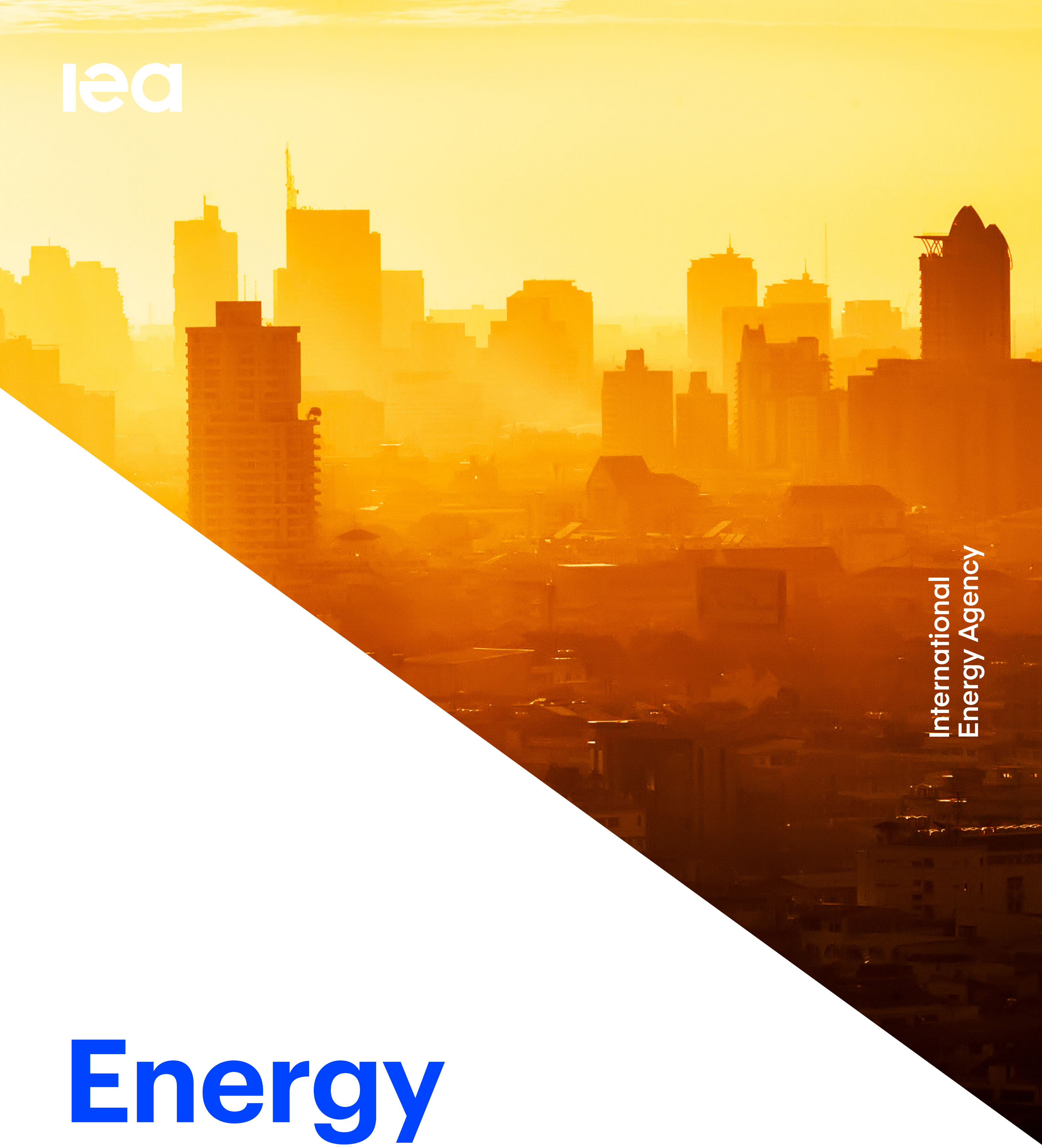


Energy Efficiency 2023

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 31 member countries, 13 association countries and beyond.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Lithuania
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Republic of Türkiye
United Kingdom
United States

The European Commission also participates in the work of the IEA

IEA association countries:

Argentina
Brazil
China
Egypt
India
Indonesia
Kenya
Morocco
Senegal
Singapore
South Africa
Thailand
Ukraine

Source: IEA.
International Energy Agency
Website: www.iea.org

Abstract

Energy Efficiency 2023 is the IEA's primary annual analysis on global developments in energy efficiency markets and policy. It explores recent trends in energy intensity, demand and efficiency-related investment, policy and technology. This tenth edition of the market report also features a new spotlight section, focused on key issues facing policy makers this year. In particular, the report details what is entailed with the proposed global target to double energy efficiency progress and what will be gained by achieving it.

This year's report comes amidst the ongoing effects of the energy and climate crises in what is expected to be the hottest year on record. In this context, 2023 global energy efficiency progress, as measured by primary energy intensity, is expected to be slightly below the long-term trend in a slow down from 2022. However, the report makes clear that a profound transformation is underway in energy efficiency and clean energy more broadly, with many governments introducing new, or strengthening existing, policies and energy-saving programmes. These policies are leading to faster deployment of efficient technologies and are contributing towards an expected peaking of fossil fuel demand in the coming years.

Acknowledgements

Energy Efficiency 2023 was prepared by the Energy Efficiency and Inclusive Transitions Office (EEIT) in the Directorate of Energy Markets and Security (EMS) and in collaboration with other directorates of the International Energy Agency (IEA).

The report was designed and directed by Nicholas Howarth, Energy Analyst (EEIT). Other lead authors were Lucas Boehlé, Federico Callioni, Hadrien Loyant, Jack Miller and Fabian Voswinkel. Diane Munro edited the report.

Principal authors (in alphabetical order) were: Clara Camarasa (cooling), Conor Gask (China and sector analysis), Pauline Henriot (systems efficiency), Kristina Klimovich (PACE and behaviour), Natalie Kauf (Southeast Asia, systems efficiency), Simrat Kaur (India), Silvia Laera (systems efficiency), Emma Mooney (behaviour, industry and EEOs), Alison Pridmore (transport), Sungjin Oh (government spending and policy updates), Josh Oxby (employment), Ksenia Petrichenko (buildings and systems efficiency), Cornelia Schenk (investment, India), and Brendan Reidenbach (investment in digital). Further support and input were provided by Juliette Denis-Senez Jappe, Caroline Fedrine, Lisa Marie Grenier, Andika Hermawan, Yujun Huang and Orestis Karampinis. Mitsidi Projetos and Ian Hamilton also provided much valued analytical support.

Lead authors for special spotlight sections were as follows: Lucas Boehlé and Federico Callioni (energy intensity progress); Hadrien Loyant, Jack Miller and Fabian Voswinkel (doubling efficiency progress); Clara Camarasa, Arnau Risquez Martin and Fabian Voswinkel (cooling in the hottest year on record); Pauline Henriot, Silvia Laera, Natalie Kauf and Arnau Risquez Martin (benefits of systems efficiency); Lucas Boehlé, Ian Hamilton, Hadrien Loyant and Ksenia Petrichenko (gas and residential heating); Simrat Kaur, Cornelia Schenk, and Arnau Risquez Martin (cooling in India).

Brian Motherway, Head of EEIT provided overall strategic direction to the report, along with Vida Rozite, Energy Analyst. Melanie Slade, Senior Programme Manager, also gave expert advice and management support to the report.

Keisuke Sadamori, Director of Energy Markets and Security (EMS) provided important expert guidance and advice. Valuable comments, feedback and guidance were provided by other senior managers within the IEA and in particular, Toril Bosoni, Laura Cozzi, Dan Dorner, Paolo Frankl, Tim Gould, Timur Gül, Dennis Hesseling and Nick Johnstone.

This year's market report benefited from a special analysis conducted by EMS colleagues Joel Couse and Louis Chambeau drawing on fuel reports from across the directorate. Particular thanks go to Carlos Fernandez Alvarez, Heymi Bahar, Eren Cam, Pablo Hevia-Koch, Gergely Molnar, and as well as Davide D'Ambrosio, Ciarán Healy, Julian Keutz, Arne Lilienkamp and David Martin.

Data and analysis from the IEA Energy Data Centre was fundamental to the report, particularly from Roberta Quadrelli, Alexandre Bizeul, Pedro Carvalho, Thomas Elghozi, Juha Köykkä, Domenico Lattanzio, Arnau Risquez Martin and Pouya Taghavi-Moharamli.

Analysis and input from the IEA World Energy Outlook, Tracking Clean Energy Progress, World Energy Investment, Energy Efficiency Hub, Energy Technology Perspectives and Sustainable Recovery Tracker teams was essential to this work. Particular thanks go to Blandine Barreau, Elizabeth Connelly, Daniel Crow, Chiara Delmastro, Tanguy De Bienassis, Araceli Fernandez Pales, Mathilde Huismans, Martin Kueppers, Shane McDonagh, Yannick Monschauer, Rafael Martinez Gordon, Apostolos Petropoulos, Arthur Roge, Jonathan Sinton, Leonie Staas, Tiffany Vass, Anthony Vautrin and Daniel Wetzel.

The report would not have been possible without the support of Jethro Mullen, Acting Head of the Communications and Digital Office (CDO), and his team who were responsible for production and launch support, especially Poeli Bojorquez, Curtis Brainard, Astrid Dumond, Zachary Egan, Therese Walsh and WonJik Yang.

The report was made possible by assistance from the Ministry of Economy, Trade and Industry, Japan. The Italian Ministry of Environment and Energy Security is also gratefully acknowledged for their support through their contributions to the IEA's Digital Demand Driven Electricity Networks (3DEN) initiative.

Peer reviewers

Many senior government officials and international experts provided input and reviewed preliminary drafts of the report. Their suggestions were of great value. They include:

Alfa Laval	Madeleine Gilborne
Alliance for an Energy Efficient Economy (AEEE)	Satish Kumar
American Council for an Energy-Efficient Economy	Steve Nadel
Applied Energy	Nick Meeten
ASEAN	Rika Safrina
Asian Development Bank	David Morgado
Asia-Pacific ESCO Industry Alliance	Alex Ablaza
Australian Alliance for Energy Productivity (A2EP)	Jarrod Leak

China National Institute of Standardisation	Pengcheng Li
CLASP	Matt Malinowski Christine Egan
Climate Strategy & Partners	Peter Sweatman
Danfoss	Sara Vad Sørensen
Eco Homes	Winifred Atanga
Economic & Human Dimensions Research Associates	Skip Laitner
Enel X	Vitoria Delicado Montoya Emanuela Sartori
Energy Efficiency & Conservation Authority, New Zealand	Brian Fitzgerald
Energy Efficiency Council, Australia	Jeremy Sung
Energy Efficiency Movement, ABB	Mike Umiker
Energy in Demand	Rod Janssen
EnergyPro	Steven Fawkes
Engie	Florence Dufour
European Heat Pump Association	Thomas Nowak
European Transport and Energy Research Centre of ITS, UC Davis	Pierpaolo Cazzola
Fraunhofer Institute for Systems and Innovation	Wolfgang Eichhammer
Ghana Energy Commission	Adolf Nii Ashong
GIZ	Liliana Campos
Government of Austria	Thomas Deuts
Government of Norway	Tom Andreas Mathiasson
Government of Spain	Mar Blazquez
Government of Türkiye	Barış Sanlı
IDAE, Spain	Marisa Olano
Independent consultants	Padu S. Padmanabhan Jacob Teter Kevin Lane
Institute of Energy Economics, Japan	Koichi Sasaki
METI, Japan	Haruto Shinoda
Ministry of Economic Affairs & Climate Policy, The Netherlands	Josephine Ris Jelte de Jong
Ministry of Economic Affairs and Employment, Finland	Timo Ritonummi
Mitsui & Co. Global Strategic Studies Institute	Takashi Hongo
Natural Resources Canada	Office of Energy Efficiency
Openexp	Yamina Saheb
Oregon Department of Energy	Edith Bayer
Regulatory Assistance Project	Jan Rosenow
Réseau de Transport d’Électricité (RTE), France	Bianka Shoai-Tehrani
RMIT University	Alan Pears
Rocky Mountain Institute	Amory Lovins
Schneider Electric	Vincent Minier

Signify	Harry Verhaar
Swedish Energy Agency	Carlos Lopez
The Institute of Energy Economics	Naoko Doi
UK Department for Energy Security & Net Zero	Daniel Weaver
UNIDO Youth Advisor	Melissa Tomassini
University College London Energy Institute	David Shipworth
University College of London	Lynnette Dray
UNOPS	John Robert Cotton
World Bank	Ashok Sarkar

Table of contents

Executive summary ... 9

Chapter 1. Energy efficiency and demand trends ... 16

Energy intensity and demand ... 16

Energy prices and affordability ... 29

Chapter 2. Sector trends in energy efficiency ... 35

Overview ... 35

Transport ... 37

Industry ... 45

Buildings ... 51

Electrification and system level efficiency ... 56

Chapter 3. Finance and employment ... 62

Efficiency investment trends ... 62

Property assessed clean energy financing ... 70

Energy efficiency employment ... 72

Chapter 4. Energy efficiency policy progress updates ... 75

International developments ... 75

National and regional developments ... 76

Regulations and standards ... 82

Behaviour change ... 85

Energy efficiency obligation schemes ... 88

Chapter 5. Key issues for governments ... 90

Why is energy intensity progress lower in 2023 despite significant policy action? ... 90

What does doubling global progress on energy efficiency entail? ... 96

How does the hottest year on record drive urgency for efficiency measures? ... 102

How are consumers benefiting from system efficiency? ... 107

Has the energy crisis accelerated the shift away from gas in residential space heating? ... 113

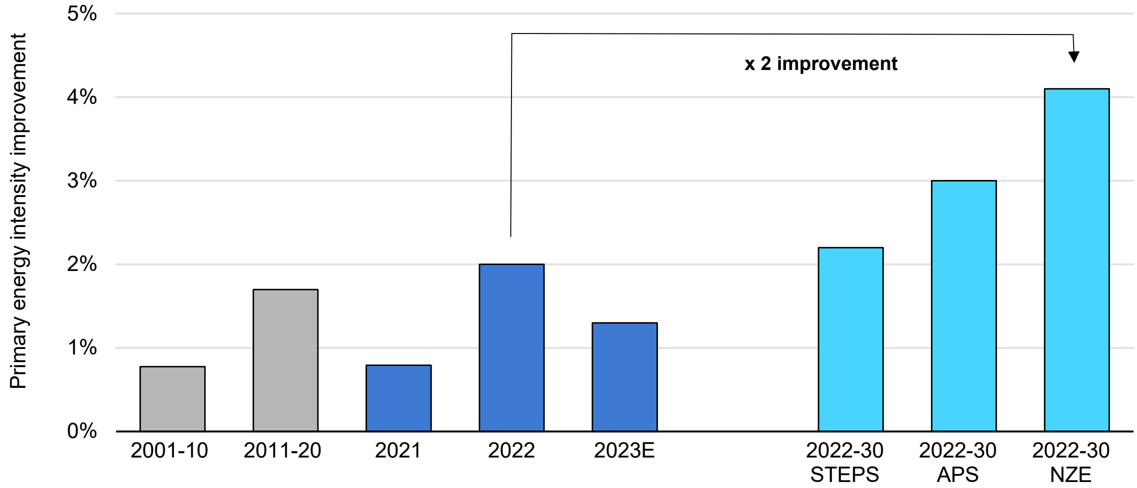
Can efficient cooling help manage fast rising electricity demand in India and achieve thermal comfort for all? ... 119

Executive summary

Efficiency policy momentum builds, but global energy intensity progress slows

Energy efficiency is currently seeing a strong global focus among policy makers in recognition of its important role in enhancing energy security and affordability, and in accelerating clean energy transitions. This comes, however, as the estimated 2023 rate of progress in energy intensity – the main metric used for the energy efficiency of the global economy – is set to fall back to below longer-term trends, to 1.3% from a stronger 2% last year. The lower energy intensity improvement rate largely reflects an increase in energy demand of 1.7% in 2023, compared with 1.3% a year ago.

Annual primary energy intensity improvement, 2001-2022, 2023E, and by scenario, 2022-2030



Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario.

At the same, this year's slower progress in global energy intensity masks exceptional gains in some countries and regions, where strong policy action, increased investments and consumer behaviour changes led to sharp improvements well above the average global rate. This year the European Union and the United States, among many others since the beginning of the energy crisis, including Korea, Türkiye and the United Kingdom, have registered robust improvements ranging from 4% to 14%.

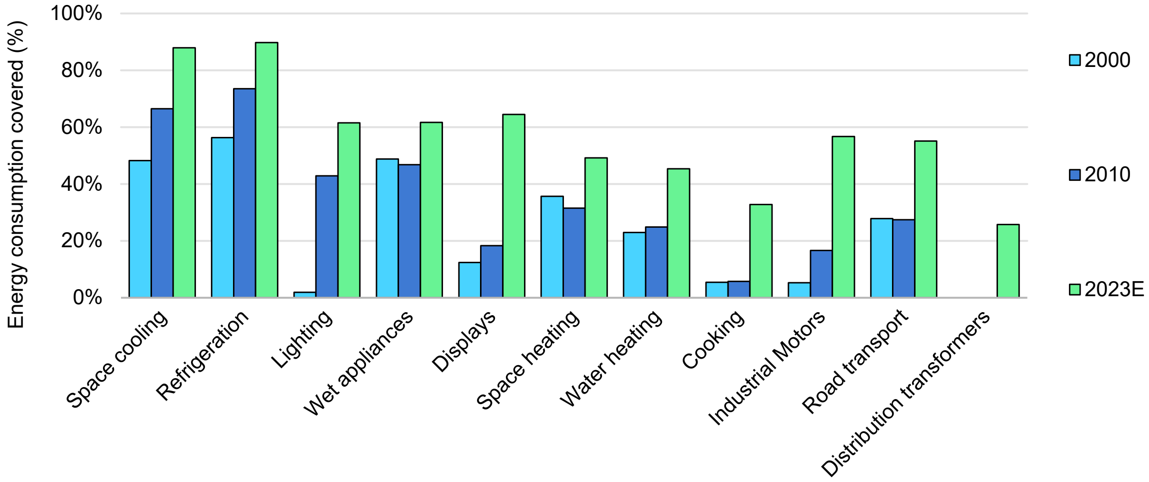
In 2023, global momentum to target a doubling in the rate of efficiency progress to 4% gathered pace, which could cut today's energy bills in advanced countries by one-third and make up 50% of CO_2 reductions by 2030. In June, 46 governments participating in the IEA's 8th Annual Global Conference on Energy Efficiency endorsed the 'Versailles Statement: The crucial decade for energy efficiency', agreeing to strengthen energy efficiency actions in line with a doubling of global energy intensity progress each year this decade to 2030.

Policy action is translating into investment and deployment

The energy crisis has unambiguously accelerated the energy transition, with energy efficiency policy action a central plank of government initiatives.

Since the start of the energy crisis in early 2022 there has been a major escalation in action, with countries representing 70% of global energy demand introducing or significantly strengthening efficiency policy packages. Annual energy efficiency investment is up 45% since 2020, with particularly strong growth in electric vehicles and heat pumps. Almost one in every five cars sold today is an electric vehicle and growth in global heat pump sales is now outpacing gas boilers in many markets.

Global energy use coverage of minimum performance standards for major end uses, 2000-2023



Note: Coverage for space cooling, space heating, water heating, refrigeration and lighting is shown for residential sectors.
Sources: IEA analysis based on the IEA Policies and measures (PAMS) database, CLASP Policy Resource Center.

According to the IEA's Government Energy Spending Tracker, since 2020 almost USD 700 billion has been spent on energy efficiency investment support, with 70% of this in just five countries: the United States, Italy, Germany, Norway and France.

The Inflation Reduction Act of 2022 in the United States includes USD 86 billion for energy efficiency actions, while the European Union has strengthened its Energy Efficiency Directive to curb energy demand.

However, the impact of new government policies, regulations and energy saving programmes, coupled with an unprecedented level of investments to scale up more efficient technologies, are not always immediate, with efficiency gains and energy intensity progress realised over a period of years. Moreover, this year's overall global intensity progress masks more significant gains in some countries and regions as others saw much lower progress.

After an energy intensity improvement of 8% in the European Union in 2022, another exceptionally high year is expected in 2023, with a 5% gain in progress. The United States is also on track to post a 4% improvement in 2023.

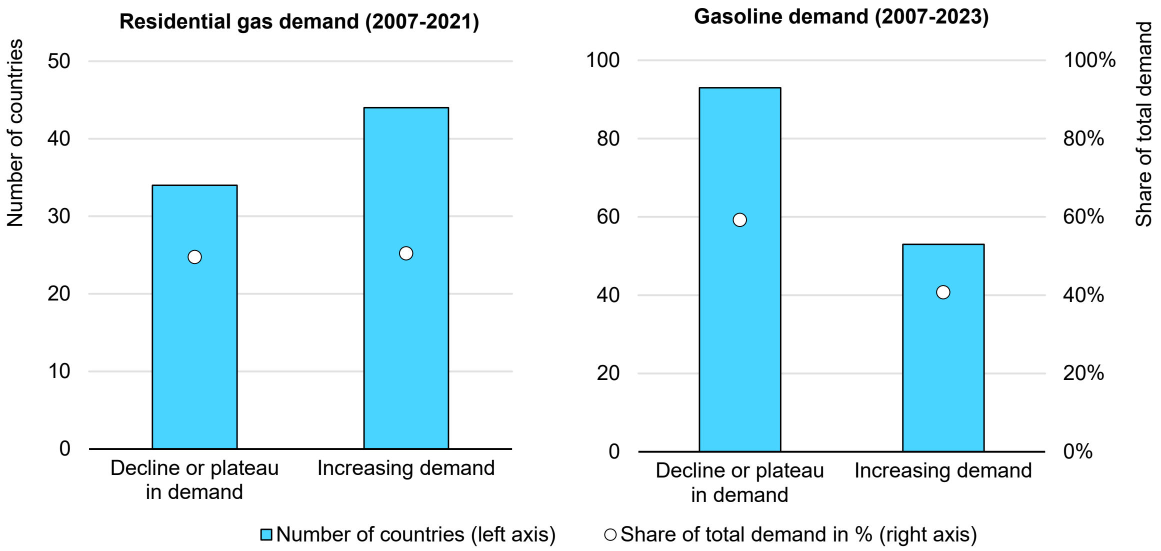
A strong post-pandemic resurgence in China's economic growth of around 5% is forecast in 2023, along with a similar rebound in energy demand. These preliminary estimates for 2023 suggest that the overall level of energy intensity in China is not expected to change this year. It takes 40% more energy to fuel GDP in China than in the United States, and almost double the energy to fuel the same growth as in the European Union. This shift in the balance of economic activity, along with a slowing of the country's energy intensity improvement along with that of some other regions this year, helps explain the slowdown in global energy intensity progress in 2023.

The deployment of efficient technologies is curbing energy demand and heralding the peaking of fossil fuels

In the first half of 2023, heat pump sales were up 75%, compared to the same period a year ago, in Germany, the Netherlands and Sweden combined. An electric vehicle or heat pump not only shifts energy use to electricity that is increasingly coming from clean energy sources but also uses much less final energy than a conventional car or gas boiler to do the same job. Consumers now have better choices when renovating their homes or buying a new vehicle. These choices are starting to open up opportunities for new levels of energy efficiency.

For example, global sales of gasoline and diesel cars, two- and three-wheelers, and trucks peaked in 2017, 2018 and 2019, respectively. This means global gasoline demand – which is mainly used by passenger cars – is expected to peak and stabilise in 2023 at around 27 mb/d. At the country level, 93 out of 146 countries representing 60% of total gasoline consumption have seen demand already peak, plateau or decline. This pattern is expected to culminate in road transport as a whole, which includes diesel-fuelled vehicles, such as trucks and buses, peaking at around 45 mb/d in 2025.

Peaking of residential gas and gasoline demands



Sources: IEA (2023), World Energy Balances, accessed October 2023; IEA (2023), Oil 2023: Analysis and Forecast to 2028.

Looking at the major heating countries around the world, residential gas demand has already peaked, plateaued, or is declining in 34 out of a total of 78 countries representing half of all demand. In Europe, residential and commercial gas demand dropped more than 15% in 2022 compared to the year before, under great pressure as a result of higher prices following Russia's invasion of Ukraine. While 40% of this decline can be attributed to the relatively mild winter last year, more than half was through various gas-saving measures, although this includes demand destruction as well as efficiency gains.

This shift to electrification of transport and heating comes at the same time as renewable energy is taking on a rapidly increasing share of electricity production. This is seeing the role of energy efficiency evolving from a consideration of end-use alone to a convergence of overall use, demand flexibility, and optimised use of variable renewable resources. In electricity systems with higher levels of variable renewable penetration, early evidence suggests that such systems thinking can deliver energy bill savings of up to a third.

The world is seeing record hot temperatures, boosting the need for cooling and lowering the need for heating

In 2023 the world also experienced its hottest year on record, threatening to trigger a vicious cycle of both higher electricity use and carbon emissions. Heat waves can also worsen health disparities, reduce productivity, raise electricity costs, disrupt essential services, and drive migration. Extreme heat puts strains on electricity systems, requiring substantial investments in grid infrastructure and power generation while burdening consumers with high cooling costs, especially for the most vulnerable.

Data shows extreme heat drives increased demand for air conditioners, with sustained average daily temperatures of 30 °C boosting weekly sales by 16% in China, for example. During the May to September global heat wave this year, people were looking online for air conditioners more than ever, with the search term's relative popularity on Google up more than 30% worldwide compared with the historical average level of searches for those months.

Higher temperatures also have different impacts on electricity demand on a regional basis. For example, IEA analysis shows that every 1 °C increase in the average daily temperature above 24 °C drives a rise of about 4% in electricity demand in Texas, while in India, where air conditioner ownership is lower, the same temperature increase drives a 2% rise.

Between May and September in 2023, power grids hit record levels of peak demand in many of the largest countries in the world, including China, the United States, India, Brazil, Canada, Thailand, Malaysia and Colombia – together accounting for more than 60% of total global electricity demand. In some regions, such as in the Middle East and parts of the United States, space cooling can represent more than 70% of peak residential demand on hot days.

A milder winter, the second warmest on record in Europe, also contributed to reduced energy demand, helping improve this year's energy intensity results in Europe and the United States.

Doubling efficiency progress could cut energy bills by one-third and make up 50% of CO_2 reductions by 2030

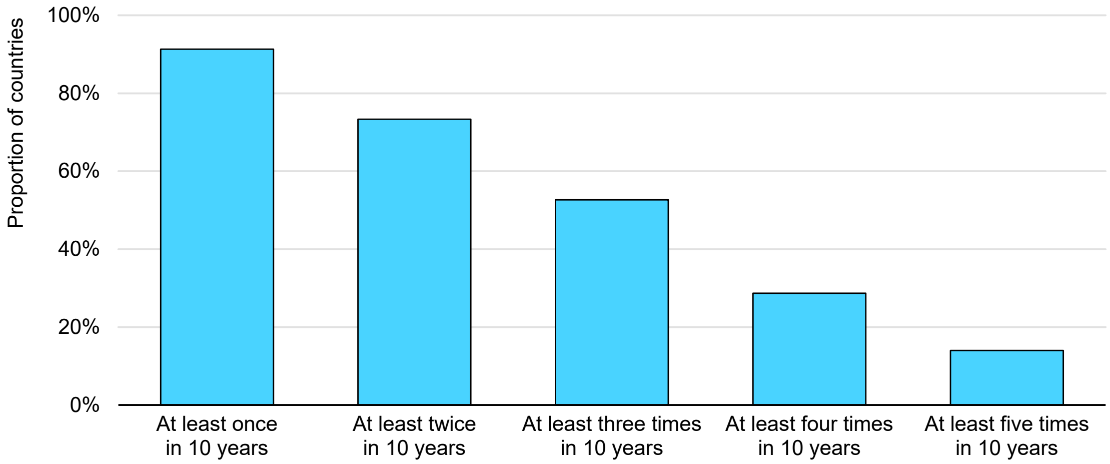
As momentum builds around the global target to double efficiency progress from the 2022 level of 2% to 4% each year until 2030, international efforts, including those at COP28, have a major role to play in shaping future energy efficiency and demand pathways.

While doubling the rate of global energy intensity progress is a challenging target, it is not an unprecedented level of progress. In the past ten years, 90% of countries have achieved the 4% rate at least once, and half have done so at least three times. However, only four G20 countries – China, France, the United Kingdom and Indonesia – have done so over a continuous 5-year period within the last decade, though several others have come close.

In most sectors, governments can make rapid progress towards doubling by building upon best practice in existing policies and accelerating the deployment of already-available technologies. For example, lighting standards in the European

Union, India, Japan, South Africa and the United Kingdom are already at or exceed the level set out in the NZE Scenario. Similarly, all industrial electric motors within a certain output range sold in the European Union, Japan, Switzerland, Türkiye and the United Kingdom must adhere to the efficiency class seen in the NZE Scenario. Similar cases can be found for building regulations, and vehicle standards improvements set to come into force by 2030.

Proportion of countries to surpass a 4% annual energy intensity improvement one or more times between 2012 and 2021



Note: 150 countries.
Sources: IEA (2023), A global target to double efficiency progress is essential to keep net zero on the table,

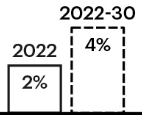
Compared to a higher energy demand scenario with around 2% annual energy intensity progress each year this decade, doubling to 4% per year would reduce CO_2 emissions by 7 Gt CO_2 – or 20% of current total emissions, taking the share of energy efficiency and related measures to half of all emissions reductions this decade. It would also cut today's energy bills in advanced economies by around one-third. Achieving the doubling target would also see 4.5 million more jobs than today in energy efficiency across the manufacturing, building renovation, construction, industry and transport sectors.

These benefits only highlight that now is not the time to pause on energy efficiency action but the time to further exploit efficiency's potential to address the multiple intersecting crises of energy, climate and cost of living.

Doubling progress on energy efficiency

There is international focus on a target to double the average annual rate of global energy efficiency improvements between now and 2030. What does this involve?

What is doubling?

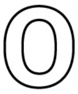


Global annual progress on energy intensity doubles this decade

The target is global, all countries have a part to play

The target will be formally considered at COP28

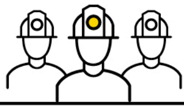
Why should we double?



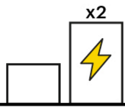
A critical step on the path to net zero

Over 7 Gt CO_2 emissions savings in 2030

Today's home energy bills in advanced economies lowered by a third



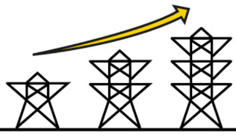
4.5 million more jobs than today



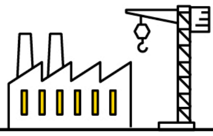
Energy savings equivalent to twice the EU's consumption in 2022

How do we double?

Strong policy packages of **information**, **regulations** and **incentives**, and a **tripling of global investment** in efficiency, lead to the following between now and 2030

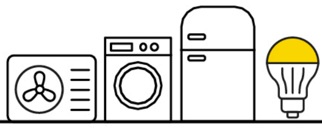


Share of electricity in energy demand increases by over a third, and smart grid investment more than doubles

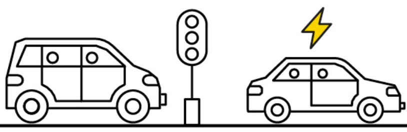


In industry, annual energy productivity grows by 2.3% per year, and electricity accounts for 30% of energy use by 2030

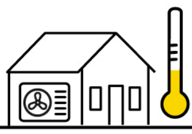
Retrofit rates for buildings more than double to 2.5% per year saving enough energy to power all the buildings in China and India today.



Appliances including ACs and refrigerators require 30% to 40% less energy to do the same job. All markets mainly sell LED lighting



Cars become 5% more efficient each year, largely through electrification and a switch to smaller vehicles



Consumers make active and ongoing behaviour changes in everyday life, like limiting heating to 19-20 °C

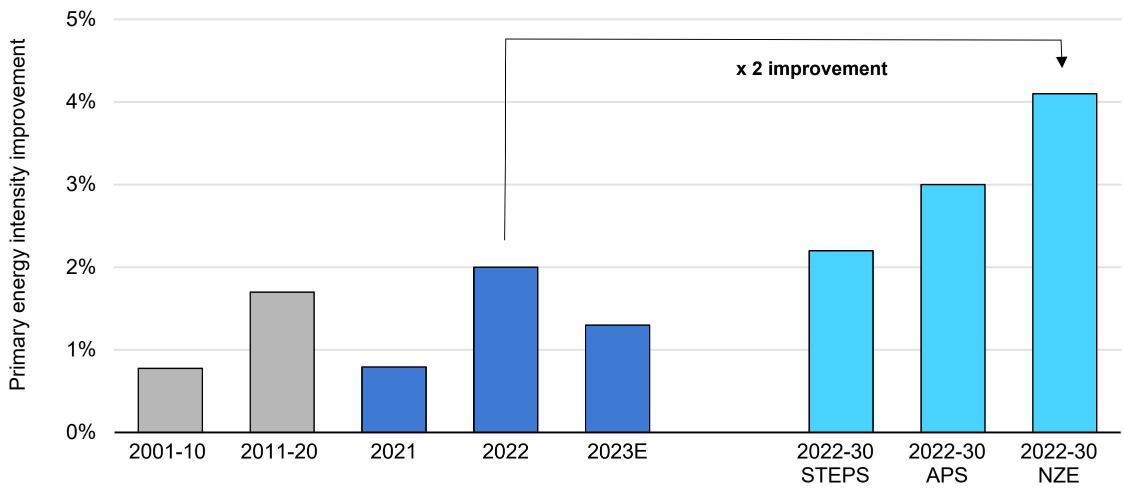
Chapter 1. Energy efficiency and demand trends

Energy intensity and demand

Efficiency policy actions rapidly increase, but global energy intensity progress slows amid myriad factors

In 2023, focus has remained steadfast on the importance of energy efficiency for accelerating clean energy transitions, reducing energy costs, and enhancing energy security. However, global energy intensity progress – or the reduction in energy intensity of the global economy – is expected to slow, after accelerating by about 2% in 2022, and falling to slower levels of around 1.3% in 2023. Energy intensity is defined as the amount of primary energy used to produce a given amount of economic output or GDP, and is the main global indicator to track progress of energy efficiency.

Annual primary energy intensity improvement, 2001-2022, 2023E, and by scenario, 2022-2030



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario. As an indicative range, a GDP growth of 3% with currently expected energy demand growth of between 2% and 1% would yield energy intensity improvement of between 1% and 2%, respectively.

Despite this year's slower global progress, it is important to recognise that the energy crisis has unequivocally accelerated the energy transition and efficiency gains in many markets. The impact of new policies and technologies are not always immediate, with efficiency gains and energy intensity progress realised over a period years. This is especially true in Europe, as well as other countries and regions, where governments have recently introduced sweeping new policies, regulations and incentives to curb energy demand while consumers and businesses continue to implement energy saving measures in response to sharply higher costs.

While the energy crisis has caused significant hardship for households and economic loss for businesses – especially those dependent on natural gas – it has also led to an important transformation in energy efficiency trends. The scale up of radically more efficient technologies that use electricity rather than directly burning fossil fuels is driving much higher levels of efficiency progress. This transformation, combined with record deployment of solar capacity, is shortening the runway for growth in fossil fuels in many markets.

Energy intensity improvement in Europe moves to record levels as energy crisis drives change

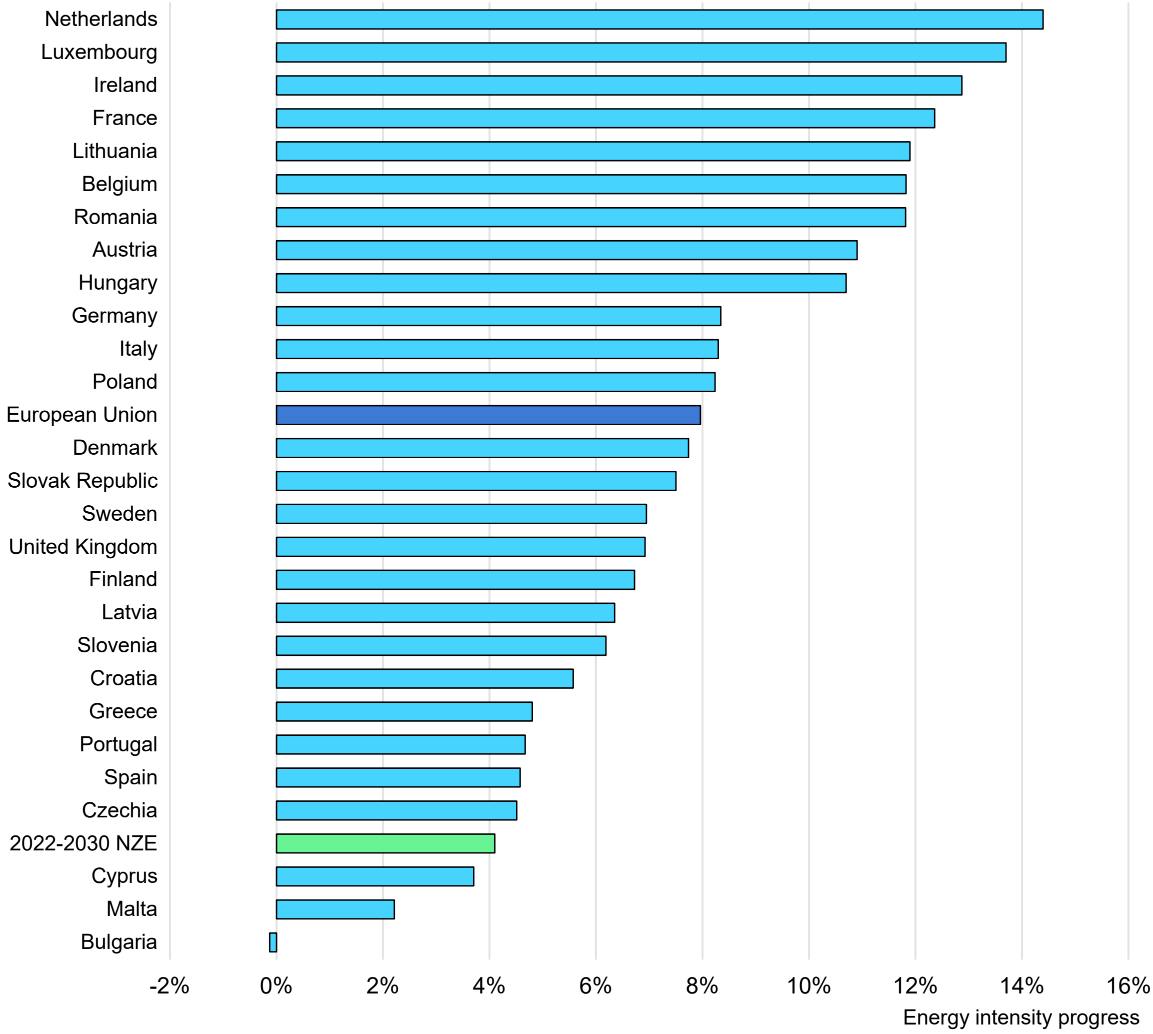
In the European Union, the energy crisis prompted government response measures and consumer behaviour changes that led to an average intensity progress of almost 8% in 2022 and to an estimated 5% in 2023. This comes as energy demand is expected to fall by 4% in 2023. By comparison, in response to the energy system repercussions of the Great East Japan Earthquake and efficiency measures introduced by the government, Japanese energy intensity improved by just over 7% in 2011.

In the Netherlands it reached an astonishing 14% in 2022 – one of the highest rates ever achieved for a major economy – amid some of the sharpest increases in energy prices in the region. Elsewhere, very strong energy intensity improvements were registered in Korea, Türkiye and the United Kingdom.

While economic growth in the European Union is expected to slow to around 0.7% in 2023, it rose to an above average 3.6% in 2022 despite it being one of the most exposed regions in the world to the energy crisis. The strong consumer spending rebound from the Covid-19 pandemic in the first half of the year drove economic growth but faded as the year progressed. Meanwhile, energy users reduced consumption by a steep 5.7% in an effort to mitigate high energy costs amid supply insecurity. Of course, some demand reduction came at the expense of lower levels of comfort, of energy intensive industrial activities, as well as improvements in energy efficiency.

By the second half of 2022 the economic impact of the energy crisis saw a major slowdown in the euro area, with many member states being pushed into recession. Energy intensive industries were particularly hard hit, with industrial gas demand falling by almost 20% y-o-y during the 2022/2023 winter season in OECD Europe. With inflation cutting deeply into household budgets and energy prices still elevated, this loss of momentum over the year is expected to reduce annual economic growth to less than 1% for 2023.

