SUSTAINABLE DATA CENTERS ROADMAP

CHAPTER 6

Government Policy

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October 2025

Innovation for Cool Earth Forum

6 Government Policy

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Data centers are foundational infrastructure for the digital economy— powering email systems, video streaming, e-commerce, artificial intelligence (AI) models and more. As the digital economy has grown rapidly in recent years, governments around the world have paid increasing attention to data centers' energy use and environmental impacts. Electricity demand from data centers has received particular attention. Data centers' greenhouse gas emissions, local air pollutants, water consumption and e-waste have received attention as well.

Policymakers use a range of policy tools to address data centers' energy use and environmental impacts, including disclosure obligations, regulatory standard-setting and fiscal incentives. By far the most common policy is a requirement to achieve a stated level of power usage effectiveness (PUE)[a]. Standards for water usage effectiveness (WUE)[b] and disclosure obligations with respect to energy and water use are becoming more common as well.

Government policies on data centers' energy use and environmental impacts vary widely by jurisdiction. The European Union and several EU countries have disclosure obligations, energy efficiency standards and other policies aligned with their net-

a Power usage effectiveness (PUE) is a data center's total energy use divided by the energy used by its IT equipment.
b Water usage effectiveness (WUE) is a data center's water use divided by the energy used by its IT equipment. WUE is typically expressed in liters per kilowatt-hour (L/kWh).

Many thanks to Minjue Wu, Gareth Jones, Nadia Maunsell and Anne-Amélie Campant for their superb assistance with the research for this chapter.

zero greenhouse gas emissions goals. China, Japan and other Asian governments have energy efficiency standards and policies to encourage data centers to use renewable power. The policies of the US federal government change dramatically from administration to administration, with the current US administration emphasizing new data center construction as a high priority while deemphasizing environmental protection. (Some US states take a very different approach.)

Economy-wide policies (not focused on data centers) play an important role in data centers' energy use and environmental impacts. Policies to promote decarbonization of the electric grid, for example, help determine greenhouse gas emissions from data center power use. (See Chapter 3.2 of this Roadmap.) Energy efficiency standards for commercial buildings, which often apply to data centers, guide the technology choices and management practices of facility operators.

This chapter reviews government policies that specifically address data centers' energy use and environmental impacts. (Economy-wide policies not focused on data centers are mostly beyond the scope of this chapter.) Section A provides a global policy landscape, summarizing policies in key jurisdictions. Section B examines policies by topic, summarizing policies on disclosure, adequacy of power supplies, energy efficiency, renewable power, greenhouse gas emissions, local air pollution, water use and e-waste. Section C discusses the impacts of government data center energy and environment policies. Section D offers recommendations.

A. Global Policy Landscape

i. European Union (~10% of global data center capacity)[1]

European data center policies reflect the European Union's strong commitment to climate action and environmental protection more broadly. Under the European Green Deal and Energy Efficiency Directive (EED) recast of 2023, most data centers must report annually on energy and environmental metrics (including energy use, PUE, water use and waste-heat utilization), implement plans for continual energy efficiency improvement, and use or recover waste heat.[2,3] The European Commission has adopted a sustainability rating system for data centers to benchmark facilities on energy, carbon emissions

and water efficiency.[2] The Climate Neutral Data Centre Pact (supported by the European Commission) commits data center operators to reach 100% carbon-free power by 2030 and meet ambitious energy efficiency targets (e.g., annual PUE ≤1.3 in cool climates and ≤1.4 in warm climates). While voluntary, the Pact was intended in substantial part to pre-empt stricter regulation.[4]

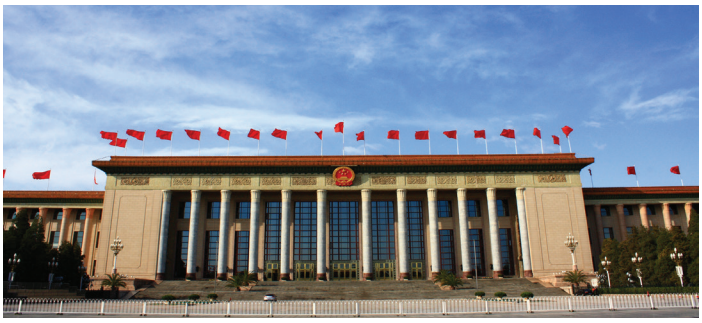
Several EU countries have their own policies to promote data center sustainability, including the following:

