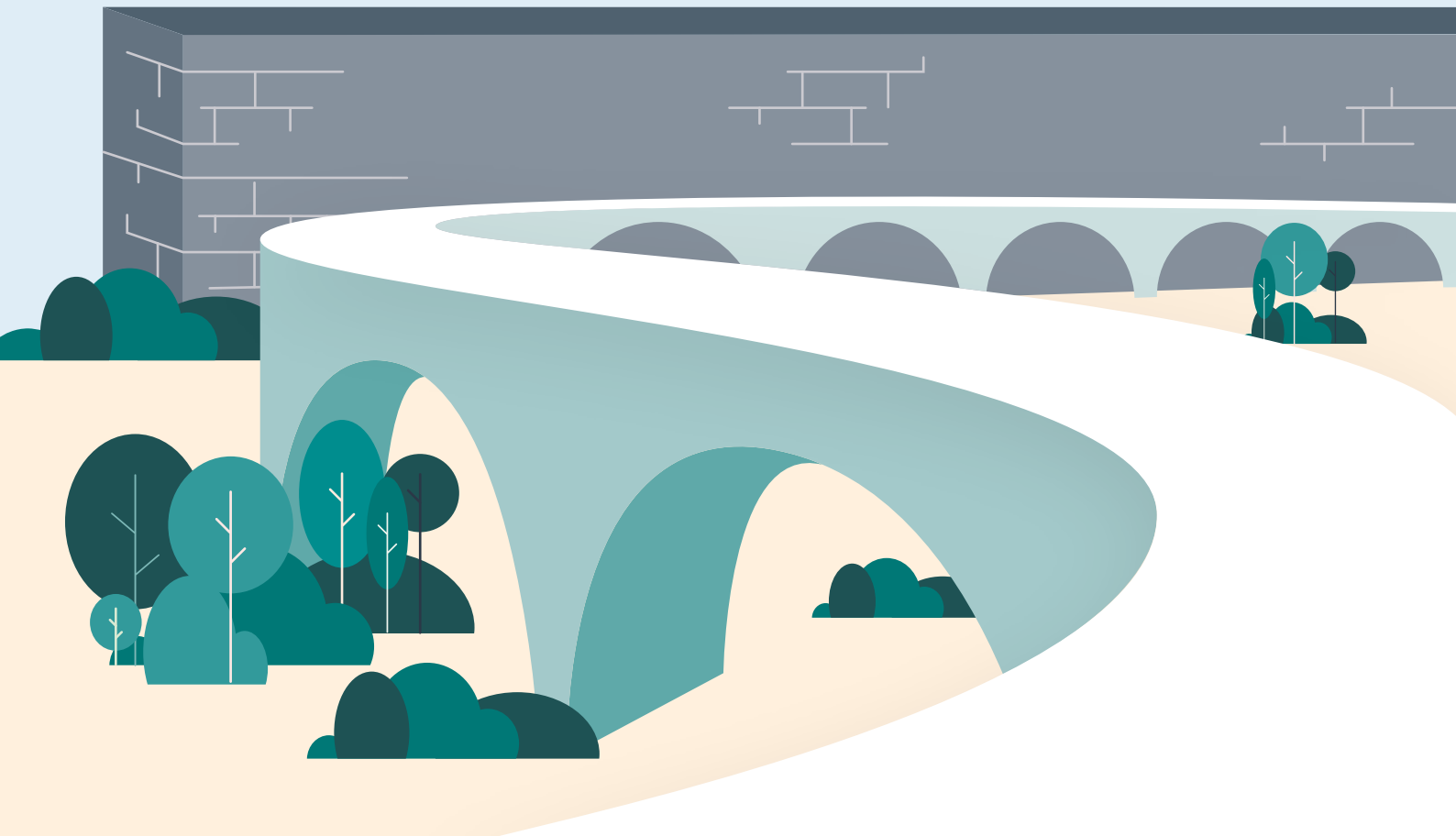
equinor

2023

Energy Perspectives

Global macroeconomic and energy market outlook



WE BUILD TOO MANY ***WALLS*** *AND NOT ENOUGH* ***BRIDGES***

Sir Isaac Newton

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THE SCENARIOS

The scenarios

Energy Perspectives presents two scenarios for global development and future global energy markets: *Walls* and *Bridges*.

