The First Global Stocktake

International Energy Agency (IEA) updated submission

March 2023

Introduction

This is the International Energy Agency's (IEA) updated submission to the first global stocktake (GST), drawing on the submission of March 2022, which aims to contribute to the goals of the Paris Agreement and its efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

With years of experience in energy and climate data collection, energy system analysis, and related policy design and implementation support, the IEA keeps track of progress in the energy sector in relation to the long-term objective of the Paris Agreement. We are pleased to update our submission to the first global stocktake and remain committed to supporting the global stocktake and its assessment of the energy sector.

The IEA is grateful for the invitation from the Subsidiary Body for Implementation (SBI) and Subsidiary Body for Scientific and Technological Advice (SBSTA) Chairs to provide inputs for the third technical dialogue to be held during the 58th Subsidiary Body sessions. Our inputs are organised around the three thematic areas of the GST (mitigation, adaptation, and means of implementation and support) as well as cross-cutting topics that address the proposed guiding questions from the Subsidiary Bodies (SB) Chairs.

Moreover, as further input to the GST, the IEA has launched a dedicated webpage "the Global Energy Transitions Stocktake" which will bring the latest analysis in one place in support of the first Global Stocktake in the lead-up to the COP28. The IEA will also release a Special Report on Climate, with a focus on the energy sector before the COP28. The IEA hopes that SB Chairs, Parties and non-Party stakeholders will find this submission and the upcoming Special Report on Climate useful to further inform discussions around GST.

Mitigation

What is the collective progress made towards achieving the long-term temperature goal in Article 2.1(a) of the Paris Agreement, in the light of equity and the best available science?

The energy sector is responsible for almost three-quarters of global emissions, and is therefore central to meeting the long-term temperature goal of the Paris Agreement. Clean energy transitions have been at the heart of the actions to tackle climate change. Since adoption of the Paris Agreement, there has been positive progress in areas of clean energy, for example renewable energy and electric vehicles.

Growth in solar PV and wind power capacity led to an increase in global renewable electricity generation in 2022 of more than 700 terawatt-hours (TWh), the largest annual rise on record. Without this increase, global CO_2 emissions would be more than 550 million tonnes higher in 2022. The rapid deployment of solar PV and wind is on track to account for two-thirds of the growth in renewable power generation, but needs to expand significantly faster to get on track with the IEA's NZE Scenario.

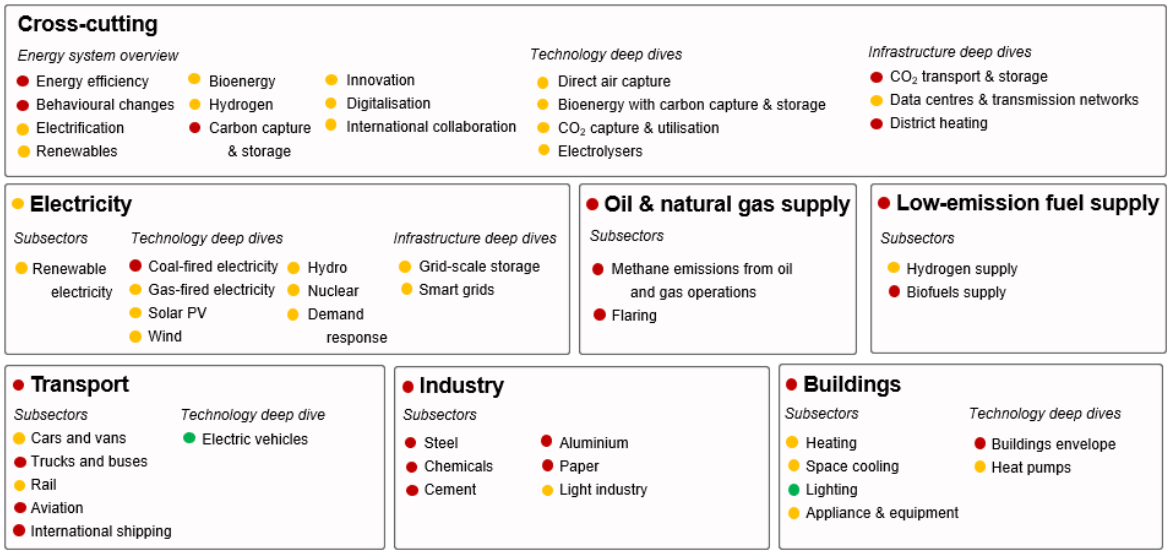
Deployment of electric vehicles (EVs) also increased in 2022. Sales of EVs exceeded 10 million in 2022, or 13% of the global car market, bringing their total number on the world's roads to over 25 million, up from practically zero in 2010. Such low-carbon energy technologies will contribute to achieve the long-term temperature goal in Article 2.1(a) of the Paris Agreement.

However, despite positive progress, accelerated actions are still needed to get on track with the IEA's Net Zero Emissions by 2050 (NZE) Scenario, which presents a credible pathway towards net zero emissions by 2050 and to limit the increase in global temperature to 1.5°C in 2100. Progress in energy efficiency improvements and reducing methane emissions from the energy sector has stagnated. In "hard to abate" sectors such as industry and long-distance transport, more effort is needed for current technologies to be brought to market through innovation and then deployed in time to meet collective climate goals.

In essential areas like energy efficiency, improvements are essential for limiting energy demand growth. The pace of global energy intensity improvements had noticeably slowed in the second half of the last decade and virtually stalled during the first two years of Covid-19. From 2010 to 2020, the rate of global energy improvements fell from 2% in the first half of the decade to 1.3% in the second half. In 2022, annual energy intensity improvements reached about 2%. Nonetheless, the pace of global energy intensity improvements is not reaching the level required to limit the global temperature rise below 1.5°C above pre-industrial levels. The NZE Scenario shows that energy efficiency improvements need to accelerate by 4% each year until 2030.

