The Evolution of Energy Efficiency Policy to Support Clean Energy Transitions

International Energy Agency

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Acknowledgements

This report was prepared by the Office of Energy Efficiency and Inclusive Transitions (EEIT) of the Directorate of Energy Markets and Security (EMS) of the International Energy Agency (IEA).

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The work benefited from strategic guidance by Keisuke Sadamori, Director of Energy Markets and Security, and of Brian Motherway, Head of the Office of Energy Efficiency and Inclusive Transitions.

The report was informed by the insights gathered during two high-level expert workshops on “Modernising Energy Efficiency Policy”, the first held on 28 February 2023 and the second at the IEA Energy Efficiency Working Party meeting held on 27 September 2023.

Thanks also go to the IEA Communications and Digital Office (CDO) for their help in producing the publication, especially to Astrid Dumond, Clara Vallois and Therese Walsh. We thank Erin Crum for copy-editing the manuscript.

Finally, the report benefited from the expertise and support provided by Japan’s Ministry of Economy Trade and Industry, as part of Japan’s presidency of the G7.

Key takeaways

Governments, businesses and citizens around the globe are facing the challenge of climate change and how to accelerate the global clean energy transition to reach net zero emissions by 2050 at the latest. Governments and citizens need to act now, with increased ambition, to adopt policies and programmes aimed at the delivery of clean energy transitions. Central to reducing energy-related emissions are the move away from fossil fuel use to electrified systems; significant and sustained improvements in energy efficiency; and an increase in renewable electricity generation capacity.

Implementing the required solutions comes with substantial challenges for governments and policy makers. As our energy system progressively electrifies, the need for increased system flexibility and demand-response measures becomes essential in delivering a secure, reliable and affordable energy future.

This report outlines the ways in which energy efficiency policies can evolve to deliver the energy system that is needed for rapid change now and for the energy system of the future. The key messages are:

- When designed to do so, energy efficiency policies resulting in a reduction in overall energy intensity can also deliver the flexibility, management and demand-response that are necessary to accelerate clean energy transitions.
- Energy efficiency policies that prioritise people can build connections between energy consumers and the energy system that serves them – a vital element in achieving quick action and inclusive transitions.
- Evolving energy efficiency policies can include levers to direct, manage and shape changes in energy systems. In this report we identify two main categories of levers to accelerate clean energy transitions: namely, flexibility levers and engagement levers.
    - Flexibility levers address aspects of the electrical system and the ways in which it can be operated and engaged with to ensure access, reliability, responsiveness and affordability.
    - Engagement levers act to put consumers at the centre of the energy system and focus on the way in which people engage with the energy system, whether through taking deliberate decisions or through prompted actions or behaviours.

This report guides policy makers towards the development of policies that incorporate flexibility and engagement levers to hasten the delivery of the energy system required for clean energy transitions. The challenge is considerable but, as this report demonstrates, governments have already begun the process of transforming their energy efficiency policies to address it. What's more, governments have the tools, technologies and measures available today to not only help meet the challenge but to increase ambition and accelerate global progress on clean energy transitions.

Introduction

In April 2023, the Group of Seven (G7) countries pledged to globally advance and promote a green transformation, working together to realise transformation of economies to reach GHG net zero by 2050 at the latest. In addition, they highlighted the real, urgent need and opportunity to increase energy security and accelerate clean energy transitions at the same time by diversifying supply, sources and routes including by rapidly deploying clean, safe, sustainable and affordable energy and enhancing energy efficiency significantly.

The path to achieving 1.5° C has narrowed, and though the growth of clean energy is keeping the path open, we need to raise our ambition and go much faster in order to achieve our net zero emissions goals. The key actions required to bend the emissions curve sharply downwards by 2030 are well understood – we have the technologies and measures available today. Increased energy efficiency and demand-side management play a central role in this acceleration.

Well-designed and implemented clean energy policies, including energy efficiency policies, are required to facilitate a reduction in fossil fuel demand and create support clean energy expansion. In the Net Zero Emissions by 2050 Scenario (NZE Scenario), strong growth in clean energy and other policy measures together lead to energy sector CO_2 emissions falling by 35% by 2030 compared with 2022.

As part of Japan's presidency of the G7, Japan's Ministry of Economy, Trade and Industry requested the IEA to examine the evolution of energy efficiency policies in the context of clean energy transitions. The aim was to support discussions among G7 countries to provide insights and direction for the G7 energy and climate agenda. This process, which included the delivery of two workshops and the development of a concept brochure, has culminated in this report.

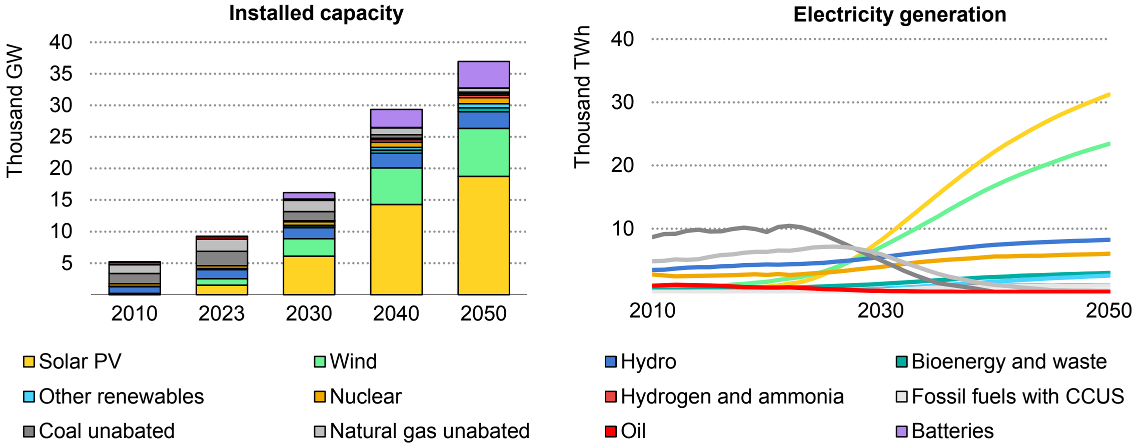
This report outlines the changing energy system and shows why traditional energy efficiency policies must evolve, globally, to ensure clean energy transitions. It proposes a way in which policies can evolve to address system-wide energy efficiency aspects such as flexibility and decarbonisation, as well as the central role of people in the clean energy transition. Finally, the report provides insights into policy developments in major economies, including innovative approaches that focus on demand response requirements in buildings and equipment, vehicle fuel economy-related regulations, and industry reporting systems.

The changing energy system

The necessity to meet climate targets, combined with the increasingly strong economic case for clean energy and the ever-present need for energy security, is causing rapid change in the energy sector. But more needs to be done and at a much faster pace to reach net zero by 2050.