- The German government requires data centers to source at least 50% of their power from renewable sources. Starting in 2026, new data centers must have a PUE 1.2 or less and reuse at least 10% of their waste heat. Starting in 2027, all data centers in Germany must source 100% of their power from renewable sources, and new data centers must reuse at least 15% of their waste heat. Starting in 2030, all data centers in Germany must have a PUE of 1.3 or less, and new data centers must reuse at least 20% of their waste heat.[5-7]

- The Irish government imposed a moratorium on data center development and is now considering a proposal to require any new data center to provide dispatchable generation and/or storage capacity equal to its load on-site or nearby.[8-10]

- Denmark recently took several steps to promote the use of waste heat from data centers, including lifting a price cap that limited incentives for use of surplus waste heat and requiring data centers over 100 kW to assess the feasibility of heat recovery.[11-13]

ii. China (~28% of global data center capacity)[1]



The Chinese government has adopted a range of policies to improve the energy efficiency and reduce the environmental impact of data centers. All new large data centers were required to achieve a PUE ≤1.3 by the end of 2023.[14,15] The Chinese government aims to reduce the average PUE of data centers nationwide to 1.5 by the end of 2025.[16,17] The central government's July 2024 Special Action Plan for Green and Low-carbon Development of Data Centers calls for increasing data centers' renewable energy utilization by 10% each year.[17,18] Some provinces, including Inner Mongolia, encourage pairing data centers with renewable power sources.[19,20]

A signature policy is the “Eastern Data, Western Computing” initiative launched in 2022. To serve demand in dense eastern cities, Beijing is incentivizing new hyperscale data center clusters in western provinces where wind, solar and hydro power (as well as land) are more plentiful. By shifting workloads west, the Chinese government aims to decouple data growth from coal-heavy grids in the east.[21,22]

iii. United States (~47% of global data center capacity)[1]

On July 23, 2025, the Trump administration released its AI Action Plan and three related executive orders. These policy documents call for (1) rapid construction of new data center capacity in the United States, (2) streamlined environmental permitting, (3) priority interconnection of dispatchable power sources, including geothermal and nuclear power, (4) construction of data centers and power generation for data centers on federal lands and (5) greater use of AI to accelerate environmental reviews, among other policies.[23,24]

Many US government policies change significantly from administration to administration. Data center energy and environment policies are no exception. Although the Trump administration’s strong support for new data center construction, geothermal power, nuclear power and the use of AI to accelerate environmental reviews are all broadly consistent with Biden administration policies, the current US administration takes a very different approach than its predecessor with respect to several issues including climate change, energy efficiency, solar power and wind power:

- The Biden administration directed all federal facilities, including data centers, to procure 100% carbon-free electricity by 2030. The Trump administration reversed this directive.[25,26]

- For many years, federal agencies ran voluntary energy efficiency programs related to data centers, such as ENERGY STAR for Data Centers (an efficiency certification) and DOE's Better Buildings Data Center Challenge. These programs are being cut significantly or eliminated under the Trump administration.[27]

- The Biden administration strongly supported solar and wind power, including for data center development.[28] The Trump administration does not.

Many US states have laws and policies related to data center energy use and environmental impacts. California, for example, offers incentives for data centers to use renewable energy and requires data centers to meet energy efficiency standards and disclose greenhouse gas emissions.[29-31] Washington exempts data centers that meet green building standards from sales and use taxes.[32] In June 2025, the Texas legislature passed a law requiring data centers and other large electric loads to pay for grid upgrades related to their power demand and to enable remote disconnection for grid operators to use in emergencies.[33-35]

iv. Japan (~4% of global capacity)[1]

In 2022, Japan's Energy Conservation Act was expanded to cover data centers, introducing mandatory energy management and reporting requirements for large facilities. Operators must report PUE and other metrics to Ministry of Economy, Trade and Industry (METI) annually and are expected to meet a "benchmark" PUE target of 1.4—a value set based on performance of the best 15% of facilities. Data centers that fail to make adequate efficiency improvements receive guidance, corrective orders and ultimately public disclosure or fines. Facilities achieving the PUE target may be recognized and eligible for energy-efficiency subsidies. This functions like a "top runner" program for data centers, continuously tightening as more operators hit the benchmark.[36,37]

Japan's "GX (Green Transformation) 2040 Vision" encourages locating data centers near low-carbon energy hubs (e.g., offshore wind farms and nuclear power plants). Announced in late 2024, this policy provides incentives (such as lowered electricity costs and tax rates) for companies to build data centers in regions with substantial renewable power.[38]

v. India (~3% of global capacity)[1]