Progress in low-carbon energy technologies is still not enough to reach the long-term temperature goal of the Paris Agreement. For example, in industry, modest improvements have been made in energy productivity and renewable energy uptake, as well as innovation. Nevertheless, the industry sector's energy mix has remained relatively unchanged since 2010. Indeed, IEA's Tracking Clean Energy Progress 2022, a comprehensive assessment of key energy technologies and sectors, reveals that based on progress in 2021, 53 out of 55 components of the energy system (including technologies, sector, infrastructure and cross-cutting CO2 mitigation strategies) require more efforts to get on track with 2030 targets consistent with reaching a net zero energy system by 2050.

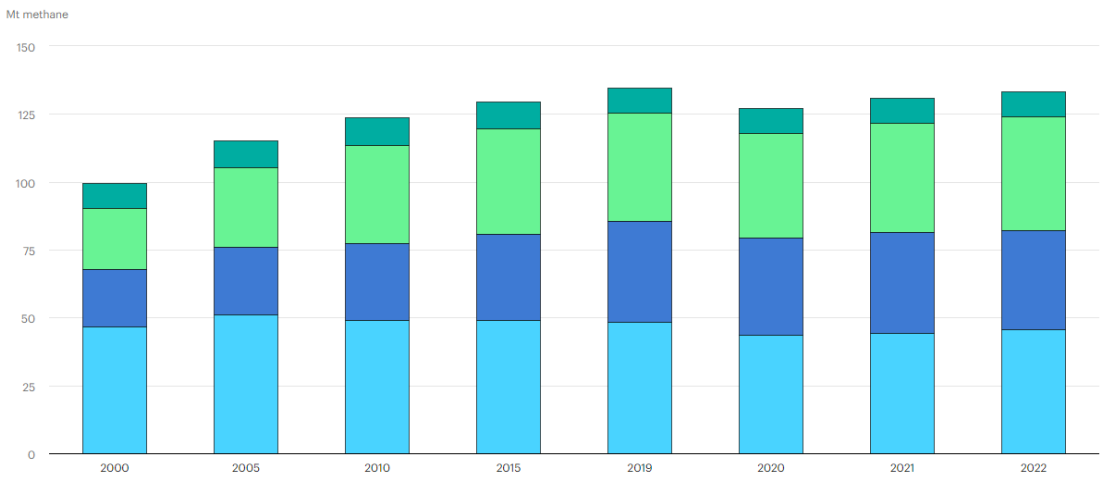
Tracking Clean Energy progress 2022



Source: IEA (2022), Tracking Clean Energy Progress: Assessing critical energy technologies for global clean energy transition.

In addition, despite the availability of cost-effective solutions, methane emissions from the global energy sector have not decreased since 2015. Methane is responsible for around 30% of the rise in global temperatures since the industrial revolution. The energy sector accounts for nearly 40% of methane emissions from human activity. The global energy sector was responsible for the release of nearly 135 million tonnes of methane into the atmosphere in 2022, a slight rise from the amount in 2021 and just marginally below the record highs observed in 2019. The Global Methane Pledge, supported by 150 countries, seeks to cut methane emissions from human activity by 30% from 2020 levels by 2030. To support this, a number of countries have published or are drafting national methane action plans. According to IEA's Global Methane Tracker 2023, application of well-known procedures such as leak detection, repair programmes, and updating leaky equipment, methane emissions from the oil and gas industry alone could be cut by 75%.

Global methane emissions from the energy sector, 2000-2022



Source: IEA (2023), Global Methane Tracker 2023.

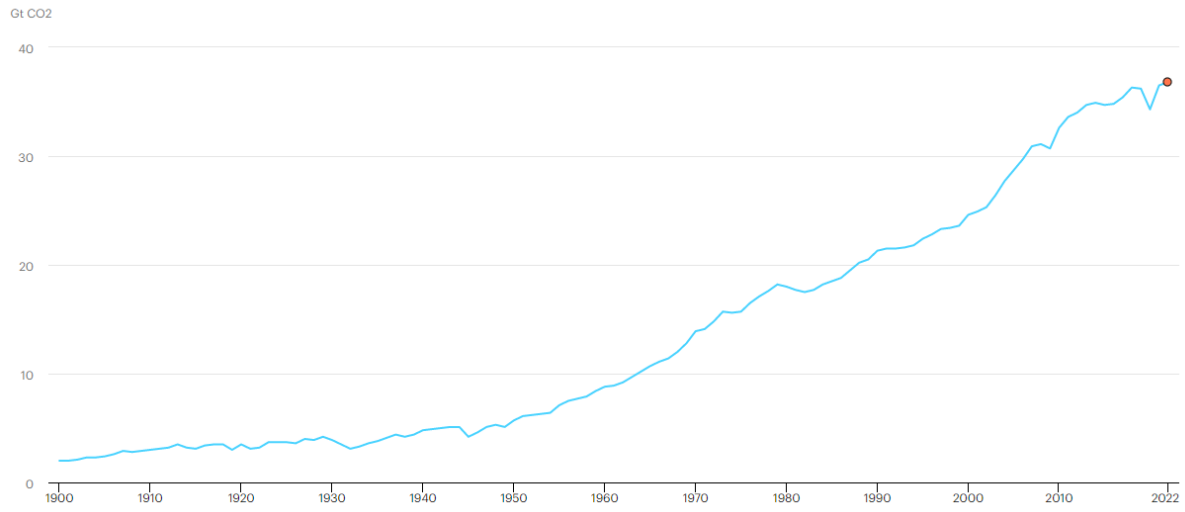
What is the collective progress made towards achieving the long-term mitigation goal in Article 4.1 of the Paris Agreement, in the light of equity and the best available science?

Rapid GHG emissions reductions in the energy sector, which accounts for almost three-quarters of the global emissions, are essential to meet the long-term goals of the Paris Agreement. Following a drop in CO_2 emissions from energy in 2019 and 2020 during the Covid-19 pandemic, global energy-related and industrial process CO_2 emissions rebounded quickly in 2021.

In 2022, global energy-related CO2 emissions rose even further in 2022 by 0.9% or 321 Mt to a new record high of over 36.8 Gt. Emissions from energy combustion increased by 423 Mt, while emissions from industrial processes decreased by 102 Mt. 60 Mt CO_2 can be attributed to cooling and heating demand in extreme weather and another 55 Mt CO_2 to nuclear power plants being offline.