Clean energy transitions will require substantial growth in renewable electricity generation and a significant improvement in energy intensity – a measure of how efficiently the global economy uses energy, along with a mix of other measures including the increase in deployment of all available low-carbon technologies, such as nuclear and carbon capture, utilisation and storage (CCUS), and an increase in the use of low-emission fuels such as hydrogen and biofuels. In the NZE Scenario, tripling the installed capacity of renewables and doubling the rate of energy intensity improvements before 2030 are central to the transformation of the energy sector.

Total installed capacity and electricity generation by source in the Net Zero by 2050 Scenario, 2010-2050

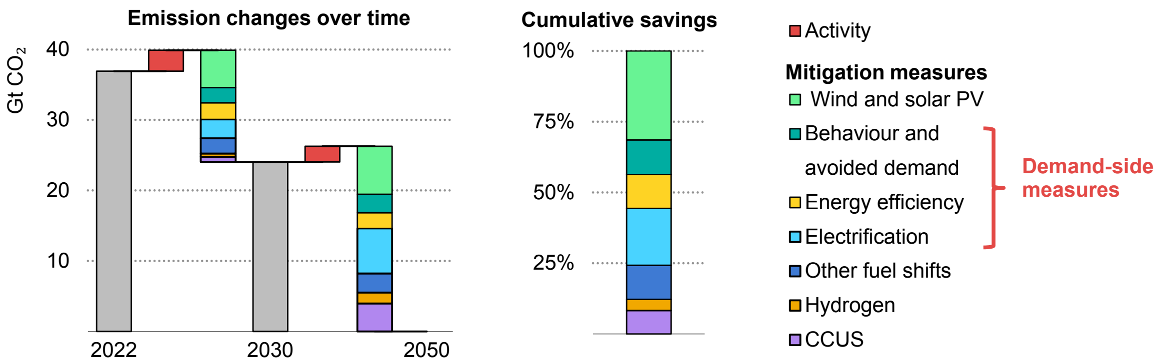


Source: IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach.

In the NZE Scenario, clean, reliable electricity is at the heart of clean energy transitions. However, the delivery of the additional electricity we will need, from clean renewable sources in a secure and reliable way, can be achieved only through a step change in the flexibility of the energy sector.

Flexibility is the ability of a power system to manage the variability of demand and supply reliably and effectively. It ranges from ensuring the instantaneous stability of the power system to supporting long-term security of supply. Electricity system flexibility requires significant growth of a diverse set of technologies and actions in which batteries and demand response play critical roles in the delivery of short-term flexibility.

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



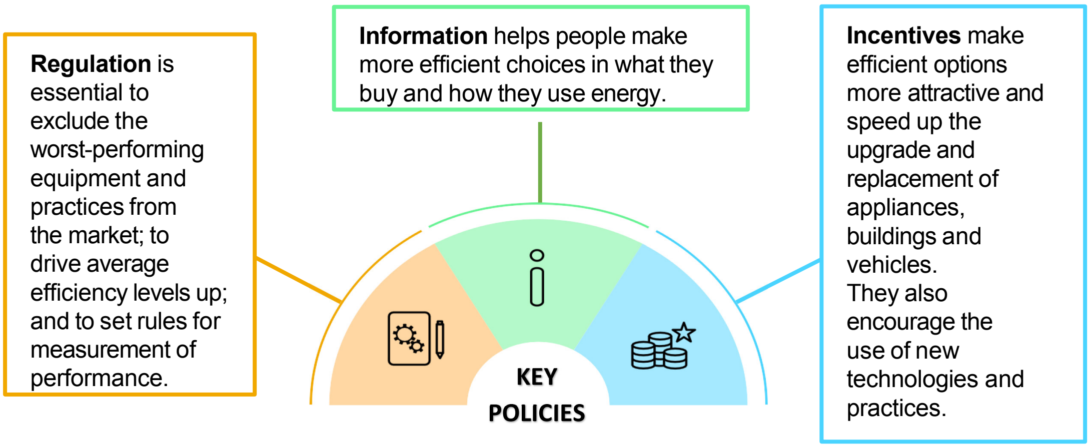
Source: : IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach.

In tandem with the increased electrification of the energy system, progress on energy intensity needs to increase quickly and dramatically. At the global level, energy intensity improvements stem from three equally important actions: improving the technical efficiency of equipment, switching to more efficient fuels, and using energy and materials more efficiently. The increase in energy efficiency in the NZE Scenario saves the energy equivalent of all oil consumption in road transport today, reduces emissions, boosts energy security and improves affordability.

In terms of policy response to the changing energy system, IEA analysis shows that governments can create early momentum by focusing on areas in which policy foundations are already in place. For example, existing tax credits or grants to incentivise the adoption of residential heat pumps can be swiftly scaled up using the same application processes and rules. Similarly, it is much easier to build on existing systems for energy efficiency standards for buildings, appliances or vehicles than to start from scratch. Many countries have standards in place that are outdated or set well below what is considered best practice. Improving these would provide a quick win.

Regulations that were previously based on minimising energy use have changed over time to focus on reducing carbon emissions. For example, fuel economy standards are increasingly based on (tailpipe) GHG emissions complementing vehicle energy efficiency, as in the United States, providing incentives for electric vehicles (EVs). Similarly, energy efficiency policies are beginning to include and address flexibility and grid considerations, as with the California Energy Commission Flexible Demand Appliance Standards for Pool Controls and the Australian demand response capability requirements for installation of all air-conditioning types.

To implement energy efficiency measures, a comprehensive policy package is essential. The IEA policy packages present a practical approach to policy design and implementation built on the foundation of three essential elements: regulation, information and incentives. This bundle of measures supports the transition to increased energy performance levels and enhanced energy system flexibility. Analysis of a sector using the lens of energy efficiency policy packages highlights the key policies available to governments, and how they can be integrated into an effective overall coherent suite of policies and actions to deliver faster and stronger efficiency gains.



IEA. CC BY 4.0.

Careful design and implementation of policy packages will deliver efficiency's full potential to enhance security, create jobs, increase living standards, cut energy bills and reduce emissions.

Using the policy package approach – including regulation, information and incentive mechanisms in policy design – provides a proven framework through which energy efficiency policy can develop to deliver early impact and serve as a foundation to further evolving policies to ramp up implementation.

Evolution of energy efficiency policies to support electrification, flexibility and demand response

	Regulation	Incentives	Information
Buildings	**Building codes** ↪ Solar photovoltaic (PV) ↪ Demand response, e.g., heat pumps ↪ Smart EV charging **MEPS for appliances** ↪ Demand response	**Energy Efficiency Obligations** ↪ Carbon-based obligations ↪ Peak demand targets	**Energy Performance Certificates** ↪ Fuel to GHG
Transport	**Fuel economy standards** ↪ Fuel to GHG ↪ ICE phase-out ↪ EV bonus ↪ EV-to-grid bonus	**Demand incentive schemes** ↪ Subsidies directed to EVs ↪ EV charger subsidies	**Energy label** ↪ Fuel to GHG ↪ EV-to-grid bonus
Industry	**Industry agreements** ↪ Energy to GHG ↪ Electrification (e.g., heat pumps) ↪ Demand response requirements	**Subsidies, grants** ↪ Carbon-reduction based	**Energy and carbon reporting** ↪ Adding GHG reporting ↪ Demand response reporting

Notes: MEPS = minimum energy performance standards; ICE = internal combustion engine.

