transmission, providing energy security as well. Africa, too, is experimenting with collaborative approaches for both gas grids and electricity grids, building African gas pipelines across several countries and creating a continental electricity market. Because the need for energy security provides impetus for action, the key actors are governments—but innovative financing mechanisms to cover the cost are yet to emerge.

UPSKILLING AND EQUITY

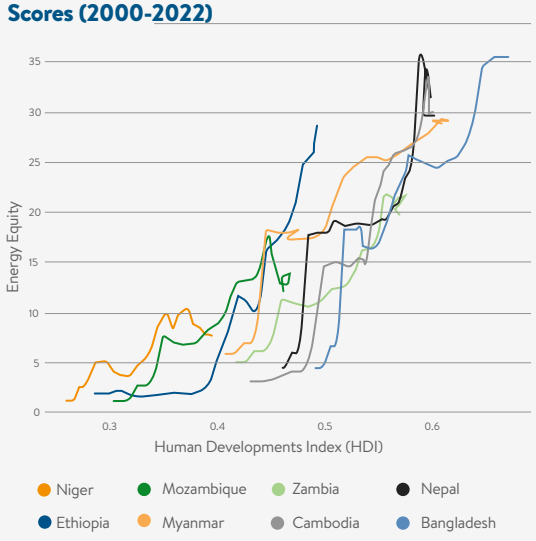
Amidst these challenges, upskilling and workforce development are key components of just transitions, underscoring the broader implications beyond energy systems to encompass economic and social dimensions. The cost of transitions also includes the cost of technology and knowledge transfer, which is enabled through the upskilling required for deployment and maintenance. For example, the new nuclear power plant in the UAE was designed with a strong focus on the upskilling of the local workforce through a strategic collaboration with South Korea and the creation of nuclear training programs across universities.

In Africa, too, there is a growing emphasis on upskilling and building capabilities, particularly through decentralized, local-based approaches. This strategy involves leveraging local institutions as pivotal actors in creating markets for new technologies and skills, tailored to the specific needs and contexts of different regions.

The rise of technology corridors for green hydrogen is also increasing the need for upskilling, particularly for the new jobs created by projects like the Namibian Green Hydrogen project. However, this upskilling and absorption of human resources is impacted by the cost of the phase-outs of fossil fuels, and who pays for this cost remains unsettled.

A compelling correlation exists between improvements observed in the Council's Trilemma Energy Equity dimension and advancements in the Human Development Index (HDI). For example, top ten improvers since 2020, including Ethiopia, Mozambique, Cambodia, and Niger, are the same in both the Trilemma Index and the HDI. This correlation underscores the interconnectedness of energy policies, environmental sustainability, and socio-economic development and emphasizes the effectiveness of implementing comprehensive strategies to achieve balanced progress across all fronts.

Figure 9: Progression in HDI and Energy Equity Scores (2000-2022)



PRODUCTIVE ENERGY USE

At its core, the productive use of energy transcends mere consumption. It embodies the application of energy to propel economic activities that increase income, improve living standards, and foster local development. This approach to energy equity goes beyond the traditional metrics of profitability to consider the socio-economic fabric it weaves within communities. Although SDG 7 aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030, it refrains from specifying a particular threshold for energy access. The importance of reliable and affordable energy as an enabler of economic prosperity is widely acknowledged, but needs to be captured in measuring progress on energy

transitions. Around 700 million people, particularly in Sub-Saharan Africa, still lack access to basic energy. Continued progress on SDG 7 remains imperative, with top improving countries such as Kenya, Benin and Ethiopia offering practical examples. The existing indicators, which focus mainly on household electricity, report that access to electricity averages 50-100 kWh per person per year. While addressing basic needs, this perspective falls short of capturing the dynamism required for comprehensive economic growth.

A MODERN ENERGY MINIMUM: BUILDING A SOCIO-ECONOMIC BRIDGE

The Energy for Growth Hub has introduced the idea of a Modern Energy Minimum (MEM) to argue that substantial economic development requires energy access that surpasses domestic boundaries to include the energy necessary to energize the broader economy, enabling productive employment and propelling economic advancement.[1] The numerical benchmark of 1,000 kilowatt hours per person per year represents a transformative threshold associated with tangible improvements in living standards. Currently, the minimum threshold of 50 kilowatt hours per person per year, often linked with extreme poverty, correlates with incomes of less than $1 a day. In contrast, reaching 1,000 kilowatt hours elevates individuals to an income bracket between six and seven dollars per day, positioning them within the global lower-middle class.

REDESIGNING EUROPEAN ENERGY PRICES

In response to the Ukraine crisis, electricity markets in Europe are undergoing significant reforms aimed at making electricity prices less dependent on volatile fossil fuel prices, accelerating the deployment of renewable energies, and improving consumer protection. A provisional agreement reached by the European Council and the European Parliament proposes reforms to the EU's electricity market design. These reforms include measures to shield consumers from price spikes, enhance the integration of renewable energies into the electricity market, and improve market transparency and monitoring.

One of the key aspects of the reforms is enabling national governments to provide direct financial support for power purchase agreements (PPAs) for renewable generation, thus making renewable projects more financially viable. Governments could act as customers for electricity generated from renewable sources, promoting the deployment of clean energy. Additionally, the reforms aim to stabilize electricity prices by introducing contracts for difference with fixed price ceilings and floors, minimizing price fluctuations inherent in renewable power generation. Moreover, the agreement includes provisions for declaring an energy crisis, allowing for measures to reduce electricity prices for vulnerable and disadvantaged customers. Energy systems are increasingly seeing introduction of net billing, time-of-use tariffs, and measures for integrating distributed energy resources, enhancing time and space granularity, and fostering new business opportunities essential for a renewable-based power system.

ENERGY EQUITY SUCCESSES

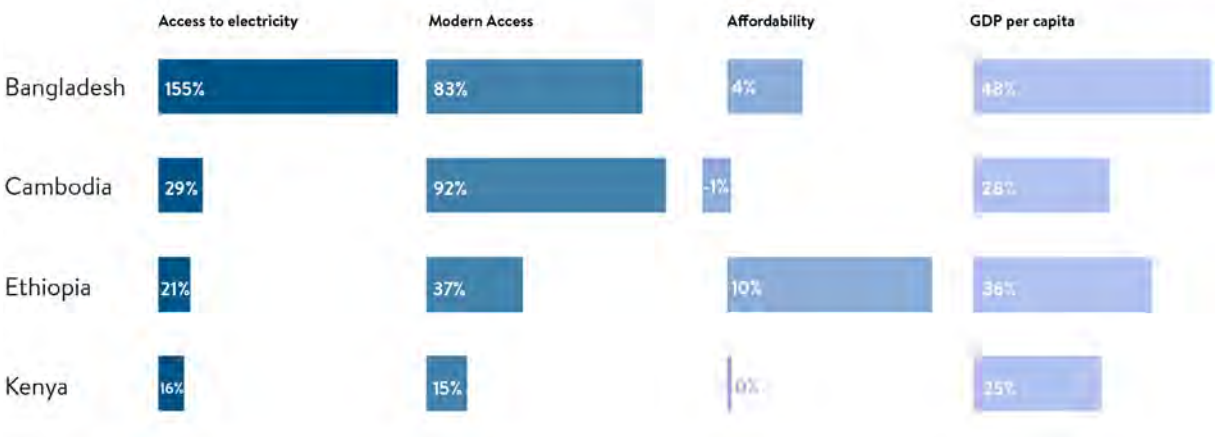
The top ten countries in energy equity rankings are characterized by low energy costs for consumers, often in the form of implicit subsidies. This dynamic explains the dominance of Gulf Cooperation Council (GCC) nations in this dimension, with Qatar, Kuwait, the UAE, Oman, and Bahrain leading the equity top 10. These countries are typically small, affluent nations boasting high GDPs, robust interconnections, and low energy prices facilitated by subsidies or abundant, easily extractable energy resources. It's noteworthy that price subsidies, whether explicit or implicit, can impede energy supply diversification, impacting scores in other dimensions of the Index.

Among the top 10 greatest improvers, seven are African states. Since 2000, these countries have shared a common focus on implementing policies to increase access to energy and make it more affordable for consumers. Kenya and Bangladesh have seen substantial improvements in access to electricity, largely due to the effective implementation of government policy.

KENYA'S ELECTRIFICATION STRATEGY

Kenya's 2018 National Electrification Strategy and subsequent government policies have resulted in increases in electrification, with access rates reaching 76.5% in 2021. In response to the recent rise in global energy prices, Kenya implemented subsidies and tax cuts for cooking gas, as well as fuel subsidy schemes. In 2022, the government enforced reduction and regulation of electricity tariffs by providing financial assistance to the national utility Kenya Power and Lighting Company (KPLC), to be passed on to household consumers.

Figure 10: Percentage changes of key drivers in the past 5 years illustrating improvements in energy equity



Source: UN, World Bank, IEA, World Energy Council

Bangladesh has shown a remarkable increase in both access to electricity and an increase in modern energy access, a success which is attributed to business models tuned to deploy off-grid systems. Although only a modest improvement was made in affordability, the substantial rise in GDP per capita suggests a robust economic growth that increases the ability and willingness to pay for energy services.

Cambodia, despite a comparatively lower access rate, has nevertheless achieved a massive improvement in modern energy access, indicating a profound enhancement in the quality and reliability of its energy supply. However, the country experienced a decrease in energy affordability, even though accompanied by a modest increase in GDP per capita. This suggests that the cost of the modernization of energy infrastructure is being passed on to the consumers.

Ethiopia has seen decent progress in both general energy access and modern energy access. The country has also experienced a sizable improvement in affordability as well as in GDP per capita, which indicates that the cost of energy in relation to income has considerably decreased.

Kenya has experienced growth in both general energy access and modern energy access. The stagnation in energy affordability suggests that energy costs may be challenging for citizens, despite an increase in GDP per capita. Recently, Kenya increased energy subsidies to protect consumers from the overall impacts of inflation rising from geopolitical crisis.

ENVIRONMENTAL SUSTAINABILITY

Figure 11: Top improvers in 2023 against their 2000 score

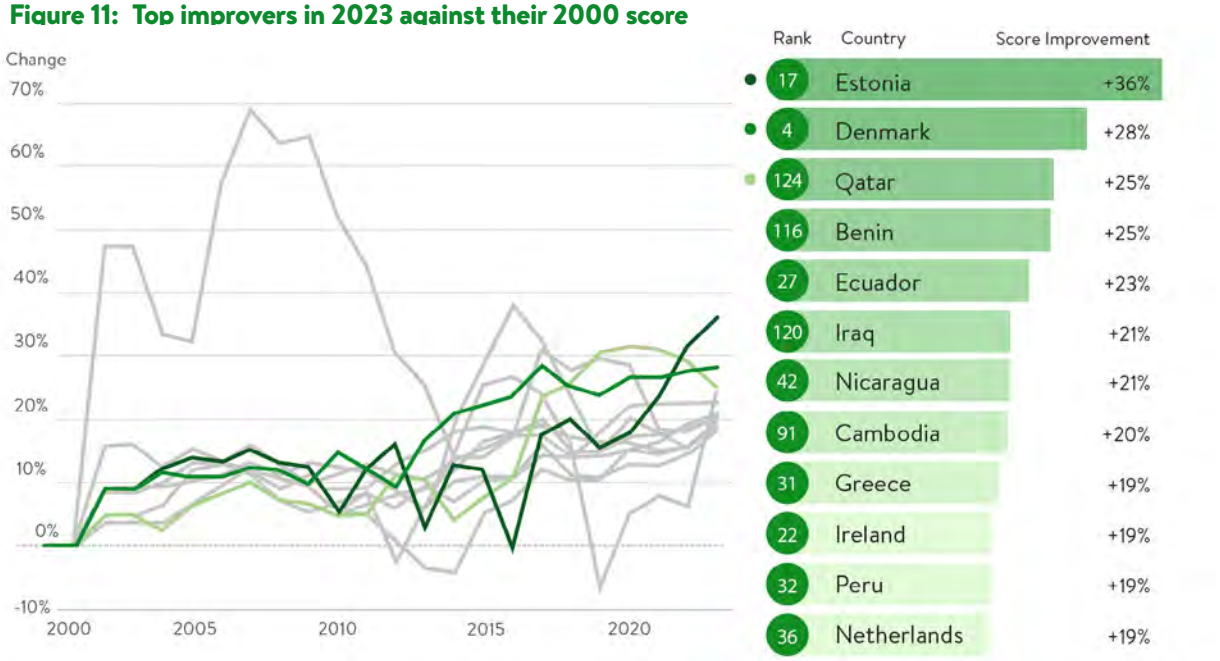
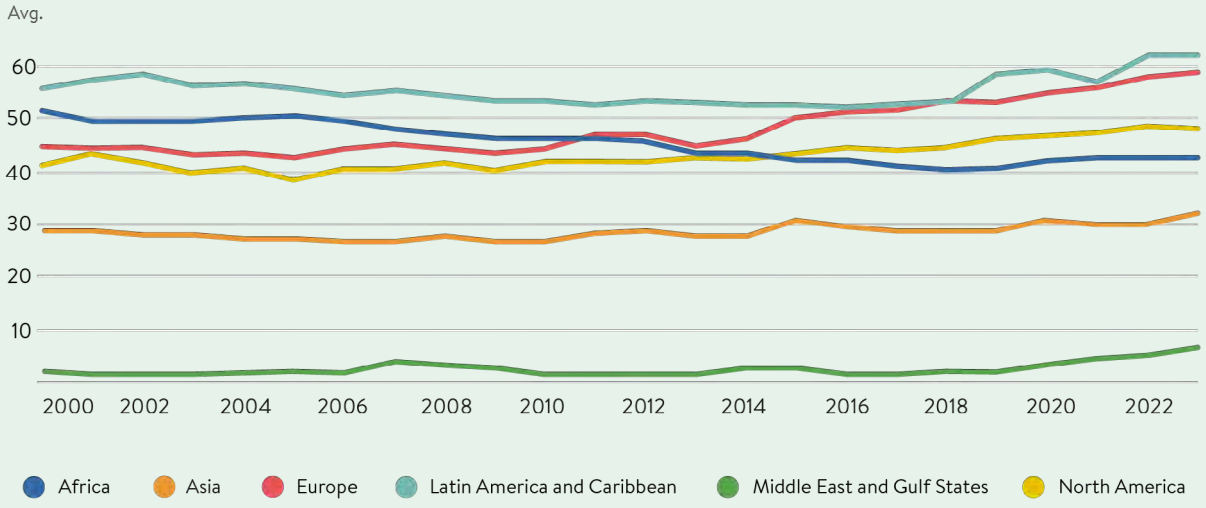


Figure 12: Diversity of Generation Regional Timeline



Source: World Energy Council, IEA

When the World Energy Trilemma framework was first introduced, environmental sustainability focused on how nations, responded to rising greenhouse gas emissions, evaluated the efficacy of emission reduction measures and managed other environmental concerns like air and water quality and biodiversity preservation. This focus has now widened considerably to encompass the global shift away from fossil fuels like oil, natural gas, and coal, towards renewable sources such as wind, solar, and lithium-ion batteries, and the existence of non-negotiable thresholds — planetary boundaries.

This widened focus requires a more holistic view of environmental impacts, including those associated with mining and mineral extraction. Key concepts such as circularity, which involves creating systems where resources are continually used, reused, and recycled, and carbon circularity, which specifically focuses on mitigating carbon emissions within these circular systems, are gaining prominence. Moreover, discussions now extend to include topics such as biofuels, biodiversity, the interconnectedness of water, food, and energy systems (known as the water-food-energy nexus), and the importance of securing a social license to operate.

For practical reasons, this discussion is often simplified to focus narrowly on decarbonisation and achieving net-zero carbon emissions. At the same time, the politicization of sustainable development has led to a perceived division between 'green' (includes only renewables, such as hydro, solar, and wind) and 'clean' (includes fossil fuels with CCS and nuclear). The 'clean' category can be blurred by corporate 'greenwashing,' where companies may exaggerate or misrepresent their environmental efforts for public relations purposes.

SUSTAINABILITY

RESILIENCE IN CONSISTENCY

Positive environmental performance is integral to effectively managed energy transitions. While the Council's environmental sustainability pillar, focused on energy sector performance, is a subset of the Yale Environmental Performance Index, similar positive trends can be observed across key countries striving to enhance the environmental performance of the energy sector and beyond. In the World Energy Trilemma Index, countries such as China, Luxembourg, and the United Arab Emirates have notably improved their energy sustainability performance over the past decade, reflecting advancements also seen in the Yale Index. This progress underscores their high level of commitment and effective actions toward achieving greater sustainability.

ENVIRONMENTAL SUSTAINABILITY: INGREDIENTS OF SUCCESS

In the Council's tracking of countries' environmental sustainability, the top ten ranked countries demonstrate robust policy efforts to decarbonize and diversify energy systems away from fossil fuels, with Switzerland, Sweden, and Norway leading the way. These nations have prioritized energy efficiency and demand management measures, implemented diversified low-carbon energy systems, and effectively utilized policy instruments to significantly reduce greenhouse gas (GHG) emissions.

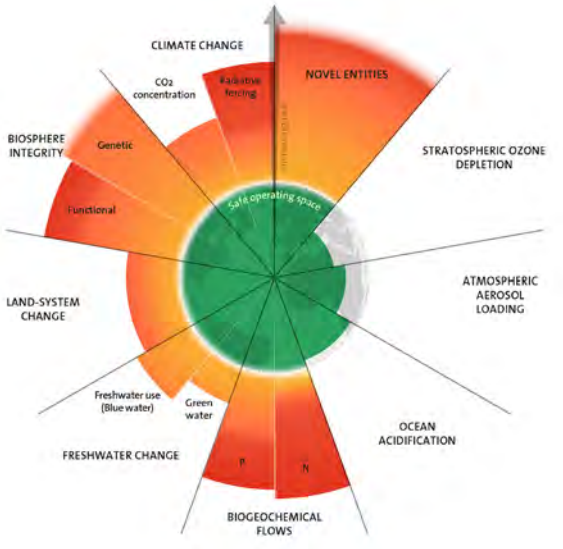
The recent stocktake at COP28 underscores a sobering reality: despite progress, the world is not on track to achieve the Paris Agreement goals. To keep the 1.5-degree Celsius goal within reach and to reach net-zero emissions by 2050, greenhouse gas emissions must be reduced 43% by 2030, renewable energy must be tripled, and energy efficiency must be doubled. Taking equity into account in transitioning away from fossil fuels also calls for addressing financial shortfalls and supporting developing countries in their energy transitions and climate plans.[2]

BEYOND NET-ZERO: ENSURING A SAFE OPERATING SPACE FOR HUMANITY

To ensure sustainable development and long-term prosperity, humanity must respect nine critical planetary boundaries that safeguard the stability and resilience of the Earth system. Alarmingly, six of these nine boundaries are currently being breached, with mounting pressure observed against almost all boundaries:

Figure 13: The 2023 Update to the Planetary Boundary

1. Climate change—crossed
2. Ocean acidification—crossed
3. Chemical pollution—unknown
4. Nitrogen and phosphorus loading—crossed
5. Freshwater withdrawals—approaching
6. Land conversion—crossed
7. Biodiversity loss–crossed
8. Air pollution—crossed
9. Ozone layer depletion—improving



Source: Azote for Stockholm Resilience Centre, based on analysis in Richardson et al., 2023

By aligning efforts toward energy transitions with respect for planetary boundaries, humanity can not only address climate change but also mitigate other environmental challenges such as biodiversity loss, pollution, and ecosystem degradation. This integrated approach ensures that actions taken to transition to a low-carbon economy are in harmony with broader sustainability objectives.

Moving towards sustainable solutions in energy requires potential unintended consequences to be taken into consideration. For example, green hydrogen might be a sustainable replacement for fossil fuels in heavy industry. But since it is produced from splitting water into hydrogen and oxygen (using renewable electricity), it also might affect local water supplies.

> *"The **World Energy Trilemma Framework** provides a legitimacy to climate policymaking that rises above labels of any particular political leaning, providing a new equilibrium where climate policies are not only acknowledged as legitimate but recognized as essential."*
>
> ***— Maria van der Hoeven***

THE IMPORTANCE OF POLITICS AND POLICIES

In 2024, around half the world's population in countries representing a third of the world's economy will elect their leaders. The prevalence of upcoming elections across the globe has contributed to increased levels of societal polarisation. Election outcomes can reshape energy and climate agendas, potentially altering the trajectory of key initiatives like the EU's Green Deal or the US Inflation Reduction Act.

Insufficiently clarified policies promoting sustainability can also elicit a backlash, as was the case with the 'yellow vest' protests in France, sparked by fuel taxes. Climate action extends beyond technological innovation, ultimately depending on political determination and community consensus.

SOVEREIGN WEALTH FUNDS: INVESTING IN THE FUTURE

Norway's Government Pension Fund Global, commonly known as 'Norway's oil fund' due to its origin from oil and gas revenues, stands as one of the world's largest sovereign wealth funds (SWFs). It invests in a wide array of international stocks, bonds, and real estate, exerting considerable influence on global investment trends. Guided by ethical guidelines, the fund eschews investments in entities linked to human rights abuses, severe environmental harm, and tobacco production, among others, reflecting a strong alignment with societal values. This approach allows Norway to address the Social License to Operate (SLO) challenges inherent in utilizing fossil fuel revenues, showcasing a steadfast commitment to sustainability and social responsibility.

The role of SWFs in supporting the energy transition is complex and often scrutinized by climate activists; yet their capacity to aid this shift is substantial. In 2022, investments in renewable energy by State-Owned Investments (SOIs), including SWFs, hit $18.7 billion globally. Notably, funds from the Gulf Cooperation Council (GCC) contributed to 29% of this investment, marking a significant move towards diversifying domestic economies and supporting the net-zero ambitions outlined in the Paris Agreement.

To have a positive impact on the fight against climate change, SWFs must handle the intricacies of traditional investment models while navigating within the broader socio-economic and political contexts. Transparency, the use of stringent Environmental, Social, and Governance (ESG) criteria, and a willingness to divest from fossil fuels where possible are essential for SWFs to contribute to global climate action efforts.

THE NEED FOR CIRCULAR SOLUTIONS

The expansion of renewable energy technologies, such as solar panels, wind turbines, and batteries, presents a critical pathway toward reducing greenhouse gas emissions and mitigating climate change.

However, in spite of their operational benefits, these technologies potentially create negative environmental impacts as well. The extraction of minerals and metals required for their production can lead to significant environmental degradation, including habitat destruction, soil erosion, water pollution, and increased greenhouse gas emissions. Mining activities associated with obtaining necessary critical minerals for battery production can, for example, disrupt ecosystems, contribute to deforestation, and generate substantial amounts of waste.

In response to these concerns, there is a growing recognition that circular economy principles need to be applied to mining activities associated with the production of renewables. Systems can be designed to promote the reuse, recycling, and repurposing of materials to minimize the extraction of virgin resources and reduce waste generation. For example, end-of-life renewable energy technologies can be dismantled, and their components recycled or refurbished for use in new installations, thereby extending their lifespan and reducing the demand for new raw materials

CIRCULAR CARBON ECONOMY FRAMEWORK

Carbon circularity frameworks, like the Circular Carbon Economy (CCE) Framework, serve as a navigation tool for identifying the potential circularity within industrial processes including the oil and gas sector. The CCE framework helps identify economic opportunities by assigning a monetary value to CO_2 emissions when kept in the loop through various processes such as carbon capture and utilization (CCU), carbon capture and storage (CCS), and carbon recycling. Amid current global challenges, including geopolitical tensions, energy security issues, and concerns about energy equity, this shift in approach responds to the reality that completely phasing out fossil fuels in the short term is extremely challenging, especially in sectors and regions heavily reliant on them for economic stability.

Addressing regulatory gaps and developing innovative financial incentives are crucial for the widespread adoption of CCUS, which is expensive. Assigning an economic value to CO_2 within the circular carbon economy framework incentivizes innovation to lower the cost of CCUS technologies. One example of such innovation is enhanced oil recovery (EOR), where compressed CO_2 is injected under high pressure into flooded oil reservoirs as a substitute for the natural gas which would otherwise be used to enhance oil recovery. This use of CO_2 also results in its being stored underground. Other examples of reusing captured carbon include converting CO_2 into durable carbon, including building materials and polymers.

CORPORATE TRANSPARENCY IN ENERGY TRANSITIONS

The advancement and increased adoption of Environmental, Social, and Governance (ESG) criteria have introduced a new layer of governance for international capital flows and corporate conduct. This shift towards greater transparency and accountability in environmental sustainability efforts has led to increased scrutiny of corporate impact on the environment. As corporations position themselves as crucial players in driving energy transitions, their leaders, consumers, and regulators must ensure that business practices align with the principles of energy security, equity, and environmental sustainability.

*"Energy is one piece of the big picture that policymakers are focused on. Leaders are simultaneously balancing political stability and security of the country, alongside economic growth and international geopolitics. Energy plays a role within each of these areas, and the **World Energy Trilemma Framework** provides a path to balance the competing priorities of energy security, sustainability and equity within the broader economy."*

— Zhai Yongping

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CHAPTER

REGIONAL

JUMP TO

AFRICA | ASIA | EUROPE

LATIN AMERICA & THE CARIBBEAN | MIDDLE EAST AND GULF STATES | NORTH AMERICA

Image from the World Energy Council's Humanising Energy Series featuring Infineon (Germany) produced by BBC StoryWorks.

Building An Inclusive Energy Transition" - taken from an article made for EEP Africa and the Nordic Development Fund (Getty Image)

AFRICA

HIGHLIGHTS

ENERGY SECURITY

Challenges include reliance on fossil-based energy, limited access to modern energy services, inadequate infrastructure, conflicting geopolitical interests, and economic and governance barriers.

ENERGY EQUITY

Unequal access and reliability, but regional integration enables economies of scale, growing market competition, more affordable electricity prices, and more reliable energy services as well as macroeconomic benefits.