Energy intensity progress, selected EU countries and the United Kingdom, 2022



Note: see Cyprus[1] disclaimer.
Source: IEA analysis based on data from IEA (2023), World Energy Balances, accessed October 2023.

[1] Note by the Republic of Türkiye
The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the “Cyprus issue”.

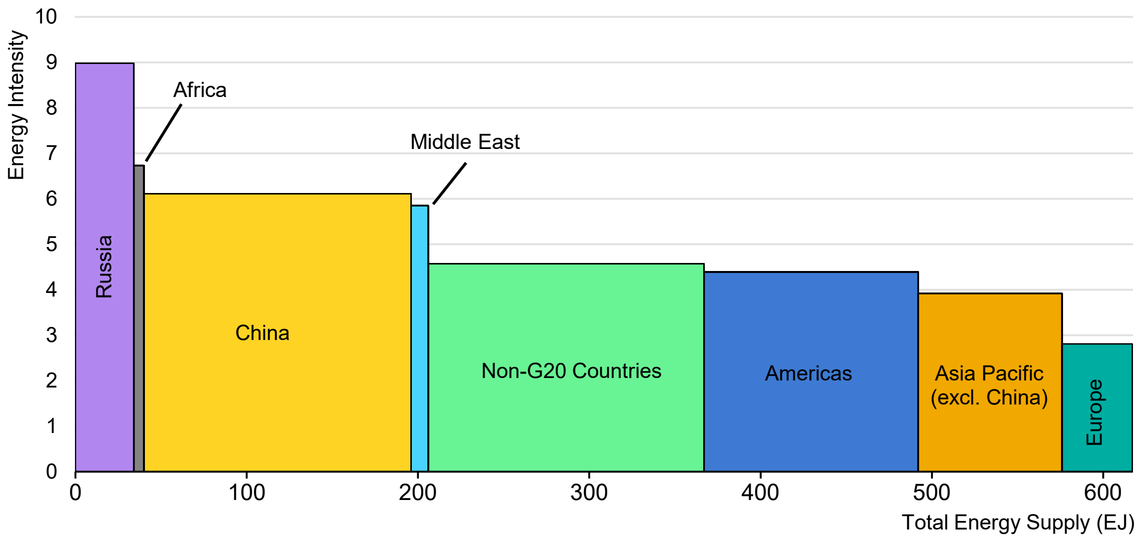
Note by all the European Union Member States of the OECD and the European Union The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Strong progress in many markets was overshadowed by more energy intensive growth in others

There is significant variation in the overall energy intensity of major economies due to differences in economic structure, efficiency levels and climate. Countries that are much colder or much warmer tend to have a higher intensity level due to greater warming or cooling demands. Meanwhile, for example, the impact of more energy-intensive industries is apparent in People's Republic of China (hereafter, "China"), which is the world's manufacturing hub. It uses 40% more energy to fuel GDP growth than the United States, and almost double the energy to fuel the same economic growth than in the European Union.

These three major countries or regions constitute almost half of global energy demand, with China having the largest share at 25%, followed by the United States at 14% and the European Union at 9%. Non-G20 nations account for 26% of global energy demand.

Primary energy intensity and total energy supply, G20 and non-G20 countries by region, 2021



Notes: Primary energy intensity is the ratio of total energy supply to GDP (MJ per thousand 2015 USD PPP).
Source: IEA analysis based on data from IEA (2023), World Energy Balances, accessed October 2023.

As the largest energy consuming sector accounting for around one-third of total demand, industry has a particularly large role in driving overall energy intensity. China has the largest share of world industrial energy consumption, accounting for 37% of the global total compared with 9% for the United States and 8% for the European Union.

In 2006 China introduced a "dual energy controls" policy that placed limits on growth in energy consumption and required reductions in energy intensity for high energy consuming entities. In combination with targets set under its five-year economic planning framework, these measures have seen annual growth in energy consumption of only half the rate of its economic growth over the past decade. China's National Development and Reform Commission (NDRC) estimates that economy-wide energy intensity has been reduced by over 26% between 2012-2022, which is the fastest overall rate of improvement for a sustained period of any G20 country.

These regional forces help explain why this year's improvement in global energy intensity is likely to be slightly below the historical average despite major transformations occurring as a result of the energy crisis. This means that without strong efficiency progress, faster growth in China relative to other regions could result in a structural shift to a more energy intensive global economy. Household consumption in 2021 accounted for around 38% of China's GDP, compared to over 68% in the United States, highlighting significant space for reduction in energy intensity as a result of wider structural changes to the economy. Recently China has signalled its intentions to enhance the fundamental role of consumption in economic development. This would mean a shift from investment-led to consumption-led economic growth, aiming to accelerate its use of electric vehicles and household appliances, boost domestic tourism and promote green products in rural areas.

Shifts in global economic and energy demand growth have major implications for intensity progress

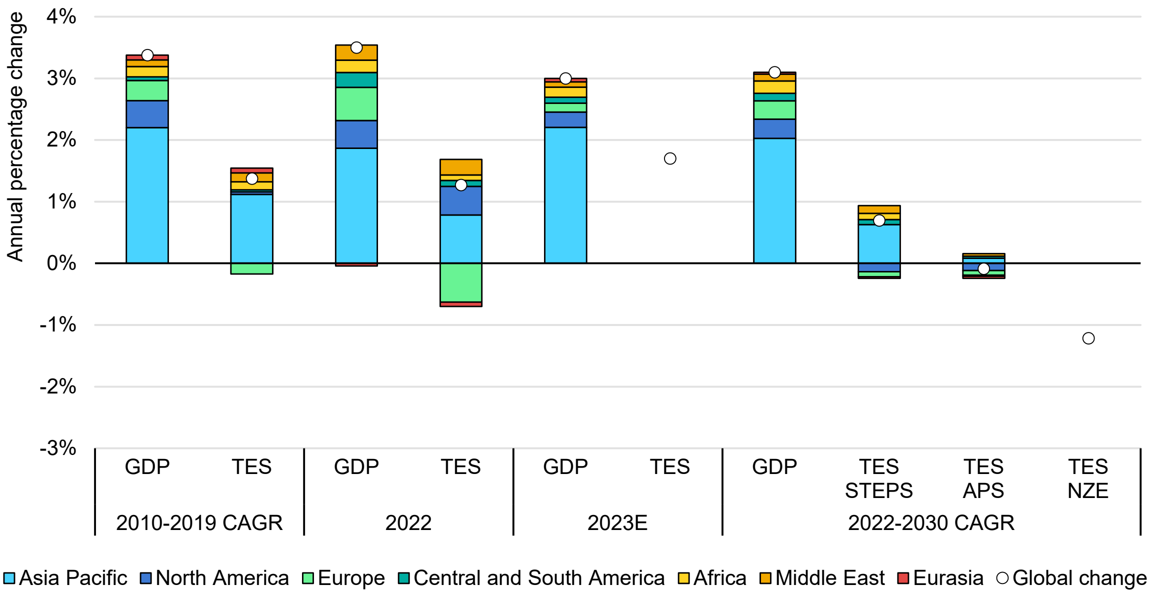
Overall global economic growth is expected to be below average compared with long-term historical trends, slowing to 3% in 2023 from 3.5% in 2022, according to the International Monetary Fund. At the same time, energy demand growth is expected to accelerate in 2023 to 1.7%, up from 1.3% the year before.

Economic growth in advanced economies is set to slow to 1.5% in 2023 from 2.6% in 2022, while in emerging and developing markets it is set to remain steady at around 4% A notable exception in this overall slowdown is an expected acceleration in growth in China to around 5%, up from 3% last year, as the country rebounds from pandemic restrictions.

While the impact of Covid-19 temporarily upended the normal relationship between economic growth and energy, over the 2000-2019 period each percentage point rise in global GDP, expressed in real purchasing power parity (PPP) terms, saw energy demand increase by about 0.6%.

Changes in energy intensity illustrate how the relationship between GDP and energy demand differs between countries and regions, as well as over time. For advanced economies, prior to Covid-19 energy intensity fell by around 1.8% per year between 2000 and 2019, involving modest GDP growth of approximately 2% and virtually unchanged energy consumption. In leading economies energy demand actually declined while GDP grew. For example, in Europe energy demand peaked in 2006 and was 10% lower by 2019, while in the United States it has stayed virtually the same.

Regional contributions to global changes in GDP and total energy supply, 2010-2023E and by scenario, 2022-2030



Notes: TES = total energy supply. STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario.
Sources: IEA (2023), Global Energy and Climate Model; IEA (2023), World Energy Balances, accessed October 2023.

In emerging markets and developing economies (EMDE), energy intensity improved at a slightly higher annual rate of 1.9% on average between 2000 and 2019, with average GDP growth of 6% per year requiring 3.6% more energy per year. Behind this energy growth story is the catch-up in living standards, with an average person in an EMDE using three times less energy in their home and four times less for transport compared with a person in an advanced economy.

In this year's market report, three energy consumption pathways are explored – high, medium and low. In the first, the Stated Policies Scenario (STEPS), which maps the trajectory implied by today's policy settings, energy intensity progresses 2.3% per year on average this decade along with GDP growth of around 3% and energy demand of just under 1% per year.

A higher rate of energy intensity progress is seen in the Announced Pledges Scenario (APS), which assumes that all aspirational targets announced by governments are met on time and in full. This sees energy demand growth decouple further from economic growth, with 3.1% energy intensity gains and holding energy demand almost constant.

The NZE Scenario, which maps out a way to achieve a 1.5 °C stabilisation in the rise in global average temperatures, alongside universal access to modern energy by 2030, sees energy intensity double from last year's level of around 2% to just over 4% on average every year between now and 2030. Such a result would see an absolute decoupling of economic growth from energy demand, with annual expansion of 3% in GDP each year on average this decade seeing just over a 1% annual decline in energy demand despite an annual expansion of 3% in GDP each year.

Greater levels of energy efficiency will be needed to secure a peaking of fossil fuel demand this decade

To provide greater vision on current energy demand trends and geographical insight into what is driving energy intensity change, this year's market report provides a synthesis view of the of the IEA's benchmark market reports for the major fuels, including electricity, oil, gas and coal. This collective analysis informs the 2023 forecast of total energy supply, and along with GDP estimates, are the main inputs for assessing the change in energy intensity for the current year of 1.3%.

In 2023, energy demand growth is centred in Asian economies, particularly China, which is expected to more than offset slowing or declining energy consumption in other major countries or regions, such as the United States and Europe. On balance, this sees growth in overall global energy demand accelerate to 1.7%.

According to the IEA's November 2023 *Oil Market Report* global oil demand is forecast to increase by 2.4% in 2023, with jet fuel and petrochemical feedstocks the primary drivers of growth. China will account for 77% of the gains following a post-Covid rebound in first half of the year.

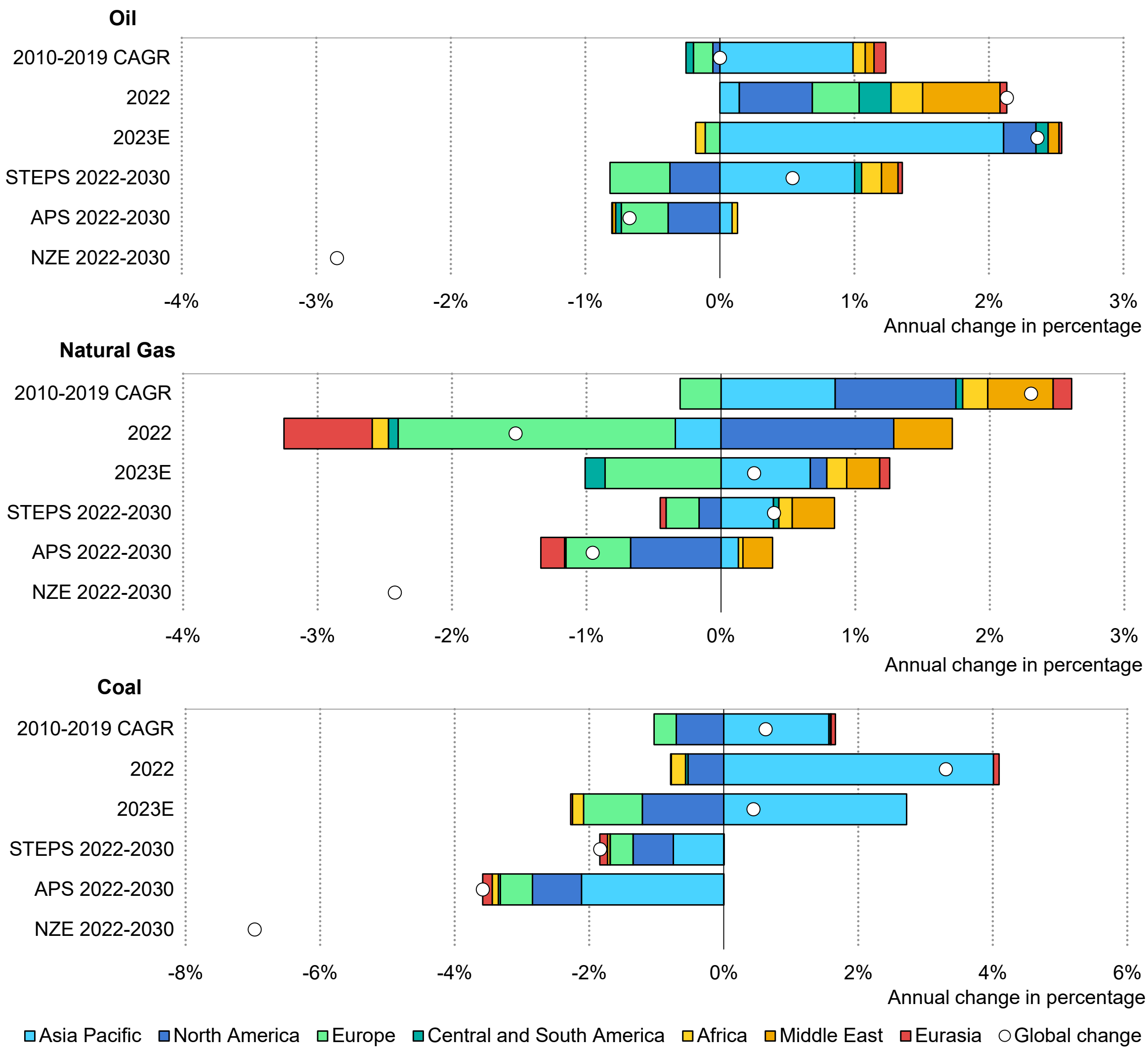
After rising by 2.4 mb/d, including 0.2 mb/d in biofuels, in 2023, global oil demand growth is expected to slow sharply, rising by just 0.9 mb/d in 2024. Road transport currently accounts for around 45% of global oil demand. Road transport fuel use, the primary driver of oil demand, is forecast to peak and begin to decline from 2025. Incremental electric vehicle sales currently displacing around 0.4 mb/d per year with the cumulative impact expected to reach 4 mb/d per year by 2030. Oil demand for passenger cars is expected to start peaking this year, and by the second half of the decade for total road transport more generally.

More than 50 countries home to 60% of the world's population now have policies to encourage electric vehicles, with 30 countries setting target dates to phase out new sales of internal combustion engine cars. According to the IEA's *World*

Energy Outlook 2023, by 2030, the STEPS sees overall global oil demand peak and plateau at around 102 mb/d, with continued growth in emerging and developing countries, while further increases in the petrochemical and aviation sectors are offset by declines in road transport.

According to the October update of the IEA's *Gas Market Report* series, following a decline of 1.5% in 2022, world natural gas demand is expected to stay broadly flat in 2023. This coincides with strong market volatility and amplified levels of uncertainty triggered by the energy crisis. As highlighted in the *Medium-Term Gas Report 2023*, the events of the past two years could bring to a close the "Golden Decade of Gas" (2011-2020), in which gas contributed around 40% of the growth in primary energy supply worldwide.

Regional contributions to global changes in fuel demands, by scenario, 2010-2030



Sources: IEA (2023), Global Energy and Climate Model; IEA (2023), World Energy Balances, accessed October 2023; IEA (2023), World Energy Outlook 2023 extended data table; IEA (2023), Medium-Term Gas Report October 2023; IEA (2023), Oil Market Report, November 2023; IEA (2023), Coal Market Update, July 2023

Gas-to-power demand in 2022 fell by just 4% in Europe, partly because hydro fell 19% in 2022, so more gas was needed for electricity. In 2023, the rebound in hydro power output, contributes to a 15% decline in gas-to-power demand.

In the mature markets of the Asia Pacific, Europe and North America, overall gas consumption has already peaked due to deployment of renewable power generation and more efficient heating, and is set to decline over the coming years. The STEPS sees global gas demand reaching a peak in 2030, with annual global growth for the rest of this decade of just 0.5% each year compared with well over 2% during the 2010-2019 period.

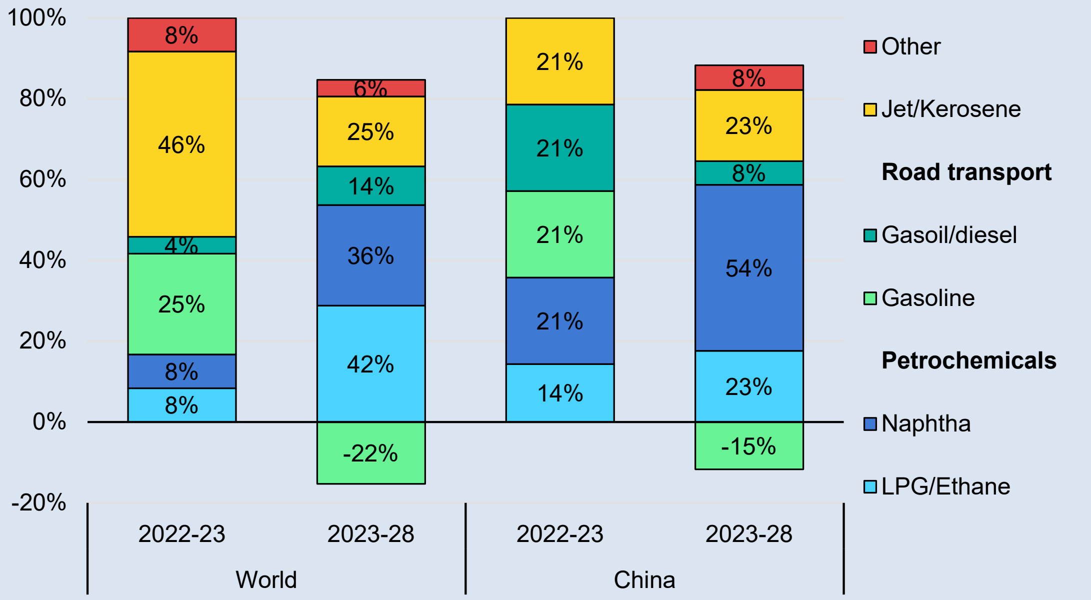
Last year, total global coal demand reached an all-time high, increasing by 3.3%, driven by its lower price relative to natural gas and ready availability in many parts of the world. Coal-fired generation was also supported by overall weak nuclear power and hydropower production. This strong growth in 2022 was particularly concerning for climate goals given coal is the single largest source of CO_2 emissions. Coal use rises to a new record in 2023 as growth slows to 0.4%, closer to its longer-term historical range. This year's growth reflects structural declines in the United States (-22%) and European Union (-17%) offset by continued growth in Asia. Based on preliminary estimates from the IEA's July 2023 *Coal Market Report*, in 2023, demand is forecast to rise by 3.5% in China and 5% in India. These estimates will be updated in December. Together, these two countries account for 70% of global coal demand.

Energy demand in China rebounds in 2023

Preliminary data suggests that energy demand increased in China by around 5% in 2023, largely due to higher economic activity after Covid-related lockdown restrictions were lifted. Coal demand, which rose by 4.6% last year, is expected to increase by 3.5% in 2023, with power sector use up 4.5% and non-power growing by 2%. Gas demand is forecast to increase by 7% in 2023, after declining for the first time in four decades in 2022. Electricity demand growth is expected at 5.3%, up from 3.7% the year before. Oil demand in China also rose by almost 10%, from 14.7 mb/d to 16.4 mb/d in 2023, with 43% of this growth coming from road transport, 36% from feedstocks and 21% from jet fuel.

Gasoline demand for road transport is forecast to rise by almost 10% this year before it starts peaking in 2024. Consumption of gasoline was responsible for 43% of total oil demand growth this year and is forecast to decline from 3.7 mb/d to 3.5 mb/d by 2028.

Change in oil demand by fuels, World and China, 2022-2023 and 2023-2028



IEA. CC BY 4.0

Source: IEA (2023), Oil 2023: Analysis and Forecast to 2028.

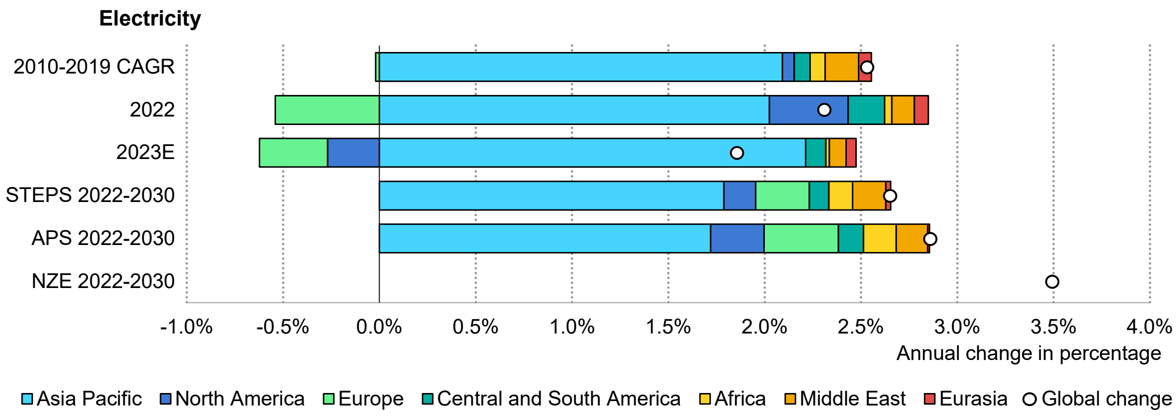
Avoided energy demand is key to achieving a faster rate of decarbonisation of the power sector

Overall electricity demand growth is expected to stay relatively steady at around 2% in 2023 following an increase of just over 2% last year. This compares with a longer-term historical trend of 2.5% growth per year on average between 2010 and 2019. In 2023, the gains are primarily concentrated in China at around 5% and India at 6.5%, while electricity demand is expected to contract in Europe and the United States by 2.5% and just under 2%, respectively.

Renewables are expected to meet all electricity demand growth in 2023 and 2024, with China accounting for around half of capacity additions, led by expansion of solar PV, especially for distributed systems. Over the past decade, avoided electricity demand from energy efficiency gains and accelerating renewable deployment contributed to the share of renewable energy in electricity generation increasing from around 20% in 2010 to about 30% in 2022.

However, fossil fuels still dominate the power sector, with a 61% share in global electricity generation in 2022.

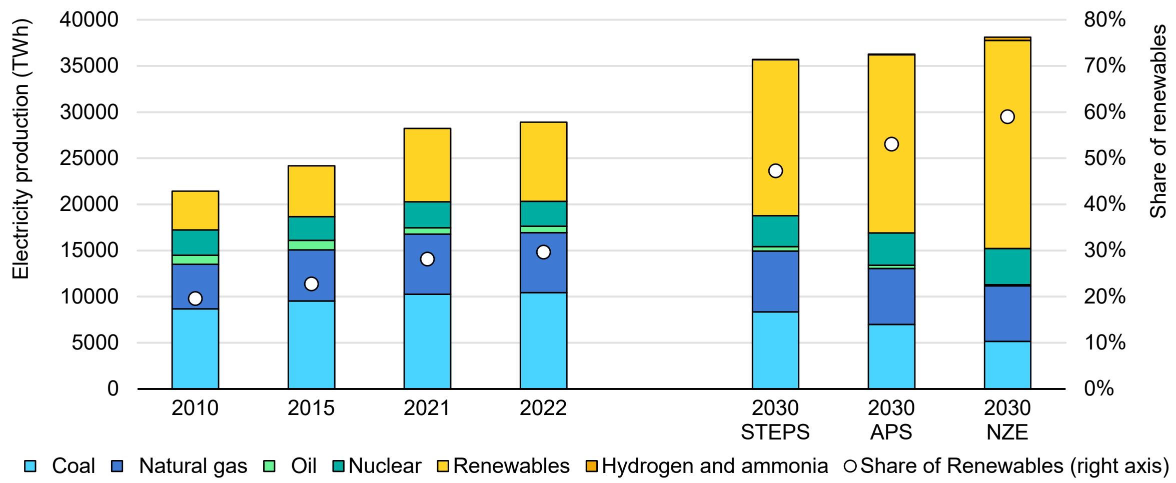
Regional contributions to global changes in electricity generation, by scenario, 2010-2030



Sources: IEA analysis based on IEA (2023) Global Energy and Climate Model and on data from IEA (2023), World Energy Balances, accessed October 2023; IEA (2023) World Energy Outlook 2023 extended data table; 2022 and 2023 data; IEA (2023) Electricity Market Report – Update 2023.

Faster action on energy efficiency means more avoided energy demand, which is essential to accelerating the substitution of fossil fuels for renewable energy. This is because the increase in demand from the electrification of end uses can be offset by overall efficiency gains. For example, switching from conventional light points to LED technology in the United States could save enough energy to power 3 million electric vehicles per year, or heat 2.6 million homes with heat pumps.

Electricity production and share of renewables, 2010-2022 and by scenario, 2030



Sources: IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach: 2023 Update; IEA (2023), World Energy Balances, accessed October 2023.

In the NZE Scenario, the rate of progress of energy efficiency doubles and installed renewable electricity capacity triples by 2030, relative to 2022, with renewables accounting for a much higher share at 59% of global electricity generation.

Profound energy efficiency transformations are taking place at country and regional levels

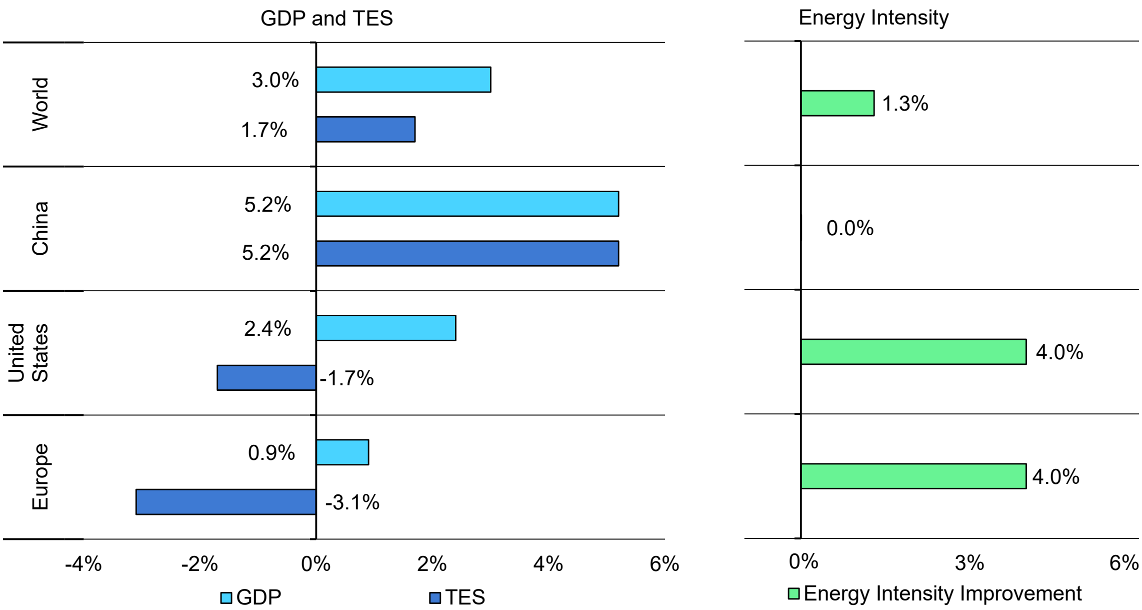
China, the United States and Europe are together responsible for more than half of global GDP and energy consumption, so developments in these regions can help quickly unpack what is behind global energy intensity trends.

In Europe the effects of the energy crisis continue to be felt, with energy demand forecast to decline by 3% in 2023 after dropping by 4.8% the year before. This is occurring as GDP growth slows to 0.9% in 2023 after 3.8% in 2022, yielding energy intensity progress of around 4% for 2023. The policy measures in the REPowerEU plan and lower demand from consumers are expected to contribute to broader European gas consumption declining by 7%, this compares with a drop of 13% in 2022. Europe's coal consumption is forecast to drop by 15% due to a combination of renewable energy expansion and strong efficiency progress. Similarly, electricity demand in the European Union is forecast to decline by 3% in 2023, falling for the second year in a row and to its lowest level in two decades, despite higher levels of electrification from record sales in electric vehicles and heat pumps.

The United States sees a strong degree of decoupling of its energy consumption from its economy in 2023, with GDP expected to grow by 2.4% and energy demand expected at a lower 1.7%, yielding an energy intensity improvement of 4%. This is partly due to the implementation of the Inflation Reduction Act (IRA) that started last year, and marks the largest investment in clean energy and climate action in the history of the country. After a sharp increase in heating and cooling degree days in 2022, an equally abrupt decline contributed a 2% fall in electricity demand in 2023, substantially lowering use of coal-fired power by 22%. Gas demand is expected to remain flat.

China has led the world in recent years in energy intensity improvements, averaging 3.8% per year over the period 2010-2019. China's economy is expected to grow by just over 5% in 2023. The country has continued its rebound from Covid-19 restrictions boosting air travel in particular. However, significant development of the petrochemical industry in 2023 has driven a sharp increase in oil use. This is contributing to the expectation that China's level of energy intensity will not change in 2023 before returning to longer terms tends of progress going forward.

GDP, total energy supply and energy intensity, 2022-2023, percentage change



Source: TES (IEA fuel market report synthesis) GDP (Oxford Economics)

China has maintained the acceleration of its clean energy transition by rapidly growing the share of renewables for power generation, but nevertheless its gas and coal demand are projected to rise by around 7% and 4%, respectively, in 2023. Coal demand in the power sector is expected to be up 4.5%, while consumption from non-power uses is projected to grow by 2%. Similarly, even though China is responsible for most global electric vehicle sales, its oil demand is expected to increase by about 10% in 2023, driven primarily by jet fuel and petrochemical feedstocks. China is responsible for 77% of global oil demand growth in 2023.

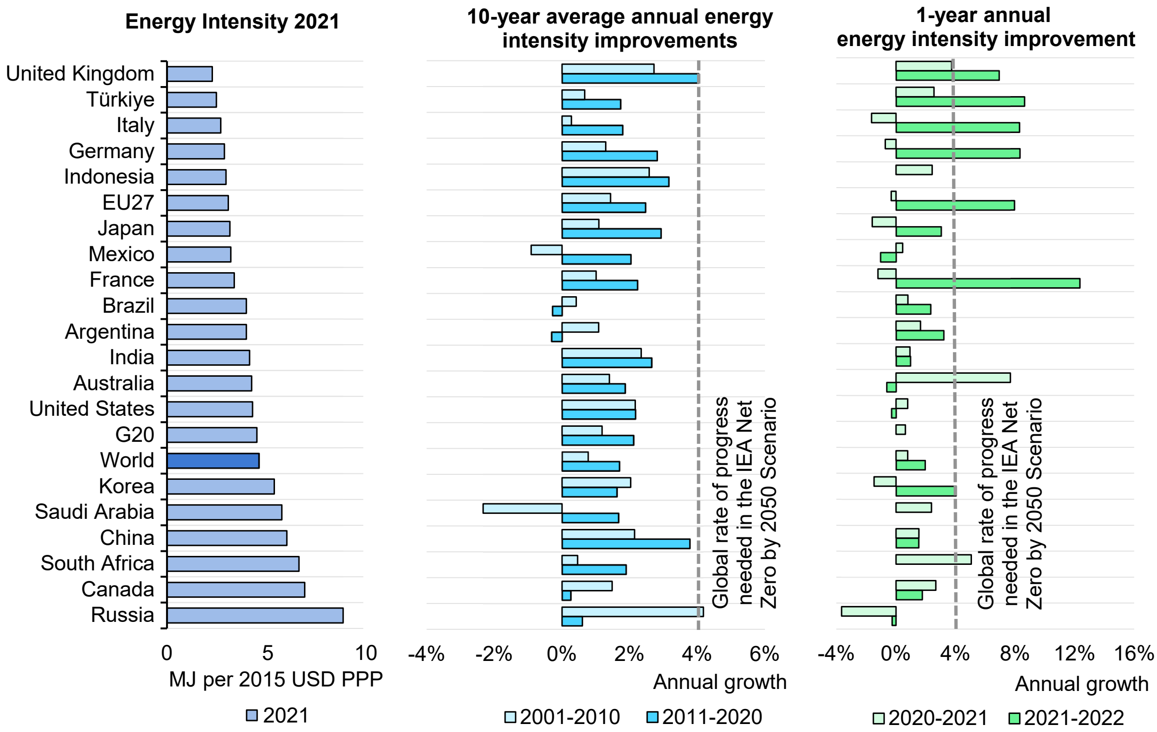
History shows a doubling of energy intensity progress is possible with strong government support

Global energy intensity progress doubled to around 1.7% per year on average in the 2011-2020 period, following an average 0.8% improvement in the previous decade. The NZE Scenario sees this progress rise to just above 4% per year on average by 2030. This rate of progress would imply a substantial and concerted effort on the part of governments to implement new, and strengthen existing, energy efficiency-related policies and measures.

Out of all individual G20 economies – together responsible for around 80% of global energy consumption – fourteen countries accelerated their energy intensity improvements during 2011-2020 compared with the previous decade. Half of those countries even doubled their rate of improvement from one decade to the next, providing evidence that significant change is possible.

Argentina and Brazil, the only two G20 countries with negative energy intensity improvements in the past decade, and whose upward trend might be associated with structural changes, switched to positive efficiency advancements in 2021 and 2022, signalling a possible turning point in their progress as well. More detail on what is involved with the doubling of energy efficiency progress this decade is explored in more detail in Chapter 5 of this report.

Primary energy intensity trends, G20 countries, 2001-2022



Note: 2022 data not yet available for South Africa, Saudi Arabia and Indonesia.
Sources: IEA analysis based on IEA (2023), IEA World Energy Balances, accessed October 2023; IEA (2023), Tracking Clean Energy Progress 2023.

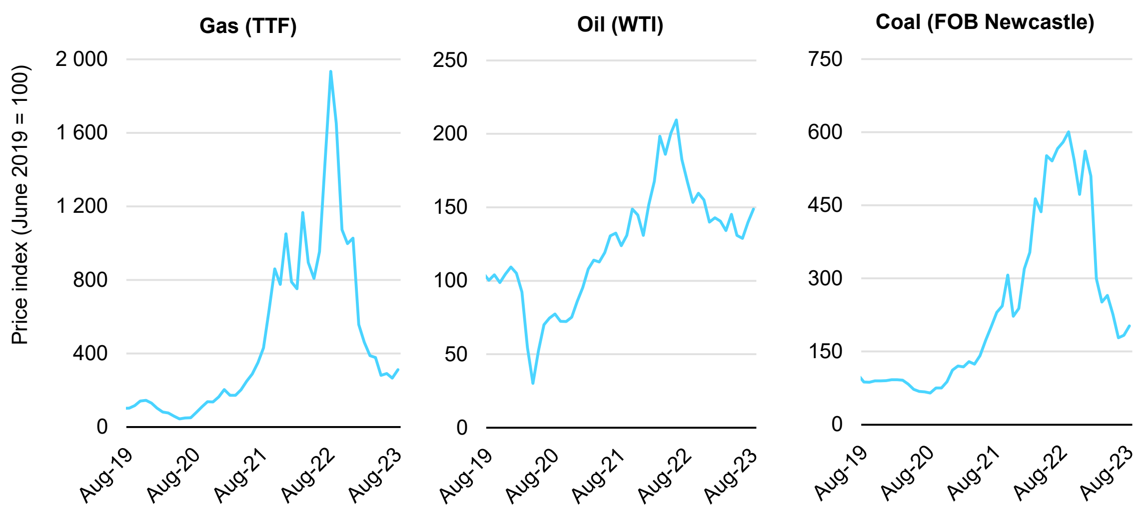
Energy prices and affordability

While new risks emerge in 2023, wholesale commodity prices have cooled after sharp increases last year

The turmoil in the Middle East has introduced new risks for energy prices and put markets on tenterhooks. These unwelcome events come following a year in which energy prices reached record levels, due in large part to the Russian Federation's (hereafter, "Russia"), invasion of Ukraine. Nevertheless, 2023 has seen a welcome cooling off of wholesale commodity prices. However, prices are still above pre-crisis levels and, in most cases, declines have not yet been fully passed through to consumers, who still face high household energy bills and commercial input costs.

European wholesale gas prices – which saw the steepest increase of all energy carriers in 2022 – have decreased most drastically, from TTF spot prices of USD 37/MBtu in 2022 to around USD 10/MBtu in July this year. As Europe prepares for another winter in which it aims to keep gas demand down, prices are not expected to show the same sharp increases as last year. Storage levels remain high following low withdrawals in 2022, and the addition of new LNG import terminals and a ramp up in natural gas production in the United States have combined to increase supply availability. Natural gas prices in the short and medium term are forecast to remain above their historical averages, which will weigh on demand growth in the coming years.

Energy commodity price indices, 2019-2023



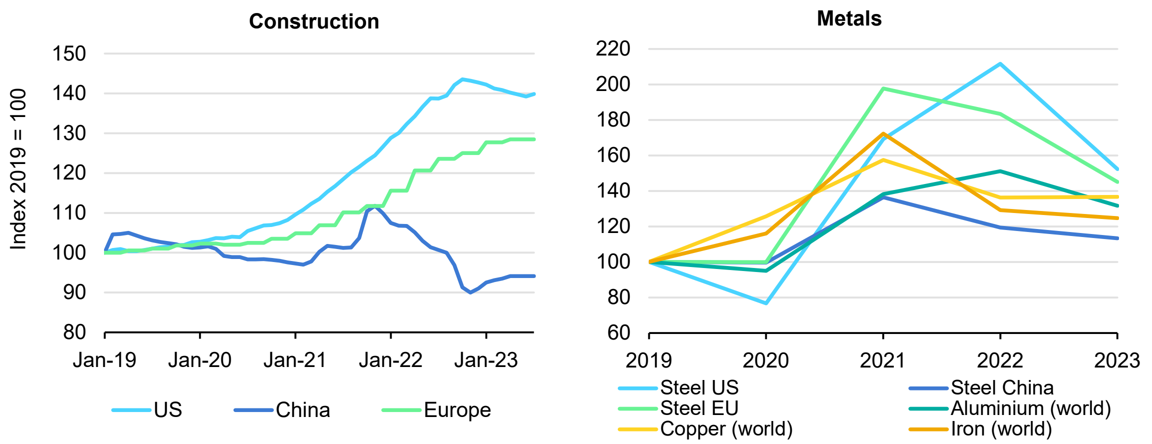
Sources: IEA analysis based on data from Argus Media Group (coal, oil) and ICIS 2023 (gas). All rights reserved.

Crude oil prices have also fallen in 2023, coming down from levels as high as USD 120/bbl for US West Texas Intermediate in spring 2022. However, prices are still higher than in 2019, when oil cost around USD 60/bbl. Given the recent conflict in the Middle East, oil supply risks have increased again. After more than a year of high prices and volatility, the price of coal dropped from USD 400/t in 2022 to around USD 140/t in mid-2023. Coal prices are forecast to plateau and remain above pre-crisis levels in the coming years. Wholesale electricity prices also increased in 2022, largely as a result of the natural gas and coal used in power generation, but have come down in 2023.

Lower energy prices also fed into supply chains for key materials in the construction and industry sectors, which can influence the pace of energy efficiency investment. Steel prices in the United States, China and the European Union have all come down from 2022 highs but not yet to pre-crisis levels. Global prices of iron and aluminium have also slightly decreased in 2023, while the price of copper remains relatively stable at elevated levels.

The construction sector does not show the same decline in costs, but higher prices appear to have peaked in 2022. The Chinese construction sector continues to face low investment and declining demand for new properties, while in Europe and North America higher interest rates are causing activity in the construction sector to stall.

