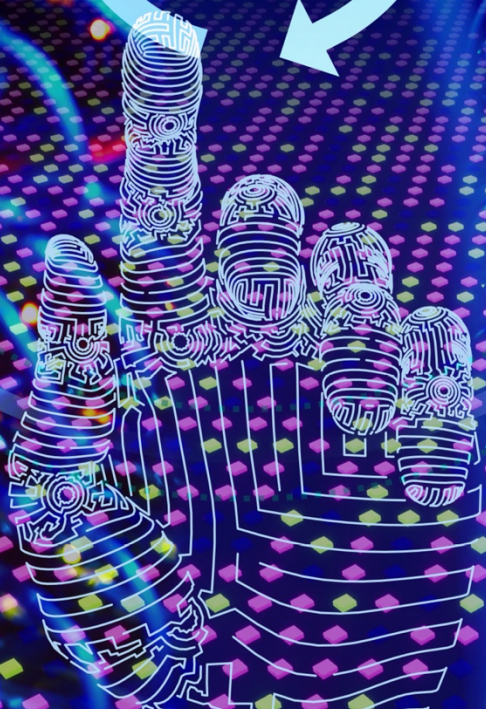**4E** Electronic Devices & Networks Annex EDNA

Policy development on energy efficiency of data centres

FEBRUARY 2024

The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP) has been supporting governments to co-ordinate effective energy efficiency policies since 2008.

Fifteen countries have joined together under the 4E TCP platform to exchange technical and policy information focused on increasing the production and trade in efficient end-use equipment. However, the 4E TCP is more than a forum for sharing information: it pools resources and expertise on a wide a range of projects designed to meet the policy needs of participating governments. Members of 4E find this an efficient use of scarce funds, which results in outcomes that are far more comprehensive and authoritative than can be achieved by individual jurisdictions.

The 4E TCP is established under the auspices of the International Energy Agency (IEA) as a functionally and legally autonomous body.

Current members of 4E TCP are: Australia, Austria, Canada, China, Denmark, the European Commission, France, Japan, Korea, Netherlands, New Zealand, Switzerland, Sweden, UK and USA.

Further information on the 4E TCP is available from: **www.iea-4e.org**

The EDNA Annex (Electronic Devices and Networks Annex) of the 4E TCP is focussed on a horizontal subset of energy using equipment and systems - those which are able to be connected via a communications network. The objective of EDNA is to provide technical analysis and policy guidance to members and other governments aimed at improving the energy efficiency of connected devices and the systems in which they operate.

EDNA is focussed on the energy consumption of network connected devices, on the increased energy consumption that results from devices becoming network connected, and on system energy efficiency: the optimal operation of systems of devices to save energy (aka intelligent efficiency) including providing other energy benefits such as demand response.

Further information on EDNA is available at: **iea-4e.org/edna**

This report was commissioned by the EDNA Annex of the 4E TCP. It was authored by Fiona Brocklehurst of Ballarat Consulting. The views, conclusions and recommendations are solely those of the authors and do not state or reflect those of EDNA, the 4E TCP or their member countries.

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POLICY DEVELOPMENT ON ENERGY EFFICIENCY OF DATA CENTRES

Fiona Brocklehurst, Ballarat Consulting

February 2024

for: IEA's Energy Efficient End-Use Equipment Technology Collaboration Programme - Electronic Devices & Networks Annex

Executive Summary

This piece of work was commissioned by the IEA's Energy Efficient End-Use Equipment Technology Collaboration Programme Electronic Devices & Networks Annex:

- To provide an overview of policies to increase energy efficiency of data centres and to oblige reporting on the energy use of data centres and

- To estimate the effect of possible policy measures if implemented worldwide using an existing model of data and energy use (the TEM).

Energy efficiency and energy reporting policies

A literature search was undertaken focused on countries being of highest interest for new data centre development.

A range of energy efficiency policies were identified, outlined in the main report and described in more detail in appendices. They have been categorised as follows, with the most prescriptive policies first:

Policy category	Countries where adopted
Government permitting schemes	China Singapore
MEPS and obligations	China France Germany Japan Netherlands
Cloud first and data and data centre consolidation policies	Canada France Singapore UK
Public sector procurement policies	Australia EU Germany Netherlands US (California)
Incentive schemes	EU France UK
Voluntary agreements	EU

Some of these policies are supported by national or supranational label or certification schemes, which are also described.

Many of these policies have been adopted recently, most since 2020.

Turning to policies obliging data centres to report energy use, these are of two types:

1. General obligations for large energy users or owners or occupiers of large buildings, that include data centres (as self-contained operations or as co-occupiers of a building). These are generally longer established (some from 2013) and more numerous than each type of energy efficiency policy (in part because in the US and Canada they are put in place by state, province or city rather than the Federal governments) and

2. Obligations specific to data centres. These are more recent (taking effect in 2023 and 2024) and are intended explicitly to gather information to make it easier to make evidence based and effective energy efficiency policies for data centres.

Some of these policies publish the reported data and this can provide an incentive for organisations to increase their energy efficiency in order to increase their competitiveness or improve their reputation for sustainability.

Modelling the effect of possible policy measures

The TEM Business as Usual (BAU) case is the starting point of this analysis. The TEM projects substantial global energy use in data centres of around 230 TWh in 2023, increasing slightly to around 250 TWh in 2030. Over this period data flows are expected to increase substantially but this expected to be largely offset by increasing energy efficiency.

Five energy efficiency measures were modelled to get an indication of their effect. The modelled scenarios and measures were:

1. Moving data flow/processing from traditional data centres to the cloud
2. Reducing energy use by data centre infrastructure
3. Increasing high activity utilisation
4. Increasing server efficiency
5. Increasing equipment shutdown when in low utilisation
6. The combination of all five measures.