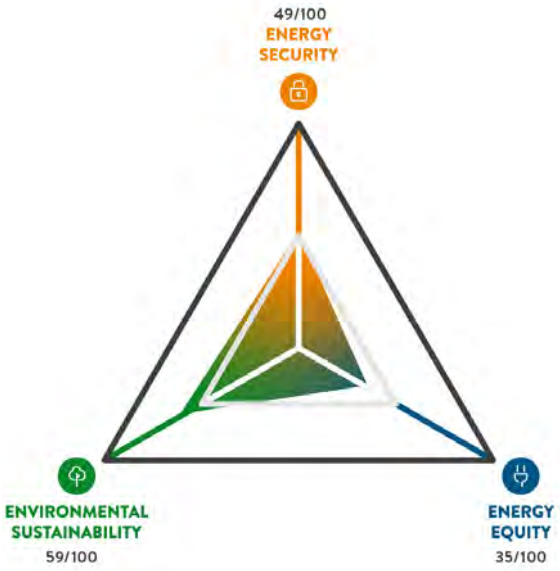
ENVIRONMENTAL SUSTAINABILITY

Rising investment in renewable energy; development of hydrogen corridors and hydropower present economic growth prospects; collaboration opportunities between Africa and international partners, with shared benefits including job creation and technology transfer.

MANAGING THE WORLD ENERGY TRILEMMA

Tension between increasing security and access and meeting sustainability targets; growing commitment to energy diplomacy and regional cooperation to address challenges collectively.

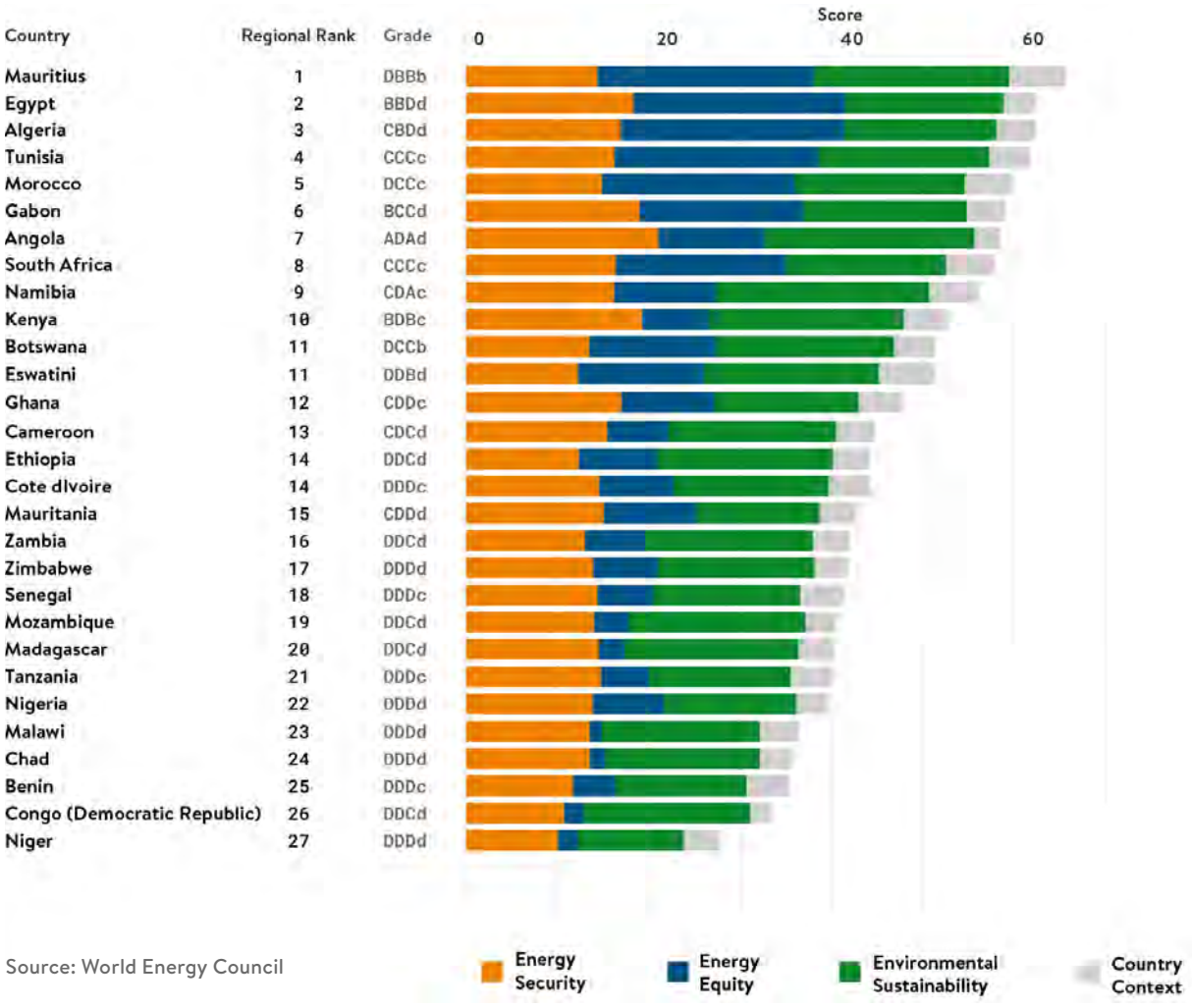
Figure 14: World Energy Trilemma Index Regional Balance - Africa



Source: World Energy Council

Africa stands at a critical juncture between two divergent energy models: the conventional, extractive model of the past and an emergent twin transition to clean energy and digitisation. In navigating a complex landscape involving access and equity, investment, sovereignty, institutional capacities, social development, and workforce building, Africa is also confronting the prevailing divergence between centralised and distributed energy generation. The pursuit of export-driven revenues often takes precedence over the need for universal access, leaving significant segments of the population without modern energy supplies. The rise of new technologies and initiatives to enhance regional energy trade and ensure supply security shapes both institutional priorities and investment landscapes.

Figure 15: World Energy Trilemma Index Regional Results - Africa



Source: World Energy Council

THE WORLD ENERGY TRILEMMA

ENERGY SECURITY

Africa's population is rapidly growing, and increased urbanisation is driving up energy consumption, leading to an expected rise in demand of 30% between 2020 and 2030.[1] Meeting rising demand while ensuring affordability and sustainability is a critical aspect of Africa's energy security.

THE OUTLOOK FOR GAS

Gas is abundantly available in a number of African countries and is increasingly viewed as a reliable and flexible energy source that can complement intermittent renewable energy technologies, providing stability to electricity grids, and meeting the rising energy demand. The acceleration of investments in LNG as a response to the Ukraine crisis is creating opportunities for new gas exploration in Mozambique, particularly in the Rovuma Basin, which has attracted substantial international interest and investment in recent years. Companies like TotalEnergies and ExxonMobil have made significant investments in liquefied natural gas (LNG) projects, aiming to capitalize on Mozambique's potential as a major LNG exporter. While geopolitical shocks may occur, the long-term outlook for gas remains strong across Africa as countries seek to diversify their energy mix and transition towards cleaner fuels.

SECURITY AND COOPERATION

Energy security in Africa is exacerbated by inadequate infrastructure, limited investment, and dependence on traditional biomass fuels. However, in recent years, there has been notable progress in addressing these challenges. Governments across Africa are increasingly priotitising energy security as a strategic imperative, implementing policies to diversify energy sources, improve infrastructure, and attract investment in the energy sector, and the rise of renewable energy technologies has presented important opportunities to enhance energy independence. Additionally, regional cooperation and integration efforts, such as cross-border electricity trade and infrastructure projects, are advancing energy security objectives, facilitating access, and promoting regional stability.

GRID DEVELOPMENT FOR SECURE SUPPLY

The continent has two priorities in relation to grid development: access and, where access is already provided, digitisation to encourage reliable supply. The migration from the old systems to the new systems to improve security of supply and reliability targets immediate challenges like load balancing and service quality. For instance, Rwanda's implementation of smart meters and energy management software targets specific issues such as electricity theft while enhancing customer service with digital solutions like online billing and payments. Similarly, the Nigerian Electricity Regulatory Commission (NERC) introduced a regulatory framework for smart grid technologies that has enabled electricity distribution companies to significantly reduce power outages and improve customer satisfaction.

Image from the World Energy Council's Humanising Energy Series featuring Rockefeller Foundation (Nigeria) produced by BBC StoryWorks.

THE WORLD ENERGY TRILEMMA

ENERGY EQUITY

Energy equity has consistently improved in the last twenty years, marked by increased access through grid extension projects and off-grid solutions. Policy and regulatory reforms have sought to stimulate investment and promote renewable energy development, while innovative financing mechanisms like pay-as-you-go models have helped overcome affordability barriers. Even so, a substantial portion of the continent's population lacks reliable and affordable access to modern energy services, with strong discrepancies between urban and rural areas. In rural areas, communities often rely on traditional biomass for cooking and heating, exposing them to health hazards and perpetuating energy poverty. Taking the case of electricity supply, it should be noted that using IEA and Our-World-in-Data information, that while the World Electricity Access is about 90% that of sub-Saharan African nations was about 53.5%.

Bridging the energy access gap requires concerted efforts in infrastructure development, especially decentralised solutions such as off-grid and mini-grid systems. The number of people connected to mini-grids has more than doubled between 2010 and 2019, growing from 5 to 11 million people. In the equity dimension of the World Energy Trilemma Index, Africa has improved consistently, and now has 7 of the top 10 performers.

IMPROVEMENT THROUGH REGIONAL INTEGRATION

The regional integration of energy systems in Africa holds significant potential for improving access to electricity and reducing prices for consumers across the continent. Regional integration initiatives can facilitate the sharing of energy resources, optimise infrastructure investments, and enhance energy security by linking electricity grids and increasing collaboration among neighboring countries. Countries can tap into a diverse mix of energy sources, including renewable energy, hydropower, and natural gas, thereby reducing reliance on costly imported fuels and mitigating supply disruptions. Additionally, regional integration promotes economies of scale in electricity generation and transmission, leading to cost efficiencies that can be passed on to consumers through lower electricity tariffs. Such integration also enables surplus power exports and promotes market competition, driving down prices for consumers.

INFORMATION AND COORDINATION: LEVERS OF ENERGY EQUITY

In November 2023, the Economic Community of West African States (ECOWAS) inaugurated the Information and Coordination Centre (ICC) for the regional electricity market in Benin. This initiative, orchestrated by the West African Power Pool (WAPP), marks the fulfillment of the commitment to make electric energy readily available for the West African region.

A DIVERSIFIED STRATEGY FOR UNIVERSAL ACCESS

Africa's diversified energy strategy combines grid expansions with off-grid solutions, thus leveraging both centralised and decentralised energy solutions. Grid expansions focus on extending electricity infrastructure to urban and peri-urban areas, capitalising on economies of scale and existing grid networks to provide reliable electricity access to densely populated regions. In parallel, off-grid solutions, including off-grid solar systems, mini-grids, and standalone power systems, cater to the needs of remote and rural communities that are not connected to the main grid, offering affordable, scalable, and sustainable energy access tailored to local contexts.

THE WORLD ENERGY TRILEMMA

ENVIRONMENTAL SUSTAINABILITY

Historically, the continent has grappled with environmental degradation exacerbated by rapid population growth and unsustainable development practices. In addition, deforestation remains a driver of carbon. But the growing recognition of the need to address the challenges has led to significant progress in recent years, supported by increasing investments in renewable energies and international partnerships and the promotion of sustainable management practices and conservation efforts.

STRANDED ASSETS?

The energy transition challenge in Africa is not a resource or a funding challenge, it is a development bottleneck. Botswana, South Africa, Nigeria, and the DRC have made commitments to restrict methane emissions and phase out coal. Moreover, Africa's energy-producing countries are challenged to deliver more returns sustainably, which exposes them to the increased risk of stranded assets with significant untapped resources. In 2022, for example, 85% of total export revenues in Nigeria were petroleum exports. In addition, the Carbon Border Adjustment Mechanism (CBAM) and Inflation Reduction Act (IRA) are reshaping international trade, and will impact oil and gas exports.

THE RISE OF HYDRO AND NUCLEAR

Hydroelectric generation is rising as many countries seek to transition to cleaner and more sustainable energy sources. Central Africa holds the largest share (40%), followed by East Africa (28%), but 90% of Africa's hydropower potential is still unexploited. African countries have ambitious decarbonisation plans, and upgrading hydropower infrastructure with state-of-the-art technology to improve flexibility services sits at the center of their priorities.

Hydropower can play a vital role in accommodating the intermittent nature of wind and solar energy production, and these capabilities are further strengthened through modernisation initiatives. In addition, nuclear is gaining traction as a low-carbon alternative, with Egypt, Nigeria, Ghana and Morocco already engaged with the IAEA to assess their readiness to embark on nuclear programs. Algeria, Tunisia, Uganda, and Zambia are also studying the possibility of nuclear power.[2] While only South Africa has an operational nuclear power plant, Ghana has nuclear reactors for research purposes and has included nuclear in its nationally determined contributions (NDCs), with the first power plant scheduled to begin construction in 2025. Nigeria also has a nuclear research reactor, a tandem accelerator and a gamma irradiation facility which were the basis for developing its nuclear power program. The rising interest in nuclear on the continent is encouraging reliable grid development to connect the nuclear power stations.

THE RISE OF HYDROGEN

Energy resources and the abundance of rare earth minerals present a major economic opportunity for Africa. In addition, hydrogen and related derivatives are at the core of strategic development discussions between Africa and Europe. The development of technology corridors, such as the SouthH_2 Corridor project between North Africa and South Europe, constitutes a developing backbone for supply security and the interconnected critical infrastructure needed for massive renewable energy capacity deployment.

Both Morocco and South Africa are building the regulatory frameworks and strategic international partnerships to secure funding and technical expertise for the development of green hydrogen. Building hydrogen corridors between Africa and Europe requires economic integration, policy harmonisation, digitalisation, and geopolitical collaboration. These corridors represent an opportunity for mutual economic growth and innovation, with potential benefits including job creation, technology transfer, and diplomatic ties. By fostering a holistic understanding of hydrogen trade, these corridors can serve as catalysts for sustainable development, energy security, and the transition to a low-carbon economy.

NAMIBIA'S GREEN HYDROGEN INITIATIVE

At COP27 in Sharm El-Sheikh, Namibia's Green Hydrogen Council launched a green hydrogen strategy supporting the country's commitment to the Paris Agreement on climate change, with the goal of reducing emissions to net zero by 2050. Earlier, through the public intermediary Green Hydrogen Namibia and with support from the Namibia Investment Promotion and Development Board, the Namibian government had issued a request for proposals for renewable energy and green hydrogen project developers. The government then entered into an agreement with Hyphen Hydrogen Energy for a $9.4 billion project that will give rights to the project to Hyphen for 40 years. The project, based in the Tsau Khaeb National Park, will ultimately produce around 300,000 tons of green hydrogen per year. Starting production in 2026, the project is expected to create 15,000 direct jobs during the first four years of construction and eventually, 3,000 permanent jobs.

MANAGING THE WORLD ENERGY TRILEMMA:

CHALLENGES AND OPPORTUNITIES

THE PARADOX OF OIL AND HYDROGEN

The surge in hydrogen development, particularly green hydrogen, signals a commitment to environmental sustainability. On the other hand, the escalation of new oil explorations underscores Africa's continued reliance on conventional energy resources, emphasising the economic significance of oil production for many African countries. These competing trends highlight the delicate balance between immediate energy security needs and environmental sustainability and underscores the complex decision-making process to navigate the energy trilemma.

SOUTH AFRICA: ADVANCING ENERGY SECURITY AND A LOW-CARBON ECONOMY

The Government of South Africa is working with the World Bank to bolster long-term energy security and facilitate the transition to a low-carbon economy through a $1 billion Development Policy Loan (DPL). This financial support represents a significant and strategic response to South Africa's persistent energy challenges. The loan will support the restructuring of Eskom, including unbundling and redirecting resources to maintenance and upgrades, and incentivizing private investment in renewable energy, while also fortifying carbon pricing mechanisms.

ENERGY TRANSITION AS A CORE SOCIAL ISSUE

In many African countries, the absence of robust industrialisation and localised value chains has led to a reliance on international aid for crucial investments. The discourse on energy access must, therefore, pivot toward the ambitious goal of generating sufficient energy to propel industrial development and foster the growth of secondary and tertiary sectors. By prioritising these broader social needs, the conversation evolves beyond immediate connectivity issues to wider social concerns.

UPSKILLING OPPORTUNITIES

In the evolving African energy landscape, there is a growing emphasis on upskilling and building capabilities, particularly through more decentralised, local-based approaches. Local institutions become pivotal actors in creating markets for new technologies and skills that are tailored to the specific needs and contexts of different regions. Social approval is particularly important in relation to the phase-out of coal. With World Bank support, South Africa decommissioned the Komati coal-fired plant but supported

workers through a comprehensive transition plan created with inputs from staff and unions. Affected workers will be transferred to other Eskom facilities and trained in renewable energy.

POSITIVE SIGNALS AND PRIVATE SECTOR FINANCING

The positive signals emerging from Africa's energy transition, including supportive policies, growing demand, cost reductions in renewable energy, and access to financing, are driving increased private sector financing and investment. In South Africa, changes in the Energy Regulatory Authority (ERA) have increased accessibility to renewable energy. In August 2021, the capacity threshold requirement was raised from 1MW to 100MW, resulting in a notable surge in renewable projects related to commercial and industrial (C&I) sectors. And easing licensing and registration requirements has contributed significantly towards making renewable energy more accessible to businesses and energy-intensive industries, such as mining, as well as a more feasible and strategic investment.

INSTITUTIONAL LEADERSHIP

Africa has demonstrated a growing commitment to regional cooperation and energy diplomacy. The Southern African Power Pool (SAPP), for example, provides a platform for multiple countries to collaboratively manage and share their electricity resources, promoting efficient utilisation and addressing energy challenges collectively. Through improved access to electricity, such initiatives enhance energy security and foster economic development. Energy diplomacy underscores a shift towards mutually beneficial relationships, where African countries engage in dialogue and negotiation to optimise energy resources and strengthen regional ties.

Despite this progress, challenges of scale remain, necessitating coordinated efforts at regional and continental levels to achieve widespread and inclusive energy development. The African Union Commission and the African Union´s Development Agency (AUDA-NEPAD) are spearheading efforts to create institutional cohesion through the Continental Master Plan (CMP) for electricity generation and transmission. AUDA-NEPAD has also initiated collaboration among the five African Regional Power Pools and has already reached several major milestones in its goal towards a single electricity market. The African Petroleum Producers Organisation (APPO) and Afreximbank have established a development financial institution to address the imminent funding challenge that the African oil and gas industry faces in the light of the call to end fossil fuel investments.

GEOPOLITICAL COMPETITION

Chinese investments in Africa continue to surpass those from Western countries. Since 2013, China has provided substantial loans to African countries under its Belt and Road Initiative, giving China unprecedented access to Africa's mineral wealth. In the Democratic Republic of Congo, for example, more than 80% of copper mines are Chinese owned.

However, between 2015 and 2022, Chinese loans declined by 56%. The African Development Bank, the Africa Finance Corporation, the EU, and the US plan to invest more than $1billion to launch a strategic corridor connecting mineral-rich countries, including the DRC and Zambia, to the Atlantic Ocean via Angola to compete with China's access to key minerals. This Lobito Corridor project will provide western markets with minerals needed for the EV industry and other important components of the energy transition. Although the primary purpose of this endeavor is to counter China's lead in access to rare minerals, the mining and processing activities will contribute to Africa's economic development.

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Image from the World Energy Council's Humanising Energy Series featuring Ohmium (India) produced by BBC StoryWorks.

ASIA

HIGHLIGHTS

ENERGY SECURITY

Driving for energy independence; aging infrastructure challenges; the climate change threat to energy security, leading to increased cooling demand and requiring the future-proofing of infrastructure; global geopolitics—the impetus for regional cooperation.

ENERGY EQUITY

Universal electricity access within reach for many countries; energy subsidies, the basis of equity in the region; interconnected energy markets and local demand management responses.

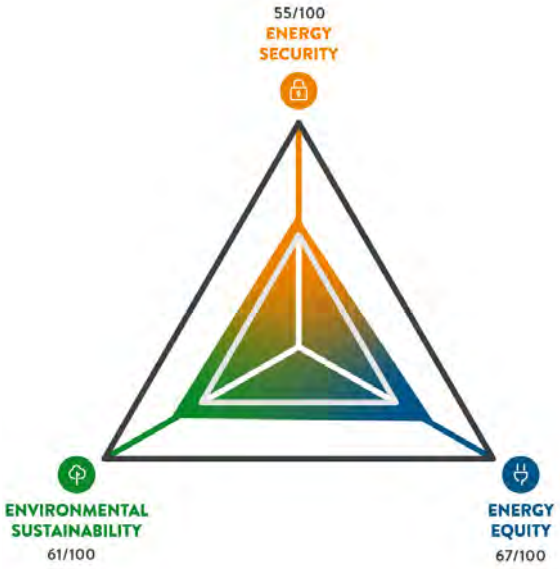
ENVIRONMENTAL SUSTAINABILITY

Global climate governance—keeping the long-term vision in focus; accelerating the deployment of EVs; the rise of hydrogen.

MANAGING THE WORLD ENERGY TRILEMMA

Encouraging financing; coal investment and disinvestment.

Figure 16: World Energy Trilemma Index Regional Balance - Asia



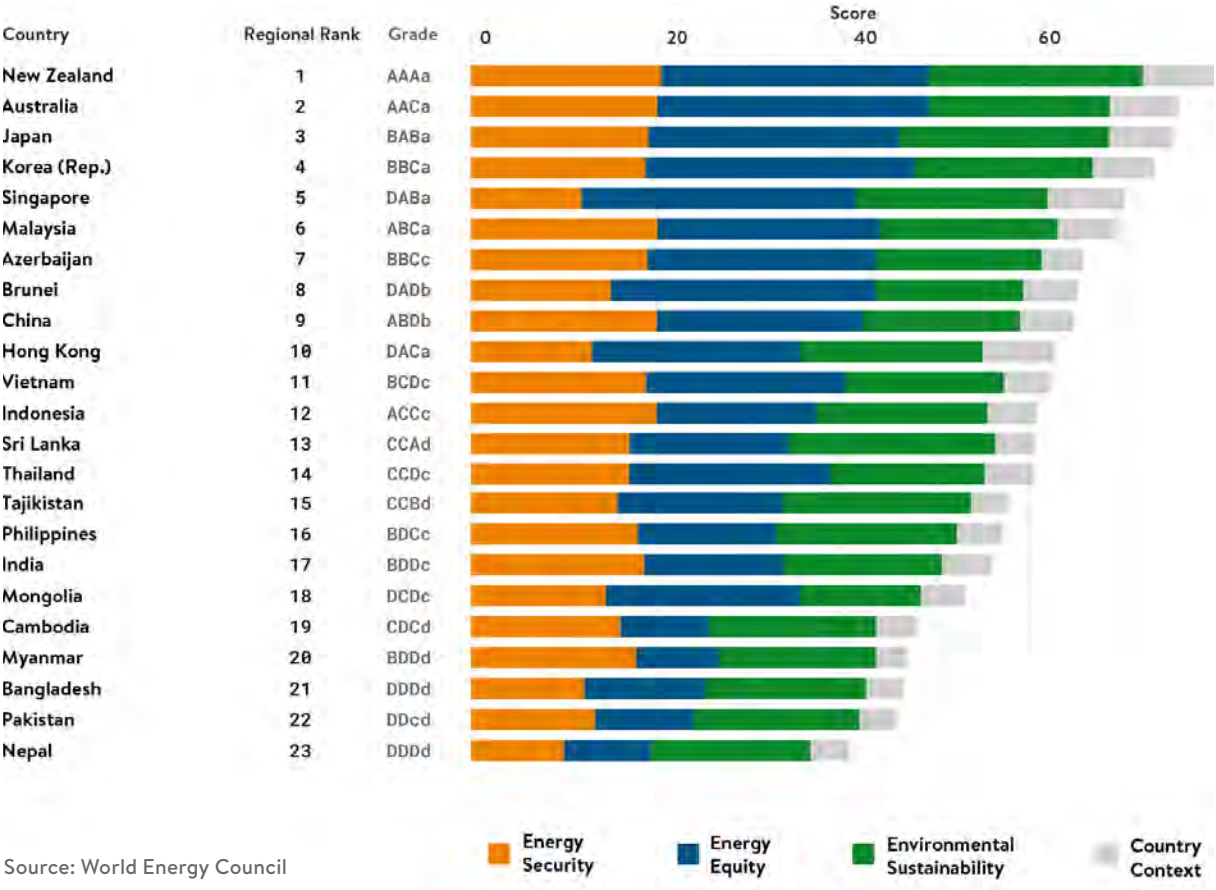
Source: World Energy Council

Asia's economic ascent over the last decade has been powered by a surge in energy demand, presenting both formidable challenges and unique opportunities. With the largest number of megacities in the world, urbanisation, industrialisation and demographic changes continue to drive up energy demand. Urban population growth has increased pressures on city infrastructure where, in many cases, the absence of flexible policy frameworks hinders private investment. Improved connectivity and the rise of the middle class are also increasing energy demand.

To meet its burgeoning energy needs, Asia continues to rely on coal. At the same time, it is shifting towards renewables, trying for least cost as well as the co-benefits of economic diversification while also attempting to fill the gaps in infrastructure.

The risks of conflict loom large over the region, with a pattern of interdependencies centered on China and deep dependence on the international economic system and financial markets in particular. With increasing climate change risks, climate change adaptation is already on the energy agenda in Asia. Even so, the current pace of the energy transition is slow. Affordability and security dominate, with sustainability regarded as a byproduct of the choices made in addressing the first two, and the overall balancing act of the trilemma is subject to upcoming elections.