The Indian government recognizes data centers as critical infrastructure, offering data center tax waivers and streamlined regulatory processes. State-specific policies encourage data center development as well, with some states offering additional incentives for data centers to use renewable energy.[39-41] Tamil Nadu, for example, provides a tax waiver to data centers that buy at least 30% of their power from renewable sources.[42] In 2010, the Bureau of Energy Efficiency (part of India's Ministry of Power) and the Confederation of Indian Industries released Energy Efficiency Guidelines and Best Practices for Indian Datacenters.[43] (The Indian Green Building Council (IGBC) has been promoting an ideal PUE of 1.4 to 1.5.)[44]

vi. United Kingdom (~2.5% of global capacity)[1]

The UK government requires data center operators to report their energy use and greenhouse gas emissions. Data center operators receive discounts on the Climate Change Levy—a tax on business energy use—if they meet energy efficiency targets.[45-47] These measures are part of broader efforts to align the sector with the UK's net-zero emissions target by 2050. To support this transition, the UK government has introduced the AI Energy Council, a cross-sector platform aimed at managing the energy demands of AI and data centers while meeting clean energy targets.[48]

vii. Singapore (~2% of global capacity)[1]

Singapore is a critical data center hub in Asia and one of the first to tie data center expansion to energy and environment issues. From 2019-2022, the Singapore government imposed a moratorium on new data centers due to power and land constraints. In 2022, the government lifted the moratorium but imposed strict standards under its Pilot Data Centre Sustainability Call. New facilities must meet "best-in-class" efficiency standards, including a design PUE of 1.3 or lower and obtain Green Mark Platinum certification. In 2024, the Singapore government released a Green Data Centre Roadmap. The Roadmap includes plans to add 300 MW of data center capacity, with 200 MW allocated to operators who use green energy. Singapore's data center best practices and building codes also include water efficiency measures (measured by WUE).[49-53]

viii. Gulf States (~1% of global capacity, but growing rapidly)[54]

Under its Vision 2030 program, the Saudi government is investing in large-scale renewable energy projects to support data center operations, including the $5 billion net-zero AI data center being developed at Neom's Oxagon hub. The Saudi government is also encouraging the growth of green data centers through tax incentives, grants and investments in renewable energy infrastructure.[55] The UAE government has established the National Team for Reviewing the Impact of Data Centers on the Energy Sector, which includes representatives from various ministries and digital authorities. This team is tasked with analyzing the impact of data centers on energy demand, evaluating the local market, and developing federal policies to regulate the operation of data centers.[56]

ix. Rest of the world

- **Australia and New Zealand (~1.5% of global capacity).**[1] Australia's government mandates that any data center hosting public sector workloads must achieve a PUE of 1.4 and a 5-star rating under the National Australian Built Environment Rating System.[57] New Zealand has no mandatory energy or emissions standards for data centers, but its clean electric grid (80% renewables) has attracted interest from hyperscalers committed to low-carbon data center development.[58,59]

- **South Korea (<1% of global capacity).**[1] South Korea's government requires new data centers to meet energy efficiency criteria as part of their power connection approvals.[60]

- **Southeast Asia (~1% of global capacity).**[1] The Malaysian government offers tax incentives for data centers that achieve several sustainability metrics, including a PUE of 1.4 and WUE of 2.2 m^3/MWh.[61,62] The Indonesian government announced a Green Data Center policy in 2022 and is exploring public-private partnerships to develop green data centers.[63,64]

- **South America, Central America and Caribbean (~1.5% of global capacity).**[1] Few countries in the region have policies specifically addressing data center sustainability, although many have policies promoting renewable energy and energy efficiency that affect data centers. The Mexican government provides subsidies for the use of renewable energy by data centers.[65]

- **Africa (~1% of global capacity).**[1] Africa's data center sector is expanding, especially in Kenya (where 90% of the power is from renewable sources) and South Africa. Governments in both countries are facilitating renewable power projects to meet the demand for cleaner energy in data centers.[66]

x. International organizations

The International Energy Agency (IEA) has emerged as a key global institution for collecting and sharing information on data centers' energy use and environmental impacts. The IEA's Energy and AI Observatory, launched in early 2025, is an important knowledge hub contributing to global policy development.[1] The International Technology Union also does work in this area.[67]

Under the Basel Convention (a treaty with more than 191 member countries), countries may not export e-waste to countries without authorized recycling facilities.[68]

