WORLD ENERGY COUNCIL

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

WORLD ENERGY

TRILEMMA INDEX 2022

In partnership with Oliver Wyman

ABOUT

WORLD ENERGY COUNCIL

The World Energy Council is the principal impartial network of energy leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all.

Formed in 1923, the Council represents the entire energy spectrum, with over 3,000 member organisations in over 80 countries, drawn from governments, private and state corporations, academia, NGOs and energy stakeholders. We inform global, regional and national energy strategies by hosting high-level events including the World Energy Congress and publishing authoritative studies, and work through our extensive member network to facilitate the world's energy policy dialogue.

Further details at www.worldenergy.org and @WECouncil

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WORLD ENERGY TRILEMMA INDEX 2022

The World Energy Council's definition of energy sustainability 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 in partnership with global consultancy Oliver Wyman, along with Marsh & McLennan Advantage of its parent Marsh & McLennan Companies. It presents a comparative ranking of 127 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

World Energy Trilemma Index 2022, published by the World Energy Council in partnership with OLIVER WYMAN.

Images from the World Energy Council's Humanising Energy Series featuring Sasol, Enertag, and Linde (South Africa) produced by BBC StoryWorks.

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EXECUTIVE SUMMARY

The World Energy Trilemma is in its 12th year of publication amidst a time of unprecedented energy shocks and multiple crises that continue to cause disruptions to energy systems. This situation has been leading to cascading impacts affecting energy security, energy affordability, and environmental sustainability across regions.

Driving a clean and just energy transition that simultaneously ensures a secure, equitable, and sustainable way forward continues to be a complex problem. 2022, a year characterised by converging crises, reinforced the need for balance in the dimensions of energy security, affordability, and sustainability. The Trilemma framework continues to offer a baseline for designing and developing new insights to assist regions in understanding the impact and track the progress of their energy transitions.

At the time of writing, governments and society at large are considering how best to move forward in terms of energy policies, prices, and new partnerships on energy security. These developments present unique opportunities to not only re-examine the importance of keeping the Trilemma dimensions balanced, but also to consider extending the existing framework as a practical tool for decision-makers.

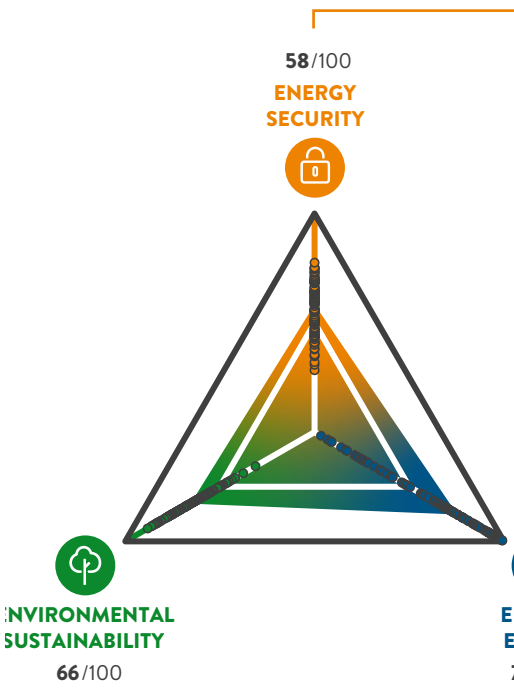
Energy transcends all sectors and contributes towards the development of world economies and is the lifeline of modern society. While the implications of the war in Europe are being felt across the world, nations continue to work urgently towards maintaining some level of security of supply amid rising affordability concerns and the negative consequences of climate change. Countries will need to evaluate the other pathways that work for people and the planet, adjusting the three pillars of the Trilemma to their national and local realities.

The emergence of new regional blocs requires stakeholders to have a more regional lens to evaluate their energy positions, policy pathways, and their unique spheres of influence. It is therefore critical to extend the Trilemma towards a scalable and flexible framework to help countries examine local trends and strategies and develop context-specific pathways to a clean and just energy transition.

In the face of a very uncertain future, a steady foundation for measuring energy performance and global trends is essential. The World Energy Trilemma Index provides a retrospective glance at the points of stress and growth over the years. For example, Germany's dependence on imported gas and dominance in sustainability has led to a weakness in its Energy Security profile. Understanding this historical dependence provides retrospective insights into ways to ensure secure, equitable and sustainable growth.

The present state of the Trilemma dimensions highlights trajectories that are not aligned to the recent energy shocks and crisis; the 2022 data is not reflective of the existing energy situation. However, the long term trends in the data remain informative as countries seek to drive a secure, equitable, and sustainable transition. This 2022 report offers a prism on the past and examines opportunities for driving forward improvements to measure the impact of the energy transition.

World Energy Trilemma Index

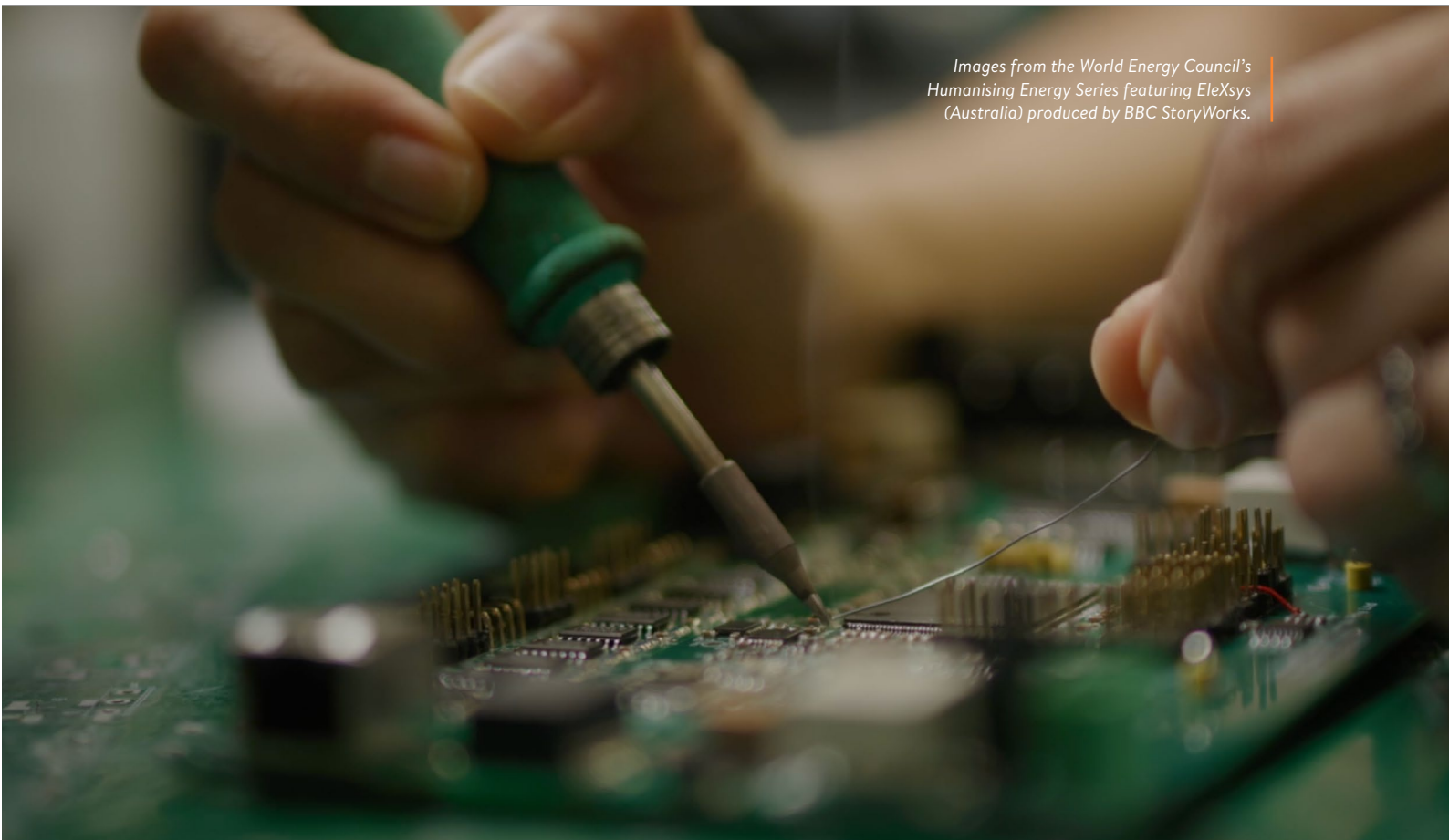


Reflects a nation's capacity to meet current and future energy demand reliably, withstand and bounce back swiftly from system shocks with minimal disruption to supplies.

Assesses a country's ability to provide universal access to affordable, fairly priced and abundant energy for domestic and commercial use.

Represents the transition of a country's energy system towards mitigating and avoiding potential environmental harm and climate change impacts.

Source: World Energy Council



Images from the World Energy Council's Humanising Energy Series featuring EleXsys (Australia) produced by BBC StoryWorks.

Image from the World Energy Council's Humanising Energy Series featuring CNH Industrial (Italy) produced by BBC StoryWorks.

BACKGROUND & INTRODUCTION

The events of 2022 have provided a forceful reminder of the relevance of the Trilemma framework. The need to balance Energy Security, Equity (Affordability) and Environmental Sustainability has never been more pressing, and the diversity of challenges faced by countries is clearer than ever. We are in the grip of a global energy crisis, however different countries are experiencing the crisis in different ways.

Indeed, it is not just one crisis, but a layering of crises. The covid pandemic brought a huge shock to energy demand in 2020. It also disrupted global supply chains, so as the world recovered from the pandemic in 2021, energy supply struggled to keep up with demand and prices started to rise across all fuels.

Then Russia's invasion of Ukraine in February this year dealt another heavy blow to energy systems, disrupting the flow of natural gas from Russia to Europe. The epicentre of that shock is Europe, but the shockwaves have reverberated around the world as Europe's efforts to replace Russian gas have pushed up prices of gas and other fuels across international markets. In Europe, oil supply has been less affected than gas, and the war in Ukraine has added a security premium to an already tight market.

While the war in Ukraine is very much in the foreground, we should not forget that before the war, and prior to the COVID pandemic, the world was already facing an energy crisis in the form of the climate emergency. Extreme weather events in 2022 have underscored the urgency. Time is running out to implement the actions required to meet the Paris agreement goals. If the world community is serious about limiting global warming to 1.5C, we need to move at pace and scale to transform our energy systems.

Let's also not forget, too many people continue to live in a state of permanent energy crisis, lacking access to the clean and convenient forms of energy that are essential to healthy and productive lives in the modern economy. Extending the benefits of the modern energy economy to everyone on the planet remains a huge challenge, and a great opportunity for unlocking human potential.

This multi-layered crisis demands a response from decision makers at all levels in society. Policymakers are the obvious first responders, and one clear outcome from the succession of shocks is a greater role for governments. However, energy leaders need to step up to the challenge wherever they are in the ecosystem – corporates, financial investors, cities, communities, think tanks, philanthropists.

It is against this background that we are releasing the latest set of results from the World Energy Trilemma Index. The Index provides a starting point for a conversation, grounded in data, about how countries are doing in addressing their energy Trilemma challenges. The main strength of the Trilemma lies in facilitating that conversation. The collaborative actions arising from these conversations is where the value lies, not in the numbers themselves.

The turbulent and fast-moving environment has highlighted some shortcomings in the construction of the Index and the data that are currently available. For example, we need to revisit the definition and measurement of Energy Security, with a greater emphasis on system resilience to extreme shocks. Together, we also need to incorporate new measures of justice in the energy system.

A priority for our community is to invest in improving the Trilemma Index as a tool for tracking progress towards a clean and just energy system. We look forward to doing that, in partnership with pioneering governments, cities and communities.

OVERALL TRILEMMA RANKINGS 2022

The overall Trilemma Top Ten countries for 2022 are largely unchanged from previous years rankings, with some new additions to the top performers. European and other OECD countries continue to dominate the top rankings due to their well-established energy policies and diverse energy systems. Slovenia and Estonia join the top ranked countries for 2022 with significant improvements on last year to both score 78.8 and share the #9 ranking. Slovenia (ABA) rising 11 places and Estonia (ABA) rising 8 places since last year. The top three of Sweden, Denmark, and Switzerland perform very well across all three Trilemma dimensions with well-established energy policies that promote diverse and decarbonising energy systems. Sweden retains its #1 ranking from last year, performing well across all three dimensions - scoring 73 for energy security, 95 for Energy Equity and 87 for Environmental Sustainability. Improving Energy Security and maintaining Energy Equity is a focus of current energy policies.

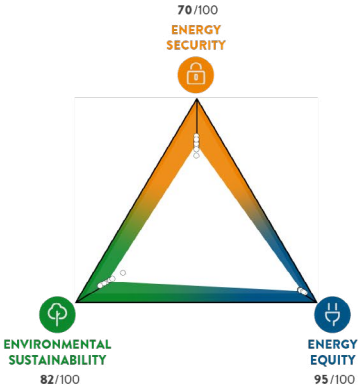
Denmark is ranked 2nd in the world with a solid AAA performance across all indicators. While Energy Equity remains stable and Environmental Sustainability is slightly increasing and has improved greatly in the past 10 years, energy security has dropped since 2020. The latter is due to the largest Danish gas field, Tyra, being under reconstruction until June 2023. In the meantime, Denmark is relying on gas imports from neighbouring countries, as well as expanding its biogas, renewable energy and power-to-X production. The country has passed peak fossil fuels production and is focusing heavily on using its off-shore experience to establish offshore wind. Denmark now has some of the highest levels of variable renewable generation, supported by strong grid integration with its neighbours. Switzerland also shares the 2nd rank position in the global Trilemma 2022 with an overall grade of 83. Despite the challenging macroeconomic and geopolitical situation, the country shows a great stability across the three dimensions, maintaining its second place from previous year. Switzerland's high rank is driven by excellent energy equity results, indicating energy's affordability for its residents, and driven by the important share of technologies with low marginal costs in the power distribution mix (nuclear and hydropower totalling 86% in 2020). Switzerland also shows a high score in Sustainability, greatly driven by the CO2 intensity of its power mix, among the lowest worldwide. Energy security remains the country's main area of improvement, especially in areas such as energy storage and dependence on imports.