Figure 17: World Energy Trilemma Index Regional Results - Asia



Source: World Energy Council

THE WORLD ENERGY TRILEMMA

ENERGY SECURITY

Like most regions throughout the world, Asia experienced a profound surge in gas prices as a result of the Russia-Ukraine war, exacerbating affordability concerns. The security challenges of the region have also been heightened by the security-driven responses of Europe, which have impacted the global LNG market, key to the energy security of Asia. While renewables are rising on the agenda and are seen as part of the long-term vision for security, the ageing infrastructure is overburdened by catastrophic climate events, and rising temperature is leading to rising demand. Energy diversification is on the agenda for long-term energy independence but remains secondary to economic growth, which requires an exponential rise in energy supply, leading to local coal and gas resources remaining the top choice.

DRIVING FOR ENERGY INDEPENDENCE

The fear of energy shortages has driven a desire for energy independence, slowing down decarbonisation in Asia. In the short term, Bangladesh, Malaysia and Indonesia have increased fossil fuel extraction for LNG and coal-based power generation. At the same time the aspiration for long-term energy independence continues to drive renewable energy generation support. For example, the Philippines has streamlined the permitting process for all new power generation, transmission, and distribution projects through an online platform for a paperless application and processing system. However, new power generation facilities will be stymied by gaps in transmission infrastructure. While China and India's power grids enable continued renewable energy deployment, Indonesia and Malaysia lack infrastructure.

AGING INFRASTRUCTURE CHALLENGES

Central Asia's energy security challenges are intrinsically linked to its aging infrastructure, heavy reliance on hydrocarbons, and geographical constraints, complicating the region's transition to renewable energy. Despite possessing significant deposits of natural resources, the legacy of Soviet-era infrastructure and the region's landlocked geography pose unique challenges to developing and integrating renewable energy sources. Countries like Kazakhstan, with its substantial hydrocarbon reserves, face the dual challenge of overcoming dependence on fossil fuels and modernising outdated energy systems that contribute to high greenhouse gas emissions. Efforts towards energy transition through investments in renewable energy projects and regulatory reforms are evident across the region and in line with commitments to the Paris Agreement. However, the transition is hampered by the need for substantial upgrades to the existing energy infrastructure to accommodate new renewable energy sources. International financial institutions play a critical role in overcoming these challenges to support the transition.

THE CLIMATE CHANGE THREAT TO ENERGY SECURITY: INCREASED COOLING DEMAND AND THE FUTURE-PROOFING OF INFRASTRUCTURE

Rapid urbanisation, economic growth, and rising living standards have resulted in a significant increase in Asia's energy cooling demand. As temperatures continue to climb due to climate change, air conditioning and refrigeration systems to maintain comfortable and safe indoor environments are becoming more crucial.

Extreme weather and climate change impacts on infrastructure are increasingly posing threats to the region's energy security. In Japan, for example, although the power grid systems were installed in full compliance with the national technical standard, a couple of strong typhoons in 2019 consecutively hit the same area, devastating local high- and medium-voltage power grid systems. The following year, Japan's Ministry of Economy, Trade, and Industry revised the standard to make the grid facilities more resilient against higher wind velocities. The WMO's State of Climate Report 2022 has highlighted the rising climate change threats in Asia. While impacts on energy security are now on the agenda, infrastructure roll-out remains the priority, as well as the need for adapting infrastructure standards and specifications in the region.

GLOBAL GEOPOLITICS—THE IMPETUS FOR REGIONAL COOPERATION

Government-led regional initiatives, such as the Asia Pacific Energy Cooperation and ASEAN+3, play a pivotal role in addressing energy security challenges. To enhance reliability, there is a push for regional and cross-border grids, exemplified by projects like the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project.

While China is aggressively pursuing dominance in the manufacturing sector and in supply chains for future energy technologies, including critical minerals, through initiatives like the Belt and Road Initiative (BRI), Japan and South Korea are adopting a collaborative stance, aligning with the United States to offer an alternative to China's regional dominance. Both countries are investing in technological innovation and nuclear energy to reduce LNG import dependency and to foster economic ties with emerging economies through investment in regional projects.

Other nations around the South China Sea are also concentrating on energy security and economic growth, seeking to lessen their dependence on China by turning to renewable energy and aligning more closely with the United States. At the same time, they are attempting to secure safe passage in the South China Sea, develop oil and gas resources, and attract foreign investment. These moves reflect broader strategies to navigate the complex interplay of energy demands, geopolitical ambitions, and the pursuit of sustainable growth in a region that is critical to the global energy market and international relations.

Image from the World Energy Council's Humanising Energy Series featuring CLP Holdings (Hong Kong) produced by BBC StoryWorks.

THE WORLD ENERGY TRILEMMA

ENERGY EQUITY

The region continues to grapple with the priorities of energy access and affordability despite the strides made by many, including Bangladesh, Indonesia, India, and Philippines. Domestic political turmoil prevents redirection of subsidies from fossil fuels. However, in some parts of the region, rising prices are encouraging progress in demand side management.

UNIVERSAL ELECTRICITY ACCESS WITHIN REACH FOR MANY COUNTRIES

Despite more than 350 million people in Asia and the Pacific facing limited electricity access, with 150 million completely without, there is notable progress towards Sustainable Development Goal 7, which advocates for clean and accessible energy. Countries like the Lao PDR, the Philippines, Thailand, and Viet Nam have made significant strides towards universal electrification, alongside

South Asian nations such as Bangladesh and Sri Lanka. The World Bank's tracking indicates a substantial increase in the proportion of the population with basic electricity access. This measurement is coming to be seen as capturing the true impact of energy on economic growth, rising between 2000 and 2020 from 60% to 96% in Central and South Asia and from 92% to 98% in East and Southeast Asia.

In spite of this notable progress toward achieving SDG7 in Asia and the Pacific, the COVID-19 pandemic and the Russian invasion of Ukraine have posed significant challenges, with energy prices soaring to record highs. Increased costs for energy, food, fertiliser, and transport have exacerbated extreme poverty and impeded progress toward universal and affordable energy access, especially in remote and impoverished areas.

ENERGY SUBSIDIES, THE BASIS OF EQUITY IN THE REGION

While market liberalization may enhance energy efficiency, it does not guarantee cheaper prices. In countries like Indonesia, Malaysia, and Singapore, removing power subsidies is politically difficult, as is evident in, for example, the delay in the planned liberalization of gas prices in Malaysia.

INTERCONNECTED ENERGY MARKETS AND LOCAL DEMAND MANAGEMENT RESPONSES

Following Europe's exodus from Russian natural gas, prices in the Asian LNG market surged, leading to operational challenges for power companies in importing nations. Demand-side management initiatives, such as Singapore's residential demand response program (to be launched by mid-2024)[1] and Japanese power utilities' reward point system for reducing power consumption during peak hours, aim to involve residents in addressing challenges of balancing electricity demand and supply, while at the same time making electricity management simpler and more rewarding. In the Philippines, the Energy Efficiency and Conservation Act is designed to manage demand as a way of deferring the need to add energy capacity and related infrastructures, thus contributing to long-term affordability.

THE WORLD ENERGY TRILEMMA

ENVIRONMENTAL SUSTAINABILITY

GLOBAL CLIMATE GOVERNANCE: KEEPING THE LONG-TERM VISION IN FOCUS

At COP28, China announced its plan to release both 2030 and 2035 national climate targets in 2025.[2] Neither China nor India signed the Global Renewables and Energy Efficiency pledge. However, China committed to a bilateral deal with the US in the run-up to COP, which featured accelerating renewable energy deployment and including methane in their next climate action plans. But because this bilateral agreement was crafted by key climate envoys, John Kerry and Xie Zhenhua, the political appointees who succeed them are crucial for determining the continuity, focus, and ambition of this pivotal climate cooperation between the world's two largest carbon emitters.

At COP28, Singapore signed a pledge to triple renewable energy capacity by 2030 and reiterated its commitment to achieve net zero by 2050. Indonesia reasserted its commitment to achieve net zero by 2060 or sooner, despite nearly 60% of power generation currently coming from coal. The cost for Indonesia's coal phase-out and renewables phase-in is estimated at $1.2 trillion through 2050.[3] At COP28, the Coal Transition Accelerator, to transition away from coal, was launched by France, the European Commission, a number of organisations, and partner countries in Asia, Africa, North America, and Europe.

ACCELERATING THE DEPLOYMENT OF ELECTRIC VEHICLES (EVS)

Singapore plans to phase out sales of internal combustion engine vehicles by 2030, reflecting a general move throughout the region for the electrification of private vehicles and public transport systems. Both Singapore and Hong Kong provide subsidies to encourage the adoption of electric vehicles. China provides subsidies for manufacturers and producers of New Energy Vehicles. Indonesia is leveraging its vast nickel reserves, crucial for battery production, to attract foreign investment as well as offering incentives for investment in EV production and adoption. Thailand has been working on promoting EV adoption through investment incentives, tax breaks, and infrastructure development, aiming to become a regional EV manufacturing hub.

THE RISE OF HYDROGEN

High gas prices have increased hydrogen's importance. The Philippines, India, and Japan are developing hydrogen strategies with usage targets for 2030 and 2050, and the Philippines is exploring hydrogen partnerships for cleaner energy in hard-to-abate industries like chemicals and steel, which are critical to the infrastructure development needed for emerging economies in the region. Australia aims to leverage its abundant resources and proximity to the Asian market to become a hydrogen-exporting country. Japan and Australia have created a partnership to establish a cross-border hydrogen supply chain under the Australian Clean Hydrogen Trade Program (ACHTP). The world's first demonstration project for the production and transportation of liquefied hydrogen, the Hydrogen Energy Supply Chain (HESC) Project, is supported by both governments and completed its demonstration phase in 2022. The exploration of hydrogen as a clean energy source also offers promising opportunities for Central Asia to leverage its renewable energy potential and contribute to global energy security.

Image from the World Energy Council's Humanising Energy Series featuring ACEN (Philippines) produced by BBC StoryWorks.

MANAGING THE WORLD ENERGY TRILEMMA:

CHALLENGES AND OPPORTUNITIES

Managing the World Energy Trilemma in Asia requires paying attention to the human context — assuring political and social stability through economic growth. Over the past decade, from 2012 to 2022, Asia's remarkable economic development has been closely tied to its unprecedented growth in energy consumption. In 2012, Asia's average per capita energy consumption was roughly half the global average, signaling a region at an earlier stage of industrial development compared to more developed economies. But by 2022, the average had risen to 85%—a leap that is a story not just of numbers, but of millions lifted out of poverty, of cities expanding, and of industries booming.

As long as energy policymaking focuses on supporting economic development first, the region is likely to move relatively slowly on transforming the energy policy landscape. However, the recent price shocks along with a drop in clean energy technology costs are creating powerful incentives for energy transition progress.

CHINA: RENEWABLE ENERGY AND ECONOMIC GROWTH

Economic development is key to maintaining social order in China. In this context, the energy transition is seen as an opportunity to develop the industries needed for the necessary infrastructure build-up. In 2022 alone, exports of electric vehicles rose by 131.8 percent, photovoltaic (PV) products by 67.8 percent, and lithium-ion batteries by 86.7 percent.[4]

Chinese dominance of solar and wind technology manufacturing continues with over 1000 GW of solar module manufacturing capacity projected to be in place by the end of 2024, while projected global demand for solar PV capacity (based on announced policies) will only be 500 GW by 2030.[5] China also leads the global market for critical minerals. While there are risks associated with Chinese investments in the mines of Congo, Chile, and Indonesia, China's capacity for processing the minerals into products gives it a distinct advantage.

Air pollution is another major challenge, especially because it is a visible aspect of energy policy. While permits for new coal production have been approved, coal is intended primarily to support the reliability of the grid and to maintain the reserve margin. China's mandatory cap and trade system currently includes coal-fired power plants and will soon expand to other high-emitting industries as well. The voluntary carbon market is also growing, largely as the result of the exposure of Chinese businesses to the pressures of European ESG and CBAM mechanisms. And since the cap-and-trade system accepts up to 5% of the credits a business earns from the voluntary markets, the system and the markets are linked.

INDIA: RENEWABLE ENERGY AND ECONOMIC GROWTH THROUGH PRODUCTION INCENTIVES

India is paying attention to the benefit of coupling renewable energy industries to economic growth. A Production Linked Incentive scheme (PLI) for batteries is intended to boost electric vehicle adoption in India, and another PLI, for advanced chemistry cell battery storage, aims at a manufacturing capacity of 50 GWh. Sector players are invited to bid, with the winner choosing suitable technology for production, raw materials, and plant machinery, and commercial production to begin by the end of 2024.

India is also using PLI schemes to encourage the production of green hydrogen. The Strategic Interventions for Green Hydrogen Transition program offers a three-year financial incentive for green hydrogen production and a five-year incentive for electrolyzer manufacturing. India has also introduced a solar Levelized Cost of Electricity (LCOE) to match the cost of coal.

COAL INVESTMENT AND DISINVESTMENT

Asia's energy mix has been heavily coal-intensive, with coal accounting for 47% of the region's energy consumption. The region's reliance on coal, responsible for more than 80% of global coal consumption, has been a double-edged sword, fueling economic engines but also contributing significantly to global carbon emissions. The Asian Development Bank (ADB) is spearheading an innovative blended finance approach called the Energy Transition Mechanism (ETM), which aims to decommission existing coal power plants ahead of their closure date and replace them with clean energy facilities. The ADB has also committed to no future funding for coal-fired power generation.

ENCOURAGING FINANCING

Financing is a key issue and was a major focus at COP28. The developing nations in Asia are potential beneficiaries of the global financing mechanism, which can be enabled through multilateral banks like the World Bank, the Asia Development Bank, and the Asian Infrastructure Investment Bank. However, the funding earmarked for renewable energy projects often remains idle, with funders working to identify viable projects. Frameworks to increase transparency could help streamline the entire funding process and encourage the private investment needed to cover the cost of transition in the region. An example of such a framework is Japan's Joint Crediting Mechanism (JCM), which finances capital expenditures for local projects, coupled with the incentive of shared carbon reduction benefits among the participating countries. However, an often-protracted implementation process requires two to three years for requisite approvals. Despite the time-intensive nature of these projects, the JCM serves as a model for the region, not only providing a funding platform but also outlining a structured approach to sharing the benefits.

At COP28, in a bid to mobilise private capital at the speed and scale needed for the transition, the UAE launched ALTÉRRA, a climate investment fund focused on emerging markets and developing economies. Initial commitments include immediate investment for the development of more than 6.0 GW of clean energy capacity in India, with the construction of solar and wind projects scheduled to begin producing clean energy by 2025.

Bangladesh's off-grid solar power program—the most extensive in the world—offers an example of a successful integration of external infrastructure financing expertise, government-led microfinancing, and private sector solar electrification. This synergy has created a scalable business model for off-grid electrification, enabling 20 million rural residents to gain access to electricity via affordable, renewable energy solutions within a public-private partnership framework. This example underscores the importance of government policies and regulations intertwined with innovative financing mechanisms to support viable clean energy technologies.

However, scaling up renewable energy initiatives in low-income economies poses significant challenges. The adoption of specific energy targets, allocation of funds for their realisation, and formulation of detailed strategies for their implementation are crucial, especially for electrifying rural and remote areas and improving energy services like cooking. Strong institutions, such as Malaysia's Sustainable Energy Development Authority, Sri Lanka's Sustainable Energy Authority, Nepal's Alternative Energy Promotion Center, and India's Bureau of Energy Efficiency, play a pivotal role in fostering policy changes within the clean energy sector to advance renewable energy and energy efficiency initiatives.[6]

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Image from the World Energy Council's Humanising Energy Series featuring Mabanaft (Hamburg) produced by BBC StoryWorks.

EUROPE

HIGHLIGHTS

ENERGY SECURITY

Energy security has risen in importance following the war in Ukraine and the cuts in supply of Russian oil. Short-term responses, such as increasing coal, are scheduled to give way to long-term structural reforms aimed at increasing security through energy supply diversification, especially through renewables.

ENERGY EQUITY

Unequal access to low-carbon technologies as well as to affordable clean energy are challenges. Rising energy prices fuel the ongoing cost-of-living crisis and negatively impact industrial competitiveness.

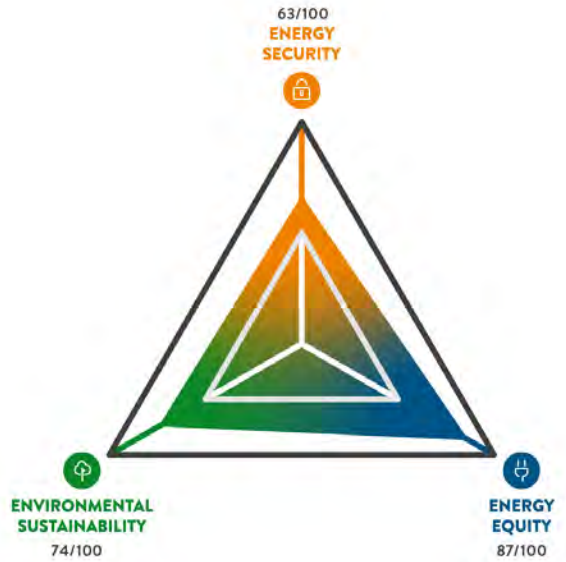
ENVIRONMENTAL SUSTAINABILITY

Despite these challenges, Europe's commitment to a sustainable energy transition seems to remain strong, influenced by global climate goals and the repositioning of Europe as a key influencer in the geopolitics of future energy systems.

MANAGING THE WORLD ENERGY TRILEMMA

The current situation has highlighted the complexities of balancing energy security, equity, and environmental sustainability and has driven significant government interventions in energy markets, many of which are well-intended, but which still have to prove a positive long-term outcome.

Figure 18: World Energy Trilemma Index Regional Balance - Europe



Source: World Energy Council

After the COVID-19 crisis motivated a commitment to pursue green recovery across most states in Europe, the war in Ukraine exposed further significant divisions within the continent's energy landscape, challenging the assumption that climate change would remain the primary focus in the near future. The European dependence on Russian gas exposed the energy security risks of relying on a single supplier and highlighted the need for Europe to diversify its energy sources and develop a more robust and resilient energy system. Energy security and the subsequent impact on energy affordability and thus equity rose to the top of political and social agendas.

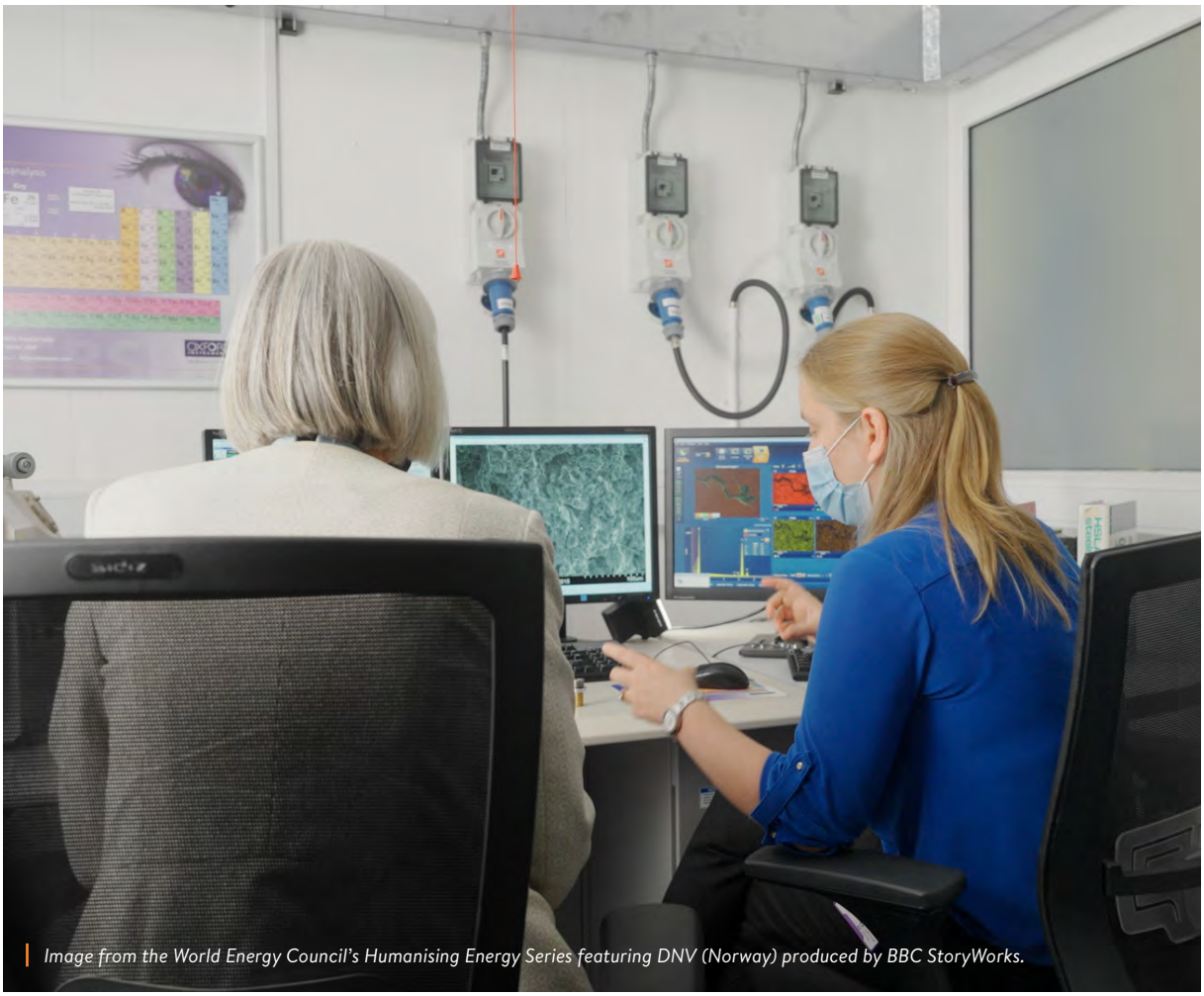
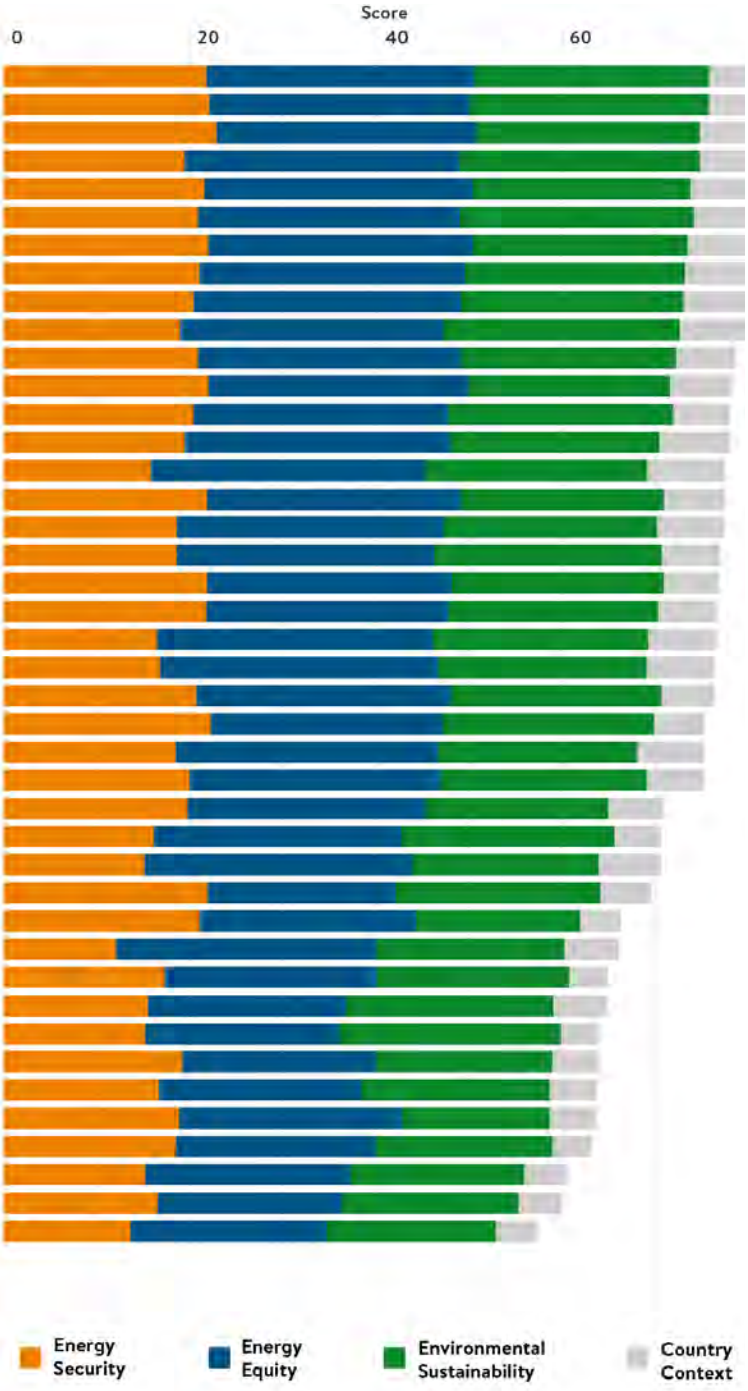


Image from the World Energy Council's Humanising Energy Series featuring DNV (Norway) produced by BBC StoryWorks.