Some of these measures have been used in existing policies (for example, China's MEPS for data centres set a minimum PUE) and some have not (for example Increasing equipment shutdown when in low utilisation). Most of these measures were modelled as a single case as there is limited evidence on what change in each metric may be applicable. The exception was energy use by infrastructure – as measured by the Power Usage Effectiveness – which is widely used as a metric in the industry and in existing policy. In this case three values were used representing three different levels of ambition.

All of the measures started taking effect in 2025 and most were phased in over three years, reaching full effect in 2027.

All of the measures resulted in significant energy savings in absolute and percentage terms. The figure below shows the energy savings for each scenario, the table below shows the cumulative savings from when each measure first takes effect in 2025, to 2030 (the end point of the TEM).
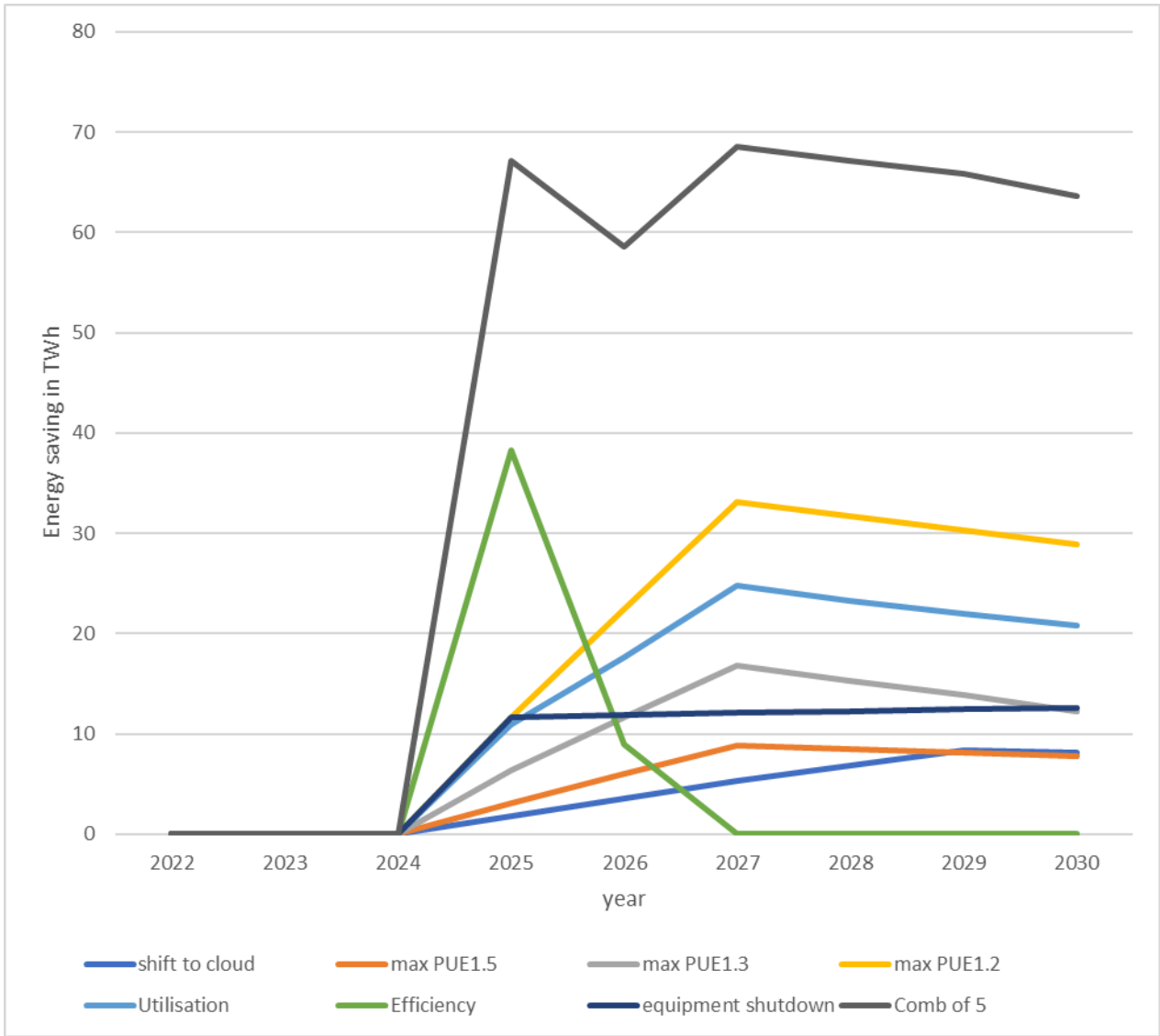
Measure	Cumulative energy savings 2025 to 2030 in TWh
Moving data flow/processing from traditional data centres to the cloud	34
Reducing the energy use by infrastructure (reducing PUE) – (the most demanding value)	158
Increasing high activity utilisation	119
Increasing server efficiency	47
Increasing equipment shutdown when in low utilisation	73
The combination of all five measures.	391

The graph shows that the effect of most of the measures decreases over time; this is because they are overtaken, to a greater or lesser extent, by the efficiency improvements in the BAU scenario. The latter are predominantly improvements in server efficiency but also, to a lesser extent, from reducing infrastructure energy use, increasing utilisation and increasing data flow to cloud from traditional data centres.

Many experts question whether the historic rate of increases in computing power, which drives increases in server energy efficiency, can be maintained. It was decided to model the effect of a reduced rate of increase in server efficiency on the BAU scenario and the effectiveness of the modelled measures. This was set at 60% of the original BAU increase for most types of data centre. In this alternative BAU energy use increased substantially to 370 TWh in 2030. The energy savings from each of the measures was greater in absolute terms than in the original case but lower when expressed as a percentage of the alternative BAU energy. Energy use in the alternative model with all the policy measures applied was found to be greater than the original BAU (with a higher rate of increase in server efficiency but no measures applied) from 2028 on– in 2030 the former is 300 TWh, the latter 255 TWh.