Three non-European countries, Canada, New Zealand and the United States, remain in the top 10 listing, with Australia, Uruguay, and Japan and also featuring in the top 20 overall rank. Uruguay is the only non-OECD/non-EU country in the top 20, with its strong performance attributable to a highly decarbonised electricity system.

The top ten overall improvers have increased their Trilemma scores by at least 25% since 2000. The list includes four Asian countries, two from Latin America, two from Europe, and two from Africa. Most are characterised by historically low levels of energy access but have made significant efforts to extend their grids and increase energy access in recent years. Notably, China ranks as the 2nd biggest improver since 2000, with increased energy access contributing to its unprecedented economic growth, which has seen it rise to be the world's second largest economy. There is no room for complacency, however, as it is not clear whether these strategies will be the most appropriate/effective in transition – other countries, particularly in the LAC region, have strongly decarbonised electricity systems that may be better placed moving forward.

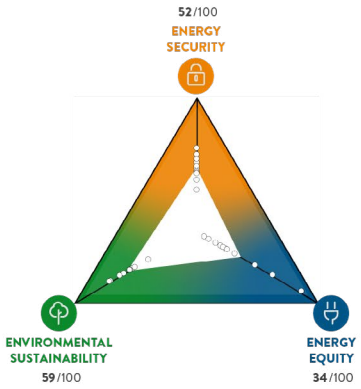
2022 TOP PERFORMERS AND IMPROVERS

TOP 10 RANK OVERALL PERFORMERS



Rank		Grade	Score
1	Sweden	AAAa	84.3
2	Switzerland	AAAa	83.4
2	Denmark	AAAa	83.3
3	Finland	AAAa	82.7
4	United Kingdom	AAAa	82.4
4	Canada	AAAa	82.3
5	Austria	AAAa	82.2
6	France	AAAa	81.1
6	Norway	BAAa	81.0
7	Germany	AAAa	80.6
8	New Zealand	AAAa	80.3
9	Slovenia	ABAa	78.8
9	Estonia	ABAa	78.7
10	United States	AACa	78.5

TOP 10 COUNTRIES OVERALL IMPROVERS



Rank		Grade	Score	Improvement since 2000
72	Cambodia	CDDd	47.5	42%
68	Kenya	BDBc	51.5	30%
77	Ethiopia	DDCd	42.6	24%
63	India	BDDC	53.6	23%
66	Mongolia	DCDc	52	22%
78	Bangladesh	DDDd	42.1	19%
84	Nepal	DDDd	39	19%
23	Malta	DAAa	73.4	16%
21	Lithuania	BBAa	74.5	16%
40	China	ABCb	65.3	15%

Source: World Energy Council

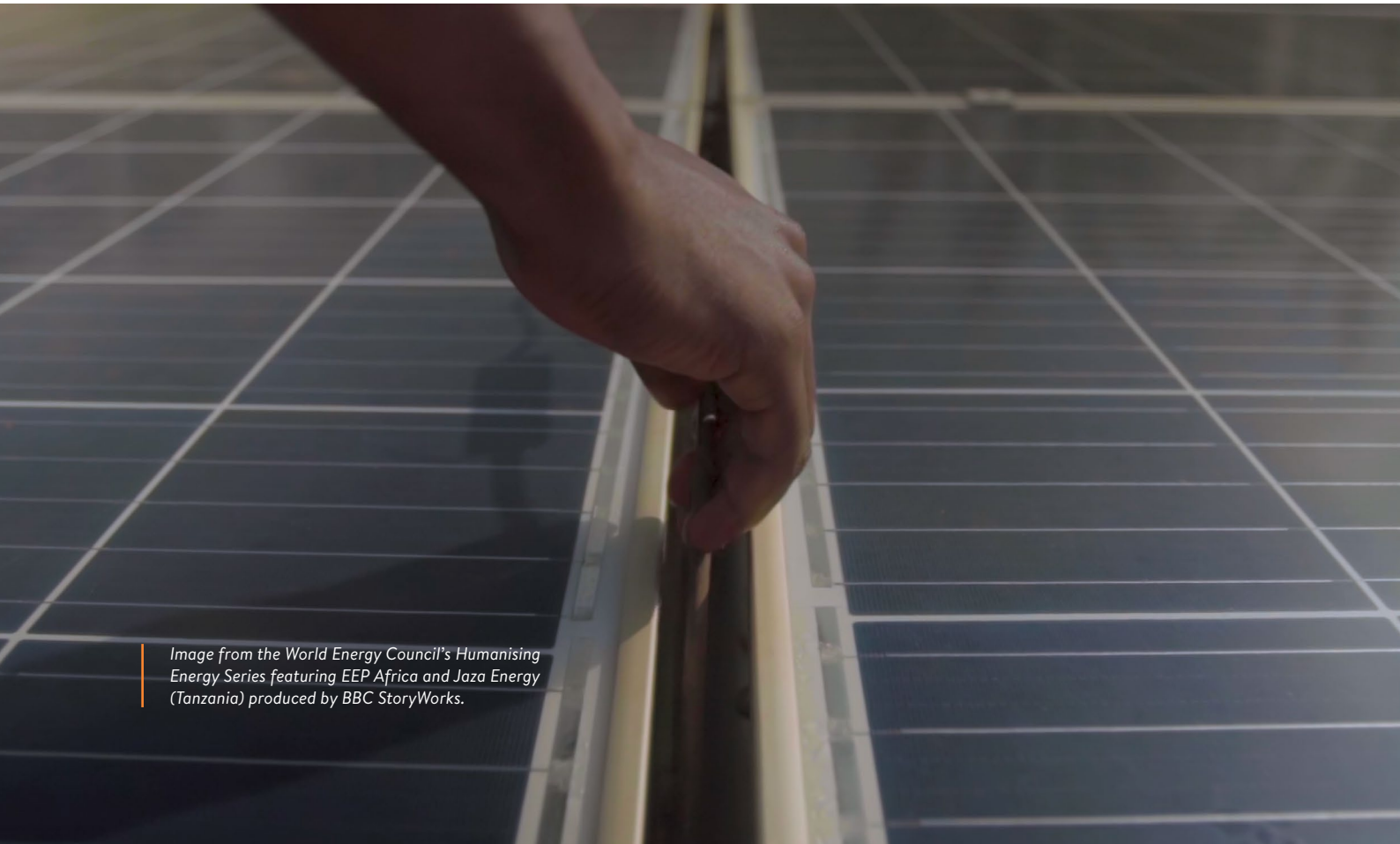


Image from the World Energy Council's Humanising Energy Series featuring EEP Africa and Jaza Energy (Tanzania) produced by BBC StoryWorks.

SUMMARY

ENERGY SECURITY

The Energy Security dimension measures a country's ability to meet current and future energy demand. An energy secure community will also be able to withstand and respond to supply shocks to minimise disruption to economic activity and consumers. In determining an energy security score, the dimension incorporates sub-indicators that cover the effectiveness of management of domestic and external energy sources, along with the reliability and resilience of energy infrastructure.

Figure 1: 2022 Top 10 Ranks in Security

Rank	Country	Energy Security Score
1	Canada	76.9
2	United States	74.1
3	Finland	73.8
4	Sweden	73.1
5	Czech Republic	72.9
6	Germany	72.5
7	Latvia	72.4
8	Hungary	72.1
9	Austria	71.6
10	United Kingdom	70.8

Source: World Energy Council

Figure 2: Historical Performance of 10 Top Improvers in Security

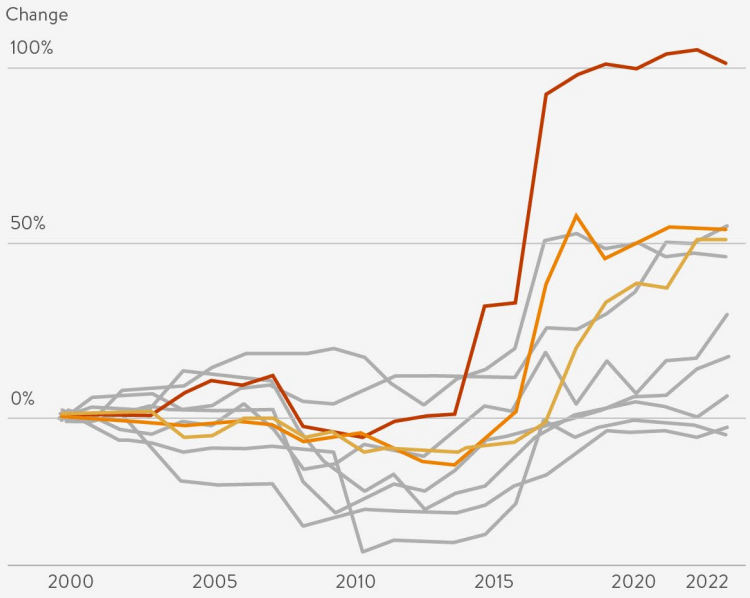


Figure 3: 2022 Top 10 Improvers in Security

Rank	Country	% Score Improvement
1	Cambodia	+101%
2	Tajikistan	+75%
3	Malta	+66%
4	Cyprus	+49%
5	Nepal	+48%
6	Jamaica	+45%
7	Lithuania	+44%
8	Myanmar	+41%
9	Kenya	+37%
10	Luxembourg	+33%

Source: World Energy Council

SUMMARY

- *Resource-rich nations Canada and the United States top the list for energy security. Finland takes third place followed closely by Sweden. The European top performers have highly diversified and innovative mixes of energy with fast adoption of renewables.*

- *Clearly, the data is not reflective of the energy security crisis in Europe. The presence of Germany in the top 10 indicates overall historical trajectories on track towards a strong performance in energy security, although this has been disrupted. In the short term, several countries in Europe may need to revert to alternative carbon intensive sources of power at the expense of environmental sustainability. In the medium and long term, the hope is that the geopolitical crisis will catalyse transitions to cleaner energy sources while keeping in mind energy security.*

- *The composition of the Trilemma data relies on lagging indicators using the latest available data which has yet to be reflective in the context of the most recent energy shocks. A more risk-based approach to diversify the electricity mix would support higher energy security.*

TRENDS IN ENERGY SECURITY

The Energy Trilemma Index by design is an analysis of energy trends. The Index uses the latest published data to calculate performance at a snapshot in time and compares with historical data to measure progress. It is not a predictive tool of what might happen in future, it is based on the data used as they are at the time. The presence of European countries among the top ten performers for Energy Security reflects their performance over time and is not indicative of the current energy security challenges facing the region.