B. Topics

Government policies with respect to data centers' energy and environmental impacts touch a wide range of topics. This section summarizes policies with respect to data centers' (1) disclosure of energy use and environmental impacts, (2) impacts on the adequacy of power supplies, (3) energy efficiency, (4) renewable energy use, (5) greenhouse gas emissions, (6) emissions of local air pollutants, (7) water use and (8) e-waste.

i. Disclosure

Many governments around the world require data center operators to disclose information on energy use, water use and greenhouse gas emissions. Some governments require corporate-level disclosures; others require disclosure at the facility level. Some governments release the disclosures publicly; others keep the disclosures private. Examples of such disclosure requirements include the following:

- The EU's Energy Efficiency Directive (EED Article 12) requires data center operators with an information technology (IT) power demand of at least 500 kW to monitor and report on their energy and water use at a facility level. This information is published in a public database.[17,69,70] The EU's Corporate Sustainability Reporting Directive (CSRD) requires data center operators to regularly report on energy and environmental indicators, including PUE, renewable power as a percentage of total power use (Renewable Energy Factor or REF), and carbon dioxide emissions per unit of energy consumed by IT equipment (Carbon Usage Effectiveness or CUE).

- Germany's Energy Efficiency Act (Energieeffizienzgesetz, EnEfG) requires data center operators to report annually to the government on both energy efficiency and total water consumption.[71,72]

- China's "Eastern Data, Western Computing" initiative requires participating data centers to report energy efficiency metrics to authorities.[73,74] Under the Special Action Plan for Green and Low-Carbon Development of Data Centers, Chinese data center operators must track and improve indicators, including PUE and renewable energy use. Facility-by-facility data are not made public.[19]

- Japan's Energy Conservation Act requires data center companies that exceed certain size thresholds to submit energy reports to METI.[75]

- California's Climate Corporate Data Accountability Act (SB 253) requires businesses with over $1 billion in annual revenues operating in California to report their Scope 1, 2 and 3 greenhouse gas emissions. This affects many data centers.[76,77]

Data center disclosure requirements are expanding to a growing number of jurisdictions and topics. Broad sustainability reporting mandates (covering energy and water use, greenhouse gas emissions and other topics) are becoming standard for large companies in Europe and the Asia-Pacific, requiring data center operators to publicly disclose their energy use and environmental impacts. A growing number of

jurisdictions now require data centers to report energy use at the facility level. Several jurisdictions, including the EU and California, now require data center operators to report Scope 3 emissions (indirect emissions throughout the entire supply chain).[17,36]

ii. Impacts on adequacy of power supply

The rapid growth of data center electricity demand is placing strains on power grids in many regions, raising concerns about the adequacy of electric power supplies (known as "resource adequacy"). Policy responses include grid connection restrictions and grid upgrade requirements.

a. **Grid connection restrictions.** Several jurisdictions with grid constraints have paused or limited new data center connections:

   - The Singapore government imposed a moratorium on new data center projects from 2019 to 2022, citing constraints on energy resources. The government has since lifted the pause but now grants approvals only through a pilot program for a limited number of new projects that can demonstrate best-in-class efficiency and have designs that minimize burden on the grid.[78]

   - In 2022, the Irish government announced that it would no longer accept interconnection applications for data centers in Dublin.[79,80]

   - The city of Amsterdam has a near-total ban on new data centers in certain areas and strict requirements related to land use and grid impact for the few locations where data center development is permitted.[81]

   - In Northern Virginia, several county and municipal governments have imposed restrictions on new data center development. In March 2025, the Loudoun County Board of Supervisors eliminated "by-right" development of data centers (which means special exceptions are now required to develop any new data centers in the county). In September 2024, the Fairfax County Board of Supervisors approved an ordinance imposing strict locational, design, and noise reduction requirements on new data centers. [82,83]

b. **Grid connection requirements.** Some jurisdictions require data centers to fund infrastructure upgrades as a condition for interconnection. The Texas legislature passed such a law in June 2025 (also requiring that data centers allow remote disconnection

in the event of grid emergencies).[33] In Ireland, the electricity regulator has proposed that new data centers will be required to provide generation and/or storage capacity to match the requested connection capacity.[84]

iii. Energy efficiency

Improving energy efficiency is a core objective of data center policies in many jurisdictions around the world. The policy toolkit includes energy efficiency standards, fiscal incentives and requirements to use waste heat. Many energy efficiency policies focus on PUE as a key metric.