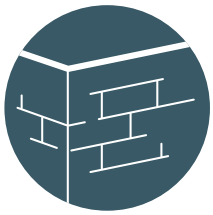
A sharp dichotomy is emerging between the slow, incremental change that characterises the energy transition seen today, and the acceleration necessary to achieve the radical changes required to move the world onto a sustainable path. The two scenarios encapsulate this dichotomy.

The future of energy markets is difficult to predict. Recent events have shown it is not only the long-term development of macroeconomics and energy markets that are uncertain. Covid-19 has only a short-term impact in both scenarios, with China being the last major economy to exit its zero-covid policy this year. The Russian invasion of Ukraine and the associated geopolitical tensions have given rise to the reappearance of obstacles to cooperation and existing trade and supply flows which may have long-lasting effects.

The scenarios start from the world as it is today, where the energy transition has begun but has yet to accelerate to the speed required to achieve the goals of the Paris Agreement. They share near-identical paths up until 2025, at which point they start to diverge. *Walls* shows a pathway of where the world could go if it continues to broadly follow current trends, whilst *Bridges* illustrates a pathway the world would need to follow to reach the 1.5°C target.

Both scenarios consider the same set of drivers, ranging from economic growth and technological development to climate policy and geopolitics, and both scenarios recognise the profound systemic change required to put the energy system on a more sustainable track. The difference between the two scenarios is the relative force of these drivers and the extent to which they influence the future path of the global energy system after 2025. In short, *Walls* fails to deliver on the transition needed to reach climate ambitions, whilst *Bridges* does not.

Energy Perspectives does not try to predict the future but shows possible future paths for the global energy system based on the choices the world makes, providing a platform for debate and informed decision-making.



Walls

Walls signify the abundance of barriers blocking fundamental and accelerated change in the global energy system.

Throughout human history, walls have been built to protect us from the things that we fear: intruders, plagues, viruses, the weather, and wild animals. Inadvertently, walls exclude us, cut off options and place obstacles in our path. Walls shield us, but also form barriers to transition and movement.

Walls protect, but they also divide.

The *Walls* scenario builds on current trends in market, technology and policy, assuming them to continue developing at a slowly accelerating pace in the future. Economic growth remains the key driver for growing energy demand, and national governments continue to prioritise short-term economic growth over long-term climate goals. Legislation such as the US Inflation Reduction Act (IRA) and the EU Green Deal Industrial Plan highlights the return of industrial policies, which may accelerate the energy transition, but may also create market distortions and inefficiencies that make the energy transition more costly. Geopolitical tensions in the wake of the Russian invasion of Ukraine lead to long-lasting effects on economic development and government policy, especially in the Commonwealth of Independent States (CIS), the EU and China.

The energy transition is limited by cooperation and trust, and although climate policies continue to tighten, with momentum driven mainly by the industrialised regions, the scenario does not meet all stated targets and does not move fast enough to satisfy the goals of the Paris Agreement. Change is simply not happening fast enough.

Walls is a story about an energy transition that is slowly accelerating, but that does not reach climate targets. However, it is important to note that the changes to the global energy system outlined in *Walls* are not a given. They will still require enormous changes to the foundations of the global energy system.

Bridges

If Walls signify the barriers to change, Bridges represent the overcoming of these barriers and the impetus towards accelerated change.

Bridges help us to connect, allowing people to reach places they would not otherwise have been able to reach and achieve things they would not otherwise have been able to achieve. Bridges are open-ended and facilitate transition, movement, trade and communication.

Bridges connect and enable.

The *Bridges* scenario is a normative back-cast constrained by an energy-related CO_2 emissions budget of 445 Gt CO_2 compliant with a 50% probability of no more than a 1.5°C temperature rise*.