Issues for policy makers to consider

There are many challenges to regulating the energy use of data centres of which perhaps the most important are: their technical complexity and the speed of technology change, the lack of suitable metrics for some aspects of performance and the lack of information on their numbers and performance. The adoption of policies requiring data centres to report their energy use should help to address this last point.

The policy review shows that there are several policy options, although most have not been in place long enough for their effectiveness to be evaluated. Some of these adapted existing policies to include data centres (as in the Japanese obligation[1]) or built on existing procedures or certification schemes (such as the EU Code of Conduct for the EU Taxonomy). However they still required time and effort to customise them for data centres or adapt them for regulatory use.

The results of the modelling undertaken on this project suggest that there is scope for significant savings, both from approaches that have been widely used in industry and mandated in policies, such as reducing infrastructure energy use, and more novel approaches, such as requiring shut down of equipment when in low utilisation.

Finally the alternative scenario, with slower increases in server efficiency, shows how crucial rapidly increasing server efficiency is in constraining data centre energy use as demand for data streaming and processing continues to grow. This may be an area that energy efficiency policy makers need to pay attention to.

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[1] Energy Conservation Act

Table of contents

Glossary

Term	description
BAU	Business As Usual
CoC	Code of Conduct
EDNA	IEA's Energy Efficient End-Use Equipment Technology Collaboration Programme Electronic Devices & Networks Annex
MEPS	Minimum Energy Performance Standard – regulation which sets a minimum energy efficiency requirement for a product to be sold
Non-streaming data	Data other than streaming
PUE	Power Usage Effectiveness defined as $$\frac{(IT\ equipment\ energy\ use + infrastructure\ energy\ use)}{IT\ equipment\ energy\ use}$$
Streaming data	Audio-visual content data transmitted over a network to a Smart TV, Casting Stick or similar entertainment device
TEM	Total Energy Model : The EDNA total energy model (TEM) is a quantitative global model of the 'total energy use' of connected devices. The current version (version 3.0) explicitly includes data centres and enables adjustment of data centre PUE, energy intensity and operating conditions such as utilisation.

1 Background and introduction

1.1 The objectives of the work

EDNA has a workstream on policy measures for energy efficiency of data centres. The goal of this workstream is to provide policy makers with information and evidence-based recommendations for policy measures to improve the energy efficiency of data centres, including the impact of these measures and suggestions for implementation.

Work to date has examined possible metrics for data centre energy efficiency, trends in data centre energy efficiency and assessing the availability of data and including data centres in more detail in the EDNA Total Energy Model (TEM). A separate report, by Brocklehurst (2022) for the IEA EBC Building Energy Codes Working Group provided an overview of existing policy measures.

This report is the deliverable from a project to build on this work to support policy development by:

1. providing an overview of current data collection and registration projects on data centre energy efficiency
2. providing an overview of current and planned government measures on data centre efficiency
3. estimating the effect of possible government measures if implemented worldwide using the TEM
4. providing actionable policy recommendations if possible; if not then issues for policy makers to consider.

1.2 Search methodology for policies and data collection schemes

National or supranational policies

EDNA did not specify particular countries or regions that were of interest. It was necessary to limit the search for relevant policies to some extent in order to deliver the work within time and budget constraints. Previous work (Brocklehurst 2022) had identified Arcadis's[2] ratings of country's suitability for new data centres (Arcadis 2021)[3]. The top 20 rated countries, in order of ranking are:

1. United States
2. Singapore
3. Japan
4. Sweden
5. Norway
6. Denmark
7. United Arab Emirates
8. Finland
9. France
10. Switzerland
11. Taiwan
12. Hong Kong
13. United Kingdom
14. Australia
15. China
16. Korea

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[2] A large multi-national design and engineering consultancy.
[3] This is based on eight factors: GDP per capita, dealing with construction permits; price of electricity; energy security; global cyber security; mobile-broadband subscriptions; domestic market size; mean download speed.

17. Luxembourg
18. Canada
19. Netherlands
20. Poland

This list provided the countries of interest for the search, supplemented by Germany (home to Frankfurt, which is one of the five main data centre locations in Europe[4]). The EU was also added as it includes several of the high ranking countries as members.

The approaches used to find data centre policies in these jurisdictions were:

- For EU countries search the ODYSSEE-MURE database
- For all countries to search the IEA policy database
- For all countries: use the Google search engine using the following search terms:
    o COUNTRY data centre energy efficiency
    o COUNTRY data centre policy
    o COUNTRY building energy benchmarking
    o COUNTRY government data centre consolidation
    o COUNTRY government cloud policy

All searches were done in English. The data centre industry is international and works largely in English so it seems likely that most policies would have been reported in English even if the policies themselves weren't available in English (as was the case for a number of the policies found).

Some policies had already been identified and described in Brocklehurst (2022); in these cases there was a search for updates and changes.

Note that EDNA specifically excluded from consideration building regulations/codes and certification/labelling schemes unless they were referenced by another policy so most of these were omitted.

North American city, state or province policies

The US is the top listed country but it was known that data centre activity is highly localised within the US and energy policy is frequently set at the city or state level. A list of US cities or regions of greatest interest was compiled based on reports by CBRE (2021) and JLL (2021). This resulted in the following list (ranked approximately by size of market):

1. Virginia
2. Dallas (Texas)
3. San Jose (California)
4. Massachusetts
5. New York
6. New Jersey
7. Chicago (Illinois)
8. Phoenix (Arizona)
9. Atlanta (Georgia)

The Canadian cities Toronto and Montreal and provinces Ontario and Quebec were also identified as active markets in the Arcadis ratings and were included.