Energy efficiency already plays an essential role in the path to net zero, but it can and should be leveraged to contribute even more. Energy efficiency policies that result in a reduction in overall energy intensity can also, when designed to do so, deliver the flexibility, asset visibility and demand response that is required for clean energy transitions. Furthermore, energy efficiency policies that prioritise people and inclusivity can build connections between energy consumers and the energy system that serves them – a vital element in achieving quick action and inclusive clean energy transitions.

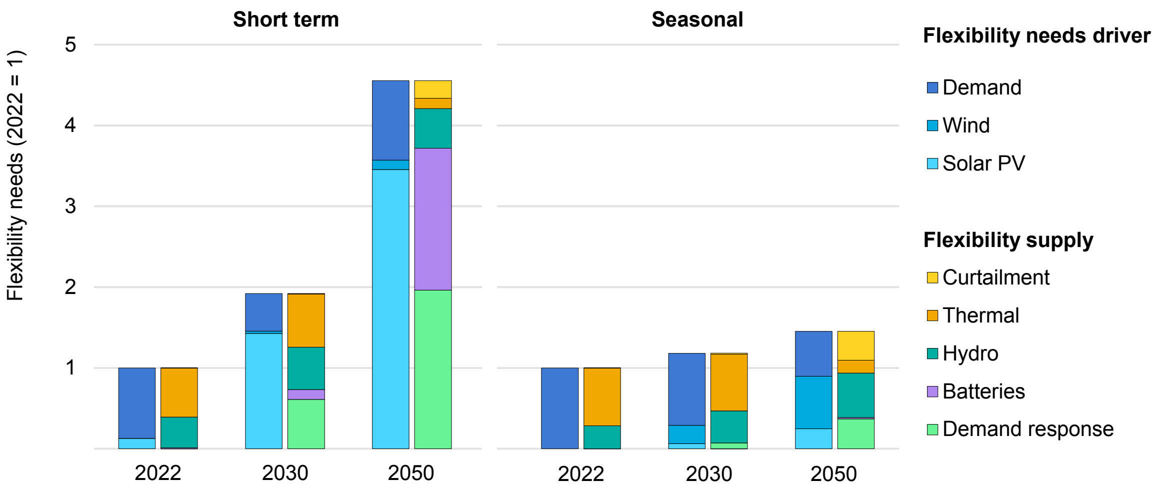
Levers to be incorporated in evolving energy efficiency policies

While reducing energy use and increasing intensity through increased energy efficiency is vital to achieving net zero goals, there are levers that can be included in evolving energy efficiency policies that will support clean energy transitions further. These can be separated into two categories: 1) flexibility levers; and 2) engagement levers, although there is some overlap between the two categories.

Flexibility levers are generally related to the electrical system, and the ways in which it can be operated and engaged with, to ensure access, reliability, responsiveness and affordability. Flexibility levers are data driven and rely heavily on digitalisation, communication and responsiveness of the system.

In the Announced Pledges Scenario (APS) short-term flexibility will need to more than quadruple between today and 2050 in response to new supply and demand patterns. This flexibility will be supplied by a mix of measures including curtailment, thermal, hydro and battery, and demand response, with batteries and demand response emerging as crucial suppliers of short-term flexibility.

Drivers of flexibility demand and supply of flexibility by source in the Announced Pledges Scenario



Notes: For this figure, flexibility is defined as the ability of a power system to reliably and cost effectively manage the variability of demand and supply. It ranges from ensuring the instantaneous stability of the power system to supporting long-term security of supply.
Source: IEA (2023), World Energy Outlook 2023.

With growing shares of variable renewable electricity supply, and increasing electricity consumption, both short-term and seasonal flexibility needs are increasing. Ensuring a reliable and secure electricity supply in the future means ensuring that enough flexible capacity will be deployed to tackle both short-term and seasonal variations of the system. Conventional power generators will have to be more flexible, consumers more responsive, and the infrastructure more equipped and digitalised. Because of the mismatch in production versus use, systems operators are under pressure to provide enough supply to keep the network running at some points while curtailing generation at others – asking people not to generate and paying them not to produce. This poses significant risks to the integrity and reliability of the power system.

Energy efficiency policies designed with flexibility in mind can help to reduce the risk of load mismatching for the system operators, giving foresight to the operator in terms of both production and demand, while increasing their ability to manage the system in real time. This can be achieved through the use of flexibility levers such as:

- **Increasing inbuilt system monitoring, data collection and analysis through policy instruments**, for example the Green Button Programme in the United States that provides utility and energy service provider customers with easy and secure access to their energy usage information in a standardised format, or Datahub in Denmark, which provides open energy system data to the public.
- **Designing energy efficiency-related policies for increased digitalisation**, as with Korea's pilot programme for auto demand response, which has flexible and reliable power system operation as one of its four goals.
- **Incorporating intelligent flexibility requirements for energy products and services, batteries, and renewables into energy efficiency policies**, for example vehicle-to-grid charging in France, Italy, the Netherlands and the United States.
- **Using energy efficiency policies to ensure a high level of demand-response-ready assets (equipment and appliances)**, as with the SG (Smart Grid) Ready label for heat pumps in Germany, which includes information on the technology used to control the heat pump, as well as interface-compatible system components.
- **Designing frameworks that enable asset management at scale across households and businesses**, such as Project Edge in Australia, which is demonstrating how consumer participation in a distributed energy resource marketplace could be facilitated, the Brazilian demand response programme designed to involve the consumer in the energy system, and the Japanese demand response project that involves trialling of remote control of residential energy storage systems in order to optimise the electricity supply-demand balance and to reduce the electricity procurement costs of electricity retailers.

- **Addressing data standardisation and interoperability of devices and systems and data**, for example the European Union interoperability requirements for access to metering and consumption data.

Engagement levers are related to the way in which we, as consumers, producers, operators or users, engage with the energy system. This can be through deliberate decisions taken or through prompted action or behaviour. Engagement levers rely on direct interaction with some aspect of the energy system, and they are often replicable actions, but can also be one-off decisions.

The global population and economy are increasing; by 2030 the world population is expected to be over 8.5 billion, increasing to almost 10 billion by 2050. With increasing population and economic growth comes an increased demand for energy-related goods and services. The actions people take and decisions they make are playing a key role in clean, inclusive transitions, and energy efficiency policies need to evolve to reflect this.