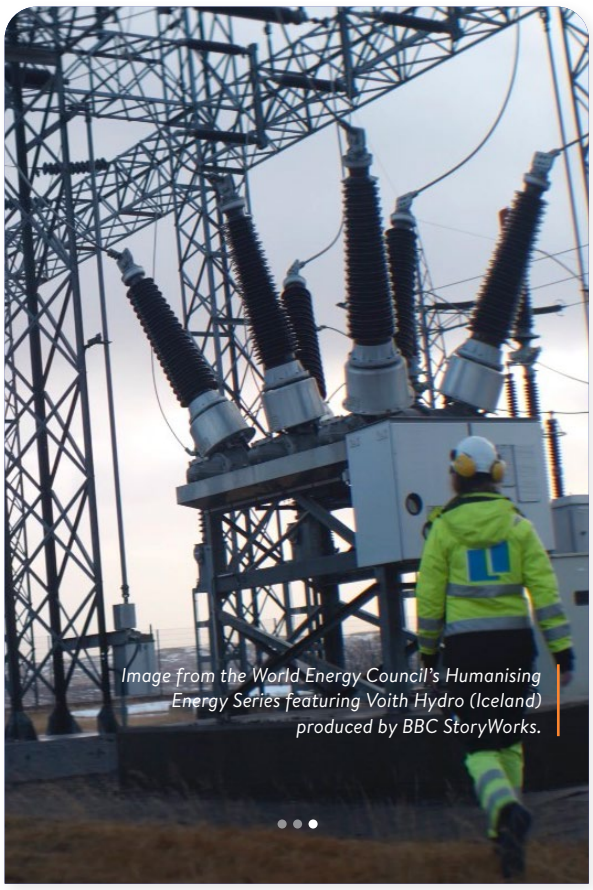


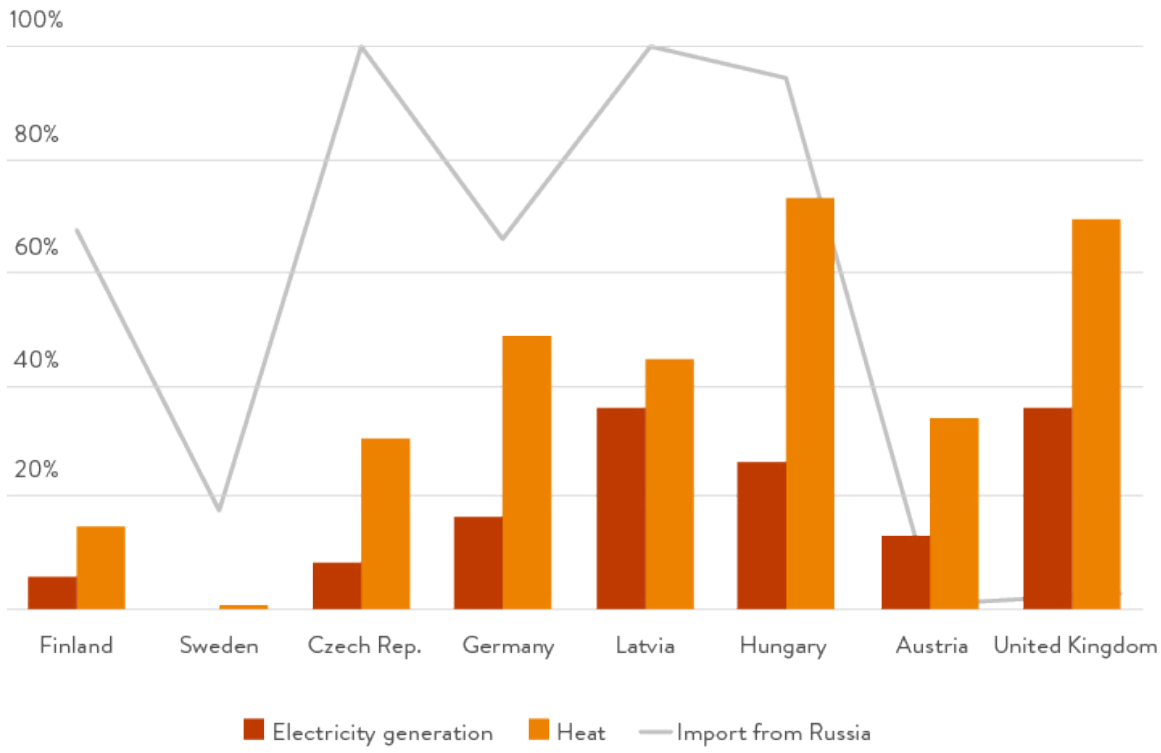
Image from the World Energy Council's Humanising Energy Series featuring Voith Hydro (Iceland) produced by BBC StoryWorks.

The threat to energy supply has rightly raised legitimate concerns about future energy security and the reliability of internal supply chains and cooperation. Many regions have enacted new energy policies to mitigate these and redesign energy systems to be more resilient to global supply shock. Europe, where the energy security crisis is perhaps most acute, has committed to eliminate its reliance on natural gas from its primary supplier Russia – replacing its natural gas demand with supply from elsewhere, plus looking to change the future energy mix through strategies like REPowerEU to accelerate development of renewable domestic energy.

The current European situation provides a prime example of why the three dimensions of the Trilemma – Energy Security, Energy Equity and Environmental Sustainability – need to be considered in concert, and not as three individual dimensions. That said, it is undeniable that many countries globally and across Europe – particularly those amongst the top 10 performers – are reporting energy security challenges. In Europe, the disruption to supply of energy imports from Russia have undoubtedly had an impact on energy security of supply fears.

But the situation across Europe is not homogenous – each country has quite different diversity supply and generation, and each relies on different import sources – some have taken advantage of being part of a complex, interconnected energy system and looking to harness domestic generation potential. Therefore, the potential impact on the Energy Security of those in the top 10 will vary – so perhaps it is not surprising to see so many European countries continue to feature in the top 10

Figure 4: Top 10 Europeans - natural gas usage vs. import from Russia



Source: IEA and Eurostat

Top performing Baltic nations like Sweden and Finland have a low share of natural gas in their energy mix, with diversified energy systems including nuclear, hydro and biomass generation. Finland does import ~70% of its gas from Russia, but gas' relatively low share in Finland's energy mix means their Energy Security scores are unlikely to be impacted significantly.

At the other end of the chart, the United Kingdom's energy system is highly dependent on natural gas – but along with Austria, their reliance on Russian imports is negligible, thus energy security is not directly impacted. Both countries have diversified energy systems with UK increasingly generation from wind and solar as well as nuclear, biomass and hydro. Austria is predominantly hydro and is also increasing shares of renewable energy. The energy security impact may come if current gas supplies are diverted to the other counties whose supplies are disrupted.

The top 10 performing European countries most at risk from an energy security challenge are Germany (which has been well documented), Hungary and Czech Republic – particularly regarding dependence on Russian gas imports for heat. Germany is the biggest consumer of natural gas in Europe, the majority of which is imported from Russia via pipelines. At the time of writing (September 2022) the main Nordsteam pipeline linking Germany to Russia through the Baltic Sea is shut off, having only operated at ~20% capacity for preceding months. Luckily Germany's energy storage (another measure of Energy Security in the Trilemma) is at high capacity, limiting the immediate energy security impacts.

Hungary and Czech Republic have the highest dependency on imported Russian gas – fed via the Turksteam and Druzbha pipelines in Southern Europe, neither of which have experienced the disruption of Nordstream (there have been minor supply disruptions to Hungary, Czech Republic and Slovakia due to disputes over transit payments, but by and large there has been minimal actual impact on energy security). Hungary's energy system is heavily reliant on natural gas, 95% of which is imported from Russia. Hungary recently (August 2022) signed a new deal to import more Russian gas in addition to

what they had already contracted. The Czech Republic have a lower share of natural gas in their energy mix but are wholly dependent on imports from Russia, so any supply disruptions would be significant.

There is no doubt the current situation in Ukraine, and the subsequent disruptions to global energy supply chains will have a lasting impact on international energy flows. The situation in Europe is changing, and in future years the energy mixes across member countries and beyond could look quite different.

As Europe faces a winter of heightened uncertainty around energy supply and security, policymakers are acting to address the immediate challenges around energy affordability, whilst also managing their transition to a net zero energy system – keeping the Trilemma in balance. Short term, addressing energy costs and ensuring energy security are overriding priorities, which has seen a temporary increase in coal use and a delay in plans to shut down plants which were due to be mothballed. Longer term, the REPowerEU plan sets out the region's strategy to end dependence on Russian fossil fuel imports through energy savings, increase diversity of supply and accelerate roll out of renewable energy.

SIGNIFICANT IMPROVERS IN ENERGY SECURITY

The top improving countries are an eclectic mix of developed and developing countries across multiple regions, each adopting different strategies to improve energy security. Developed nations with sophisticated energy systems have focused improvement on different indicators compared with developing nations, with others showing a more rounded improvement across all indicators. Malta is the outstanding energy security improver, whose significant increase in score is due to its integration into the European energy network in 2015. This helped Malta rapidly diversify its energy supply mix and significantly reduce dependence on sea-borne energy imports. Malta's energy system has continued to evolve in line with European Union requirements – compliance with has also been a driver energy security improvement for of Lithuania, who have increased both diversity of supply and energy storage over the period.

Small, wealthy energy import dependent countries Luxembourg and Singapore feature here due to increasing diversity of import suppliers to spread the risk. Luxembourg have also improved diversity of generation by adding some domestic renewables generation.

In contrast, security improvements in developing nations like Cambodia, Tajikistan and Myanmar are primarily due to investments in energy infrastructure to expand network coverage, diversify generation and improve system stability and recovery. All three countries have increased share of hydropower over the period, with Cambodia and Tajikistan also increasing coal usage and Myanmar expanding on natural gas – which does help diversify their energy systems from a security perspective, but not so good for environmental sustainability. Cambodia are also one of the biggest improvers on increasing electricity access, expanding coverage to an additional 50% of their population – making it one of the top improvers for Energy Equity also.

The two countries that have improved most consistently across all Energy Security Indicators are Jamaica and Cyprus. These are two sizeable energy import dependent island states, but both have made steady incremental improvements on diversity of supply and generation, import independence, energy storage and marginal improvements to energy system resilience.

Estonia is the country with the biggest numerical score increase (as opposed to % increase). Estonia is diversifying their energy mix, phasing out their historical dependence on oil shale by 2035 and replacing with gas and renewables. An under the sea gas pipeline from Estonia to Finland has been operational since 2020 and a domestic fixed rate subsidy scheme has boosted solar generation. Estonia aims to disconnect Baltic electricity from Russian synchronous areas and synchronize instead with Europe.

Energy Security is an emotive issue, and as covered above is closely tied with Energy Equity and Environmental Sustainability. For the top performing countries – all developed nations integrated into global energy markets where universal access to affordable, reliable energy at the flick of a switch is taken for granted – the threat of supply disruption is frightening and is resulting in a rewiring of global energy trade flows. Global energy trade will continue, and many countries will continue to rely on others for energy imports – but increasingly countries are looking to harness domestic generation potential where possible to improve energy security.

For developing nations, Energy Security is perhaps more about increasing energy access, increasing energy supply and generation, and improving energy system reliability though investments in energy infrastructure. A significant share of new capacity is renewable energy, but also into gas for some, which will impact Sustainability scores.

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

Figure 5: Top 10 Performers in Equity

Rank	Country	Energy Equity Score
1	Luxembourg	100
2	Qatar	99.9
3	Kuwait	99.8
3	UAE	99.8
4	Oman	99.6
4	Iceland	99.6
5	Bahrain	99.5
6	Ireland	98.6
7	Trinidad & Tobago	98.4
7	Switzerland	98.4
8	Israel	98.3
9	United States	97.3
10	Saudi Arabia	97.2
10	Norway	97.2

Source: World Energy Council

SUMMARY

ENERGY EQUITY

The Energy Equity dimension assesses a country's performance in providing reliable access to affordable energy – two asynchronous inputs which must be tackled in tandem to help support economic development and prosperity. Reliable energy access is assessed both from a binary basic measure aligned to UN Sustainable Development Goal 7 (SDG7) plus, increasingly, on the more nuanced metric of quality energy access required to enable economic growth. Energy affordability is determined by a combination of energy prices and broader socio-economic improvements, which influence how affordable a commodity like energy really is.

Figure 6: Historical Performance of Top 10 Improvers in Equity

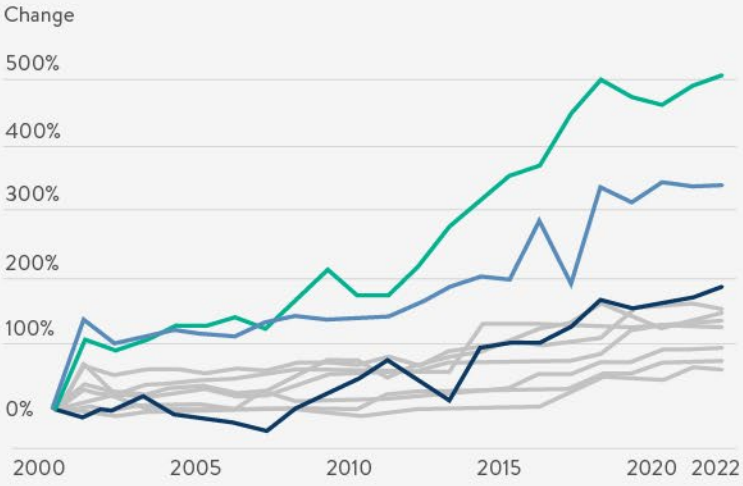


Figure 7: Top 10 Improvers in Equity

Rank	Country	% Score Improvement
1	Ethiopia	+102%
2	Kenya	+91%
3	Nepal	+69%
4	India	+60%
5	Mongolia	+57%
6	Cambodia	+51%
7	Nigeria	+50%
8	Tanzania	+47%
9	Bangladesh	+42%
10	Sri Lanka	+37%

Source: World Energy Council

SUMMARY

- *Energy Equity scores are improving, including the thresholds to achieve an A, B or C rating – but there are countries at the bottom of the ranking who are not progressing and thus creating a widening equality gap in Energy Equity.*
- *The impact of increased wholesale energy prices through late 2021 and 2022 are not yet fully reflected in the 2022 Energy Equity dimension results – scores for energy import dependent countries will be most affected by prolonged high energy prices; for both developed high performers and developing countries .*
- *Energy exporting countries dominate the top Energy Equity performers – especially the Middle Eastern countries whose energy is heavily subsidised by the state.*
- *The top Energy Equity improvers are from sub-Saharan Africa and South East Asia, whose progress is primarily due to investments in energy infrastructure to substantially increase energy access to their populations.*
- *All the top improvers despite their progress, are still within the lowest D rating for Energy Equity – so there is still much progress to be made to help these, and perhaps more importantly the other lowly ranked countries that are not improving, to catch-up and close the equality gap.*

TRENDS IN ENERGY EQUITY: WIDENING INEQUALITY IN ENERGY EQUITY

The Energy Equity dimension measures performance in providing access to reliable and affordable energy as an enabler of socioeconomic development. The dimension assesses basic binary access to electricity and clean cooking fuels and technologies, the reliability, availability and abundance of energy as well as the affordability of fuel, electricity and gas (if applicable).

The significant price rises in energy commodities such as oil, gas and coal through 2021 and 2022, and their subsequent impact on retail energy prices, are not fully reflected in the results below. The Trilemma model uses latest published annual datasets, so any in year dramatic changes are not always immediately included. The report does assess the potential impact to Energy Equity scores from sustained price increases.