a. **Energy efficiency standards**. Many jurisdictions require data centers to meet energy efficiency targets. PUE is overwhelmingly the most common metric

- The European Union sets PUE targets for new data centers (1.3 in cold climates and 1.4 in hot climates) as part of the Climate Neutral Data Centre Pact (a voluntary pact established in part to avoid more stringent regulation).[85]

- Under Germany's Energy Efficiency Act (Energieeffizienzgesetz, EnEfG), all data centers must progressively improve PUE. Starting July 1, 2026, new data centers must achieve PUE ≤1.2—one of the world's most stringent data center energy efficiency standards.[86]

- The Chinese government has a national average PUE target of 1.5 or below for domestic data centers.[16] The "Eastern Data,

Western Computing" initiative funnels new data centers to western regions with ample land, significant renewable power and cool temperatures. These new data centers are required to be highly efficient (PUE well below 1.5) and use free cooling when possible.[87]

- The Singapore government has a PUE target of ≤1.3 at 100% IT load over the next 10 years.[51,88]

- The Australian government requires any data center housing federal agencies' data to achieve a 5-star rating under the National Australian Built Environment Rating System (NABERS), which includes a requirement to achieve a PUE roughly equivalent to 1.4.[17,89]

b. Fiscal incentives. Several governments offer reduced tax rates for data centers that meet energy efficiency benchmarks. The French government, for example, offers a reduced electricity tax rate for operators of energy efficient data centers that adopt certain best practices.[90] The UK government offers a discount on the Climate Change Levy (an energy tax) to data center operators that commit to meeting energy efficiency targets (often PUE or energy usage per rack).[91,92]

c. Waste heat reuse. Several jurisdictions impose requirements related to waste heat reuse in data centers. (See Chapter 2.4.) The European Union requires data centers to reuse waste heat where technically and economically feasible.[93] The German government imposes steadily increasing waste heat reuse obligations on new data centers in the years ahead.[86,94]

Governments take a range of other approaches to improving data center energy efficiency. The Japanese government encourages data centers to be energy efficient with technical guidance and periodic reviews.[36,37] In the United States, some state public utility commissions encourage utilities to run energy efficiency incentive programs targeting data centers. In California and Oregon, for example, power companies offer rebates for installing more efficient cooling or IT equipment.[36,95]

Energy efficiency policies for data centers are a mix of carrots and sticks, including energy efficiency standards (mainly PUE) and tax breaks. There is a trend toward more ambitious approaches, with steadily lower requirements for PUE and higher requirements for waste heat reuse (although the current US federal government is moving in the opposite direction—an important exception).

iv. Renewable energy

A growing number of governments require data centers to purchase renewable power or promote construction of data centers near renewable energy sources. Examples include the following:

- The German government requires data centers to cover 50% of their energy needs with unsubsidized renewable electricity, increasing to 100% by 2027.[86]

- The Chinese government aims to increase data centers' renewable energy utilization rate by 10% annually. Policies support direct transmission of renewable electricity to data centers and establishment of "green power industrial parks" with dedicated renewable sources and storage.[16,17,19] Some provincial and municipal governments in China now require new data centers to include renewable energy integration plans (like solar panels on site or agreements to buy wind power) when seeking approval.[96]

- The Irish government promotes co-location of renewable generation facilities with data centers and encourages advanced energy storage solutions. (85% of data centers in Ireland reportedly use renewable energy sources.[96])

- The Japanese government's GX 2040 Vision supports relocating tech industries near carbon-neutral energy hubs, including offshore wind farms and nuclear plants.[38]

v. Greenhouse gas emissions

A few jurisdictions have adopted greenhouse gas goals for data centers. Many jurisdictions have broader policies that affect data centers' greenhouse gas emissions, such as carbon taxes, emissions trading programs or economy-wide carbon neutrality goals. (See Chapter 3 for a broader discussion of data center greenhouse gas emissions.) The energy efficiency and renewable energy policies described above

generally help reduce greenhouse gas emissions from data centers as well.[c]

a. **Data center carbon neutrality goals.** The Japanese government's Green Growth Strategy calls for data centers to be carbon neutral by 2040.[97] A European Commission white paper on Shaping Europe's Digital Future (February 2020) says that data centers "can and should become climate neutral by 2030."[98]

b. **Broader climate change programs.** Globally, at least 80 jurisdictions have implemented carbon taxes or emissions trading programs.[99] At least 139 countries representing more than 76% of global GDP have pledged carbon neutrality.[100,101] Although these programs generally do not mention data centers specifically, they play an important role in reducing data centers' greenhouse gas emissions – in particular from offsite power plants that sell electricity to data centers (Scope 2 emissions) and from manufacturers of iron, steel, cement, electronic equipment and other products in the data center supply chain (Scope 3 emissions). (See Chapters 3.2 and 3.3 of this Roadmap.)