Non-energy commodity price indices, 2019-2023



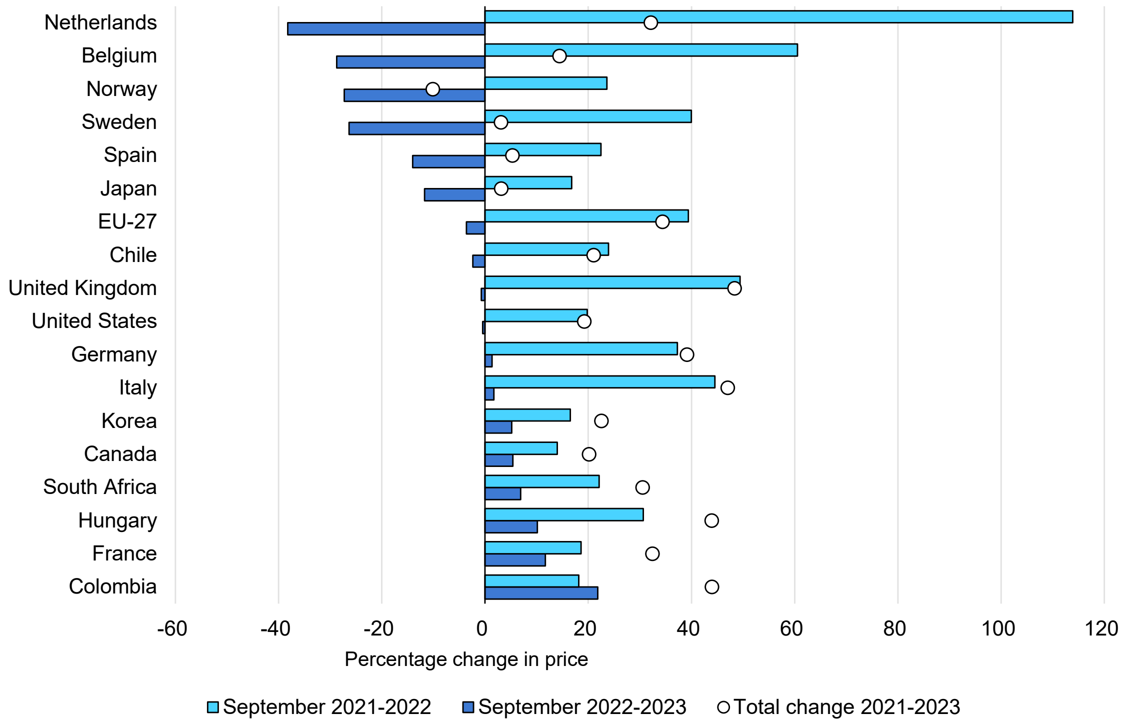
Sources: IEA (2023), World Energy Investment 2023; NBS China, ex-factory price index of industrial products; Eurostat, construction costs, new residential buildings quarterly data; United States Census Bureau, Construction Price Indices.

Consumers still feel the pressure on their energy bills as retail prices take time to adapt

While wholesale prices have come down in Q1-Q3 2023, consumer energy prices remain highly elevated. 2022 saw one of the sharpest increases in energy inflation in countries across the globe. This upward pressure has slowed, and in some cases reversed, with most countries seeing a drop in the level of energy price inflation across 2023 relative to 2022. However, because prices increase while inflation is positive, many countries have yet to see absolute energy prices drop. Where prices have come down, they are in most cases still above pre-crisis levels. Moreover, there are many countries in which consumers are spending even more on energy in 2023 than they did in 2022.

High consumer energy prices are also reflected in continued above-average household energy expenditures in 2023. Household natural gas and electricity bills do not always immediately see the changes in wholesale prices for several reasons, including the practice by energy retailers of purchasing wholesale energy far in advance, delays in passing lower costs through to consumers, or in some cases increases in the fixed charges in energy bills relative to unit prices. Additionally, some government schemes to shield consumers from high prices initiated during the crisis have come to an end or are being tapered off.

Percentage change in consumer energy prices, year-on-year in September and total change Sep 2021 - Sep 2023, selected countries



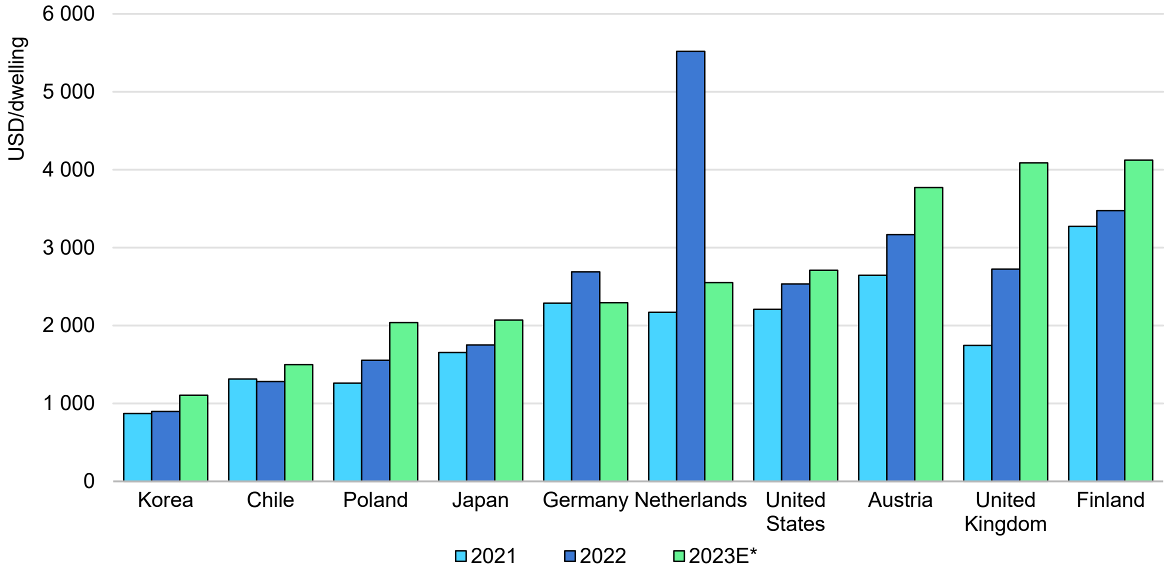
Source: OECD (2023), OECD Energy Consumer Price Index Database, accessed October 2023.

Some European countries have seen average household energy expenditure per dwelling rise further in 2023 compared to last year – with a few notable exceptions such as the Netherlands, which saw prices fall after having one of the highest consumer energy price increases in 2022 due to the country's heavy dependency on natural gas for residential heating.

As a result, the number of households living in energy poverty is increasing. For example, Europe saw an increase in people being unable to keep their home adequately warm from 6.9% in 2021 to 9.3% in 2022. In some European countries, purchasing power is at its lowest level in 40 years, largely due to energy costs.

Consumer transport fuel prices at the pump are generally quicker to adapt to changes in crude oil prices because consumers are not tied to fixed-price, longer-term contracts, although this effect can be mitigated by changes in taxation rates. As a result, most European consumers saw transportation fuel costs decline slightly in 2023 compared to 2022.

Average home energy expenditure per dwelling, 2021-2023



* 2023 is estimated based on data from Q1-Q2 2023.
Notes: Data includes home heating and other non-transport energy expenditure. Estimates based on annual prices.
Sources: IEA analysis based on IEA (2023), Energy Prices, accessed October 2023; IEA (2023), Energy End-uses and Efficiency Indicators, accessed October 2023; IEA (2023), World Energy Balances, accessed October 2023.

Targeted efficiency investments are needed to temper high energy bills and ease rising public budget deficits

As of June this year, governments spent over USD 900 billion on financial support to shield households from the worst of the energy bill increases. However, sustained high energy prices and decreases in purchasing power continue to pose challenges for households and risks further increasing energy poverty.

Record levels of spending to fund the post-19 pandemic economic recovery and energy crisis have put considerable pressure on public budgets. In this context, untargeted interventions pose sustainability challenges on multiple levels, with the European Commission urging EU countries to stop untargeted energy aid by 2024.

Targeted support and ramping up efficiency investments can ease energy poverty, while having less of an impact on budget deficits. Energy efficiency measures structurally lower energy bills, rather than only a temporary fix, and provide a range of other multiple benefits. For example, the United Kingdom has announced plans to decrease its energy price cap further, but at the same time helped ensure some of the most vulnerable consumers remain supplied this winter by expanding access to the Warm Home Discount Scheme for low-income households. In response to increased costs of living, the United Kingdom further announced that the Great British Insulation Scheme will specifically raise support to households in the lowest council tax bands or living in a home with lower energy performance.

Chapter 2. Sector trends in energy efficiency

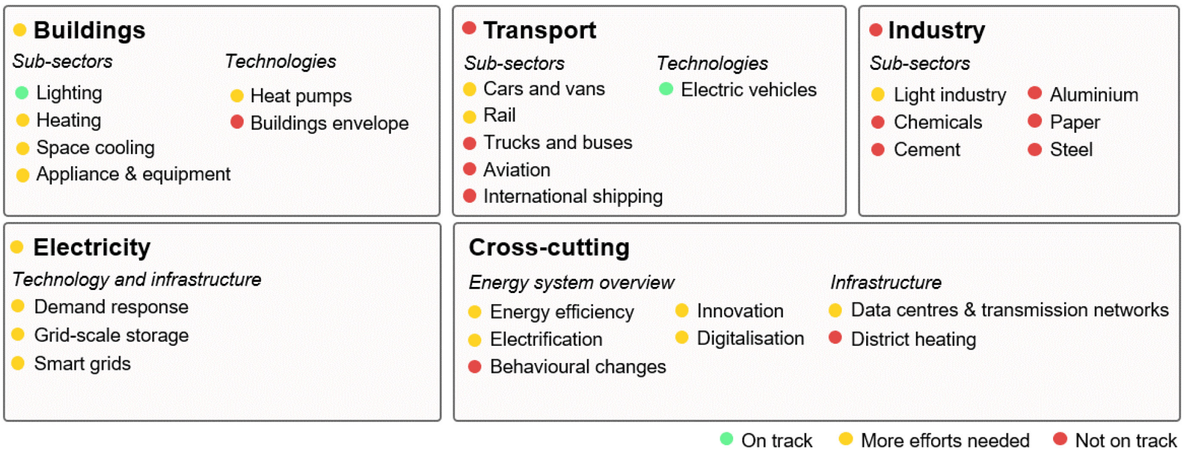
Overview

Progress on energy efficiency will determine the global trajectory for energy demand

In the IEA's Tracking Clean Energy Progress 2023 report, all the key elements that contribute to achieving the avoided energy demand needed to lift annual progress in energy intensity to 4% are analysed in detail. To achieve this target, energy efficiency plays a major role in all sectors across hundreds of technologies, along with the overlapping and closely related avoided energy demand measures of electrification, behavioural change, digitalisation and material efficiency.

Global total final energy consumption was around 440 EJ in 2022, with industry responsible for the biggest share at 38%, followed by buildings at 30% and transport at 26%. Other end uses contributed the remaining 6%. The level of improvement in energy intensity over this decade will determine whether the world develops along a high-, medium- or low-energy demand pathway. This will have profound consequences for other CO_2 mitigation measures. Under current policies in the IEA's Stated Policies Scenario (STEPS), final energy consumption rises by about 1% per year on average this decade to 2030, in the Announced Pledges Scenario (APS) it stabilises, while it falls by about 1% per year on average in the Net Zero Emissions by 2050 Scenario (NZE Scenario).

IEA tracking of the key elements related to energy intensity progress



Source: IEA (2023), Tracking Clean Energy Progress 2023.

Of all the sub-sectors and technologies related to improving energy intensity progress, only two are “on track” to deliver the avoided energy demand in the NZE Scenario – electric vehicles and lighting. Most require ‘more effort needed’ to achieve the milestones by 2030, while many are “not on track”, particularly in the industry sector.

As part of the radical lift needed in efficiency progress, the increasing pace of electrification and renewable energy deployment means the role of energy efficient technologies is also changing towards digitally enabled system optimisation to lower energy bills, increase grid stability and maximise emissions reductions. This section dives into these different sectors and cross-cutting areas to give a more granular insight on energy intensity trends.

A new IEA Efficiency Policy Level Index

For this year’s report, a new Efficiency Policy Level Index has been developed to enable clear comparisons of energy efficiency policies across different countries, policy types and end uses. The index is scaled to the efficiency level for each end use as described in the NZE Scenario to help countries track progress against net zero goals. The NZE Scenario presents one possible pathway to reach net zero emissions in 2050. However, countries may follow different pathways with differing policy priorities. An index value of 100 denotes the policy level equivalent to the NZE Scenario in 2030. In this year’s report, the index is applied to energy performance standards and sectoral electrification levels.

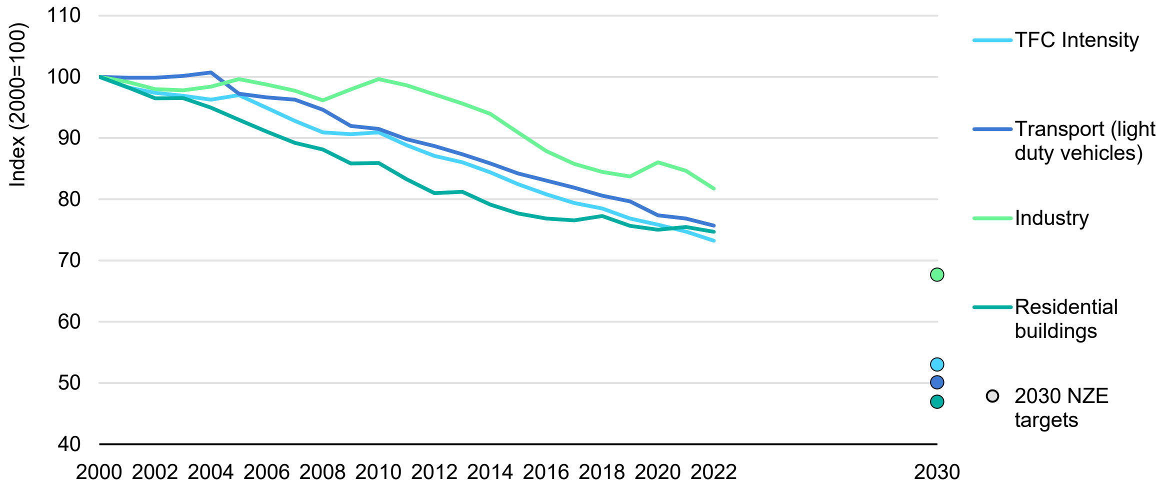
The world has moved from being ‘not on track’ to ‘more efforts needed’ to reach efficiency levels for net zero

The energy crisis propelled 2022 to a record year for intensity progress, with almost all countries posting improvement rates well above their historical averages. In Tracking Clean Energy Progress 2023, the indicator for energy efficiency changed from being “not on track” to “more efforts needed”.

Between 2000 and 2022, energy intensity at the sector level improved most in the buildings and transport sectors, with the amount of energy consumed per unit of floor area and energy used per passenger kilometre travelled falling by around 25%. Efficiency progress was slightly slower in the industrial sector, with the amount of energy needed to produce a unit of value falling by almost 20% – or around 1% per year.

During the years leading up to the energy crisis in 2022, there was a notable slowdown in efficiency improvement in all sectors except transport, where consistently higher sales of electric vehicles transformed progress. Efficiency progress in residential buildings stalled because of increasing demand and a growing housing stock, while energy intensity in industry fell more slowly – and actually increased during the pandemic – largely due to strong steel production growth in China.

Global energy intensity by sector in the Net Zero by 2050 Scenario, 2000-2030



Note: End-use indicators used for transport, industry and residential buildings are road passenger kilometre energy intensity (MJ/pkm), value added energy intensity (MJ/USD) and residential floorspace energy intensity (MJ/square metre), respectively.
Source: IEA (2023), Tracking Clean Energy Progress 2023.

Transport

Transport energy consumption gradually returns to pre-pandemic levels as the transition gathers pace

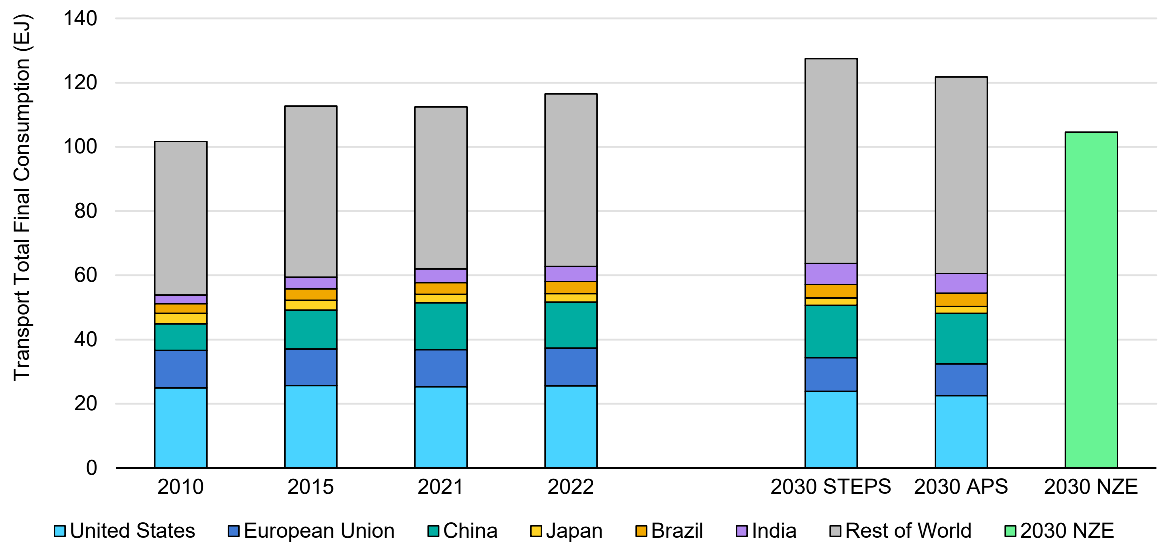
The transport sector accounts for around 120 EJ, or 26%, of total final energy consumption, responsible for nearly 8 Gt of global CO_2 emissions in 2022. From 2010 to 2022, total energy consumption in the sector grew at an average of just under 1.2% per year despite a large increase in the distance travelled. For example, the number of passenger kilometres travelled in cars rose by an average of about 3% per year between 2010 and 2022.

Around 44% of transport energy consumption is from the three largest energy consumers, the United States, the European Union and China. Between 2010 and 2022 transport energy consumption grew at an annual rate of 5% in China, rose slightly by 0.2% in the United States, and stayed constant in the European Union.

Japan was a standout performer in terms of efficiency progress, with energy demand falling by around 2% per year even as the number of passenger kilometres travelled slightly rose.

Transport was the most seriously impacted end-use sector by Covid-19, with demand falling by 14% in 2020, and is only now returning to pre-pandemic levels. In 2022, transport energy demand was still rebounding, rising by 4%, and most of this coming from aviation, which is still a quarter lower than 2019 levels.

Total final energy consumption for transport, 2010-2022, and by scenario, 2030



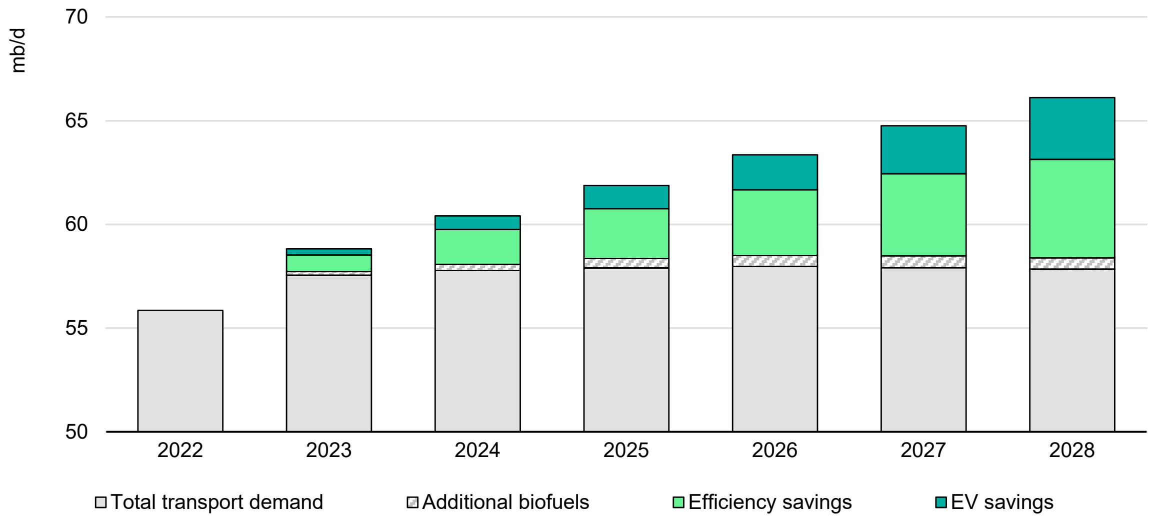
Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario. International bunkers final consumption included in *Rest of World*.
Source: IEA (2023), World Energy Outlook 2023.

Transport is the sector most heavily reliant on oil, which accounts for nearly 91% of final energy use, down only 3.5% from the early 1970s. Only around 1% of transport energy consumption is currently electric, although this is changing fast, with electricity demand from road transport up 60% in 2022 compared with 2019 levels. With electric vehicles – which are generally much more efficient than conventional cars – gaining market share rapidly, the transport sector is perhaps the most dynamic end-use sector for the clean energy transition.

Global gasoline demand plateaus this year, impacted by improving passenger car efficiencies and electrification

In 2023, total oil demand in the transportation sector is expected to account for 58 mb/d, or around 60% of the projected 102 mb/d in global consumption. Gasoline demand – which is mainly used by passenger cars – is set to peak and stabilise at around 27 mb/d the same year, followed by road transport as a whole in 2025 at 45 mb/d. Crucially, demand for oil from combustible fossil fuels (which excludes biofuels, petrochemical feedstocks and other non-energy uses) is forecast to hit its apex at 81.6 mb/d during 2028, according to the IEA's medium-term outlook, Oil 2023. This milestone is driven by the historic pivot towards lower-emission transport sources.

Total transport fuel demand, efficiency and EV savings, 2022-2028



Source: IEA (2023), Oil 2023: Analysis and Forecast to 2028.

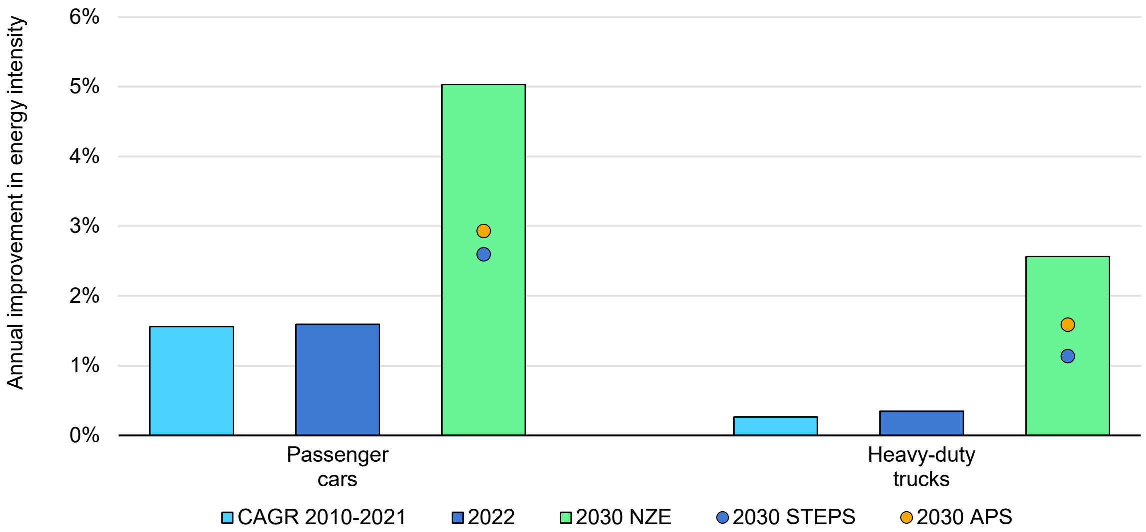
At the regional level, overall transportation oil demand is expected to continue to grow in China and India, while the OECD as whole may see demand peak in 2023. Projected demand in 2028 would be 7.8 mb/d higher without the savings from new EVs and efficiency improvements from 2022 onwards.

Electrification is set to drive a radical lift in passenger vehicle efficiency while trucks stay in the slow lane

Sales of gasoline and diesel cars, two- and three-wheelers and trucks peaked in 2017, 2018 and 2019, respectively. Just two years ago, around 4% of vehicles sold were EVs. This rose to around 15% of car sales in 2022, while in 2023 around 18% of vehicles sold are expected to be electric. In the STEPS the share of electric cars in total car sales reach a share of 40% by 2030, and in the NZE Scenario the share increases to more than 65% by 2030 and 100% by 2035.

In the NZE Scenario the average annual improvement in energy efficiency for passenger cars more than triples from current rates of around 1.6% per year to 5% a year by 2030. For heavy-duty trucks efficiency improvements are relatively slower due to the lower electrification levels, with the annual improvement increasing to over 2.6% in 2030, from only 0.3% per year from 2010-2021.

Global energy intensity progress for passenger cars and heavy-duty trucks, 2010-2022, and by scenario, 2030



IEA. CC by 4.0

Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario. Energy intensity calculated in PJ/passenger-kilometre for passenger cars and PJ/tonne-kilometre for heavy-duty trucks.

Sources: IEA (2023), Tracking Clean Energy Progress; IEA (2023), World Energy Outlook 2023.

Although they represent fewer than 8% of vehicles (excluding two- and three-wheelers), trucks and buses, which mainly use diesel rather than gasoline, are responsible for more than 35% of direct CO_2 emissions from road transport. In 2022, CO_2 emissions from trucks rebounded to around their 2019 level and current trends suggest that they are set to reach record levels in 2023.

In 2022, nearly 66 000 electric buses and 60 000 medium- and heavy-duty trucks were sold worldwide, representing about 4.5% of all bus sales and 1.2% of truck sales worldwide. In 2023, proposals for strengthening standards for heavy-duty vehicles have been put forward in Europe and the United States. The European Union has proposed revisions for more stringent CO_2 standards for heavy-duty vehicles, including a 100% zero emission target by 2030 for city buses and a 90% reduction for trucks by 2040. The original standard covers 70% of emissions while the new standard would cover 95%.

Mexico City increases electrification efforts in public transport

Mexico City's first fully electrified Metrobus line started operating in 2023, consisting of a total of 60 buses with 330 km range, allowing 18-hour shifts. These buses can be fully charged overnight, by using 32 high power chargers deployed in a dedicated charging station, taking less than four hours. Another important Metrobus line, carrying 120 000 daily commuters, is being electrified with the deployment of 55 new electric buses, with more to come as diesel buses reach the end of their lifespan. The trolley fleet has also been renovated and expanded, with 425 new units added in the last five years and a new line opened in 2023, with another expected in 2024.

The electrification of the taxi fleet is also progressing, with hundreds of cars already in operation. Additionally, with the new programme Financiamiento al Transporte Público Individual Sostenible launched in 2023, the city increased the efforts to replace part of the more than 25 000 nearly obsolete taxis, providing grants of MXN 180 000 (USD 10 000) for the acquisition of electric vehicles and MXN 135 000 (USD 7 500) for hybrids.

In the United States, higher standards were proposed which include new targets for heavy duty highway vehicles for model years 2028 through 2032, as well as updates to the previously finalised standards for 2027 trucks. In March 2023, Indonesia announced the country will, with the support of the IEA, develop fuel economy standards for trucks. In April 2023 Phase 1 of India's fuel consumption standards for heavy duty vehicles were implemented, introducing a minimum performance requirement. In Korea, its first GHG emission standard to cover trucks (above 3.5 t) aims to reduce emission by 2% in 2023, 4.5% in 2024 and 7.5% in 2025, compared with the average value from 2021 to 2022 of all vehicles sold domestically.

Fuel economy standards for cars are being strengthened with countries starting to align with net zero levels

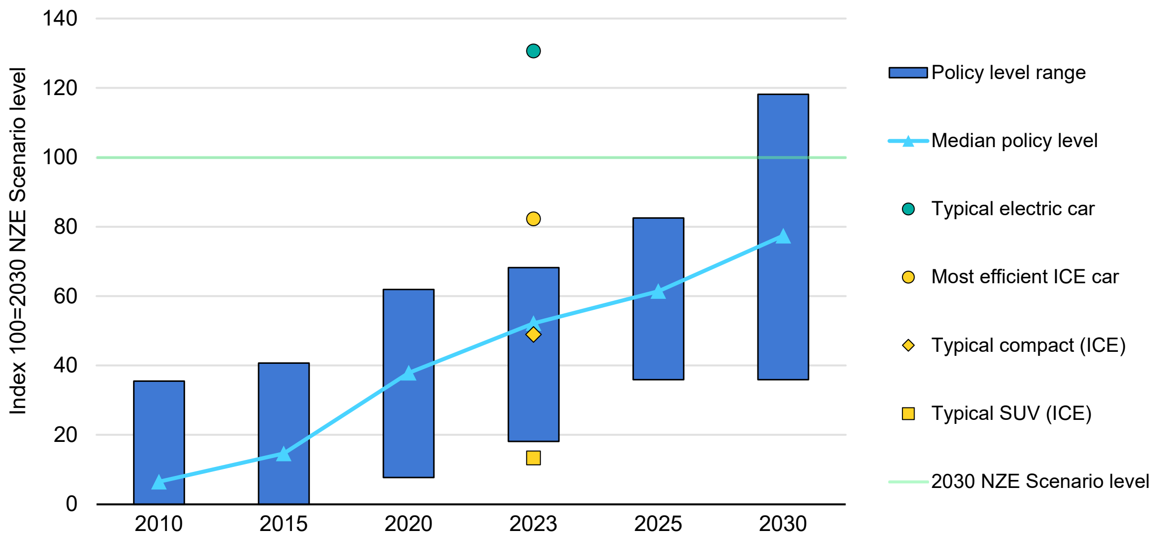
The stringency of many fuel economy standards has strongly increased over the last decade, with a growing number of countries also strengthening incentive programmes. At least three jurisdictions – the European Union, the United Kingdom and the United States – have put in place or have under proposal fleet average standards for new passenger vehicle sales that are in line with the NZE Scenario. This level is reflected by a value of 100 or above in the IEA Efficiency Policy Level Index. There has been substantial progress in this area with the Index increasing from a median level of 5 in 2010 to above 50 in 2023. With current expected improvement pathways, it will reach almost 80 by 2030, closely approaching NZE Scenario levels.

Fuel economy standards in many jurisdictions follow tank-to-wheel efficiencies that do not consider the production of the fuel. However, with electric vehicles on the rise, production efficiencies increase in importance as they can vary widely, especially depending on the share of fossil fuel inputs in electricity generation. For this reason, in its fuel economy standard for 2030, Japan is employing a well-to-wheel approach which allows comparing the primary energy needed for moving the vehicle across different fuels, including also electricity and hydrogen.

New standards are also being put in place. New Zealand's first-ever emissions standards for light-duty vehicles came into force in 2023, and the Australian government is currently developing fuel efficiency standards for new light-duty vehicles.

In March 2023, the European Union strengthened the 2030 tailpipe emissions reduction target for new cars from -37.5% to -55% compared to 1990 levels and introduced a 100% reduction for 2035. In the United States, proposals to update fuel economy standards could involve targets for a 2% per year improvement in fuel efficiency for passenger cars and 4% per year in light trucks.

IEA Efficiency Policy Level Index, fuel economy standards for new passenger cars, global country range, 2010-2030



Notes: ICE = internal combustion engine. All fuel consumption is normalised to the WLTP test cycle and tank-to-wheel efficiencies according to the ICCT methodology. Fuel economy standards 2023 are in force, 2030 include in force and proposed values. All example vehicles model year 2023. Most efficient ICE car: Mazda 2 Hybrid 1.5, Typical compact (ICE): Ford Fiesta, Typical SUV (ICE): Nissan Qashqai, Typical electric car: Tesla Model 3. An index of 100 denotes the fuel economy policy level for 2030 in the NZE Scenario (3 lge/100 km). It covers only usage phase efficiency and does not allow lifecycle assessment. Country sample represents 69% of global road transport energy demand.

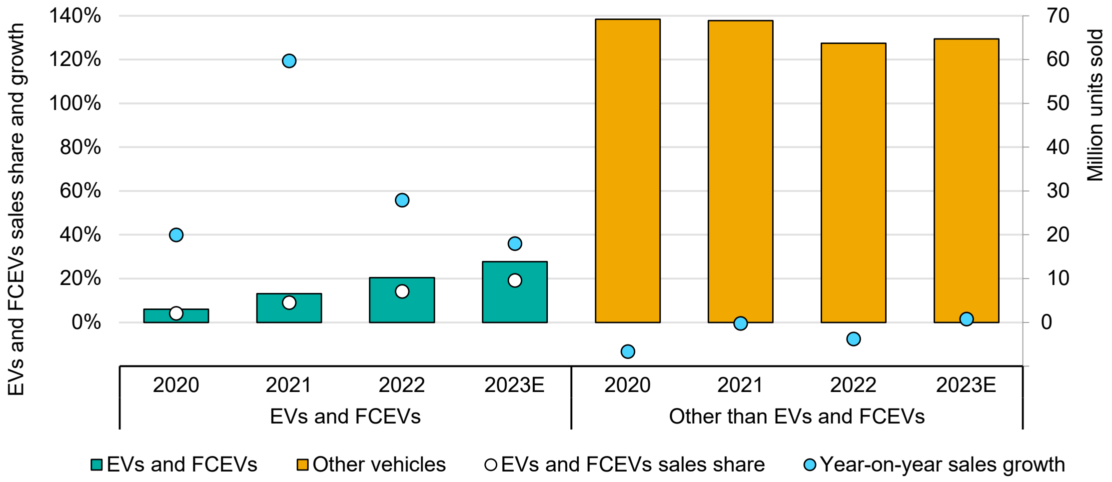
Sales of electric vehicles are growing strongly, underpinned by more ambitious targets

Electric car markets are seeing strong growth with global sales exceeding 10 million vehicles in 2022. By the end of 2023, 14 million in vehicle sales is expected, a 35% year-on-year increase. As a result, electric cars could account for 18% of total car sales globally in 2023. Two- and three-wheelers have the highest electrification shares today of any road transport mode, in particular in emerging market and developing economies.

More than half of the electric cars on roads worldwide are in China, where the share of sales at 29% in 2022 has already exceeded its national target of 20% for 2025. In Europe, the second largest market, electric car sales increased by over 15% in 2022, meaning that more than one in every five cars sold was electric. Electric car sales in the United States – the third-largest market – increased 55% in 2022, reaching a share of 8%.

India, Thailand and Indonesia also saw notable increases in electric mobility in 2022. Collectively, sales of electric cars in these countries more than tripled relative to 2021 and in 2022 were seven times higher than in 2019. Over half of India's three-wheeler registrations in 2022 were electric, with growth driven by support from government incentives, lower lifecycle costs compared with conventional models, as well as higher conventional fuel prices.

Annual new vehicle sales by car type, EV sales share and year-on-year sales growth, global, 2020 to 2023



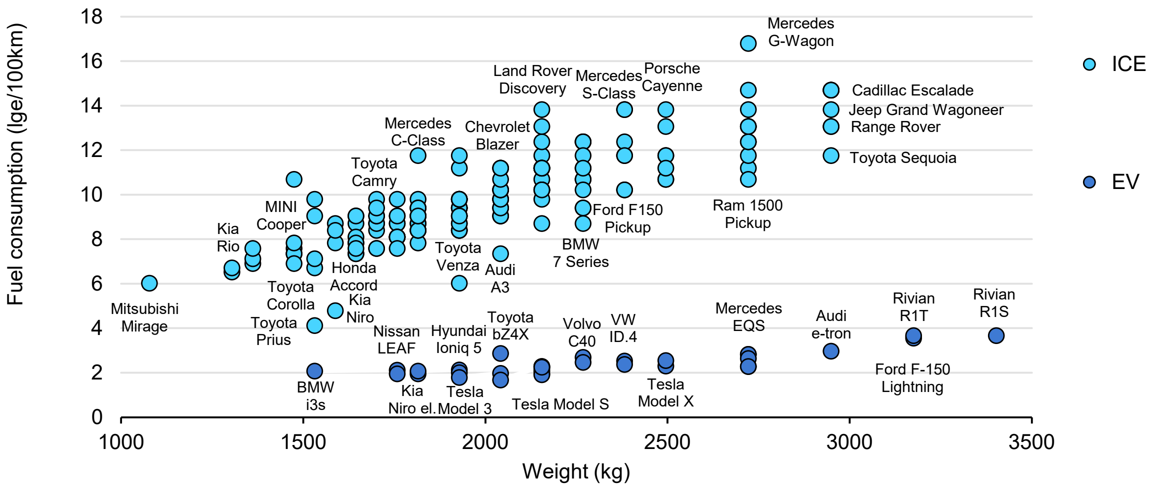
Notes: Electric vehicles (EVs) include battery electric and plug-in hybrid vehicles. FCEVs = fuel cell electric vehicles.
Source: IEA (2023), Global EV Outlook 2023.

Global EV growth is underpinned by adoption of increasingly ambitious strategies for promoting zero-emission vehicles in a range of countries. The Australian government is developing a national EV strategy which aims to encourage increased EV demand and affordability. Canada will require all new cars to be zero-emission vehicles by 2035, with at least 20% in 2026 and 60% in 2030. In Costa Rica, the Law of Incentives for Green Transportation to promote EV purchases was approved in 2022, while Ghana's recently released EV strategy aims for 4%, 16% and 32% of new sales to be EVs in 2025, 2030, and 2050, respectively. In Indonesia, government vehicles have been required to be electric since 2022, and EV purchase subsidies were put in place in 2023.

With larger cars becoming more popular than ever, electric vehicles offer a radical efficiency breakthrough

In 2022, SUVs accounted for around 46% of global car sales, up from only 16% in 2010, with noticeable growth in the United States, India and Europe, among others. The trend towards heavier conventional vehicles with higher fuel use is putting upward pressure on oil demand. In the United States, for example, an average standard SUV weighs 800 kg more and needs around 45% more fuel than an average medium-sized car to travel the same distance. For EVs, the energy consumption increase of a standard SUV over a compact car is 33% at an equal weight difference.

Vehicle efficiency (usage phase) and weight, new vehicles, United States, 2023



Notes: lge = Litres of gasoline equivalent. All vehicles are model year 2023, except for BMW i3s and Volkswagen Golf (model year 2021) and Hyundai Ionis 5 (model year 2022). For SUVs and pickup trucks, the all-wheel drive version is used. The efficiencies follow US EPA methodology, covering tank-to-wheel efficiencies. ICE = internal combustion engine vehicle, EV = electric vehicle.

Source: U.S. Environmental Protection Agency.

Electric SUV numbers are also growing rapidly, accounting for around 16% of total SUV sales, and for over half of global EV car sales for the first time in 2022. Compared to a conventional car, even some of the largest and heaviest electric SUVs require less energy to travel the same distance than the most efficient conventional small cars. However, larger batteries, the heaviest and largest single component of an electric car, put additional pressure on battery supply chains, require higher energy use in vehicle production and further increases demand for critical minerals, while larger SUVs result in increased road and parking space requirements, greater risk to the safety of pedestrians and, reflecting their higher cost, can result in issues relating to equity and access to car ownership.

Addressing these risks in advance is possible through a number of actions, including incentivising the market to reduce average car weight for both conventional and electric SUVs. For example, since 2022 France's Bonus Malus Scheme has accounted for weight and from 2024 in Paris and Lyon weight-based parking charges will apply.

In Norway, taxes were introduced for EVs for the first time. From January 2023 a weight tax of NOK 12.5 (USD 1.24) for every kg of vehicle weight above 500 kg was implemented, as well as a tax based on vehicle price. In Korea, an energy efficiency label and rating was introduced for electric vehicles and will be displayed from April 2024, making it easier for consumers to choose the most efficient option.