A benign geopolitical landscape is established, supporting renewed cooperation and friendly competition among nations. Energy markets become more integrated and technological advancements are shared more readily. Climate action remains the key driver, and all regions are under pressure to rapidly phase out fossil fuels, build renewable capacity, improve energy efficiency and make drastic behavioural changes. The accelerated transition brings significant changes to the energy system even before 2030.

This ambitious scenario serves to illustrate the enormous challenge the world is faced with. It is technically within reach, but whether it is also practically and economically achievable, and saleable to voters once all the implications are clear, is open to debate. The scenario is not anchored in detailed analytical convictions but rather aims to stimulate discussions around the feasibility of the changes required to limit global warming to 1.5°C by the end of the century.

** The IPCC's 6th Assessment Report puts the CO_2 budget for 2020-50 period at 500 Gt. This budget is to be shared between emissions in energy, in industrial uses like cement, and in agriculture. In this analysis a budget of 445 Gt is allocated to emissions for energy purposes.*

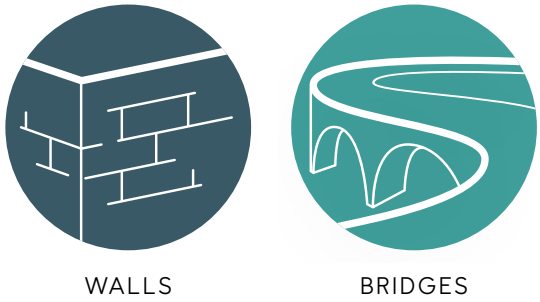
KEY INSIGHTS

Key insights from Energy Perspectives 2023

Energy Perspectives presents two scenarios for economic and energy market development, *Walls* and *Bridges*.

Walls builds on current energy market trends and energy and climate policies, assuming climate action to progress at a slowly accelerating pace in the future.

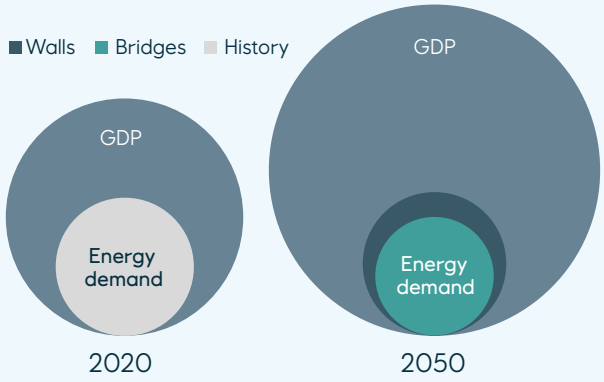
Bridges is a normative back-cast complying with the 1.5°C carbon budget, demonstrating the enormous and sustained efforts required to reach this target.



The world will continue to need energy, but will become more energy efficient

Historically, between 1990-2020 energy intensity improved by 1.2% per year.

Towards 2050, the energy intensity declines by 1.9% per year in *Walls* and 3.2% per year in *Bridges* with electrification being the key enabler.



Source: IEA, © Oxford Economics Limited 2023 (history), Equinor (projections)

Peak demand for fossil fuels arrives before 2030

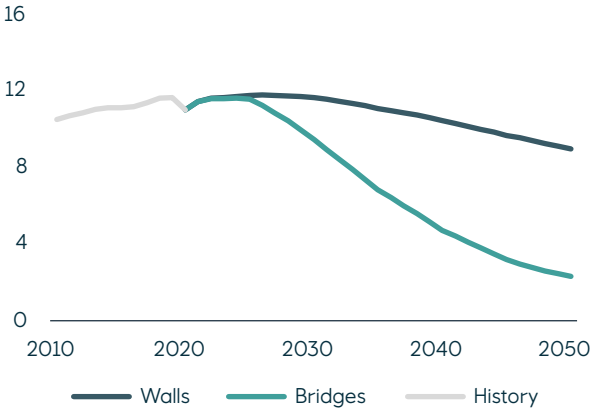
In *Walls*, the peak occurs in 2026, followed by a gentle downward trajectory.