Figure 19: World Energy Trilemma Index Regional Results - Europe

Country	Regional Rank	Grade
Denmark	1	AAAa
Sweden	1	AAAa
Finland	2	AAAa
Switzerland	3	AAAa
Austria	4	AAAa
France	5	AAAa
Germany	6	AAAa
Estonia	6	ABAa
United Kingdom	7	AAAa
Norway	7	BAAa
Slovenia	8	ABAa
Czech Republic	9	ABBa
Spain	10	ABAa
Netherlands	11	AAAa
Hungary	12	ABBa
Luxembourg	12	CAAa
Belgium	13	BAAa
Portugal	14	ABAa
Slovakia	15	ABAb
Latvia	16	ABAa
Ireland	16	CAAa
Iceland	17	CAAa
Croatia	17	ABAb
Romania	18	ABAb
Lithuania	19	BBAb
Italy	20	ABAb
Poland	21	ABCb
Greece	22	CBAc
Malta	22	CABa
Bulgaria	23	ABBc
Russia	24	ABCd
Cyprus	25	DABb
Georgia	26	CCAb
Turkey	26	BBBd
Albania	27	DCAc
Serbia	28	BCCc
Montenegro	29	CCBc
Kazakhstan	30	BBDc
Bosnia and Herzegovina	31	BCCd
Armenia	32	CCCc
North Macedonia	33	CCCc
Moldova	34	DCCc



Source: World Energy Council

THE WORLD ENERGY TRILEMMA

ENERGY SECURITY

The EU Commission has a very broad definition of energy security, including adequate electricity supply, security of gas supplies, sufficient gas storage capacities, protection of critical infrastructures, cybersecurity, emergency stocks of oil across member states, critical mineral access, and industrial production capacity for renewables.

Since Russian gas supplied 32% of EU and UK gas demand in 2021, the 2022 Russian invasion of Ukraine made gas supply central to national debates about energy security.[1] In addition to exposing the need for alternative fuel sources, the Ukraine crisis also highlighted the flawed future-proofing of government regulatory design as well as the failure of the energy markets to deliver in times of crisis.

Before the Ukraine war, energy security in Europe was presumed to be guaranteed. The diversification of energy sources for electricity generation was a priority and viewed as key to energy security, while the need for a diversity of suppliers was relatively ignored, especially given the underlying assumption that the economic benefit of the energy trade would ensure peace and therefore supply security. This assumption has been challenged along with the assumption of the availability of critical mineral supply chains for clean energy technologies. The shattering of these assumptions has raised collective awareness of the need for comprehensive strategies and long-term public policies for energy security in the face of evolving geopolitical, environmental, and technological challenges.

UKRAINE CRISIS: SHORT-TERM RESPONSES AND LONG-TERM REFORMS

Countries in the EU varied in their short-term responses to the energy crisis resulting from the Ukraine war. Germany temporarily delayed its planned nuclear phase-outs, while France, Belgium, and Sweden reoriented their energy strategies. And some countries increased their reliance on coal. In these emergency conditions, targeted policy measures were put in place, including a record inflow of liquefied natural gas (LNG). Floating re-gasification units in Germany helped to provide a rapid response to pipeline supply cuts. A steep drop in energy consumption by both households and industry was partially the result of the pandemic but also a response to higher prices, which drove efficiency efforts, and the luck of a mild winter. A combination of factors, including lower demand from China, allowed Europe to secure LNG, together with bidding higher prices, which led to the rerouting of LNG tankers away from Asia towards Europe. These measures allowed the gas storage in the EU to reach nearly 95% of capacity in Q4 2022. By the end of Q1 2023, gas storage stood at 56%.[2]

European leaders have recently voiced their support for significant structural reforms of the European energy system, with a strong emphasis on accelerating decarbonisation. The proposed reforms include: first, to increase electrification and enhance energy efficiency; and second, to substantially increase the production of low-carbon electricity. However, the definition of low-carbon electricity varies from one country to another, with natural gas seen as a necessary transition fuel in some countries. Nuclear energy is in the clean energy portfolio of several countries, while in Germany, it has been phased out.

REGIONAL DIVERSITY AND IMPORT INDEPENDENCE

Guaranteed electric power generation through hydro in Norway and nuclear and hydro in Sweden and consequent low consumption of natural gas and oil meant that the interruption of Russian oil and gas supplies was not as critical for the Nordic region, except in terms of prices. Norway is a major exporter of natural gas and oil to the EU and has an overabundance of hydrocarbon energy supply, so the higher prices were economically beneficial. But while Finland has significant biomass, nuclear, and hydroelectric capacity, it was faced with replacing the approximately 24% of its imported oil previously sourced from Russia with imports from alternative suppliers. Moreover, Russia cut off gas deliveries to Finland, which then had to switch to the Baltic connector pipeline from Estonia and increase LNG shipping to meet its natural gas needs.

One of the reasons individual European countries have usually scored well on the World Energy Trilemma security index is that they have diverse supply in the energy mix compared to the rest of the world, with gas and electricity coming through interconnected grids. However, these interconnections are of limited help when all the neighbors face the same supply shock.

THE WORLD ENERGY TRILEMMA

ENERGY EQUITY

The rise in energy costs associated with the Ukraine war posed a significant challenge to vulnerable communities. The call for "affordability" drove massive government intervention in energy markets, fundamentally shifting the balance between the state and the market in energy. As an example: to protect consumers and businesses from the impacts of the energy crisis, the EU spent 758 billion euros in additional energy subsidies, with a third of the benefits allocated specifically to vulnerable groups and the remaining broadly distributed to households and firms across European countries.[3] In September 2022, the EU placed a tax on fossil fuel companies' record profits. However, in many countries, energy companies fought the tax in court and won. Public sentiment against fossil fuel companies and a lack of trust in the regulatory environment to deliver a just solution have both remained strong.

ELECTRICITY MARKET REFORMS FOR ENSURING EQUITY

The Ukraine war has acted as a catalyst for considerable reforms in Europe's electricity markets. At the end of 2023, the European Council and the European Parliament reached a provisional agreement to reform the EU's electricity market design (EMD) in order to insulate consumers from extreme price surges, foster a greater inclusion of renewables in the energy mix, and boost the transparency and oversight of the market.

A pivotal feature of these reforms is the encouragement of national governments to directly finance power purchase agreements (PPAs) for renewable energy projects, thereby bolstering the financial feasibility of such initiatives. By potentially acting as purchasers of green electricity, governments can significantly propel the adoption of renewable energy. The reforms are also designed to mitigate the volatility of electricity prices through the adoption of contracts for difference, which set predefined price limits to buffer against the price variability typical of renewable energy. Furthermore, the agreement outlines criteria for declaring an energy crisis, paving the way for targeted measures to alleviate electricity costs for the most vulnerable and disadvantaged groups in society.

EQUITABLE ACCESS TO LOW-CARBON TECHNOLOGIES

Although universal grid access has been achieved in Europe, economic disparities play a pivotal role in the accessibility and affordability of clean energy. For example, while the emphasis on building electric vehicle (EV) infrastructure is a positive step toward sustainable mobility, currently, the affordability of EVs and the accessibility of charging infrastructure potentially exclude particular segments of the population from participating in this aspect of the clean energy transition. Heat pumps in buildings could reduce energy demand by two thirds, but still require incentives and the regulatory framework to make their deployment affordable for all. Future lower prices for EVs and heat pumps are expected to improve the situation, although for heating, building refurbishments remain a difficult and expensive enterprise.

ACCESS TO HYDROGEN

The rise of green hydrogen to replace gas, especially in heavy industry, creates an equity issue in that the electricity supply needed for domestic consumption may compete with the electricity supply needed to produce green hydrogen. To ensure that green hydrogen does not cannibalise renewables from other sectors, the 'additionality' criteria for renewables in green hydrogen projects in Europe are designed to ensure that the electricity used in the production of green hydrogen comes from additional renewable energy sources, rather than displacing renewable energy that would otherwise be supplied to the grid. Under the new EU rules formally adopted in June 2023, two delegated acts outline detailed rules on the definition of renewable hydrogen, including the principle of 'additionality'. These rules specify that all renewable fuels of non-biological origin (RFNBOs) must be produced from renewable electricity, ensuring that the expansion of green hydrogen production directly contributes to the increase of renewable energy available in the EU.[4]

THE EMERGENCE OF HYDROGEN VALLEYS

The recent surge of interest in decarbonised hydrogen as a key element in energy transitions has led to the emergence of 'hydrogen valleys' across Europe. The integration of hydrogen into local energy systems and the resulting innovation in various sectors not only promises to help decarbonise hard-to-abate industries and transportation but also to drive economic growth and cross-border collaboration.

The North Adriatic Hydrogen Valley, led by Slovenia's HSE utility company, and spanning Italy, Slovenia, and Croatia, stands out as Europe's first cross-border hydrogen valley. In the Northern Netherlands, EU-funded projects like the Hydrogen Valley Campus Europe led by the University of Groningen, prioritise human capital development for the hydrogen economy. Meanwhile, the Norwegian company Z.E.G Power is working on advanced hydrogen applications, emphasising seamless integration into the energy value chain and collaborative knowledge-sharing for more rapid progress.

THE WORLD ENERGY TRILEMMA

ENVIRONMENTAL SUSTAINABILITY

European countries continue to rank among the top 10 overall in Trilemma results, representing only 7% of global carbon emissions while representing 15% of global GDP. This is the legacy of decades of consistent policy design changes geared towards decarbonisation, with electrification as the key pillar.

LOCK-IN EFFECTS OF INSTITUTIONAL AND INFRASTRUCTURAL POLICIES

In the pursuit of environmental sustainability, Europe is committed to reducing carbon emissions, embracing low-carbon energy sources, including renewables and nuclear, adopting practices that ensure the conservation of natural resources and biodiversity, promoting circular economy principles, supporting the rise of hydrogen for hard-to-abate sectors, and ensuring that economic growth decouples from increased emissions. This commitment is shaped by global climate governance, with the Paris Climate Agreement influencing regional sustainability goals and businesses aligning their strategies with these principles.

While the European region has demonstrated results with its long-term commitments, the Ukraine war has challenged all actors on the energy landscape, eliciting short-term responses that have slowed the progress of energy transitions in many countries. These hasty policy responses have also created path dependencies for a prolonged use of gas in the energy mix and infrastructure build-up for LNG terminals. But even though the current crisis has elicited short-term reactions aimed at increasing energy security, the clean energy supply-side gains of the last two decades have lock-in effects that continue to align government policies with environmental sustainability.

THE ROLE OF CORPORATE TRANSPARENCY IN ATTRACTING ESG INVESTMENT

Corporate ESG transparency is encouraged through ESG metrics and other signals, such as those derived from the Corporate Sustainability Reporting Directive (CSRD), which requires the filling of annual sustainability reports, and the European Sustainability Reporting Standards (ESRS), which requires standardised climate change and ESG reporting. The 2023 Green Deal includes an EU Green Bond Regulation, which allows investors to distinguish between companies that are merely 'greenwashing' and those whose strategies actually help further the energy transition.[5]

STREAMLINING PERMITTING FOR RENEWABLES

In September 2022, the EU passed an emergency law to simplify and fast-track the permitting process for renewables. Key changes included the Emergency Regulation on Permitting and the revised Renewable Energy Directive (RED III) provisions, which mandated a two-year deadline for permit provision, required digitalisation of permitting procedures, and emphasised considering the whole population of a species for

biodiversity impacts. While streamlining the permitting process is a step forward, ample options for appeal are available in the European legal courts, which can introduce uncertainty for investors.

Germany's rigorous implementation of the "Overriding Public Interest" concept effectively expedited several projects. Spain increased staffing for permitting processes, and Poland modified its distance rule for wind turbines, contributing to the increase in permits awarded. In 2023, Germany led the region with 7.5 GW of new permits for onshore wind farms. Spain followed with permits for over 3 GW, France issued permits for 2.2 GW (a 12% increase), and the UK approved just over 1 GW.[6]

THE NORDIC REGION—GLOBAL LEADERS IN THE TRANSITION

The Nordic region stands out as having achieved significant decarbonisation of its electricity sector. Nordic countries, including Iceland (geothermal), Norway (hydropower), Sweden (nuclear, hydropower), Denmark (wind), and Finland (biomass and nuclear), are on track to be completely carbon neutral by 2050. Their sustainable power sectors, characterised by low-carbon and renewable power generation, make them leaders in the global effort to combat climate change.

THE POWER OF LONG-TERM POLICIES

The 2019 European Green Deal was focused on providing affordable and clean energy. In May 2022 the update of REPowerEU added an emphasis on independence from Russian gas supplies.

An important legal asset for CO_2-reduction control is the EU Emission Trading System, which came into effect in 2005, with a decreasing number of emission allowances until 2030 (and likely beyond). This means that the polluters pay, but via a market mechanism, whereby the reduction is dictated, with the price of allowances serving as the variable that reflects scarcity or not. Over the coming years, that ETS will be extended beyond the electric power sector and high-emissions industries, to include the building and transportation sectors.

An additional key feature of the Green Deal is the Carbon Border Adjustment Mechanism (CBAM), which is a CO_2-weighed import border tax. Building on the success of the ETS cap and trade system, the CBAM aims to stem carbon leaks and encourage key trading partners to reduce emissions from industries or to enable carbon markets, thereby nurturing the EU's technological advantages.

The EU's Green Deal Industrial Plan, launched in February 2023, is an update of the Green Deal.[7] Widely viewed as a response to the 2022 US Inflation Reduction Act, the Plan amends state aid rules, facilitating the use of existing EU funds for clean tech and offering two important proposals: to set up a European Sovereignty Fund and to establish net-zero industry academies with up-skilling and re-skilling programs in strategic industries to develop the necessary workforce for the green transition. In addition, the Plan contains measures to facilitate access to the EU labour market for third-country nationals in priority sectors.

MANAGING THE WORLD ENERGY TRILEMMA:

CHALLENGES AND OPPORTUNITIES

The Ukraine crisis focused attention on gaps in infrastructure, the insufficient diversity in contract portfolios of gas suppliers, and the dependence on certain critical infrastructure linked to one supply source, such as Nord Stream's pipelines. It also encouraged expanding renewables and nuclear in Europe as well as increasing investment in interconnections to facilitate cross-border energy flows and diversify supply routes.

INTERCONNECTIONS AND SYSTEM RELIABILITY

Regional interconnections are critical to increasing the flexibility and balancing of the electricity grids, especially because demands for instantaneous electric power are expected to surpass twice the current levels by 2030 and expand to seven times the current size by 2050. These flexibility needs will likely constitute 25% of the present total electric power demand by 2030 and up to 80% by 2050.[8]

The recent physical threats to critical energy infrastructure are raising concerns over the potential of increased cyberattacks on current and future electric power grids as well as natural gas and communication grids. The 2015 malware attack on the Ukrainian electric power grid, the 2022 sabotage of the Nord Stream 1 and 2 pipelines in the Baltic Sea, and the severing of the Baltic connector gas pipeline, an underwater communications cable between Finland and Estonia, have all demonstrated the vulnerability of critical energy infrastructure. Offshore infrastructure vulnerability is particularly significant because of the time required for repair following an attack.

The rise of renewables is creating its own challenges for energy security, given the effects on the grid of wind and solar variability and stochasticity. The share of renewables in the EU's total electricity generation (in 'energy' terms) was 38.6 % in 2022, with wind and solar accounting for 22.3 % of total annual electricity generation, exceeding electricity generation by natural gas (at 19.9 %). These increases do not guarantee increases in flexibility, so sufficient balancing mechanisms must be constructed. To compound the challenges, there is a looming shortage of human resources trained to deploy green technology.

In addition to these challenges, Europe risks shifting from dependence on imported fossil fuels to dependence on imported technologies and materials. Current value chains largely rely on countries outside Europe, especially China, where, for example, 95% of solar panel wafers are made. This material and manufacturing supply chain dependence is not an immediate threat, but is a most important longer-term concern.

Promoting energy equity while at the same time designing policies to enable long-term stability in energy markets poses significant challenges to policymakers. In some countries fossil fuel subsidies hinder the uptake of clean energy alternatives, and while there is collective agreement to address barriers for project licensing and permitting, implementation on the country level is uneven.

Over the long term it seems likely that Europe will lurch from energy insecurity to market fluctuations and experience a somewhat uneven and uncoordinated transition with national divergences. In spite of the challenges, social will and overall government policy are fundamentally supportive of the transition to a more sustainable energy future.

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Image from the World Energy Council's Humanising Energy Series featuring Raizen (Brazil) produced by BBC StoryWorks.

LATIN AMERICA AND THE CARIBBEAN

HIGHLIGHTS

ENERGY SECURITY

The energy sector is adapting to climate impacts through regulatory reforms and market changes, while high prices fuel new oil and gas explorations. Political unrest adds investment uncertainties, highlighting the need for stronger regional integration to enhance security.

ENERGY EQUITY

Equity challenges persist, with subsidies being a primary mechanism for maintaining affordability amidst political and economic instability.

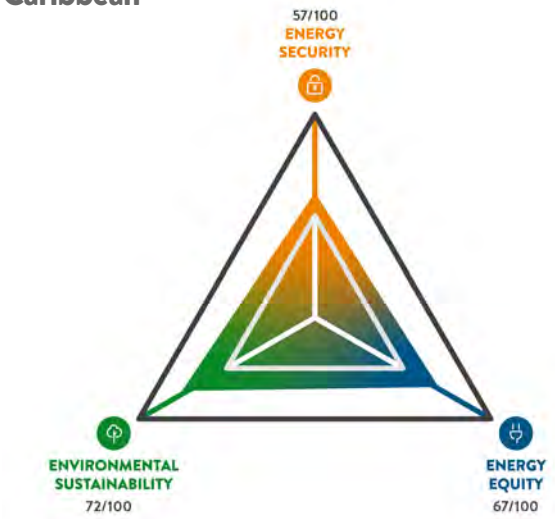
ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability is highlighted by a heavy reliance on renewables, particularly hydro, but challenged by climate change. The rise of sustainability-linked and ESG bonds is unlocking finance, supported by frameworks to guide investments towards sustainable energy transitions.

MANAGING THE WORLD ENERGY TRILEMMA

Civil society's growing influence on energy projects affects security and equity. The rising importance of critical minerals for future energy systems is an opportunity for the region. Managing the trilemma involves fostering public-private partnerships, adopting long-term visions resilient to political shifts, and enhancing institutional capacity.

Figure 20: World Energy Trilemma Index Regional Balance - Latin America and the Caribbean

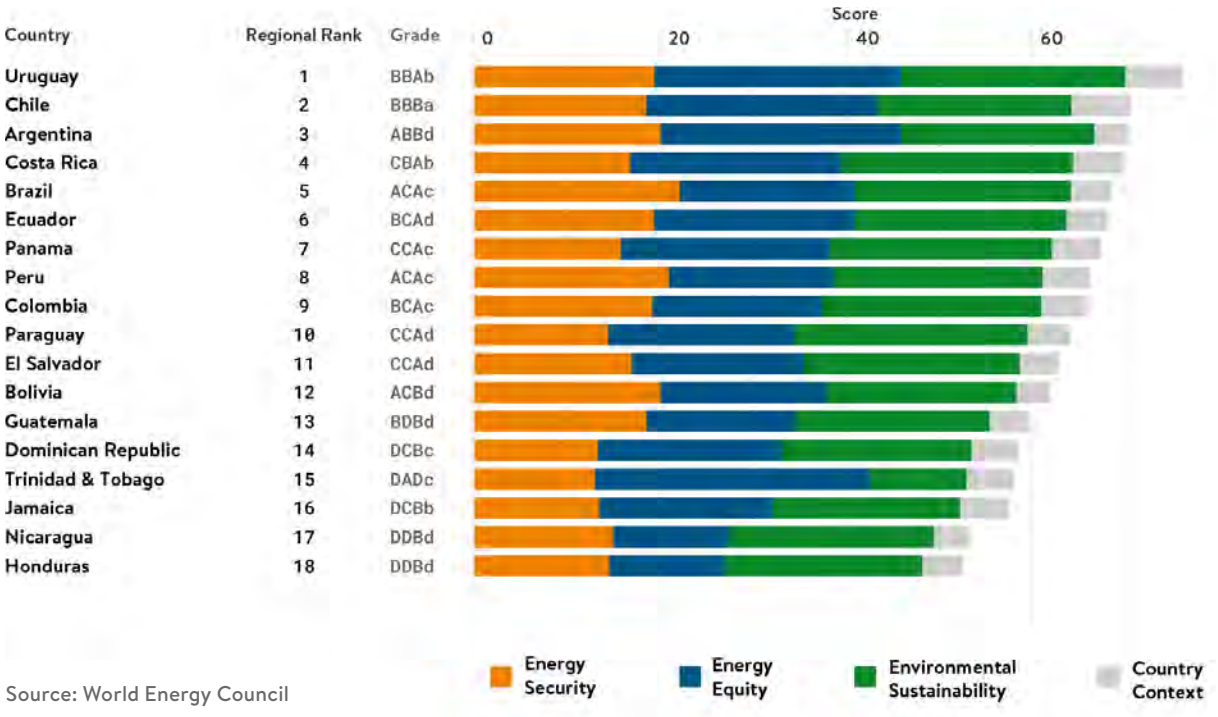


Source: World Energy Council

The COVID-19 pandemic has had far-reaching consequences in the region. Latin America has grappled with some of the highest death rates per capita and endured severe economic repercussions. The pandemic has disrupted the political system, with very few incumbents successfully winning re-election. Political unrest is rendering it difficult for politicians to develop crucial regulations, or to engage in long-term planning, or to invest in long-term projects that require at least a modicum of economic stability.

The effects of the pandemic and the war in Ukraine on the economy have presented unprecedented challenges to regional and global collaboration, worsening social and economic energy price equity, increasing trade barriers, and strengthening tendencies towards protectionism. The unsurprising result is an increased emphasis on regional energy security and equity.

Figure 21: World Energy Trilemma Index Regional Results - Latin America and the Caribbean



Source: World Energy Council

THE WORLD ENERGY TRILEMMA

ENERGY SECURITY

The only nation in the region which is in the top tenth of energy security is Brazil, which has significantly improved its diversity of electricity generation and overall energy storage. Peru and Argentina are in the top 25%, but most of the other nations in the region fall into the last quartile, with a grade of D on energy security. The low score on energy security persists in spite of the historical focus on securing energy sources for the population and industries, particularly in remote or less developed areas.

UKRAINE CRISIS REINFORCES FOSSIL FUEL FOR SECURITY AND CREATES HURDLES FOR ENERGY DIVERSIFICATION

As in the rest of the world, the immediate impact of the Ukraine crisis is a spike in energy prices, directly impacting affordability in importer states in the region—but also triggering increased interest in alternative fossil fuel suppliers. Unconventional production in Argentina and offshore fields in Guyana and Brazil have significantly increased their oil and natural gas production, together contributing approximately 15% of the global increase in oil supply from 2019 to 2022, an expansion that is expected to continue. In Brazil, further oil and gas exploration is being supported, even in the equatorial margins and offshore, while Argentina and Suriname are considering the development of natural gas. Meanwhile, Venezuela and Argentina have held discussions on the possible export of liquefied natural gas (LNG).

The supporting argument for this development is the promise of using the revenues from oil exports towards the domestic energy transition through dedicating funds for clean energy uptake. Opponents point out that institutional changes are needed in order to secure this funding, including assurances that the generated revenue will not simply be used for general budget needs. The supporting arguments for the explorations and development of new oil and gas fields is based on the success of the transitions in Gulf States; however, the political systems and institutional structures of the Gulf are different from those of the LAC region, so the Gulf's transition pathways might not be a useful model A global and regional shift away from fossil fuels that does not compensate for the fiscal revenues of the region poses a challenge.

CLIMATE CHANGE CHALLENGES THE ROLE OF HYDRO AND HIGHLIGHTS THE NEED FOR STRUCTURAL CHANGES TO THE SYSTEM

Currently, fossil fuels dominate the energy landscape in the region, constituting two-thirds of the total energy supply, with oil accounting for 40%, natural gas for 23%, and coal for 4%. But even though fossil fuels dominate in absolute terms, this region has the lowest fossil fuel share amongst all the regions, due to its exceptionally high percentage of hydro. On the other hand, the dependence on hydro exposes the energy infrastructure to climate risks in the form of erratic rainfall and droughts. The effects of El Niño on hydrologic basins are felt across the region. Ecuador, for example, had to introduce electric power cuts for several hours a day during the last quarter of 2023. While a regional interconnection allowed Ecuador to secure energy from Colombia, the electrical energy obtained could not cover the demand. Meanwhile, in Colombia, recent institutional and regulatory changes, such as compensating hydro producers for drought-related losses, could discourage investments in other renewable energy sources. While pumped hydro can be optimised, energy security at the moment is provided by gas and coal, not through alternatives such as storage or demand-side management.

THE GLOBAL NEED FOR CRITICAL MINERALS— A SIGNAL TO THE REGION'S MINING SECTOR

The growing global need for critical minerals has found a response in the mining-based economies in the region. Latin America accounts for 40% of the global production of copper, led by Chile (27%), Peru (10%), and Mexico (3%).The region supplies 35% of the world's lithium, led by Chile (26%) and Argentina (6%), and holds more than half of global lithium reserves, mainly located in Argentina (21%) and Chile (11%). Because mining is a key driver for the economic growth of the region, institutional structures are already in place to capture this opportunity. Chile has a robust lithium mining strategy, for example, and Brazil has eased rules for lithium exports.

Image from the World Energy Council's Humanising Energy Series featuring Engie (Brazil) produced by BBC StoryWorks.

THE WORLD ENERGY TRILEMMA

ENERGY EQUITY

Energy equity is a key concern in the region. The average GDP per capita is below the global average, and lack of access to clean and affordable energy continues to be a challenge for policy makers in the region.

ENERGY SUBSIDIES AS POLICY LEVER FOR EQUITY

The public sector has long used subsidies to deliver affordable energy to the population, including additional relief in response to COVID and the Ukraine crisis Despite progress in expanding access to energy, disparities persist, particularly in remote regions lacking infrastructure or facing affordability issues. While there are ongoing efforts to expand access, energy equity does not receive the same level of attention as issues related to energy security. Moreover, the concern for equity and the dependence on subsidies means that the cost of decarbonisation is a key driver of energy policy.