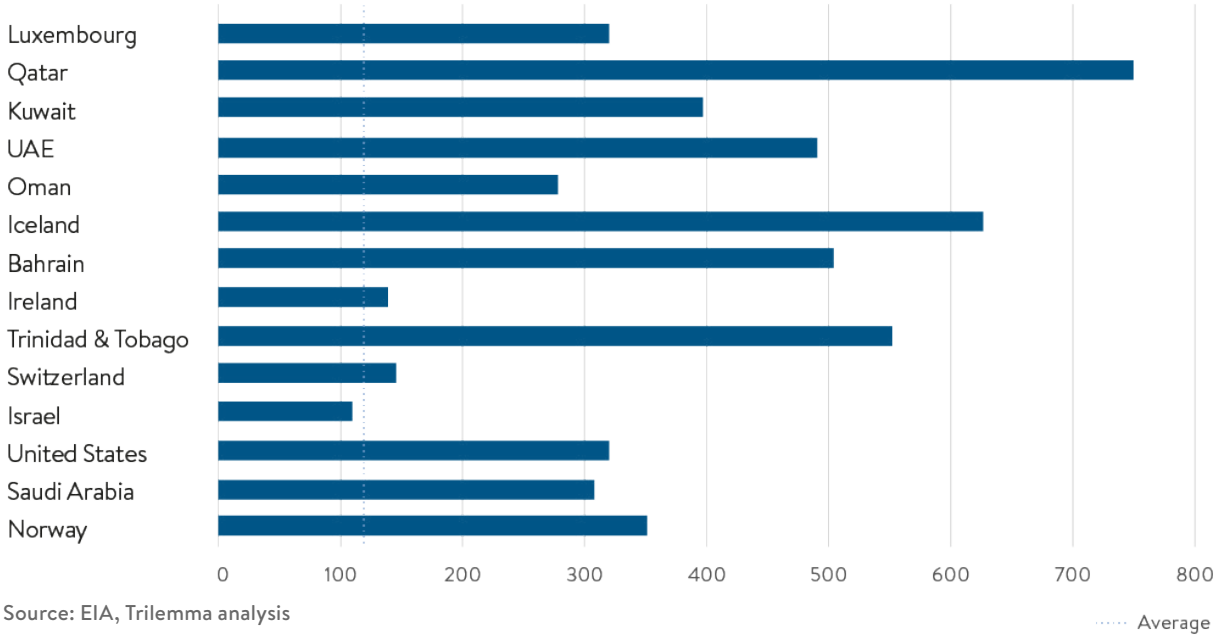
Strong Energy Equity performance is directly correlated with strong socioeconomic metrics such as GDP per capita or UN Human Development Index, creating a virtuous cycle of improving economic prosperity and quality of life where abundant, reliable, affordable energy taken as given and energy policies and investment are aligned to maintain this expectation. In contrast, many of the poorest Energy Equity performers are also some of the least economically developed, creating a vicious cycle of underinvestment in energy infrastructure to boost even basic energy access requirements. The gap between top and bottom performers is widening, and those in the bottom are in danger of being left behind.

The top ranked Energy Equity performers are all developed, higher GDP countries with universal access to abundant, reliable, affordable prosperity enabling energy at the flick of a switch. It may be contradictory that Luxembourg, a country with limited energy resources and highly dependent on energy imports is #1 ranked for Energy Equity, where almost all other top performers are energy resourced, energy independent countries. Luxembourg benefits from its central Europe location to be well interconnected to neighbouring energy networks in Germany, France and Belgium, plus has some of the lowest energy taxes in Europe coupled with the highest GDP per capita – helping to make energy quite affordable. However, the high purchasing power / low tax scenario creates less incentive to invest in sustainable domestic energy to align with EU targets, and the low taxes on fuels also encourages 'energy tourism' from neighbouring countries to the extent that non-residents account for approx. 2/3 of Luxembourg's transport fuel consumption.

Hydrocarbon-resource rich countries of the Middle East Qatar, Kuwait, UAE, Oman and Bahrain make up the top #5 ranked Energy Equity performers. These smaller GCC countries, along with larger neighbour Saudi Arabia, are consistently amongst the top Energy Equity performers given their abundance accessible oil and gas reserves. The social contract between Government and citizens to use these reserves to benefit socio-economic development means energy costs are heavily subsidised and made very affordable.

Trinidad and Tobago is the first Latin American country to feature in the top performers for Energy Equity – improving 14 ranking places this year to get into the top 10. Although its hydrocarbon production has declined significantly over the last decade, Trinidad & Tobago remains an energy exporter, exporting >80% production. It also has the 5th highest energy consumption per capita globally, nearly 10x that of other Latin American countries. In fact, the correlation between energy equity and energy consumption per capita is quite startling – most of the top performing Energy Equity counties are amongst the top energy consumers, which demonstrates if energy is abundant and available, then it will be consumed. Only Israel is below the 118 gigajoules per capita average.

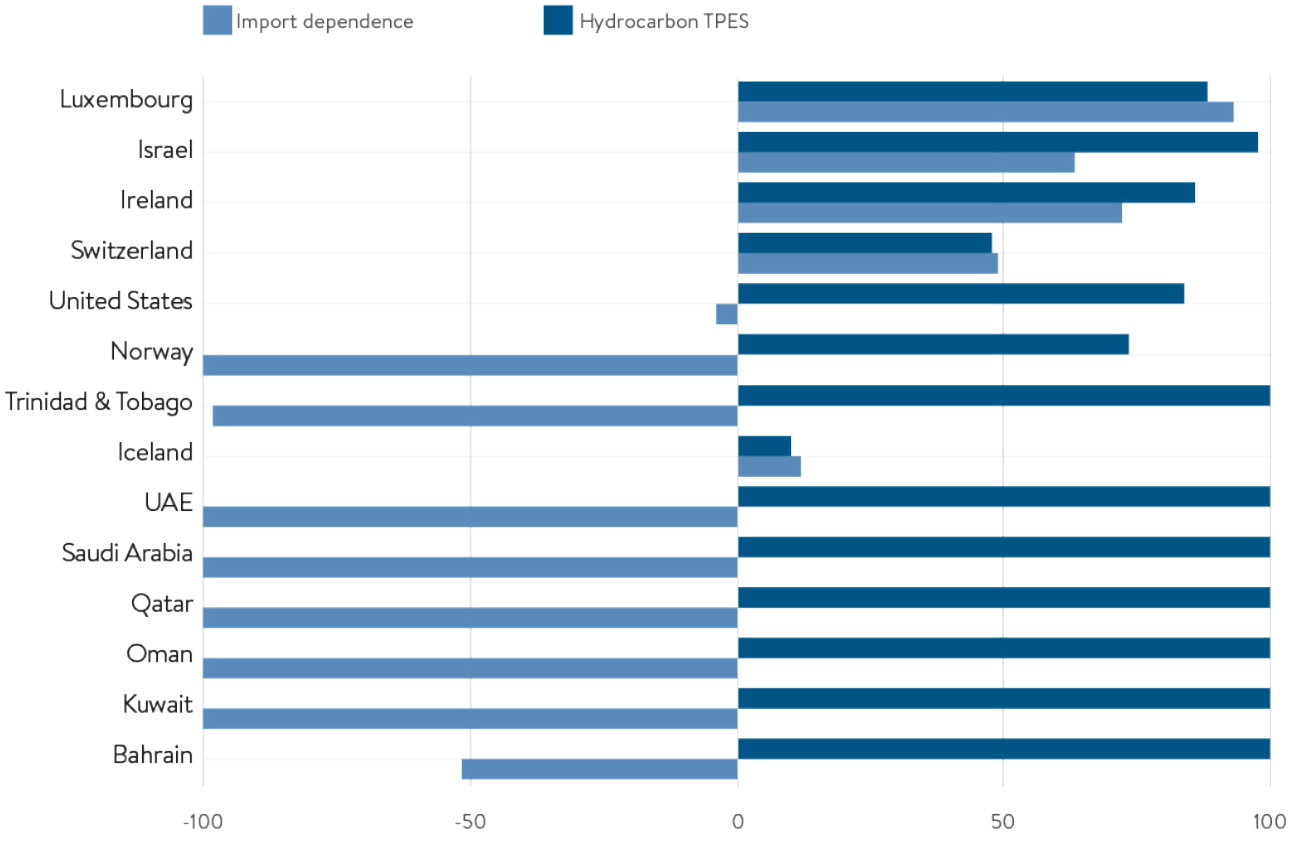
Figure 8: Total energy consumption per capita (gigajoules)



Source: EIA, Trilemma analysis

As caveated above, the rise in wholesale global commodity prices which led to higher energy prices for many are not reflected here. Coupled with higher inflation, the energy equity scores of the top performers could be impacted quite differently:

Figure 9: Energy import dependence % vs. share of hydrocarbons in Total Primary Energy Supply (TPES)



Source: EIA, Trilemma analysis

- Most susceptible are the energy importing countries whose energy systems include a high share of hydrocarbons. Luxembourg, Ireland, Israel, and Switzerland are most likely to be impacted if global commodity prices and energy prices remain high.

- Least susceptible are the hydrocarbon producing and exporting countries in the Middle East. High wholesale commodity prices are boon for their broader hydrocarbon-based economies, and their subsidised domestic energy systems will ensure prices remain affordable for consumers.

- Energy exporting countries like the United States, Norway and Trinidad & Tobago where there is a decoupling of wholesale energy and consumer energy prices (as opposed to Middle East where these are integrated) may also see some impact.

- Iceland with low import dependence and low share of hydrocarbon TPES may also be minimally impacted.

ENERGY EQUITY – TOP IMPROVERS

While the top energy equity performers have little room for improvement, further down the rankings some countries have made remarkable improvements through increasing energy access and affordability. The top 10 improvers since 2000 and over the past decade are dominated by a consistent group of developing sub-Saharan African and South East Asian countries whose energy policies have driven energy equity score improvements.

Each of the top improving countries have taken different actions and are on different trajectories for improvement. East African neighbours Kenya and Ethiopia are amongst the most consistent year-on-year improvers, with both countries making significant progress on improving electricity access as per UN Sustainable Development Goal 7 (UNSDG7); Ensure access to affordable, reliable, sustainable and modern energy for all. Kenya's ongoing National Electrification Strategy to provide universal electricity access has added >50% of the population to the electricity network over the past decade which has helped to double their energy equity score over the period. This expansion in access is coincident with rapid growth in economic productivity, with Ethiopia one of the fastest growing GDP per capita over the past 10 years.

That said, both Kenya (ranked #100) and Ethiopia (#94) achieve a D rating for energy equity, so still a lot of room to continue to improve, especially on key metrics like clean cooking technologies. Biomass is the primary energy source (86% in Ethiopia, 65% in Kenya), which will rebalance as electrification expands. For electricity generation, each country harnesses domestic natural energy resources – in Ethiopia >96% of generation is hydro while Kenya ~50% is geothermal, followed by hydro and solar/wind. Both countries have negligible hydrocarbon-based energy

The country with the biggest absolute point improvement in equity score over the decade and another consistent improver is Mongolia – a country with a very different energy system than Kenya and Ethiopia. Mongolia's energy system is almost entirely fossil fuel based, with coal (92%) the primary source of electricity generation and the source of electricity generation. But like Kenya and Ethiopia, Mongolia's improvement is due to progress on the UNSDG7 goals – extending electricity and clean cooking access to additional 20% of the population and achieving near universal electricity access. Again, like Kenya and Ethiopia, despite the improvements Mongolia (ranked #70) still achieves a D rating for energy equity. In fact, all the top improvers listed above are rated D.

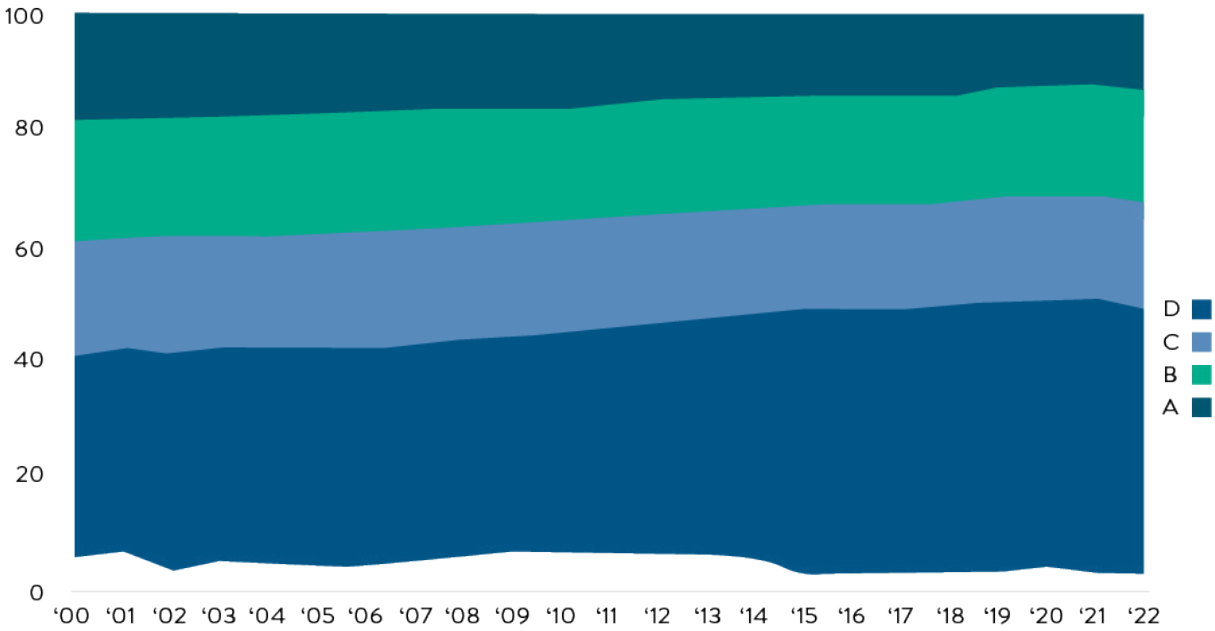
ENERGY EQUITY EQUALITY – ARE SOME COUNTRIES AT RISK OF BEING LEFT BEHIND?