Global CO_2 growth in 2022 was well below global GDP growth of 3.2%, despite gas-to-coal switching in many countries, energy price shocks, rising inflation, and disruptions to traditional fuel trade flows. Increased deployment of clean energy technologies such as renewables, electric vehicles, and heat pumps helped prevent an additional 550 Mt in CO_2 emissions. Industrial production curtailment also averted additional emissions.

Global CO2 emissions from energy combustion and industrial processes and their annual change, 1900 – 2022



Source: IEA (2023), Global Energy Review: CO_2 Emissions in 2022.

The present energy crisis provided a short-term boost to demand for coal and oil as consumers in many regions scramble for alternatives to high-priced gas. IEA projects coal demand peaks in the next few years, natural gas demand reaches a plateau by the end of the decade, and oil demand reaches a high point in the mid-2030s before falling.

What are the projected global GHG emissions and what actions are Parties undertaking to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty (Article 4.1 Paris Agreement, Decision 19/CMA.1, paragraph 36(b))?

1) Projected Global CO_2 emissions

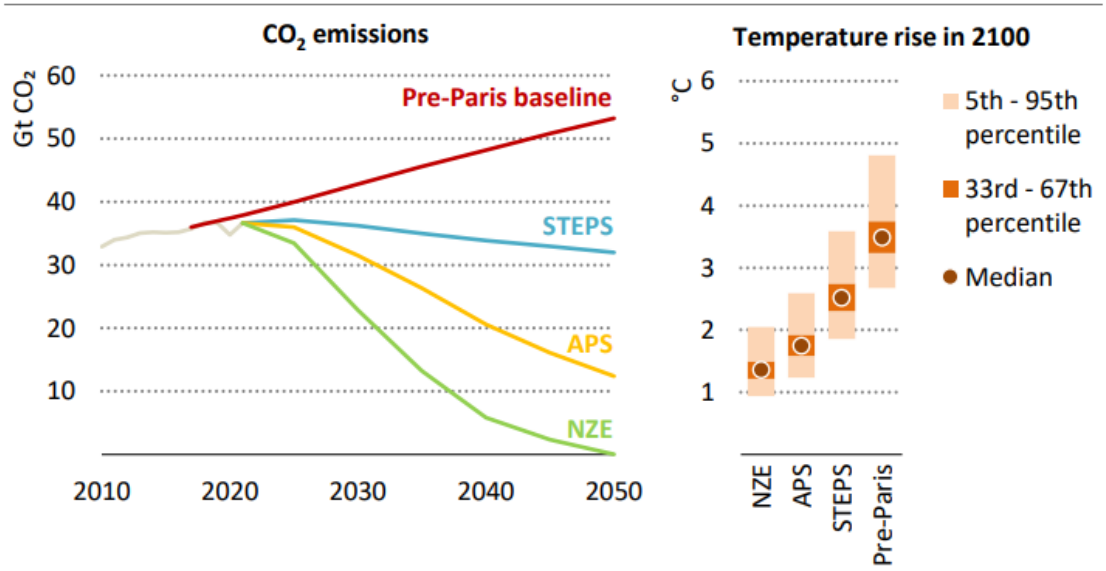
The IEA presents various potential trends in future energy-related CO_2 emissions and the corresponding increase in temperature, each of which is based on various assumptions on how the energy system might develop. World Energy Outlook 2022 (WEO 2022) explores three main scenarios[1] for the future: the Stated Policies Scenario (STEPS), the Announced Pledges Scenario (APS) and the Net Zero Emissions by 2050 (NZE) Scenario. The STEPS shows the trajectory implied by today's policy settings. The APS assumes that all aspirational targets announced by governments are met on time and in full, including their long-term net zero and energy access goals. The NZE is a normative scenario and sets out a pathway to the stabilisation of global average temperatures at 1.5°C above pre-industrial level while also meeting the key energy-related UN Sustainable Development Goals, achieving universal access to energy by 2030 and securing major improvements in air quality.

Energy-related CO_2 emissions increased to a new record high of 36.8 Gt in 2022. In IEA's STEPS emissions hit a plateau at around 37 Gt and then slowly declines to 32 Gt in 2050, following a trajectory that would result in a 2.5 °C increase in global average temperatures by 2100. This is around 1 °C lower than implied by the baseline trajectory prior to the Paris Agreement, indicating the progress that has been made since then. The policy settings assessed in the WEO-2022 STEPS scenario indicate some degree of collective progress as opposed to the WEO-2021 STEPS scenario. Coal use falls back within the next few years, natural gas demand reaches a plateau by the end of the decade, and rising sales of EVs mean that oil demand levels off in the mid-2030s before ebbing slightly to mid-century. The share of fossil fuels in the global energy mix has been high, at around 80%, for decades. By 2030 in the STEPS, this share falls below 75%, and to just above 60% by 2050.

But there is still a lot to be done. In the WEO-2022 APS scenario, emissions reach their peak in the middle of the 2020s and decline to 12 Gt in 2050, resulting in a projected 1.7 °C increase in the global mean temperature in 2100. In the NZE Scenario, CO_2 emissions fall to 23 Gt in 2030 and to zero in 2050, a trend that will limit global warming to less than 1.5 °C by 2100.

[1] The IEA assesses the outlook for all fuels and technologies including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, and demand side management. All of IEA's scenarios listed hereunder refer to the energy sector only.

Energy-related and process CO2 emissions, 2010-2050 and temperature rise in 2100 by scenario



Source: IEA (2022), World Energy Outlook 2022.

Full achievement of all climate pledges would move the world towards a safer climate future, but there is still a large gap between today's ambitions and a 1.5°C stabilisation. In the NZE, the 1.5°C goal is achieved by reducing annual energy-related CO_2 emissions to 23 Gt by 2030 and to net zero by 2050. Getting on track for the NZE Scenario will require a tripling in spending on clean energy and infrastructure to 2030, alongside a shift towards much higher clean energy investment in emerging markets and developing economies.