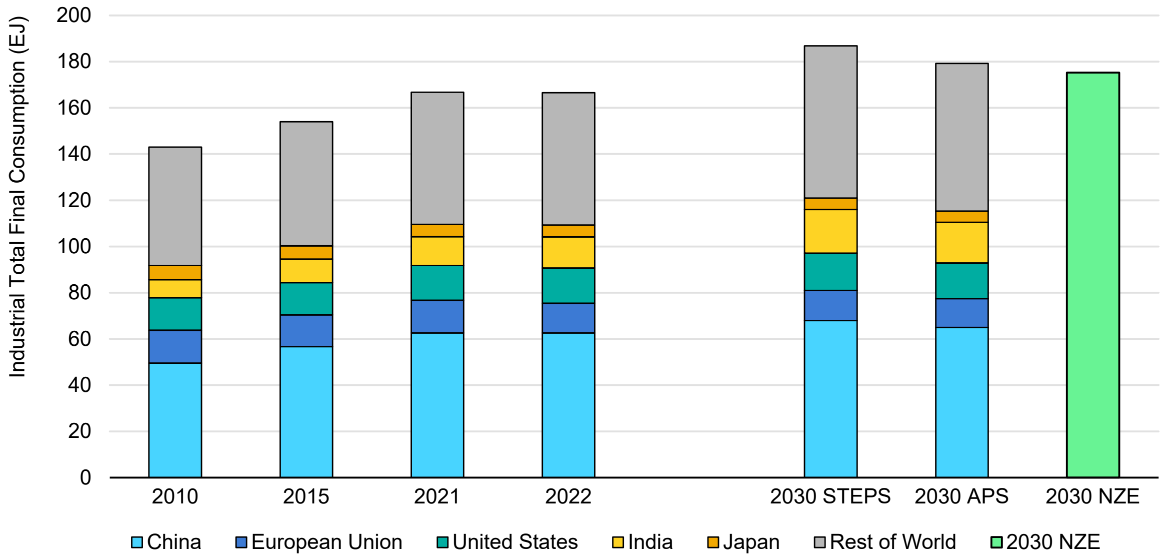
Industry

Industrial energy consumption will continue to grow over the next decade

The industry sector accounts for almost 170 EJ, or about one-third of today's global total final energy consumption. Industrial energy consumption has steadily risen in recent years, by around 1.3% per annum from 2010 to 2022. Since 2000, total global energy industry consumption rose by almost 70%.

Around 38% of global industrial energy consumption is in China, greater than the European Union, United States, India and Japan combined (28%). Between 2010 and 2022, it grew at an annual rate of 2% in China, 4.5% in India, and 0.7% in the United States, while it fell by 0.8% in the European Union and 1.4% in Japan.

Total final energy consumption for industry, 2010-2022, and by scenario, 2030



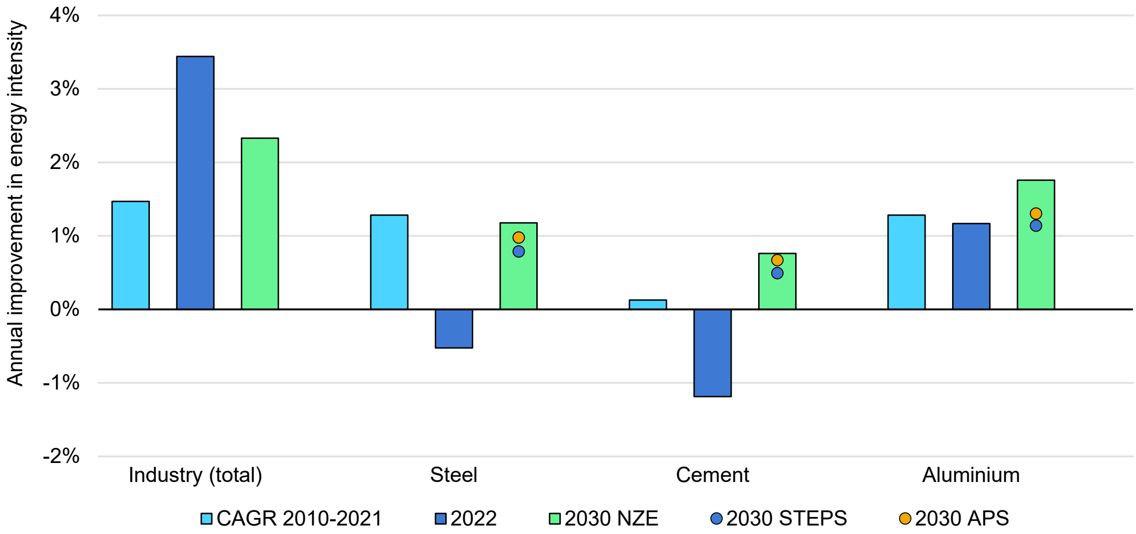
Source: IEA (2023), World Energy Outlook 2023.

Industry energy consumption increases further under all IEA scenarios over the next decade, rising by 1.4% per year in the STEPS by 2030. Under the NZE Scenario, global growth in industry energy demand is limited to 0.6% per year, driven by mass deployment of more efficient and digitalised processes, technologies, increased recycling and electrification. Despite the recent slowdown in demand growth in China, it will continue to put upward pressure on industrial energy demand along with India, which under the STEPS will see the largest energy demand growth of any country in the next three decades at 3.3% per year.

Industrial emissions slightly declined by around 2% in 2022, with the sector being responsible for emitting about 9 Gt CO_2 through combined energy use and process emissions, equivalent to about one-quarter of global emissions, but not including indirect emissions associated with electricity consumption.

Industrial energy use is heavily dominated by fossil fuels, with coal accounting for 28%, natural gas 18% and oil 19%. Electricity provides 23%, with its share steadily increasing, and biomass and waste heat represent the remainder. Steel, cement and aluminium together account for almost 60% of industrial energy consumption. Energy efficiency options are mostly based on fuel switching, recycling and material substitutions, as well as more efficient motor systems and equipment, and advanced energy management systems.

Global energy intensity progress for total industry and by major segments, 2010-2022, and by scenario, 2030



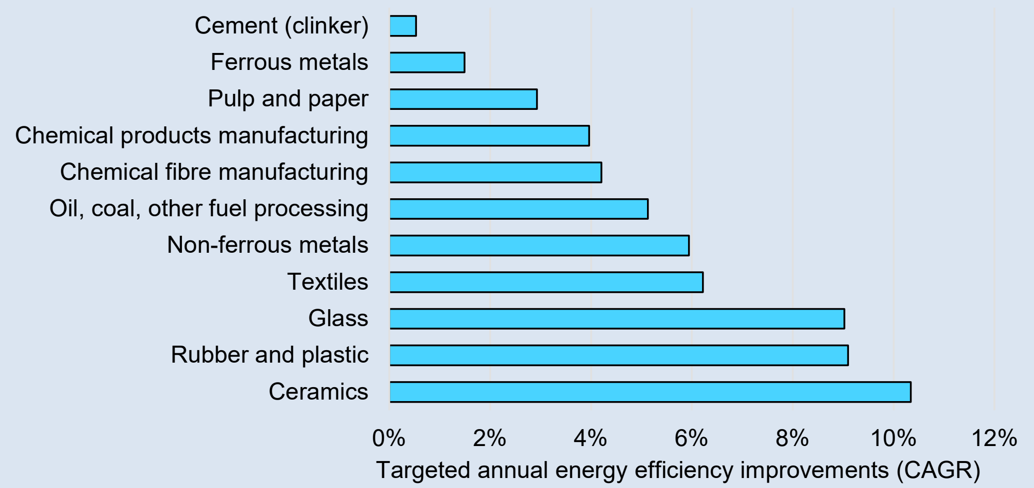
Note: Energy intensity calculated in PJ/USD Billion (2022, PPP) for industry (total) and PJ/Million tonne for steel, cement and aluminium.
Sources: IEA (2023), Tracking Clean Energy Progress; IEA (2023), World Energy Outlook 2023.

China expands coverage of industrial energy efficiency benchmarks

China has taken actions in the past decade to reduce energy intensity in industry, which accounts for about two-thirds of the country's total energy consumption. The government's Action Plan for Increasing Industrial Energy Efficiency sets out broad-based targets for the period from 2021 to 2025, including aims to reduce energy consumption per unit of value added by 13.5%, increase the proportion of new energy-efficient motors to exceed 70% of sales, and for electricity to account for 30% of total final industrial energy consumption.

The plan also aims to curb development and eliminate high-energy-consumption, high-emission and low-quality projects, including through adjustments to energy efficiency benchmarks. Industrial energy efficiency benchmarks were expanded in July 2023 to cover 80% of all industry sectors. Existing processes, including cement clinker, steel, iron and copper smelting, are required to meet benchmarks by the end of 2025. Newly added processes including urea, industrial silicon and woven fabrics have an extended deadline of 2026.

Targeted energy efficiency improvements for key sectors in China, 2020-2025



Notes: Targeted annual improvements in energy efficiency calculated based on CAGR between the base rate (2020) and reference rate (2025), with averages calculated for each sector based on individual sub-sector rates. For example, the rate of 5.9% for non-ferrous metals is based on an average of CAGR of targets for various methods of copper, lead, zinc, aluminium and silicon smelting. Assumes 100% of specific sub-sectors would meet targeted improvements from 2020-2025, based on a range of metrics (e.g., cotton textiles measured in kg standard coal/10 metres; phosphate fertilisers in kg standard coal/tonne; aluminium smelting kWh/tonne)

Sources: Calculations based on China's National Development and Reform Commission (NDRC (2023), Energy Efficiency Benchmarking Levels and Benchmarking Levels in Industrial Key Areas (2023 Edition).

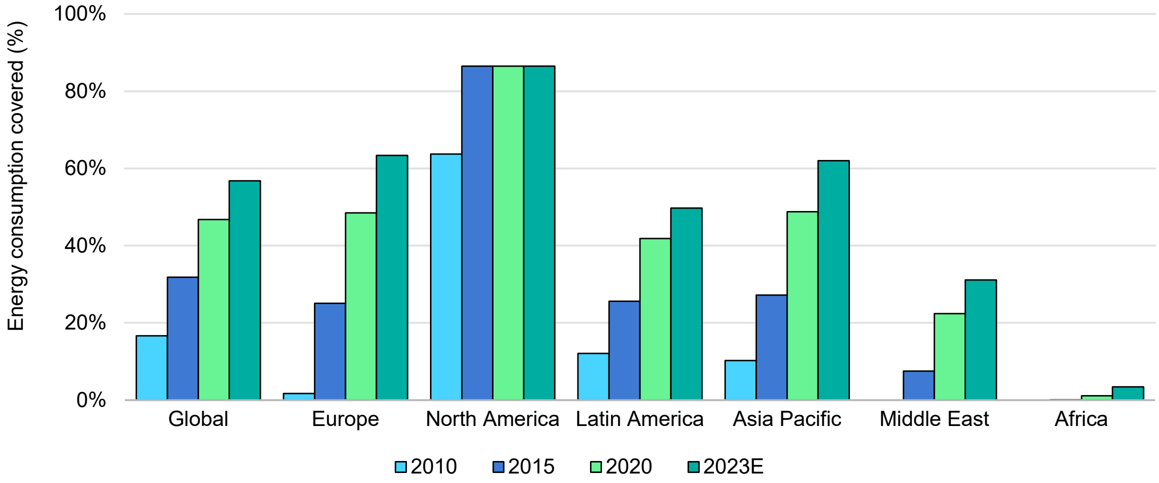
Improving the coverage of efficient electric motor systems will be crucial for decarbonising light industry

Light industries include activities such as food, machinery or construction. A higher electricity share of almost 37% in 2022 compared with heavy industries such as cement or steel at below 20% means the scope for efficiency gains are substantially higher.

A new study by the industry forum Energy Efficiency Movement finds that systemic measures such as connecting assets (Internet of Things), smart building management and industrial heat integration have the highest emissions savings potential from energy efficiency measures. However, they identify motors as having the highest potential of a single technology for reducing energy intensity of light industry processes. These constitute components in motor-driven systems such as compressors, fans or pumps. While the efficiency performance of the motor itself is essential to ensure maximum efficiency, other system components also need to be optimised and sized properly for use with the efficient motor.

An important policy tool for increasing motor efficiency are minimum energy performance standards (MEPS), referred to as an international efficiency (IE) class. In 2010, only 13 countries had MEPS in place for motors, covering about 17% of global energy consumption. Progress has been made since 2010 and 62 countries had MEPS for industrial electric motors in place by 2023, covering 57% of global energy consumption.

Share of energy consumption in industrial electric motor stock covered by minimum energy performance standards, by region, 2010-2023

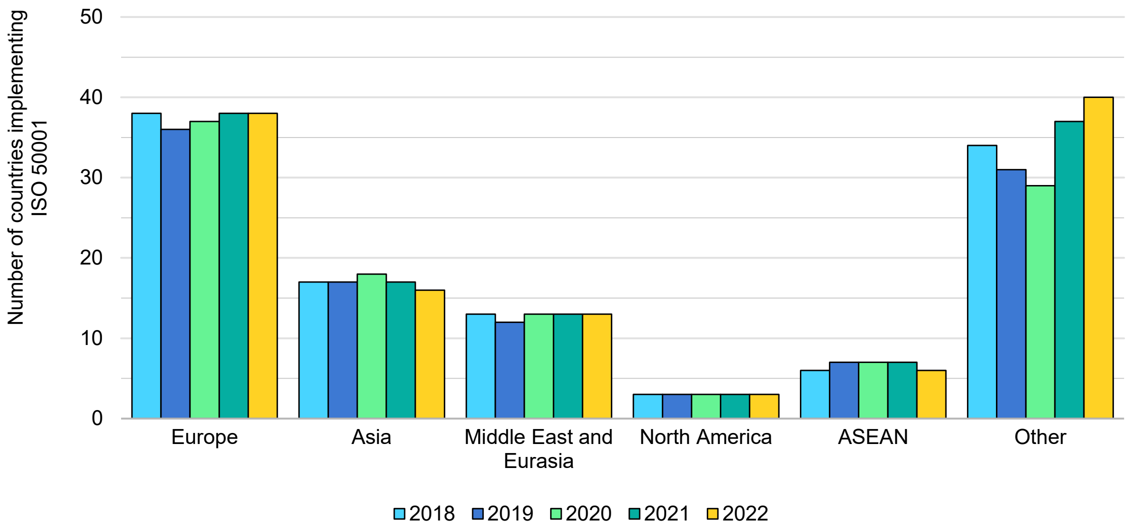


In addition to greater coverage, the stringency of MEPS for motors has improved significantly, with the European Union and Türkiye leading the way by requiring the IE4 standard in new motor sales. Currently, the most efficient and commercially available electric motors are classified as IE5 and use Variable Speed Drives (VSD). However, the long turnover times for new investment is slowing faster adoption, meaning it takes time for new code compliant motors to diffuse into the full stock.

Expanding engagement in energy management activities enabling greater efficiency progress in industry

Energy management systems are an important lever to enable energy efficient operation of industrial processes by improving the visibility of energy use and spend. One of the key frameworks for energy management systems in use is the international standard known as ISO 50001. The ISO 50001 system is based on a process of monitoring, targeting and implementing energy saving measures in a cycle of continuous improvement. The Geneva-based International Organization for Standardization (ISO) gathers global data on the certificates issued every year, and best practices are highlighted by the Clean Energy Ministerial (CEM) forum through their annual Energy Management Leadership awards.

Number of countries issuing ISO 50001 certifications by region, 2018-2022



Source: ISO (2023), ISO Survey 2022 of certifications.

In 2022, the number of ISO 50001 certificates issued worldwide grew by almost 30% to 28 000. Spain experienced the largest growth in percentage terms, with around 3 300 certificates issued. This was sparked by a drive from businesses to reduce energy costs as prices rose, along with the increased inclusion of certification as a requirement or evaluation criterion in many public tenders. This ranks Spain as the country with the third-largest number of certificates issued in 2023 after China, which saw an increase of over 40%.

Germany remains a frontrunner in Europe, where energy certification schemes serve as an exclusive alternative to the mandatory energy audit for companies required in the EU's Energy Efficiency Directive. The 2023 recast of the Directive obliges enterprises with an annual energy consumption above 85 TJ to implement an independently certified Energy Management System, and includes many other new measures to help accelerate energy efficiency progress.

In North America, the number of ISO 50001 certificates issued is relatively low since the United States uses the voluntary Superior Energy Performance (SEP) programme for energy management system implementation.

The public sector plays an important role in increasing the visibility of energy efficiency technologies and system programmes in action, as well as the benefits of management standards for large industrial and commercial businesses, and other local and regional governments. One case study highlighting this role was the Government of Ras Al Khaimah in the United Arab Emirates (UAE), which in

2023 became the first in the world to achieve ISO 50001 certification across all of its entities. The government reported a 25% electricity savings at the end of three years.

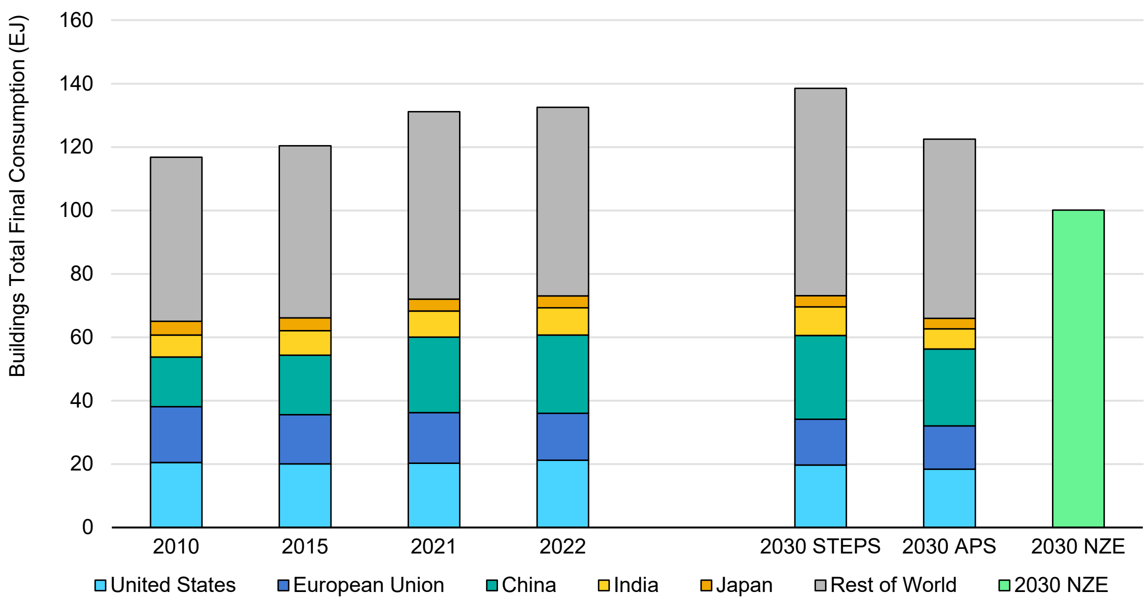
Buildings

Global energy consumption in buildings is rising with emerging economies and space cooling leading growth

Energy consumption in buildings accounted for 30% of global final energy demand in 2022 along with 26% of emissions, made up of direct emissions at 8 percentage points, such as gas heating and cooking, and indirect emissions at 18 percentage points from the consumption of electricity.

Global buildings sector energy consumption increased from 2010 to 2022 by an average of 1.1% each year, to an estimated 133 EJ. The strongest growth has been in China, rising by 4.8% per year, followed by India at 1.9% per year. In the same period, energy consumption in buildings was relatively stable in the United States, while falling by 1.3% per year in the European Union and 1.1% in Japan as efficiency progress lowered demand, even as activity levels rose – such as from a larger and greater number of houses.

Total final energy consumption for buildings, 2010-2022, and by scenario, 2030



Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario.
Source: IEA (2023), World Energy Outlook 2023.

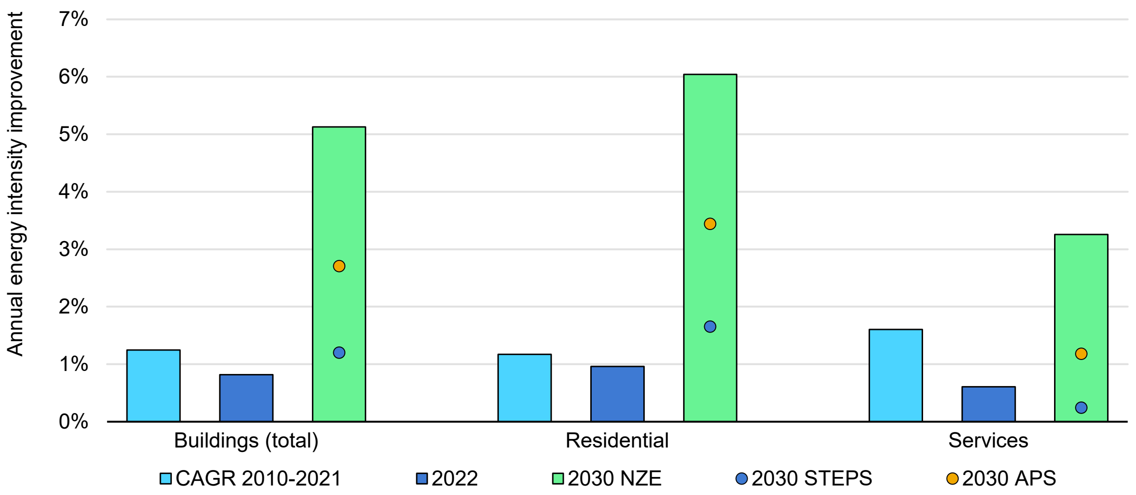
Buildings efficiency progress quadruples by 2030 in the NZE Scenario

Energy intensity in residential buildings has decreased steadily between 2010 and 2022, with an average annual improvement of 1.2% leading to a 13% reduction over the period. The energy intensity of the residential building stock worsened in 2021 during the Covid-19 lockdowns as many more people stayed at home, but progress levels partially recovered in 2022 to 1%. Commercial buildings have seen stronger improvements over the last decade.

In the NZE Scenario, average energy intensity improvement rates for the buildings sector reaches 5.1% on average from now until 2030. This is a more than quadrupling of the average rate of 1.2% in the last decade. Reaching and sustaining this level of improvement would deliver a reduction in energy demand almost equivalent to China and India's combined total buildings consumption in 2022.

In the NZE Scenario, all new buildings and 20% of existing buildings are zero-carbon-ready by 2030, which will entail more than doubling of the current global annual retrofit rate to reach 2.5% by 2030.

Global energy intensity progress for buildings, 2010-2022, and by scenario, 2030



Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; and NZE = Net Zero Emissions by 2050 Scenario. Energy intensity calculated in PJ/Million square metre.
Sources: IEA (2023), Tracking Clean Energy Progress; IEA (2023), World Energy Outlook 2023.

Space heating and cooling offer the greatest potential for improved energy efficiency in the buildings sector

The largest energy consuming end use in buildings is space heating, and total global heated floor area is projected to grow from 157 billion m^2 in 2022 to 170 billion m^2 by 2030. Space heating is currently dominated by fossil fuels, however there is significant opportunity for electrification, especially through increasing adoption of efficient electric heat pumps, both for individual dwellings and for district heating networks fuelled by waste heat sources such as wastewater or data centres. Heat pumps can use three to five times less energy than a typical gas boiler. They have been seeing phenomenal market growth in 2022 and, in some European markets, in the first half of 2023. However, heat pump sales are set to decrease in 2023 in several countries, such as Italy, Finland and Poland, due to a combination of factors, including a high electricity to gas price ratio and changes in government policies, while consumers are struggling with high interest rates and cost of living increases. The European Commission is working on an EU Heat Pump Action Plan, which is aimed at removing barriers and accelerating the uptake. Global installed capacity of heat pumps accounted for 12% of space heating demand in 2022, with a target to more than double the share to 25% by 2030 in the NZE Scenario.

Space cooling, particularly the use of air conditioners, is showing the fastest growth in final energy consumption among building end uses. Heat waves are increasing in frequency and intensity worldwide, making the cooling seasons longer, requiring cooling for longer periods each day and expanding needs to more regions. Increased income, especially in emerging markets and developing economies, is also improving access to air conditioning and puts strong upward pressure on demand. For example, around 5 billion households have a substantial need for space cooling, but only one-third of them currently have an air conditioner.

Mandatory building energy codes are expanding but many older ones need to be updated

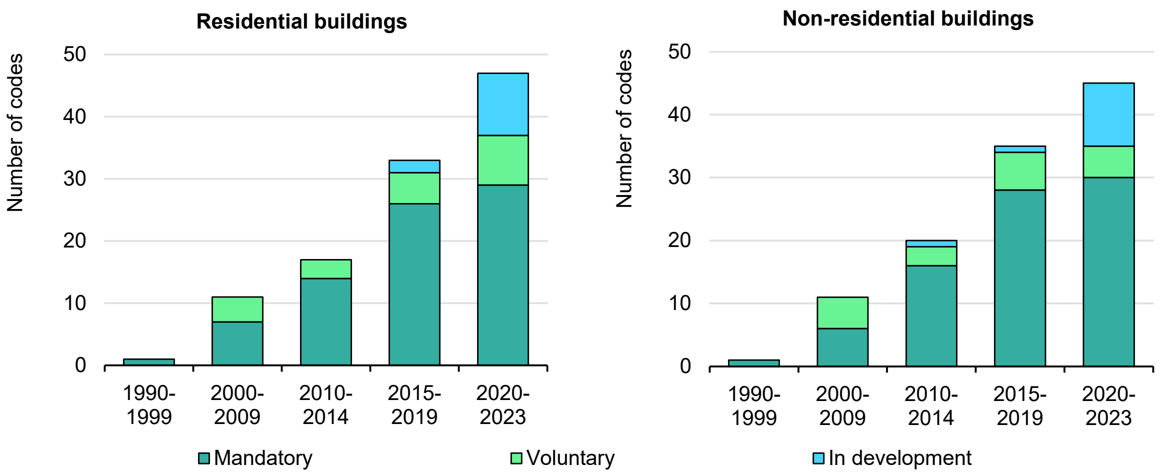
Building energy codes play a pivotal role in advancing energy efficiency and sustainability in the buildings sector, with global coverage expanded in recent years. Since 2021, the mandatory national building energy codes have been adopted in 39 countries. In 2023, the total number of adopted mandatory national building energy codes for residential and non-residential buildings were 81 and 77, respectively. In addition, there were 17 national level building energy codes in development as of 2023.

Around 80% of all building energy codes globally are mandatory, but one-third of them have not been updated since 2015. Only a few building energy codes have been updated to set the requirements for achieving net zero emission performance for new and retrofitted buildings. The potential energy and climate benefits are large. Retrofitting around half of existing buildings to be zero-carbon-ready by 2040 would more than halve demand for space heating and cooling between today and 2050, despite a 55% increase in buildings sector floor area.

The past 18 months has seen a number of countries make progress to align their codes with the Paris Agreement. If the revision proposal for the EU's Energy Performance of Buildings Directive is adopted, all member countries will need to align their codes to support requirements for new buildings to be zero emission by 2030. A number of countries, such as Denmark, Sweden and France, have either implemented or are preparing to introduce changes to their building codes to include embodied carbon emissions requirements. Japan has introduced targets for buildings to achieve performance in line with zero energy buildings standards by 2030 for new buildings, and by 2050 for existing buildings. Canada's updated energy code for buildings aims to have all new construction to net zero energy ready standards by 2030.

In 2022, India introduced an energy conservation code for commercial and residential buildings that promotes the use of renewable energy. As of April 2022, China's national building code also includes a mandatory requirement for installation of rooftop solar PV on all new buildings.

Building energy codes globally, year of most recent update, 1990-2023



Note: Voluntary codes may be enforced on a local level.

Big wins to be realised from introducing building energy codes in emerging and developing countries

Despite a growing number of stronger building energy codes being put into action, there are still regions around the world where big wins can be made by putting regulations into place. For example, there are many countries in Africa, South America and Asia where building energy codes are yet to be developed, remain voluntary or are limited in scope and stringency.

Few countries in South America have adopted mandatory building energy codes, while a majority are either in development or generally do not have mandatory performance standards available. In Southeast Asia several countries, including Malaysia and Singapore, have had building codes and standards for many years, and many others are in the process of developing them.

Africa is set to embark on one of the biggest expansions of building floor area in the world, driven by growing populations and increasing incomes, with the residential building stock projected to double to almost 50 billion square metres by 2050. However, the majority of countries in Africa do not have building energy codes, with only a few in development and a handful of mandatory codes. Kenya has been working on updating its buildings regulations in line with the European construction guidelines, commonly known as Eurocodes. An updated building energy code is expected to include performance-based requirements and encourage environment-friendly construction practices.

Modernisation of energy codes will prepare buildings for interactions with the electricity system

Buildings present a unique opportunity to provide flexibility to the grid through installation and connection of various devices and distributed energy resources. Such buildings are not only efficient, smart and increasingly automated, but can also be considered grid-interactive.

Buildings equipped with smart sensors and meters can communicate with the grid, offering flexibility in managing energy loads by utilising behind-the-meter generation, energy storage, and participation in demand response programmes. This can enable buildings to become more active players in the energy system, communicating with electricity grids and responding to their needs by adjusting use, especially during surges in demand. To avoid locking out the flexibility potential of buildings, it is essential to prepare the buildings sector for potential interactions with the grid.

Mandating smart and interactive features in building energy codes, while implementing measures on improving cyber and grid security, is an important step to enabling buildings to become grid-interactive, at both the national and sub-national levels. The IEA's recent report on Efficient Grid-Interactive Buildings in ASEAN highlights the role that grid-interactive buildings can play in providing flexibility services and other benefits to the wider power system, including the opportunities for expanding application across the region.

Electrification and system level efficiency

The role of efficient technologies is changing as electrification and renewables deployment gathers pace

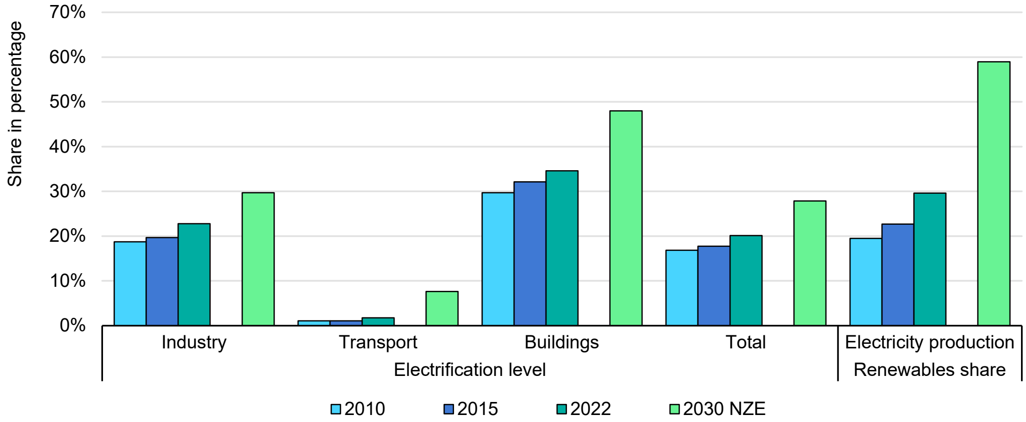
From 2010 to 2022, electricity consumption grew by almost 40% while total final energy demand grew by only 15%. Consequently, the share of electricity in total energy demand grew from less than 17% in 2010 to over 20% in 2022 globally. In the same time frame, renewable energy increased its share in overall electricity production from 19% to 30%, or more than 1.5 times as much.

As the share of variable renewable energy generation increases and the scope of electrified end uses expands, huge strains will be placed on power systems. New digitally enabled efficient end-use technologies hold the potential not only to take the burden off grids directly by lowering demand, but they can also provide a tool for turning such pressures to consumers' advantage through increased control and demand flexibility.

In 2020, 45 GW of demand response was available to system operators worldwide – around half of this was provided from buildings and half from industrial users. In the NZE Scenario, by 2030 demand-side response reaches 500 GW.

A 2023 report from the IEA on unlocking grid opportunities estimates that digitally enabled demand response from buildings, industry and transport could reduce the curtailment of variable renewable energy systems by more than 25% by 2030, increasing system efficiency and infrastructure utilisation, thereby reducing costs for consumers. The benefits to the consumer of system efficiency in environments of high renewable energy penetration are further explored in a special focus spotlight in this report in Chapter 5.

Share of electricity in final energy consumption by sector and renewables share in electricity production, 2010-2022 and 2030 for the Net Zero by 2050 Scenario



Source: IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach: 2023 Update.

Electrification rates vary widely by region and sector

Electrification levels differ greatly across countries and regions. For example, space heating and cooling dominates energy consumption in the buildings sector. Countries with high cooling demand and low heating demand, such as the UAE, have a larger electricity share in buildings because of the significantly higher number of air conditioners in use.

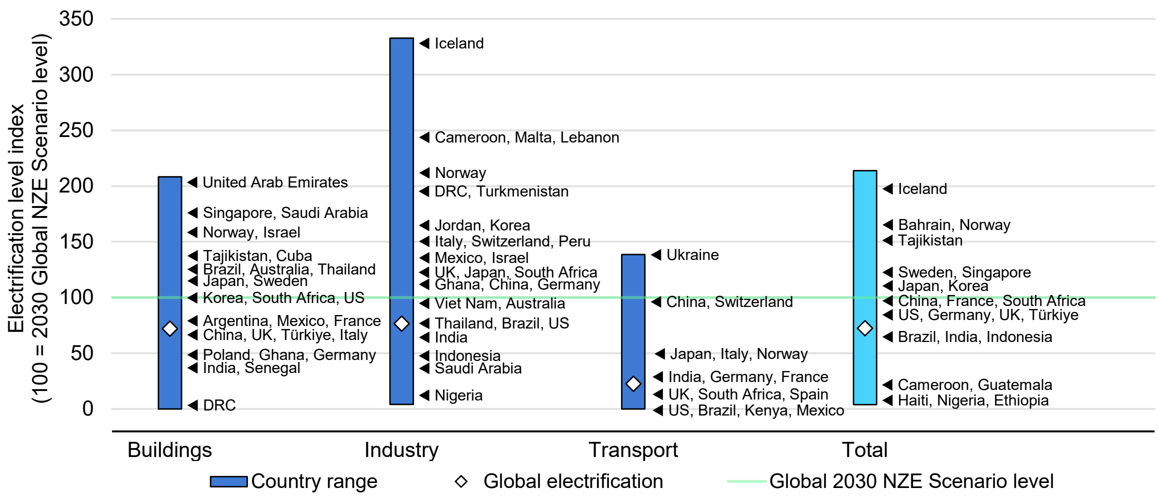
By contrast, European countries that use gas for heating and have less need for cooling have a lower share of electricity in total building sector energy demand. There are, however, some notable exceptions such as Norway and Sweden due to their high use of electric heating, reflecting their roles as worldwide leaders in the use of efficient heat pumps for space heating.

A priority for countries with higher temperatures is therefore not necessarily to increase building electrification so much as to improve cooling efficiency, such as through using passive cooling, efficient building design and high efficiency space cooling equipment. District cooling can also be an efficient solution and is less susceptible to demand peaks.

Electric end uses are typically also much more efficient than burning fossil fuels directly. For example, EVs are typically 2-4 times more efficient than current conventional vehicles and heat pumps 3-5 times more than fossil fuel boilers.

However, to better understand the system efficiency and greenhouse gas emissions impacts of different end uses it is also important to look beyond efficiency at the operation level of the energy consuming activity. For example, an electric vehicle may be more efficient to operate but still relies on electricity generated by systems predominantly powered by fossil fuels. For this reason a more complete perspective can be provided by well-to-wheel analysis, which assesses the CO_2 emissions incurred in fuel supply and operating the vehicle.

Share of electricity in final energy consumption by sector in 2021, indexed to 2030 global average Net Zero by 2050 Scenario level



Notes: Electrification is defined as the share of electricity in total final energy consumption per sector and overall. The level measure is indexed to the 2030 global average NZE Scenario level at value 100. It does not imply NZE Scenario levels for individual countries. DRC = Democratic Republic of the Congo, US = United States, UK = United Kingdom

Sources: IEA (2023), World Energy Balances, accessed October 2023; IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach: 2023 Update

In the industrial sector, countries with predominantly light industries and low-temperature processes have greater electrification possibilities available. Iceland and Norway have had abundant cost-effective electricity from hydropower for a long time, giving rise to strong electrified development of industry. By contrast, countries dominated by heavy industry, such as the cement, steel or the petrochemical sectors, face limited and very challenging routes for electrification.

In transport, countries with extensive electric train networks, such as many former Soviet Union countries, have traditionally had higher levels of electrification. This picture is expected to expand as the electrification of the road vehicle fleet accelerates.

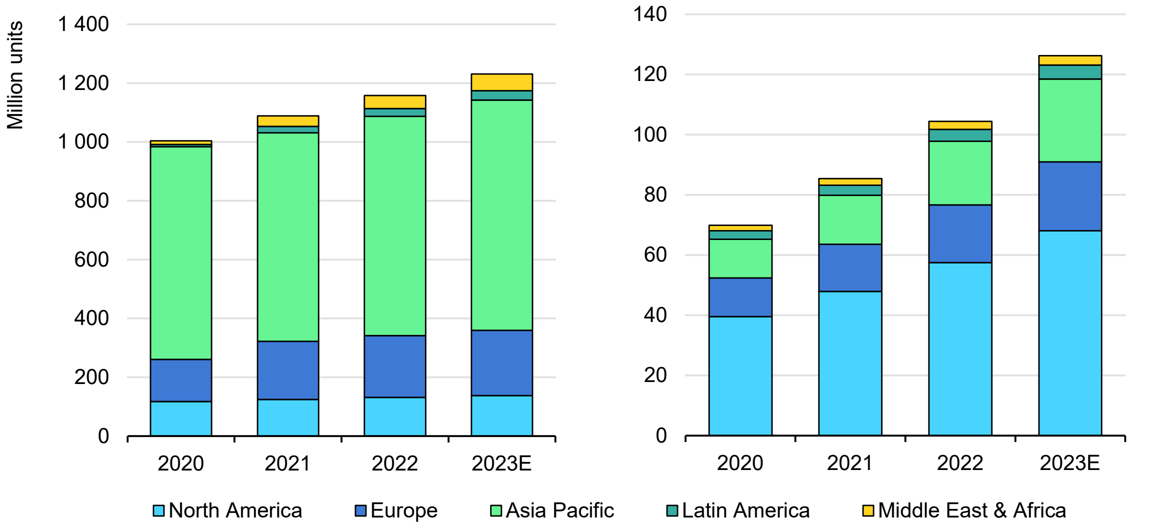
Technologies for demand response, and digital tools that enable them, continue to be rolled out – but gaps remain

At current rates, the global deployment of smart meters, currently at 46%, will increase to around 58% by 2030, with strong growth in Asia where building activity, urbanisation and investments in grid infrastructure are highest.

Since 2020, Indonesia's national electric utility PLN has been rolling out smart meters to customers. Over a ten-year span, PLN expects to expand the programme to 79 million smart meters. In early 2022, Malaysia's national power utility met its target of installing 1.8 million smart meters in Klang Valley, including Greater Kuala Lumpur and Melaka. By 2026, the utility plans to expand the number of installations to 9.1 million smart meters.

Penetration of controllable devices such as smart thermostats is far lower but also increasing, a trend accelerated by government and consumer responses to the energy crisis. In the Netherlands, sales of smart thermostat rose by 32% in 2022. Globally, 100 million homes now have some type of smart thermostat device, and over 400 million are expected to be deployed by 2030.

Global stock of smart meters (left), and connected smart thermostats (right), 2020-2023



Sources: IEA analysis based on data from Guidehouse and BloombergNEF.

However, rates of digitalisation are lagging in a range of the main appliances that should be capable of providing demand flexibility. For instance, while most heat pumps can send and receive data, few units are currently set up for grid interaction (capable of sending and receiving information from the grid with a common protocol), allowing them to pre-warm heating systems before peak hours, or briefly shut down during peak events. If current low rates of grid-interactivity persist, issues may arise for system balancing and with grid congestion.

Smart charging is another important source of future flexibility. Estimates indicate that the integration of smart charging technology for EVs with buildings, particularly those equipped with time-of-use tariffs demand charges and energy production such as solar PV, could yield significant savings for consumers.

EVs can be charged during off-peak times to reduce consumer bills while also alleviating strain on the system. If supported by bidirectional charging, EVs could also serve as a source of energy storage, as parked EVs could create dynamic energy loads by providing electricity back to the building during times of high prices or higher demand. For example, one study in Southeast Asia showed if 10 million EVs were charged with smart charging, the peak demand would only increase by 0.5 GW instead of by 3 GW with unsupported charging. However, studies find that for each doubling of vehicle mass, the energy consumption increases by at least 40% and up to 100%, meaning larger vehicles will place greater pressure on electricity grids.