Energy efficiency policies must ensure that consumers are actively involved, engaged, considered and at the heart of power systems. This must be a smooth interaction, where the consumer does not have to think about their relationship with a complex energy system, but rather takes energy efficient actions easily, in a frictionless manner.

This type of interaction and level of engagement can be achieved only through the design and delivery of energy efficiency policies that take the central role of the consumer into account.

Some key engagement levers include:

- **The upscaling of clean transition capacity-building measures** for the evolving energy system, to match (in magnitude of service provision and in delivery timelines) the goals of energy efficiency policies, as demonstrated by the energy adviser recruitment, training and mentorship to support the Canada Greener Homes Initiative.
- **The provision of clear, consumer-friendly energy-related information** (energy use, rating etc.) for energy-related actions at or before the decision-making stage, such as the It All Adds Up energy awareness campaign in the United Kingdom.
- **The inclusion, at purchase stage, of operation and maintenance regulation/provision/structure** for energy-using devices and technologies, as is the case for boilers in France.
- **The use of the choice architecture approach** (prompting choices, in line with the policy goal, by changing the environment in which people make decisions) to facilitate energy efficient choices, as enacted in Norway's Zero-Growth Goal,

which discourages private car travel in urban areas, through the reallocation of road space in cities to uses other than driving.

- **The inclusion of behavioural insights in the design of energy efficiency policy**, as demonstrated in Australia, Brazil, Canada, Finland, Ireland, Japan, the United Kingdom and Uruguay, where dedicated behavioural science teams support policy makers in policy design and implementation.
- **The sharing of best practices and approaches in a systematic manner**, as demonstrated by the Clean Energy Ministerial Energy Management Leadership Awards.

As can be seen from the examples above, many countries are already incorporating some of these levers into their energy efficiency policies; however, there remains a wide scope for further inclusion.

More detailed insights into where and how energy efficiency policy is already evolving, with a focus on the buildings and equipment, transport, and industrial sectors, are given in the next section.

Focus 1: Demand response requirements in buildings and equipment

Electricity currently accounts for 35% of energy use in buildings and is on a significant growth trajectory. Globally, in the buildings sector, the largest increase in energy demand is due to the growth in space cooling, fuelled by, among others, more frequent heat waves and higher standards of living in emerging markets and developing economies. Coupled with this increase in energy use to provide cooling is the growth in electricity demand to address space and water heating requirements as systems are increasingly electrified, primarily using heat pumps. Current globally installed heat pump capacity for both space and water heating is 1 000 GW. In the Net Zero Emissions by 2050 Scenario (NZE Scenario) the capacity reaches 3 000 GW by 2030, with heat pumps meeting 25% of space heating demand, up from a current 12%. In the NZE Scenario electricity use in buildings accounts for 48% in 2030 and 70% in 2050.

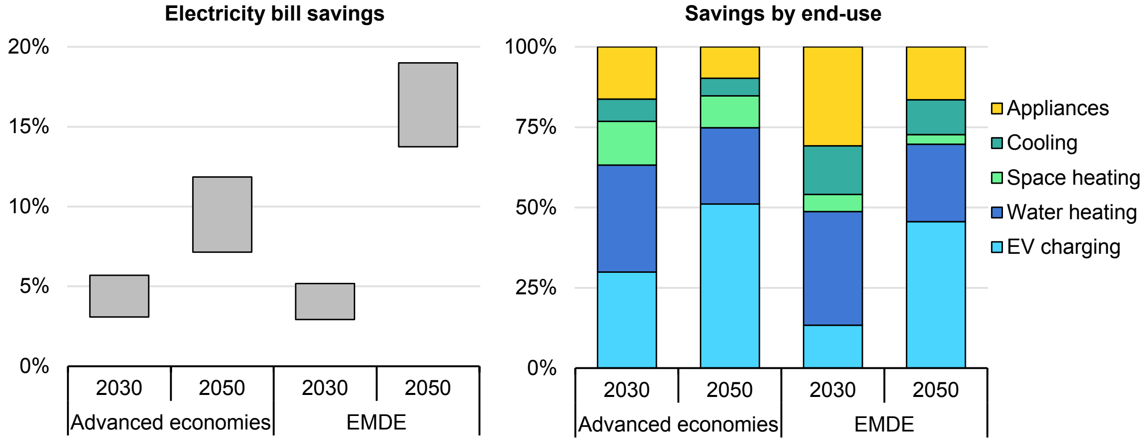
To align with current announced pledges around the world while at the same time delivering the energy services required, the global power system must increase its short-term flexibility almost twofold by 2030. While currently, demand response measures fulfil only a small part of flexibility needs, demand response is expected to grow to about one-third of total short term flexibility needs by 2030.

In power systems with demand-side programmes or aggregators (commercial entities that provide demand response programmes and services) in place, buildings and appliances equipped with smart sensors, meters and controls are enabled to communicate with the grid, and vice versa. Smart systems (combinations of sensors, meters and control devices) enable more efficient management of electricity consumption and can lead to improved energy load management via behind-the-meter generation, storage and participation in demand response. This allows active engagement with the grid and the ability to respond to grid requirements, a particularly important lever for power system stability and in managing peak demand situations.

Smart interfaces offer benefits to both consumers and manufacturers/providers. Smartphone apps offer consumers practical options such as remotely controlling their heating system, for example, to preheat their building after a period of inoccupation or to display a graphical representation of heating load. Depending on data protection policies, manufacturers can use information on heating and app use for advanced data analysis.

In the NZE Scenario, by utilising demand-side response measures consumers can potentially achieve energy bill reductions of nearly 20% by 2050, especially through adjustments in EV charging and water heating schedules. Furthermore, demand response along with smart grids and energy storage enhances power grid stability by motivating customers to adjust their electricity consumption through various incentives, effectively managing variable renewables and growing electricity demand.

Electricity bill savings from demand response for households and by end use in the Net Zero by 2050 Scenario, 2030 and 2050



Notes: EMDE = emerging market and developing economies. Demand response refers to the ability of a consumer to shift consumption in time with no or limited impact on comfort. Estimates of the potential demand-response measures account for technology and acceptability limitations.
Source: IEA (2023), World Energy Outlook 2023.

Most space and water heating heat pumps currently on the market, as well as many air conditioners, are equipped with an interface that at its minimum allows the temporary switching on and off. More advanced control interfaces that can either receive direct commands from the grid operator or receive signals such as energy price or carbon intensity are growing.

However, having interfaces in place does not always result in demand-response-enabled controllers being used, as the benefits to the energy system are not immediately apparent to the consumer. Regulatory action that requires the use of demand-response-ready controls is already being enforced in many regions or is currently proposed as a policy update.

To support the demand response polices there is a need for the design and implementation of effective policy measures and activities based on three fundamental policy elements: regulation, information and incentives. Several countries have already introduced policies to promote demand response and flexibility for both energy-using products and buildings.