Importantly, there are a few potential bottlenecks to take into account in the clean energy transition towards achieving the goals of the Paris Agreement. For instance, many of the clean energy technologies used today, such as electric vehicles, electricity networks and wind turbines, depend on critical minerals. The demand for critical minerals is set to rise sharply, more than doubling from today's level by 2030 in the WEO-2022 APS Scenario. Copper sees the largest increase in terms of absolute volumes, but other critical minerals experience much faster rates of demand growth, notably silicon and silver for solar PVs, rare earth elements for wind turbine motors and lithium for batteries. Continued technology innovation and recycling are vital to ease strains on critical minerals demand.

2) Actions undertaken by Parties

Nationally Determined Contributions (NDCs) form the basis for countries to achieve the objectives of the Paris Agreement. The last synthesis report of the UNFCCC, published in September 2022, shows the 166 latest available NDCs communicated by 193 Parties. Most of the Parties (74%) that submitted new or updated NDCs have strengthened their commitment to reducing or limiting GHG emissions by 2025 and/or 2030, demonstrating increased ambition in addressing climate change.

Based the latest available NDCs and announced targets by governments, the WEO-2022 APS scenario shows a near-term peak in annual emissions followed by a faster decline to 12 Gt by 2050. This is a bigger reduction than in the WEO-2021 APS scenario, reflecting the additional pledges that have been made over the past year. If implemented on time and in full, these additional national commitments keep the temperature rise in the APS scenario in 2100 at around 1.7°C.

Although it is the first time in history that governments have come forward with targets of sufficient ambition to hold global warming to below 2 °C, these pledges still fall well short of what is needed to keep the door open to 1.5 °C. This would require rapid progress on reducing emissions between now and 2030.

Adaptation

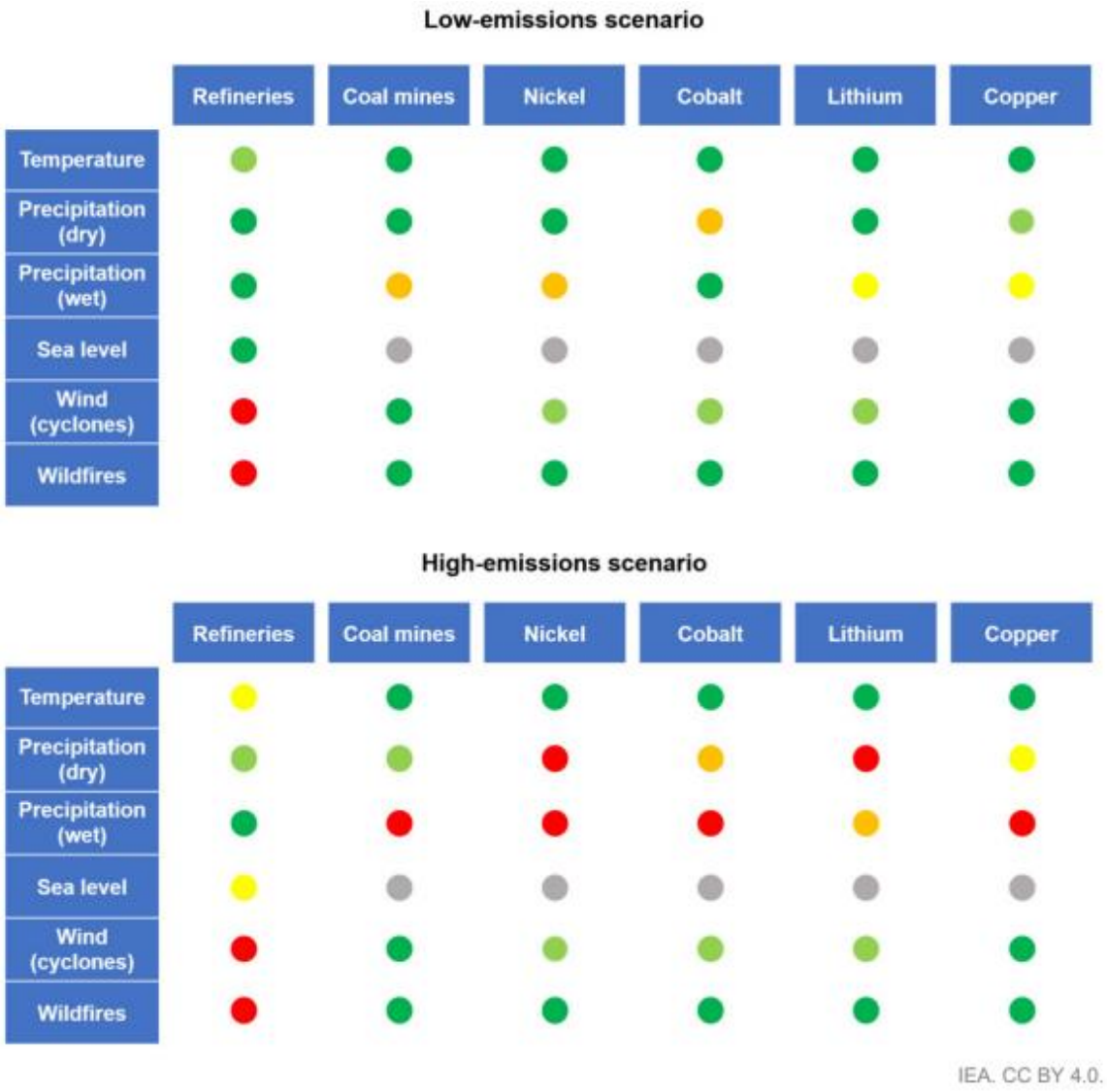
[Two guiding questions combined] What is the overall progress in achieving the global goal on adaptation, in the context of climate impacts, risks and vulnerabilities (Article 7.14 (d) Paris Agreement)? What actions have been taken to increase the ability to adapt to the adverse impacts of climate change and foster the climate resilience of people, livelihoods, and ecosystem? To what extent have national adaptation plans and related efforts contributed to these actions (Decision 19/CMA.1, paragraph 36(c)?