More policies and incentives are needed to support demand-side flexibility

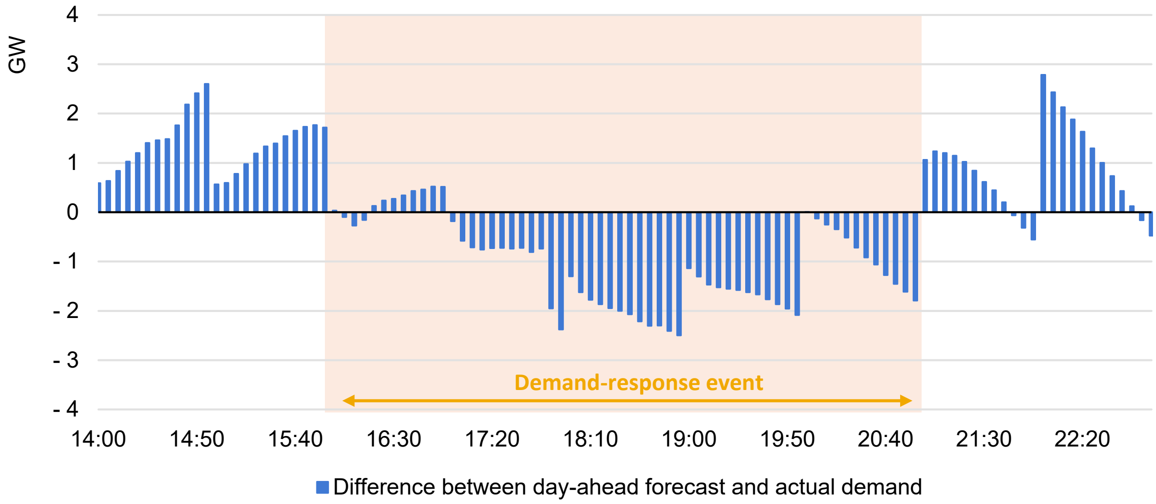
California had a large demand response event on 6 September 2022 when an extreme heat wave led to a record peak in electricity consumption, far above day-ahead forecasts, which threatened to cause blackouts.

The system operator first used formal demand response protocols, and then issued a general emergency text alert, asking households to reduce their electricity use. This led to an almost 2 GW drop in consumption, providing relief to the system and avoiding power outages.

At the end of 2022, the European Union set a mandatory reduction target of 5% for electricity consumption in peak hours, and allows EU member states to choose the appropriate measure to reduce consumption.

The Japanese government has introduced demand response provisions under the Energy Conservation Act of April 2023. Large consumers are incentivised to reduce electricity consumption at peak times with announcements of excellence and bonuses for meeting off-peak goals, and also penalties for not lowering use during peak periods.

Demand response event – California 6 September 2022, difference between day-ahead forecasts and actual demand



Source: California ISO.

In December 2021, California extended its Emergency Load Reduction Program (ELRP) to residential consumers. It rewards consumers who reduce their demand during grid emergencies (USD 2 000/MW). In 2022, residential customers were estimated to have reduced their consumption on average by almost 700 MW per event, the equivalent of a combined-cycle gas turbine unit running at full capacity.

Energy efficiency obligation schemes are also being used to reduce peak demand. For example, in 2022 the Australian state of New South Wales set a new tradable certificate called the Peak Demand Reduction Scheme. This programme is legislated until 2050 with the objective of delivering the lowest cost electricity in the summer peak demand period (2:30 pm-8:30 pm). The initial demand reduction target of 0.5% in 2022 will be raised to 10% by 2030.

In the United Kingdom, the Electricity System Operator offers a Demand Flexibility Service that incentivises reducing consumption during peak days. An estimated 1.6 million households and businesses participated in this scheme during the winter of 2022/2023, saving over 370 MWh across 22 peak events.

As a result of increasing congestion issues in the electricity grid, the Dutch government announced new measures to alleviate pressure, including potentially obliging large energy consumers to sign congestion management contracts, which allow the network operator to temporarily decrease their electricity supply during peak hours to create bandwidth on the grid. Similar initiatives are currently being discussed in Australia.

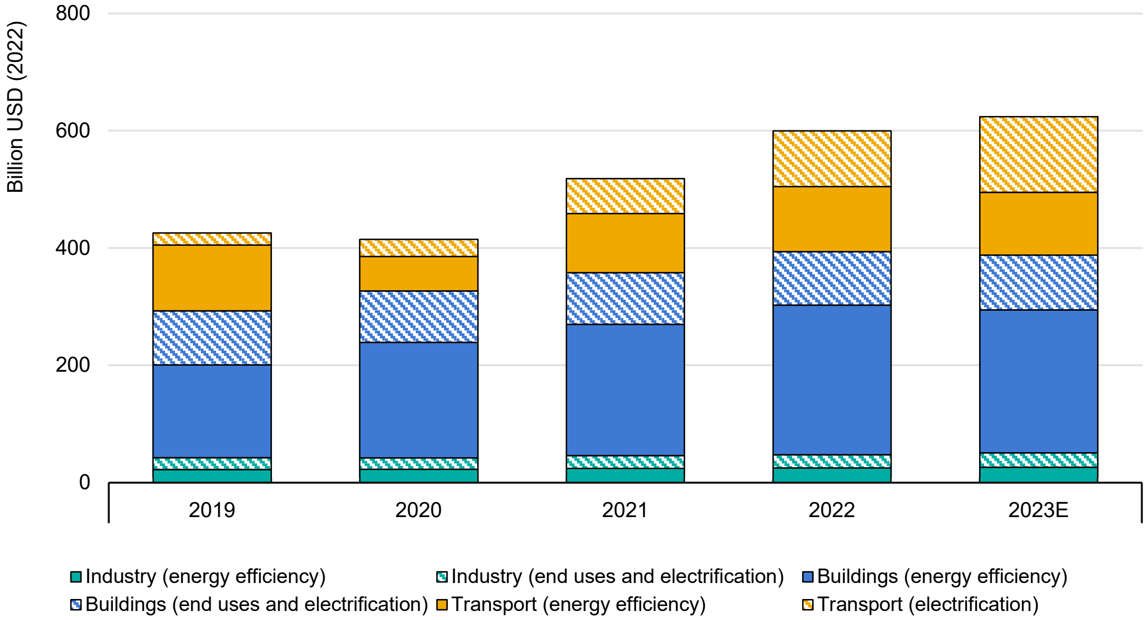
Chapter 3. Finance and employment

Efficiency investment trends

Efficiency-related investment growth undermined in 2023 by rising interest rates and higher costs

Expansive government stimulus spending packages to accelerate economic recovery from the Covid-19 pandemic and energy crisis helped propel investment growth in energy efficiency up by an astonishing 45% from 2020 to 2022. However, based on preliminary data, inflation of project costs and rising interest rates are expected to reduce investment growth to just 4% in 2023, compared to an average 20% for the previous two years. Nevertheless, investment in efficiency activities is estimated at historically high levels of just over USD 620 billion in 2023, which is around USD 200 billion above pre-pandemic levels.

Global investment in energy efficiency, electrification and renewables for end uses, 2019-2023E



Note: The IEA defines energy efficiency investment as incremental spending to acquire equipment that consumes less energy than would otherwise have been used for the same service. Investments in renewable energy for end uses include spending on behind-the-meter use, such as efficient solar thermal, bioenergy and geothermal systems in buildings and industry.
Source: IEA (2023), World Energy Investment 2023.

The growth of EV sales is the major driver behind the overall increase in efficiency-related investment in 2023, with electrification spending in transport up by a very strong 35% compared to 2022. Widespread switching to electric heat pumps contributed to a slight increase of 3% in electrification spending in the buildings sector over the same period.

To support a doubling in energy intensity progress from 2022 levels in the Net Zero Emissions by 2050 Scenario (NZE Scenario), global annual energy efficiency-related investment would need to triple from current levels, to over USD 1.8 trillion per year by 2030.

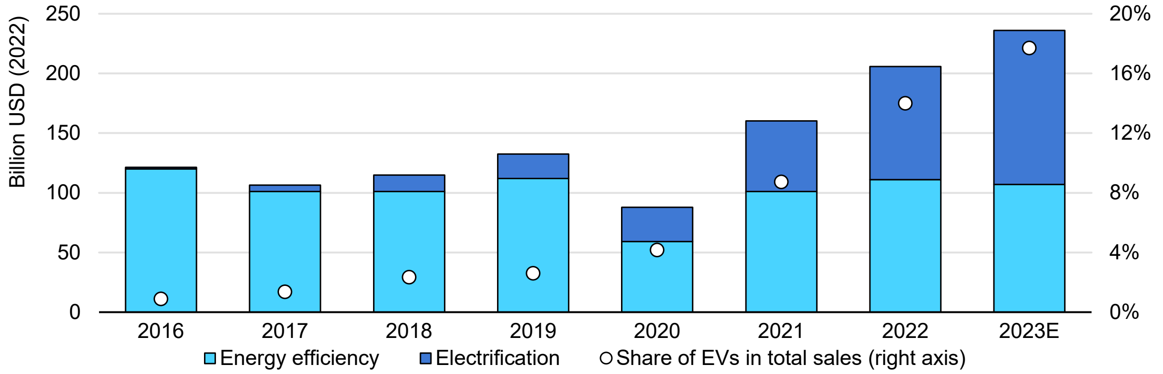
In recent years, countries with more fiscal power made efforts to focus post-pandemic economic stimulus and new jobs creation on clean energy investment, with spending on energy efficiency a major target. Such investments were also driven by aims to shelter consumers from cost-of-living pressures from rising energy prices. Overall, for every USD 1.00 spent on capital investment related to fossil fuels worldwide, USD 1.70 is being spent on clean energy – of which USD 0.60 is invested in energy efficiency.

However, approximately USD 9 out of every USD 10 spent on clean energy since 2021 has taken place in advanced economies plus China. This is leading to a widening of the gap with EMDEs that have not had the flexibility in public finances to ramp up spending.

Electric vehicles drive investment growth in transport efficiency but could go faster still

Continued growth in global vehicle electrification is expected to lift total investment in road transport efficiency to new highs of over USD 235 billion in 2023. Electrification spending overtakes efficiency investments in transport for the first time in 2023, at nearly USD 130 billion. Supply chain disruptions, macroeconomic shocks, high commodity and energy prices, and a contraction in the global car market continue to pose headwinds, but progress is expected to remain strong, especially while oil and petrol prices remain high.

Energy efficiency and electrification spending in the transport sector, 2016-2023E



Source: IEA (2023), World Energy Investment 2023.

Electrification in transport also includes public transport, which contributes a major share in China. Passenger light-duty electric vehicle sales are expected to maintain strong growth levels, reaching around 18% of sales, or 14 million units sold globally. China, the European Union and the United States account for 95% of new EV sales. One headwind to even faster uptake is the relatively high cost of EV insurance. For example, it can typically cost almost double to ensure an EV with average premiums rising by 72% for EVs and 29% for conventional cars in the year to September 2023.

In 2022, China accounted for almost 60% of all new electric car registrations, and more than half of the global EV fleet. Despite the phaseout of a 10-year running purchase subsidy programme, 3.1 million new battery and plug-in hybrid EVs were sold in the first half of 2023, a 37% increase year-on-year. EV sales are also rising in some EMDEs, especially for two- and three-wheelers. In 2022, electric car sales more than tripled in India, Thailand and Indonesia, reaching a combined total of nearly 80 000. In India, 55% of three-wheelers sold in 2022 were electric, while the Indonesian government aims to subsidise the sales of 200 000 electric two-wheelers in 2023.

Several governments and commercial financiers offer zero or no-interest loans to stimulate investment in EVs. From 2023, France has offered interest-free loans for lower-income households, along with purchase and scrappage premiums, while Canada's Infrastructure Bank supports the purchase of zero-emission buses. Since 2022, three commercial lenders in Kenya have offered green loans for personal and public vehicles.

New industrial energy efficiency plans aim to increase investment, improve competitiveness and provide jobs

Energy efficiency-related investment in industry has grown by 20% since 2020, from just over USD 40 billion to USD 50 billion in 2023, driven by new policy frameworks in Europe and the United States, as well as several Asian markets. In 2023, efficiency spending in China and India is expected to reach around USD 16 billion and USD 6 billion, respectively.

Ambitious new policies have been put in place to strengthen investment in industrial energy efficiency, including the EU's 2023 Green Deal Industrial Plan, which aims to reduce bureaucracy, enhance skills, improve access to finance, and open trade for resilient supply chains. The EU's Net-Zero Industry Act (NZIA) is focused on scaling up the overall strategic manufacturing capacity of net zero technologies to at least 40% of annual deployment needs by 2030.

In the United States, the Inflation Reduction Act (IRA) provides direct incentives for industrial decarbonisation, making clean technology investment accessible for hard-to-abate sectors like steel, cement and chemicals production. Government incentives for priority purchasing of green products or decarbonisation of cement manufacturing send a strong signal to the industry.

China invests USD 27 billion in ultra-low emission steel production

At over 900 million tonnes from Jan-Aug 2023, steel production is approaching an annual limit of just over 1 billion tonnes based on 2022 totals. According to the China National Development and Reform Commission (NDRC), crude steel output was reduced by 30 million tonnes in 2021 and 18 million tonnes in 2022, meeting aims to reduce overall output. The China Iron and Steel Association claims that in the first half of 2023 energy consumption per tonne of steel from its member enterprises had decreased 1.33% y-o-y, with 87 steel enterprises completing ultra-low emissions transformation. For the sector overall, from July 2022 to July 2023 investment in ultra-low emission transformation was almost USD 7 billion, taking cumulative investments to more than USD 27 billion (CNY 200 billion).

So far this year, steel production registered an increase of 6.3% y-o-y from January to August. The China Iron and Steel Industry Association attributes this growth to increased domestic demand for steel used for automobiles and household appliances, in addition to infrastructure construction such as wind power and photovoltaics.

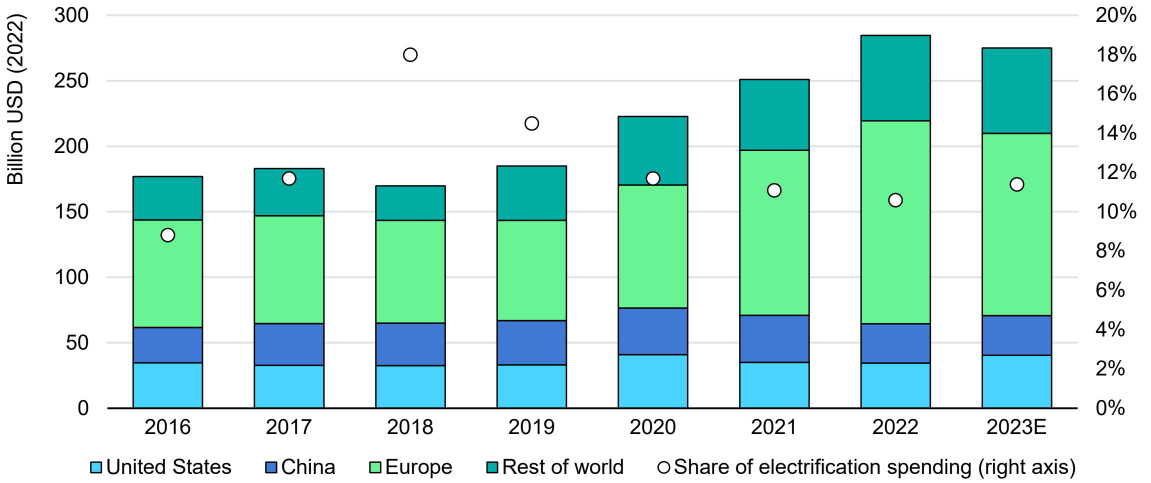
Growth in heat pumps not enough to offset slowing retrofit and construction activity as costs rise

A rise in heat pump-related spending pushed electrification elements of building sector efficiency investment up by about 3% in 2023. However, this increase is not enough to prevent overall efficiency-related spending in the building sector to fall by 2%, to around USD 338 billion in 2023. This decrease is being driven by higher input and borrowing costs and the phasedown of several fiscal stimulus measures, which is leading to lower activity and confidence in the construction market in Europe, Asia and South America.

The lending market continues to promote investment in energy efficiency, with 19% of the largest banks globally offering green mortgages to prospective homeowners to improve the efficiency of their properties. Starting with four products in 2019, the UK green mortgage market now boasts 60 products, mainly focusing on new developments, while preparations for piloting property-linked finance are underway to mobilise further investment.

Despite a tightening of support conditions, the Italian Superbonus programme is still expected to see an increase in spending in 2023. As of October 2023, the programme had led to more than USD 100 billion in energy efficiency investments in buildings over its lifetime. Major adjustments to Germany's Federal Funding for Efficient Buildings (BEG) programme were implemented starting in 2022 and continued in 2023. In the United States, investment in efficient buildings is growing despite headwinds, and could reach around USD 40 billion in 2023, while in China it is slowing. In Korea, the mandatory certification of zero energy buildings (ZEB) for all buildings and public housing programmes was expanded, which is expected to give positive impetus to efficiency investments.

Efficiency, electrification and end-use renewables investment in buildings by region, 2016-2023E



Source: IEA (2023), World Energy Investment 2023.

ESCO activity is on an upward trend with developments in African markets

Energy performance contracting remains the main contract model for public sector projects, particularly buildings in China, the United States and many European markets. Preliminary results from the 2023 global Energy Service Company (ESCO) market survey conducted by the IEA indicate growth in energy performance contracting markets in at least 19 EU members in the period until 2024. The complete survey results are expected to be available next year.

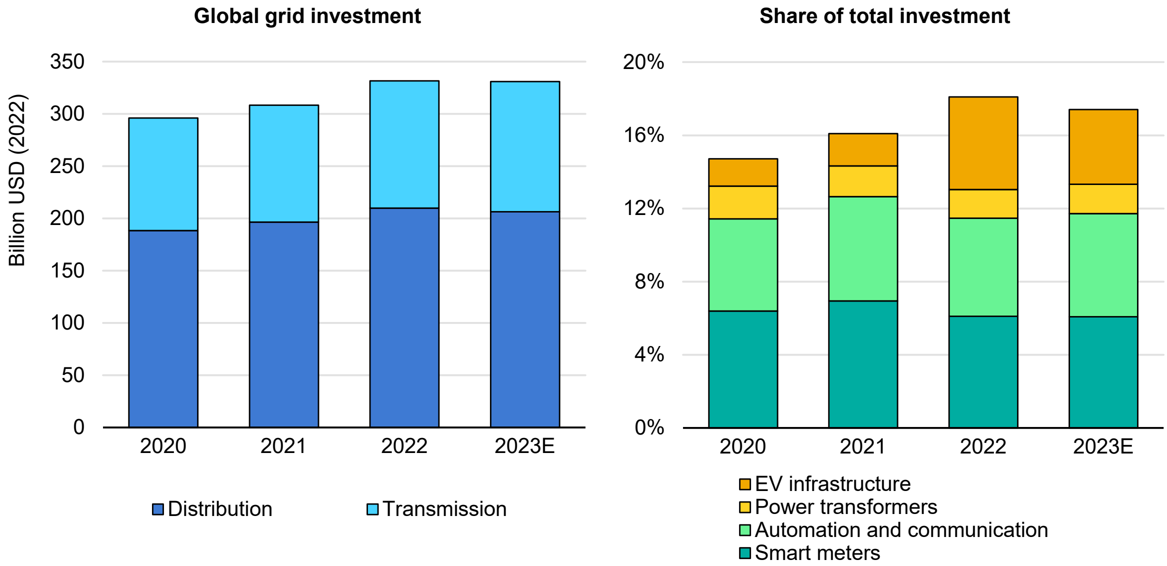
Public Super ESCOs have been created in several countries to kickstart an energy efficiency market. The USD 5 million Africa Super ESCO Acceleration Programme of the African Development Bank (AfDB), launched in February 2023, supports the establishment of public Super ESCOs in nascent markets such as Rwanda, Senegal and South Africa. It also aims to provide support services to private ESCOs and develop harmonised regional certification schemes.

Investment in system level efficiency through digitalisation of power grids rose steadily in 2023

Global investment in power grid infrastructure grew by 8% in 2022 to over USD 330 billion. Projects include smart meters, electric vehicle infrastructure, and various controls and systems which enable communication and automation of where, when and how energy is consumed. These system level efficiency investments are expected to help reduce the curtailment of variable renewable energy systems by more than 25% by 2030, increase efficiency and reduce costs for customers.

Advanced economies and China are responsible for 80% of total grid investment and are expected to continue to ramp up spending in coming years. The share of total investment in power system infrastructure spent on digitalisation of grids has steadily increased, from a little over 10% in 2016 to around 20% in 2023, with spending on these technologies surpassing that of some physical infrastructure components such as transformers.

Global grid investment by segment and share of total investment of selected components, 2020-2023E



IEA. CC BY 4.0.

Source: IEA analysis based on transmission and distribution companies' financial reports, and data from Guidehouse (2022).

In 2022, the European Commission presented the EU Action Plan on Digitalising the Energy System worth more than USD 620 billion. In September 2023, the Smart Energy Expert Group was formally established, which will assist the commission on implementing the plan. Additionally, there are schemes to create a sophisticated digital twin model of the European electricity grid, and in parallel there will be the development of Smart Grid Indicators to stimulate investments in smartening the grid. The European Union also funds Projects of Common Interest, such as the USD 310 million Danube InGrid project in Hungary and Slovakia and a USD 193 million project in Czechia and Slovakia.

In the United States, the Grid Resilience Innovative Partnership (GRIP) programme provided funding in 2022 and 2023 to upgrade and expand the electric grid, including a USD 2.5 billion for grid resilience, USD 3 billion for smart grids and USD 5 billion for grid innovation. Major utilities have allocated more than USD 36 billion in investments in grid modernisation between 2018 and 2023. Canada's government also invested USD 73 million between 2019 and 2023 in smart grid technologies through its Green Infrastructure Smart Grid Program, and announced USD 3.2 billion until 2035 for its Smart Renewables and Electrification Pathways Program.

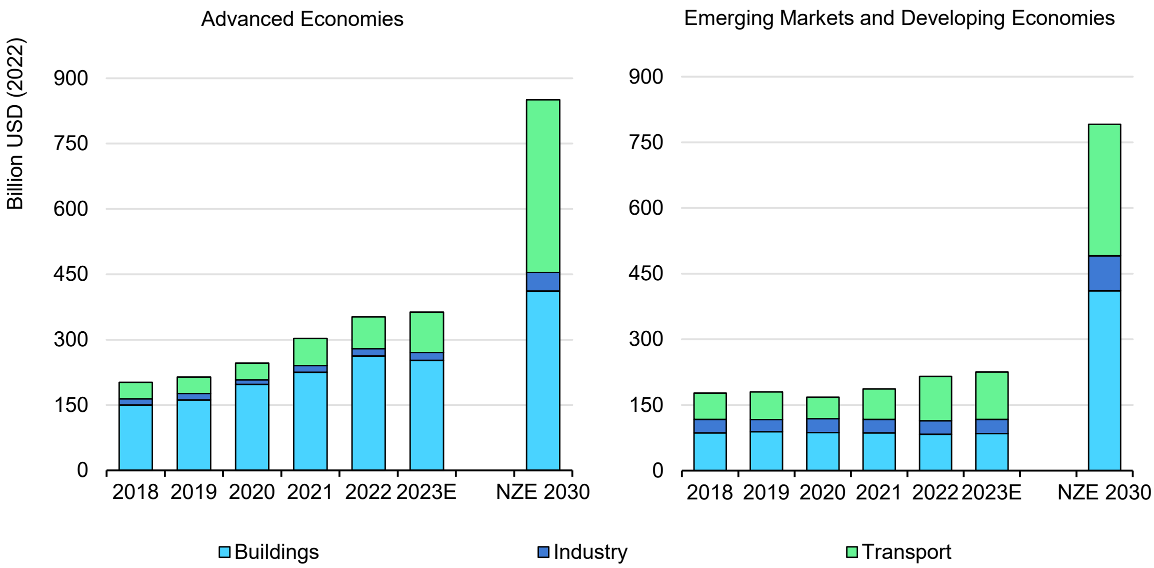
The State Grid Corporation of China (SGCC) announced power grid investments of USD 77 billion in 2023, which is part of the larger USD 329 billion spending in power grid modernisation between 2021 and 2025. China's Southern Power Grid will also invest USD 99 billion, bring the national total to USD 442 billion.

Mechanisms to scale up private investment in emerging and developing economies are set to be strengthened

Energy efficiency investments are currently highly concentrated in advanced economies and China, creating a gap in needed investment to put other EMDEs onto a clean energy transition pathway. While efficiency-related investments would need to more than double in advanced economies, emerging economies would have to see 3.5 times higher investment levels by 2030.

The largest investment opportunities are in the buildings sector to satisfy rapidly growing housing needs. Given the relatively small number of older existing buildings in EMDEs, only 3% of investment is expected to be dedicated for retrofitting the current building stock in the NZE Scenario.

Investment in energy efficiency and end use in advanced economies and emerging markets and developing economies, 2018-2023e, and Net Zero by 2050 Scenario, 2030



Source: IEA (2023), World Energy Outlook 2023.

Besides a typically stronger reliance on public investment by governments and state-owned enterprises, EMDEs are challenged by limited financial resources and utilities that lack the capacity to develop and finance efficiency projects. This translates into higher borrowing costs in emerging economies, with the cost of capital for clean energy projects about 2-3 times higher than in advanced economies and China, according to the IEA's Cost of Capital Observatory.

Mobilising the necessary investment therefore calls for an upscaling of domestic and international private investment, with public finance remaining an important catalyst. Reforms to domestic policies and regulatory frameworks, international co-operation, and the involvement of finance institutions can also help stimulate investment.

Just Energy Transition Partnerships (JETPs) among emerging market economies and a group of international partners aim to provide affordable financing sources to catalyse such private investment. The JETPs with Senegal and Indonesia include energy efficiency but as part of their wider decarbonisation efforts, while the Climate Investment Fund's Accelerating Coal Transition Investment Plan, which is part of the USD 8.5 billion South Africa JETP, specifically targets energy efficiency projects.

In June 2023, during the Summit for a New Global Financial Pact, public and private actors from around a hundred countries affirmed their collective determination to address climate and socio-economic challenges by increasing global co-operation. As part of this objective, the IEA has committed to delivering recommendations in early 2024 on ways to reduce the cost of capital for the energy transition in developing countries.

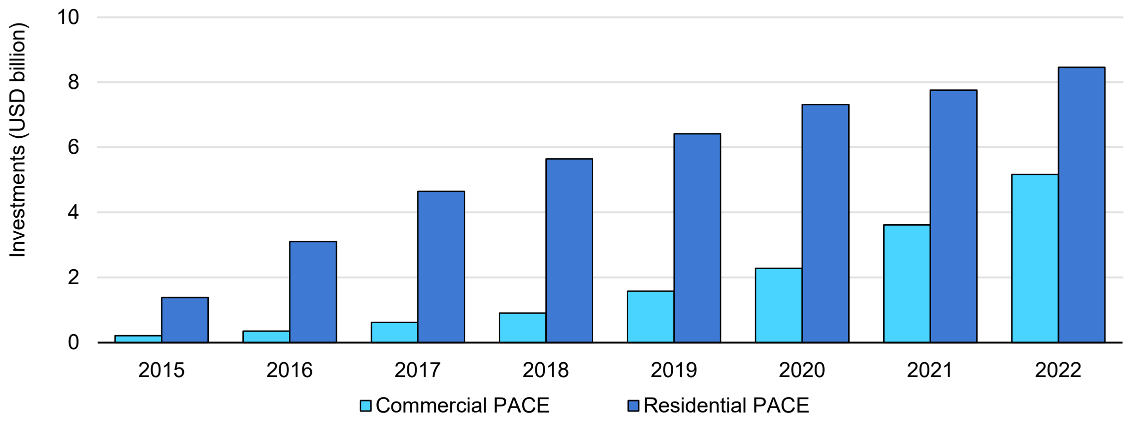
In July 2023, G20 countries agreed a Voluntary Action Plan for Lowering the Cost of Finance for Energy Transitions to stimulate development of blended finance solutions, encourage international financial institutions to mobilise private finance and develop new mechanisms such as local currency lending, strengthen enabling frameworks and experience exchanges between countries and key stakeholders.

Property assessed clean energy financing

Linking financing to property ownership is one of the fastest growing sources of energy efficiency investment

The Property Assessed Clean Energy (PACE) programme in the United States enables commercial and residential building owners to access upfront, long-term financing for clean energy building upgrades. The PACE financing model is based on a loan attached to a property instead of to an individual and is repaid with property taxes and charges. In the United States, individual states must pass enabling legislation justifying the use of a tax system to support the collection of loan repayments.

Cumulative residential and commercial PACE investments in United States, 2015-2022



Note: PACE = Property Assessed Clean Energy programme in the United States
Source: PACE Market Data (2023).

To date, 38 states and Washington, DC have passed PACE-enabling legislation, while 30 states and DC have active PACE programmes offering financing to homeowners and businesses. PACE has financed more than USD 13.6 billion worth of home and commercial building renovations since tracking began in 2009. Energy efficiency projects account for the largest share of PACE financing for commercial buildings at 55% and residential buildings at 37%. The PACE market continues to exhibit strong growth, with commercial PACE financing rising the fastest as it approaches matching the scale of residential loans.

This growth has been aided by large cities like New York, Boston and Chicago offering commercial PACE. State legislators are expanding the range of eligible measures to include resiliency investment such as shielding, roof hardening, and seismic retrofits, as well as allowing the use of PACE for new construction.

The combination of regulatory pressure to comply with new building standards, market recognition of PACE, and the increasing need for upfront financing of high capital costs of efficiency investments are contributing to the upward trend in PACE financing. The regulatory landscape remains fragmented however, as state and local governments impose varying requirements for eligible measures, and collection and repayments terms.

The commercial PACE market has consolidated over the last few years, where national players with capacity to operate across state lines dominate the business. As the market matures, nearly half of all projects now exceed USD 5 million, with several transactions surpassing USD 100 million. Life insurance companies remain a major funder, with some companies pursuing securitisation via private offerings to qualified institutional buyers. Cut Carbon Notes have recently been used to fund commercial PACE projects reducing carbon emissions. This offers an approach to raising capital via a secured, publicly traded, investment-grade rated fixed-income product.

PACE-inspired finance programmes are spreading beyond the United States to help leverage private capital

While the programme structure and the mechanism for attaching the financing to a property may differ, PACE is a public policy that allows private financing to be channelled into energy-efficient building renovations.

PACE-style programmes vary by market and depend on national legal frameworks. For instance, in Australia the Environmental Upgrade Finance (EUF) is attached to a property and repaid quarterly through council rates over a term of up to 20 years. The Sustainable Australia Fund has been offering EUF to commercial property owners since 2011 and has delivered projects in 27 local governments amounting to over AUD 75 million in financing.

Similarly, in the Canadian province of Alberta, the Clean Energy Improvement Program (CEIP) offers upfront financing to residential and commercial property owners; the loan is repaid via a property tax bill. On the east coast of the country, PACE Atlantic works with municipalities to establish local programmes for businesses and homeowners.

In the Netherlands, a programme, which is based on the Municipal Sustainability Regulation (GVR), allows homeowners in participating municipalities to renovate their homes without the upfront costs and repay the investment over 30 years via a tax levy. In the United Kingdom, the Green Finance Institute (GFI) is looking to introduce Property Linked Finance (PLF) and is seeking banking partners to jointly develop residential and commercial PLF offers.

Energy efficiency employment

Efficiency-related activities have boosted jobs, with electrification driving a reshuffling in transport sector

Boosted by historic government crisis-response programmes aiming to strengthen energy efficiency, 2022 saw a strong rise in global efficiency-related employment, with the total number of jobs rising by around 1 million. A major shift in energy employment worldwide has been underway since the pandemic, with growth coming almost entirely from clean energy jobs in 2019-2022. Looking ahead to 2030, the growing demand for more efficient technologies and services, underpinned by higher investments, means the jobs market for energy efficiency is set for continued growth as the clean energy transition accelerates to 2030.

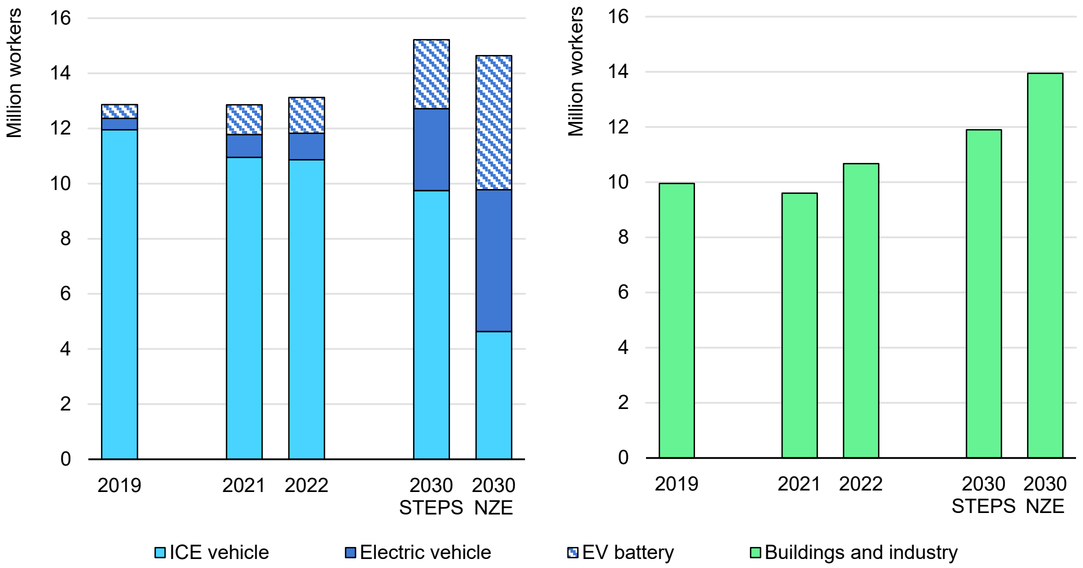
In addition to roles in architecture, building, contracting and equipment manufacturing, these jobs will be based around specific activities such as:

- Efficient building retrofits and weatherisation.
- The production and installation of heat pumps, and other clean heating and cooling equipment.
- The production and installation of energy management systems.
- The design and manufacture of efficient appliances and building materials.
- The operation of community, utility, and regional energy efficiency programmes.
- Energy service companies (ESCOs) and other energy management activities in buildings and industry.
- Implementing energy efficiency upgrades in industry.

In the transport sector, while employment in vehicle manufacturing continue to grow, electrification is reshuffling the jobs and workforce landscape away from conventional vehicles and towards battery manufacturing and EVs.

The extra efficiency-related jobs inherent in doubling energy intensity progress to around 4% per annum this decade could lead to around 4.5 million more jobs in 2030 than in 2022, across buildings, industry and transport. This includes around 1.5 million in automotive manufacturing and over 3 million in buildings and industry. Overall, this is around 1.5 million more jobs compared with the Stated Policy Scenario (STEPS), which sees energy intensity progress of just over 2% per year this decade.

Global employment in vehicle manufacturing, EV battery production, and activities that increase efficiency in buildings and industry, 2019-2022, and by scenarios, 2030



Notes: STEPS = Stated Policies Scenario, NZE = Net Zero Emissions by 2050 Scenario. Non-transport includes efficient building retrofits and weatherisation; production and installation of heat pumps, and other clean heating and cooling equipment (e.g. solar heating, other geothermal); production and installation of energy management systems; design and manufacture of efficient appliances and building materials; operation of community, utility, and regional energy efficiency programmes; Energy service companies (ESCOs) and other energy management activities in buildings and industry; implementing energy efficiency upgrades in industry.
Source: IEA (2023), World Energy Employment 2023.

Governments are fine-tuning EV policies to encourage manufacturing and secure supply chains

In many markets, the balance of government EV support is shifting from consumer purchase subsidies towards incentives for EV charging infrastructure and battery manufacturing. Investments in new battery manufacturing capacity reached record levels in 2022, and raised available capacity to 1.5 TWh, up by a sharp 50% year-on-year, enough for around 30 million EVs with an average battery capacity.

The EU's 2023 Net-Zero Industry Act aims to satisfy 90% of the group's annual battery demand by local manufacturers. In the United States, IRA offers Advanced Manufacturing Production Credits, subsidising domestic battery production with up to USD 35/kWh, and an additional USD 10/kWh for module assembly. India's Production-Linked Incentive (PLI) scheme of 2021 is also providing support with the USD 2.2 billion Advanced Chemistry Cells (ACC) battery manufacturing programme, and USD 3.2 billion for EV and component manufacturing.

Chapter 4. Energy efficiency policy progress updates

International developments

A target to double progress provides the focal point for international co-operation on energy efficiency in 2023

The energy crisis sharply escalated government concerns over energy security and the inflationary impact of higher energy prices on households and the world's economies, with a range of policies introduced last year to address these critical issues. At the core, increasing energy efficiency is widely recognised as the first and best response to simultaneously align security, affordability and climate goals.

A target to double efficiency progress by 2030 has been put forward in a range of international forums. In response, leaders from across the globe have signalled their support for strengthened policy implementation and, among other aims, raised the need to implement this ambition at COP28.

In April, the European Commission proposed that a global target for energy efficiency and renewable energy could mobilise countries ahead of COP28. This came as the IEA identified annual energy intensity improvements of more than 4% this decade as being essential to a credible pathway to 1.5 °C. A global doubling target was also the focus of discussions at the IEA 8th Annual Global Conference on Energy Efficiency in Versailles. In an address to an audience of more than 600 senior leaders from governments, businesses and other experts from the international community, Executive Director Dr Fatih Birol outlined the IEA's vision of 'two and three' by 2030 – a doubling of energy efficiency progress and a tripling of renewable power capacity.

During the conference, 46 governments participating in a ministerial discussion endorsed the 'Versailles Statement: The crucial decade for energy efficiency'. In doing so, the participants stated their support for "stronger policies and actions towards the goal of putting the world on track to achieving a doubling of the global average rate of energy efficiency improvements this decade, in line with the IEA's Net Zero Emissions by 2050 Scenario." In addition, the European Commission and the COP28 Presidency agreed to work towards a global pledge to double energy efficiency progress.

The doubling target was also brought forward as part of India's Presidency of the Group of 20 (G20) and Japan's Presidency of the Group of 7 (G7) meetings. In

April, the G7 Climate, Energy and Environment Ministers' Communiqué in Sapporo noted that "the IEA projects that a global acceleration of primary energy intensity improvements of 4% per year until 2030 is needed to be consistent with its Net Zero Scenario".

Meanwhile, G20 leaders, as well as energy ministers at the G20's 4th Meeting of the Energy Transitions Working Group, officially took note of the Voluntary Action Plan on Doubling the Global Rate of Energy Efficiency Improvement by 2030. The action plan, which the IEA supported India's Bureau of Energy Efficiency to develop, outlines measures along five pillars: buildings, industry and transport sectors, energy efficiency financing and sustainable consumption.

With the leadership of the COP28 Presidency and European Commission, countries are now aiming to formalise the doubling target at COP28, alongside the renewables target. The IEA has been providing support through a series of high-level dialogues co-chaired by the IEA Executive Director and COP28 President, and with a range of analytical support. The target is also examined in detail in a special focus section of this report in Chapter 5.

National and regional developments

Almost USD 700 billion in government spending has supported energy efficiency investments since 2020

Total energy efficiency-related government spending monitored by the IEA's Government Energy Spending Tracker has risen significantly since the start of the Covid-19 crisis. As of June 2023, governments had spent almost USD 700 billion to support overall energy efficiency-related investment since 2020, including spending on mass and alternative transit, efficient buildings and industry, and low-carbon vehicles.

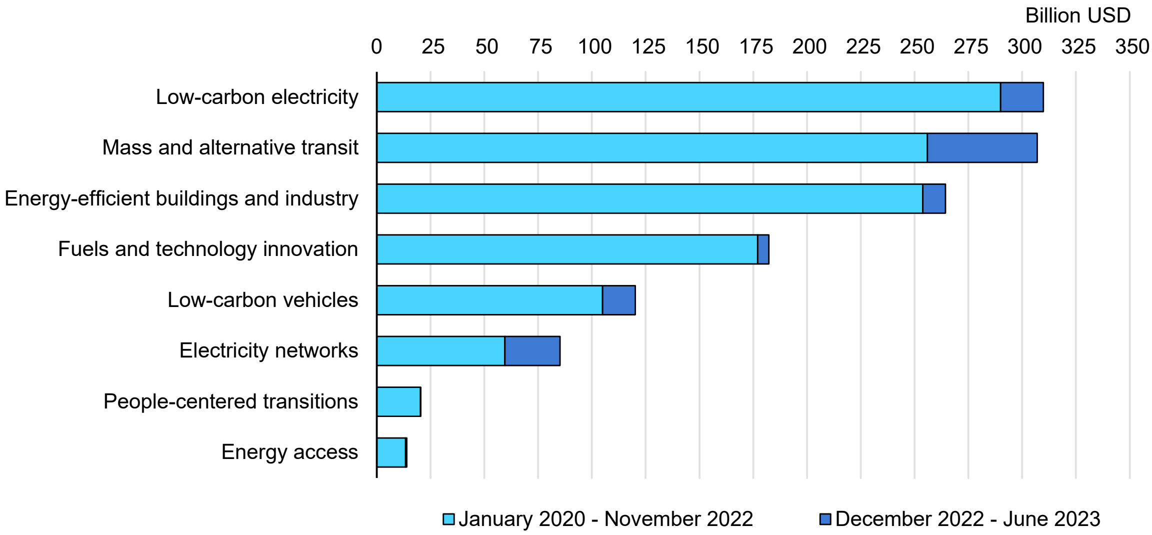
The share of government spending dedicated to energy efficiency in the total clean energy investment support has remained stable, comprising about half of all spending since 2020.