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[4] Dublin, Frankfurt, London, Amsterdam, Paris

Information on policies was searched for by:

- For all places searching the DSIRE database[5]
- For all places searching the ACEEE policy database[6]
- For all places using the Google search engine using the following search terms:
    - CITY/STATE/PROVINCE data centre energy efficiency
    - CITY/STATE/PROVINCE data centre policy
    - CITY/STATE/PROVINCE building energy benchmarking
    - CITY/STATE/PROVINCE cloud policy
- Using the Institute for Market Transformation resource on building energy benchmarking[7]

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[5] https://programs.dsireusa.org/

[6] https://database.aceee.org/

[7] https://www.imt.org/resources/map-u-s-building-benchmarking-policies/ for the current status and https://www.imt.org/resources/canadian-policies-for-existing-buildings-benchmarking-transparency-and-beyond/

2 Summary of data centre policies: existing and in development

A range of types of policies have been identified and classified into six categories. They are:

1. Government permitting schemes
2. MEPS and Obligations
3. Cloud first and data consolidation policies
4. Public sector procurement policies
5. Incentive schemes
6. Voluntary agreements

Some of which are supported by:

7. Labels and certification schemes

The classification was based on similarities of policies by the means of effect of the policy. Some of the policies could fit into more than one category – for example all incentive schemes are voluntary but the main driver of the policy is expected to be the incentive.

The policies are summarised by category below, with fuller descriptions of each policy, to a standard format, in appendices 1 to 7. They are listed with the most prescriptive policies first, moving from mandatory to incentives and voluntary initiatives.

2.1 Government permitting schemes

In some jurisdictions large scale data centre development[8] requires permits from the central government. Two such policies were found in the regions of interest. The key points of each policy are summarised in Table 1; there is more detail in Appendix 1.

Table 1 Government permitting schemes

Jurisdiction	Policy name	Date of introduction	Parameters covered and target values
China	Three-Year Action Plan on New Data Centres	2021	PUE ≤ 1.3, utilisation rate > 60%
Singapore	Pilot Data Centre Call for Application	2022	PUE ≤ 1.3, Green Mark Platinum rating

2.2 MEPS and Obligations

Two jurisdictions have Minimum Energy Performance Standard (MEPS) for data centres: China, has a Minimum Energy Performance Standard (MEPS) for new data centres and Germany for existing and new data centres. Three jurisdictions place obligations on organisations that are large energy user or the owner/tenants of large building operators to reduce energy and/or meet targets which include data centres.

The key points of each policy are summarised in listed in Table 2 in alphabetical order of jurisdiction.

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[8] For the Chinese policy this is defined as 3000 standard rack sizes (2.5 kilowatt per rack, ie 7.5MW). There is no information on scale in the Singapore announcements.

Table 2 MEPS and obligations

Jurisdiction	Policy name	Date of introduction	Scope	Parameters covered and target values
China	Data centre MEPS. NB Also functions as an energy label	2022	Newly built, renovated and expanded data centres, individual or modular units of data centre buildings with independent power distribution, air cooling, and electric air-conditioning.	PUE with three grades: ● Grade 1: ≤ 1.2 ● Grade 2: ≤ 1.3 ● Grade 3: ≤ 1.5 (minimum)
France	ELAN Decree n° 2019-771 relating to obligations for actions to reduce final energy consumption in buildings for tertiary use	2019 (first target date 2030)	Tertiary buildings with a floor area > 1000m^2 (including small IT rooms in those buildings)	Energy intensity reduction of 40% expressed as kWh/m^2. Data centres can choose to meet a target PUE instead – value dependent on data centre size.
Germany	Energy Efficiency Law	2023	Data centres with IT load ≥300kW	PUE. Data centres existing before 1 July 2026 need to reach: ● ≤ 1.5 by 1 Jul 2027 ● ≤ 1.3 by 1 Jul 2030 New data centres (from 1 July 2026 on) need to achieve PUE ≤ 1.2 and reuse at least 10% of energy.
Japan	Energy Conservation Act	2022	Server rooms with an area of 300m^2 or greater	Target (benchmark) PUE of 1.4

Jurisdiction	Policy name	Date of introduction	Scope	Parameters covered and target values
Netherlands	Energy Saving Obligation and Energy Saving Notification Obligation	2019	Commercial data centre business locations which consume more than 50,000 kWh of electricity or 25,000 m³ of natural gas (equivalent) per year.	Adoption of energy saving measures with a payback period of five years or less. There are three data centre-specific and six server room-specific measures. Businesses are also required to report which of the measures they have adopted every four years.

More detail is in Appendix 2.

2.3 Cloud first and data centre consolidation policies

Historically governments have owned and operated their own data centres and in the last decade or so have looked to consolidate them in order to save costs and energy and increase service robustness. Subsequently, or in parallel, Governments having seen the advantages[9] in moving their computing to the cloud have drawn up policies to encourage this. Examples of one or more these were found in five countries. The key points of these policies are summarised in Table 3, listed by alphabetical order of jurisdiction.

Table 3 Cloud first and data centre consolidation policies

Jurisdiction	Policy name	Date of introduction	Scope
Canada	Cloud Smart	2018 (renewal)	Federal Government digital supply
Canada	Data centre consolidation	2016	Federal Government enterprise data centres
France	Cloud au centre	2021	All State digital services
Singapore	Digital Government Blueprint	2018	Government digital systems
UK	Cloud first	2011	Central government and other public sector organisation (local authorities, health authorities etc)

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[9] The UK government lists the advantages of moving to cloud that (https://www.gov.uk/guidance/use-cloud-first) are:
• spending more time building the services that are important to users and less time running data centres
• avoiding upfront investments on infrastructure
• reducing overall costs by making use of the scalable pricing model
• having greater flexibility to trial new services or make changes, with lower cost and effort
• meeting the Greening Government strategy, and reduce your environmental impact by using cloud facilities with more efficient use of power and server space
• having greater security as the provider will make regular technology upgrades and apply security patches
• having better service availability for all users
• increasing access to skilled resources to support staff
• allowing for better continuous improvement planning

Jurisdiction	Policy name	Date of introduction	Scope
US	Cloud Smart Strategy	2019	Federal Government and their agencies
US	Federal Data Center Optimization Initiative (DCOI)	2016	Data centres operated for 24 Federal departments and agencies
California, US	Cloud first	2014	California agencies and state entities

More detail is in Appendix 3.