Without actions for adaptation and resilience, climate change could put global energy security at risk. It is already affecting the extraction, processing and transport of fuels and minerals, and altering power generation potential, efficiency and reliability. Some of the major energy-sector disruptions seen in 2022 were due to extreme climatic conditions, which are becoming more frequent and intense because of climate change. These range from heatwaves in Europe, Hurricane Ian in North America and record flooding in South Asia. Severe droughts in South America and flooding in Southern Africa also disrupted the global supply of critical minerals such as copper and cobalt.

Climate change impacts on energy are likely to grow in the coming decades. The mean surface temperature in the locations of refineries, mines, power plants and grids is expected to reach over 2.1°C in 2080-2100 compared to the pre-industrial period in a low-emissions scenario (SSP1-2.6), while recording 6.5-16.8 more hot days (with a maximum temperature exceeding 35°C). In a high-emissions scenario (SSP5-8.5), the mean surface temperature will exceed 5.5°C with additional 27.7-54.4 hot days. Higher temperatures could lead to more frequent heatwaves and early snowmelt, greater variability in rainfall with an increasing likelihood of flooding and droughts, and more intense tropical cyclones, which could bring critical impacts on energy system resilience and security.

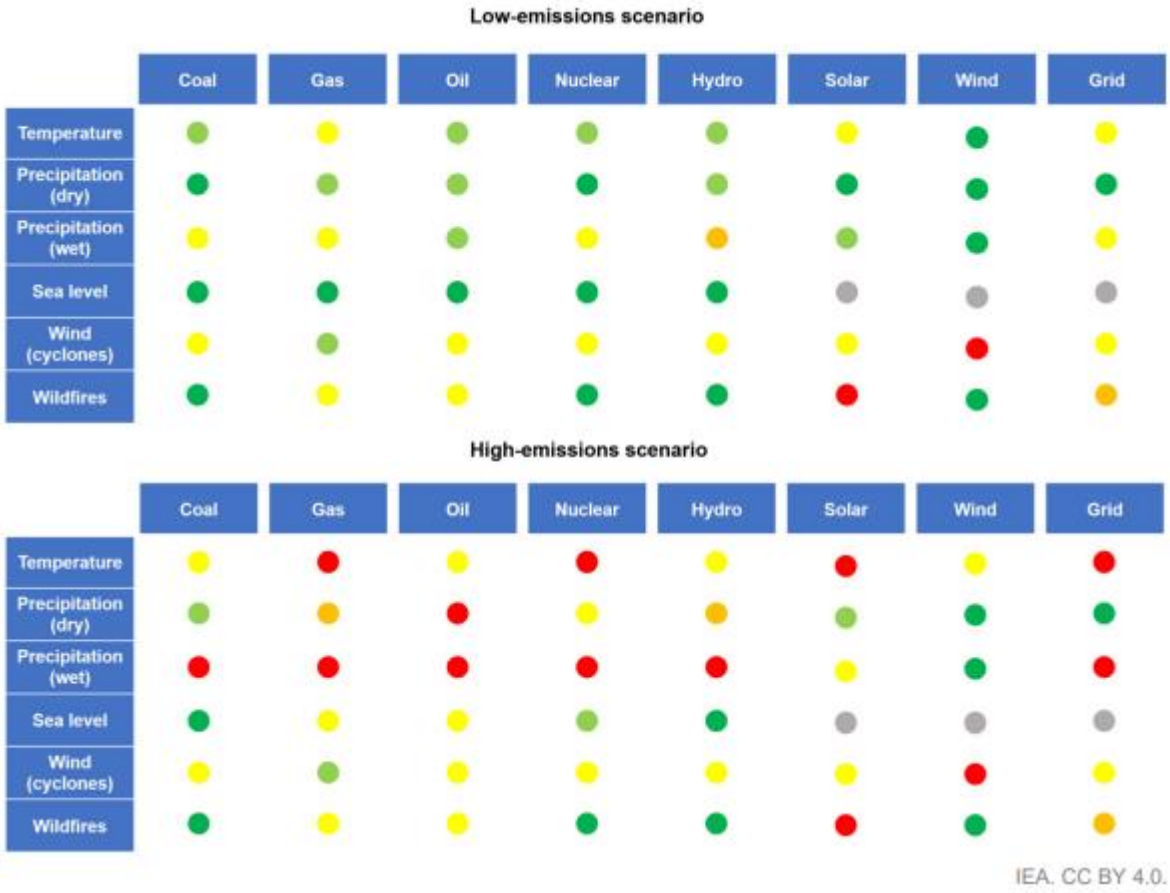
To build a climate-resilient energy system, climate risk and impact assessments for the energy sector need to be in place. Although there has been progress in the accessibility and accuracy of climate data and information, further efforts are needed to understand and address specific climate risks to the energy sector, as stated in the 2022 State of Climate Services: Energy. The IEA has contributed to global, regional and national efforts to assess climate risks and impacts on energy systems, closely collaborating with stakeholders. The IEA's Climate Resilience for Energy Security provides a climate risk assessment for energy systems and measures the potential impacts of climate hazards on each segment of the energy supply chain. It shows that most of the global energy system is subject to climate change impacts and unabated emissions could trigger more disruptions to energy security. Higher temperatures and more frequent droughts could affect the cooling water availability for thermal power plants and reduce the efficiency of wind power generation. Some regions may experience more drought-driven disruptions in critical minerals production, thermal plant cooling and hydropower generation; while other regions could face more frequent heavy rainfalls and flooding with physical damage to electricity networks. Sea level rise and associated impacts (e.g., storm surge, coastal erosion) could also threaten the energy infrastructure in coastal areas.

Comparison of climate change risks to fuels and minerals in the low-emissions and high-emissions scenario, 2080-2100



Source: IEA (2022), [Climate Resilience for Energy Security.]

Comparison of climate change risks to power systems in the low-emissions and high-emissions scenario, 2080-2100



Source: IEA (2022), Climate Resilience for Energy Security.

Parties have made progress in highlighting climate risks and impacts into their NDCs, National Adaptation Plans (NAP), energy strategies and other policies. These high-level plans have an important role to play since they can send a strong signal to energy companies and investors to choose more resilient options. According to the Climate Resilience Policy Indicator, around 75% of IEA member and association countries consider climate resilience for energy systems in at least one of their national plans with a dedicated section and identified actions.