In *Bridges*, fossil fuel demand declines at a rapid pace after 2025. By 2050, all remaining fossil fuel use is either fully abated or compensated by carbon removal.

Source: IEA (history), Equinor (projections) →

Global fossil fuel demand

Gtoe



Gas demand will continue to grow in *Walls*, but declines sharply in *Bridges*

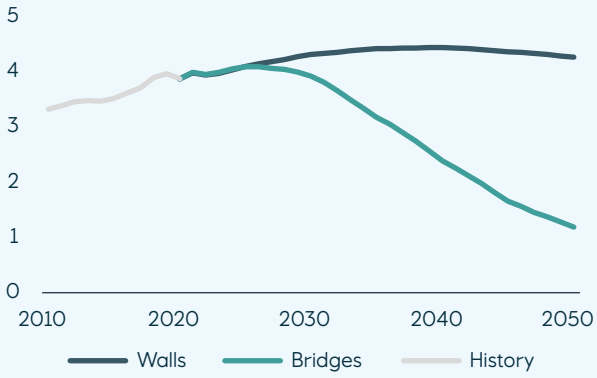
In *Walls*, gas demand peaks in 2039 and is around 10% higher than today's level in 2050.

In *Bridges*, gas demand peaks in 2025 and falls to around a third of today's level in 2050.

Source: IEA (history), Equinor (projections) →

Global gas demand

Thousand Bcm



Energy consumption shifts towards electricity

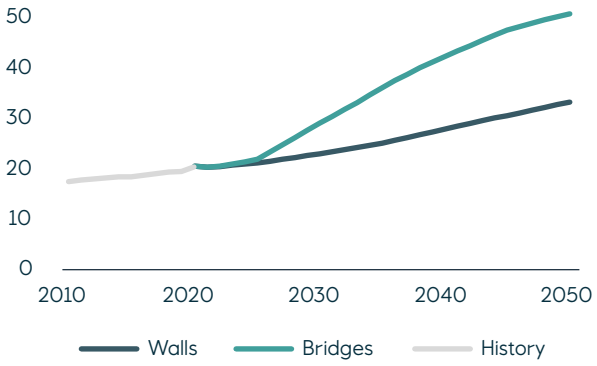
In *Walls*, electrification accelerates steadily towards 2050, increasing its share by half.

In *Bridges*, a massive acceleration happens before 2030. By 2050, the share exceeds 50%, two and a half times as large.

Source: IEA (history), Equinor (projections) →

Electricity share of total final energy consumption

%



Wind and solar photovoltaics (PV) capacity show significant growth compared to 2020 levels

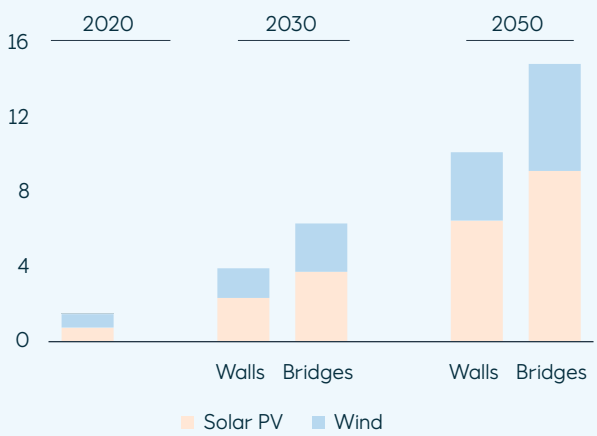
In *Walls*, wind capacity is five times greater, and solar PV capacity nine times greater in 2050 compared with today.

In *Bridges*, wind capacity is eight times greater, and solar PV capacity 13 times greater in 2050 compared with today.