A small number of countries are mobilising the majority of energy efficiency-related government spending

According to the IEA's Government Energy Spending Tracker, 70%, or around USD 470 billion, of the total government energy efficiency investment support since 2020 was enacted by five countries: the United States, Italy, Germany, Norway and France. This amount is roughly equivalent to what the same governments allocated to short-term energy affordability measures aimed to shield consumers and industries facing soaring energy prices since Russia's invasion of

Ukraine. Government energy efficiency spending on the transport sector has accounted for the lion's share at USD 300 billion, with spending on buildings and industry accounting for the remaining USD 170 billion.

Government clean energy investment support, as of June 2023



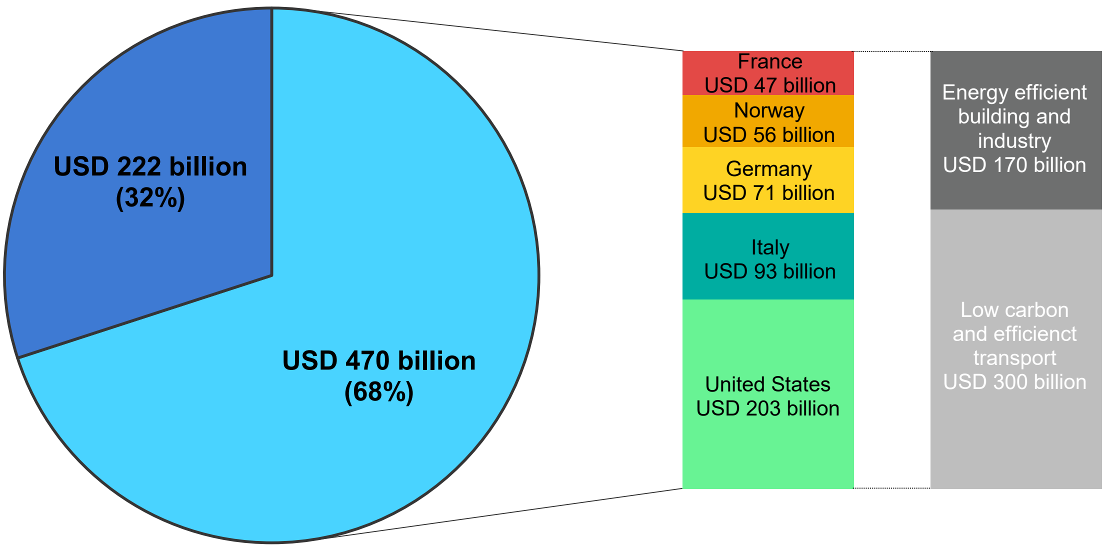
Note: This tally captures all government enacted spending to help consumers manage prices, including direct grants, vouchers, tax reductions and government approved direct transfers to energy companies to cover losses caused by mandated price regulations. Further details can be found in the IEA's Government Energy Spending Tracker.
Source: IEA (2023), Government Energy Spending Tracker: Policy Database, accessed October 2023.

Major efficiency policy announcements have been made by countries covering over 70% of energy demand

The United States has invested more than USD 200 billion in public spending on energy efficiency investment support since 2020, with a large proportion (USD 140 billion) for transport. The Inflation Reduction Act (IRA), of which energy efficiency provisions account for USD 86 billion, provides grants, loans and tax rebates for low-carbon vehicles. It also targets efficiency in the residential sector with measures including tax credits, rebates, and supports grants for low-income households and disadvantaged communities.

In the European Union, the recast of the Energy Efficiency Directive (EED) in 2023 sets the new binding 2030 energy efficiency target to reduce final and primary energy to 11.7%, compared with the 2020 reference scenario projections. It also lays out the Energy Efficiency First principle, including a binding, cumulative energy savings obligation for EU countries of 1.49% per year on average between 2024 and 2030. Furthermore, new rules set a specific obligation for the public sector to achieve an energy consumption reduction target of 1.9% per year, including a requirement to renovate each year at least 3% of total floor area of public buildings to a nearly-zero energy buildings (NZEB) standard.

Government energy efficiency-related investment support, April 2020 – June 2023



Note: Top five countries with the highest government spending in energy efficiency-related investment support.
Source: IEA (2023), Government Energy Spending Tracker: Policy Database, accessed October 2023.

A new German Energy Efficiency Act targets a final energy consumption reduction of 26.5% by 2030 from 2008. As part of the France 2030 plan, the government has included a stronger focus on green investments to decarbonise the heavy industry, with around USD 6 billion allocated to the challenge. In Spain, the government approved the Energy Savings Certificate system, a new market tool to make it easier for the business sector to meet savings obligations through the implementation of energy efficiency measures.

The Netherlands tightened their energy savings obligation, which legally requires companies to implement all energy efficiency measures with a payback period of five years or less. The new legislation extends the obligation to energy intensive industry, including EU emissions trading system installations and the horticulture sector, and mandates a wider range of energy saving measures, including fuel switching and small-scale renewable energy production. Lists of recognised measures are provided to help companies with their obligation to report the implemented measures every four years to the authorities. These monitoring authorities can apply for financial benefits from a USD 56 million fund to help create additional capacity for the supervision and enforcement of the energy saving obligation.

Select national policy developments for energy efficiency (2022 – present)

Country	Policy Developments
Australia	The 2023/2024 budget provides USD 1.6 billion for a new Energy Savings Package to support energy upgrades in households and businesses.
Argentina	A new National Energy Efficiency Bill is under review in congress, with an amendment focusing on establishing fundamentals of energy efficiency policy actions across all economic sectors.
Canada	A new measure was proposed to promote low- to median-income households to switch from heating oil to heat pumps, among other initiatives to lower energy bills.
China	Expanded and strengthened the benchmark levels scheme for industries to improve energy efficiency.
EU	The Energy Efficiency Directive has been amended to establish EU legally binding targets and specific actions to reduce final energy consumption by 11.7% by 2030 relative to the 2020 scenario.
France	The France 2030 plan now includes a focus on investments to decarbonise its heavy industry (USD 6 billion).
Germany	The new Energy Efficiency Act mandates compulsory energy saving in all sectors with the national energy saving goal of 26.5% by 2030.
India	Launched four new energy efficiency policies for residential appliances, in support of reducing the nation's energy intensity by 45% by 2030.
Indonesia	Commercial and public buildings with annual energy consumption above 500 tonnes of oil equivalent are mandated to adopt energy management programmes.
Italy	Superbonus programme prompted more than USD 100 billion in energy efficiency investments in buildings between July 2020 and October 2023.
Japan	Strengthened the Act on Rationalizing Energy Use through Ministry of Economics, Trade and Industry's Energy Efficiency Subcommittee on additional demand-side measures.
Korea	Implemented a new fuel economy standard and labelling for EVs.
Spain	Approved the Energy Savings Certificate System.
South Africa	Amended the energy performance certificate for buildings, introducing the compulsory registration of the type and size of buildings by 2025.
United States	The Inflation Reduction Act of 2022 extends the tax credit for home energy performance improvement, retrofit and clean energy solutions.

In Japan, an energy savings and efficiency package of more than USD 7.1 billion (JPY 962 billion) was introduced that focuses on subsidies for replacing inefficient facilities in factories and buildings, residential retrofitting, and water heat pump installations.

Korea introduced at a country-level first fuel economy standard scheme for EVs in 2023, while the nation achieved a significant improvement in energy intensity in support of strengthened overall targets.

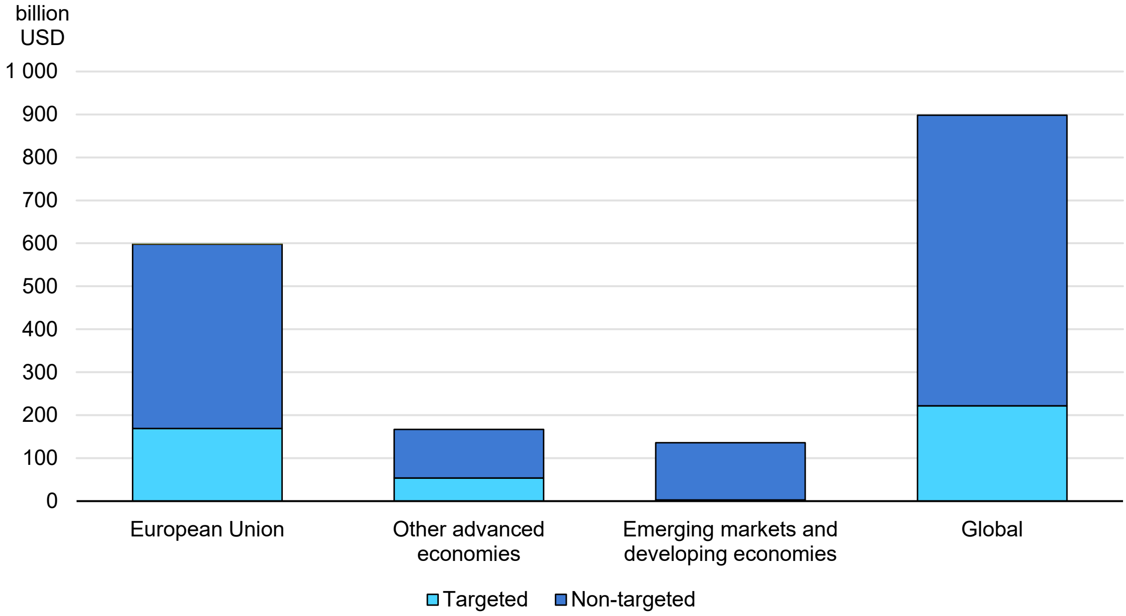
China is expanding its energy efficiency benchmark scheme for industries from 25 to 36 major sub-sectors, aiming for long-term efficiency gains in petrochemical production processes, in support of the nation's goal to reach peak carbon emissions before 2030. India launched new energy efficiency policies for table and wall-mounted fans, pedestal fans, multi-door refrigerators, and induction cookstoves. These policies are projected to reduce CO_2 emissions by an estimated 9 million metric tonnes by 2030, contributing to the nation's overall aim to improve energy intensity by 45% by 2030.

Australia has presented its USD 1.01 billion Energy Savings Plan, including major support for upgrading energy efficiency in residential homes and social housing, while at the same time encouraging improvements in small and medium-sized enterprises (SMEs) and commercial buildings. Argentina's amended Energy Efficiency Bill, which introduces efficiency frameworks for all economic sectors, including vulnerable groups, was submitted to congress and is under review.

USD 900 billion short-term energy affordability spending has been shielding consumers from rising energy bills

As of June 2023, over USD 900 billion was spent by governments, mainly in advanced economies, to subsidise consumer energy bills, with USD 270 billion allocated between November 2022 to April 2023. Only 25% of these investments are targeted towards specific groups, like low-income households, social housing tenants or energy-intensive industries. With 75% of affordability spending non-targeted, the issue of transitioning to more structural efficiency support versus short-term affordability measures remains an important consideration. For example, the European Union, responsible for two-thirds of global affordability support, has been considering the shift from direct bill support towards targeted, structural efficiency investment.

Government energy affordability spending earmarked by region, Q2 2023



Source: IEA (2023), Government Energy Spending Tracker: Policy Database, accessed October 2023.

Tapping into energy efficiency potential in Latin America and the Caribbean

Efforts to enhance energy efficiency in Latin America and the Caribbean deliver numerous benefits, including reduced in energy consumption and related emissions, bolstering energy security, and generating new job opportunities.

Exploiting energy efficiency does not necessarily require significant additional costs. Energy efficient appliances reduce energy bills, especially for low-income households, and supporting the deployment is often a more economical alternative to increasing energy supply. For example, in Mexico, a programme replacing air conditioners and refrigerators demonstrated a payback period of four years. In Brazil, the Energy Efficiency Program (PEE) resulted in savings of 63 TWh and a reduction in peak demand by 2.8 GW.

Beyond reducing energy consumption and emissions, enhancing energy efficiency strengthens energy security by diminishing reliance on oil product imports. This is relevant to importers as well as to oil producing countries, given the lack of sufficient refining capacity in the region. Efficiency standards also mitigate peak electricity demand, particularly for air conditioners.

Improving energy efficiency requires critical institutional collaboration. For appliances, aligning technical specifications, testing methods and labelling criteria ensures consistent performance of appliances at lower cost and facilitates greater cross-border trade, a larger market area and easier access for manufacturers.

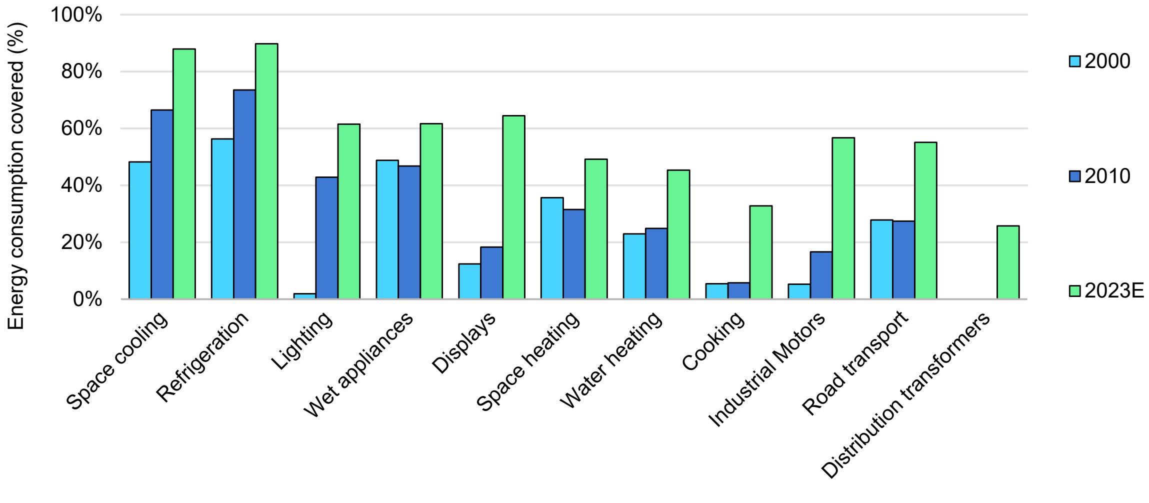
Regulations and standards

Minimum energy performance standards cover increasingly larger parts of global energy use

In 2023, minimum energy performance standards (MEPS) are in place in more than 110 countries worldwide, including all the largest energy consumers. To encourage consumer choices that surpass regulated minimum standards, they are often combined with comparative labels, which are employed in over 100 countries as well. For example, in South Africa, new efficiency requirements for lamps were published that stipulate all new lamps sold will need to use energy efficient LED technology.

Cross-border alignment of MEPS and labels in regions such as the Economic Community of West African States (ECOWAS), the Southern African Development Community (SADC), Australia and New Zealand, and the European Union provides substantial benefits. They include having a smaller number of testing methods, lower compliance costs for industry and reduced government expenditure for compliance testing.

Global energy use coverage of minimum performance standards for major end uses, 2000-2023



IEA. CC BY 4.0.

Note: Coverage for space cooling, space heating, water heating, refrigeration and lighting is shown for residential sectors.
Source: IEA (2023), Policies and measures (PAMS) database, accessed October 2023, CLASP Policy Resource Center.

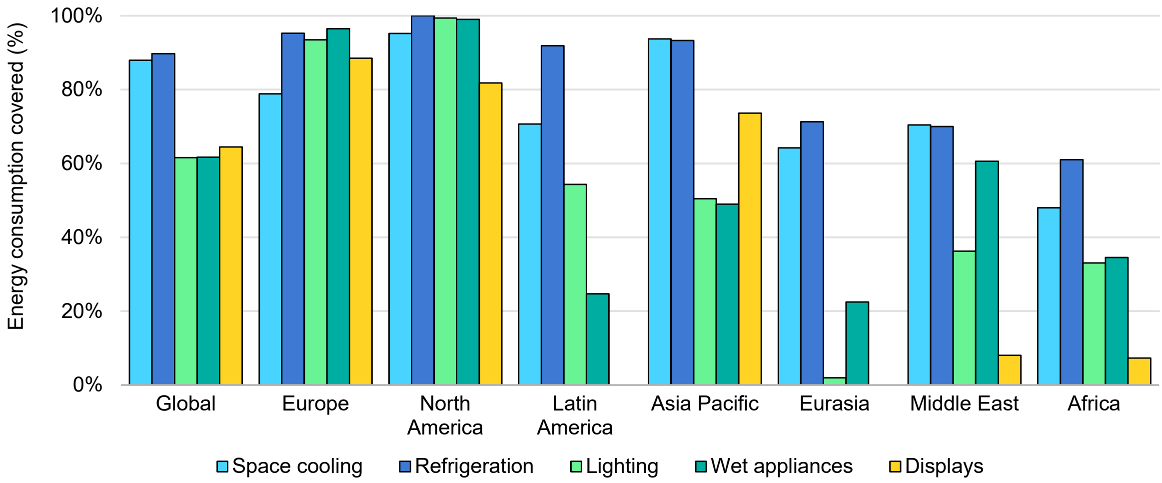
While almost 100 countries have MEPS in place for air conditioners, refrigerators or lighting equipment, other end uses are less often regulated. For example, only between 40 and 65 countries have MEPS in place for cooking stoves, space and water heating appliances, or fuel economy standards for road vehicles.

Recently, there has been a move to regulate the efficiency of distribution transformers, particularly in emerging markets and developing economies. Such regulation is an important tool to increase overall system efficiency and decrease distribution losses. Ghana introduced a standard in 2022, followed by Botswana in 2023 while Viet Nam, Brazil and Peru implemented their regulations in 2018, bringing the number of countries to 46.

Coverage of MEPS widely varies across regions, highlighting the potential for international co-operation

MEPS coverage also significantly varies across regions, which underscores the opportunity for international co-operation in this realm. Europe, North America, and Asia Pacific are leading in coverage for key end uses while there is potential for wider policy implementation in Africa, Eurasia and the Middle East.

Energy use coverage of MEPS for major end uses by region, 2023



Note: Coverage for space cooling, refrigeration and lighting is shown for residential sectors. Space cooling includes air conditioners and fans. Refrigeration includes residential refrigerators and freezers. Wet appliances include residential clothes washers, clothes dryers, washer-dryers and dishwashers. Displays include televisions and computer screens.
Sources: IEA (2023), Policies and measures (PAMS) database, accessed October 2023, CLASP Policy Resource Center.

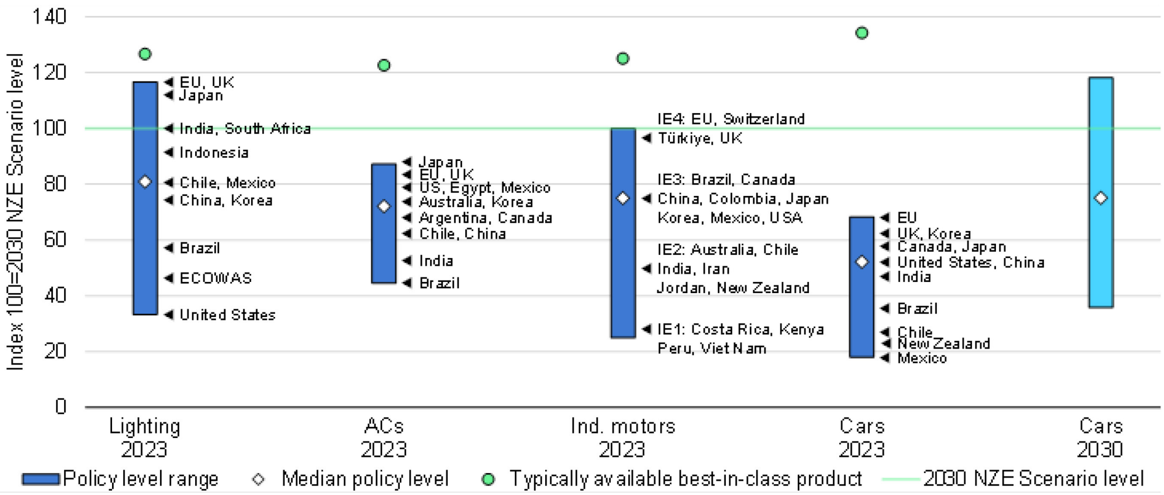
MEPS are one of the most widespread and effective tools of energy efficiency policy, helping ensure that new equipment complies with minimum requirements. However, their impact depends on the level of stringency compared to equipment available in the market. For example, MEPS which require a minimum standard that is already on the lower end of the market before its introduction will have little effect, while more stringent MEPS with efficiency levels above the market average will have a stronger impact.

The IEA introduces a new Efficiency Policy Level Index to help compare strength of efficiency regulations

To help make comparisons of energy efficiency policy levels across different countries, policy types and end uses, for this year's *Energy Efficiency 2023* market report a new IEA Efficiency Policy Level Index has been developed. Four key end uses have been developed: lighting, air conditioners, industrial electric motors and passenger cars.

The index shows that the strength of efficiency regulations varies widely between countries. Some leading countries and regions already have put in place energy performance standards consistent with levels for those end uses described in the Net Zero Emissions by 2050 Scenario (NZE Scenario) for 2030. For all end-use technologies, there are already products on the market which far exceed the minimum policy level foreseen in the NZE Scenario. This highlights the key role of consumer choice and labelling to inform buyers of new products on the efficiency implications of their decisions.

Minimum Energy Performance Standards, IEA Efficiency Policy Level Index end uses, global country range, 2023 and 2030



Notes: Except for fuel economy standards in cars that apply to fleet averages, efficiency policy levels refer to the most commonly sold type of each end-use equipment type. An index of 100 denotes the MEPS stringency level for 2030 in the Net Zero Emissions by 2050 Scenario (NZE Scenario). ACs = Air conditioners. Ind. Motors = Industrial electric motors. IE1 = Standard Efficiency, IE2 = High Efficiency, IE3 = Premium Efficiency, IE4 = Super Premium Efficiency, IE5 = Ultra Premium Efficiency. All fuel consumption is normalised to the WLTP test cycle and tank-to-wheel efficiencies according to the ICCT methodology. Fuel economy standards 2023 are in force, 2030 include in force and proposed values. Country names are not shown for 2030 due to pathways that may incur changes in some jurisdictions. ECOWAS = Economic Community of West African States (currently active members: Benin, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea Bissau, Liberia, Nigeria, Senegal, Sierra Leone, Togo). Country samples represent 84% of global buildings demand (Lighting), 61% of global buildings energy demand (ACs), 81% of global industry energy demand (Motors), 69% of global road transport energy demand (Cars).

In the case of fuel economy standards for passenger cars, legislation in force today foresees improving pathways for manufacturer fleet averages towards 2030 and beyond. As policies are still evolving in this area, country names have been omitted for 2030, but the proposed levels are indicated in the range.

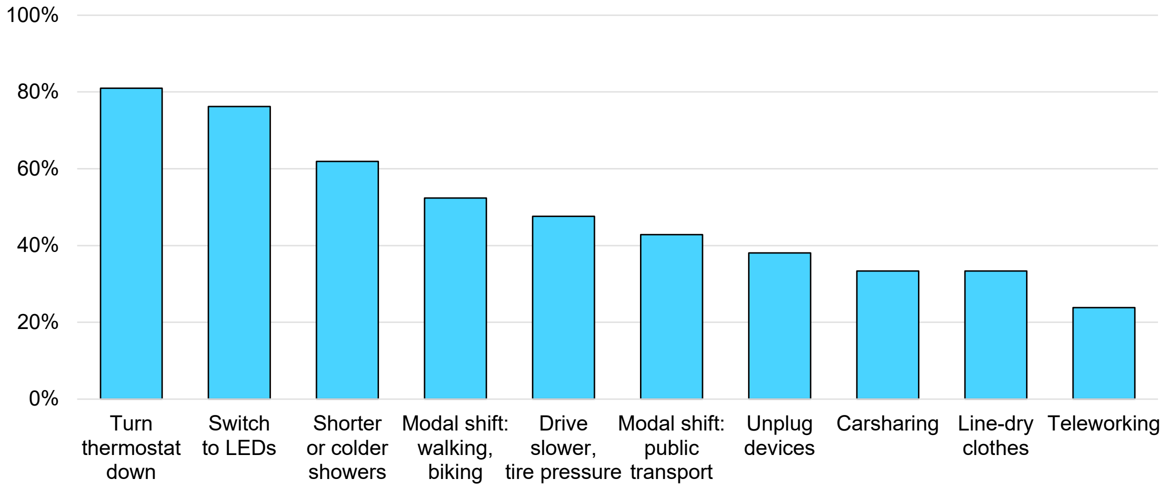
Behaviour change

Governments use energy saving behaviour campaigns to help consumers through the energy crisis

Governments are increasingly using behavioural insights to improve the effectiveness of policy. For instance, a better understanding of behaviour can help encourage insulation uptake, increase policy compliance and convince citizens to act on implementing energy efficiency measures. The 2022 energy crisis sparked a rapid roll out of energy saving campaigns aimed at shielding consumers from skyrocketing prices and energy supply risks.

More than 20 behavioural change campaigns were launched in the early stages of the energy crisis. Most offered a set of practical low-cost tips, while some were linked to support schemes for larger efficiency investments. The most prevalent messages included affordability, sustainability and energy security, and linked the suggested actions to these underlying motivations. Behaviour changes like those promoted in recent campaigns also play a wide-ranging and systemic role in the NZE Scenario, where additional behavioural measures, such as shifting from short flights to rail, are integral to limiting warming to 1.5 °C.

Most frequently mentioned tips in energy-saving campaigns, 2022-2023



Source: IEA analysis based on 21 campaigns.

In Paris, the home of the IEA, the Eiffel Tower reduced its nighttime illumination to a minimum, a symbolic gesture with a message about the urgent need to save energy to residents and tourists alike. Similar actions were taken in many countries, including the Netherlands, Germany and Belgium, where public building and monument façade lighting was turned off at night, demonstrating that the public sector was leading by example.

Japan also encouraged consumers and businesses to save energy with practical tips, based on a detailed survey identifying most effective energy-saving actions by season and by region. India's Lifestyle for Environment (LiFE) initiative aims to shift behaviour of at least a billion people over the course of multiple years. The adoption of LiFE measures worldwide would potentially reduce annual global CO_2 emissions by more than 2 billion tonnes (Gt) in 2030.

Best practices for campaign design, implementation and tracking emerge from the wide range of campaigns

Campaigns have demonstrated creativity and a wide range of techniques to help governments and consumers, from which lessons can be learned. For instance, Finland's Down a Degree campaign used images of ice plunges and wood chopping, highlighting the toughness and resilience of the Finnish people, to bring the society together against a common threat. The campaign's advertising budget of more than USD 150 000 was enough to reach more than 11 million impressions on social media and 34% of the country's population on printed media.

Emerging best practice tips in delivering energy-saving campaigns

Design	Implementation	Tracking
Campaigns have benefitted from a dedicated government team working on strategy and design.	Working with industry groups and community associations can help amplify a campaign's reach.	Tracking immediate campaign results can help tailor it.
Defining campaign goals and the target audience early on can improve its effectiveness.	Showcasing government actions to save energy sends a powerful message.	Assess longer-term impact of a campaign.
Creative, clear and consistent messaging can help people connect with the campaign.	Using multiple channels to promote campaigns can help reach a wider audience.	Communicate results to maintain support internally.
Highlighting existing subsidies, grants and support schemes already in place.	Refresh the messages to avoid potential campaign fatigue.	Track uptake of measures against baseline control group.

Sources: UsersTCP (2023), CampaignXchange Task.

To reach a wider audience and amplify the message, governments often tapped into existing networks in the private and the non-profit sectors. The Energy Savings Coalition in the Netherlands connected trade associations, municipalities and NGOs to amplify the message and increase direct support through almost USD 11 million in grants for energy saving projects such as a tool allowing SMEs to get advice on energy efficiency.

Governments also tailored messages to the environmental context, such as Canada promoting insulation in winter and efficient air conditioner use in summer and Ireland retargeting the campaign to low-income groups amid affordability concerns to keep warm and well. Others like Belgium and Canada highlighted existing programmes by directing homeowners to grants for renovations.

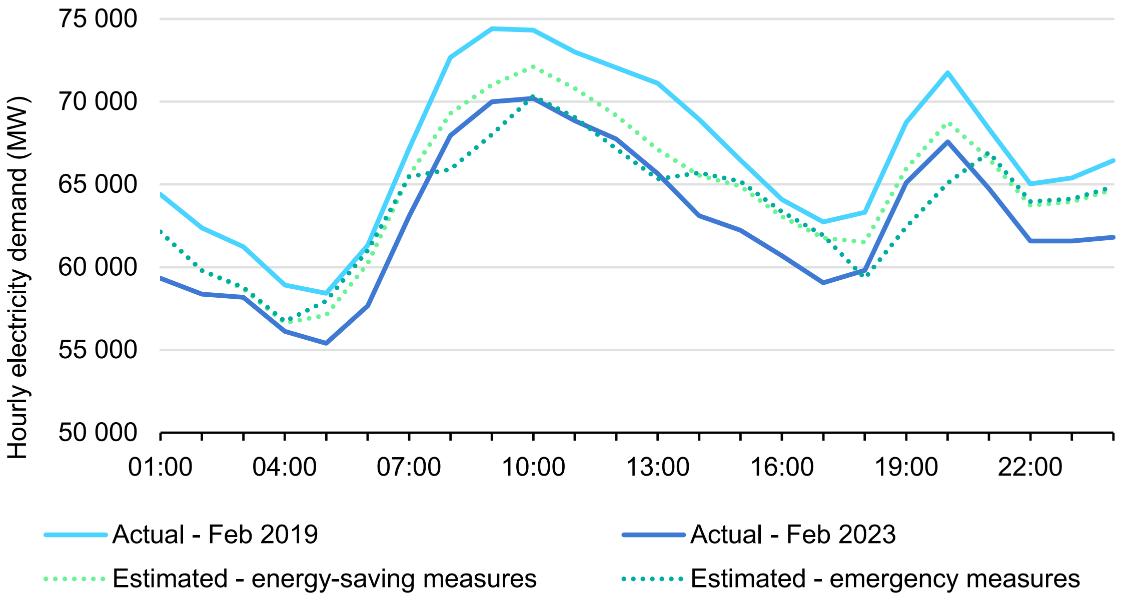
A Côte d'Ivoire campaign used TV and radio ads, activities in shopping centres and in schools, and placed road signs featuring energy saving tips. The campaign used humour to deliver a message and featured a local shop owner whose warmth and friendly persona would resonate with the audience. Sénégal's Agency for the Economy and Energy Management worked with famous actors and singers as ambassadors of energy savings; messages were delivered in French and Wolof. Uruguay focused on schools, launching competitions for high school students, encouraging them to find new solutions and learn about practical applications of energy efficiency. In the Kingdom of Saudi Arabia, the Saudi Energy Efficiency Centre has also carried out a range of awareness raising campaigns focused on the public, government staff and schools.

Energy saving behaviours have had a significant impact lowering energy consumption during the crisis

Measuring the direct effects of a campaign on actual energy savings is challenging because it requires to disentangle the various factors affecting behaviour. IEA analysis of electricity consumption in France shows that in February 2023 during the energy crisis consumers lowered energy consumption significantly during the period when the government's Energy "Sobriété" Campaign was actively encouraging energy saving measures as part the "sobriety plan". Recommended actions included the lowering of thermostat for space and water heating, banning leaving doors open in heated shops, switching to LEDs and moving consumption to off-peak times.

The scheme had two levels of recommended energy saving measures depending on grid conditions and consumers could opt to be kept informed through an app and additional messages. The French Transmission System Operator RTE estimated the potential of behavioural actions could save up to 9 GW in peak time. IEA data from the real-time electricity tracker show that peak electricity consumption on a cold day in February 2023 was indeed around 6% lower than on comparable days in 2019 during a period with similar temperatures, suggesting the measures had a significant impact.

Hourly electricity consumption in France in February 2019 and 2023, compared with estimated effects of behaviour campaign saving and emergency recommendations



Source: IEA analysis based on data from RTE.

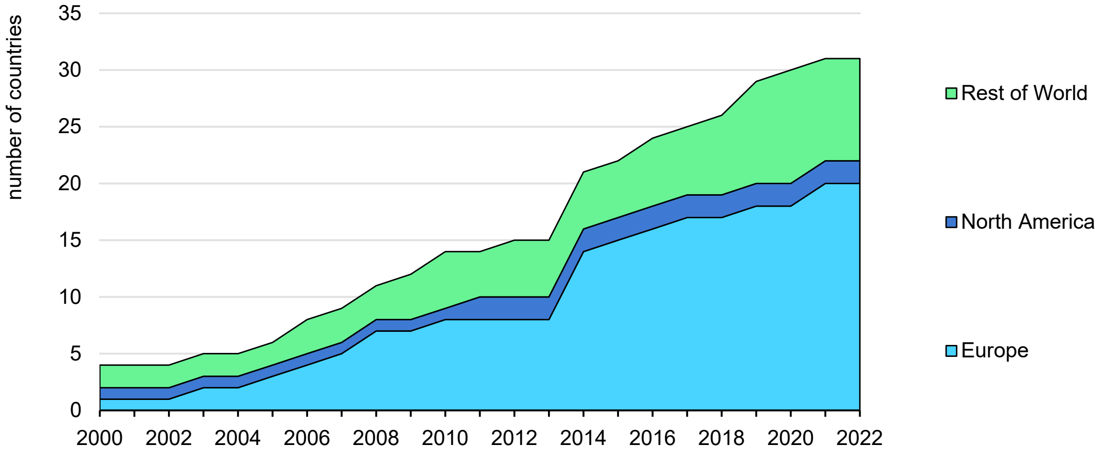
Energy efficiency obligation schemes

Market based mechanisms are being used to deliver energy savings, demand flexibility and affordability goals

Energy Efficiency Obligation (EEO) schemes are market-based mechanisms that can be used at the national or sub-national level, setting energy savings targets for an "obligated party", most typically an energy supplier or utility company. In addition, these schemes can be used for other objectives such demand flexibility and as a means to support vulnerable consumers.

EEOs are in use in 31 countries globally, with the number of schemes having grown steadily over the last 20 years. In the past few years, Hungary and Lithuania have set up new programmes to help meet the European Energy Efficiency Directive. Korea, which had run pilot phases of its Energy Efficiency Resource Standard (EERS) obligation scheme since 2019, announced USD 72.2 million in funding for 2023 with the expectation that the scheme will soon become mandatory. The Canadian province of New Brunswick legislated for an EEO scheme to start in 2023 by setting the New Brunswick Energy Marketing Corporation a goal of 0.5% electricity savings per year, increasing to 0.7% by 2027.

Number of countries with active Energy Efficiency Obligation schemes, 2000-2022



IEA. CC BY 4.0.

Other countries broadened the scope of already existing schemes. In 2023, Spain expanded its EEO, which since 2014 requires energy suppliers to make an annual contribution to the national energy efficiency fund (FNEE - Fondo Nacional de Eficiencia Energética). The Energy Savings Certificate System was introduced as an alternative to the contribution to the FNEE.

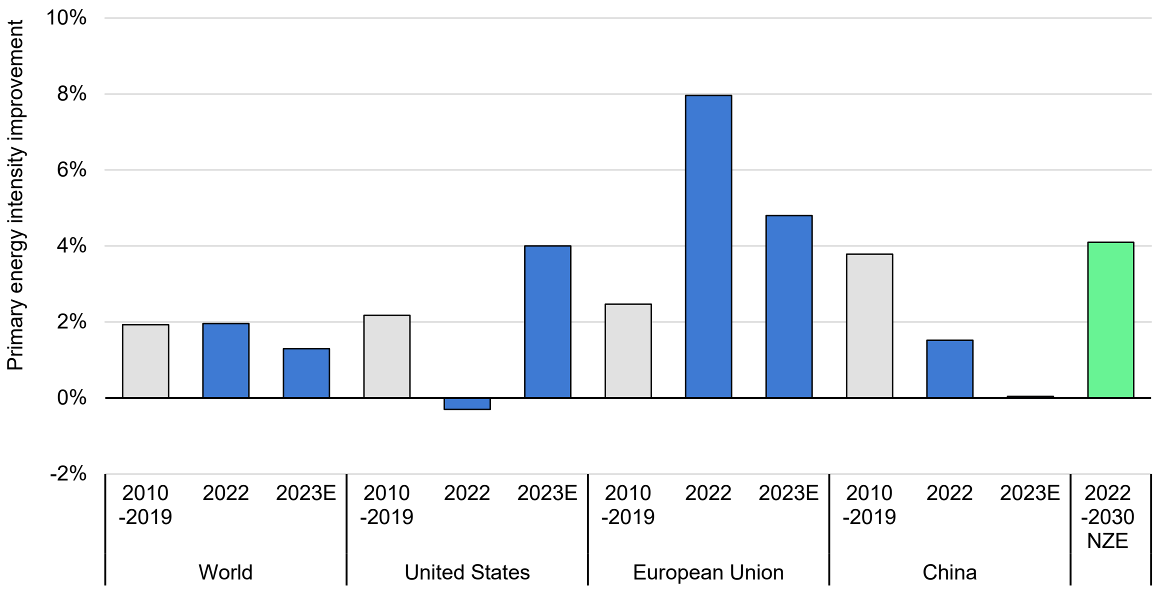
Chapter 5. Key issues for governments

Why is energy intensity progress lower in 2023 despite significant policy action?

Slower global intensity improvement in 2023 hides profound progress at country and regional levels

In 2023, energy intensity progress is expected to be 1.3%, making it a below average year for energy efficiency. This comes despite a vast number of countries ramping up policy action and the ongoing effects of the energy crisis reverberating in many regions. This makes it particularly important to understand the drivers behind the average year for intensity change in 2023. Three dynamics are considered particularly important and are examined here: regional differences; time lags between policy changes and their impacts; and lifestyle and technology trends.

Annual primary energy intensity improvement, 2010-2023, NZE Scenario



IEA. CC BY 4.0.

Global energy intensity changes average out many different regional trends. With China, the United States and the European Union together responsible for more than half of global GDP and energy consumption, analysing developments in these regions can help provide quick assessment of what may be behind the global trends.

The effects of the energy crisis were felt most immediately and strongly in Europe. In the European Union energy intensity progress registered almost 8% in 2022 followed by 5% in 2023 due to continued pressure to conserve energy through the energy crisis as well as the initial effects of incentives from REPowerEU starting to bite. Based on initial data overall energy demand is expected to fall by around 4% in 2023 while the economy grows by less than 1%. While a milder winter, the second warmest on record, contributed to reduced energy demand, this may have been partially offset by an exceptionally hot summer and drought in Europe.

The United States also achieved significant energy intensity progress, posting an improvement of 4% in 2023 . This was driven by high energy prices, especially at the pump, and a warmer winter and cooler summer, while much of the record heat experienced elsewhere missed the country. In the first nine months of 2023 degree days were down 8% for heating and 5% for cooling compared with the same period the year before.

By contrast, China, saw weaker energy intensity progress, which weighed heavily on the overall global energy intensity rating. China returned to trend economic growth in 2023 of around 5% following the end of pandemic restrictions that slowed it to 3% in 2022. The post-Covid-19 rebound also boosted air travel. But a significant buildout of the petrochemical industry in 2023 has sharply increased in oil use in petrochemical feedstocks. This in combination with capped energy prices contributed to early estimates of exceptional energy demand growth of 5% overall, yielding almost unchanged energy intensity levels in the country for 2023.

It takes 40% more energy to fuel GDP in China than in the United States, and almost double the energy to fuel the same growth as in the European Union. This shift in the balance of global economic activity, along with a slowing of energy intensity progress in China along with that of some other regions, helps explain the slowdown in overall global energy intensity gains this year. Without this effect, intensity progress in the rest of the world would have been around 1.8% in 2023, almost 40% better than the global average for the year.