The top performing countries consistently score 100 or high 90s - with little room to improve. At the other end of the scale some of the lowest performing countries are not improving - and in fact the gap between best and worst scores is wider now than it was in 2000.

The trend for energy equity performance shows overall improvement since 2000, with average scores up 11% over the period. Improvements for most countries mean more counties are achieving A or B ratings, with the thresholds to achieve each rating also increasing since 2000 (A rating threshold up 7%, B rating up 11% and C rating up 20%). However, there are a cluster of mainly sub-Saharan African countries perennially in the D rating which are not improving and widening the equality gap.

A closer look at the D rated countries, and particularly those in sub-Saharan Africa highlights the energy equity disparity at a geographic level. The energy policies of top improving countries like Kenya, Ethiopia or Tanzania focused on investment in energy infrastructure to improve electricity access, which in turn has helped boost economic productivity over the past decade. Alongside Ghana and Cote D'Ivoire these five countries that have increased electrification the most in the region combined experienced average economic productivity growth of >70%.

Figure 10: Energy equity performance



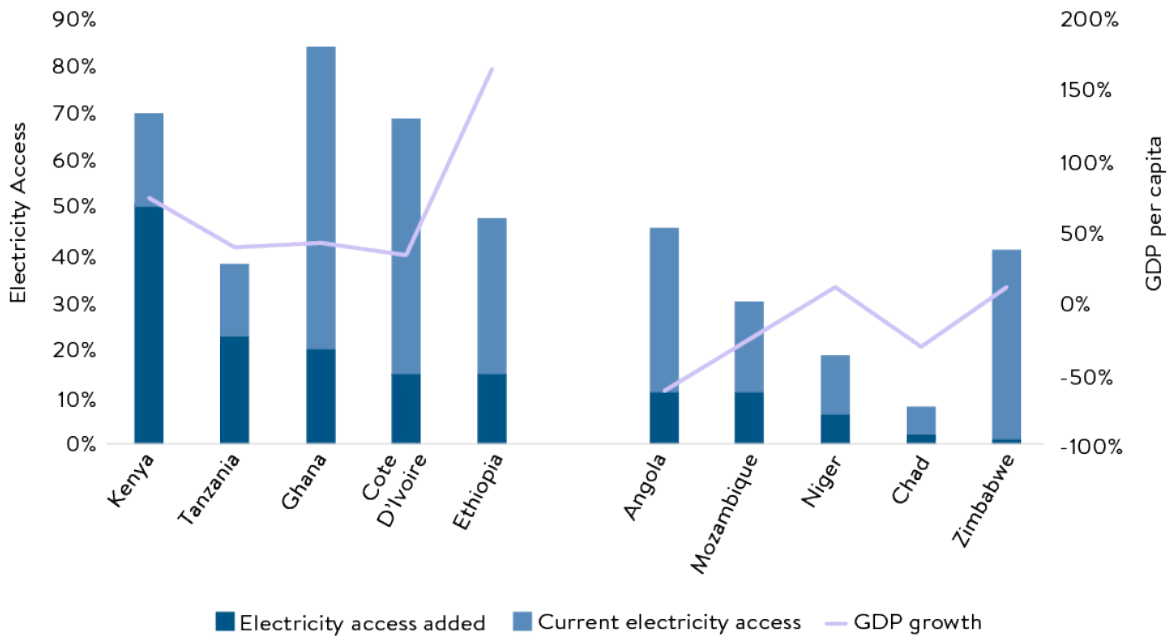
Source: World Energy Council

In contrast, the sub-Saharan African counties that have not progressed on fundamental energy access metrics are caught in a vicious cycle of low energy access and lower economic growth, and in many cases shrinking economic productivity in real terms – a situation that has been exacerbated over the latest years due to the impacts from COVID. Chad and Niger are amongst the lowest scoring countries for energy equity and have seen scores decline over the past decade. They have the lowest electrification rates globally, and along with Zimbabwe, have made least progress in increasing electricity access over the past decade – which has had a knock-on impact of stifling economic productivity and development. Alongside Angola and Mozambique being the five countries that have made least progress on electrification, the combined average economic productivity for these fell by ~20%.

Angola is an interesting case – a country with similar electrification levels as Ethiopia, economic performance is starkly different. A net energy exporter and second largest hydrocarbon producer on the continent after Nigeria, Angola's hydrocarbon based-economy has been impacted especially hard due to downturn in demand due to COVID. GDP per capita declined >35% since the pandemic and coupled with a relatively high cost of living (until recently Luanda was one of the most expensive cities to live in Africa) has impacted energy affordability.

Access to reliable, affordable, quality energy is an enabler of socioeconomic development. Further progress is needed on providing fundamental universal access to close the energy equity equality gap and ensure poorest performers are not left behind. Energy systems also need to evolve to harness sustainable domestic generation opportunities, reducing dependence on imports of energy sources whose wholesale prices are subject to fluctuation.

Figure 11: Electricity access growth vs. GDP productivity growth 2012-2022



Source: UNSDG7, World Bank, Trilemma analysis

SUMMARY

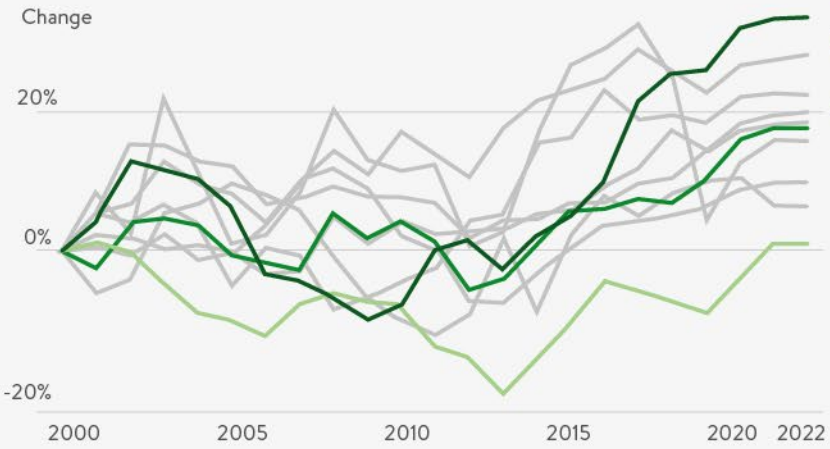
ENVIRONMENTAL SUSTAINABILITY

Environmental Sustainability measures the performance of a country's energy system in avoiding environmental damage and mitigating climate change. It considers energy resource efficiency, decarbonization, carbon dioxide and methane emissions, and air pollution. In order to ensure a fair comparison across countries, the Sustainability score is calculated by incorporating information on population, overall energy production, and GDP.

Figure 12: Top 10 Performers in Sustainability

Rank	Country	Sustainability Score
1	Sweden	87.5
2	Switzerland	87.1
3	Norway	85.8
4	Denmark	84.7
5	Uruguay	84.0
6	France	83.4
7	United Kingdom	83.2
8	Brazil	82.8
9	Albania	82.7
10	Luxembourg	82.1

Figure 13: Historical Performance of Top 10 Performers in Sustainability



Source: World Energy Council

Figure 14: Top 10 Improvers in Sustainability

Rank	Country	Score Improvement
1	China	+32%
2	Angola	+25%
3	Saudi Arabia	+20%
4	India	+19%
5	Ecuador	+18%
6	Qatar	+18%
7	Uruguay	+17%
8	Denmark	+16%
9	Malta	+15%
10	Benin	+15%

SUMMARY

- *Sweden, Switzerland, and Norway are the top performers in the Environmental Sustainability dimension with low carbon sources providing for over 95% of electricity generation in each country.*
- *Uruguay and Brazil are the only two non-European countries in the top 10, benefitting from a large contribution of renewables to their energy mix.*
- *Angola, China, and Saudi Arabia are the top improvers since 2012. Despite progress made, these three countries still occupy low positions in the global Environmental Sustainability ranking.*
- *After plunging in 2020 due to the COVID-19 pandemic, global greenhouse gas emissions from energy rebounded in 2021, slowing countries' progress towards their decarbonisation commitments and highlighting the need to adopt new technologies to support the transition.*
- *Climate change is posing unprecedented challenges to energy systems, with worsening physical impacts on infrastructure often not designed to withstand more frequent and intense weather extremes. Hydropower is particularly exposed, and its financial viability, together with power generation itself, is increasingly threatened by climate change.*

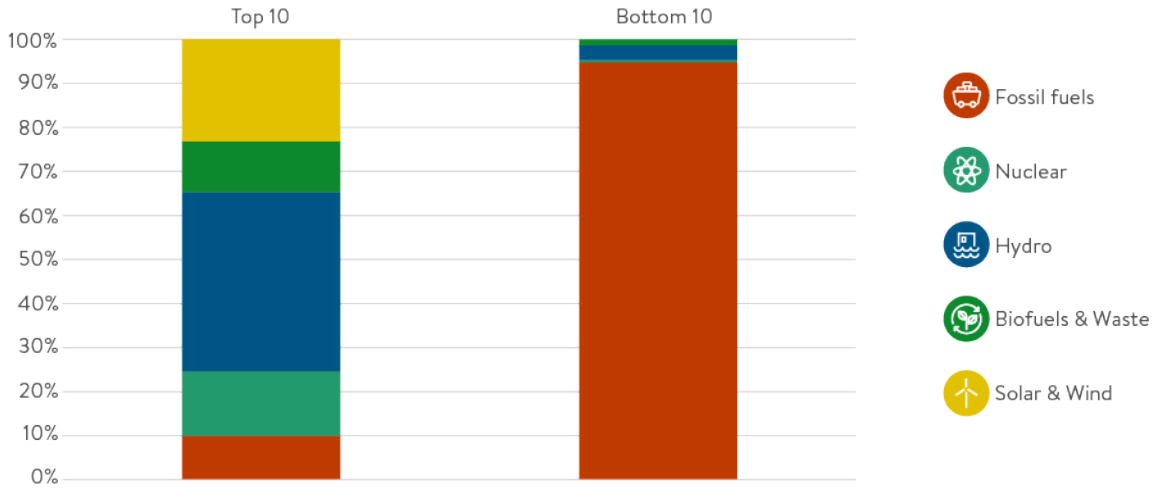
TRENDS IN THE ENVIRONMENTAL SUSTAINABILITY

The global average sustainability score has only marginally improved (by 2.4%) in the last decade. This underscores the need to accelerate decarbonisation, which is increasingly complicated by the ongoing affordability crisis, energy market disruption, and climate change impacts.

The top 10 ranking in environmental sustainability remains dominated by European countries, due to high levels of low-carbon electricity generation and energy system efficiency (Figure 12). Eight of the top 10 spots go to European nations, with Sweden topping the ranking thanks to its low energy consumption relative to GDP, and to the low levels of emission made possible by the country's reliance on hydroelectricity (44% of total electricity generation in 2020), nuclear power (30%), and solar and wind (18%). Uruguay and Brazil, the only two non-European countries in the top 10, are benefitting from a large contribution of renewables to their energy mix. Uruguay generates 45% and 31% of its electricity from solar and wind, and hydropower, respectively, whereas hydroelectricity accounts for 64% of power generation in Brazil. Luxembourg entered the top 10 ranking thanks to the steady improvement made over the last decade in decarbonizing its energy generation and reducing air pollution, with a notable increase in the percentage of low-carbon electricity generation since last year.

High sustainability scores are typically driven by the large-scale deployment of low-emission energy sources such as nuclear and renewables, and by high levels of energy efficiency. Figure 15 presents a comparison between the average electricity generation mix for the top and bottom 10 countries in the sustainability ranking. The top 10 countries are characterised by much higher contributions of hydropower, nuclear, solar, wind, and biomass, and by a lower dependency on coal and natural gas. The bottom 10 countries, on the other hand, remain heavily reliant on fossil fuels, on average accounting for about 95% of their electricity generation.

Figure 15: Average electricity generation mix for the top 10 and bottom 10 countries



Source: World Energy Council

Among the top improvers in Environmental Sustainability since 2012 (Figure 14), China moved from the 118th to the 95th position in the global ranking. The country has been the largest investor in renewable technologies for most of the past decade and has been making steady progress in efficiency by increasing its CO_2 intensity, measuring CO_2 emissions per unit of GDP produced. Efforts to decarbonise, however, have been partly counterbalanced by a rapid rise in energy consumption. Angola, as the second among the top improvers, moved from the 91st to the 40th position by substantially increasing its share of low-carbon electricity generation and improving on greenhouse gas emissions from the energy sector.