THE WORLD ENERGY TRILEMMA

ENVIRONMENTAL SUSTAINABILITY

The Latin American and Caribbean region is diverse not only in its socio-economic realities but also in the resources governing its energy transition. As one example: while its total primary energy mix has a high proportion of fossil fuels, its power mix relies a great deal on renewables, primarily from hydro energy. Sixteen of the 33 countries in the region have pledged to achieve net-zero emissions targets by mid-century or earlier. Together, these countries represent a substantial share of the region's GDP and energy-related CO_2 emissions.

PARAGUAY: 100% CLEAN ELECTRICITY FROM HYDROPOWER

Paraguay has been one of the key success transition stories in Latin America, with nearly 100% of its electricity production coming from clean hydropower through its Itaipu and Yacryreta dams. The country scores as one of the highest hydropower producers per capita in the world. Such an outcome has been achieved through massive infrastructure investment and economic development schemes planned and executed by the country's state-owned, vertically integrated National Electricity Administration (ANDE). The 2040 Energy Policy of the Republic of Paraguay sets an even more ambitious strategy to promote job creation around a future based on renewables.

Despite achieving a clean supply of electricity, Paraguay still experiences a high demand for hydrocarbons. Attracting investment, creating equitable renewable jobs, and further exploiting the renewable potential are essential steps towards meeting the country's climate targets.

SUPPORT FOR ALTERNATIVE FUELS

In response to the global pandemic, nearly all countries in the region introduced electricity and fuel subsidies. But Brazil also continued to support biofuel-ethanol as well by providing tax advantages to ethanol producers and distributors to ensure that ethanol remained competitive as a transport fuel. Only states scrapping taxes for ethanol were allowed to remove taxes on petrol.

AIR POLLUTION AND PUBLIC TRANSPORT

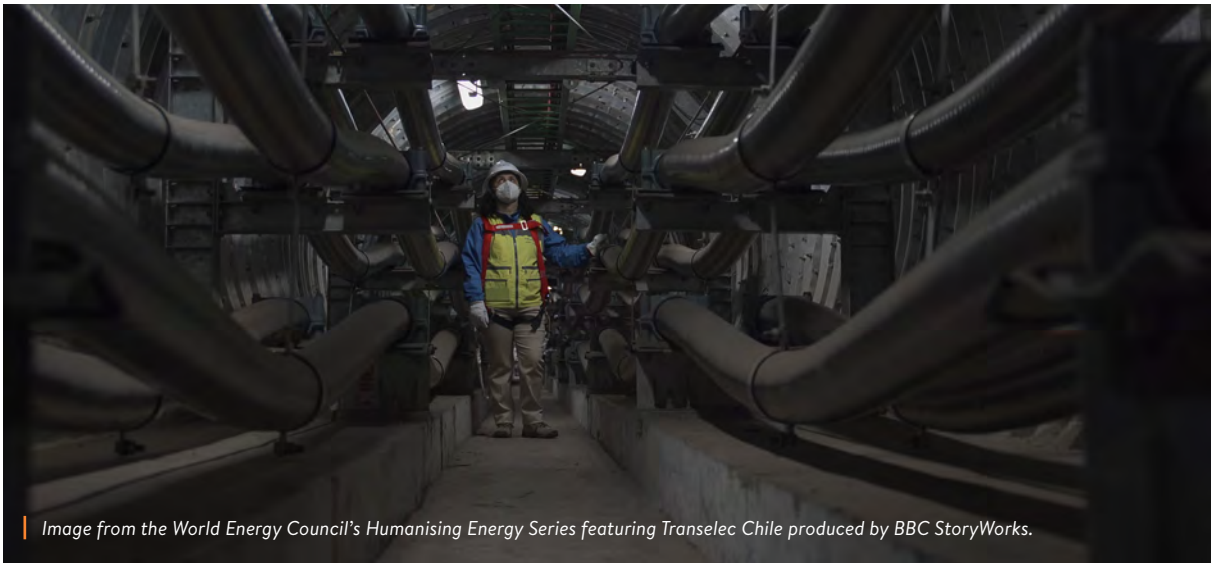
Urbanisation and economic growth are raising the transport sector energy demand, which is dominated by combustion engine vehicles, posing a challenge to the pace of energy transition in the region. To counter this, some countries are expanding their EV charging infrastructure, even though EVs are not a significant factor for residential users. However, public transport has made significant gains in electrification, largely as a response to rising air pollution. More than 5,000 electric buses operate in the region, and by 2030, 25,000 are expected to be deployed over 30 cities.[1] Brazil has joined Chile to become a regional leader in sustainable biofuel use and EV fleets.

NATURE-BASED SOLUTIONS FOR DECARBONIZATION

Several countries in the region have acknowledged the vital role that forests play in mitigating climate change and maintaining ecological balance by reversing the trend of deforestation and adopting nature-based mitigation solutions. In 2023, Brazil hosted an Amazon Summit, where regional ministers collaboratively devised environmental policies on issues such as sustainable forest management, agroforestry plans, payment for ecosystem services, and community-led initiatives. These initiatives underscore a commitment to balancing economic development with environmental conservation.

In addition, the region has witnessed a notable surge in the development of renewable energy sources, particularly in solar and wind power. The embrace of biofuels, especially in Brazil, and the production of low-emission hydrogen further underscores the commitment to transitioning towards cleaner and more environmentally sustainable energy alternatives. In 2020, Chile initiated the move towards hydrogen in the region, followed by Colombia in 2021. Currently, Brazil, Costa Rica, Panama, Paraguay, and Uruguay are in the process of crafting their hydrogen strategies. Simultaneously, Argentina, Bolivia, Peru, and Trinidad and Tobago are engaged in preliminary discussions and pilot projects. These efforts not only contribute to the mitigation of climate change but also foster energy security and resilience.

Chile, Colombia, and Brazil are poised to respond to a signal from Europe around cross-border carbon pricing and the possible emergence of a climate club, and a call for "embedded carbon" has entered the political conversation on the economic impacts of climate change. But, in general, the cost of decarbonisation remains the key concern, and the role of civil society in actively shaping the energy transition is seen as secondary.



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MANAGING THE WORLD ENERGY TRILEMMA:

CHALLENGES AND OPPORTUNITIES

PHASE-OUTS NEED JUST TRANSITION FRAMEWORKS

The economies of the fossil fuel-producing countries in the region are heavily dependent on the rents from oil and gas exports. Recent oil discoveries, for example, present lucrative opportunities for countries in the region to boost their economies, even though these opportunities complicate the transition towards clean energy. A global and regional shift away from fossil fuels that does not compensate for the fiscal revenues of the region poses a significant challenge.

THE CHALLENGE OF SUBSIDIES

Subsidies that support equity often distort the energy market, discourage private investment, and inflate fiscal country deficits. Subsidy reform is usually on the agenda only when a country is faced with economic failure. For the most part, the region has no appetite for paying the cost of the transition until the political and economic situation improves, and basic access is achieved. Argentina provides the example of a notable exception, having taken significant steps to address its fiscal crisis by cutting energy subsidies as part of broader economic reforms.

ARGENTINA: SUBSIDIES AND ECONOMIC REFORM

Argentina has taken significant steps to address its fiscal crisis by cutting energy subsidies as part of broader economic reforms. The government's decision to reduce energy subsidies is part of a larger effort to deal with a massive fiscal deficit, which includes measures like devaluing the peso by 50% and canceling tenders for public works. These moves are seen as short-term pain aimed at avoiding economic catastrophe and getting the economy back on track. The International Monetary Fund (IMF) has supported Argentina's subsidy cuts, highlighting the fiscal necessity of reducing energy and transport subsidies.[2] Furthermore, Argentina plans to eliminate subsidies on natural gas and power supplies for wealthy residents and big companies, including those in oil refining, biofuel production, and natural gas processing. This decision will save the state significant amounts annually, while not expected to affect the final price of biofuels, fuel, and gas for consumers. The poor will continue to receive subsidies, highlighting the government's intent to shield vulnerable populations.

PROTECTING BIODIVERSITY: BENEFITING SUSTAINABILITY, BUT CHALLENGING ENERGY SECURITY AND EQUITY

Ecuadorians passed a landmark referendum aimed at ceasing the expansion of new oil wells in the Yasuní National Park, renowned not only because of its biodiversity but also because it serves as the habitat for two of the last remaining "uncontacted" indigenous communities voluntarily living in isolation. While over 58% of the electorate supported the preservation of this unique biosphere, approximately 41% were opposed. This major policy shift means that around 726 million barrels of oil beneath the park will not be developed—a phase-out of resources so far not met with a concrete phase-in of new capacities to support energy security and economic prosperity.

PUBLIC-PRIVATE PARTNERSHIPS—OPPORTUNITIES FOR MANAGING THE ENERGY TRILEMMA

The energy sector in the region has a long history of being state-led with close ties between politics and business. Some countries in the region have at least partially liberalized markets. Chile, for example, has been open to private investment for several decades and relies largely on private-public collaborations to advance knowledge and policymaking around the energy industry. In recent years, this has led to a significant increase in clean energy investment and the early adoption of new technologies such as green hydrogen, ultimately aiming to underpin the country's energy security and to provide economic benefits.

LONG-TERM VISIONS IN TIMES OF TURMOIL

Two distinct groups emerge in the trilemma narrative. OECD countries like Chile, Colombia, and Costa Rica showcase long-term strategies and institutional capacity, fostering clean energy investment. Chile's hydrogen strategy is one such long-term vision which is supported by all factions of the political system. Additionally, the Chile Climate Act aims at strengthening the long-term vision of net zero institutionally. In contrast, countries tied to political environments grapple with challenges in governance, impacting private sector investment. The trilemma implications underscore the importance of mobilising regional integration for furthering renewable energy additions, aligning fossil fuel expansions with energy transition goals, and bolstering long-term visions resilient to political shifts.

CHILE: THE HYDROGEN STRATEGY

Chile has launched a hydrogen strategy, committing to 5GW of electrolysis capacity by 2025 and 25 GW of green hydrogen by 2030, eventually leading to a role as a high global hydrogen exporter.[3] To solidify this commitment and to provide a clear market signal, Chile is also working on legislation to officially recognize hydrogen as a fuel. This legal framework could offer stability and confidence to stakeholders, signaling the government's unwavering support for hydrogen initiatives. As regional cooperation gains traction, Chile's initiatives could become a catalyst for a broader, collective effort toward sustainable and low-carbon energy solutions in Latin America and the Caribbean.

CHILE'S CLIMATE CHANGE FRAMEWORK LAW

Chile's 2022 Climate Change Framework Law makes the net-zero target by 2050 legally binding. By decentralising climate actions, integrating diverse sectors, and establishing robust governance mechanisms, Chile aims to position itself as a leader in climate action in Latin America. In addition, the law has resulted in creating carbon budgets, which paves the way for carbon markets. The law also establishes new governance structures, including a Council of Ministers for Sustainability and Climate Change and a Scientific Advisory Committee. These bodies play crucial roles in approving regulatory instruments and incorporating scientific expertise into climate policy design and implementation. Significantly, the legislative process that resulted in the law's passage involved unprecedented public participation. The Ministry of the Environment published a draft of the bill for public comment, receiving unprecedented public responses.

ENHANCING INSTITUTIONAL CAPACITY FOR INTEGRATED POLICY PLANNING

Strong institutions are needed for fundamental policy changes, but there is a lack of trust in the governance process across the region. This trust deficit poses a challenge for channelling private sector investment to enable faster, fairer, and far-reaching energy transitions in the region. For example, some countries in the region, including Brazil and Colombia, have proposed structural changes to their regulatory frameworks to compensate the hydro producers for consequences from the El Niño phenomena, but these proposed changes have produced confusing signals for investors. [4]

SUSTAINABILITY-LINKED BONDS

Europe's Cross Border Carbon Adjustment Mechanism and the ESG debt instruments are encouraging businesses in the region to invest in sustainable projects. Multilateral institutions, such as development banks, are also playing a crucial role in de-risking projects in the region. In 2021, there was an exponential growth in the international issuance of sustainability-linked bonds (SLB) by companies in the region.[5] Issuances of ESG-related bonds in Latin America and the Caribbean from January to April 2021 totaled a record $16.55 billion.[6]

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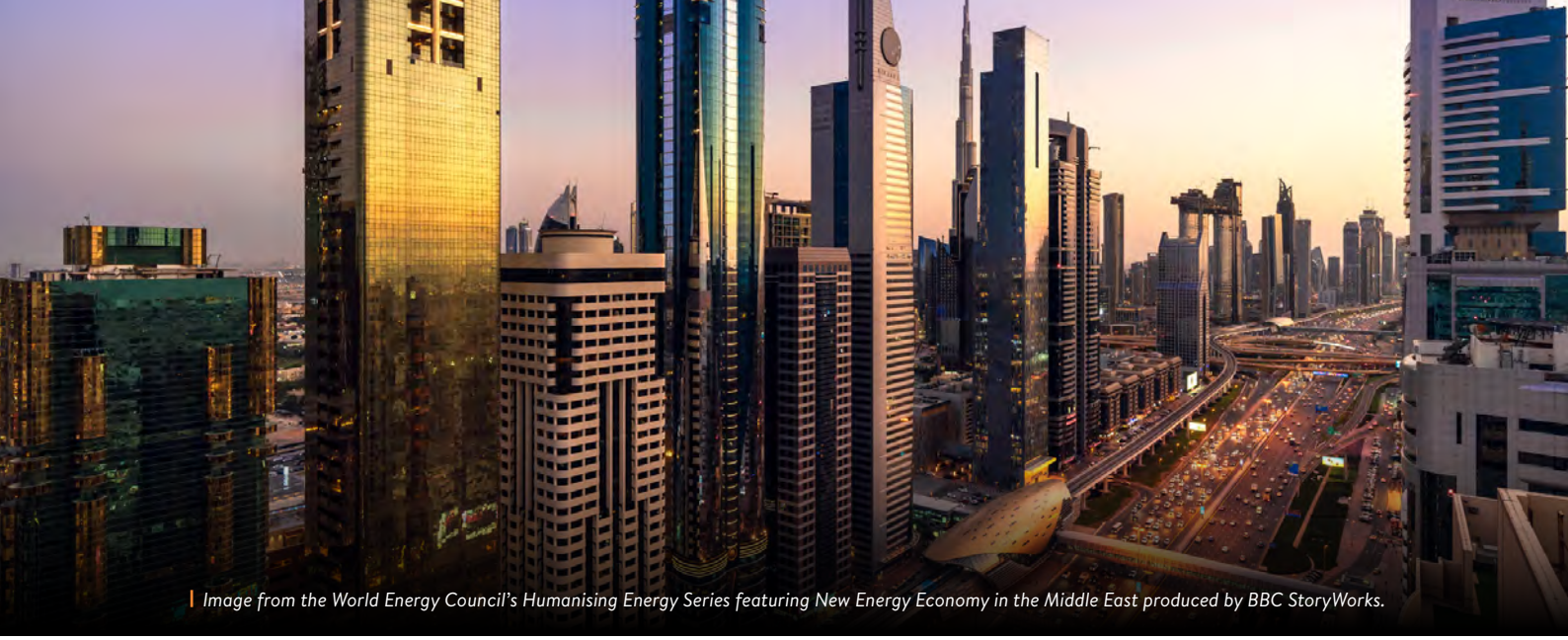


Image from the World Energy Council's Humanising Energy Series featuring New Energy Economy in the Middle East produced by BBC StoryWorks.

MIDDLE EAST AND GULF STATES

HIGHLIGHTS

ENERGY SECURITY

With the highest share of fossil fuels in their energy mix, the MEGS region is navigating a delicate balance between leveraging its vast oil and gas reserves, diversifying its energy mix, and responding to the global decarbonization push. The region's strategic initiatives, including Qatar and the UAE's long-term LNG agreements and the UAE's Barakah nuclear power plant, underscore a multifaceted approach to ensuring energy security while embracing clean energy transitions.

ENERGY EQUITY

The GCC Interconnection Authority's expansion plans and Saudi Arabia's initiatives to support low-income groups exemplify regional strategies to promote equitable energy access. Moreover, efforts to enhance energy security and access beyond the region through initiatives such as Saudi Arabia's $50 billion support in Africa and the UAE's Etihad 7 program highlight a broader commitment to global energy equity.

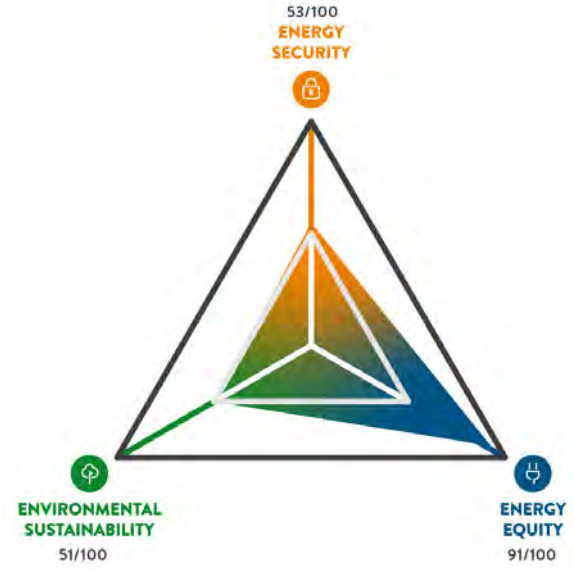
ENVIRONMENTAL SUSTAINABILITY

The push for environmental sustainability is evident in the energy portfolio diversification efforts across the MEGS region. Ambitious renewable energy targets in Saudi Arabia, the UAE, and Jordan, coupled with strategic investments in nuclear energy and renewable projects, reflect a significant pivot towards sustainable energy sources. Sovereign wealth funds play a pivotal role in financing the transition, with notable investments in renewable energy projects and technologies that support a low-carbon future.

MANAGING THE WORLD ENERGY TRILEMMA

Institutional and political stability are key to managing the energy Trilemma, with initiatives like nuclear power projects and international collaborations marking steps towards a sustainable energy future. Challenges such as developmental disparities and the impacts of climate change on water scarcity and agriculture necessitate a nuanced, tailored approach to energy transition.

Figure 22: World Energy Trilemma Index Regional Balance - Middle East and Gulf States



Source: World Energy Council

The Middle East and Gulf States (MEGS) region, vital for its geopolitical significance and abundant energy resources, is undergoing a transformative phase driven by the global shift towards sustainable energy. This transition presents challenges and opportunities for nations in the region. Having historically shaped the global energy landscape with their oil and gas reserves, the region is responding to the changing paradigm towards renewables and climate action.

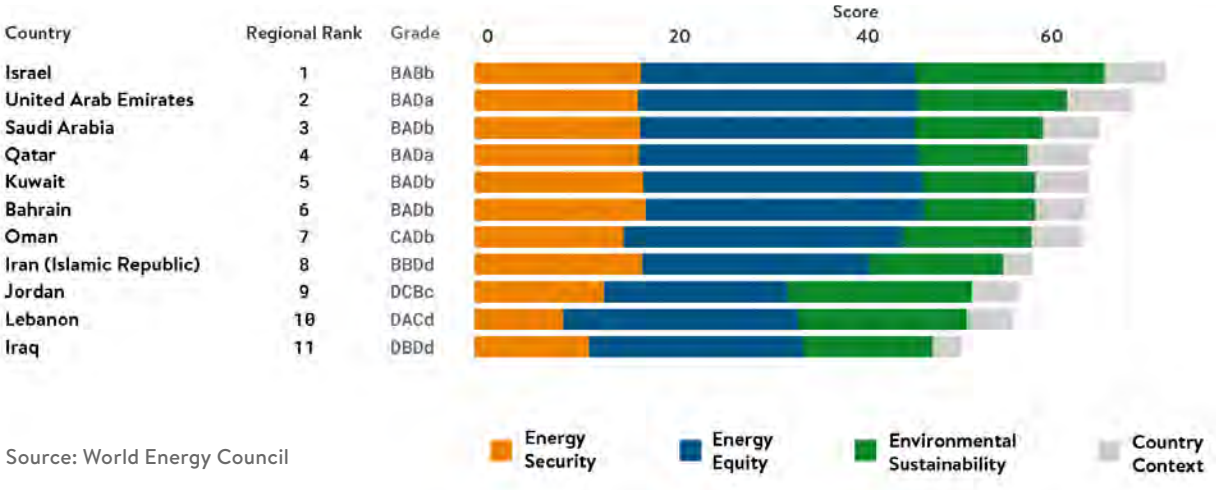
With its abundant low-cost oil and gas, the MEGS region has been both a major contributor to and beneficiary of the traditional fossil-fuel based energy system. Just over 3% of the world's population has been supplying about a third of the world's oil. Unsurprisingly, the region has the highest share of fossil fuel in its energy mix (~98%), and relatively high per capita energy consumption and carbon emissions. The region continues to see higher rates of carbon emissions.[1] Of all regions, the MEGS region has the most gas flaring and the highest rate of carbon emissions.

Within this region, however, Saudi Arabia has second -lowest recorded level in flaring intensity/barrel produced, in large part because Riyadh has upgraded its gas system to maximize utility of carbon and to reduce flaring and its carbon footprint.[2]

Now the region is having to respond to the shifting global landscape. While there's a global push to decarbonise and move away from fossil fuels, at the same time countries are lining up to secure supplies of oil and gas from the region. A big challenge for the region is navigating these mixed signals from the rest of the world. At the same time, a significant advantage for the region is its accumulated financial resources (especially in sovereign wealth funds), which enables it to make bold and visionary steps towards energy transition.

The MEGS region's diversity is evident in the distinct situations of its nations. While some Gulf countries focus on economic diversification and net-zero commitments, others contend with political instability, water scarcity, and developmental disparities. Emerging nations like Jordan and Lebanon, facing energy import challenges, seek resilience amid global market fluctuations. Low-income countries balance economic growth, energy security, and sustainability amidst developmental issues. This diversity emphasises the need for tailored, context-specific approaches to the ongoing energy transition.

Figure 23: World Energy Trilemma Index Regional Results - Middle East and Gulf States



Source: World Energy Council

THE WORLD ENERGY TRILEMMA

ENERGY SECURITY

The MEGS region, historically a pivotal player in global energy markets, is undergoing profound shifts in its energy security landscape characterised by diversification of its energy supply. The critical components in the region for developing energy security based on renewables are political stability, access to low-carbon technology, and clear regulatory frameworks to attract investments for clean energy projects. Even though renewables and nuclear are rising as part of the energy mix, the slowness of the rise has deferred concern about grid stability as an aspect of energy security.

GULF STATES: PILLARS OF GLOBAL ENERGY SECURITY

In the contemporary global energy landscape, the Gulf States have emerged as pivotal players, holding the reins of the world's energy security. Qatar and the United Arab Emirates (UAE), for example, have attempted to provide reliable energy supplies amidst shifting geopolitical alliances and the increasing urgency for energy diversification. In a strategic pivot from its traditional focus on Asian markets, QatarEnergy has formed a 27-year agreement with Shell to provide LNG to the Netherlands and with TotalEnergies to supply LNG to France. These deals are the largest and longest of their kind.[3]

In 2022, UAE's state-owned Abu Dhabi National Oil Company (ADNOC) delivered its first LNG cargo to the Elbehafen floating LNG terminal in Brunsbüttel. This milestone, part of the broader UAE-German Energy Security and Industry Accelerator (ESIA) Agreement, not only fortifies the bilateral relationship between the UAE and Germany but also sets a precedent for cooperation in energy security and the transition towards lower-carbon fuels.[4]

THE RISE OF NUCLEAR

One indication of the move to diversify energy supply is the increase in nuclear power projects. The transition towards nuclear power is a long-term endeavour since a project adhering to international standards set by the International Atomic Energy Agency (IAEA) typically takes 10 to 15 years to come online. The UAE's Barakah nuclear power plant has three out of four units operational, with the fourth scheduled to start in March 2024.[5] The nuclear program in the UAE, which is creating 20,000 new jobs, also includes the job upskilling critical for just transitions.

Image from 2019 World Energy Congress in Abu Dhabi, UAE

THE WORLD ENERGY TRILEMMA
ENERGY EQUITY

As these nations grapple with transitioning from traditional fossil fuel dependency to cleaner and more sustainable alternatives, the delicate equilibrium of future energy equity becomes a central concern.

REGIONAL INTERCONNECTIONS FOR FUTURE ENERGY ACCESS

The GCC Interconnection Authority oversees the existing interconnection across the six GCC countries and has expansion plans for the region. In 2023 it awarded $220 million to establish an electric link between the GCC countries and Iraq in the form of a dual-circuit 400 kV line stretching from Kuwait to southern Iraq. Spanning 295 kilometers, this transmission line is designed to support a total capacity of 1,800 megawatts (MW), which will be a significant step towards enhancing regional power connectivity.

ENSURING EQUITY IN A WORLD OF ENERGY REFORMS

As the Gulf countries consider transitioning to cleaner energy by removing fossil fuel subsidies, the challenge lies in making the transition equitable. Redirecting profits from traditional energy sources and pre-allocating subsidies are designed to prevent disproportionate impacts on low-income groups.

Providing equal access to areas beyond cities in spread-out countries like Saudi Arabia poses unique challenges, especially in the context of transitioning from fossil fuels to renewables. To mitigate the impact of energy price reforms on low-income groups, Saudi Arabia has created citizen accounts for direct cash transfers.

In addition to supporting initiatives within its own region, Saudi Arabia and UAE have reached out to ensure equity in other regions as well. Saudi Arabia is also leading efforts to enhance food and energy security in Africa through a holistic strategy, which includes addressing energy access challenges. For example, one of the country's Middle East Green initiatives, "Clean Fuels Solutions for Cooking," was launched in 2021 and attempts to provide clean cooking solutions to meet immediate energy needs while also promoting environmental and social sustainability by ensuring that all solutions (LPG, solar, biodigesters) bridge the accessibility gap. Furthermore, Saudi Arabia has pledged $50 billion in investments, agriculture, energy, infrastructure development, and more to ensure stability and long-term security in the African region. In 2022, the UAE launched Etihad 7, dedicated to securing funding for renewable energy projects in Africa. The program aims to supply clean electricity to 100 million people by 2035.