2.4 Public sector procurement policies

National governments, state governments and agencies who work for both all purchase data centre services. Several cases of compulsory or voluntary procurement guidance for data centres were found in regions of interest. Some of this guidance has been specifically developed for this purpose, other policies use certification against an existing label of scheme (see section 2.7 and Appendix 7 for information on the latter).

The key points of each policy are summarised in Table 4, listed in alphabetical order by jurisdiction.

Table 4 Public sector procurement policies

Jurisdiction	Policy name	Date of introduction	Mandatory or voluntary	Scope	Parameters covered/ certification used
Australia (New South Wales)	Resource Efficiency	2019	Mandatory	Data centres owned or leased by government agencies	NABERS Infrastructure and IT Equipment rating of at least 4.5 stars
EU	Green public procurement guidelines	2020	Voluntary	Data centres, server rooms and cloud services	Numerous
Germany	Resource Efficiency Programme III	2020	Voluntary with the intention of becoming mandatory.	All IT procurement by the federal government	Blue Angel certification
Netherlands	Sustainable Public Procurement guidance for Networks, Telephone Services and Telephone Equipment	Unknown	Voluntary	Includes data centres	Numerous
California, US	Green Building Action Plan (data centers)	2014	Mandatory	State-owned and leased data centres	PUE, virtualisation, temperature and humidity range

More detail is in Appendix 4.

2.5 Incentive schemes

Incentive schemes for 'good' environmental performance may offer an immediate financial benefit as in the UK case. Alternatively the incentive may be less direct – by making large companies report which of their activities are sustainable, the EU Corporate Sustainability Reporting Directive is expected to organisations that follow good practice to more attractive to investors. This Directive makes use of the EU Taxonomy, which for data centres uses the EU Code of Conduct. The key points of these schemes are summarised in Table 5.

Table 5 Incentive schemes

Jurisdiction	Policy name	Date of introduction	Incentive	Scope	Parameters covered/ certification used
EU	Corporate Sustainability Reporting Directive (CSRD)	2023	Attractiveness to investors	Large EU companies initially, extending to large third country companies which do substantial business in the EU or have securities listed on EU regulated markets (by 2028)	The EU Taxonomy provides a classification system for sustainable economic activities that is applied within the CSRD. Data centres can be assessed as meeting the Taxonomy requirements if they are certified as following the EU Code of Conduct
France	French finance law article 167 and REEN	2021	Rebate on carbon tax	Unclear	Numerous
UK	Climate Change Agreement	2013	Rebate on carbon tax	Colocation data centres with a minimum power supply of 240kW, a floor area of over 200m^2 and emergency back-up power to allow continuous running	Meeting % target reduction in PUE over a two year period.

These policies are described in Appendix 5.

2.6 Voluntary agreements

One voluntary agreement was found in the regions of interest, in the EU. The key points of this policy are summarised in Table 6.

Table 6 Voluntary agreements

Jurisdiction	Policy name	Date of introduction	Scope	Parameters covered and certification used
EU	Climate Neutral Data Center Pact	2023 (deadline to certify adherence)	Trade associations representing data centre operators or companies that own or operate data centres (≥50kW of maximum IT power demand) within the EU	New data centres PUE ≤ 1.4 by Jan 2025. Existing data centres, PUE ≤ 1.4 by Jan 2030. Signatories are required to use accredited third party auditors to certify adherence.

More detail is in Appendix 6.

2.7 Labels and certification schemes

There are numerous labels and certification schemes, many of which are listed in an earlier report[10]. Some schemes are drawn on by one or more policies above and so are included here. The key points of each policy are summarised in Table 7, listed by alphabetical order of jurisdiction.

Table 7 Labels and certification schemes

Jurisdiction	Policy name	Date of introduction	Associated policy	Scope	Parameters covered/ certification used
Australia	NABERS	2014	NSW Resource Efficiency (procurement)	87,600 kWh for 1 year or with IT equipment greater than 10 kW for Infrastructure ratings	Star rating Rating is based on GHG emissions using a customised benchmark. For infrastructure ratings this is related to PUE.
EU	Code of conduct (CoC) for data centres	2008	EU CSRD via EU taxonomy	Not stated	Many parameters – including PUE.
EU	EU taxonomy	2022 (for data centres)	EU CSRD	Not stated	Data centres can be certified as meeting the screening criteria by being assessed as following the EU CoC using the assessment framework.

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[10] Brocklehurst 2022

Jurisdiction	Policy name	Date of introduction	Associated policy	Scope	Parameters covered/ certification used
Germany	Blue Angel	2012 (2023 update)	Resource Efficiency Programme III (procurement)	Not stated	Many parameters including PUE and server utilisation.
Singapore	BCA-IDA Green Mark for Data Centres	2013 (2020 update)	Pilot Data Centre Call for Application (Government permitting)	Not stated	There are four levels of certification: • Certified, • Gold, • Gold plus • Platinum with many parameters including PUE.
US	ENERGY STAR	2010	North American benchmarking policies	A number of parameters including a constant power load of 75 kW or more	Score of 0 to 100. Buildings with an ENERGY STAR score of 75 or higher are certified.

More detail is in Appendix 7.

3 Summary of data collection and benchmarking policies

It has been recognised that increasing the amount of published data on data centre performance could have positive effects:

1   Directly – by enabling customers to compare the performance of different data centre providers enabling them to make informed decisions and choose more efficiency suppliers.