Figure 16: Top 10 relative improvers (%) in Environmental Sustainability since 2012

Country	2022 score	2012 score	Percentage change
China	59.4	44.9	32.2%
Angola	74.7	59.7	25.1%
Saudi Arabia	51.7	43.1	19.8%
India	51.0	43.0	18.7%
Ecuador	76.4	64.7	18.0%
Qatar	46.2	39.2	17.8%
Uruguay	84.0	71.6	17.3%
Denmark	84.7	73.0	16.1%
Malta	78.4	67.9	15.4%
Benin	43.5	37.8	15.2%

Source: World Energy Council

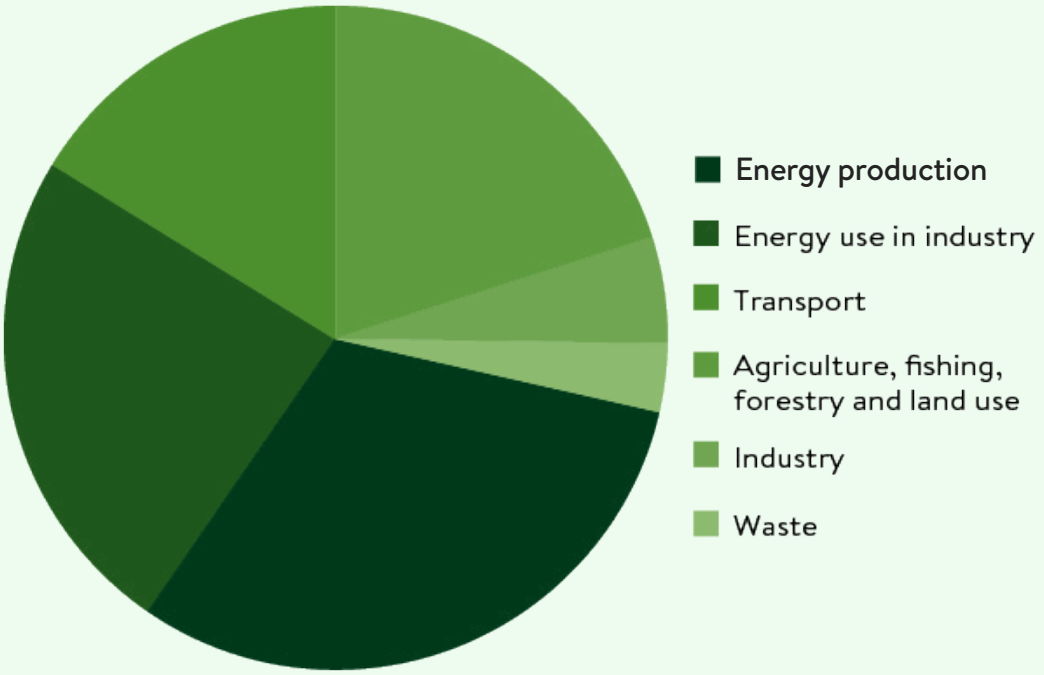
NET-ZERO: PROGRESS OR STALLING?

Since the adoption of the 2015 Paris Agreement at COP21, a growing number of countries and organisations have been committing to net-zero. Efforts to decarbonise have gained further momentum since 2020 and culminated with COP26 in 2021, with over 140 countries pledging to reach net-zero by mid-century, and 40 countries committing to phase out coal.

THE ROLE OF ENERGY SYSTEMS IN THE TRANSITION TO NET-ZERO

Reaching net-zero means stabilising our planet's atmospheric concentration of greenhouse gases. This will require a dramatic reduction of emissions, with any outstanding imbalance being removed from the atmosphere either by natural processes such as reforestation or through the deployment of novel greenhouse gas sequestration technologies. Electricity and heat production and additional emissions from the energy sector contributed to about 31.1% of global greenhouse gas emissions in 2020 (Figure 17), highlighting the critical importance of decarbonising energy systems in achieving net-zero.

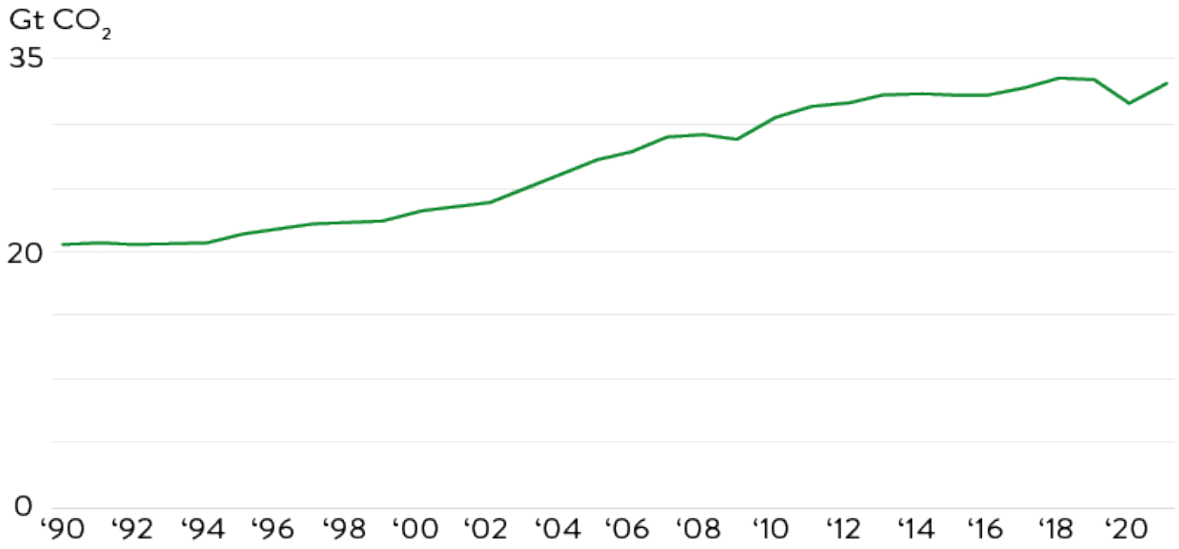
Figure 17: Sources of global greenhouse gas emissions by sector (2020)



Source: OurWorldInData.org, Climate Watch, World Resources Institute. Data licensed under CC-BY by Hannah Ritchie (2020).

Despite accelerating efforts, however, achieving net-zero will be challenging. Progress with decarbonising energy systems has been slow in many countries, and despite a sharp decrease in global carbon dioxide emissions during the COVID-19 pandemic, greenhouse gas emissions from energy rapidly rebounded to the highest levels ever recorded by the end of 2021 (Figure 18).

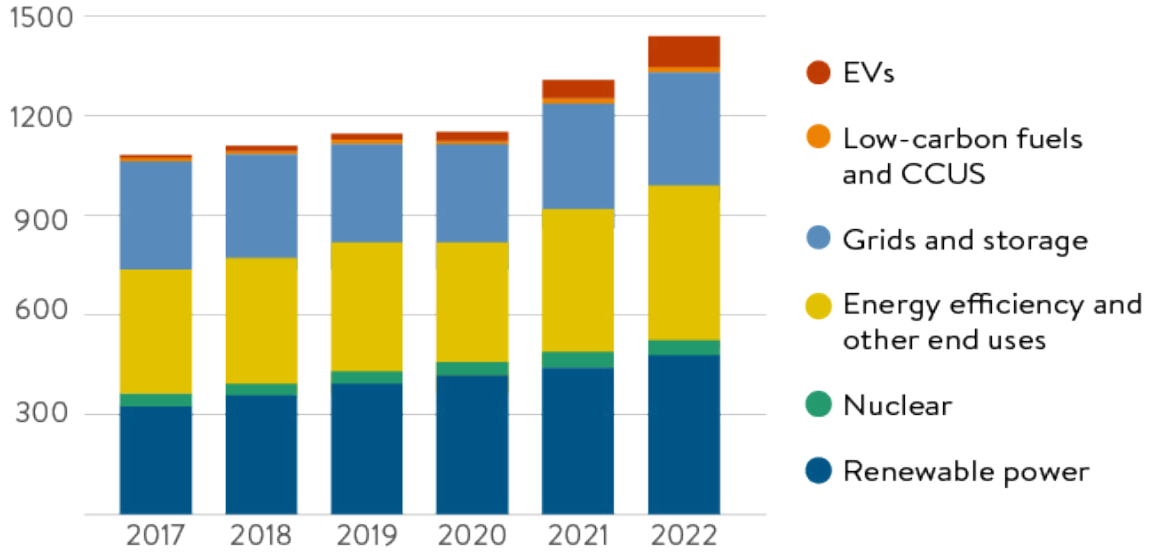
Figure 18: Global CO_2 emissions from energy



Source: International Energy Agency's Global Energy Review 2021

Achieving carbon neutrality will require decarbonisation of energy systems, and governments and private organisations are ramping up investments in low-carbon generation, energy efficiency, grids, and storage (Figure 19). Government spending in the wake of COVID-19 led to a rise of energy investments globally, with financing in 2022 expected to be well above pre-pandemic levels. Investment in clean energy have increased significantly and they now account for about three quarters of the growth in energy investments.

Figure 19: Global investment in low-carbon generation, energy efficiency, grids, and storage



Source: International Energy Agency's World Energy Investment 2022

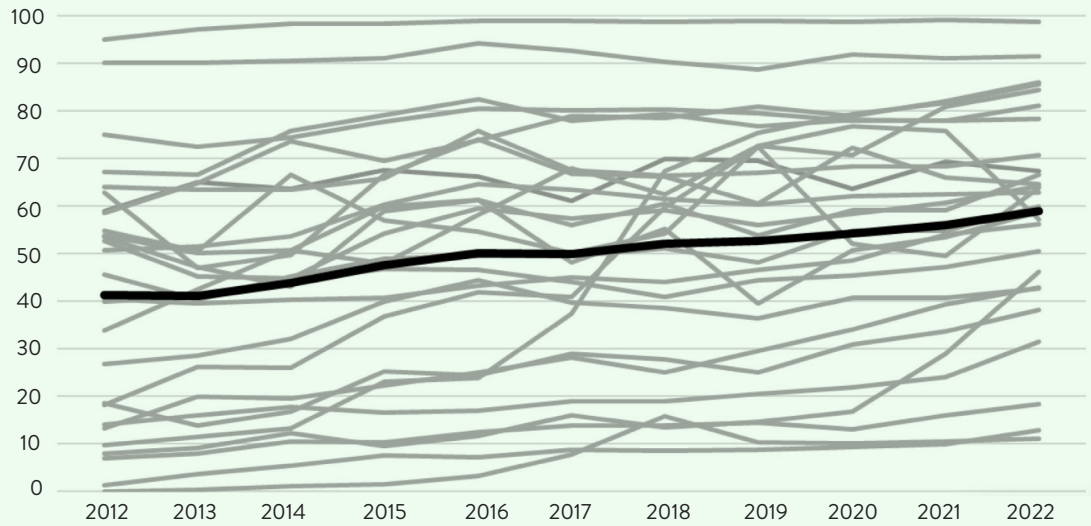
The rise of investments in renewables is linked to the growing competitiveness of low-carbon generation technologies: According to IRENA, in 2021 costs continued to fall for onshore wind (15%), solar photovoltaic (13%) and offshore wind (13%), leading to a record-high 9% increase in global renewable capacity generation compared to 2020.

There is, however, a widening gap between major economies such as the European Union, the United States, and China, and most emerging markets, with the former seeing a sustained growth in clean energy investments during and after the pandemic. In 2020, on the contrary, clean energy investments in developing countries saw an 8% contraction, followed by a modest growth in 2021 and in 2022. As a result, per-capita clean energy investments in advanced economies and China in 2022 are expected to be about 10 times and 6 times higher than in developing economies, respectively.

EUROPE'S CHANGING ENERGY STRATEGIES AND NEW DECARBONIZATION COMMITMENTS

Following the invasion of Ukraine in February 2022, Russian exports of natural gas have substantially decreased, disrupting the world's energy market: During summer 2022, gas prices in Europe were six times higher than the year before. The impact on decarbonization efforts across Europe is currently unclear: In the short term there could be an increased reliance on coal, but in the medium to long term the need to bolster energy security may lead to an acceleration in decarbonization efforts. European Union member countries have very different levels of low-carbon electricity generation in their energy mix, as represented by the C2a sub-indicator in the Trilemma model, they have been making progress in decarbonizing their energy systems (Figure 20). With the REPowerEU plan, the European Commission has committed to accelerate the phase out of fossil fuels by significantly increase investments in energy efficiency and renewable generation.

Figure 20: Low-carbon electricity generation (C2a) scores for European Union member countries (grey lines), and EU27 average (black line)



THE ROLE OF TECHNOLOGY

Achieving net-zero energy systems will require heavy investments in transition technologies such as hydrogen, battery storage, and carbon capture, utilization, and storage (CCUS). Research and development efforts have led to great progress in recent years, but some hurdles still exist hindering the large-scale deployment of these technologies. Both public and private involvement will be needed to accelerate the process. Reaching net-zero by 2050 will require a six-fold increase in hydrogen production compared to present-day levels, as well as investments to decarbonise production. Further technological developments in lithium-ion battery will be critical to boost energy storage, a necessary step to increasing access and reliability of renewables and to increase grid resilience. Carbon capture technologies are still in their infancy, but the number of CCUS facilities operating and in development has been rapidly growing. In 2010, 11 plants were operational and other 69 had been announced or were under construction. In 2021, the number of operating plants rose to 27, with 168 additional facilities at different stage of development. Global funding for CCUS jumped more than fourfold in 2021 compared to 2020, having previously only accounted for less than 0.5% of global investment in clean energy up to 2020. Although recent progress is encouraging, the planned pipeline of projects would fall short of delivering the 1.7 billion tonnes of CO_2 capture capacity deployed by 2030 in the Net Zero by 2050 scenario.