vi. Local air pollution

Many data centers rely on diesel-fired generators for backup power. These generators are used sparingly but emit nitrogen oxides (NOx), particulate matter and other local air pollutants when used. Citizen groups are increasingly raising concerns about air pollution related to backup generators at data centers, especially in Virginia (which has the largest concentration of data centers in the world).[102-105] Governments have a range of policies to address this problem, including emissions standards, zoning rules and policies to promote cleaner backup power.

a. **Emissions standards.** In the United States, emergency backup generators are subject to relatively lenient federal emissions standards, provided they run during outages and are limited testing only.[106-108] In the EU, data center generators are generally subject to emissions limits under the Medium Combustion Plant Directive (MCPD). If a data center has a large diesel capacity that runs beyond emergency use, it could be regulated under the Industrial Emissions Directive (IED), which has stricter permitting rules.[109]

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c In some situations, energy efficiency and renewable energy policies might not reduce greenhouse gas emissions from data centers. This could happen if (a) energy efficiency improvements lead only to more computation at a data center and not to less energy consumption (a 100% rebound effect) or (b) renewable power supplies in a region are fully utilized and unable to expand, so requiring data centers to use renewable power simply displaces businesses that would otherwise have used renewable power, forcing them to use higher-carbon power such as coal or natural gas instead. These situations are by no means impossible, but in most cases greater energy efficiency and more renewable power will reduce greenhouse gas emissions.

b. **Zoning.** The clustering of data centers has led to targeted zoning and permitting rules to mitigate hotspots of diesel exhaust and noise. In 2024, Fairfax County, Virginia limited the size of data centers in certain zones and included stricter site plan requirements (e.g., placing generators away from residential property lines) to address air pollution and noise concerns.[17,110]

Some governments are funding pilots and demonstrations to develop cleaner backup generators. The EU has funded projects exploring hydrogen fuel cell generators for large data centers, and some European data centers have tested fuel cells in place of diesel generators.[111]

vii. Water use

Governments are addressing data centers' water use with a range of policies including disclosure requirements, efficiency or effectiveness targets, and required use of reclaimed water.

a. **Disclosure requirements.** The European Union requires annual disclosure of data center water withdrawals and consumption (EED Article 12).[2,112] The German government requires data centers to report total water consumption and water use efficiency indicators (Energy Efficiency Act).[72,113]

b. **WUE requirements.** A growing number of governments are imposing requirements related to WUE or similar water use measures. (For a broader discussion of WUE and data center water use, see Chapter 5.) The Chinese government, for example, requires data centers serving government needs to use no more than 2.5 L/kWh of IT energy.[114,115] Governments in Beijing, Ningxia and Gansu mandate higher water use efficiency for data centers and are phasing out those with low water efficiency.[19] The Singapore government aims to reduce the median WUE for data centers from 2.2 m^3/MWh in 2021 to 2.0 m^3/MWh or lower by the early 2030s.[51,88]

c. **Reclaimed water.** In the western United States, some municipalities require use of reclaimed water for cooling and/or stipulate maximum water withdrawal amounts in permits.[116] The Loudon County, Virginia government supports a pipe network that provides reclaimed water to data centers.[117] Singapore encourages use of reclaimed water as well.[118]

Other policy tools for managing data center water use include the requirement to submit water management plans (such as in Singapore).[88] Water use policy for data centers is evolving, with more disclosure requirements, as well as incentives or mandates pushing facilities to adopt cooling solutions that drastically reduce freshwater consumption.[119]

viii. E-waste

The management of electronic waste (e-waste) generated by data centers is a growing concern. (See Text Box on E-Waste.) Key policies include the following:

a. **Hazardous materials restrictions.** Many jurisdictions—including the EU, China, South Korea and California—limit or prohibit the use of toxic substances, such as lead, cadmium and brominated flame retardants, in electronics.[120]