However, actions for adaptation and resilience in the energy sector still require further efforts. In the energy plans of most countries, energy sector adaptation is less prioritised than mitigation. According to the 2022 State of Climate Services: Energy, just 40% of NDCs submitted by Parties to the UNFCCC prioritise adaptation in the energy sector. According to the Climate Resilience Policy Indicator, around 30% of IEA member and association countries are insufficiently prepared against the level of their future climate risks. This imbalance between adaptation and mitigation measures may add challenges to energy security in countries where the adverse impacts of climate change continue to grow.

Finance flows and means of implementation

What is the state of current global climate finance flow and the overall progress made towards making the financial flows consistent with the pathways towards low GHG emissions and climate-resilient development, in the light of equity and the best available science (Article 2.1(c) Paris Agreement)?

The lasting solutions to today's energy crisis lie in speeding up clean energy transitions via greater investment in efficiency, clean electricity and a range of clean fuels. There are various ways for handling the current energy crisis that can open the door to a safer and more secure future. According to the World Energy Investment 2022 report, world energy investment is expected to increase across all sectors by over 8% in 2022 to hit a total of USD 2.4 trillion, significantly higher than pre-Covid 19 levels. All areas of the energy sector are seeing an increase in investment, but the main boost in recent years has come from the power sector - particularly in renewables and grids - and increased spending on end-use efficiency. Investment in the production of oil, gas, coal, and low-carbon fuels is still below the levels observed before the pandemic in 2019.

Nearly three-quarters of the increase in total energy investment is expected to come from clean energy investment, which is projected to increase to more than USD 1.4 trillion in 2022. The annual average growth rate in clean energy investment in the five years after the signing of the Paris Agreement in 2015 was just over 2%. This rate has increased to 12% since 2020, a significant step in the right direction but still well below what is needed to meet the international climate goals. The gains have been underpinned by policy and fiscal measures put in place to support transitions as well as the growing cost competitiveness of many renewable energy technologies. Governments worldwide have set aside USD 710 billion for long-term clean energy and sustainable recovery initiatives.

More than 80% of all investments in the power industry are currently made in renewables, grids, and storage. Nearly half of new investments in renewable energy go toward solar PVs. With more than 20 GW installed and an estimated USD 40 billion in spending in 2021, the emphasis for wind power is shifting offshore. Another significant area of growth is investment in increased energy efficiency, which is fuelled by higher fuel costs and government incentives.

What are the barriers and challenges, including finance, technology development and transfer and capacity-building gaps, faced by developing countries?

Emerging markets and developing economies (EMDEs) (except for China) account for nearly two-thirds of the world's population, but only one-third of global energy investment and just one-fifth of clean energy investment. However, a critical component of EMDEs' capacity to achieve sustainable development objectives is the accessibility of capital for investing in renewable energy transitions. The EMDE policy settings in place today do not offer electricity access or emissions reductions that support sustainable development objectives. A challenge that all EMDEs face is how to finance the ramp-up in capital-intensive investments for power, energy efficiency and end-use electrification. Compared to fossil fuels, such investments generally have lower lifetime operating expenses; however, the cost of financing plays a larger role in the overall economic burden. To attract investment and shift capital allocations to clean energy, it is essential to be able to borrow money, pay off a bigger share of debt, and guarantee sufficient risk-adjusted returns on investment for equity holders. To make these transitions affordable, managing financing expenses and diversifying the sources of funding are becoming increasingly crucial.

Energy investments in EMDEs today rely heavily on public sources of finance. However, in IEA climate scenarios, over 70% of clean-energy investments - mostly renewables and efficiency - are privately financed. EMDEs face heightened macroeconomic risks and domestic capital constraints. Over 90% of EMDE investment needs are in countries with underdeveloped banking and capital markets. Debt burdens are on the rise in a number of economies, and EMDEs do not have sufficient resources for sustainable recovery. Domestic savings are unevenly distributed across regions, while currency risks and restrictions on direct investment can dissuade foreign investors. Cross cutting investment issues can be better addressed through policy predictability, setting clear and ambitious clean energy strategies and good governance. Stronger international efforts are also needed. Realising the commitment by advanced economies to mobilise USD 100 billion per year in climate finance is a critical starting point.

Another major financial challenge for developing countries is the cost of capital. The cost of capital shows how confident debt providers are in getting their loans back and how confident investors are in getting the expected return on equity. Investment is negatively impacted by a high cost of capital, particularly for capital-intensive projects like renewable power generation that require significant up-front expenses. The cost of capital is a major component of renewables' Levelised Costs of Electricity (LCOE). Because LCOE varies by region, investment spending in emerging and developing economies is disproportionately impacted. The cost of capital for a typical solar PV plant in 2021 was between two and three times higher in emerging and developing economies than in advanced economies and China.

What is the collective progress made towards achieving the long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions referred in Article 10.1 of the Paris Agreement? What is the state of cooperative action on technology development and transfer?

Achieving our long-term net-zero goals will require increased technological innovation and deployment. The majority of energy technologies and sectors are not on track to achieve the world's energy and climate objectives, according to IEA's Tracking Clean Energy Progress. Only two out of 55 components of the energy system (EVs and lighting) are currently fully on pace to achieve the world's energy and climate goals. Unprecedented action has been taken in recent decades to hasten the development of clean energy, especially for renewable energy sources and road transport, but much more is required across all sectors.

Reaching net zero emissions by 2050 won't be possible without a major acceleration in clean energy innovation. Nearly half of the CO_2 emission reductions required by the NZE Scenario come from technologies that are currently in the demonstration or prototype stage. In industries such as heavy industry and long-distance transportation, where emissions are especially hard to abate, this percentage is even higher. While only USD 25 billion is currently budgeted, the NZE Scenario estimates that approximately USD 90 billion in public funds should be mobilised globally as soon as possible to complete a portfolio of demonstration projects before 2030. Additionally, many of the currently already available technologies need to be more affordable, perform better, and be customised for particular climatic conditions or regional preferences.