Source: IEA (history), Equinor (projections) →

Wind and solar PV capacity

Thousand GW



Electrification and hydrogen, including its derivatives will contribute to the decarbonisation of transport

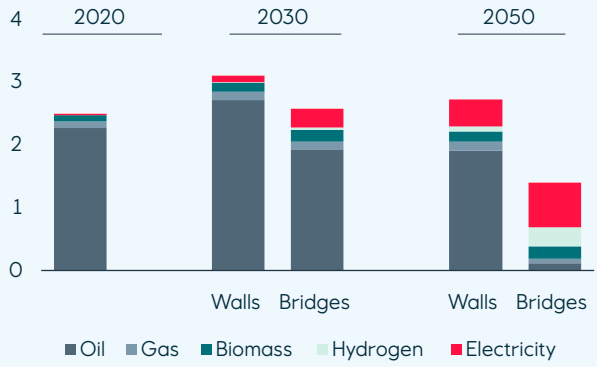
In both scenarios, electric vehicles replace internal combustion engines in road transport but to a different extent.

In *Bridges*, further decarbonisation is achieved by increasing the use of hydrogen, including its derivatives in marine and air transport.

Source: IEA (history) Equinor (projections) →

Transport fuel mix

Gtoe



Carbon capture, utilisation and storage (CCUS) will play an essential role in the decarbonisation of the power and industry sectors

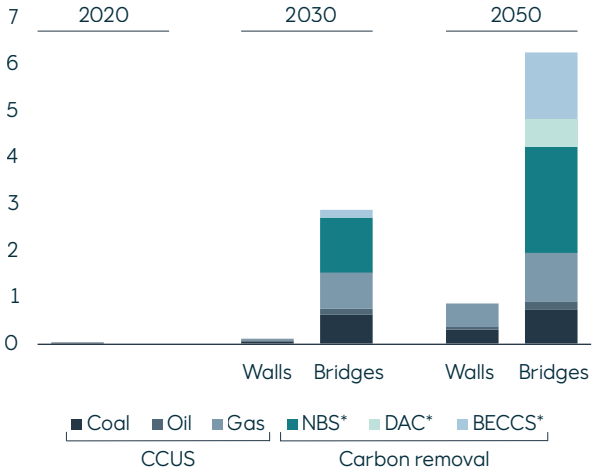
In *Walls*, CCUS on both coal and gas starts to accelerate after 2030.

In *Bridges*, there is massive growth in CCUS even before 2030, and after 2030 there is extensive contributions from carbon removal technologies and practices.

Source: IEA (history) Equinor (projections) →

Carbon captured and stored annually

Gt CO_2



** Nature-based solutions (NBS), Bioenergy with carbon capture and storage (BECCS), Direct air capture (DAC)*

Current net zero commitments are not enough to avoid global warming above 1.5°C

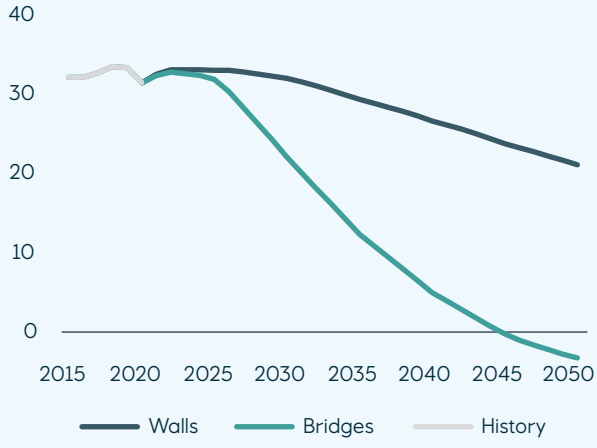
In *Walls*, the 1.5°C budget is exhausted by 2033.

In *Bridges*, current commitments are met, and further commitments are made that enable emissions to remain within the 1.5°C carbon budget with the help of carbon removal technologies.

Source: IEA (history) Equinor (projections) →

Global energy-related CO_2 emissions, after carbon removal

Gt CO_2



The demand for minerals needed to support the energy transition is set to increase significantly

In *Walls*, the demand** for minerals doubles by the early 2030s compared with the average annual demand from 2016 to 2020.