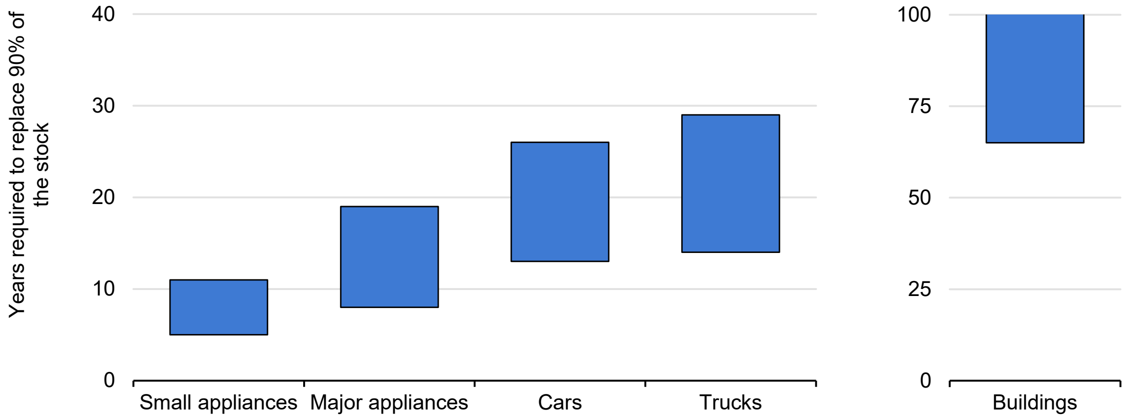
Energy efficiency standards and regulations are ramping up, but it takes time to drive observable demand change

Implementing stringent efficiency regulations with policies such as Minimum Energy Performance Standards (MEPS) and fuel efficiency standards have significant effects on the energy efficiency of products available in the market.

However, due to slow stock turnover and time to incorporate design and production changes, it can take from several years to decades for these changes to turn into significant energy savings at a national level.

IEA analysis in its report Achievements of Energy Efficiency Appliance and Equipment Standards and Labelling Programmes shows it takes time to replace stocks of old, inefficient units with new, more efficient ones, resulting in the annual rate of improvement across the entire stock lagging behind the improvement rate of new appliances.

Estimated time required to replace 90% of the existing stock under normal replacement rates



IEA. CC BY 4.0.

Sources: IEA analysis based on data from Eurostat, ACEA, Lawrence Berkeley National Laboratory and IEA (2022), World Energy Outlook, 2022.

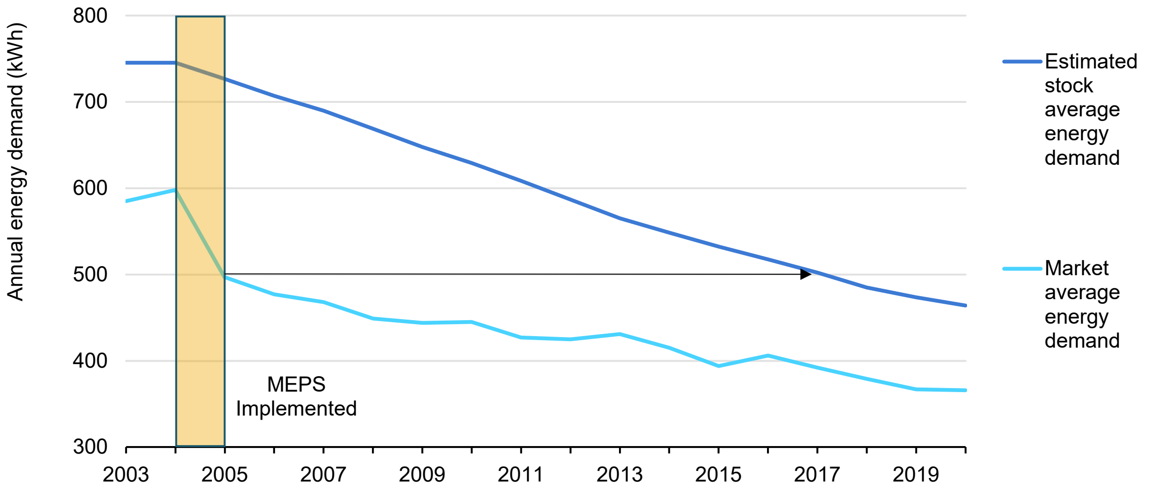
Slow stock turnover can be observed in many sectors and by equipment types, with different durations depending on the lifetime of the products and their affordability. Since an asset bought today could remain in use for more than 20 years, the promotion and fast incorporation of today's best available technologies plays a major role in reducing the future energy demand. Additionally, more incentives can accelerate stock turnover, removing aged products by implementing replacement programmes and scrapping bonuses, taking into account lifecycle costs and emissions.

For example, with the case of MEPS introduced for refrigeration appliances in New Zealand in 2005, a reduction of almost 20% for the average energy consumption of new products was observed, bringing the average value of sold refrigerators to 497 kWh/year. However, IEA analysis shows that it took more than 10 years for the stock to renovate in order to reach the same average value.

In Norway, the government has set ambitious targets for the market uptake of zero- and low-emission vehicles in 2025 and 2030, and implemented policies to support this. In 2023, almost 90% of new vehicles sold are electric, but a 90% penetration of ZEVs into the stock of passenger cars is not expected to occur until 2039.

Regulations can also require several steps to enter into force, especially when multiple parties negotiate on the conditions. It is normal for administrative processes to take time to translate announcements and decisions into legislation and active programmes. For example, the European Commission proposed the recast of the EU Energy Efficiency Directive in July 2021, but it took until September 2023 to reach a formal agreement. Implementation into national legislation will take EU countries another two years. Similarly, India's PAT scheme was included in the National Action Plan for Climate Change (NAPCC) launched in 2008, but entered into force only in 2011, with the first cycle starting in 2012.

MEPS impact for refrigerators and freezers (from market to stock)

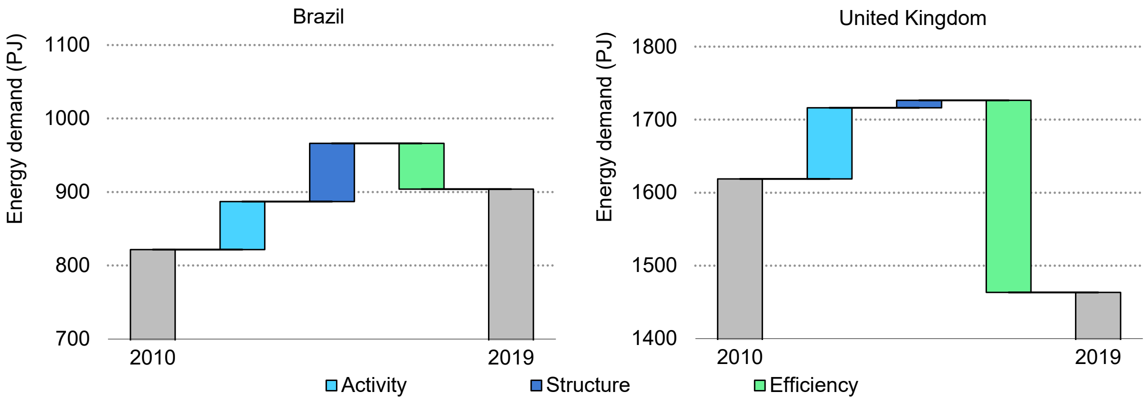


Sources: IEA analysis based on New Zealand's Energy Efficiency & Conservation Authority (EECA) sales and efficiency data.

The world is more efficient, but people are living in bigger homes, driving further and using more devices

Improving the efficiency of homes, vehicles and appliances directly contributes to reducing energy intensity. However, certain consumer choices can offset such efficiency gains. Decomposition of energy demand into efficiency, structure and activity effects allows policy makers to observe trends, which can help inform why, despite strong progress on efficiency, we observe energy consumption continuing to rise in some instances. For example, although the energy consumption of buildings per square metre in many countries has been steadily declining, the average size of a home has increased. Such examples include Brazil and the United States where, as a result, the energy intensity of buildings remained relatively constant while residential energy demand steadily rose between 2010 and 2019. In the United Kingdom, on the other hand, efficiency gains in the residential sector were significantly larger than structural and activity effects, causing residential energy demand to decline in the same decade.

Decomposition of pre-Covid residential energy demand trends in Brazil and the United Kingdom, 2010 - 2019



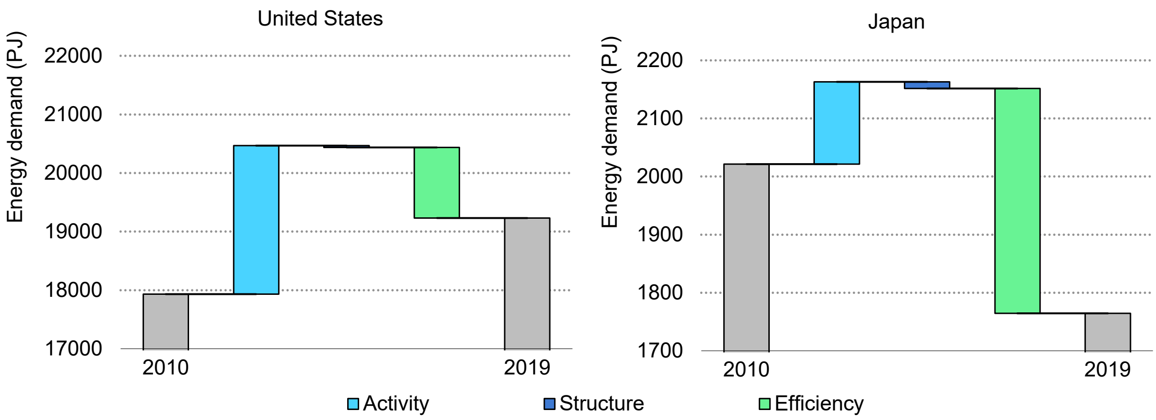
Source: IEA (2023), Energy End-uses and Efficiency Indicators, accessed October 2023.

In the transport sector, fuel economy standards of vehicles have improved rapidly in the last decade. However, cars have been getting larger. In India, shares of SUVs in total car sales doubled in five years, from 24% to 47%. Globally, more than half of all new electric car sales were SUVs in 2022. Cars are also often being used more. In the United States, for example, an increase in passenger per kilometres also more than offset any efficiency gains at the level of the car. Driving more and in bigger cars results in upward pressure on energy demand, despite the savings delivered by efficiency improvements, underscoring the importance of consumer behaviour. This is happening in both advanced economies and in emerging markets and developing economies (EMDE). However, an average person in an EMDE still uses three times less energy in their home and four times less energy for transport compared with an average person in an advanced economy.

While consumer choices and actions are hard to predict as these can be influenced by different factors, such as social norms and current events, including behavioural insights in policy design can help identify, and avoid or minimise, potential pitfalls. Governments need to be aware of issues such as the so-called “moral licencing effect”, which entails households counterbalancing energy-saving behaviour in one area of their lives with an increase in consumption in another. For example, purchasing an electric vehicle could justify driving more, especially when costs are low. In Japan, where government policy stimulates the acquisition of smaller cars, structural changes have positively contributed to reducing energy demand and one can observe a decline in consumption in the transport sector despite some increase in distances travelled.

Furthermore, behavioural insights could be useful in encouraging people to change their mode of transport. The integration of choice architecture, a behavioural tool used to nudge people to make different choices, in policy has been shown to increase engagement and uptake. For example, to encourage cycling, local governments in the Netherlands did not just encourage citizens to use bikes more often but put in place convenient parking garages and dedicated lanes to make the option of cycling more attractive and change behaviour that way. Norway has a Zero-Growth Goal that achieved a reduction in private car travel through spatial planning conducive to biking and walking.

Decomposition of pre-Covid transport energy demand trends in the United States and Japan, 2010-2019



Source: IEA (2023), Energy End-uses and Efficiency Indicators, accessed October 2023.

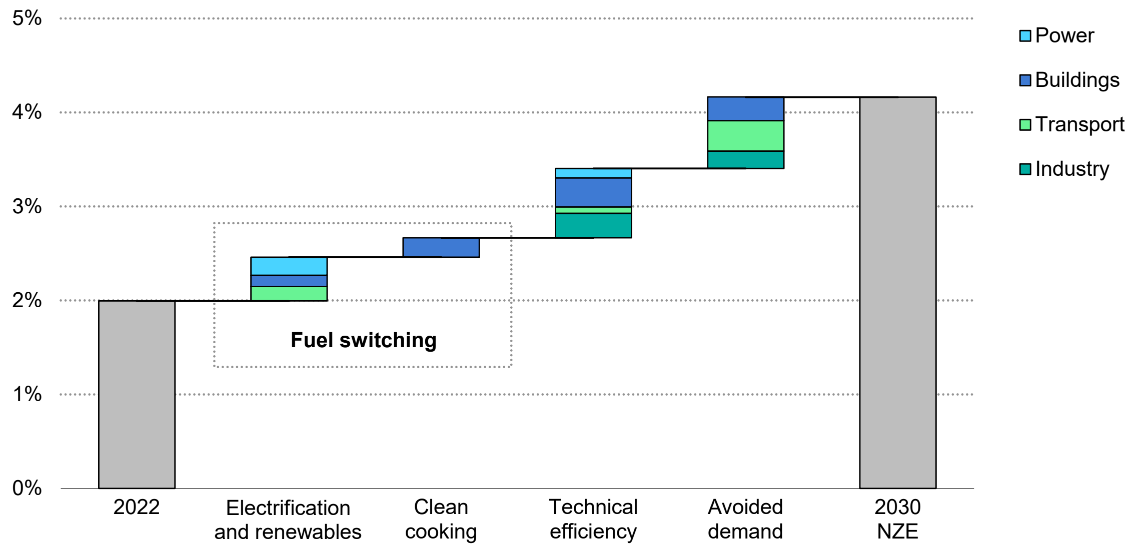
A similar trend can be observed for household appliances such as televisions, refrigerators, and other electrical devices. While efficiency standards are going up, the gains in energy consumption can be partly offset through consumers buying more of them, and in some cases opting for larger models. As more households get access to electricity in EMDEs, the volume of the appliances market will increase further. Similarly, consumers in advanced economies tend to increase the number of appliances they own, thus contributing to upward pressure on demand.

What does doubling global progress on energy efficiency entail?

More rigorous polices to boost electrification, energy and resource efficiency, and behaviour change

The IEA's landmark Net Zero Roadmap, which was updated in a new report released in October 2023, sets out an ambitious but achievable pathway to global net zero emissions by mid-century. One of a series of interim steps to achieving this is to double the rate of average global primary energy intensity improvement from the 2022 level just over 2%, to slightly above 4% until 2030. This rate of improvement would mean that energy demand in 2030 is nearly 10% lower than in 2022, even as the global economy expands by almost 30%.

Groups of actions contributing to a doubling in the rate of annual primary energy intensity improvements in the Net Zero by 2050 Scenario



IEA. CC by 4.0.

Source: IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach: 2023 Update.

The IEA Net Zero Emissions by 2050 Scenario (NZE Scenario), which serves as the basis for the Net Zero Roadmap, also illustrates a path to achieving this doubling of efficiency improvement through a range of key actions across sectors. These energy intensity improvements stem from three equally important global actions:

- **Switching to more efficient fuels (0.7 percentage points).** This comes in large part from electrifying incumbent fossil-fuelled systems, for example with heat pumps in buildings and electric vehicles in transport. Electric technologies are radically more efficient in providing energy services, leading to significant efficiency gains. Universal access to clean cooking in lower-income countries is a 2030 milestone in the NZE Scenario, with the switch to clean cookstoves leading to further improvements in efficiency.

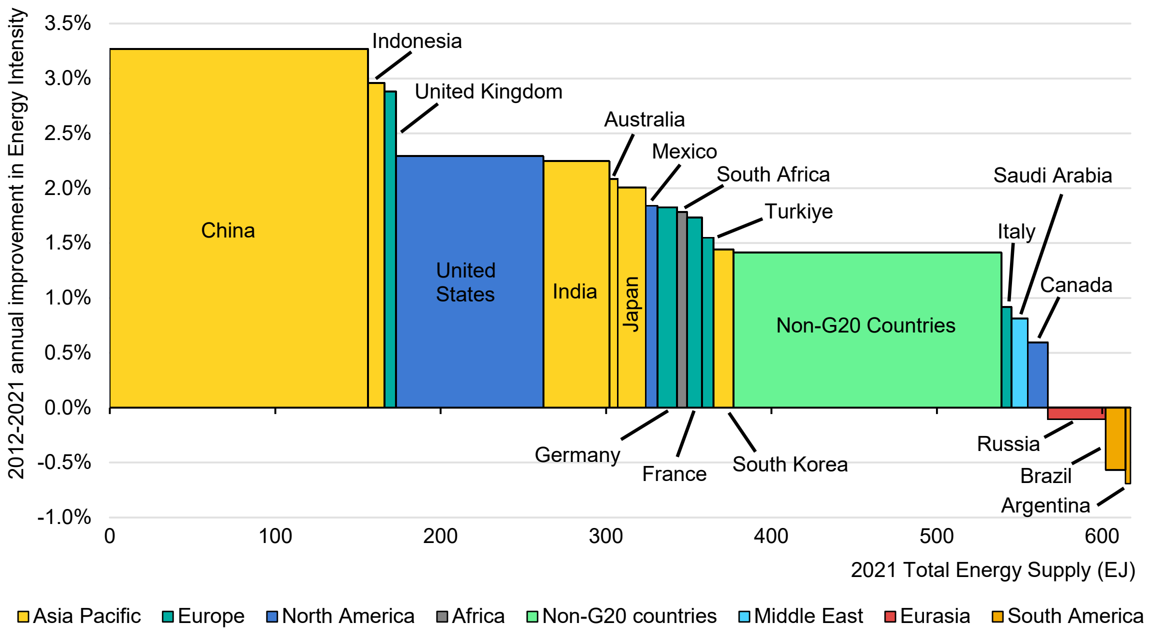
- **Improving technical efficiency (0.7 percentage points)**. Significant savings can be made through new building construction, better renovations, more insulated buildings; using more efficient air conditioners, motors, refrigerators and other appliances; driving more fuel efficient vehicles; and improving industrial processes that use less energy.
- **Using energy and materials more efficiently, leading to avoided demand (0.8 percentage points).** Examples include changes in behaviour by consumers such as adjusting space heating temperatures, and opting for public transport, walking or cycling over private car journeys. Minimising the material content of products while recycling metals and plastics can also radically reduce the energy required to manufacture them. Increased circularity and more efficient supply chains and shifts to services and lower energy intensive activities also will have a large role to play.

Doubling means different things to different countries depending on how close they are to 4% today

For a range of reasons countries have experienced differing levels of progress towards improving energy intensity in recent years. These can span economic and structural dimensions, levels of electrification, the efficiency policies that have been developed and the technologies available.

Critically, the aim to double energy intensity progress is an ambitious global target. No major country has sustained an annual average improvement exceeding 4% for a full decade, and a step change is required by every government if it is to be met. However, countries that have made stronger progress in recent years need relatively fewer improvements to surpass the 4% level.

Primary energy intensity improvement, 2012-2021, and total energy supply in 2021, selected countries

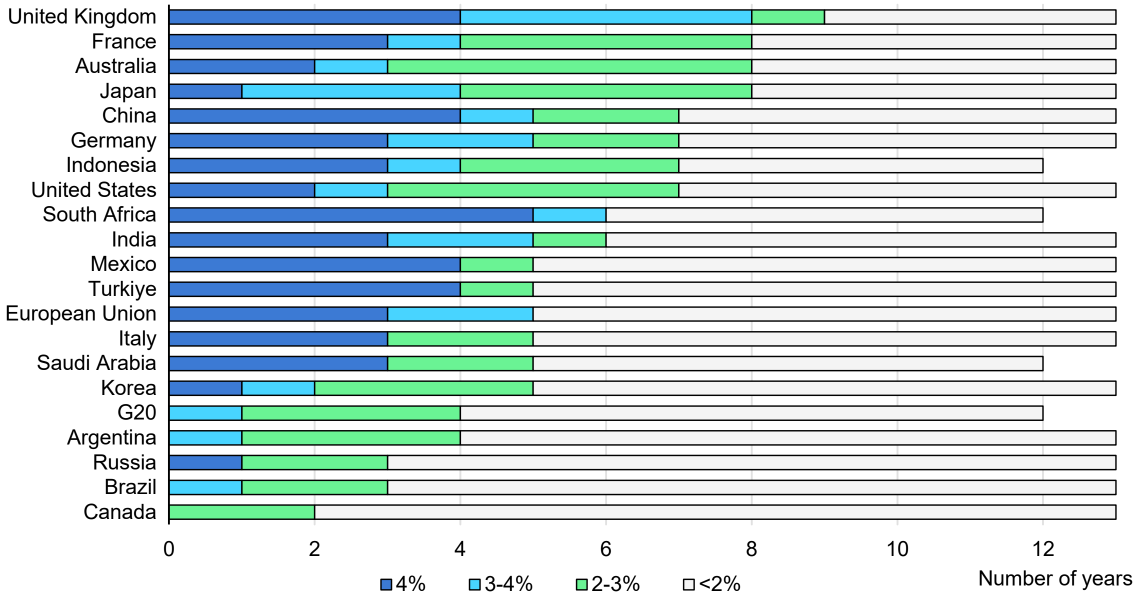


Notes: Primary energy intensity is the ratio of total energy supply to GDP.
Source: IEA (2023), World Energy Balances, accessed October 2023.

Doubling the global rate of energy intensity improvement this decade is challenging, but not unprecedented

Doubling efficiency progress is a challenge requiring higher policy ambition and investment from governments and industries. But many nations have already set a precedent for achieving it during limited periods. Of the 150 countries for which data exists since 2012, almost all (91%) improved energy intensity by 4% or more at least once and more than half (53%) did so at least three times. For the members of the G20 nations, whose progress contributes a greater weight toward the global target, 75% of countries exceeded 4% or came close with annual improvements above 3% at least once in every four years.

Energy intensity progress, number of years above 2%, 3% and 4% for G20 countries, 2010-2022



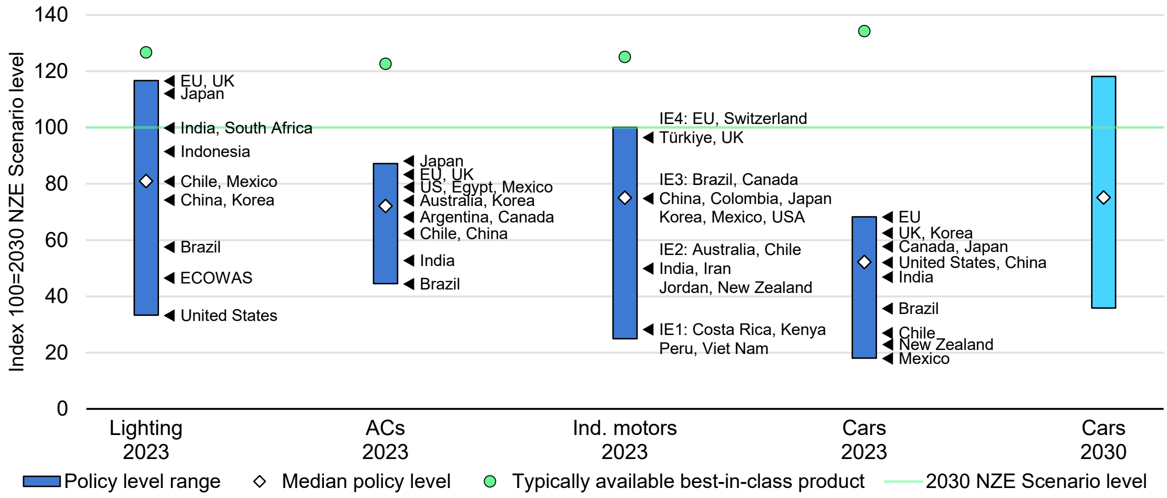
Note: 2022 data not yet available for South Africa, Saudi Arabia and Indonesia.
Source: IEA (2023), World Energy Balances, accessed October 2023.

The challenging task ahead for governments, however, is to meet this benchmark consistently for the rest of the decade. Four G20 countries – China, France, Indonesia, and the United Kingdom – have in recent years managed to sustain an average of 4% or more over a continuous five-year period, with several others coming close.

The policies and technologies are already in place to achieve doubling in almost all areas

In most sectors, governments can make rapid progress towards doubling by building upon existing policies and accelerating the deployment of already-available technologies. This is illustrated by examining governments' existing Minimum Energy Performance Standards (MEPS) – which set a minimum performance level for products sold – and comparing them with the efficiency levels of those products compatible with the NZE Scenario. The strength of these regulations varies widely among countries, but many are already at or very close to levels set out in the NZE Scenario. If all governments were to implement standards to these levels across all key sectors, then they would collectively achieve a doubling of energy efficiency progress in this domain.

Minimum Energy Performance Standards, IEA Efficiency Policy Level Index
Key end-uses, global country range, 2023 and 2030



Notes: See Chapter 4 Regulations and Standards for methodology.

For example, lighting standards in the European Union, India, Japan, South Africa and the United Kingdom are already at or exceed the level set out in the NZE Scenario. Similarly, all motors within a certain output range sold in the European Union, Japan, Switzerland, Türkiye and the United Kingdom must adhere to the efficiency class IE4 or better. Similar cases can be found for building regulations, and vehicle standards improvements set to come into force in 2030, for example in the United States and European Union.

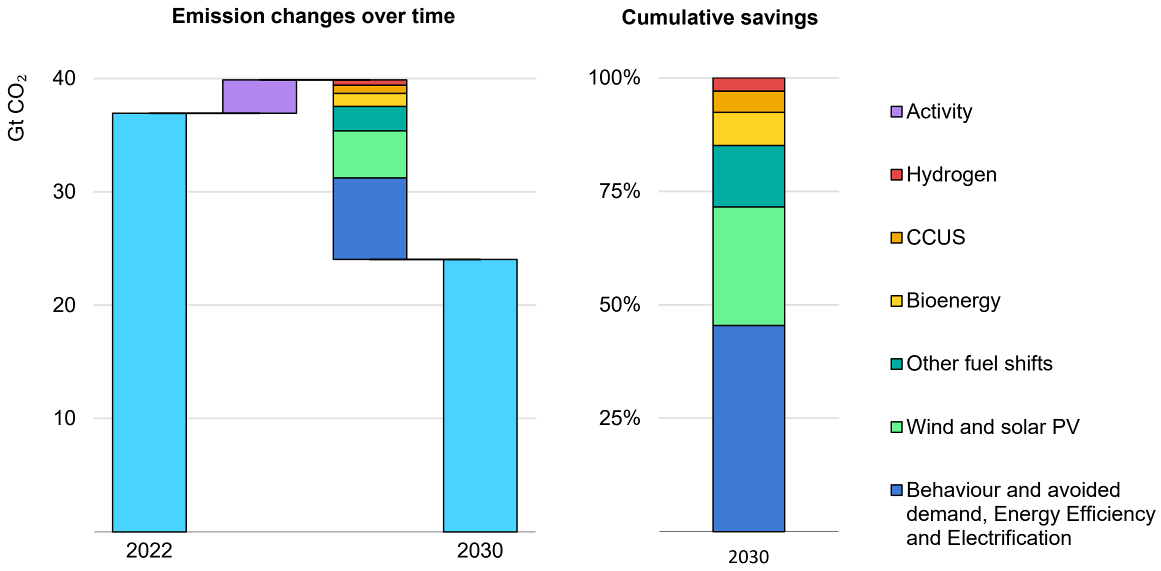
However, having MEPS in place is only part of what is needed. Regulations must be implemented and, crucially, rigorously enforced as part of a policy package that includes financial incentives and information for consumers. In combination, this ensures not only that the poorest-performing technologies are eliminated from markets, but that consumers can be incentivised towards purchase of the most efficient products. Increasing the replacement rate of old inefficient equipment with new more efficient equipment is key as is consumer choice.

Doubling efficiency progress could cut energy bills by a third and make up 50% of emissions reductions by 2030

Achieving the doubling target by 2030 is a critical step if governments are to get on track to reaching net zero emissions by 2050. In terms of energy savings alone, global demand in the NZE Scenario is almost 100 EJ less in 2030 than today – savings roughly equivalent to the entire final energy consumption of China in 2022.

Key actions to double efficiency progress – namely improvement in the technical efficiency of buildings and equipment, material efficiency, behavioural changes, and greater electrification – reduce emissions by more than 7 Gt in 2030 in the NZE Scenario relative to 2022, accounting for nearly half of all cumulative emissions reductions over the period.

CO_2 emissions reduction by mitigation measure in the Net Zero by 2050 Scenario, 2022-2030



Source: IEA (2023), World Energy Outlook 2023.

For consumers, the energy savings brought about by doubling efficiency progress would result in significant savings in energy bills. Today's energy bills in advanced economies could be lowered by a third, for example. Wasting less energy also results in a smaller energy system that requires less physical infrastructure. Doubling would therefore also provide substantial cost savings to industry and governments.

The energy efficiency-related measures needed to achieve the doubling target would result in the creation of around 4.5 million jobs in 2030 compared to today, with more workers needed to help retrofit buildings, install energy-saving technologies and manufacture more efficient vehicles. This is around 1.5 million more jobs in 2030 than is seen in the Stated Policies Scenario (STEPS). The bulk of new efficiency jobs come in the buildings and industrial sectors with around 3 million jobs for activities such as building retrofits, heat pump installation, putting in place industrial energy management systems and efficiency upgrades, and the manufacture of other efficient equipment. In the transport sector, on balance an overall 1.5 million new jobs are created in the NZE Scenario, driven by the substantial growth in electric and more efficient vehicle manufacturing as well as with batteries.

How does the hottest year on record drive urgency for efficiency measures?

The world is seeing record hot temperatures, boosting the need for cooling

The world has recently endured its hottest summer on record —from scorching temperatures in the United States, the Middle East and China exceeding 50°C to heat waves like Cerberus in Europe, causing thousands of deaths, wildfires, and disruptions in sectors like agriculture and tourism.

Rising temperatures are driving greater cooling demands, threatening to trigger a vicious cycle of higher electricity use and carbon emissions. Heat waves can also worsen health disparities, reduce productivity, raise electricity costs, disrupt essential services, and drive forced migration. Extreme heat puts strains on electricity systems, requiring substantial investments in grid infrastructure and power generation while burdening consumers with high cooling costs, especially for the most vulnerable.

Various policy levers are being used to address the challenge of rising cooling demand, ranging from enforcing stricter standards for air conditioning units to introducing demand response programmes to help balance the grid.

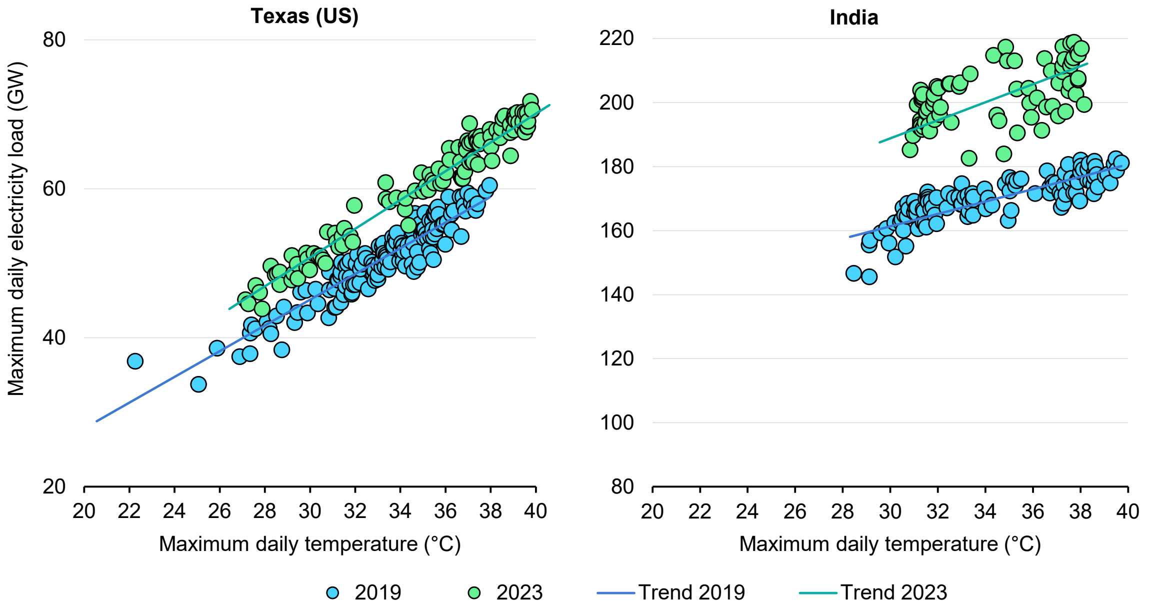
Extreme heat levels are driving a surge in air conditioner sales and record power demand

Data shows extreme heat drives higher purchase of air conditioners, with sustained average daily temperatures of 30 °C boosting weekly sales by around 16% in China, for example. During the May to September global heat wave, people were looking online for air conditioners more than ever, with the search term's relative popularity on Google up more than 30% worldwide compared with the historical average level of searches for those months. Online sales data from China in June 2023 revealed a 60% year-on-year increase in air conditioner sales – a tenfold rise compared to figures from January – and an increase of sales in electric fans of almost 90%.

Higher temperatures have a significant impact on electricity demand. IEA analysis shows that every 1 °C increase in the average daily temperature above 24 °C drives a rise of about 4% in electricity demand in Texas, while in India, where air conditioner ownership is lower, the same temperature increase still drives a 2% gain.

Between May and September this year, power grids hit record levels of peak electricity demand in more than 10 countries around the world, including China, the United States, Canada, India, Brazil, Thailand, Malaysia and Colombia – together accounting for more than 60% of total global electricity demand. In some regions, such as in the Middle East and parts of the United States, space cooling can represent more than 70% of peak residential demand on hot days.

Daily electricity load versus temperature May to September 2019 versus 2023



IEA. CC BY 4.0

Sources: IEA (2023), Weather for Energy Tracker; IEA (2023), Real-Time Electricity Tracker.

Cooling already represents an estimated 9% of global electricity demand today and will steadily see its share to grow. The most significant increase is observed in emerging markets and developing economies, where the stock of air conditioners is set to double by the end of the decade due to rising temperatures as well as growing populations and economic growth. Cooling demand is being further boosted by extended cooling seasons as well as longer use each day.

Increase in cooling demand are leading to supply shortages, restrictions and blackouts worldwide

Numerous nations have experienced the impacts of heat waves, with notable instances such as Argentina experiencing a massive blackout in March 2023 affecting 20 million people, attributed to a power line fire exacerbated by the heat wave. In Mexico, recent summer heat waves resulted in multiple deaths and power generation capacity nearly reached the maximum limit. Egypt faced rolling blackouts due to surging air conditioning demand, and India estimates an income loss equivalent to 5.4% of GDP due to higher temperatures and reduced working hours across various sectors.

Between April and June 2023, major cities in Viet Nam were prompted to mitigate increased demand due to increased temperatures and heat waves, ultimately leading to power cuts for businesses and households which affected productivity and gave rise to various health issues. The government applied power-saving measures, including implementing energy efficiency measures, cutting back on streetlighting, and encouraging households to reduce electricity consumption.

Increased cooling needs can often mean grid operators need to bring older, inefficient and more polluting power plants online to cope with the spikes in demand. For instance, in June 2022, Sichuan experienced extensive power restrictions and in May 2023, China Huadian's Sichuan subsidiary recorded its highest purchases of coal for power generation in several years.

Demand response programmes offer new ways to reduce the burden on power grids

To relieve pressure on power grids during hot periods, operators are embracing new strategies. This includes enabling appliances and cooling devices to be flexible and adapt energy usage according to real-time electricity demand, thus aiding grid balance during peak periods and offering consumers cost savings. This "demand response" can involve voluntary electricity use reduction during emergencies or financial incentives for consumers who reduce consumption.

For example, in Texas, when electricity demand hit an all-time high this summer, the grid operator increasingly used its demand response and energy flexibility programmes. These programmes reward large energy consumers for reducing demand during grid stress or shifting consumption to off-peak hours. In 2023, demand response payments are 20 times higher, benefiting programme participants.

In China, the Huzhou air conditioner demand-side management pilot was the first of its kind aimed at the residential sector. Wi-Fi connected air conditioners were enabled allowing users to adjust their settings via a smartphone app. The Chinese government has developed demand-side management plans to cover at least 5% of the country's electricity consumption by 2025, mostly from industry and cooling in public sector buildings.

Additionally, district cooling systems can play a role in alleviating strain on power grids reducing the demand for individual air conditioning units, particularly during hot days. For instance, Tabreed, a company headquartered in the UAE's capital of Abu Dhabi, currently delivers around 4.5 GW of cooling across 89 plants located throughout the Gulf region.

Improved cooling for all has far reaching social and economic implications

These growing cooling needs have far-reaching social implications that demand attention for inclusive transitions. While affordability of air conditioning is expanding, it remains constrained by income and wealth disparities. For example, in Sub-Saharan Africa only 5% of households own air conditioners due to financial limitations and, in some cases, a lack of access to electricity. By contrast, more than 85% of households in countries like Japan, Korea, and the United States have access to air conditioning.

In regions grappling with high electricity prices, inefficient cooling burdens residents with high cooling costs. Consumers are also facing rising purchase prices for units, as inflation escalates and in the warmer seasons when demand is most urgent.

Rising temperatures, increasingly frequent heatwaves, and heat-induced labour stress disproportionately affect low-skilled, outdoor job sectors, affecting the productivity of vulnerable low-income households primarily engaged in agriculture and construction.

Unreasonably hot temperatures in buildings, also presents significant health risks like heat-related illnesses, dehydration, and disrupted sleep patterns, potentially affecting elderly, children and pregnant women the most.

Highly efficient air conditioner units are within reach

The IEA's Net Zero Emissions by 2050 (NZE) Scenario foresees MEPS levels for air conditioners between 5-6.5 W/W in 2030. Recent IEA analysis shows that efficient air conditioners, aligned with NZE Scenario targets, are available in almost all global markets and do not necessarily come with higher upfront costs.

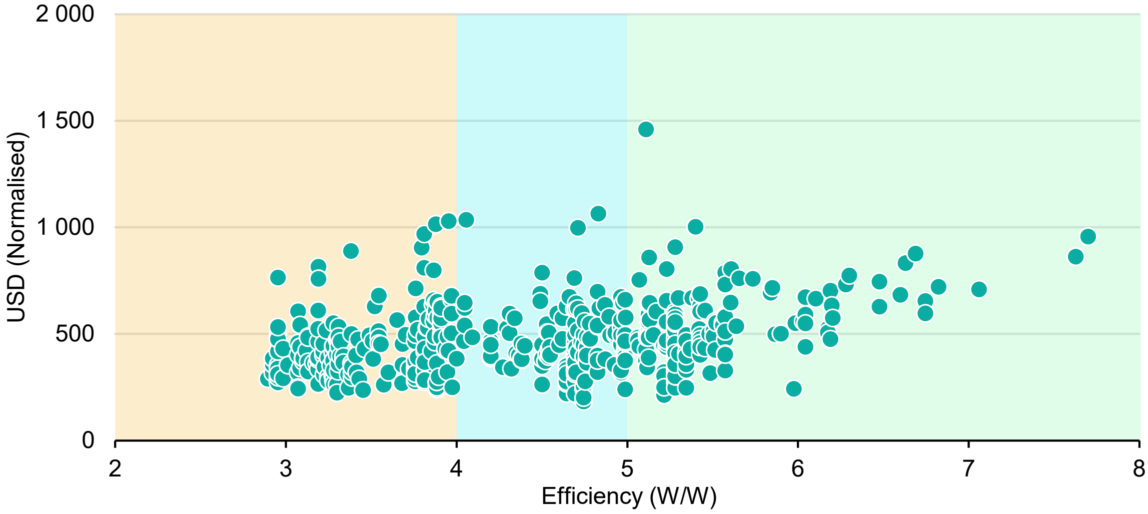
For example, in Thailand, consumers with a budget of USD 350 can choose between a low-efficiency unit at 3 W/W and one that is double as efficient (6 W/W), which are both selling at the same price. Purchasing the more efficient unit could almost halve their electricity bill, resulting in savings of up to USD 2 000 over the unit's lifetime. This pattern is not exclusive to these countries and is evident in market data for most places around the world.

Policy solutions are available to support large-scale deployment of highly efficient products. In countries with the longest-running policy programmes, such as the United States and Europe, MEPS and labels have helped more than halve the energy consumption of air conditioners.

In China, new regulations for room air conditioners introduced in 2020 raised efficiency standards, and by the end of 2021, units exceeding minimum requirements increased their market share from 19% to 56%.

Such policies could quickly double the average efficiency of air conditioners being sold. When combined with insulated buildings and better built neighbourhoods and cities, enhanced efficiency not only leads to reduced operating costs for air conditioning but also lowers the need for investments in new electricity generation and grid capacity. In this way, energy efficiency policies assume a dual role in helping achieve net zero emissions objectives while also strengthening the capacity to adapt to soaring temperatures and promote inclusive transitions.