In order to spread the cost and risk of innovation across various actors, facilitate the exchange of ideas across sectors and geographic boundaries, allow for the sharing of best practices in policymaking among policymakers, and support market deployment by harmonising performance standards and

codes, international co-operation is crucial in the field of energy technology innovation. Multilateral platforms are already working to speed up innovation and coordinate the deployment to scale up clean energy technologies. The Technology Collaboration Programmes (TCPs) give governments a forum to collaborate on the advancement of energy technology research, development, and commercialisation. There are 39 TCPs, each concentrating on a particular field of energy technology. The IEA collaborates closely with a number of other organisations, including the Clean Energy Ministerial and Mission Innovation. The global energy innovation community has expanded recently as a result of the inclusion of innovators from EMDEs. As a result, the TCPs have seen an increase in involvement. A lot of TCPs and other multilateral projects would like to add new members. Although there have been encouraging results, more work is needed in order to expand the number of participating nations and completely reap the rewards of co-operation.

International co-operation needs to pick up speed on all fronts in order to meet the goals of the NZE Scenario projections. The IEA is actively fostering collaboration between existing multilateral initiatives, as well as increasing engagement with EMDEs, as emphasised at the 4th TCP Universal Meeting in 2021, at COP26 and in the Breakthrough Agenda report. International co-operation provides EMDEs with an opportunity not only to gain access to technologies and knowledge developed abroad more quickly, but also to showcase home-grown concepts and enable their diffusion through exports. This can be especially helpful in nations where funding for innovation is more limited (possibly attributable to low budgets for R&D and demonstration, the cost of capital, or the availability of human capital), or where the need for economic development limits the willingness to invest in less-developed technologies.

Cross cutting

To achieve the purpose and long-term goals of the Paris Agreement (mitigation, adaptation, and finance flows and means of implementation, as well as loss and damage, response measures), in the light of equity and the best available science, taking into account the contextual matters in the preambular paragraphs of the Paris Agreement:

a. What are the good practices, barriers and challenges for enhanced action?

Since rapid progress has been made in national commitments to achieve the Paris Agreement's goals, global co-operation is now more crucial than ever to meet enhanced ambitions. Through the efforts of various stakeholders, there has also been improved global co-ordination in the energy sector. The IEA, as the global energy authority, has helped countries better align on key issues and challenges. Ministers from countries representing 80% of global energy consumption and global carbon emissions took part in the IEA's Clean Energy Transitions Summit in July 2020 to discuss measures to reduce global emissions. Following the inaugural summit, the second summit, "IEA-COP26 Net Zero Summit", was held in March 2021. Decision makers from more than 40 countries focused on the critical need for international collaboration and policy implementation to accelerate clean energy transitions. They highlighted the importance of catalysing near-term implementation, accelerating technology and innovation in key sectors, and mobilising clean energy investment. Again, this year, the IEA will organise another high-level event in October to strengthen the global momentum and accelerate co-operation to limit the global warming below 1.5°C above the pre-industrial level.

Despite the recent progress in national commitments and international co-operation, there are still some remaining questions on how to ensure and disseminate benefits of climate actions among people in a fair and equitable way. Although implementing clean energy transitions to meet the long-term goals of the Paris Agreement would bring overall benefits to the world, there could be some workers and communities that might be negatively affected. Therefore, enhanced climate actions should be truly people-centred and inclusive, creating jobs, enhancing quality of life, supporting social and economic development and protecting communities. The Global Commission for People-centred Clean Energy Transitions, created in January 2021, brings together government leaders, ministers and experts and proposes key recommendations, including: designing transitions to maximise the creation of decent jobs; developing tailored government support for communities and workers; incorporating gender, equality and social inclusion considerations in all policies; ensuring fair distribution of clean energy benefits; and integrating the voices of younger generations in decision making.

Scale up financing for clean energy transitions is another urgent task to pave the way towards a cleaner energy future. Although clean energy investment started to pick up and exceeded USD 1.4 trillion in 2022, the annual average growth rate in clean energy investment in the five years after the signature of the Paris Agreement in 2015 was just over 2%, which is well below the required level. Moreover, the rise in investment has been concentrated in advanced economies and China, while clean energy spending in emerging and developing economies (excluding China) remains stuck at 2015 levels. To accelerate clean energy investment in emerging and developing economies, the IEA organised a high-level forum on Financing the Energy Transition in Africa (IEA-AUC) at COP27 in November 2022. In this forum, African policymakers came together to discuss specific African energy transition pathways to speed up efforts to mobilise funding. The High-Level Forum expanded on the Africa Energy Outlook 2022 (AEO 2022), identified opportunities for meeting the energy requirements of the continent; bridging the policy and funding gaps; creating universal access to modern and affordable energy services by 2030; and bolstering international co-operation. The IEA's World Energy Investment 2023

(upcoming, May 2023) will contribute to the global discussion on clean energy investment by tracking investment trends across the world.

b. What is needed to make finance flows consistent with a pathway towards low GHG emissions and climate-resilient development?

Decisions made in emerging market and developing economies (EMDEs) will increasingly affect the future of the world's energy and climate. A tremendous opportunity to create a new, lower-emission pathway for prosperity and growth is presented by the falling cost of key clean energy technologies. To seize the opportunity, a huge increase in energy investment is essential. From USD 1.3 trillion today, clean energy investment would be above USD 4 trillion by 2030 in the NZE Scenario, which requires a significant rise from above USD 2 trillion in STEPS scenario.

The financing of clean energy transitions calls for strong strategic mandates to finance clean energy from International Financial Institutions, an increase in international climate finance and blended finance, and incentives for international capital markets to finance clean energy investments in emerging and developing economies. Other criteria address cross-cutting issues that influence investment risks and returns, such as domestic capital access, subsidies for fossil fuels, harmonisation of sustainable finance frameworks, and reporting of climate risk. In addition, expanding and modernising grids, making all new structures and appliances more efficient, spending more in effective and electrified mobility solutions, and raising renewable energy demand will scale up private capital. Focus on the transition's most challenging aspects by redesigning the industrial infrastructure and low-carbon fuel scaling strategies for major producer economies, accelerating the move away from unabated coal, and assuring a people-centred transition.