Policies that target the replacement of inefficient products and appliances with those that are more efficient can have a quick impact on energy use and have a direct influence on the active stock efficiency levels; in contrast, building regulations can be harder to implement and enforce but have the potential for significant energy reduction impacts in the medium and long term. A well-balanced policy mix takes account of both policy levers. Examples are listed in the following table.

Example of policies and programmes to promote demand response

Country	End use	Policy, description	Year	Status	Type
European Union	Building	**Energy Performance of Buildings Directive – Smart Readiness Indicator.** Quantifying the energy flexibility capability of buildings and representing it in a meaningful way for stakeholders.	2024	Planned	Information
United States, California	Building	**Building Energy Efficiency Standards.** Requirements to install demand response automated systems for heating and cooling as well as lighting using OpenADR, a common open standard for two-way communication.	2022	In force	Regulation
United Kingdom	All appliances	**Smart Systems and Flexibility Plan.** Mandate for large domestic-scale appliances to be interoperable with demand-side response service providers.	2024	Planned	Regulation
European Union	All appliances	**Code of conduct for the energy-smart appliances manufacturers.** Aiming at developing of Interoperability requirements.	2024	Planned	Regulation
Australia	Air conditioners	**Greenhouse & Energy Minimum Standards Demand Response Readiness.** Requirements for room air conditioners to publicly register if they are “demand-response-ready”. Since 2023 only air conditioners that meet the demand response capability requirements can be connected to the South Australian electricity distribution network.	2023	In force	Regulation
Australia	Air conditioners	**PeakSmart air conditioning.** Electricity distribution network operators in Queensland offer rebates for customers who install an air conditioner with digital demand response controls.	2021	In force	Incentive

Country	End use	Policy, description	Year	Status	Type
Korea	Buildings and appliances	**Energy Pause programme** for residential demand response for small consumers and individual households below 200 kW for smart lighting and smart appliances.	2019	In force	Incentive

Since 2020, numerous markets have been expanding their demand response capacity, with some countries initiating their inaugural auctions or broadening their array of demand-side resources. For instance, in 2022, the grid flexibility auction in Japan achieved 2.3 GW in successful bids from demand response operators, constituting roughly 60% of the total bid capacity, more than traditional peak power supply. This marked an almost 80% increase compared with 2020. Likewise, as of November 2022, Korea's demand response market registered around 4.9 GW of capacity.

The progression of demand response polices in the buildings sector can be demonstrated by, for example, following the development of the European Union's Energy Performance of Buildings Directive (EPBD). The first iteration of the EPBD in 2002 included instruments such as Energy Performance Certificates. Updates in 2010 included a focus on near-zero-energy buildings, while the latest update in 2018 introduced building automation and control systems, EV charging infrastructure and a Smart Readiness Indicator. The next EPBD recast, expected to be published in 2024, foresees the inclusion of demand response requirements as well as MEPS for buildings.

Another example of evolving demand response policy can be seen in the proposed updates of Japanese energy efficiency policies to make use of demand response potentials. A specific focus is on incentives and regulation for water heating decarbonisation, with water heating currently accounting for 30% of residential CO_2 emissions in Japan.

And a further example of the progression of demand response programmes can be seen in their use on an as-needed basis in the case of grid overload. For example, as of mid-2022, California extended the Emergency Load Reduction Program (ELRP) to residential consumers and rewards them with USD 2 000/MW demand reduction during grid emergencies. Similarly, in Texas, when electricity demand hit an all-time high this summer, the grid operator increasingly used its demand response and energy flexibility programmes. Such smart interactions require appliances from different manufacturers to be able to communicate and exchange information. Harmonisation of protocols is essential for demand response to streamline communication and ensure interoperability. For example, several major manufacturers have joined together to form the Connectivity

Standards Alliance in order to develop standards that make their products interoperable, leading to the creation of the open-source Matter standard published in 2022.

To deliver flexible and smart demand response systems, policy mandates are required for the standardisation of monitoring, management and data-sharing mechanisms. These mandates act to address barriers to data access, sharing and use, and to ensure robust mechanisms for data protection and cyber resilience for the entire energy value chain. Enforcement mechanisms, including penalties for non-compliance with regulations, are crucial since they ensure adherence and accountability. The level of consumer engagement or compliance is also crucial for demand response as it directly influences the effectiveness of energy-saving measures, optimising resource utilisation. The UK government, the electricity regulator Ofgem and Innovate UK set up the Energy Data Task Force to develop an integrated data and digital strategy for the energy sector in 2018. In its recommendations released in 2019, the Task Force highlighted that progress towards modern energy systems is hindered by poor quality, inaccurate or missing data, and it outlined the actions needed to tackle these problems. Following these recommendations, in 2021 the Energy Digitalisation Task Force was established to continue to support progress towards the effective use of data for clean and affordable energy. Subsequently, the UK government commissioned a digital spine feasibility study with the aim of developing a blueprint of a digital architecture to enable effective data sharing and data interoperability with all the benefits of a smart, flexible, decarbonised energy system.

Examples of countries and regions with standards and norms to control and monitor equipment are shown in the table below.

Examples of standards and norms to control and monitor equipment

Region	Name	Description	Type
European Union	Norm EN 50631-1:2020: European Norm	Describes the necessary control and monitoring for household appliances.	Norm
United Kingdom	PAS 1878:2021	Requirements and criteria for electrical appliance to be classified as energy smart.	Norm
Australia	AS 4755 – Demand Response Standard	Demand response capability and modes of appliances and smart device.	Standard
United States	ANSI/CTA-2045	Specifies a modular communications interface to facilitate communications with residential devices for applications such as energy management.	Standard

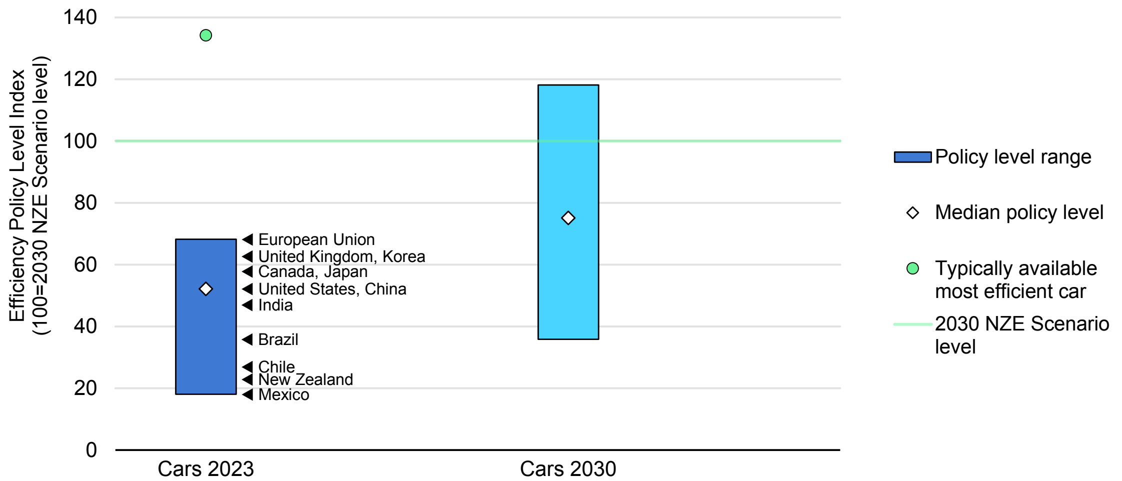
Region	Name	Description	Type
International	IEC 62746-10-1	Open automated demand response system interface between the smart appliance, system or energy management system and the controlling entity.	International standard
United States, California	Senate Bill 49 – The Flexible Demand Appliance Standards	Authorises the Energy Commission to adopt standards for appliances to facilitate the deployment of flexible demand technologies.	Bill