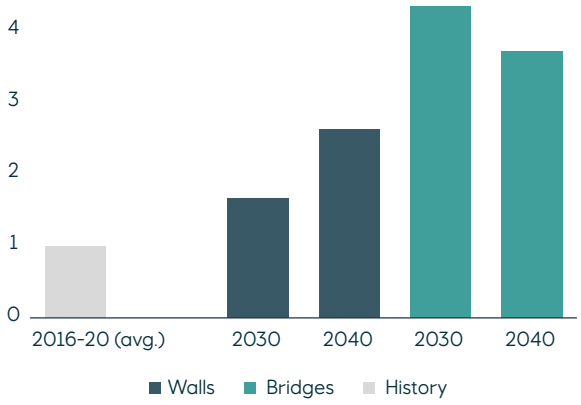
In *Bridges*, demand peaks by 2035 and then drops towards 2040 driven by mineral intensity improvements and a slowdown in new annual capacity additions.

*** Mineral demand needed to support annual capacity additions of solar PV and wind in power generation*

Source: Equinor →

Mineral demand**

Indexed 2016-20 (average demand) = 1

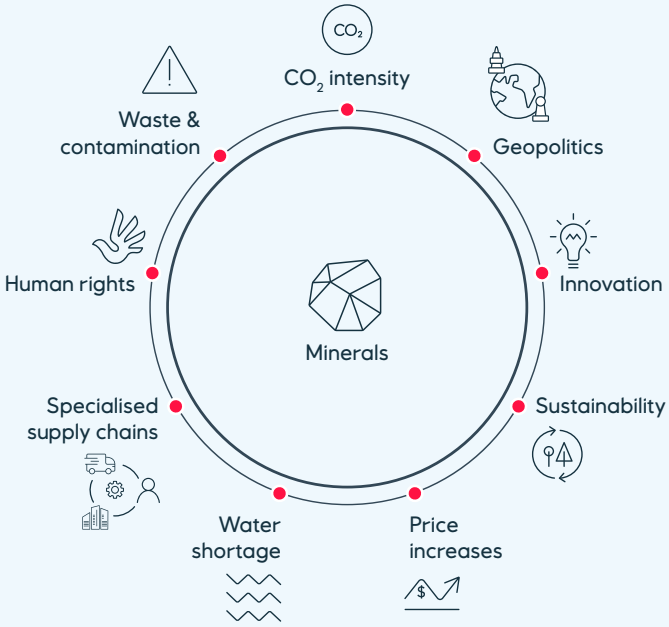


The mineral value chains are complex

Geopolitics, specialised supply chains, price hikes, as well as environmental, social and governance issues are all challenging future supply of minerals.

Innovation will be an important enabler to secure future mineral reserves and ease demand for those in short supply or ethically compromised.

Source: Equinor →



For some minerals, current production levels are insufficient to meet future demand

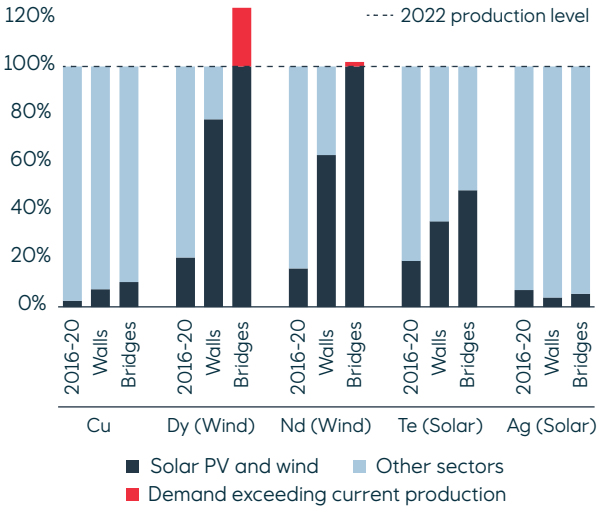
In both *Walls* and *Bridges*, increased mineral demand** will challenge supply, with the future annual demand for certain minerals exceeding current production levels.

For future mineral demand and supply to balance, production levels must increase or innovation must drive demand down.