CLIMATE IMPACTS HINDERING DECARBONISATION EFFORTS: THE CASE OF HYDROELECTRIC POWER

Climate change is posing unprecedented challenges to energy systems, with worsening physical impacts on infrastructure often not designed to withstand more frequent and intense weather extremes. Hydropower is particularly exposed, and its financial viability, together with power generation itself, is increasingly threatened by climate change.

Hydroelectric power is the largest source of renewable energy globally, accounting for about 60% of renewable generation 16% of total electricity production. It plays a critical role in many energy systems, with 24 countries generating more than 50% of their electricity needs from it in 2020. Additionally, hydropower's flexibility is particularly important for grid stability, as electricity can be stored and then quickly supplied in response to demand surges to help avoid blackouts.

Hydropower plays an important role in the decarbonization strategy of the top three performers in the Environmental Sustainability dimension, accounting for 44, 55%, and 92% of total electricity generation in Sweden, Switzerland and Norway, respectively. China is the world leader for installed hydropower capacity with over 390 GW – more than three times the next largest country, Brazil – and accounted for around 80% of new capacity installed in 2021. Hydropower has also become an important source of electricity in Africa, accounting for about 17% of the continent's generation capacity. In the Democratic Republic of Congo, Ethiopia, Malawi, Mozambique, Uganda, and Zambia, the share of hydropower in electricity generation exceeds 80%. However, while representing a low-carbon energy source, hydropower projects can pose significant risks to the environment and local communities, with large-scale projects, particularly dams, often marred by controversy.

While an important tool in the fight against climate change, hydropower is also particularly vulnerable to global temperature increases: Greenhouse gas emissions are disrupting our planet's water cycle, causing water scarcity and increasing the frequency, severity, and duration of droughts, while also triggering more severe intense rainfall events that can overwhelm old reservoir structures. Ghana, for example, sicuhas been suffering power shortage crises since 1983 due to low levels of water in the Akosombo dam resulting from severe droughts. Similar drought conditions occurred in 1997-1998, 2007-2008 and 2012-2015 with lack of precipitation causing malfunctioning of hydropower plants, leading to a 32% drop in hydropower generation since 2010.

More recently, the extremely dry conditions that impacted large stretches of Europe in summer 2022 were made more likely by climate change. This event occurred in the midst of an energy crisis caused by decreasing imports of Russian natural gas and led to further disruption in European energy systems by significantly decreasing the continent's total hydropower generation. Hydroelectricity output in France and Italy dropped by about 30% and more than 50%, respectively, and lack of rainfall pushed electricity prices in Norway to record highs and led to announcements of possible cuts in energy exports. During the same period, extreme heat and dry conditions in China led to a hydropower generation deficit in Sichuan and to an increased reliance on coal.

Impacts will vary by region but are expected to affect most major economies and will need to be accounted for in the planning and design of new hydroelectricity infrastructure. For example, the United States infrastructure bill approved in 2021 committed over $900 million in funding for new investments in hydropower. New plants will need to be designed to be ready for changing climate conditions. Several studies indicate a growing risk of water scarcity across many key river basins in the United States, with negative impact on hydropower generation. Similar effects will also be felt in developing countries. IEA research on African hydropower has shown that climate change will lead to a considerable decrease in generation in Morocco, Zambia, Zimbabwe, the Democratic Republic of Congo, and Mozambique, while shifting rainfall patterns may increase the potential generation in the Nile basin countries such as Egypt, Sudan, and Kenya.

Climate impacts may complicate hydropower project financing, with large upfront investments usually requiring many years for amortization. In order to prepare, countries need to assess climate vulnerabilities of their energy system, and plan accordingly to bolster their resilience. As the risk rapidly increases across the globe, sustainable water management will become increasingly important. Some countries have started to switch to other renewables, such as solar, wind, and tidal, which are all less susceptible to water scarcity. Uruguay dropped its share of hydropower by 47% since 2010, and increased wind share of electricity generation from less than 1% to around 30% today, whilst also growing total power generation by 50%. This has allowed the country to reduce reliance on hydropower while increasing the overall resilience of its energy system. Kenya has also managed to reduce its dependence on hydropower while meeting its energy needs by doubling its geothermal capacity in the last decade.

ENERGY SYSTEMS' VULNERABILITY TO FLOOD RISK

Flood risk is projected to increase globally due to climate change. Marsh McLennan's Flood Risk Index shows that a 3.5 °C warming would lead to a dramatic increase in flood risk globally, and that even limiting temperature rise to 1.5 or 2 °C would substantially worsen the threat of flooding. 23% of the world's power generation capacity is currently estimated to be threatened by flooding, with this share expected to increase to 37%, 41%, and 48% under 1.5 °C, 2 °C, and 3.5 °C scenarios.

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

REGIONAL ENERGY PROFILES

AFRICA

NECESSITY DRIVES INNOVATION BUT UNCERTAINTIES THREATEN ADVANCEMENTS TO ENERGY SECURITY

Africa has improved substantially in management of system stability and recovery; there is a rising uptake of new energy produced from renewables. Strides made towards energy access in the region, has been impeded by the COVID-19 pandemic, knock-on impact from the European war in Ukraine and the global geopolitical challenges, such as volatile fuel hikes due pose a risk to the region's energy security opportunities. Natural gas offers a short-term, pivot towards a just energy transition. Security opportunities may arise by enabling infrastructure that supports new energy systems and developing a cost-effective way to leverage Africa's abundant energy sources. In the last decade, increased development in off-grid energy solutions has improved energy access. On environmental sustainability, better governance around environmental challenges and solutions are needed even as part of the region continues to drive it's just energy transition in an environment of political instability.

ASIA

ENERGY DEMAND IS ON THE RISE AND TECHNOLOGY IS USED TO ACCELERATE TRANSITION

With over half the world's population increasingly demanding more energy, the region is poised to adapt new technologies rapidly. Recent investments in infrastructure in China and India are reflected in higher scores in many WE Trilemma indicators. Transitioning away from coal-based energy remains a substantial challenge for the region. Energy equity is a strength of the region, with reasonably priced energy available in many places. Adverse climate events across the region have displaced many people and increased demand for energy. While the political leadership for net-zero goals may be negligent, the private sector leads worldwide in pursuing renewable technology. The proliferation of wind and solar power by groups like the Ayala Corporation in the Philippines and Tata in India drive a culture of optimism and accelerated innovation.

EUROPE

URGENT NEED FOR DIVERSIFICATION QUESTIONS COMMITMENT TO SUSTAINABILITY GOALS

The current energy crisis in Europe has disrupted previous assumptions about the state of energy worldwide. As the region scrambles to diversify, the crisis has serious knockon effects for many countries around the world. The threat to energy security, coupled with rising inflation worldwide, has highlighted energy affordability issues. The hope is that increased investment in renewables and green hydrogen will foster more affordable energy. The energy crisis has challenged the region's commitment to sustainability as they face soaring energy bills and limited supply. In the short term, it is likely the region will require increased fossil fuel consumption to meet growing energy demand. However, the current geopolitical crisis may also accelerate the energy transition as there remains substantial room for investment in carbon reduction opportunities.

LATIN AMERICA AND CARIBBEAN

INNOVATION HELPS TO DRIVE A JUST TRANSITION IN THE FACE OF POLITICAL INSTABILITY

Significant hydropower development and more recently solar and wind electricity generation allow the region to score well in Sustainability. Access to energy systems in some isolated regions has also improved. However the high price of fossil fuels and maintenance of electricity prices is a burden for most consumers across the region, negatively affecting energy equity. The possibility of regional energy integration that could improve the systemic efficiency is hampered by lack of trust among countries. These factors, together with the unstable political context that worsens the overall performance of countries in the region, make it difficult to advance in a more just transition.

MIDDLE EAST

FOCUS ON INCREASED EXPORTS TO MEET DEMAND

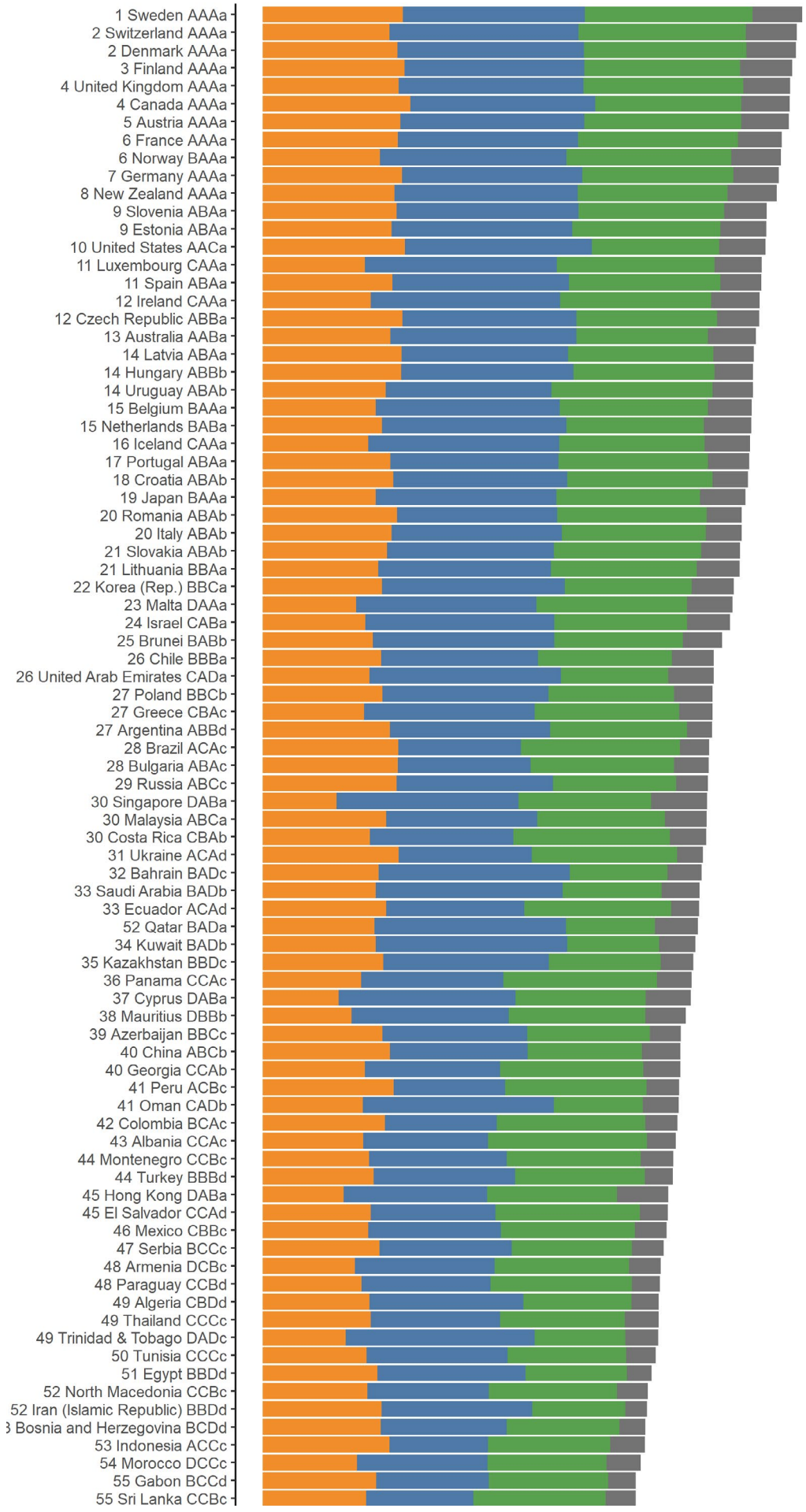
Fossil fuel extraction continues to drive the focus in the Middle East, particularly as Europe looks for new sources of imports. Energy equity remains a nominal strength of the region. However, in many countries it is a by-product of subsidies that are not sustainable in the long term. Key leaders in the region are keen to diversify their energy mix. While recent political upheaval in Lebanon has halted renewable projects from a federal level, the insecurity has led to a 2500% increase in solar power over the last decade. Saudi Arabia is venturing into gas in order to move into the Hydrogen market.

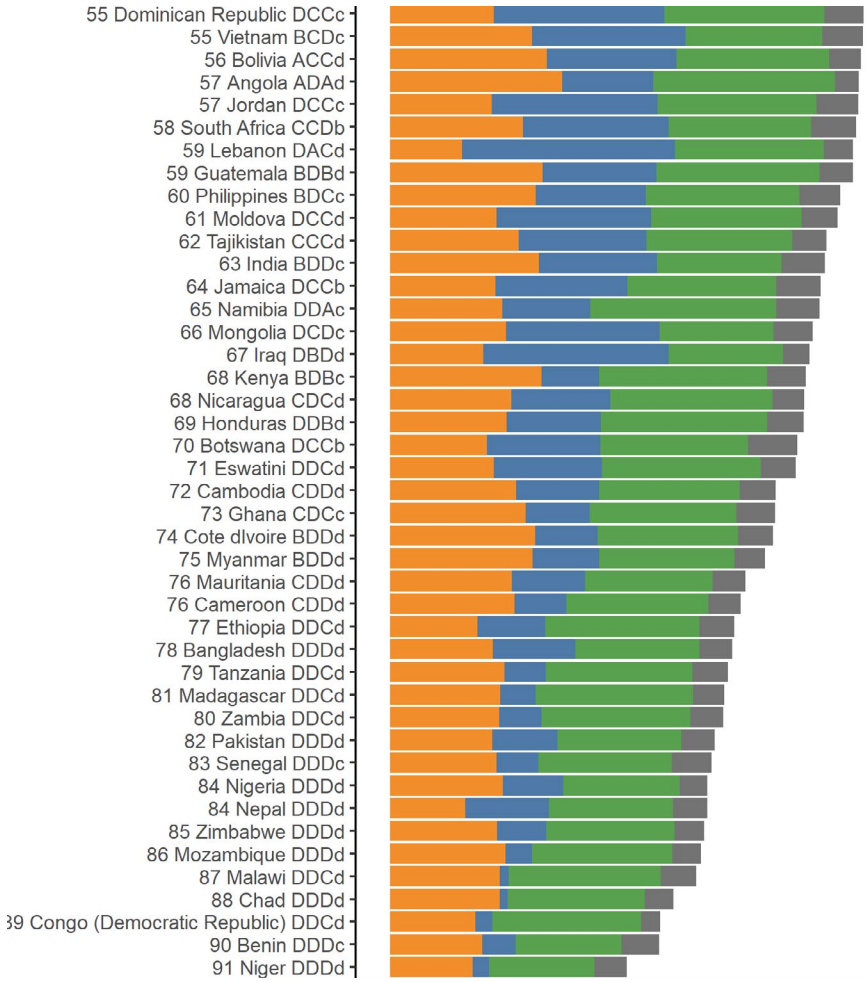
NORTH AMERICA

PRESSING NEED TO ACCELERATE ENVIRONMENTAL SUSTAINABILITY INITIATIVES

Canada and the United States continue to lead in energy security. Recent inflation coupled with high energy burdens have exposed energy inequities for cities and communities. The US and Canada continue to have very high emissions per capita, which are not lowered at the expense of people worldwide. The Inflation Reduction Act represents a substantial step towards lowering emissions in the US. Polarized discussions delays decisions and obscures pathways for a just energy transition.