A variety of financing models and innovative financing instruments is needed that can be used to overcome financing barriers in investment in the clean energy transitions. For instance, IEA's AEO 2022, explores pathways for Africa's energy system to evolve toward achieving all African development goals, illustrated that possible financing instruments for the continent included public-private partnerships, international carbon markets, and international financial contributions to the high upfront capital requirements for, for example, the deployment of large electrolysers, and investments in basic infrastructure to further industrial development and increase trade across the continent.

c. What are the needs of developing countries related to the ambitious implementation of the Paris Agreement?

As outlined in most NDCs of developing countries, they will need financial, technology and capacity building support to implement their mitigation and adaptation actions pledged under the Paris Agreement. Developing nations outside China make up two-thirds of the world's population but only receive one-fifth of investments in clean energy as highlighted by IEA's Special Report on Financing Clean Energy Transitions in Emerging and Developing Economies. Since 2016, annual investments in the energy sector have decreased by around 20% in developing countries across all parts of the energy sector, as difficulties in raising capital increased as Covid-19 weakened corporate balance sheets, reduced consumer purchasing power, and increased pressure on public finances.

To place nations on a road towards net-zero emissions consistent with the Paris Agreement goals, clean energy spending requires an unprecedented increase. The annual capital expenditures on clean energy in developing countries should increase by more than seven times, to above USD 1 trillion, by the end of the 2020s. In order to mobilise capital on this scale, the private sector will need to play a

significantly larger role. An enhanced role for international and development finance institutions will be critical to catalyse this investment.

Furthermore, low costs of capital will be crucial for implementing clean energy transitions in developing countries. At the moment, costs of capital in developing countries are up to seven times higher than in the United States and Europe. It will therefore also be crucial to increase the amount of capital financiers and developers devoted to clean energy in developing countries. Project-specific factors such as creditworthiness and availability of enabling infrastructure are compounded by broader issues, such as fossil fuel subsidies, bureaucratic and currency risks, and weaknesses in local banking and capital markets.

Many developing countries also need technical support and capacity reinforcement to develop sustainable national energy information systems and energy modelling capabilities, both essential for clean energy policy planning. For instance, the IEA has been providing support to selected countries in Sub-Saharan Africa to improve their tracking against energy-related NDCs, SDGs, and other energy and climate policy goals, as well as long-term energy planning. Additionally, the IEA collaborates with UNFCCC on joint capacity building efforts for enhancing the quality of energy data for climate reporting purposes.

What is needed to enhance national level action and support, as well as to enhance international cooperation for climate action, including in the short term?

According to IEA analysis, if all announced climate pledges are fulfilled in full and on time, this would be sufficient to keep the increase in global temperature to 1.7 °C at around 2100, the first time that a value comes within the parameters of the goals set forth in the Paris Agreement. However, achieving those objectives within the announced deadlines will not be simple. The IEA has also demonstrated that immediate action is still insufficient and does not align with governments' bold promises for the coming decades. To bridge the gap, the international energy and climate sector, governments, industry, financial institutions, international organisations and civil society should form a Grand Coalition and collaborate in focussing on concrete actions to reverse the growth in carbon emissions this decade, focussing on all the fuels and existing technologies that can help achieve that goal. At the IEA we believe there are three important dimensions to follow:

- Shape and implement concrete policies to achieve the targets set.
- Monitor and keep track of these policy results.
- Make sure that those policies, while boosting clean energy transitions, do not jeopardise the security of the energy system; decent jobs and worker protection; social and economic development; and inclusiveness and fairness.

Resources

Reports

- World Energy Outlook 2022, https://www.iea.org/reports/world-energy-outlook-2022.
- Government Energy Spending Tracker, December 2022 update, https://www.iea.org/reports/government-energy-spending-tracker-2.
- Renewables 2022, https://iea.blob.core.windows.net/assets/ada7af90-e280-46c4-a577-df2e4fb44254/Renewables2022.pdf.
- Energy Technology Perspectives 2023, https://iea.blob.core.windows.net/assets/a86b480e-2b03-4e25-bae1-da1395e0b620/EnergyTechnologyPerspectives2023.pdf.
- Electric Vehicles Tracking Report, https://www.iea.org/reports/electric-vehicles.
- Energy Efficiency 2022, https://www.iea.org/reports/energy-efficiency-2022.
- Tracking Clean Energy Progress, https://www.iea.org/topics/tracking-clean-energy-progress.
- Coal in Net Zero Transitions, https://iea.blob.core.windows.net/assets/4192696b-6518-4cfc-bb34-acc9312bf4b2/CoalinNetZeroTransitions.pdf.
- Global Energy Review: CO2 emissions in 2023, https://iea.blob.core.windows.net/assets/3c8fa115-35c4-4474-b237-1b00424c8844/CO2Emissionsin2022.pdf.
- Global Methane Tracker 2023 (methane emissions from the energy sector), https://www.iea.org/reports/global-methane-tracker-2023.
- Africa Energy Outlook 2022, https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf.
- Climate Resilience for Energy Security, https://www.iea.org/reports/climate-resilience-for-energy-security.
- World Energy Investment 2022, https://www.iea.org/reports/world-energy-investment-2022.
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- Financing Clean Energy Transitions in Emerging and Developing Economies, https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies.
- Net Zero by 2050, A Roadmap for the Global Energy Sector, https://www.iea.org/reports/net-zero-by-2050.

Programmes

- Energy Sub-Saharan Africa, Promoting Sustainable and Inclusive Economic Growth, https://www.iea.org/programmes/energy-sub-saharan-africa.

- Technology Collaboration Programmes (TCPs), https://www.iea.org/areas-of-work/technology-collaboration.

- An Affordable and Sustainable Energy System for Sub-Saharan Africa, https://www.iea.org/programmes/energy-sub-saharan-africa.

Data products

- Weather for Energy Tracker, https://www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker.

- Cost of Capital Observatory, https://www.iea.org/reports/cost-of-capital-observatory.

- Climate Resilience Policy Indicator, https://www.iea.org/reports/climate-resilience-policy-indicator.