2   Reputationally – providing an incentive for data centre providers to improve performance.

3   Enabling informed and therefore more effective policy making.

The policies in the regions of interest are described in this section, firstly national and supranational schemes followed by city, state and province policies (all in North America).

3.1 National and supranational data collection and benchmarking policies

Four policies which require the energy use of data centres to be reported and in some cases benchmarked were found in the countries of interest. Two of these are broader building energy reporting policies which include or have been extended to include data centres, in France and Japan. These policies also place other obligations on data centre performance which are outlined in section 2.2 and described in more detail in appendix 2. The other two examples, in the EU and Germany, place obligations on reporting specific to data centres; the German law also places other obligations on data centres as described in section 2.2. A fifth policy, also in France, places an obligation on data

centres to have and publish targets in line with national targets, for reducing their environmental footprint, particularly in terms of reducing greenhouse gas emissions and the lifecycle impact of their products. All of these policies have been adopted in the last few years.

The key points of each policy are summarised in Table 8 listed in alphabetical order of jurisdiction.

Table 8 Key features of national and supranational data collection and benchmarking policies

Jurisdiction	Policy name	Date of introduction	Threshold	DC specific or general	Energy data published	Additional requirements
EU	Energy Efficiency Directive (recast)	2024[11]	IT equipment ≥ 500kW	Specific	Yes, aggregate	Data centres ≥ 1MW to take into account best practices in EU CoC. Also to ensure these data centres use waste heat unless not technically or economically feasible
France	ELAN	2023	Total building area ≥ 1000 m^2	General	Energy performance of a sector for a given year	See the description in section 2.2
France	REEN LAW no. 2021-1485 of November 15, 2021 aimed at reducing the environmental footprint of digital technology in France	2023	In development	Specific	No (no energy data reported)	Targets for reducing environmental impact
Germany	Energy efficiency law	2024?	IT equipment ≥ 300 kW	Specific	Yes	See the description in section 2.2
Japan	Energy Conservation Act	2022	Total building area ≥ 300m^2	General	No	See the description in section 2.2

More detail is provided in Appendix 8.

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[11] The EED data reporting requirement applies from May 2024.

3.2 North American province, state and city data collection and benchmarking policies

The first policies requiring annual reporting of the energy use of large buildings in North America were adopted in the US the early 2010s. The rate of adoption is increasing[12] and provinces and cities in Canada[13] have followed the US lead. Ten policies were found for cities, states or provinces in areas of interest. All of them are general, that is they apply to buildings with a floor area above a given threshold (which vary) but include data centres. There is a mix of requirements: some publish the data, fully or in part; some policies place obligations beyond reporting. All the policies that describe how to submit data (not yet available for the most recent policies) require building owners/operators to use US Environmental Protection Agency's ENERGY STAR Portfolio Manager to report a site's energy data. This tool includes 80 or so property types, one of which is specifically for data centres[14].

The key points of each policy are summarised in Table 9, listed in alphabetical order of city/state/province.

Table 9 Key features of North American province, state and city data collection and benchmarking policies

Jurisdiction	Policy name	Date of introduction	Threshold (total building area)	Energy data published	Additional requirements
Atlanta	Commercial Energy Efficiency Ordinance	2019	area ≥ 2322 m^2	No	ASHRAE Level 2 energy audit conducted every ten years.
Boston	Building Energy Reporting and Disclosure Ordinance (BERDO).	2019	area ≥ 1858 m^2	Yes	Third-party verification of buildings' data is required for the first year of reporting. Emissions requirements are set for five year periods, starting 2025-2029, expressed in kgCO$_2$e/SquareFoot/yr
California	Building Energy Benchmarking Program	2018	area ≥ 4645 m^2	Yes	None
Chicago	Energy Benchmarking Ordinance	2013	area ≥ 4645 m^2	No	Data has to be reviewed by 3rd party every 3 years

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[12] See https://www.imt.org/resources/map-u-s-building-benchmarking-policies/ for the current status

[13] See https://www.imt.org/resources/canadian-policies-for-existing-buildings-benchmarking-transparency-and-beyond/ for the current status

[14] See https://portfoliomanager.energystar.gov/pm/glossary?_gl=1*wjsrmj*_ga*MTU3MjUxMDc0Ny4xNjg0MzMzMjk4*_ga_S0KJTVVLQ6*MTY4ODA0OTUxNC4zLjAuMTY4ODA0OTUxNC4wLjAuMA..#DataCenter

Jurisdiction	Policy name	Date of introduction	Threshold (total building area)	Energy data published	Additional requirements
Massachusetts	Act Driving Clean Energy and Offshore Wind	2024	area ≥ 1858 m^2	Yes	None
Montreal	Energy disclosure law	2022	Now area ≥ 5000 m^2 2024, ≥ 2000 m^2	No	GHG emissions performance rating is assigned and has to be displayed publicly
New Jersey	Energy Benchmarking	2023	area ≥ 2322 m^2	unclear	None
Ontario	Energy and water reporting	2018	area ≥ 4645 m^2	Yes	For properties > 9290m^2 values have to be certified by 3rd party
San Jose	Energy and Water Building Performance Ordinance	2018	area ≥ 4645 m^2	No	From 2023 if not meet energy and water efficiency standards need to take action to improve performance. Reviewed every 5 years.
New York City	Energy benchmarking	2012	area ≥ 2323 m^2	Partial	None

More detail is in Appendix 9.

4 Estimated energy savings from adoption of measures worldwide

4.1 Modelling Approach

The TEM models three types of data centre:

- Traditional data centres
  These are smaller, and have low efficiency (high PUE) infrastructure. The ICT equipment is similarly less efficient with low performance servers and low utilisation.
- Cloud data centres
  These represent the current generation of data centre technology and operation. They have average-high efficiency infrastructure and are highly virtualised.
- Next generation data centres
  These are less well-defined and represent future and upcoming technologies. This could include edge, specialised and heterogeneous computing (e.g. AI). The infrastructure would be the current best available technology and highly efficient.