b. **E-waste recycling mandates.** Many jurisdictions have laws requiring electronic equipment to be collected and recycled at end-of-life. This obligation is often imposed on the manufacturer or importer (an approach known as "extended producer responsibility"). A leading example is the EU's Waste Electrical and Electronic Equipment Directive, which obligates manufacturers of electronic goods, including servers and IT hardware, to finance and facilitate the take-back and recycling of e-waste. In 2021, Singapore introduced an E-Waste Management System that places responsibility on producers and importers to collect and recycle e-waste. At least 25 US states have legislation addressing e-waste, with a range of provisions including mandatory recycling requirements and landfill bans.[121-125]

c. **Import and export bans.** China historically was a destination for global e-waste, but in 2017 it banned e-waste imports. Other countries, including Thailand, have adopted similar laws.[126-128] Under the Basel Convention, countries may not export e-waste to countries without authorized recycling facilities. More than 190 countries are Parties to the Basel Convention.[68,129]

C. Impacts of Government Policies

Government policy makers are paying increasing attention to data centers' energy use and environmental impacts, due largely to the surge in data center construction in recent years.[17,47,130,131] In the United States, for example, more than 500 bills related to data center energy use were introduced in state legislatures in the first seven months of 2025—an enormous increase in the number of such bills from prior years.[132] A series of new measures are under consideration in the European Union, Japan and elsewhere.[9,17]

Yet the literature evaluating the impact of data center energy and environment policies is sparse. A 2021 report for the Australian government reviewed studies on energy efficiency of data centers, concluding that "There is little evidence on the effectiveness of the metrics, policies and certifications described in this report."[133] A 2024 report for the IEA on policies regulating data center energy use found that "most have not been in place long enough for their effectiveness to be evaluated."[134] A search for this Roadmap yielded very few studies evaluating the impact of data center energy and environment policies.

Several factors make evaluating the impacts of government policies in this area difficult.

First, data are limited. Data center owners and operators do not typically disclose energy use at the facility level. Some companies volunteer such information for some sites, but facility-level disclosure of energy use at data centers is not standard industry practice. (Facility-level disclosure of water use is more common.)[134-137] Some jurisdictions require disclosure of data center energy use at the facility level, although the information may be closely held by governments and not available to the public. (See Section B.i of this chapter.)

Second, data center operators have incentives to improve energy and environmental performance independent of government policies. Energy efficiency measures can reduce costs and increase output. Use of solar and wind power can speed development of data centers and, in many locations, cut costs as well.[138] "Green" policies can help improve public acceptance of data centers, which are becoming increasingly controversial in some jurisdictions, and head off regulation through voluntary action.[139,140] These factors and others can make it difficult to determine which trends result from government policies and which result from other factors.
Third (and related to the foregoing), the data center industry has longstanding voluntary initiatives to promote clean energy and reduce environmental impacts.[141,142] Indeed the pledges and actions of some of the industry's leading companies with respect to renewable power and greenhouse gas emissions are significantly more ambitious than the policies of many governments.[143,144] (See Chapter 3 and text box on Voluntary Industry Initiatives in this Roadmap.) Figuring out when government policies

are additive to voluntary initiatives can sometimes be challenging.

Recognizing these challenges, this section considers three questions with respect to the impacts of data center energy and environmental policies.

First, do current government policies to promote data center energy efficiency have significant impacts?

There are reasons to be skeptical:

- Most government policies on data center efficiency focus on PUE; however, PUE is a very limited metric. PUE measures the energy efficiency of cooling, lighting and other systems that support servers at a facility, but not the energy use per unit of computation or work.[145] PUE is somewhat analogous to measuring the energy used by a car's air conditioning, lighting and other support systems, but not the car's miles-per-gallon or liters-per-kilometer.

- In addition, as noted above, many data center operators have significant incentives to improve energy efficiency independent of regulatory requirements. This is especially the case where electricity costs are high (such as in much of Europe) and where access to power is the biggest short-term constraint to data center development (such as in the United States today).

- Finally, rebound effects (Jevon's Paradox) significantly complicate assessments of the impact of energy efficiency policies related to data centers. More energy efficient equipment may lead to more computation at a site, not less energy consumption—indeed, it likely already has. Some important objectives of policies to improve the energy efficiency of data centers may not be achieved in whole or in part due rebound effects, although the topic needs considerably more study.[146-148] (See Chapter 1.)

Despite the foregoing, some government policies may help improve energy efficiency at data centers.[140] The US government's ENERGY STAR program has been praised for helping data center owners and operators improve energy efficiency and save money.[149] The EU's Code of Conduct for Energy Efficiency in Data Centers Energy Efficiency may have had similar impacts.[111] The 2024 IEA study noted above found that stricter PUE limits and other government policies would likely reduce energy use at data centers in the years ahead.[36]

Further study on this topic is needed to help guide policymakers.