2022 WORLD ENERGY TRILEMMA INDEX





Source: World Energy Council

What does the country's performance show?

GRADE

Range of values: A (best), B, C, D (worst)
Example: AAAa, ABAc, BCDb, DCDd
Meaning: A grade is given for performance in three main dimensions (1st letter for Security, 2nd Equity, 3rd Sustainability) which cover 90% of the overall grade and an additional dimension (4th letter for Country Context) which covers the remaining 10%. The value of the grade depends on which quartile the country's score falls into:

- Grade A: top 25% countries
- Grade B: between top 25% and 50%
- Grade C: between 50% and 75%
- Grade D: between 75% and 100%

RANK

Range of values: 1 (best) ... 125 (worst)
Example: Shared rank 4 determined by the 4th best score value of 82.1
Meaning: The rank provides only a very short and limited information about a country's performance – it only informs where the country lies in the full Index, therefore the grade, the score, the context and especially the full indexed history of the country's performance should be taken into account when comparing with others.
We have used dense ranking approach because some scores are tied at one decimal place.

SCORE

Range of values: 100 (best) ... 0 (worst)
Example: 84.3, 53.4, 32.1
Meaning: A score value is given for overall performance as well as for each dimension (Security, Equity, Sustainability, Country Context) determined by country's performance in the indicators; the score can change even if the data did not change because the score reflects performance in comparison with other countries who may have improved in a given indicator.

Please note that because the Methodology has evolved direct comparisons of ranking, grades and scores to previous reports is not possible. Historical performance has been recalculated using the same revised Methodology back to the Index year 2000.

ANNEX B

TRILEMMA REIMAGINED

The energy community worldwide has voiced an urgent need for transparent, reliable, high-velocity data collection. Across the sector, energy transitions need to happen at a faster pace than data is currently being collected. Institutions are working to leverage advances in the data collection and AI community to bring this about. In this landscape, the World Energy Council offers the unique perspective of a human-centric approach to data collection and analysis drawn from the secretariat. With a holistic view of what energy transitions affect various sectors of society, the Council is prepared to reimagine the Trilemma indicators and methodology to unlock pathways for energy transition.

COMMUNITY CONCERNS DRIVE INDICATOR DEVELOPMENT

As the Trilemma looks to offer a benchmark for increasingly urgent goals, adding indicators that reflect the realities of stakeholders on the ground is of the utmost importance. The community has voiced a need to incorporate the following into future iterations of the Trilemma.

WATER/ ENERGY NEXUS

Access to and use of water has emerged as a pressure point in the Trilemma. Many countries rely on hydropower for energy security, which promotes sustainability. However, adverse climate effects like drought can severely limit capacity and resilience, threatening supply. Energy equity issues around the system emerge as water rights are contested.

REGIONAL INTEGRATION

Several members of the community have voiced the need to incorporate measures of regional integration into the Trilemma. Connecting with energy infrastructure in the region has been a key driver for several of the top improvers in the overall Trilemma score. This score is not currently measured in the Trilemma.

FUEL POVERTY

Fuel poverty, defined as when a household cannot adequately afford fuel, offers a measure of affordability currently not included in the Trilemma. This household measure is necessary to measure the trade offs that happen at the individual and household level.

ENERGY STORAGE

A successful energy transition requires innovative storage solutions. The Trilemma must evolve to measure storage for renewables. Energy storage remains a critical question for viable energy transitions.

HUMANISING ENERGY

Any measures of a just transition must be human-centric. The Trilemma aims to incorporate new measures of how energy contributes to quality of life. Trust between and within communities has been voiced as a key element of viable transitions. Measures for trust will be added going forward.

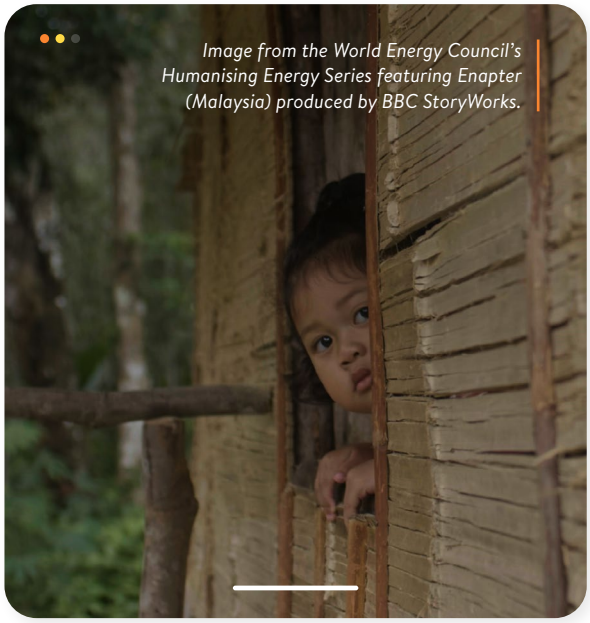


Image from the World Energy Council's Humanising Energy Series featuring Enapter (Malaysia) produced by BBC StoryWorks.

Image from the World Energy Council's Humanising Energy Series featuring EEP Africa and Jaza Energy (Tanzania) produced by BBC StoryWorks.

SCALABLE AND FLEXIBLE TRILEMMA AS A PATHFINDING POLICY TOOLS

The World Energy Trilemma framework is evolving, with additional insights available every year thanks to the adaptable new global datasets. In that regard, the World Energy Council is aiming to extend the framework and adapt it into a scalable and flexible framework that can be used as an analytical and decision-making tool for different users. The element of this process is to create a comparative Index based on the same three dimensions, but for a cluster of countries, regions, and/or cities, and to derive a new set of rankings for these clusters.

The Scalable World Energy Trilemma extends the Trilemma Framework from the national level to administrative regions within a nation including the state, city or neighbourhood. Where historical data is available, the Scalable Trilemma can be used to benchmark progress towards local transition goals. Examining the long-term trends of the Trilemma at a local dimension can help policymakers implement changes that are circumspect of all elements of a just transition.

The Flexible World Energy Trilemma adapts the Trilemma Framework to produce a bespoke and localized pathfinding tool from gathered data and the input of local perspectives. Instead of providing a comparison on performance, the Flexible Trilemma simulates possible policy interventions in a region. Anchoring the solutions on the Trilemma Framework ensures project goals support the path to secure, equitable, sustainable energy transitions.

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

ANNEX C

FREQUENTLY ASKED QUESTIONS

The 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 2022 Index is based on an evolved methodology and focuses on a historical Index of progress. 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, 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, withstand and bounce back swiftly from system shocks with minimal disruption to supplies. The 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. The 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 of energy systems represents the transition of a country's energy system towards mitigating and avoiding potential environmental harm and climate change impacts. The dimension focuses on productivity and efficiency of generation, trans-mission and distribution, decarbonisation, and air quality.

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

The Energy Trilemma Index has been prepared annually by the World Energy Council in partnership with global consultancy Oliver Wyman and Marsh & McLennan Advantage since 2010.

The goal of the Index is to provide insights into a country's relative energy performance with regards to Energy Security, Energy Equity and Environmental Sustainability. In doing so, 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. Index rankings provide comparisons across countries on each of the three dimensions, whilst historical indexed scores provide insights into the performance trends of each country over time.

WHERE CAN I FIND THE FULL RESULTS?

- The results are published once a year. Results can be downloaded for free from the Council's website.
- The **online tool**, presenting full results: https://trilemma.worldenergy.org/
- The **full report** with insights and regional profiles: https://www.worldenergy.org/transition-toolkit/world-energy-trilemma-index

WHAT IS THE SCOPE OF THE INDEX?

The Index tracks **133 countries, 82 of which are member countries** of the World Energy Council. However, rankings have only been produced for **127 countries**, with six countries not being ranked due to political instability and/or poor data coverage. The countries that are tracked but not ranked are: Barbados, Libya/GSPLAJ, Syria (Arab Republic), Taiwan, Venezuela, and Yemen.

The Index aggregates around **60 datasets into 30 indicators** to create a snapshot energy profile for each country. Furthermore, it calculates a historical Index for each dimension back to a baseline year of 2000.

WHAT TIME PERIOD DOES THE 2022 INDEX CAPTURE?

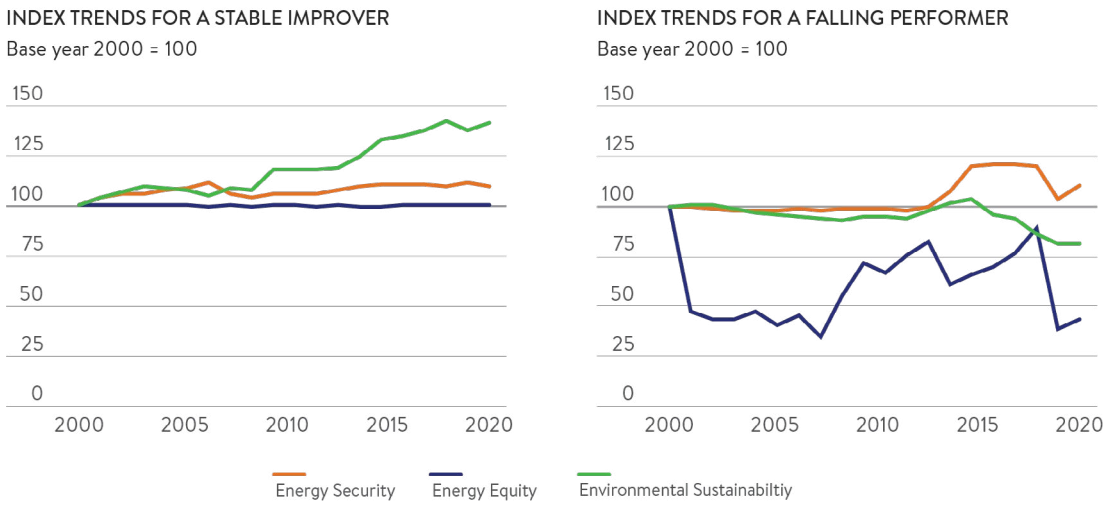
The 2022 Index ranking reflects data from 1998 to 2021 using the most recent available data at global levels. The online Trilemma Tool presents Index performance since 2000 using longitudinal data with individual country profiles. Particular indicators feature some data delays, which mean recent world events or the most recent transitions in the energy sector that could affect the Index's outcomes may not be fully captured (as mentioned in the previous chapters, the pandemic as well as geopolitical or social unrest in the Middle East or Venezuela).

HOW ARE THE INDEX RESULTS PRESENTED?

Countries are provided with an overall Index ranking from #**1 to** #**127**, as well as rankings for each dimension of Energy Security, Energy Equity and Energy Sustainability of their energy systems. The top performing country is awarded a #1 ranking, while the lowest ranking country is assigned rank #122 (because of the fact that some ranks were shared, in 2021 the lowest rank is #91). In addition, scores for the three dimensions of Energy Security, Energy Equity, and Environmental Sustainability are distributed into four balance grades (A, B, C and D).

Every country is thus assigned a set of balanced grades (e.g. 'ABC'). 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; 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. Index results and analysis are also complemented by regional overviews as well as individual country profiles with expert commentary form the Council's national Member Committees.

Figure 21: Differences between index trends for a stable improver and a falling performer



ANNEX D

INDEX RANKINGS & POLICIES

WHAT DOES THE INDEX TELL US ABOUT THE 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 policy specific and contextual 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 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 10 out of 127 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 affecting their performance 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, in partnership with Oliver Wyman and Marsh & McLennan Advantage, 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 from year to year are not directly comparable due to the changes in methodology.

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 between 2021 and 2022 Index rankings is not possible given changes in methodology, the indexation illustrates now 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, WHICH 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 country with triple-A balance grades highlights their superiority within a dimension compared to other countries which do not have A grades. However, they 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 E

KEY DATA SOURCES AND SELECTION CRITERIA

HOW ARE INDICATORS SELECTED FOR THE INDEX?

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
- The Human Development Index

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.

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