THE WORLD ENERGY TRILEMMA
ENVIRONMENTAL SUSTAINABILITY

DIVERSIFYING PORTFOLIOS

Nations within the MEGS are proactively diversifying their energy portfolios, focusing on a transition towards more sustainable and renewable energy sources. Saudi Arabia is advancing its renewable energy agenda, setting an ambitious target to generate 50% of its electricity from renewable sources by 2030; Jordan has pledged to achieve a 14% reduction in greenhouse gas emissions by the year 2030; and the UAE is making significant investments in nuclear energy, aiming to achieve a 50% clean electricity capacity by 2050.

These commitments involve the promotion of renewable energy sources through both development and utilization, alongside efforts to attract investments in the renewable energy sector. Jordan's strategic goal is to achieve a 31% share of renewables in total power generation capacity and a 14% contribution to the overall energy mix by 2030.

The strategic choices made by MEGS nations on diversification, renewable energy adoption, and economic restructuring not only impact regional stability but also contribute to the global trajectory of efforts to combat climate change.

THE ROLE OF SOVEREIGN WEALTH FUNDS

The collaboration of sovereign wealth funds from GCC countries in funding projects within the region demonstrates a form of regional cooperation to further the energy transition. Until recently, investment plans were linked to fluctuating oil prices, which destabilized long-term plans. However, the emerging trend is to strengthen the commitment to energy transition by decoupling plans from prices.

The Public Investment Fund (PIF) of Saudi Arabia includes a significant stake in ACWA Power, a leader in renewable energy projects, and Lucid Motors, an innovator in electric vehicles. And the PIF's initiative in developing The Red Sea Development Company underscores its ambition to set new standards for sustainable tourism, powered entirely by renewable energy sources.

Mubadala Investment Company of the UAE supports Masdar Clean Energy, which engages in solar and wind projects across the globe, as well as Siemens Gamesa Renewable Energy, a leader in wind turbines. In 2022, Mubadala also launched Emerge, a high-tech investment platform aimed at nurturing innovative technologies, including those that can accelerate the energy transition.

SUPPORTING CCUS, HYDROGEN, AND A CIRCULAR ECONOMY

Within the updated NDCs for the Gulf Cooperation Council, most countries mention natural sinks in their climate plans. CCS is also mentioned in most NDCs. Hydrogen, in turn, is only mentioned in Saudi Arabia's and UAE's NDCs, even though Oman is the first in the region to adopt a national hydrogen strategy. Saudi Arabia shipped the world's first export of blue ammonia to Japan in 2020 and developing hydrogen production and exporting facilities in NEOM. Oman has also established a national hydrogen alliance, emphasizing its strategic location for exports. Saudi Arabia aims to be among the main producers and exporters of clean hydrogen by 2030 and to capture 9 MT of CO_2 through CCUS by 2027 and 44 MT by 2035. The UAE has launched its first Hydrogen Roadmap, targeting 25% market share of low-carbon hydrogen and derivatives in key markets by 2030, with an initial focus on Japan, South Korea, India, and Europe. Its first shipment of low carbon ammonia was to Germany in 2022.

EMPOWERING EFFICIENCY

The Saudi Energy Efficiency Program aims to reduce electricity consumption by 30% by 2030. Encompassing sectors responsible for 90% of the country's energy demand, including buildings, industry, and transport, the program consists of over 35 initiatives in areas such as governance, capacity building, energy efficiency standards, specifications, benchmarks, and public awareness.

The UAE has also established a comprehensive energy efficiency program. The Abu Dhabi Demand Side Management and Energy Rationalization Strategy provides system reliability as well as significant economic and environmental benefits. The strategy addresses supply and demand issues through a nine-programme, multi-stakeholder approach that aims to reduce electricity consumption by 22% and water consumption by 32% by 2030.

NATURE-BASED SOLUTIONS

Saudi Arabia has recently launched the Saudi Green Initiative (SGI) and the Middle East Green Initiative (MGI), which aim to address issues such as emissions reduction, desertification, dust storms, and shifting precipitation patterns. The SGI pledges to plant 10 billion trees in Saudi Arabia and an additional 40 billion trees across the entire region. This ambitious undertaking is projected to reduce greenhouse gas (GHG) emissions by 4% annually. In addition, 30% of its land and sea territory will be placed under protection by 2030.

In 2021, SGI announced 60 initiatives, representing an investment of around $200 billion until 2030. The MGI has a vision to remove more than 670 million tons of CO_2e. Saudi Arabia, as a key player in the MGI, has earmarked $2.5 billion over the next decade to support this initiative.[6]

The UAE's diversity strategy is designed to alleviate pressures on its marine and terrestrial biodiversity by focusing on habitat protection and the restoration of damaged ecosystems. The initiative has

established 49 protected areas, covering 15.5% of its total territory, and has declared 12% of its territorial waters as marine protected areas.

Another nature-based solution that contributes to carbon capture and storage benefits is the preservation of 100 million date palm trees under the International Initiative to Protect the Date Palm Oases Under Climate Change Challenges. Additionally, the adapted Ghaf trees play a crucial role in reforestation and carbon sequestration efforts in desert conditions. The Abu Dhabi Blue Carbon Demonstration Project, initiated in 2012, revealed that blue carbon ecosystems in Abu Dhabi have the remarkable capacity to store over 41 million tonnes of CO_2eq.[7]

GCC LEADS THE WORLD IN THE DECARBONIZATION OF FOSSIL FUELS

Under the Middle East Green Initiative (MGI), a proposal has been developed for cooperation between the GCC countries to establish a regional CCUS hub, which could allow fossil fuel resources to be carbon neutral. Saudi Arabia and the UAE have made commitments to achieve net zero for scope 1 and scope 2 emissions in their national oil companies by 2050. By emphasizing carbon intensity and methane intensity per unit of energy, GCC companies are poised to assume a strategic advantage over other fossil fuel producers.

LEBANON: A TRANSFORMATIVE APPROACH TO ENERGY SUPPLY

In 2023, Lebanon's Distributed Renewable Energy law marks a significant turning point in the nation's energy landscape. Amid macroeconomic difficulties and environmental concerns, the country has seen a decrease in emissions due to non-operational power plants. Concurrently, there's been a notable shift towards solar energy in the residential and industrial sectors, including in vital institutions, like schools and hospitals. Previously, limitations were placed on the production and sale of solar energy, confining its use mainly to personal applications within the residential sector. The new law, catalysed by economic pressures, introduces a transformative approach by permitting the private sector to produce and sell electricity, thereby enabling peer-to-peer trading. This legislative shift not only addresses the pressing need for energy diversification but also aligns with global sustainability goals by leveraging Lebanon's solar potential, moving the country towards balancing the energy trilemma amidst ongoing economic challenges.[8]

MANAGING THE WORLD ENERGY TRILEMMA:

CHALLENGES AND OPPORTUNITIES

The MEGS region is at the forefront of managing the energy trilemma—balancing energy security, equity, and environmental sustainability. However, diverse priorities influenced by political divisions and developmental challenges complicate the transition to cleaner energy, demanding substantial investments and infrastructure deployment. As a cornerstone, institutional and political stability play pivotal roles in managing the trilemma. Stability emerges as a critical factor in addressing energy equity and achieving sustainable outcomes.

While initiatives like nuclear power projects and international collaborations showcase positive steps, the challenges posed by corruption, governance issues, and diverse developmental priorities necessitate flexible and context-specific solutions. The pursuit of a sustainable and equitable energy future in the MEGS region requires a nuanced understanding of local dynamics and a commitment to addressing disparities

THE UAE: NAVIGATING THE ENERGY TRILEMMA

The UAE is balancing energy security and environmental sustainability through nuclear power projects and efforts to achieve net-zero emissions in national oil companies by 2050 through decarbonizing fossil fuel production. It also has ambitious targets for renewables, hydrogen projects, and energy efficiency. The UAE's commitment to environmental sustainability extends to biodiversity conservation, notably through the National Biodiversity Strategy, which designates protected areas and marine conservation zones. Furthermore, the focus on rare elements and the mining sector underscores economic diversification in alignment with the UAE's 2030 vision, stimulating growth beyond hydrocarbons. Scientific exploration and nature-based solutions, including the preservation of date palm trees and Ghaf trees, contribute to carbon capture and storage benefits. Initiatives, such as the Abu Dhabi Demand Side Management Strategy, not only address supply and demand issues but also demonstrate a commitment to economic, environmental, and system reliability benefits. The consistent efforts on all three dimensions of the Trilemma has pushed the UAE forward on the global rankings of the Trilemma Index

NAVIGATING CLIMATE CHALLENGES

The Middle East, already grappling with a harsh environment marked by desertification, dust storms, and shifting precipitation patterns, faces complex challenges exacerbated by climate change. Changing precipitation patterns can lead to unexpected flooding, straining infrastructure ill-prepared for heavy rain. Water scarcity, a pressing issue for initiatives like the Saudi Green Initiative and the Middle East Green Initiative, poses challenges for agriculture—a major water consumer globally. Nature-based solutions, such as planting mangroves and utilizing seawater for irrigation, are considered sustainable options. However, the diverse environmental landscape in the region requires tailored solutions to address water scarcity effectively.

BALANCING ACT: DIVERSIFYING ECONOMIES AND ENERGY PORTFOLIOS

Saudi Arabia, the UAE, and Qatar, known for their oil production, acknowledge the imperative to respond to climate change impacts while simultaneously diversifying economies heavily dependent on oil exports. Initiatives like Saudi Arabia's Vision 2030 and its commitment to achieving net zero by 2060 exemplify a concerted effort to transition away from oil-based economies. Ambitious projects such as NEOM and the Red Sea Project contribute to economic diversification, fostering industries like environmentally conscious tourism.

THE KSA: NAVIGATING THE ENERGY TRILEMMA

The Kingdom of Saudi Arabia has placed its energy transition at the center of its wider economic diversification agenda. Saudi Arabia has launched over 23 GW of renewable energy projects, with 2.8 GW already operational. The KSA's commitment to a sustainable energy future is highlighted by the ambitious target of generating 50% of its electricity from renewable sources by 2030 aiming to tender 40GW by 2025. This effort is supported by the installation of more than 1200 measurement stations and plans for 40.1 GWh of energy storage to stabilize the grid, which will displace up to 1.08 million barrels of oil equivalent from the power sector. The Kingdom's significant investments in renewable energy include the Saudi Green Initiative, which aims to plant billions of trees, and the launch of advanced CCUS technologies to combat carbon emissions. Saudi Arabia is increasingly involving the youth, and notably included a young workforce in the first EV manufacturing facility of the region (Lucid). The GCC Interconnection Authority's plans to connect Saudi Arabia with Jordan and Egypt are designed to enhance regional energy security and foster interconnected energy economies. In 2023, the Red Sea Development Company launched the first regenerative tourism destination globally. Additionally, NEOM has outlined plans to commence the exportation of green ammonia by 2026, and Saudi Aramco has set a goal to achieve net-zero emissions by 2050. Saudi Arabia is also incubating and supporting the Middle East Initiative. Through a strategic blend of innovation, investment, and international cooperation, Saudi Arabia is navigating the energy trilemma.

As the world transitions away from fossil fuels, dependencies shift from traditional oil and gas to new dependencies on technology centres rich in critical minerals. The Gulf countries are now considering their potential in rare earth elements. Saudi Arabia plans to use its mining sector to achieve three main 2030 vision objectives: stimulate economic growth beyond hydrocarbons, create value jobs, and drive economic development of remote areas.[9] The UAE plans to increase the number of mining licenses and enhance the overall sustainability of the mining sector with the goal of increasing the sector's share of non-oil GDP by 5% by 2030. However, more research is needed to ascertain the abundance of these elements in the region.

The challenges posed by the energy trilemma in MEGS are complex, requiring a nuanced approach that considers economic diversification, environmental sustainability, and societal transformation. The MEGs region is committed to addressing these challenges, with a recognition of the need for international cooperation, technology transfer, and a focus on the unique dynamics and environmental conditions of the Middle East and Gulf Estates. Balancing the energy trilemma in MEGS is not just an economic or political imperative, but a crucial step towards ensuring a sustainable and resilient future for the region and the globe.

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Image from the World Energy Council's Humanising Energy Series featuring Capital Power (Canada) produced by BBC StoryWorks.

NORTH AMERICA

HIGHLIGHTS

ENERGY SECURITY

Power outages and disruptions challenge energy security. Recent investments aim to strengthen grid resilience, but transitioning to renewables poses new challenges in management of supply variability and reliance on critical mineral and renewable energy equipment imports.

ENERGY EQUITY

Energy equity is strongly linked to social justice issues that have spurred community-level responses. Communities in North America continue to adapt to regional and global uncertainties and support the energy transition in different ways. Local initiatives play a significant role in supporting policies and introducing incentives for renewable energy. Community-owned cooperatives allow consumers to invest in sustainable energy infrastructure. Collaborations among community leaders, businesses, and governments have spurred local development.

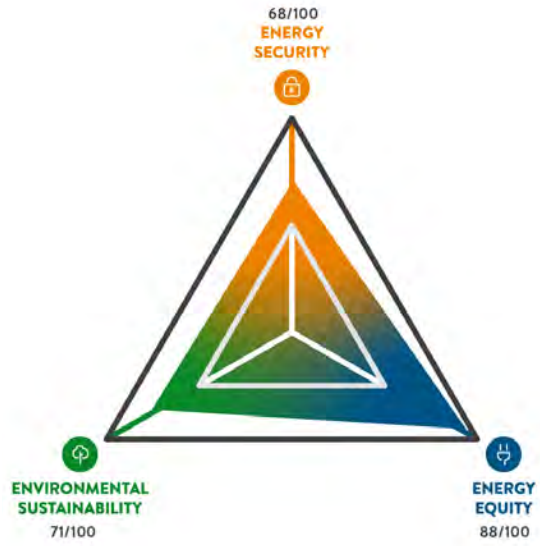
ENVIRONMENTAL SUSTAINABILITY

The Inflation Reduction Act (IRA) supports adoption of sustainable technologies and incentivizes low-emission electricity generation from nuclear and natural gas. Grassroot movements catalyse collaborations between communities and governments. More rapid licensing spurs nuclear technology innovation.

MANAGING THE WORLD ENERGY TRILEMMA

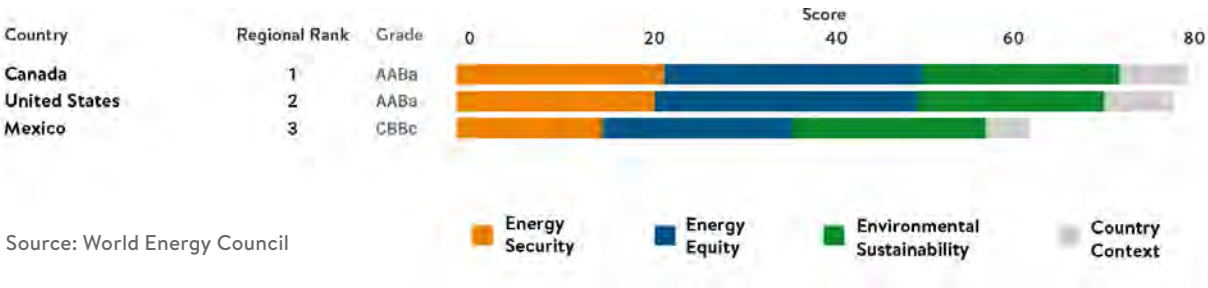
Challenges to the energy transition include affordability, permitting, supply chain issues, lack of investment in transmission infrastructure, and vulnerability to electoral politics.

Figure 24: World Energy Trilemma Index Regional Balance - North America



Source: World Energy Council

Figure 25: World Energy Trilemma Index Regional Results - North America



Source: World Energy Council

THE WORLD ENERGY TRILEMMA

ENERGY SECURITY

North America is the only region in the rich industrialised world that is a net exporter of fossil fuels. Shale gas in the US and oil sands in Canada have not only boosted their economies, but also guaranteed energy security. The result is that energy security in North America is primarily focused on fortifying the infrastructure against disruptions.

CLIMATE CHANGE: A RISING THREAT TO ENERGY SECURITY

The immediate energy security issue for the region is the vulnerability of its energy supply chains to severe weather events. The region has increasingly faced billion-dollar extreme events, including storms, floods, and wildfires. A deadly freeze in Texas in 2021 caused power outages that left millions of customers without electricity to face the winter storm. In 2023, the US government issued an emergency order to support Texas's struggling grid in facing record heat. In response to such events, the US recently announced an investment of almost 3.5 billion to strengthen and improve the resilience of the electrical grid. Grid resilience to extreme temperatures and more intense and variable weather is under intense

study, and both planning and operations are evolving to address weather-related events such as extreme cold, coastal flooding, and wildfires.

Natural gas, which is often used to assure supply reliability, is increasingly being opposed on sustainability grounds. In the state of Virginia, for example, a proposed natural gas plant would generate electricity during high-demand hours, with four natural gas turbines powering up to 250,000 homes, as well as provide reliable power during extreme weather and surging demand. But the proposed plant faces opposition from activists, who argue that additional natural gas production would violate the zero-emissions standards set by the Virginia Clean Economy Act. The opposition to the proposal raises concerns in the industry about possible stranded assets.[1]

AGING INFRASTRUCTURE: A THREAT TO ENERGY SECURITY

While an increase in renewables may increase the diversity of energy supply, it also brings new energy security challenges, especially in managing the variability of wind and solar supply and the increased reliance on imports of renewable equipment and critical materials. Most importantly, the aging energy infrastructure requires significant upgrades to accommodate the transition. Even with traditional energy sources, the Northeast blackout of 2003 serves as a stark reminder of the vulnerabilities in North America's energy grid, underscoring the need for robust investments in modernization. A CA$964-million program launched by the Canadian government in 2021 supports grid modernization projects among other efforts aiming to encourage energy-mix diversification.[2]

MEXICO'S ENERGY POLICY: EFFECTS ON SECURITY

The Mexican government has recently attempted to build energy self-sufficiency by rolling back the 2013 energy reforms that had been designed to diversify energy sources and enhance competition by attracting foreign investment. Even without foreign investment, Mexico's rich natural resources for renewable energy—such as solar, wind, hydro, and geothermal—offer significant opportunities for enhancing energy security through diversification if tapped effectively.

THE WORLD ENERGY TRILEMMA

ENERGY EQUITY

SUPPORT FOR LOW-INCOME ENERGY USERS

Awareness of the relation of energy equity to larger equity and poverty issues was raised during COVID and recent Black Lives Matter and indigenous movements.

NAVAJO TRANSITION FROM COAL

The Navajo Nation boasts abundant energy resources such as coal, uranium, and solar power. However, the historical trend has seen the predominant share of power generated on Navajo lands being directed to urban centers outside the Reservation. Over the years, the Navajo community has shouldered disproportionate burdens, experiencing substantial health and environmental impacts, while the benefits of resource extraction and power generation have primarily accrued to neighboring states.

In the aftermath of the closure of the Navajo Generating Station (NGS), the Navajo Nation proactively sought to diversify and transition its energy economy. Taking a significant step, it became one of three U.S. tribes to apply for Economic Development Administration (EDA) grants aimed at providing crucial support to communities undergoing a shift away from coal-dependent industries.

Community development planners attempt to consider equity and demographics in spite of the complexity of the underlying drivers. Actions designed to advance energy equity in the region have included innovative rate design and bill support for low-income customers, energy efficiency programs providing incentives and direct support, and local community ownership of solar and other energy developments. As one example of support for energy equity, the 1981 US Low Income Home Energy Assistance Program (LIHEAP) has helped millions of households with heating and cooling costs over many years.

Another type of approach to lowering energy costs is based on the expectation that investing substantial upfront funds to stimulate private investment in clean energy will lower energy costs in the long run. In 2022, Canada set up a 30% refundable tax credit for clean technology investments, including in electricity generation and storage systems.[3] The projected increase in energy efficiency and the shift away from expensive fossil fuels are expected to decrease household energy expenditures by 12% by 2050.[4]

US RESPONSE TO UKRAINE WAR: AFFORDABLE ENERGY FIRST

In keeping with its long-term goal of energy independence, the US responded to the disruption in global oil supplies following the Russian invasion of Ukraine by the largest release of oil to the market from the Strategic Petroleum Reserve and by allowing record levels of oil and gas production to keep prices down for consumers.

THE WORLD ENERGY TRILEMMA

ENVIRONMENTAL SUSTAINABILITY

SIGNIFICANT GROWTH IN CLEAN ENERGY

A push for environmental sustainability in the region is driving the adoption of clean energy technologies and policies aimed at reducing carbon emissions. The growth of electric vehicles (EVs), supported by tax incentives and an expanding charging infrastructure, illustrates this shift.

US: RENEWABLE ENERGY PROJECTS: A SAMPLE

Atlantic Shores is a joint venture between Shell New Energies US LLC and EDF Renewables North America. Located off the coast of New Jersey, it is part of the state's ambitious plan to transition to clean energy. The project aims to deliver 1,510 megawatts (MW) of offshore wind energy, sufficient to power nearly 700,000 homes.

Hitachi Energy reported that over 20 gigawatts (GW) of utility-scale solar capacity is presently under construction in the US and projected to be operational in 2023. Furthermore, there are over 250 battery storage projects (approximately 20 GW) in various stages of development, with nearly 140 projects (6.4 GW) currently undergoing construction.

The region is also making strides in harnessing wind, solar, and hydroelectric power. Texas, an exporter of oil and gas, is also a leader in wind energy, boasting the largest installed capacity in the US. The increase in the closure of coal plants is expected to lead to a rise in demand for natural gas.

Meanwhile, Canada's hydroelectric power continues to be a cornerstone of its power generation portfolio. By increasing its share of renewables in the energy mix and introducing clean fuel standards and carbon pricing, Canada is actively reducing its greenhouse gas emissions and moving

towards a net-zero emissions future. Canada expects nearly 342 megatons of cumulative GHG emissions reductions between 2024 and 2050 from the electricity generation sector alone.

Mexico has pledged to deploy an additional 30 GW of renewable energy capacity by 2030, aiming to double its renewable capabilities. To achieve this goal, Mexico is investing around $48 billion. This commitment, announced in conjunction with efforts to meet new climate goals in collaboration with the United States, represents a significant push towards reducing emissions and enhancing sustainability in the region.

LANDMARK US INFLATION REDUCTION ACT (IRA)

The IRA is poised to have a profound positive impact on environmental sustainability by fostering a significant increase in renewable energy capacity and encouraging reductions in greenhouse gas emissions. In addition, it significantly bolsters energy efficiency across the US through financial incentives and support mechanisms that directly impact homeowners and the broader energy market. By extending and expanding tax credits for energy efficiency improvements and introducing rebates for high-efficiency appliances and home retrofits, the IRA not only makes it financially viable for consumers to invest in energy-saving upgrades but also aligns its support with existing state and city-level initiatives like the New York Green Bank and Colorado's energy programs. These initiatives, which aim to facilitate the transition to a more sustainable energy future, can leverage IRA provisions to amplify their impact, driving investment in efficiency projects. Simultaneously, the growth of solar and battery storage initiatives is expected to surge, propelled by attractive incentives embedded in the bill.

THE IRA: IMPACT ON NUCLEAR ENERGY

The IRA introduced a production tax credit (PTC) for existing nuclear facilities that aims to recognize and financially support the zero-emission electricity they generate, making them more economically competitive against cheaper fossil fuels and renewable energy sources. The financial incentive per kilowatt-hour of electricity produced helps to ensure that existing nuclear plants remain operational, thereby preserving a critical component of the nation's low-carbon energy infrastructure. The IRA also encourages investment in advanced nuclear technologies by providing financial incentives for research, development, and deployment, including small modular reactors (SMRs) and other next-generation nuclear designs. However, challenges remain in relation to nuclear waste management, high costs, operational complexity, and safety.[5]

By making low-carbon energy sources more economically attractive and providing a clear signal of the government's commitment to clean energy, the IRA may facilitate a more favourable investment climate for nuclear projects. This could lead to a reduction in the perceived risks associated with nuclear energy investments, potentially easing the path for new projects and innovations in the sector.

COLLABORATIONS AS TRANSITION DRIVERS

In North America, communities, particularly those reliant on coal, are pivotal players in the ongoing energy transition. A compelling example is found in the coal-dependent communities of Appalachia, where a historic reliance on coal mining has spurred a collective effort towards sustainable alternatives. Collaborations between local governments, businesses, and residents are driving investments in renewable energy projects and facilitating retraining programs for displaced coal workers. These community-driven initiatives not only address environmental concerns but also attend to social and economic aspects, effectively navigating the complexities of the energy trilemma.

MANAGING THE WORLD ENERGY TRILEMMA:

CHALLENGES AND OPPORTUNITIES

CRITICAL NEED: TRANSMISSION INFRASTRUCTURE

A significant hurdle in the US energy transition is the lack of sufficient investment in transmission infrastructure, crucial for distributing renewable energy across vast distances. Texas, for example, has substantial renewable energy capacity, but is disconnected from major consumption centres due to inadequate transmission infrastructure.

IRA VULNERABILITIES

Reliance on bureaucracy: While the IRA is a landmark in U.S. climate policy, it falls short in addressing the transmission infrastructure gap. In addition, given the act's reliance on numerous federal agencies for implementation, there's a risk that bureaucratic hurdles and regulatory delays could slow down progress towards filling this gap, as well has fulfilling its other goals.

Need for consumer behaviour change: The success of the market mechanisms enabled by the IRA hinges on parallel efforts to shift consumer behaviour. Without heightened awareness and a concerted effort to promote energy-efficient habits, the potential of these financial incentives could be undermined, illustrating the need for connecting economic incentives with cultural change.