Second, are governments using the right metrics in data center energy and environment policies?

Again, there are reasons to be skeptical.

A wide range of metrics are available to assess the energy and environmental impacts of data centers. Some of these metrics have been discussed and analyzed by experts for many years:

- In 2010, Japan's Green IT Promotion Council proposed a metric it labeled Data Center Performance per Energy (DPPE), which considers factors beyond the energy efficiency of a facility's cooling, lighting and other support systems, including the energy efficiency of the IT equipment (IT Equipment Energy Efficiency or ITEE), how effectively IT equipment in the data center is being used (IT Equipment Utilization or ITEU), and the proportion of renewable or green energy sources used (Green Energy Coefficient or GEC).[150,151]

- The Green Grid, an industry organization committed to resource efficient data centers since 2007, recently proposed two new metrics: Data Center Resource Effectiveness (DCRE), which "integrates multiple factors that include water usage, geographic consideration, and facility energy effectiveness," and IT Work Capacity (ITWC), which "equips operators to boost energy efficiency [and] supports compliance with global regulations."[152]

- Other relevant metrics include the percentage of energy captured for reuse (Energy Reuse Factor or ERF) and two metrics mentioned in section B.i of this chapter—renewable power as a percentage of total power use (Renewable Energy Factor or REF) and carbon dioxide emissions per unit of energy consumed by IT equipment (Carbon Usage Effectiveness or CUE).[153]

These metrics and others are important for capturing the full range of data centers' energy and environmental impacts. Yet despite a rich literature on these metrics, few government policies refer to metrics other than PUE. There are exceptions, including the EU's Corporate Sustainability Reporting Directive (CSRD), which requires reporting on metrics including REF and CUE, and the growing number of policies that refer to WUE. But the use of metrics other than PUE is not common, frequently limiting the impact of government policies.

Third, what impact do broad economy-wide policies have on data centers' energy and environmental performance?

Although rigorous studies are lacking, broad economy-wide policies appear to have significant impacts on data centers' energy and environmental impacts. Low-carbon goals for the power sector, for example, are central to reducing the carbon footprint of data centers buying electricity from the grid. As noted above, at least 80 jurisdictions have implemented carbon taxes or emissions trade programs[99]; at least 139 countries representing more than 76% of global GDP have pledged carbon neutrality.[100,101] Virginia, which hosts the world's largest data center hub, requires utilities to supply 100% carbon-free electricity by 2045.[154] Policies to speed the permitting of solar and wind power help data center developers meet their voluntary renewables procurement goals.[155]

Green finance policies are another example. As data centers adopt more sustainable practices, they have leveraged green finance products to help access financing and reduce costs.[156] Equinix, the largest global data center and colocation provider of cloud computing, has issued approximately $5.6 billion of green bonds to build sustainable data centers, including a colocation data center in Paris.[157] Fund manager and property owner Areim has raised a total of $971 million to support development of sustainable data centers in Nordic countries through its Areim DC Fund.[158] Singapore-based DayOne Data Centers secured $3.58 billion (SG$4.6 billion) in green financing to support the development of data centers in Malaysia.[159]

Government policies with respect to data centers' energy and environmental impacts are evolving rapidly. Many of these policies have important goals, including managing data centers' considerable energy footprint and minimizing adverse environmental impacts from data center development. But well-intentioned policies can sometimes fail to produce the desired results.[160,161] More work is needed to systematically assess data center policies and refine them for the years ahead.

D. Recommendations

1. *Governments should **collect and share data** on data centers' energy use and environmental impacts.*

2. *Governments should **build capacity to better understand fast-moving trends** with respect to data centers' energy use and environmental impacts.*

3. *Governments should **use a broad set of metrics when regulating data centers' energy use and environmental impacts**, including not just PUE.*

4. *Governments should **assist the rapid buildout of clean power capacity** to help meet growing data center power demand.*

5. *When governments procure data center services, they should **require vendors of data center services to disclose their energy use, water use and greenhouse gas emissions.**[57]*

6. *IEA Member governments should **expand the IEA's Energy and AI Observatory,** devoting additional resources to monitoring and reporting on data centers' energy use and environmental impacts, as well as policy trends with respect to data centers around the world. The Clean Energy Ministerial should **expand CEM's work on data centers** under its power sector and artificial intelligence initiatives.*

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