*Source: USGS, Wang et al***, Equinor* →

**** Wang et al. (2023) Future demand for electricity generation materials under different climate mitigation scenarios, Joule 7, 309-332. Elsevier Inc.*

Solar PV and wind demand for selected minerals in 2040 as share of 2022 annual production



APPENDIX

Key figures

		2020	2050		2020-2050 growth per year (%), CAGR	
	Units		Walls	Bridges	Walls	Bridges
Global GDP	2015-USD trillion	81.4	158.0	158.0	2.2	2.2
North America, Europe, Industrial Asia Pacific	2015-USD trillion	49.0	75.9	74.7	1.5	1.4
China	2015-USD trillion	14.8	36.3	37.0	3.0	3.1
Rest of World	2015-USD trillion	17.6	45.8	46.3	3.2	3.3
Global energy intensity - indexed to 2020		100	55.4	38.0	-1.9	-3.2
Global population	billion	7.8	9.7	9.7	0.7	0.7
Global energy demand	Gtoe	13.77	14.81	10.15	0.2	-1
Coal	Gtoe	3.66	1.69	0.27	-2.5	-8.3
Oil	Gtoe	4.09	3.7	1.02	-0.3	-4.5
Gas	Gtoe	3.21	3.54	0.99	0.3	-3.8
Nuclear	Gtoe	0.7	1.04	0.98	1.4	1.1
New renewables	Gtoe	0.36	2.73	5.28	7.0	9.3
Oil excl biofuels	mbd	88.9	81.4	24.3	-0.3	-4.2
Gas	Bcm	3,866	4,256	1,197	0.3	-3.8
Global energy-related CO_2 emissions	billion tonnes	31.4	21.2	1.1	-1.3	-10.7
North America	billion tonnes	5.2	2.7	0.2	-2.2	-10.8
Europe	billion tonnes	3.4	1.0	0.0	-3.8	-15.9
China	billion tonnes	10.2	4.5	0.1	-2.7	-15.1
India	billion tonnes	2.1	3.0	0.1	1.2	-8.9
World CO_2 emissions from fossil fuel use removed by CCUS	Mt	15	858	1,964	14.4	17.6
World CO_2 emissions removed from atmosphere	Mt	0	0	4,300	-	-
Global light duty vehicles (LDVs) fleet	million	1,375	1,614	1,368	0.5	0.0
LDVS oil demand	Mtoe	987	542	29	-2.0	-11.1
LDVs biofuel demand	Mtoe	65	46	1	-1.2	-14.0
LDVs electricity demand	Mtoe	2	197	292	16.9	18.4

Units

Coal	Btce	billion tonnes of coal equivalent
Oil	mbd	million barrels per day
Gas	Bcm	billion cubic metre
Power	TWh	terawatt-hour
	GW	gigawatt (1 watt x10^9)
Energy	Mt	million tonnes (1 tonne x 10^6)
	Gt	gigatonnes (1 tonne x 10^9)
	Mtoe	million tonnes of oil equivalent
	Gtoe	gigatonnes of oil equivalent
Carbon	Gt CO_2	gigatonnes of carbon dioxide
Monetary	USD	1 US dollar

Definitions

Energy demand and consumption

History: 1990-2020
Projection: 2021-2050

Regions

There are 12 regions modelled.
Industralised: European Union, Industralised Asia Pacific, North America, Other Europe.
Emerging: Africa, China, CIS (Commonwealth of Independent States), India, Middle East, Other Americas, Other Asia Pacific, Southeast Asia

Sectors

There are 8 sectors modelled.
Industry, residential, other stationary, transport, non-energy, power & heat, hydrogen, other transformation

Acknowledgements and disclaimer

Acknowledgements

The analytical basis for this outlook is long-term research on macroeconomics and energy markets undertaken by the Equinor organisation during the first half of 2023. The research process has been coordinated by Equinor's unit for Macroeconomics and Energy Market Analysis, with crucial analytical input, support and comments from other parts of the company. Joint efforts and close cooperation in the company have been critical for the preparation of an integrated and consistent outlook for total energy demand and the projections of the future energy mix in different scenarios. We hereby extend our gratitude to everybody involved.

The editorial process concluded on 8th June 2023.

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Energy Perspectives 2023