Each of these data centre types has two modes of operation: streaming and non-streaming, so six modes are modelled in all. Some of the changes are assumed to affect all data centre types and streaming modes and some only apply to selected types. This is described for each scenario below.

The approach has been to model five types of measures that change data centre performance plus the combination of all of them. These are:

1. Moving data flow from traditional to cloud
2. Reducing PUE
3. Increasing utilisation
4. Increasing server efficiency
5. Adopting low utilisation equipment shutdown
6. Combining the most ambitious reduction in PUE with all the other policies

The TEM has eight geographic regions so it is possible to apply measures differentially geographically, however in this analysis measures have been applied in all regions.

The ambition was to model three levels of stringency for each measure, in order to get an impression of the degree of sensitivity to each measure. However the lack of data for many parameters and to some extent the assumptions in the model (which was itself driven by the paucity of input data) has meant that has not been practicable; the factors are complex and options are limited. Three levels of reduction in PUE have been modelled, as there is scope for this within the model assumptions and there is reasonable evidence to support different stringency levels. For the other four effects a single value has been applied, with all values relatively arbitrary. If evidence on any of these points is found these values could be adjusted.

Some measures could be due to a range of policies and some policies could include or exclude certain measures. It was decided to model each measure rather than try to assign a measure to a specific policy. The policies which are known to have been used for each measure are listed in the description of each measure below.

It is important to note that the TEM is not a 'bottom up' model as commonly used for energy efficiency appliance and lighting policy modelling. This means that it is not possible to apply measures to only newly sold products; they are applied to the complete population of data centres.

In some ways this is appropriate for data centres – while complete new structures are being built existing ones are constantly being upgraded (for example by replacing the servers or changing cooling arrangements) and extended. Also, all of these proposed measures could be applied to existing data centres as well as new, and some of them, involving changes to software and systems, could be done, in principle, very quickly. An example of this is the percentage low utilisation equipment shutdown (scenario 5). Other measures require organisational change or changes to infrastructure and are assumed to take some time to take effect over the whole population.

Year of effect of changes

The TEM is populated to 2030. The year of implementation of policies has been chosen to be 2025. This is a short timescale for the development and adoption of policies from the date of this analysis but given this end date using later dates would not allow the effect of the policies to be clear.

The TEM model is of a highly dynamic data centre market, with data flows, server efficiency and utilisation changing year by year so the effect of each change is time specific. The calendar dates need to be stated – rather than a non-specific timescale of number of years following the adoption of a measure. For most measures the same change introduced two years later will have less effect as the Business As Usual (BAU) 'catches' up' with the policy imposed effect.

4.2 Modelled measures

Scenario 1: Switching data flows

Description and BAU

The TEM assumes that the volume of data processed increases substantially between 2024 and 2030, with non-streaming data increasing by over three times and streaming data increasing by over four times[15].

Cloud data centres are widely acknowledged as being more energy efficient than traditional with lower PUE and higher utilisation and server efficiency. National Governments have also recognised that there are other advantages in switching to cloud providers as described in section 2.3. This scenario models the effect of additional data flow switching in response to such policies. This scenario assumes an additional switching from traditional to cloud from 5% in 2025 to 25% in 2029, continuing a current trend.

Policies known to have applied this measure

Public sector cloud first policies (see section 2.3)

Scenario values and rationale

Very few of the "Move to cloud" policies found have specified a target of the proportion of government data centre usage to be moved by a given date. Some of the policies have been running for some years but none have reported what proportion of their computing has been moved. Further, it has not been possible to find figures on the proportion of computing that is due to the public sector in any of the countries of interest, although it seems reasonable that this is a significant portion. An arbitrary value of 25% of all traditional data flows has been selected as the maximum value for 'extra' switching. It is assumed that this change happens relatively slowly with 5% extra being switched every year. That is: 5% in 2025, 10% in 2026, 15% in 2027, 20% in 2028, 25% in 2029 and 2030. BAU values by year are in Appendix 10.

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[15] Streaming service providers have implemented content delivery networks - servers as close to the customer as possible. This means that an increasing amount of streamed data goes through the network and not between data centres. This data flow behaviour is included in the TEM.

Scenario 2: Reducing average PUE

Description and BAU

PUE (Power Usage Effectiveness) is defined as:

$$PUE = \frac{(IT\ equipment\ energy\ use + infrastructure\ energy\ use)}{IT\ equipment\ energy\ use}$$

Thus the lower the value of PUE, the less energy used for infrastructure (for example cooling and lighting) the better, with a theoretical minimum value of 1.

PUE is the most widely used sustainability indicator for data centres as it can be calculated using readily available data. It is also the longest established data centre metric, having been proposed in 2007. It has been adopted in measurement standards EN 50600 4:2 and ISO/IEC 30134-2.

The BAU values are different for the three data centre types and with different levels of improvement as shown in Table 10.

Table 10 PUE by data centre type and year

Data centre type	PUE in 2024	% improvement by 2030
Traditional	1.880	2%
Cloud	1.345	3%
Next generation	1.195	4%

BAU values by year are in Appendix 10.

Policies known to have applied this measure

Government permitting (2.1) MEPS and obligations (2.2), procurement (2.4), incentive schemes (2.5) voluntary agreements (2.6). labels and certificates (2.7)

Scenario values and rationale

The three values for maximum PUE were selected as follows:

- Low ambition: maximum PUE 1.5.
  Some policies (China MEPS minimum (grade 3), German Energy Efficiency Law[16]) are asking for PUE of ≤ 1.5 for new data centres or existing data centres now or in the short term.
- Medium ambition: maximum PUE 1.3
  Some policies are asking for PUE ≤ 1.3 now for new (Singapore, China MEPS grade 2, NL public procurement) data centres or for existing data centres in a few years (German Energy Efficiency Law, 2030)
- High ambition: maximum 1.2
  Cloud service providers are reported[17] to achieve PUE ≤ 1.2 as shown in Table 11. This is also the grade 1 China MEPS requirement and the requirement for new data centres under the German Energy Efficiency Law from July 2026.