Air conditioners' efficiency rating and retail prices (normalised) in Southeast Asia, 2023



IEA. CC BY 4.0.

Notes: Air conditioners are wall-mounted single split type. Southeast Asia, including Indonesia, the Philippines, Thailand, and Viet Nam, in 2022. Purchase prices are normalised to 12 000 BTU/hour cooling capacity. Low efficiency = below 4 W/W; Medium efficiency = 4-5 W/W; High efficiency = above 5 W/W.

How are consumers benefiting from system efficiency?

System efficiency offers new benefits as electrification and renewable energy transform leading energy markets

The electrification of heating and cooling, road transport and industrial processes is driving higher peaks in electricity demand, increasing its hourly, daily and seasonal variability. At the same time renewable energy is taking on an increasing share of electricity production, thereby increasing variability on the supply side.

System efficiency – provided through new digital technologies that enable improved management and control as well as energy savings – is helping the consumer manage this increase in variability on both the supply and demand side. System efficiency helps bring down consumer bills and other costs as more straightforward energy efficiency opportunities become exhausted.

Flexibility – the ability to rapidly adjust supply or demand in response to a signal such as price – is today sourced primarily from the ability to turn thermal generation supply up and down, as well as from large-scale hydropower and, increasingly, battery storage. However, as variable renewable energy penetration deepens, displacing thermal units, more flexibility is needed on the demand side from consumers adjusting when and how much electricity they consume.

Flexibility increases electricity security and offers the opportunity to reduce costs, by allowing users to take advantage of low-priced electricity and by preventing system operators from having to make costly network reinforcements. At a time when consumers globally are already suffering from high electricity prices and consumer bills, demand flexibility can help boost competitiveness and the affordability of energy.

Time-of-use tariffs are a key tool to unlocking flexibility, and are becoming more widespread as governments search for ways to align consumer behaviour with increasingly variable electricity supply. For instance, India has announced that starting in 2024 it will strengthen time-of-use tariffs to encourage consumption during hours when solar production is at its peak, and penalise consumption in the evening when supply is low and demand peaks.

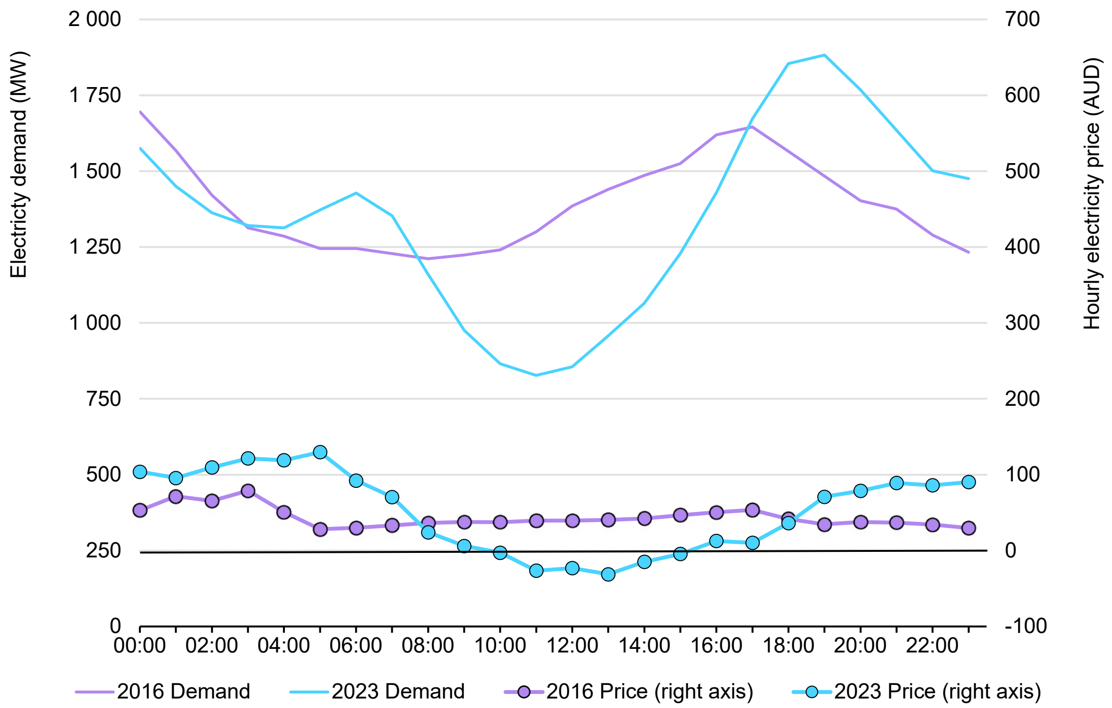
Efficiency is evolving to a convergence of delivering energy savings, flexibility and localised renewables

Even though it accounts for a relatively small share of overall national electricity demand, South Australia is recognised as a global leader in terms of its high share of electricity coming from renewables. For example, in December 2022 wind and solar contributed over 85% of South Australia's electricity demand, surpassing the previous record of 76% achieved in December 2021.

As part of this transformation, South Australia has also become a leader in the use of technologies that support systems efficiency to help manage increased price variability and other grid pressures. For example, following a 2016 statewide blackout, grid resilience has been improved using measures such as virtual power plants and battery storage, while and solar capacity has increased more than fourfold, to 3.1 GW as of September 2023.

As more countries move to implement their net zero goals, the experience from South Australia offers an important case study on the evolving role of energy efficiency in jurisdictions with extremely high levels of renewable energy penetration.

Net electricity demand and wholesale prices in South Australia, hourly, January 2016 and 2023



Source: IEA (2023), Real-Time Electricity Tracker.

Today, distributed PV has a visible impact on daily net electricity demand in South Australia, with rooftop solar currently installed in around 40% of homes. This has also changed the nature of wholesale prices throughout the day, with a deepening valley during midday hours, when self-consumption peaks and demand on the grid drops drastically. The changes have been so great in the region that negative wholesale prices were recorded for more than 120 days between January and September 2023. This has also led to curtailment of solar generation at times, as well as lower feed-in tariff prices for exports to the grid.

While swings in demand and prices can present challenges, they also represent an opportunity for customers to significantly reduce their monthly bills by shifting their consumption towards solar peak hours. The South Australian Government has moved to encourage more flexible devices to facilitate this. For instance, under the new Technical Regulator Guideline, the state has mandated that air conditioners installed after 1 July 2023 must be demand response ready.

Next generation micro-grids offer system efficiency to lower costs and improve reliability for consumers

Operating in this dynamic environment, several companies are adapting their business models to take advantage of system efficiency. For example, a produce supplier in South Australia invested in solar panels and batteries to better manage the plant's energy bill and to improve resilience in case of grid failure. The creation of this microgrid allows the business to be self-sufficient in its energy supply and reap the benefit of net savings on its energy bills.

Similarly, the University of Queensland in Australia installed the state's largest behind-the-meter battery, with 1.1 MW capacity and 2.15 MWh storage. By joining Enel X's Virtual Power Plant, the university earned more than USD 47 000 n the first quarter of operations, while supporting renewable integration and grid balancing.

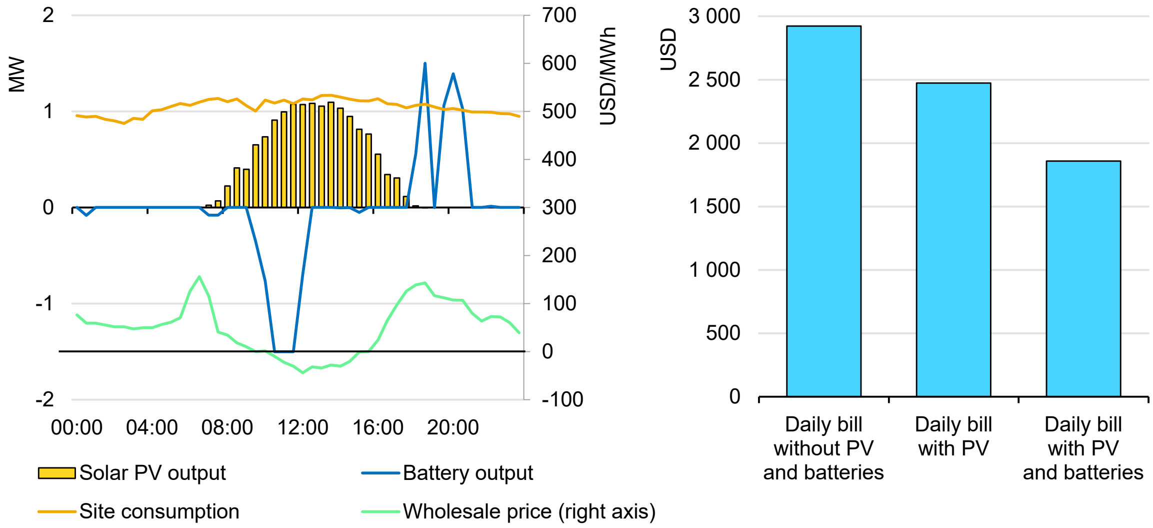
Smaller residential consumers are also beginning to gain access to wholesale markets for the first time, helping to spread the benefits of flexibility even wider. For instance, the Tesla Virtual Power Plant project in South Australia installs solar panels and home batteries in social housing properties.

Tesla centrally manages the batteries and solar system, to reach wholesale market scale. It provides frequency stabilisation service and maximises benefits on wholesale markets. In exchange, households are offered a lower electricity rate. From 2020 to 2023, Tesla, with some funding from the Australian Renewable Energy Agency, equipped 4 000 homes through this programme. In 2023, Tesla gained authorisation to install 3 000 more. The company's goal is to reach 250 MW of rooftop capacity across 50 000 households.

The resulting evidence so far suggests the use of digital tools in large non-residential buildings has delivered benefits (improved energy performance, reduced emissions and bills) almost three times higher than initial costs over a ten-year period.

To further explore the cost benefits of investing in flexibility, the IEA analysed the case of one large industrial consumer in South Australia that has provided data under condition of anonymity. This consumer invested in a microgrid with solar PV and batteries as part of an energy efficiency and building energy management package. This package includes a 1.5 MW battery which has helped the business take greater advantage of periods when prices are negative by charging batteries during these times and discharging them in the evening when prices tend to be high.

Site production, storage and consumption (left) and daily bill (right) of a large commercial energy user in South Australia on a typical day in 2023



Source: IEA analysis based on data from Schneider Electric.

Such digitally enabled building energy management systems, integrated with efficient equipment, have helped provide significant savings on the consumer's energy bills. For instance, on a typical day in 2023 supplying the plant's load curve at wholesale price would have cost USD 2 920 if no solar panel or batteries had been installed. Adding solar PV alone would have reduced the bill by 15%, to USD 2 470. By adding a battery and using it to better align consumption with times when solar production is high, the cost dropped to USD 1 860, or a 36% reduction in energy costs. On that day, savings obtained from batteries exceeded those obtained from solar PV.

In addition to saving on energy costs, the use of batteries and solar PV diminish the user's carbon footprint, by increasing the share of renewable electricity in its consumption. These measures also help protect the consumer against grid outages.

Demand response schemes are rapidly expanding in many other regions around the world

A multitude of countries are now exploring opportunities for demand response programmes to support consumers. Between November 2022 and March 2023, the UK's Electricity System Operator launched a demand flexibility service pilot programme that saved a typical participating household up to USD 120 over the course of the programme. In Thailand, the Energy Policy and Planning Office and Metropolitan Electricity Authority initiated a pilot demand response programme for 2023 that aims to reduce the peak load by 19.5 MW through commercial, industrial and residential consumers.

In 2022, Korea launched a new pilot programme for automated demand response, with intelligent appliances able to automatically respond to demand reduction requests. The results showed a 24% improvement in electricity savings compared to consumers' manual adjustments and paved the way for another pilot programme, which started in September 2023.

The Reynolds Landing Smart Neighbourhood programme by Alabama Power includes the construction of 62 energy efficient homes equipped with smart wall outlets, smart home control panels, smart and energy efficient appliances, triple-pane Low-E glazing, heat pump water heaters, ventilation energy recovery, and wall insulation. Preliminary analysis shows that these homes are generally 35-45% more efficient than Alabama's typical newly constructed dwellings and can offer space cooling load shedding for around four hours without compromising indoor thermal comfort. In the United States alone, it is estimated that a large-scale deployment of efficient grid-interactive buildings would reduce electricity consumption by 400 TWh and peak demand by 120 GW by 2030.

Some projects are also targeting vulnerable households. In Brazil, Smart City Laguna involves the installation of photovoltaic panels, energy storage systems and digital energy management capabilities in 150 homes in Laguna. A series of sensors registering information from electrical systems will alert residents directly on their mobile phones through the Planet App interface, allowing them to adapt their energy consumption. The project proposes a shared benefits arrangement, reducing final users' bills and offering ancillary services.

International learning and knowledge building is a valuable enabler as new fields emerge

Given the regional diversity of experience on this topic the IEA, under its Digital Demand-Driven Electricity Networks (3DEN) Initiative, supported by the Italian Ministry of Environment and Energy Security, is working with countries around the world to enhance knowledge and build capacity. 3DEN's work aims to lead to new and improved policies to support the deployment and use of digital technologies for clean and inclusive energy transitions. Drawing on relevant international trends and best practices, in October 2023, the IEA also published a report on efficient grid interactive buildings that lays out a way forward for countries to improve their policy framework for buildings of the future by increasing energy efficiency and flexibility.

Has the energy crisis accelerated the shift away from gas in residential space heating?

Global residential gas demand rose rapidly until 2022

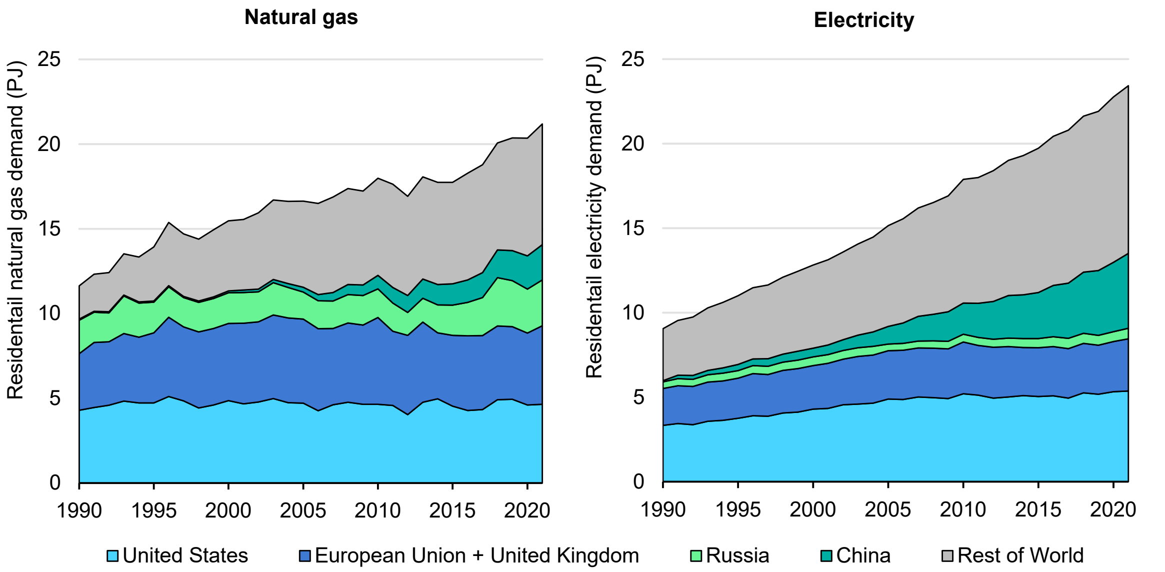
Heating is a significant driver of global energy demand, both in buildings and in industry, and is an important component of energy expenditure for households, especially in colder climates. Many households use natural gas to warm their homes, provide hot water and to cook. However, high gas prices during the energy crisis - and significant policy action in response – have made the business case for electrification of heat more attractive, which is reflected in the sharp increase of residential heat pump sales in 2022. Several countries have implemented or announced plans for phaseouts of fossil fuel boilers, although these have sometimes proven controversial. Governments also introduced minimum energy performance standards requiring heat pumps to be installed. Given all these developments, the energy crisis may have accelerated the shift away from gas for residential space heating.

Based on the most recent data, countries representing 50% of global residential gas consumption have seen their demand peak, stabilize or fall, while countries representing the other half are still experiencing demand growth. The IEA's Outlooks for gas markets and investment report estimates that gas demand in buildings is expected to decline by 65 bcm in advanced economies from 2021 to 2030 thanks to a swift acceleration of efficiency improvements and widespread adoption of heat pumps.

In 2021, the United States (22%), the European Union (17%), Russia (13%) and China (10%) accounted for almost two-thirds of global residential natural gas consumption. From early 2000 until the energy crisis in 2022, residential natural gas consumption remained stable – and high – in the United States, increased and then plateaued in the European Union, and rapidly rose in China and the rest of the world. In particular, a large expansion of housing stock combined with reduced use of coal and fuel switching to gas caused an eighteen-fold increase in residential natural gas demand in China since 2000.

In parallel, electricity demand in the residential sector more than doubled globally – with an eightfold increase in China – between 2000 and 2022. Part of this is driven by increasing consumption through more access to electricity in EMDEs, and growth in the number of appliances such as ACs in both advanced economies and emerging and developing countries, but another part is from a higher level of electrification of heating installations.

Evolution of natural gas and electricity demand in residential sectors, by country and region, 1990-2021



Source: IEA (2023), World Energy Balances, accessed October 2023.

The energy crisis likely marked a pivot for gas due to high prices, new policies and better electric heating

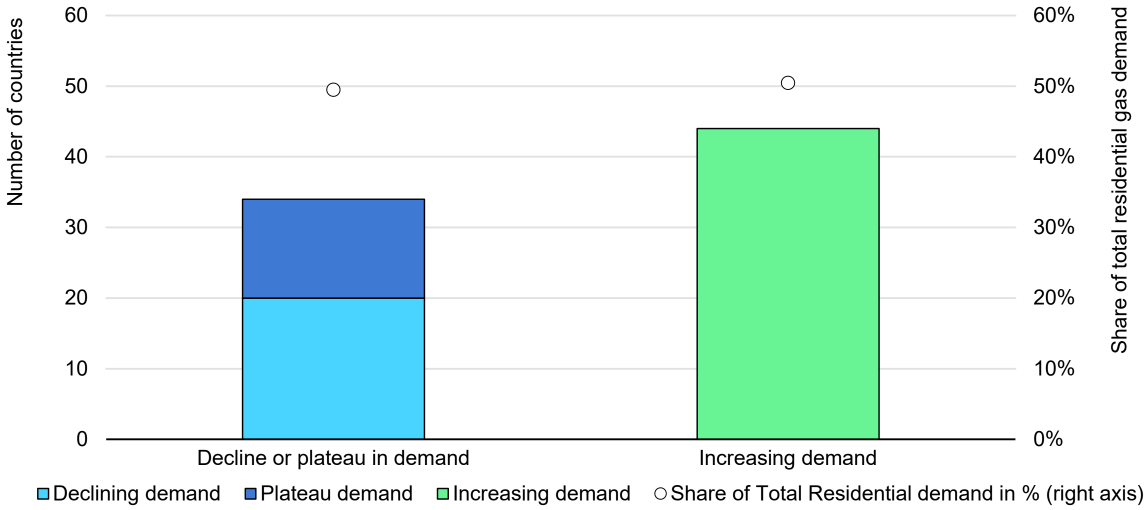
It is likely that the energy crisis has marked a turning point for residential gas demand in Europe. Residential and commercial gas demand dropped by more than 15% in 2022 compared to the year before. While 40% of the decline in residential and commercial demand in Europe can be attributed to weather-related factors (reduced space heating needs due to a mild winter), a substantial part was achieved through various gas-saving measures. These included households switching to alternative fuels, behaviour changes and efficiency improvements such as building retrofits and heat pump installations. Due to the high energy prices, some households and businesses also had to involuntarily reduce their energy consumption.

In 2023, this trend is continuing in the region, with an estimated 9% decrease in Q1-Q3 overall gas demand in OECD Europe, compared to a year before. This suggests natural gas demand in Europe in the residential and commercial sectors is set for a moderate, sustained reduction in the coming years.

Lower natural gas heating demand is also expected in the United States, with the Inflation Reduction Act providing financial support for energy efficiency measures and heat pumps. Residential and commercial gas demand in the United States is forecast to decline at around 1% per year between 2022 and 2026 due to efficiency gains and deployment of heat pumps.

Gas use in the residential sector in China has grown strongly, boosted by policy incentives to replace coal-powered boilers with gas-fired ones. However, residential and commercial gas demand growth is forecast to slow to 5% on average between 2022 and 2026. In emerging markets and developing economies in Asia, residential and commercial gas demand is expected to increase marginally in the medium term.

Residential natural gas demand, World, 2021



Source: IEA (2023), World Energy Balances, accessed October 2023.

Heat pumps fuel an efficiency transformation as supportive policies push sales growth to double digits

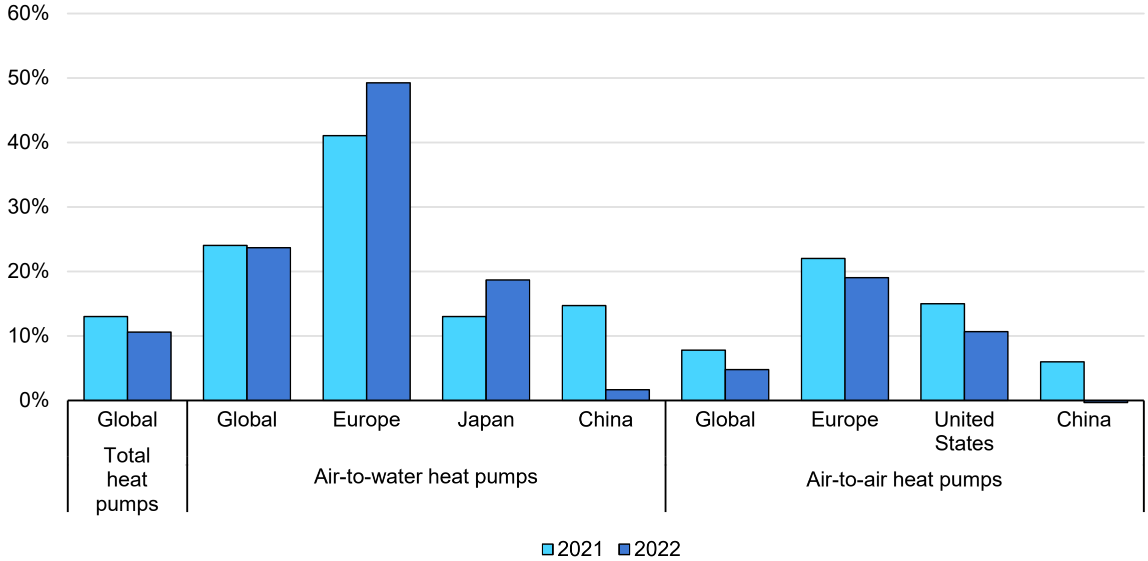
Heat pumps are a central technology in reducing emissions from space and water heating in the buildings sector. Globally, over 100 million households use heat pumps as a main heating source, meaning that one in ten homes that require substantial heating are served by heat pumps. As a result, heat pumps are providing around 10% of the global heating needs in buildings. In the IEA's Net Zero Emissions by 2050 Scenario (NZE Scenario), this increases to 25% in 2030 and 55% in 2050.

The heat pump market has seen a remarkable development during the last years. Global sales rose by 11% in 2022, driven by policy support and incentives amid high natural gas prices and efforts to reduce emissions. Europe experienced a record year, with sales increasing by nearly 40%, particularly for air-to-water models, which saw a 50% rise. In the United States, heat pump purchases surpassed gas furnaces in 2022, while sales in China, the largest heat pump market, remained stable, maintaining the largest overall sales worldwide.

Heat pump sales have been boosted by financial incentives that are currently available in over 30 countries around the world. Collectively, these countries make up more than 70% of global heating demand for buildings. Many countries are also further strengthening existing incentives for heat pumps. In Canada, for example, a new programme announced in October 2023 will make the average heat pump free by providing a grant up to almost USD 11 000 in Atlantic provinces for households at or below median income.

Several countries showed strong growth in the first half of 2023, with heat pump sales up 75% in Germany, the Netherlands and Sweden combined. However, heat pump sales are set to decrease in 2023 in several other countries, such as Italy, Finland and Poland. As a result of the expected decline in sales in 2023 in some countries, the European Heat Pump Association has called for strong and consistent policies to provide certainty for investors and consumers and accelerate the residential energy transition.

Annual growth for heat pump sales in buildings worldwide and in selected markets, 2021 and 2022



IEA. CC BY 4.0

Source: IEA (2023), Global heat pump sales continue double-digit growth.

The United Kingdom has directly linked efficiency and heating system performance through the Boiler Upgrade Scheme, a government financial incentive programme designed to promote the replacement of fossil fuel heating systems with a heat pump or biomass boiler. Countries can also enact requirements for improving the efficiency of existing buildings and thus prepare them for adopting high-performance heating and cooling systems. For example, France prohibits buildings with very low energy efficiency levels (above 450 kWh/m²) to be rented full-time. Requirements will become more stringent with a prohibition to be rented long-term for buildings with EPC class G from 2025, class F from 2028 and class E from 2034.

Residential gas demand expected to show some resilience as more phaseout plans are delayed

In 2022, the United Kingdom, Norway and seven countries across the European Union – together accounting for 80% of residential gas use in the region – had implemented or announced plans to ban new gas boilers in new or existing buildings. In 2023, some governments made these plans more concrete and laid out specific dates on fossil fuel boiler phaseouts or minimum energy performance standards for heating installations. However, other countries have delayed the announced phaseout plans amid acceptance and implementation concerns.

Since 2018, there has been a ban for gas boiler installations in new buildings in the Netherlands. In 2022, the Dutch government announced a new standard from 2026 requiring a (hybrid) heat pump to be installed in buildings when an existing gas boiler needs to be replaced. The updated energy savings obligation mandates hybrid heat pumps for space heating for businesses under certain conditions from 1 July 2023.

The Danish government has had a ban on gas and oil boilers in new buildings in place since 2013 and plans to replace all fossil fuel boilers by 2029 through district heating and heat pumps. Luxembourg announced a phaseout of fossil heating when replacing an existing boiler as well, but initially on a voluntary basis. In Australia, a recent ban on gas boilers installations for new residences in Victoria starting on 1 January 2024 sparked other jurisdictions such as the city of Sydney to announce similar intentions. After the state of California removed incentives to use natural gas in new buildings, the Air Resources Board approved the 2022 State Strategy for the State Implementation Plan, which includes a ban of all fossil fuel-fired boilers by 2030.

The German government proposed to require new heating systems in new and existing buildings to run on at least 65% renewables from 2024 onwards. After months of negotiations, the German parliament passed an amendment to this Buildings Energy Act, which sets the 2024 requirement only for buildings in new development areas, while for installations in all other new and existing buildings the deadline has been extended to 2026 in larger cities and 2028 elsewhere.

The United Kingdom initially planned to ban new oil, LPG and gas boilers in new-built homes from 2026, and new gas boilers in existing buildings from 2035. However, these plans have been pushed back to 2035 and the ban on new gas boilers in existing properties will have 20% of households exempted.

In France, gas boiler installations have been banned in new buildings since 2022 and the government has considered to phase out gas boilers in existing buildings from 2026 onwards. However, in September 2023 the French president ruled out a ban on gas boilers in existing buildings.

The REPowerEU plan also proposed setting stricter limits for heating systems, which were specified in an Ecodesign and Energy Labelling Consultation Forum in April 2023, where the European Commission proposed energy efficiency requirements of space heating by 2029, which would effectively ban stand-alone fossil fuel boilers and mandate (hybrid) heat pumps. However, given the different viewpoints, no decision has yet been made, and the Commission is consulting on possible exemptions.

The energy crisis has led to higher prices for residential gas heating and accelerated the uptake of heat pumps, strengthened by the rollout of government support policies. However, countries are still reluctant to ban gas boiler installations completely given the risk of high upfront investment costs of heat pumps, the lock-in effect of the existing gas infrastructure and current cost of living pressures for households. Recent announcements in several countries to delay such boiler bans show the end of natural gas in residential space heating is not yet in sight, but the transition away from gas is gaining speed.

Can efficient cooling help manage fast rising electricity demand in India and achieve thermal comfort for all?

Increased cooling needs put strains on Indian power grids and people's health

Temperatures have been steadily rising in India, bringing the onset of summer forward by at least one month, combined with more frequent and intense heat waves. With rising daily average temperatures, and growing ownership of air conditioners, peak electricity demand has been growing on average 4% annually over the last decade. As average daily temperatures cross 25 °C, a sharp increase in cooling demand can be observed.

The El Niño-year 2023 saw multiple heat waves, starting with the hottest February on record in the country. Most of the impact from El Niño's heat is expected in 2024. Average mean and maximum temperatures in August were the hottest ever recorded due to large rainfall deficiency and weak monsoon. During August, India's peak electricity demand reached records of over 220 GW on at least 13 days, which marks an unprecedented 23% increase in peak electricity demand. Active cooling technologies, including fans and ACs, were driving forces behind these record peak loads. Only 3% of Indian households use energy efficient ceiling fans, which currently often entail a higher upfront cost but consume 50% less energy than conventional models.

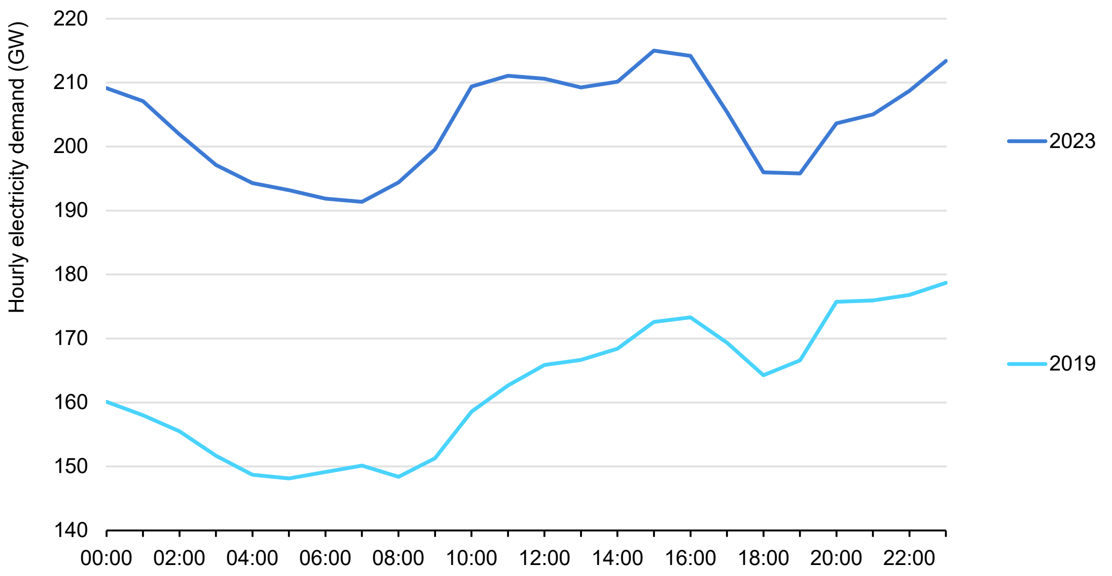
Despite low access rates to air conditioning equipment, ownership rates are increasing. Before 2019, only 1 in 10 households had access to an air conditioner, while 24% of households owned either an evaporative air cooler or an air conditioner in 2021. Electricity consumption due to space cooling increased 21% between 2019 and 2022, and today nearly 10% of electricity demand comes from space cooling requirements. However, there remain many heat-exposed and vulnerable sections of the community who have fewer privileges to stay indoors and lower access to cooling. More than half of the labour force in the country is employed in heat-exposed sectors, including agriculture, mining, and construction.

India is rising to the challenge of electricity records while providing thermal comfort to the most vulnerable

Rising cooling needs and growing ownership of cooling equipment are among the main sources of the increase in India's peak electricity demand. Data on daily electricity loads in the summer months of May and June show that every 1 °C increase in the average daily temperature above 24 °C drives a [2% rise in electricity demand](#).

Between 2019 and 2023, India's hourly electricity demand on a high-temperature day in June (above 36 °C maximum daily temperature) increased on average by about 28%, caused largely by increased ownership of air conditioners to meet higher cooling needs and other appliances. Morning and evening peaks also show a more distinct profile, reaching highs during evening hours. More frequent and prolonged heatwaves, like the one experienced in June 2023 in northern India, put immense pressure on electricity grids by pushing up peak demand for cooling. These can lead to power outages, leaving people without the ability to restore healthy levels of thermal comfort and to keep food and medicines at appropriate temperatures. While solar PV generation matches daytime cooling needs, India's cooling demand also peaks during late evenings and at night.

Electricity demand profile on a high temperature day in June in 2019 and 2023



Source: IEA (2023), Real Time Electricity Tracker.

Under current policy conditions, peak electricity demand rises around 60% from 2022 levels by 2030, with cooling accounting for almost half of this increase.

Meeting growing cooling needs sustainably and reducing peak demand through energy efficiency policies and demand-side management helps to alleviate grid impacts and can lower grid investment needs and system costs, including for storage and expensive standby generation capacity, while providing thermal comfort to all.

Under India's G20 presidency in 2023, the role of efficient cooling and thermal comfort has been recognised in the G20 Voluntary Action Plan and Strategic Plan for Advancing Energy Efficiency across Demand Sectors by 2030. The "Cool COP28" in Dubai is expected to continue this momentum through a Global Cooling Pledge.

India is employing a leading mix of policy instruments, business models and community approaches

Flagship programmes of India's Bureau of Energy Efficiency under the Ministry of Power, including Standards and Labelling (S&L) of appliances, the Energy Conservation Building Code (ECBC), and Eco-Niwas Samhita (ENS), are instrumental in managing rising energy demand in India.

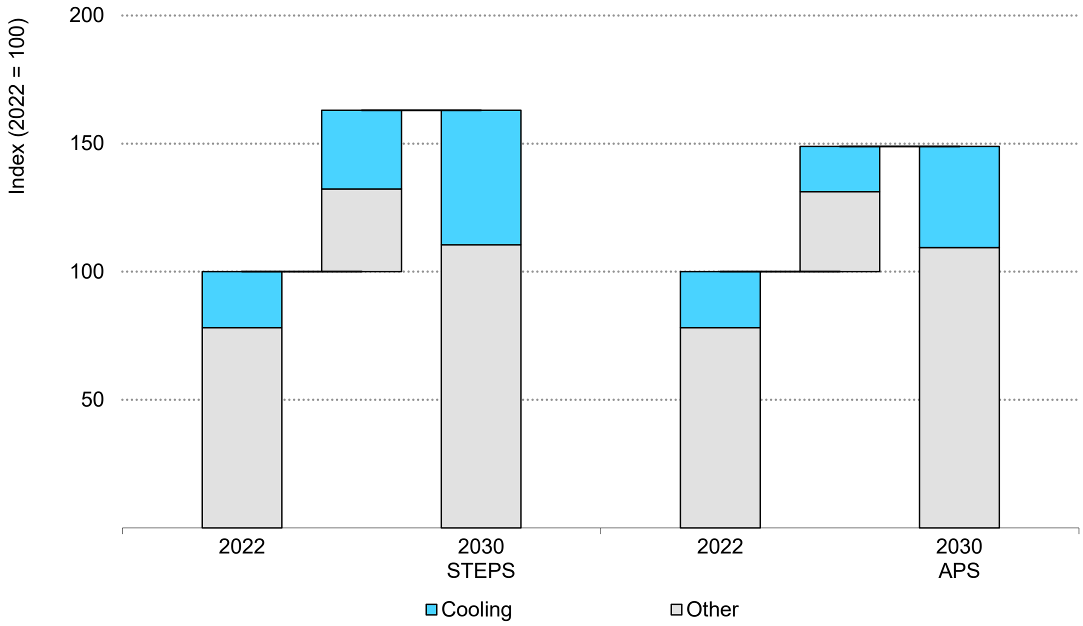
A mandatory S&L programme for air conditioners has been in place since 2009, requiring a 24 °C default temperature setting for all room air conditioners since 2020 as an important measure to induce behaviour change. MEPS and labels for air conditioners now cover 100% of residential space cooling consumption, up from only 37% in 2009.

Given the importance of fans, the mandatory "star-rating" programme was extended to ceiling fans in 2022. In FY 2021-22, these programmes together saved 69.78 TWh and avoided 57 Mt CO2 emissions.

Passive cooling measures, such as cool roofs, could be one of the simplest and most cost-effective interventions to mitigate the need for active cooling and provide thermal comfort. Community-led cool roof programmes have been initiated in Indian cities such as Jodhpur, Bhopal, Surat, and Ahmedabad.

Several demand response programmes are currently being piloted to reduce peak demand. Tata Power Delhi Distribution and Auto Grid launched a pioneering AI-enabled smart energy management system focusing on the behavioural demand response for residential customers in Delhi in 2021, which was expanded to Mumbai in 2023. It aims to engage 55 000 residential consumers and 6 000 large commercial and industrial customers to achieve up to 200 MW of peak capacity reduction by 2025.

The contribution of cooling to peak electrical load in India, 2022 vs 2030 by scenario



Source: IEA (2023), World Energy Outlook 2023.

India's Super ESCO Energy Efficiency Services Ltd (EESL) is working on a market transformation programme for deploying 10 million energy-efficient fans, which consume roughly 50% less energy than traditional fans. These market transformation programmes could provide triggers for the replacement of current ceiling fans with energy efficient fans, potentially resulting in 40 TWh/yr energy savings and peak power demand reduction of 14 GW. Furthermore, a first-of its-kind online marketplace for efficient appliances and equipment will be launched to aggregate demand for energy efficiency projects and open new channels for financing.

Gujarat International Finance Tech (GIFT) City is India's first district cooling system. This system supplies air conditioning to the city's commercial, residential and social buildings through a central plant, thereby eliminating the need for independent air conditioning units. The 14th Clean Energy Ministerial and 8th Mission Innovation meetings held in Goa in July 2023 also saw the launch of district cooling guidelines to support their more widespread implementation.

Energy efficiency companies in India are also beginning to provide innovative technical and financial solutions. The cooling-as-a-service model is being implemented by Smart Joules in several Indian hospitals, resulting in energy savings, reduction of CO_2 emissions and monetary savings to the clientele. The Solar Decathlon India challenges college students to design net zero-energy-water, affordable and resilient buildings to combat climate change and work with real estate developers in implementing net zero solutions.

Abbreviations and acronyms

AC	Air conditioners
APS	Announced Pledges Scenario
CAGR	Compound annual growth rate
CCGT	Combined-cycle gas Turbine
CCUS	Carbon capture, utilisation and storage
CEM	Clean Energy Ministerial
CO_2	Carbon dioxide
EEO	Energy efficiency obligations
EERS	Energy Efficiency Resource Standard
EMDE	Emerging market and developing economies
ESCO	Energy service company
EU	European Union
EV	Electric vehicle
GDP	Gross Domestic Product
GHG	Greenhouse gases
GT CO_2	Gigatonne of carbon dioxide
ICE	Internal combustion engine
IMF	International Monetary Fund
IRA	Inflation Reduction Act (United States)
ISO	International Organization for Standardization
JETP	Just Energy Transition Partnerships
LNG	Liquified natural gas
MEPS	Minimum energy performance standards
NDRC	China's National Development and Reform Commission
NZE Scenario	Net Zero Emissions by 2050 Scenario
PACE	Property assessed clean energy programme
PPP	Purchasing power parity
SME	Small and medium-sized enterprises
Solar PV	Solar Photovoltaics
STEPS	Stated Policies Scenario
SUV	Sports utility vehicle
VSD	Variable speed drives
VFD	Variable frequency drives
W/W	The ratio of the cooling capacity(W) versus power consumption(W)

Units

bcm	billion cubic meters
Btu	British thermal unit
EJ	exajoule
GJ	gigajoule
Gt	gigatonne
Gt/yr	gigatonnes per year
Gt CO_2	gigatonne of carbon dioxide
Gt CO_2/yr	gigatonnes of carbon dioxide per year
GW	gigawatt
GWh	gigawatt hour
Ktoe	thousand tonnes of oil equivalent
kW	kilowatt
mb/d	million barrels per day
MBtu	million British Thermal unit
Mt	million tonnes
Mt CO_2	million tonnes carbon dioxide
Mtoe	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt hour
PJ	petajoule
t/yr	tonne (metric) per year
TWh	terawatt hour

IEA Publications
International Energy Agency
Website: www.iea.org
Contact information: www.iea.org/contact

Typeset in France by IEA - November 2023
Cover design: IEA
Photo credits: © Shutterstock