Risks to energy security: The IRA's focus on boosting renewable energy production and infrastructure modernisation could significantly enhance US energy security through energy diversification. However, the potential market distortions, such as overinvestment in certain technologies or displacement of traditional energy sectors, might introduce new vulnerabilities. For instance, a rapid shift away from fossil fuels without adequate transitional strategies could temporarily destabilize energy supply chains and markets, posing risks to energy security during the transition phase.

Possibility of unequal benefits: While the IRA aims to make clean energy more accessible and affordable, its success in promoting energy equity will depend on how well its benefits are distributed across different societal groups and regions. The act's heavy reliance on tax credits and financial incentives might not equally benefit all communities, particularly those with lower socioeconomic status or those that lack the infrastructure to readily adopt renewable technologies. Additionally, if the act leads to market distortions that favour certain regions or technologies, it could exacerbate existing disparities in energy access and affordability, counteracting efforts to achieve energy equity.

Reliance on least-cost solutions: The energy system, and especially the electricity sector, is tuned to least-cost solutions, which means that utilities are reluctant to pay the cost of the transmission infrastructure needed to utilize the renewable energy resources that would help in the transition towards a low-carbon energy system.

Vulnerability to electoral politics: Energy transition policies have become a differentiating factor in US party politics. The IRA was passed by a Democratic administration. Republicans argue that the clean energy measures within the IRA, coupled with other administration policies, artificially raise energy costs by prioritizing renewables over traditional fossil fuel resources. They also argue that the IRA's encouragement of increased renewable integration might jeopardize grid reliability and could increase reliance on China and other potentially adversarial nations for crucial minerals essential for EVs and other clean energy technologies. Another criticism is that tax incentives like the Production Tax Credit (PTC) and the Investment Tax Credit (ITC) distort the market and accelerate the phasing out of reliable baseload power sources such as natural gas and coal.

TECHNOLOGY SUPPLY CHAIN VULNERABILITIES

A key challenge to the energy transition is the dependence on vulnerable supply chains for necessary components of solar panels and the large transformers necessary for electrification as well as for the minerals that are critical for electronics. Governments, utilities, manufacturers, and developers are all focused on these supply chain issues. In Canada, for example, the 2022 national strategy called for an increase in the supply of responsibly sourced critical minerals and bilateral international agreements relating to the critical mineral value chain. A Critical Mineral Exploration Tax Credit and a new Investment Canada Act are both designed to encourage the mining of critical minerals. In addition, the 2023 Strategic Innovation Fund supports projects across the ore mining life cycle. In the past year, Canada also unveiled international cooperation agreements on critical minerals with the UK and South Korea.

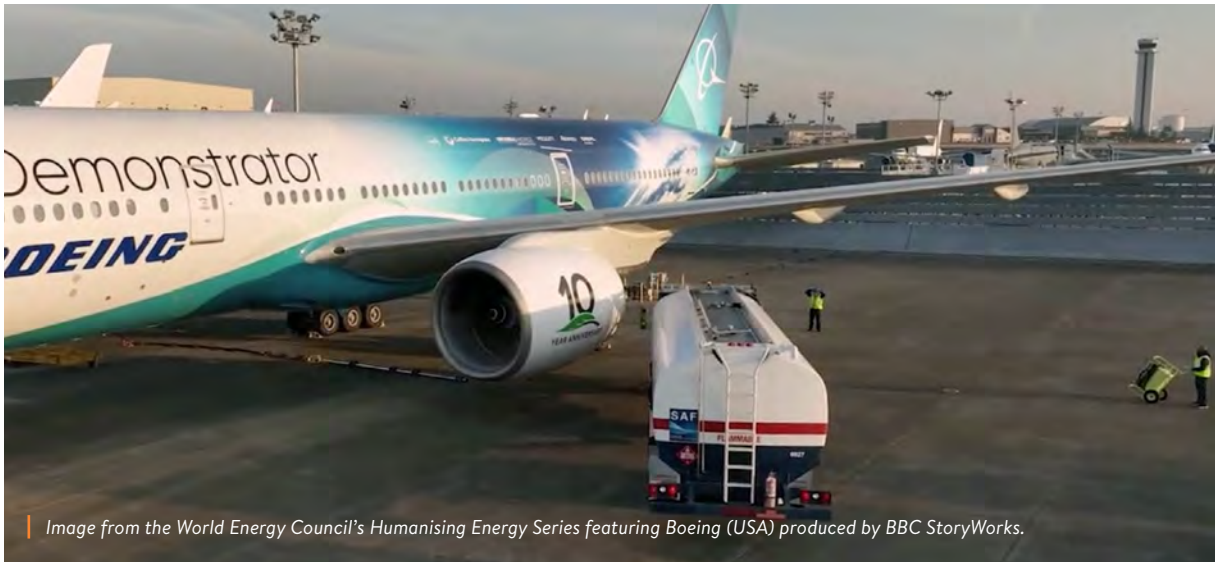


Image from the World Energy Council's Humanising Energy Series featuring Boeing (USA) produced by BBC StoryWorks.

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USING THE TRILEMMA:

CASE STUDIES

For examples of the way the World Energy Council's Energy Trilemma is being used around the world, we've asked a city, a region, and two countries to respond to the following questions:

1. How are you using the Trilemma?
2. How has the Trilemma been developed or applied further in the context of your community or country?
3. What is its impact?

CASE STUDY

BARRANQUILLA

The Council's Member Committee (MC) in Colombia is working with the mayor's office of the city of Barranquilla (as well as other cities in Colombia) to set up workshops for the communication and diffusion of the World Energy Trilemma tool. The aim is to construct Trilemma measurements for the city of Barranquilla as an incentive for other cities in Colombia to develop measurements that allow each of them to evaluate their energy performance year after year. The MC expects that an adapted World Energy Trilemma tool will not only serve as an assessment tool but will also drive the creation of innovative energy projects and support overall decision-making processes in line with one of the World Energy Council's major objectives—humanizing energy.

CASE STUDY

THE BALTICS: ESTONIA, LATVIA, AND LITHUANIA

Localizing the Trilemma: Experts from MCs in Estonia, Latvia, and Lithuania, along with the Future Energy Leaders of Latvia, worked together to adjust the benchmarking measurements of the World Energy Trilemma Index to better reflect specific local circumstances. For example, clean cooking is not an issue; but affordability of electric vehicles is. While there might be different policy instruments facilitating change (subsidies, taxes, etc.), the group felt it was important to fix a current value and a target destination. Thus, a localised World Energy Trilemma provides opportunities not only for comparing a country with other parts of the world, but also for measuring the gap to the target, making the World Energy Trilemma tool attractive to policy makers.

Even though the Baltic World Energy Trilemma working group has not finalised its work, the exercise has already had a significant impact. People involved across the discussions now have a much deeper understanding of factors to consider in energy transitions. The results of the work were discussed with MC members, as well as presented to a wide range of stakeholders through conferences, projects, and discussions. In this way, the World Energy Trilemma Framework already plays an important role in uniting different parties in a shared understanding of what a well-balanced sustainable energy policy means. The group plans to further develop the methodology as an important support tool for policy development and decision-making.

Publications: Since 2023, the MC Latvia journal, *Energy*, has been published twice a year. The authors of the articles are the members of the MC – representatives of various energy fields, industry-leading companies, academia, government institutions, and public organizations. Libraries, ministries, municipalities, members of Parliament, universities, and energy-related NGOs and organizations all receive a copy of the journal.[1]

In addition, during the last two years several international scientific publications discussed the Trilemma and other World Energy Council tools. The scientific *monograph*, Towards Climate Neutrality: Economic Impacts, Opportunities and Risks, included authors from other MCs as well as an introduction by Dr. Angela Wilkinson, Secretary General and CEO of the Council.[2]

Education: The World Energy Trilemma was integrated as a subject into the content of the Masters degree program course, "EU Energy Policy," at the University of Latvia.

Government: The Latvian MC highlighted the World Energy Trilemma Framework in four governmental research program projects, as well as in a project co-financed by the European Parliament.

Conferences and media coverage: Over the period of 2022-2023, the World Energy Trilemma Framework was presented at around 20 international and local conferences, including the annual conference of the Academies of Science of the region, debates of the Latvian political parties' leaders, and the State President-organized conference in Riga Castle, which ended with a lecture at a secondary school. The regional conference, "Energy Trilemma: The Backbone for Energy Transition—Baltic Sea Region Focus," in Riga on December 11-12, 2023, drew over 200 experts, regional policymakers, and energy company executives on-site, with an additional 51,000 people joining the event via livestream (with about 390 thousand video sticky logs). This was a tremendous number for Latvia, which has just 1.9 million inhabitants.

Media covered the conference during its most popular TV time slots and in newspapers. While conferences on specific energy topics are common, a conceptual discussion on an integrated picture of the entire energy-related ecosystem is not. The second day of the conference was devoted to a deep dive for the Council's community, discussing definitions, drivers, challenges, trends, and actors for each of the dimensions of the trilemma.

CASE STUDY

NEW ZEALAND

Publications frequently cite the World Energy Trilemma across an array of private and public sector institutions in New Zealand, including ministries, agencies, and regulatory bodies. As the transition to a more sustainable energy system advances to more complex stages, requiring more nuance and pragmatism across the Trilemma's three dimensions, the World Energy Trilemma framework has become widely known, even when the term "Trilemma" is not used.

As the country's transition progresses, it is very likely public references to the Trilemma Framework will continue, as it remains at the heart of all decisions taken by companies, Ministers, and regulators in the energy sector. Ongoing mentions of the Trilemma by decision-makers prove advantageous, signalling their understanding of the intricate challenges and trade-offs within the energy system. This awareness boosts the likelihood of their adoption of evidence-based policies that minimize unintended consequences.

In addition, institutions that formulate policy and regulate markets in New Zealand often cement the World Energy Trilemma Framework into their assessment as to whether a regulatory intervention is appropriate and proportionate in maintaining or achieving the desired system outcomes. In this way, in New Zealand, the Trilemma acts as a proxy for a set of principles steering the direction of travel towards a favoured outcome, evident through frequent references to the Trilemma in cabinet papers, consultation documents, and other publications detailing policy recommendations.

Similarly, the Boston Consulting Group and the Aotea Circle have used the Trilemma to design key performance indicators in their respective energy sector 'score cards' for assessing New

Zealand's energy system and its desired state into the future. The World Energy Trilemma tool has also been used to create the key performance indicators for a recently developed joint project that has established a framework between energy sector firms and the New Zealand Government. This framework aims to create a shared approach to reduce decarbonization challenges and make progress towards building more renewable energy generation over the next decade.

Overall, because of these applications of the World Energy Trilemma framework, New Zealand is inclined towards adopting the most efficient set of policies to strike a balance between competing and occasionally conflicting objectives. The New Zealand Member Committee believes the pursuit of balanced policies that consider the three Trilemma dimensions have notably contributed to New Zealand consistently attaining high scores on the World Energy Trilemma Index. While not flawless, the Trilemma has provided a framework for a secure, affordable, and sustainable system that forms the foundation of New Zealand's economic prosperity.

CASE STUDY

INDIA

India is a frontrunner in fulfilling its Nationally Determined Contribution (NDC) commitments, with a visionary goal of 50% cumulative electric power installed capacity from non-fossil-fuel-based energy sources and a commitment to a substantial 45% reduction in emissions intensity by 2030. At the subnational level, India comprises 29 states and 7 Union Territories (UTs).[3] The States and UTs are not only diverse geographically, culturally, and linguistically, but also in energy resources and demand. The national electricity grid, one of the largest operational synchronous grids in the world, connects the States and UTs across the geographical zones.

Adapting the World Energy Trilemma Index methodology for India: Drawing broadly from the Council's Trilemma Index methodology and similar indices, in 2020, World Energy Council India began developing a National Energy Trilemma Index (NETI) to propel States and UTs towards undertaking multi-pronged interventions to provide energy security sustainably for the inclusive growth and well-being of its people. The preparation of the third edition of NETI is close to completion.

While keeping the three energy dimensions of energy security, equity, and environmental sustainability, NETI expanded the fourth dimension—State or UT context, weighting each of the four dimensions at 25%. These dimensions are broken down into a total of 11 indicators and 38 sub-indicators against which the performance of each State or UT is scored. The selection and weight assigned to each indicator reflects its respective significance in the Indian context.

The top five performers and improvers in overall ranking as well as across dimensions are generated separately for both States and UTs. Summaries offer brief insights into contributing factors for top performers. NETI reports are freely accessible on the World Energy Council India website, and highlights are shared with World Energy Council India member organizations who are the energy sector majors of the country.

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[3] In UTs, the Central Government appoints the Lieutenant Governor, who is the administrator and the representative of the President of India, whereas the States have their own elected governments

WORLD ENERGY TRILEMMA INDEX

Beginning in 2010, the World Energy Council has published a yearly World Energy Trilemma Report. This report includes "The World Energy Trilemma Index," which measures the performance of 126 countries' energy systems across three dimensions:

ENERGY SECURITY

This dimension reflects a country's ability to reliably meet current and future energy demands, recover quickly from disruptions, and maintain steady energy supplies. It includes the management of both domestic and external energy sources and the resilience of energy infrastructure.

ENERGY EQUITY

This dimension includes the accessibility, affordability, and abundance of energy for all citizens, covering access to electricity and clean cooking facilities, levels of energy consumption conducive to prosperity, and the affordability of electricity, gas, and fuel.

ENVIRONMENTAL SUSTAINABILITY

Focusing on minimizing environmental damage and climate change impacts, this dimension reflects the efficiency and productivity of energy generation, transmission, and distribution, as well as efforts towards decarbonization and air quality improvement.

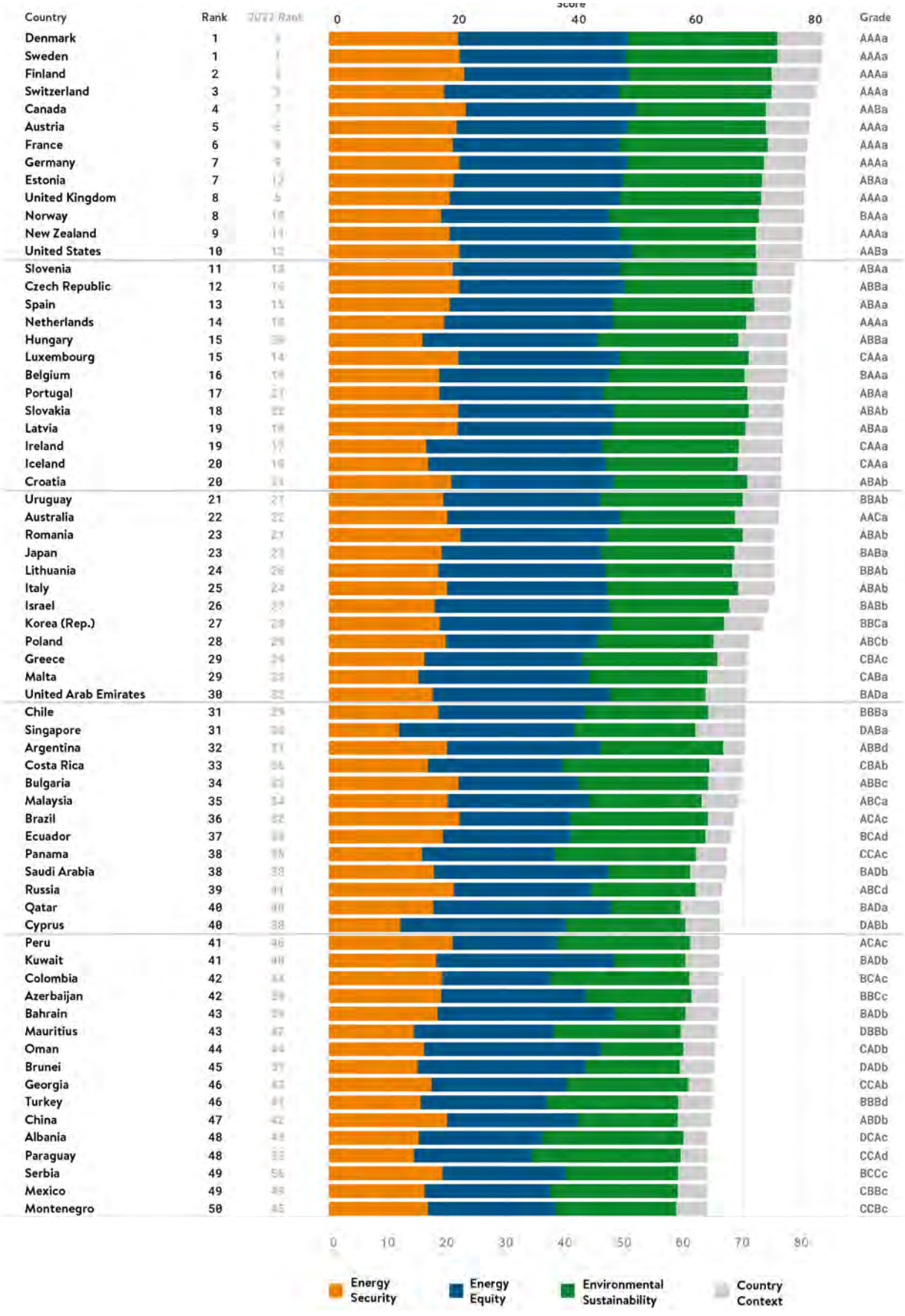
Managing to negotiate trade-offs among these three pillars of any energy system is increasingly difficult as the world shifts towards decentralized, decarbonized, and digital energy systems. The Index serves as a resource for policymakers, energy leaders, and financial sectors, highlighting opportunities for improvement and facilitating comparisons of energy performance over time and across countries. More specifically, the tool enables users to:

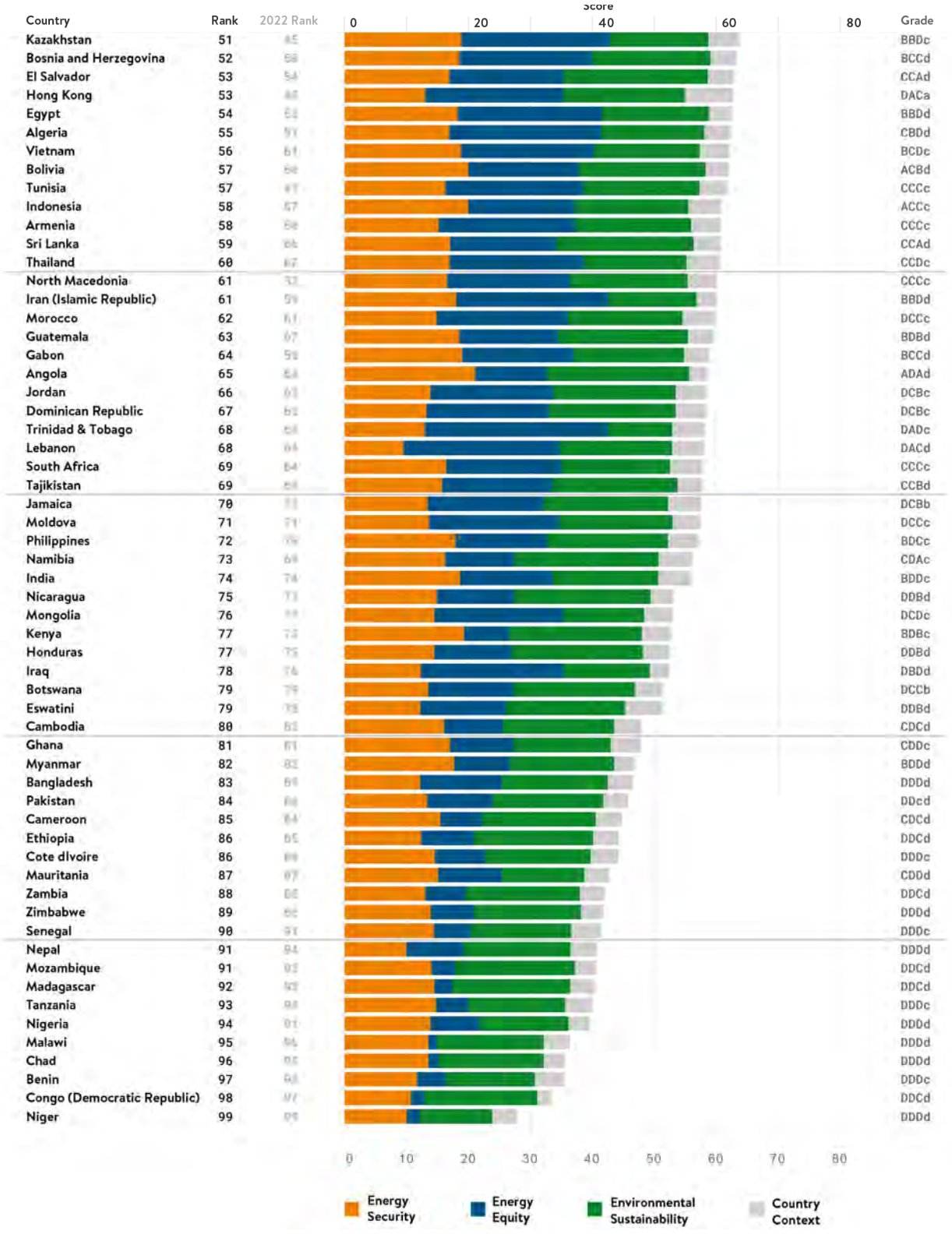
- Benchmark against leading practices and performers.
- Evaluate the effectiveness of energy policies in managing a balanced transition.
- Prioritize among competing energy needs.
- Examine the impacts of shifting focus and adopting new strategies.
- Foster discussions on policy innovation and integration.

The World Energy Trilemma Index not only allows countries to showcase policy achievements and positive trends but also facilitates collaboration among national Member Committees and the Council to tailor national and sub-national Trilemma models, fostering a cooperative approach to addressing global energy challenges.

A delay in reporting a number of indicators featured in the 2023 Index means that the Index may not fully capture the effects of recent transitions in the energy sector or the effects of recent world events—the war in Ukraine, unrest in the Middle East, pandemic recovery. Despite these data gaps, the underlying long-term data trends provide valuable insights for countries aiming for a secure, equitable, and sustainable energy future. The following figures provide a snapshot of the overall results of the 2023 Index.

Figure 26: World Energy Trilemma Index 2023





Disclaimer: The 2023 Index ranking reflects data using the most recent complete datasets at global levels. Some global energy sector timeseries feature data delays, which mean that most recent world events or national developments that could affect the Index's outcomes may not be fully captured.