Focus 2: Vehicle fuel economy-related regulations

The transport sector plays its role in moving towards net zero through improved efficiency, decarbonised fuel and greater electrification. In the Net Zero Emissions by 2050 Scenario (NZE Scenario), electric cars make up more than 65% of sales by 2030. The adoption of electric cars is already rapidly increasing. Between 2015 and 2022, electric car sales increased by nearly 2 000%, with over 25 million sold over the period, equivalent to more than all the cars on the road in Canada. By the end of 2023 approximately 14 million in sales could be expected, a 35% year-on-year increase.

Currently, fuel economy/GHG emission standards for new cars exist in over 40 countries, covering more than 80% of new vehicle sales worldwide. The global country range for fuel economy standards for new passenger cars is shown in the following figure, in the context of the IEA Efficiency Policy Level Index.

IEA Efficiency Policy Level Index, fuel economy standards for new passenger cars, global country range, 2023-2030



Notes: An index of 100 denotes the MEPS stringency level for 2030 in the NZE Scenario. 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. Country sample represents 69% of global road transport energy demand.
Source: IEA (2023), Energy Efficiency 2023.

The index is scaled to the efficiency level for new passenger cars as described in the NZE Scenario to help countries track progress against net zero goals. An index value of 100 denotes the policy level equivalent to the NZE Scenario in 2030. The NZE Scenario presents one possible pathway to reach net zero emissions in 2050. However, countries may follow different pathways with differing policy priorities.

There has been substantial progress in this area for new passenger cars, with the Index increasing from a median 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, which have developed over time, have increasingly included provisions to facilitate the uptake of EVs and vehicles using other alternative fuel sources. Regulatory approaches have included:

- zero emissions accounting – EV/hydrogen vehicles are treated as having zero (tailpipe) emissions
- additional counting – each EV/hydrogen vehicle can be counted "more than once" using multipliers/super credits (with terminology differing by country) in the calculation of manufacturers' fleet average emissions.

Combining these two provisions increases their contribution to overall compliance, as the impact of an EV being counted as zero emissions is multiplied. In effect, the production of electricity/hydrogen vehicles makes compliance with regulation relatively easier, reflecting that fuel economy standards for new passenger vehicle sales are primarily on a fleet wide/fleet average basis.

The table below summarises the approaches used in selected countries. The mechanisms of zero emissions accounting and additional counting (multipliers/super credits) have been used in six out of the seven G7 countries, with additional counting being phased out over time. Increasingly, there is a move to phase out ICE vehicles and require that all new sales be zero emissions vehicles.

Vehicle fuel economy-related regulation approaches used in selected countries

Electric vehicle inclusion in regulation	Standard type	Measures to facilitate EVs				Measures to capture impacts		Measures to achieve EV targets	
		EVs are treated as zero emissions/zero energy use		Inclusion of EVs has additional weighting		Accounting of (upstream) electricity related GHG emissions		ZEV mandates or mandate-style approaches	
		Current /Historic	Future	Current /Historic	Future	Current /Historic	Future	Current /Historic	Future
Canada	GHG emissions limits	✓	✓ limit	✓		✓ once cap reached	✓		✓ state level
EU (incl. France, Germany, Italy)	CO_2 emissions	✓	✓	✓					✓
Japan	Fuel efficiency standards top runner approach			✓	✓ (revision)				
United Kingdom	CO_2 emissions	✓	✓	✓					✓
United States	Fuel economy standards and GHG emissions limits	✓	✓ limit	✓		✓ once cap reached	✓		✓ state level

Note: ZEV = zero emissions vehicle.

Source: IEA analysis based on ICCT (2018), ICCT (2019).

In relation to the evolution of vehicle energy efficiency policy two key themes are considered further here. The first relates to GHG emissions and energy use across the vehicle life cycle, and the second relates to the impact of vehicles becoming increasingly larger and more powerful. These themes and the relevant country-led actions are considered below.

To compare the GHG emissions impacts of vehicles across different fuel-powertrain options requires investigation beyond their rated tailpipe CO_2 emissions. 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 example, while tank-to-wheel efficiencies are very high for EVs; due to the absence of thermal losses associated with ICE vehicles, there are combustion and other losses in power generation, transmission and distribution. Low-GHG emissions electricity is needed for full climate change benefits. To obtain a more complete picture of efficiency and CO_2 emissions, a well-to-wheel analysis of EVs is important, particularly in regions where electricity is still predominantly generated by coal.

Life-cycle analysis (LCA) is a way to assess the environmental impact of all stages of a vehicle's life. Increased understanding of upstream and downstream impacts of products and fuels helps ensure that emissions savings are optimised throughout the life cycle. LCA is increasing in importance as vehicle types and the fuel mix change.

While ever more stringent regulations have resulted in vehicles becoming more efficient, gains can be offset by vehicles becoming larger and more powerful. For example, globally, these shifts eroded up to 40% of improvements in fuel economy between 2010 and 2019. Additionally, an increasing number of SUVs are electric at around 16% of total SUV sales, which accounts for over half of global EV car sales for the first time in 2022. For EVs, the increasing size of vehicles has implications for batteries, with average battery sizes increasing by 60% between 2015 and 2021, which has knock-on implications such as increased demand for metals used in batteries. Larger, heavier vehicles can 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.

These factors are starting to be recognised by governments, and countries are putting measures in place to encourage the development and purchase of cars that are efficient over their full life cycle and address increasing vehicle size as part of their vehicle policy packages.

Related to the former, in its fuel economy standard for 2030 Japan is employing a well-to-wheel approach that allows the comparison of primary energy needed for moving the vehicle across different fuels, including electricity.

Other G7 countries are using and developing a range of tools to understand LCA impacts. At the European level, work is being undertaken on a harmonised life-cycle assessment standard for zero emissions vehicles that will enable comparisons between different powertrains and fuel types. In the United Kingdom, research on the LCA of UK road vehicles has been completed. In the United States, Argonne National Lab analysis published new life-cycle analysis in 2022 that includes a broader range of vehicle technologies and current and future conditions. In Canada, specific life-cycle analysis tools are used. The United States and Canada also recognise upstream electricity emissions (well-to-wheel).