Figure 27: Indexed trends since the baseline of 2000

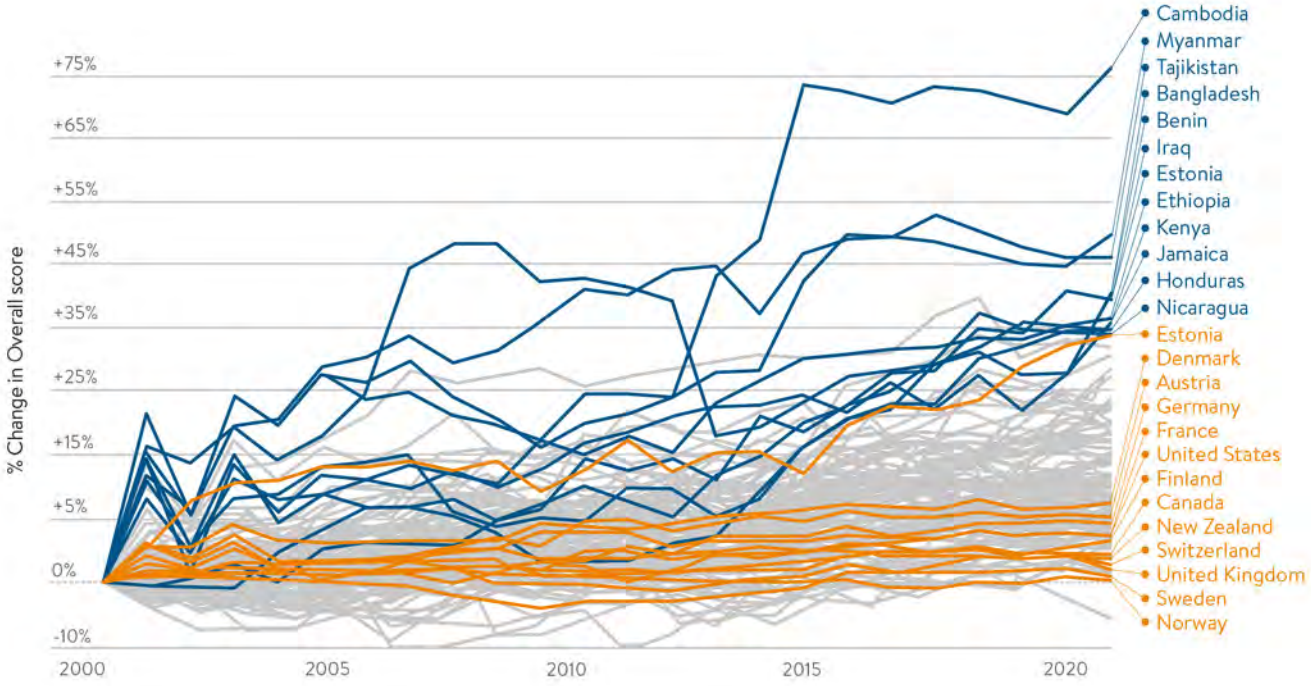
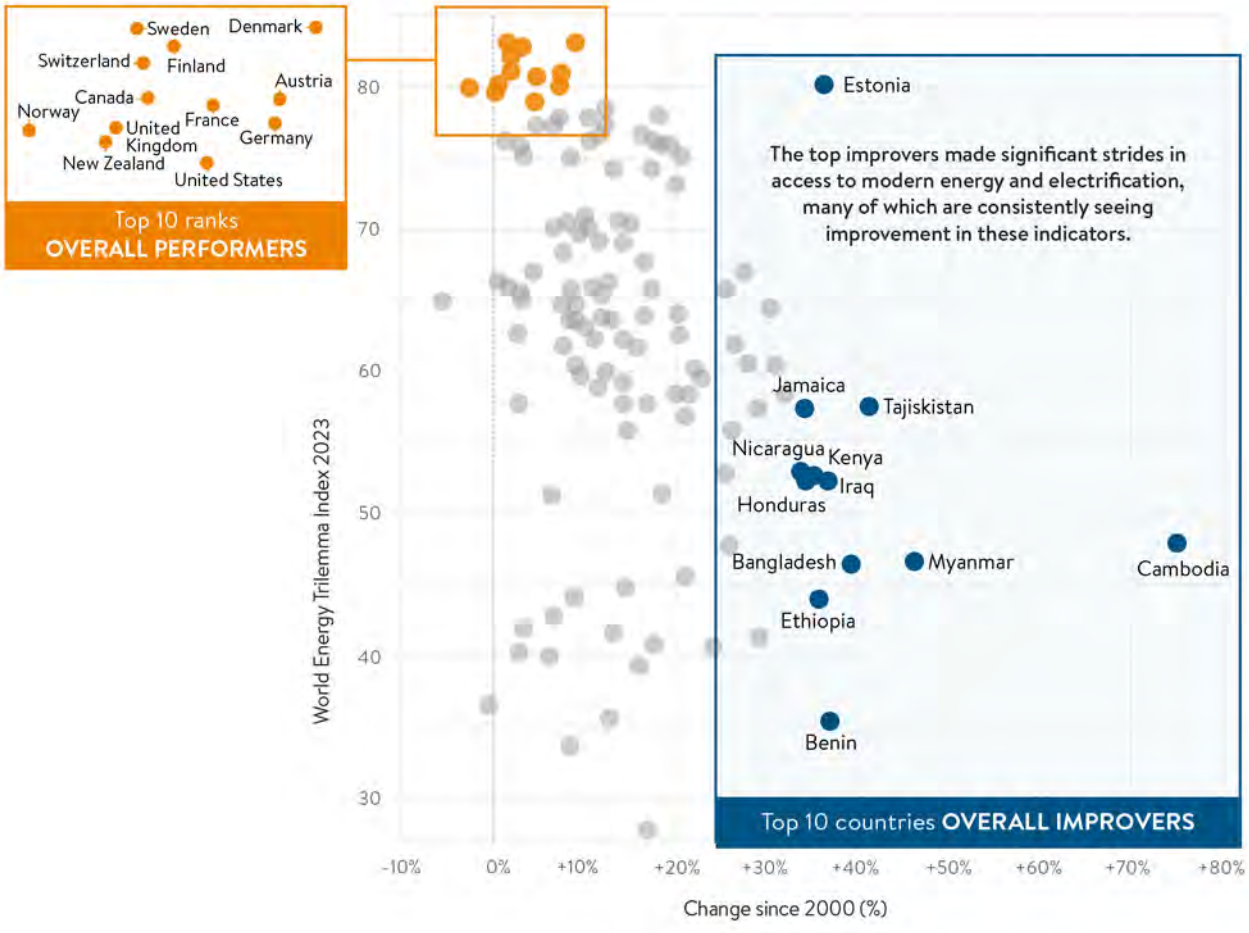


Figure 28: 2023 scores against the percentage change since 2000



ANNEX A

A PRIMER ON THE WORLD ENERGY TRILEMMA INDEX

The World Energy Trilemma Index aims to support an informed dialogue about improving energy policy by providing decision-makers with an objective relative ranking of countries' energy system performance across three core dimensions of Energy Security, Energy Equity and the Environmental Sustainability of energy systems. The 2023 Index is based on an evolved methodology and focuses on a historical index of progress established in 2021. This means that while the results cannot be directly compared with previous report iterations, the Index builds upon last year's new time-series analysis capability that has calculated Trilemma performance back to 2000.

WHAT IS THE WORLD ENERGY TRILEMMA INDEX?

The World Energy Trilemma Index is a quantification of the Energy Trilemma, which is defined by the World Energy Council as the triple challenge of providing secure, equitable and affordable, environmentally sustainable energy. Balancing these priorities is challenging but is also the foundation for the prosperity and competitiveness of individual countries.

The Energy Trilemma Index assesses current and past performance across the three dimensions of Energy Security, Energy Equity, and Environmental Sustainability. A fourth dimension of Country Context is also included within the calculations in order to capture important differences in countries' institutional and macroeconomic contexts.

Energy Security measures a nation's capacity to meet current and future energy demand reliably and to withstand and bounce back swiftly from system shocks with minimal disruption to supplies. This dimension covers the effectiveness of management of domestic and external energy sources, as well as the reliability and resilience of energy infrastructure.

Energy Equity assesses a country's ability to provide universal access to reliable, affordable, and abundant energy for domestic and commercial use. This dimension captures basic access to electricity and clean cooking fuels and technologies, access to prosperity-enabling levels of energy consumption, and affordability of electricity, gas, and fuel.

Environmental Sustainability focuses on elements that enable countries to develop and implement energy policy effectively and to achieve energy goals. This dimension describes the underlying macroeconomic and governance conditions, the strength and stability of the national economy and government, the country's attractiveness to investors, and the country's capacity for innovation.

Country Context focuses on elements that enable countries to develop and implement energy policy effectively and to achieve energy goals. This dimension describes the underlying macroeconomic and governance conditions, the strength and stability of the national economy and government, the country's attractiveness to investors, and the country's capacity for innovation.

In providing insights into a country's relative energy performance in relation to Energy Security, Energy Equity, and Environmental Sustainability, the Index highlights a country's challenges in balancing the Energy Trilemma and opportunities for improvements in meeting energy goals now and in the future. The Index aims to inform policy makers, energy leaders, and the investment and financial sector through rankings that provide comparisons across countries on each of the three dimensions. In addition, historical indexed scores provide insights into the performance trends of each country over time.

WHAT IS THE SCOPE OF THE INDEX?

The Index tracks **133 countries**. However, rankings have not been produced for seven countries, in most cases because of political instability leading to poor data coverage. The countries that are tracked but not ranked are Barbados, Libya, Syria (Arab Republic), Chinese Taipei, Ukraine, Venezuela, and Yemen. The Index aggregates around **60 datasets** into **32 indicators** to create a snapshot energy profile for each country. In addition, it calculates a historical index for each dimension back to a baseline year of 2000.

WHAT TIME PERIOD DOES THE 2023 INDEX CAPTURE?

The 2023 Index ranking reflects data from 1998 to 2022 using the most recent available data at global levels. The online Trilemma Tool presents Index performance since 2000 using longitudinal data with individual country profiles. Particular indicators feature some data delays, which means that recent world events or the most recent transitions in the energy sector that could affect the Index's outcomes may not be fully captured.

HOW ARE THE INDEX RESULTS PRESENTED?

Countries are provided with an overall Index ranking from #**1 to** #**126**, as well as rankings for each Trilemma dimension—Energy Security, Energy Equity, and Energy Sustainability. The top performing country is awarded a #1 ranking, while the lowest ranking country is assigned rank #126. Because some rankings are shared, the lowest rank in 2023 is #99.

In addition to an overall ranking and the individual rankings for each Trilemma dimension, countries are also assigned a set of dimension grades from A (highest) to D (lowest). Each letter reflects one dimension of the Energy Trilemma: the first letter refers to Energy Security; the second letter to Energy Equity; and the third letter to Environmental Sustainability. The mean and standard deviation of the scores in each dimension is calculated, and balance grades for each dimension are then assigned using bands based on the mean and standard deviation. High performance across all three dimensions is awarded 'AAA'. Sets of grades such as 'ABC' or 'CBD', highlight the balance or imbalance across a country's energy performance. An imbalance in energy performance suggests current or future challenges in the country's energy policy.

WHERE CAN I FIND THE FULL RESULTS?

- The results are published once a year and can be downloaded for free from the Council's website.
- The **online tool**, presenting full results, is available at: https://trilemma.worldenergy.org/
- The **full report** with country and regional profiles is available at: https://www.worldenergy.org/publications/

ANNEX B

READING THE INDEX RESULTS

WHAT DOES THE INDEX TELL US ABOUT A COUNTRY'S ENERGY PERFORMANCE AND POLICY?

The Index shows how well each country is performing on the Energy Trilemma and captures the aggregate effect of energy policies implemented over time. Because the Index shows aggregate policy effects, it does not identify the effectiveness of a particular policy; each policy interacts with a set of contextual and policy-specific factors unique to that country over different periods. Nonetheless, by broadly measuring aggregate policy outcomes, the Index provides important insights into the efficacy of energy policies and choices.

Historical calculations for each of the three energy dimensions indexed to the year 2000 provide performance trends for Security, Equity and Sustainability, which can then be compared to policies and exogenous factors over time, providing potential insights on the effects of different factors on energy outcomes.

WHAT WILL AFFECT A COUNTRY'S RANKING IN THE INDEX?

The Index is weighted in favour of energy performance (Energy security, Energy equity and Environmental sustainability dimensions) versus contextual performance (Country Context dimension). Therefore, changes in energy performance will have a greater effect on a country's ranking than changes in its macroeconomic and governance conditions.

Few countries manage to perform well across all three energy dimensions—just 9 out of 126 countries managed to achieve AAA grades across the energy Trilemma dimensions. Currently, many countries achieve stronger performance in two dimensions but falter in one, suggesting trade-offs between energy dimensions. For example, the abundance of oil in some energy-exporting countries means that they enjoy highly secure and affordable energy. However, low prices limit incentives to reduce energy consumption and to engage in energy efficiency programs, so they are likely to perform lower in Environmental Sustainability due to higher greenhouse gas emissions.

HOW CAN A COUNTRY MOVE UP OR DOWN THE INDEX?

It is important to note that the Index is a comparative ranking and shows the performance of a country relative to all other countries. To move up in the Index, a country must improve its overall score. For example, a country's ranking on the indicator "Diversity of electricity generation" will depend on how its diversity of electricity generation (from hydroelectricity, biomass and waste, geothermal, solar and wind) ranks against other countries.

Similarly, if a country's score remains stable but those of its peers improve, it will move down in the rankings. Put differently, a country's underlying indicator data can remain the same year-on-year, but its Index position can move due to changes within other countries. Thus, performance stagnation could impact the Index position in the same way as retrograde motion of the energy performance data.

In 2021, the World Energy Council used a revised methodology from 2019 to calculate indicator scores. The use of a refined methodology has resulted in a new set of relative performance rankings, strengthened by historical trend analyses. It should however be stressed that the results published in previous reports are not directly comparable to those published in this report.

HOW DOES THIS YEAR'S RANKING COMPARE WITH PREVIOUS YEARS?

It has been challenging to compare Trilemma rankings across years due to the historical methodology used, which comparatively ranked countries solely on that year's Trilemma calculation. Using the rankings alone, it was not possible to judge whether a country had improved its own performance or not, and instead only whether a country's ranking had improved in comparison to others in that year.

The inability to provide insight into country performance year-on-year was a key driver in evolving the methodology to include indexation so that direct comparison with earlier years' performance could be made. While direct comparison of 2022 and 2023 Index rankings is not possible, given changes in methodology, the current indexation reveals how performance by key dimension indicators has evolved for each country.

WHY ARE SOME COUNTRIES WITH TRIPLE-A BALANCE GRADES NOT INCLUDED IN THE TOP 10 COUNTRIES WHILE OTHERS THAT DO NOT HAVE TRIPLE-A BALANCE GRADES ARE?

A country's overall score is determined by the weighted average of dimensions A to D scores. A triple-A balance grade indicates a country's superiority within a dimension compared to other countries that do not have A grades. However, the same country may not fall into the top 10 as the values based on which the grades are assigned may be at the lower threshold for the specific grade category. A country's triple-A grades may be composed of relatively 'lower-score' As. In practice, this could result in a lower overall weighted average score than an AAB country where the A grades and B grade are well beyond the threshold levels.

WHAT POLICIES WILL AFFECT A COUNTRY'S SCORE AND POSITION ON THE INDEX?

Policies can affect multiple data points aggregated by the Index such that their effects are not exclusive to a single indicator or even a dimension. Thus, it is often difficult to pinpoint how any single policy affects a country's performance against an indicator or dimension. For example, policies to increase penetration of renewable energy could affect security (by diversifying energy mix and reducing demand for imports) and sustainability (by reducing carbon dioxide emissions). If the policies contributed to higher electricity prices, the policies could also impact the equity dimension. External factors like technological change (e.g., changes in renewables technology) can also have an impact, and are not directly measured by the Index.

Those factors noted, countries that implement a range of clear and predictable energy policies resulting in an overall framework that addresses the three aspects of Energy Trilemma typically rank higher in the Index.

ANNEX C

WORLD ENERGY TRILEMMA INDEX METHODOLOGY

Each indicator category is composed of a set of carefully selected indicators that meet our selection criteria and are highly relevant to the World Energy Council's understanding of the Energy Trilemma.

It is also critical that the indicators can be consistently and readily derived from reputable sources and cover a high proportion of the World Energy Council's member countries; some potential indicators were excluded from the Index due to low member country coverage.

The key data sources for the Energy Trilemma Index model are:

- IEA World Energy Balances, Indicators, World Energy Prices, and Emissions
- World Bank/UN SDG 7 tracking data
- World Bank Getting Electricity report
- JODI and IGU data
- World Resources Institute
- Global Competitiveness Index, WEF

Indicator selection criteria includes:

Coverage: The World Energy Council includes indicators that are critical to the Index's methodology and strives to ensure that each indicator possesses a strong coverage of data (more than 75% coverage across the 133 tracked countries).

Comparability: Data to calculate indicator scores are derived from as unique and comprehensive sources as possible, focusing on a single source per indicator as far as practical, to ensure comparability between countries.

Relevance: Indicators are chosen or developed to provide insight into country situations in the context of the project goals and in line with the narrative.

Distinctiveness: Each indicator focuses on a different aspect of the issue being explored and avoids overlaps or redundancy with other indicators.

Contextual sensitivity: Indicators capture different country situations (e.g., wealth, size) and, where appropriate, indicators are normalised by GDP (PPP), GDP (PPP) per capita, population, or other relevant metrics.

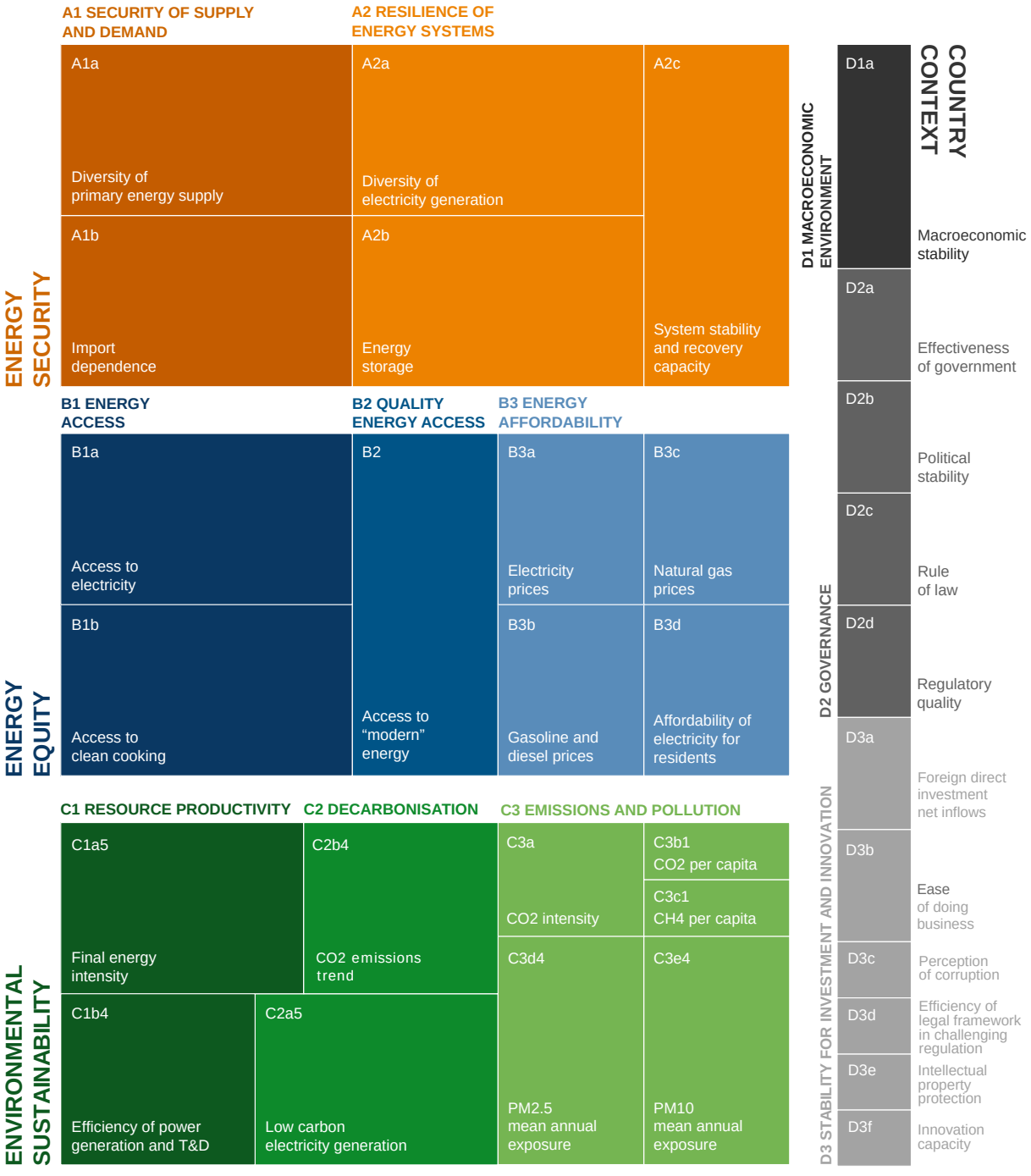
Robustness: Indicator scores are computed from data made available by reputable sources with the most current information available at sufficient coverage.

Balance: Indicators within each dimension (and dimensions across the Index) exhibit coverage of different issues.

WHAT IS THE INDEX BASED ON?

Each country's overall Index ranking is based on the calculation of 32 underlying indicators which aggregate up to 11 categories across the four dimensions (including country context). Some of these indicator calculations are based on multiple datasets, while others rely on just one. For example, the category "Affordability" is measured using four indicators, each of which is supported by multiple datasets. Two additional indicators (A2d. System resilience and C2c. Transport sector decarbonisation) and one sub-indicator (A2b.c. Energy storage – electricity) were not included in the model due to lack of available data, and remain placeholders for future Trilemma iterations. Figure 46 provides an overview of the indicators and their weighting.

Figure 29: Energy Trilemma Index structure and weighting of the indicators



WHY WAS THE INDEX METHODOLOGY REFINED IN 2021?

The original Trilemma Index methodology has been revised throughout the years with the aim of improving transparency and offering stakeholders better insights to help improve their energy policies. Until 2019, the Energy Trilemma was a comparative ranking of usually about 130 countries, assessed across the dimensions of security, sustainability, and equity. While a comparative ranking might be a good way to start a conversation about energy policy by tapping into competitive instincts and highlighting which dimension might need the most focus, it is less helpful in providing guidance on how to improve a country's energy policy. One could look at the top-ranking countries for the different dimensions to understand the reasons for their better performance, but whether or not their policies would be relevant to other countries would require further analysis of the differing domestic contexts. The main criticism of comparative rankings comes from the fact that one country's improved performance might not be recognised if other countries have improved more. Here time-series or longitudinal analysis can be more insightful.

A time-series analysis enables performance to be assessed over time to understand whether a policy intervention has made a positive contribution or if further refinement might be necessary. Presenting a dynamic picture of performance over time also helps to identify the most effective policy interventions and enables the Energy Trilemma to become a policy pathfinding tool. By seeing performance at a country level over time, it becomes easier to identify where a policy intervention might be best targeted and subsequently to track its impact. This follows the usual evidence-based policy assessment approach.

WHAT ARE THE KEY DESIGN AND METHODOLOGY CHANGES REFLECTED IN THE 2023 INDEX?

The 2023 Index is based on the significantly updated 2019 Methodology, with updates on the data coverage. The resulting analysis provides a richer view of a country's energy performance, incorporating contemporary indicators and datasets that better represent the current world energy context.

The changed methodology has been applied to all countries and to the full back-series of historic index performance going back to the index base year of 2000. That means that comparisons need to be against the time-series and not last year's publication. Shared rankings have also been kept, so if countries' overall scores differ by less than 0.1, they share the same rank position. The methodology uses a dense ranking approach because some scores are tied at one decimal place.

Updated data sources are also used and are reflected in the online tool. Typically, changes in a country's energy performance evolve slowly over several years, and these changes will be reflected in a gradual upward or downward trend in the Index graph, which can be tracked via the online tool.

WHY ARE CATEGORY AND INDICATOR WEIGHTS GIVEN UNIQUE WEIGHTS INSTEAD OF EQUAL WEIGHTS?

The weights assigned remain unchanged with respect to 2022. The indicator categories have been set up to provide a comprehensive picture of each dimension. Their weights are determined by the number of indicators included in it and its relevance to the dimension.

The individual indicators reside at a level under dimension categories; they serve as the building blocks of the dimension categories. Their weights are determined by their relevance to the indicator category.

WHY ARE SCORES NORMALISED? AND WHAT IS THE BENEFIT OF USING NORMALISATION ONLY RATHER THAN A COMBINATION OF STANDARDISATION AND NORMALISATION?

Aggregating scores using normalisation rescales them to the range 0 to 100. Scores with different ranges of values are thus adjusted to a common scale for comparison, allowing for a more accurate reflection of the data within Index results. As analogous results can be obtained by applying both standardisation and normalisation, an approach involving normalisation only is preferable because it is both simpler and more transparent.

WHY IS THE RESCALING RANGE FOR INDICATORS DETERMINED BY CALCULATED AND/OR DERIVED VALUES INSTEAD OF ACTUAL MINIMUM AND MAXIMUM VALUES?

When using actual minimum and maximum values for normalising, outliers can cause the distribution of normalised data to be skewed. Furthermore, actual minimum and maximum values may not be meaningful and/or accurate in representing the indicator if there is a theoretical minimum and maximum involved, or it does not consider the nature and significance of the indicator in relation to the status quo and goals of the energy system. By contrast, using calculated or derived values helps to mitigate the effects of outliers. For example, taking the average of the bottom and top five performing countries for the indicator C2b. GHG emissions trend as the minimum and maximum values mitigates the impacts of countries with extremely high or low values. Additionally, such values help to better represent indicator scores with a theoretical minimum and maximum. For example, indicator B1a. Access to electricity, which is represented as a percentage of total population has a natural minimum value of 0% and a maximum value of 100%. Moreover, using calculated or derived values helps indicators to accurately depict the status quo and goals of the energy system. For example, indicator C3a. CO_2 intensity uses a minimum score calculated by the global average CO_2 intensity targets to reach the 2030 1.5°C IPCC target.

WHY ARE GRADES ASSIGNED USING THE ACTUAL DISTRIBUTION OF SCORES WITHIN A DIMENSION?

Assigning grades using the actual distribution of scores provides a better representation of the data. It presents the absolute difference between the countries' performance in each dimension and avoids artificially dividing countries into different categories with a fixed number of countries within each category as, for example, would occur using an even distribution approach.

WHY ARE GATE CRITERIA USED?

Gate criteria were introduced to address heavily skewed data as well as the differences in countries' natural endowments and macroeconomic positions. This is to ensure that cross-country comparisons across the three dimensions are meaningful. For example, a gate criterion for electrification rate was introduced for the indicator B3d. Affordability of electricity for residents. Only countries with more than 90% access to electricity are assigned a score for this affordability indicator, as it is mostly relevant for countries that are already largely electrified. A gate criterion helps group similar countries (e.g. those with a high rate of electricity access) and thereby prevents the skewed data from excessively influencing outcomes.

WHICH (SUB)-INDICATORS ARE SUBJECT TO A GATE CRITERION?

The following indicators and sub-indicator are subject to a gate criterion:

- A1a. Diversity of primary energy supply
- A1b. Import dependence
- A2b.b Energy storage (gas)
- B3c. Natural gas prices
- B3d. Affordability of electricity for residents

Please refer to the section Indicators description in the Methodology document for a detailed explanation of the gate criteria and the rationale behind the gate criteria for each of the indicators and sub-indicators.

WHY IS MISSING DATA REPLACED BY THE COUNTRY GROUP AVERAGE?

The country group average is a good representative of countries in the same region in terms of economic development, social situation, political conditions, etc. This representativeness renders missing values less likely to distort country outcomes. The groups are based (jointly) on economic groups and geographic region.

Economic groups are defined as:
- GDP Group I: GDP per capita greater than USD 33,500
- GDP Group II: GDP per capita between USD14,300 and USD 33,500
- GDP Group III: GDP per capita between USD 6,000 and USD 14,300
- GDP Group IV: GDP per capita lower than USD 6,000

Geographic regions are defined as:
- Asia
- Europe
- Latin America and Caribbean (LAC)
- Middle East and North Africa (MENA)
- North America
- Sub-Saharan Africa (SSA)

WHAT ARE THE LIMITATIONS OF THE INDEX?

The Index cannot capture real-time Energy Trilemma performance due to the challenges of capturing large volumes of reliable data for a wide range of countries. The Index cannot isolate the impact of a single policy.

The Index uses around 60 data sets. In a few instances, data for specific countries is not available (i.e., the data set has missing data), in which case missing data is replaced by the country group mean.

Full details on the Index methodology, including the sources of all datasets and how each indicator is calculated and treated, are provided in the comprehensive Methodology document that is available to the Council's Community.

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