LCA is also being included in the incentives and information part of the policy package. Currently, the French government offers buyers of EVs grants of between EUR 5 000 and EUR 7 000; however, from December 2023, the EV purchased will have to meet an environmental score in order to receive the incentive. Car models will need to meet thresholds for a number of factors, including energy used in the life-cycle process (e.g. to make their materials, in their assembly and in their transport to market) and the type of battery in the vehicle. Based on LCA data, the Swedish Energy Agency is considering the development of a guide for vehicle labelling, incorporating the manufacturing phase impact.

In terms of actions to address vehicle size, Japan has promoted very small, lightweight vehicles (Kei-cars) through reduced acquisition and insurance taxes; discounts on rural highway tolls; and exemptions from parking space requirements. Fuel consumption labelling has been mandatory in Japan since 2000. Japan also offers up to JPY 800 000 in subsidies for individual and company purchases of EVs.

In France, fiscal incentives have contributed to CO_2 emissions around 9% lower than the EU average in new passenger cars sold. The “bonus-malus” scheme was strengthened further in 2020, with the maximum "penalty" for consumers of new high-emitting vehicles being doubled to EUR 20 000, and in 2022 when the scheme accounted for the weight of the vehicles. Additionally, advertising of the most polluting vehicles will be banned in France from 2028.

Several cities have started addressing vehicle weight as well. From 2024 in Paris and Lyon, weight-based parking charges will apply. Weight-based charges are also being applied in Tübingen, Germany.

In the United States, proposals to update fuel economy standards for cars and light trucks have been released. These could involve targets of a 2% per year improvement in fuel efficiency for passenger cars and a 4% per year improvement in light trucks and SUVs. The latter reflects the further opportunity to improve the fuel economy of these vehicles and the remaining benefit of fuel economy standards in terms of market share and their fuel consumption. The recent Inflation Reduction Act introduces limits in relation to the price of EVs with credit unavailable for more expensive vehicles.

Internationally, case studies to be drawn upon include Norway and Korea. In Norway, nearly 90% of vehicle sales are now electric, reflecting the use of a broad range of incentives alongside regulatory and information approaches. In 2023, for the first time, taxes were introduced for EVs. From 1 January 2023 there is a weight tax of NOK 12.5 (Norwegian kroner) (USD 1.24) for every kilogramme of vehicle weight above 500 kg as well as a tax based on vehicle price, with value-added tax (VAT) being applied to the portion of the price of battery electric vehicles that exceeds a threshold of NOK 500 000 (USD 49 600).

For the first time in Korea, an energy efficiency label and rating has been provided for electric cars to make it easier for consumers to choose the most efficient EVs, with the requirement that all EVs have it on display by 1 April 2024. In addition, a new facility to test EV fuel economy is planned, and a minimum fuel economy standard will be introduced as an evaluation factor when subsidising electric buses.

Focus 3: Industry reporting systems

Industry is the most energy-consuming and CO_2-emitting end use sector. It accounts for 38% of total final energy consumption and 47% of CO_2 emissions (including emissions from electricity and heat).

It can be a challenging sector to decarbonise; while some industries share similar processes and methods, others are highly individual in their nature, with diverse processes and often proprietary methods. Solutions for energy efficiency and decarbonisation can, subsequently, be highly individual. However, the influence and impact of industrial policy decisions is significant in terms of climate and clean energy transition goals. The challenge for policy makers is to incentivise industrial decisions that set a path towards higher energy efficiency, decarbonisation and just transitions without hurting competitiveness and innovation.

A core requirement to enable successful policy decision-making is the availability of reliable and high-quality information. Improving data collection, tracking and classification systems is one of the recommendations for industry of the IEA's Tracking Clean Energy Progress (TCEP). Access to high-quality data enables governments to track granular progress in their industrial decarbonisation, to initiate or modify key policy strategies, and to evaluate the outcome of policy measures and improve them through data-led decisions. For businesses themselves, the requirement to collect and report on energy and emissions data can help make energy and emissions performance much more visible to senior management. In turn, this can encourage target-setting, and lead to energy efficiency-related projects and commitments to demonstrate improvements year-on-year.

Industrial reporting polices can include measures for capacity building (training and upskilling) in energy and emissions reporting, along with the reporting framework itself. This can help increase the reliability of the data collection and reporting, benefiting both the organisation, at site performance level, and the overall industrial sector, in terms of assessment, benchmarking and competitiveness. Some policy frameworks, such as the EU Energy Efficiency Directive, may gather information through obligated energy audits or energy management system reporting, for enterprises that exceed certain thresholds. These measures which target energy efficiency and energy savings can result in the gathering of energy use-related information; however, reporting is not mandatory.

For several decades, G7 countries have been using reporting systems where industries, above a certain threshold, must regularly report their energy consumption and/or GHG emissions to a government body. This information helps ensure consistency, accuracy and reliability of national energy balances and is used to inform the development of policies and programmes to reduce emissions. Japan has linked its emission control area (ECA) reporting system to a non-binding target for companies to reduce their average energy consumption by at least 1% per year.

In the context of increasingly stringent measures to mitigate climate change, industry reporting has put a stronger focus on GHG emissions accounting to monitor improvement over time. This shift in the focus of industrial reporting towards climate-related mandatory disclosure has grown out of global voluntary initiatives such as the Global Reporting Initiative (GRI), the CDP (formerly known as the Carbon Disclosure Project) and the release of the Recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD) in 2017. Climate-related disclosure incorporates reporting on governance, strategy, risk management and metrics (such as Scope 1, 2 and 3 GHG emissions) as well as corporate targets. These encompass core aspects of effective business management of which energy management (incorporating energy efficiency, demand management and sourcing renewable energy) is a valuable component. Japan is in the process of developing an updated industrial reporting scheme that features demand response provisions, explicitly addressing the challenges of growing peak electricity demand in industrial energy consumption.

From the voluntary foundations of climate-related disclosure, many governments are now establishing mandatory requirements for both public and private businesses. Jurisdictions that have implemented or are developing climate-related disclosure legislation include New Zealand, the European Union, Australia, Singapore, United Kingdom and California. Alongside and supportive of legislative initiatives, clear and consistent reporting standards are being developed to enable interoperability across jurisdictions. Significantly, the International Sustainability Standards Board (ISSB) released the International Financial Reporting Standards (IFRS) S1 (General Requirements for Disclosure of Sustainability-Related Financial Information) and S2 (climate-related disclosures) in June 2023.

The growing uptake of climate-related financial disclosure is supported by efforts of governments to clearly define requirements around climate-related transition plans. Such plans complement mandatory reporting requirements by laying out an entity's targets and actions as it transitions towards net zero emissions. Requirements to develop and/or disclose transition plans will further encourage businesses to consider and implement initiatives associated with electrification, energy efficiency and demand management as part of the organisation's wider climate risk and GHG emissions reduction strategy.

Mandatory disclosure regimes are likely to influence reporting beyond those entities that have legal obligations to report due to requirements for the organisations to report on Scope 3 emissions (that is, emissions that occur beyond the reporting organisation's boundary and across their value chain). This focus on value chains is expected to encourage greater collaboration between businesses as companies exert pressure on their suppliers. Thus, bringing renewed attention to energy management across value chains and expanding the suite of energy and emissions reduction initiatives. This will, in turn, lead to significant and beneficial reductions in energy and emissions and financial costs while simultaneously delivering risk management and reputational benefits.

Though emissions reporting mechanisms are gaining momentum for industrial decarbonisation, the importance of monitoring and reporting actual final energy usage figures should not be underestimated by policy makers. To achieve the Net Zero Emissions by 2050 Scenario will require not only a shift to zero-carbon fuel sources but also, as outlined in this report, reduced energy intensity and increased levels of flexibility and demand management. Therefore, it is essential that final energy usage is reported, understood and reduced, which is facilitated by keeping data and ambitious energy efficiency targets a strong focus of industrial reporting mechanisms and by all decarbonisation strategies and policies.

The following tables provide an overview of major industrial reporting schemes in G7 countries and beyond that have focused on reporting energy and/or GHG emissions to government agencies.

Overview of industry reporting schemes in G7 countries and further examples

Country	Short name	Start year	Status	Reporting threshold level**			Threshold metrics			Metric reported			Demand response provision	Public disclosure
				Site	Organisation (National)	Organisation. (Global)	CO_2	Energy cons.	Energy prod.	CO_2	Energy cons.	Energy prod.		
Australia	NGER	2007	In force	✓	✓			✓	✓	✓	✓	✓	No	Yes
Canada	GHGRP	2004	In force	✓			✓			✓			No	Yes
Japan	ECA	1993*	In force	✓	✓			✓		✓	✓		Yes (revision)	Yes
Korea	GHG-ES	2011	In force	✓	✓		✓			✓	✓		No	Yes
Korea	ECR	1980	In force	✓				✓			✓		No	No
South Africa	NGERs	2011	In force	✓				✓		✓			No	No
United Kingdom	SECR	2019	In force	✓				✓		✓	✓		No	Yes
United States	GHGRP	2009	In force	✓	✓	✓	✓			✓			No	Yes
California	CA-GWSA	2006	In force	✓			✓			✓			No	Yes

* The start year of Japan's ECA refers to the previous legislation. Japan's updated industrial reporting scheme is currently under development and will feature a demand response provision.
** The threshold defines the level at which an organisation begins to be obligated by the reporting scheme.
Note: cons. = consumption; prod. = production.

Further details of industry reporting schemes in G7 countries and further examples

Country	Policy name	Key objectives	Non-conformance enforcement mechanism	Related incentives
Australia	National Greenhouse and Energy Reporting scheme (NGER)	• inform government policy and the Australian public • help meet Australia's international reporting obligations • assist Commonwealth, state, and territory government programmes and activities • contribute to the achievement of Australia's greenhouse gas emissions reduction targets by specifying and ensuring that prescribed Safeguard Mechanism scheme outcomes are achieved.	Civil and criminal penalties and infringement notices.	Australian Carbon Credits Units scheme & The Safeguard Mechanism & Renewable Energy Target (RET)
Canada	Greenhouse Gas Reporting Program (GHGRP)	• support accurate tracking of GHG emissions • contribute to policies and strategies related to climate change, industrial activities, and energy use • provide a consistent, more precise picture of the issue, and contribute to solutions	Penalty in the form of a fine.	Decarbonization Incentive Program
Japan	Rational Use of Energy - Energy Saving Act. (ECA)	• provide industry with judgement criteria • improve efficiency (1% per year) • guideline for implementing energy-saving initiatives.	Penalty in the form of a fine.	Advanced energy efficiency investment
Korea	Greenhouse Gas Emissions Reporting	• one of the South Korean government's main tools in meeting the GHG emissions reduction target of 40% by 2030, as well as the goal of being carbon-neutral by 2050	Penalty in the form of a fine.	Soft Loan for Energy Saving Facilities & Tax Incentives
South Africa	National Greenhouse Gas Emission Reporting Regulations (NGERs)	• register and report annual GHG emissions data and associated activity data • quantify GHG emissions and the embedded parameters for assessing the annual GHG emissions • facilitate easy access to the parameters and GHG emissions factors database embedded into the system.	Penalty in the form of a fine, followed, if necessary, by criminal penalties.	Resource efficient and cleaner production (RECP) interventions
United Kingdom	Streamlined Energy and Carbon Reporting (SECR)	• increase awareness of energy costs and enhanced visibility to key decision-makers • create more of a level playing field among large organisations, in terms of energy and emissions reporting • provide data to inform adoption of energy efficiency measures and opportunities to reduce their impact on climate change.	Penalty in the form of a fine, or prison in extreme cases.	Industrial Energy Transformation Fund Industrial Energy Efficiency Accelerator
United States	Greenhouse Gas Reporting Program (GHGRP)	• provide a better understanding of the sources of GHGs to guide development of policies and programmes to reduce emissions • help businesses track emissions and identify saving opportunities • inform policy at the state and local levels and provide important information to the finance and investment communities.	Penalty in the form of a fine, under the Clean Air Act	EPA technical assistance and partnership programmes

Concluding remarks

Energy efficiency is called the "first fuel" in clean energy transitions, as it provides some of the quickest and most cost-effective CO_2 mitigation options while lowering energy bills and strengthening energy security. However additionally, in this report it is shown that by expanding the scope of energy efficiency policies – from focusing primarily on energy savings to also considering the expansion of renewable electricity supply, system flexibility requirements and heightened consumer engagement – governments can use energy efficiency measures to ensure that people are at the heart of the energy system and that net zero targets can be reached.

The findings and conclusions of this report are the result of a strong and fruitful co-operation between Japan's Ministry of Economy Trade and Industry, as part of Japan's presidency of the G7, and the IEA. This co-operation was further strengthened by the governments that participated in the project workshops and gave the invaluable input and insights that form the basis of this report.

Building on the support provided to the Japanese G7 presidency, the IEA will also support the Italian G7 presidency in 2024 on the road from Hiroshima to Puglia. The IEA's Digital Demand-Driven Electricity Networks (3DEN) initiative, which focuses on the policy, regulatory and investment context needed to accelerate power system modernisation, will strengthen the upcoming Italian G7 presidency continuing the themes of global economic security, energy security and international co-operation, and on the path towards net zero, look towards the grids and cities of the future.

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Typeset in France by IEA - December 2023
Cover design: IEA
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