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[16] Descriptions of these policies are in section of the report.

[17] Tue Apr 25 2023, Which cloud computing platform is the most environmentally-friendly? By Andrea Kuijt, Xomnia, https://www.xomnia.com/post/ai-carbon-footprint/, accessed 28th August 2023

Table 11 PUE reported by cloud service providers

Cloud service provider	Server location	PUE
Google Cloud Platform	Europe – west4	1.110
Amazon Web services	Netherlands	1.200
Microsoft Azure	West Europe	1.125

In all cases the average PUE in each data centre type was applied starting in 2025 and taking full effect in 2027, with linear interpolation for the intervening years. This was done because reducing PUE requires changes to data centre infrastructure and design and so would take time to take effect over the complete population.

For years when the BAU value was less than the maximum in the measure the BAU value was used. The 1.5 limit only affected traditional data centres; the 1.3 and 1.2 maxima affected traditional and cloud data centres but not next generation (values by year are in appendix 10).

Scenario 3: Increasing high activity utilisation

Description and BAU
The TEM sets two levels of utilisation:

- High utilisation, 16 hours and 86% of data traffic
- Low utilisation, 8 hours and 14% of data traffic

It is possible to increase high utilisation by using virtualisation[18]. This means that fewer servers provide the same processing, increasing energy efficiency.

Policies known to have applied this measure
Government permitting schemes (see section 2.1), public procurement (2.4, for example via Blue Angel 2.7)

Scenario values and rationale
It is assumed that it is not possible to use virtualisation in traditional data centres as one of the distinguishing features of traditional data centres is that they do not use virtualisation (which is required to increase utilisation substantially). The BAU assumes that the utilisation of cloud and next generation data centres increase gradually up to 2030 from 22.7% and 25.7% respectively in 2024 (values by year are in appendix 10).

Utilisation values are not widely reported and it is difficult to estimate what current values are and the scope for improvement. We have used an estimate of a one off increase of 20% increase of the BAU 2025 value starting in 2025 and taking full effect in 2027, with linear interpolation for the intervening years. This is then maintained until 2030, unless it is exceeded by the value in the BAU case.

Scenario 4: Increasing server efficiency

Description and BAU
The TEM uses the parameter 'equipment energy intensity', which is the TWh energy consumed per exabyte of data processed by the equipment when operating at 100% utilisation. The equipment

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[18] Virtualisation enables multiple virtualised to be hosted on the same physical infrastructure, which can simultaneously be used by separate applications and/or organisations. This not only helps in optimal IT infrastructure/resource utilisation, but also in reducing data centre capital and operational costs.

intensity is the inverse of the energy efficiency and is a characteristic of the ICT equipment and software.

The BAU values in the TEM are related to the energy efficiency/intensity of generations of chips, assuming:

- Streaming efficiency is much higher than for non-streaming (generally about ten times) because there is almost no data processing in streaming – only data storage and retrieval
- The increasing efficiency of chips feeds directly into server efficiency, with interpolation to allow for a gradual replacement.
- Next generation data centres adopt the new servers first, followed by cloud DCs with a two year delay, followed by traditional with a further six year delay.

This means that the equipment energy intensity increases markedly between 2025 and 2030 for all types of data centres (41% for traditional, 42% for cloud and 36% for next generation).

Policies known to have applied this measure
Government permitting (section 2.3 for example via BCA-IDA Green Mark for Data Centres), public procurement (2.4 EU GPP, or via Blue Angel 2.7)

Scenario values and rationale
There are existing MEPS for server efficiency for example in the EU.

A 'standard' MEPS would only affect the least efficient data centre types, that is, traditional. However it is conceivable that different levels could be adopted for servers with different levels of performance. The TEM assumes that next generation data centres adopt the most efficient servers as soon as they are available so a MEPS could not have any effect.

It is difficult to judge what might be an appropriate level for a MEPS. Taking each type of data centre in turn:

- as an initial estimate the MEPS for traditional data centres is set at 20% lower energy intensity than the 2025 BAU value and is retained until the projected BAU increase in performance overtakes it (in 2027) when values revert to BAU.
- If the same approach were taken for cloud data centres the energy intensity would be lower than that for next generation, which is not feasible. Instead the 2025 energy intensity for cloud data centres was set to that for next generation in 2025 and retained until the projected BAU increase in performance overtakes it (in 2027) when values revert to BAU.
- As the next generation data centres are already using the most efficient there is no scope for MEPS

Values by year are in appendix 10.

Scenario 5: Increasing equipment shutdown when in low utilisation

Description and BAU
It is possible to shut down some of the IT equipment when in low utilisation. By shutting down a proportion of the equipment is possible to raise the load of the operating equipment and increase energy efficiency. With no evidence of current values this is set to zero for all data centre types in the BAU scenario.

Policies known to have applied this measure
None identified.

We are not aware of any evidence of suitable values. This effect is largely referred to in advertisements from providers with savings expressed as cost savings.

It is assumed that it will not be possible to alter this in the relatively limited operating systems of traditional data centres. An initial value of 20% from 2025 on is used for cloud and next generation data centres.

Scenario 6: All five measures in combination

Description

All five measures described above were applied, with the most stringent PUE, 1.2, used.

Policies known to have applied this measure

None identified.

Scenario values and rationale

The scenario values are described above with the most ambitious PUE value used. The rationale was to identify the scope for savings from all measures combined.

4.3 Initial results

BAU

The energy use in the original BAU is shown in Figure 1.
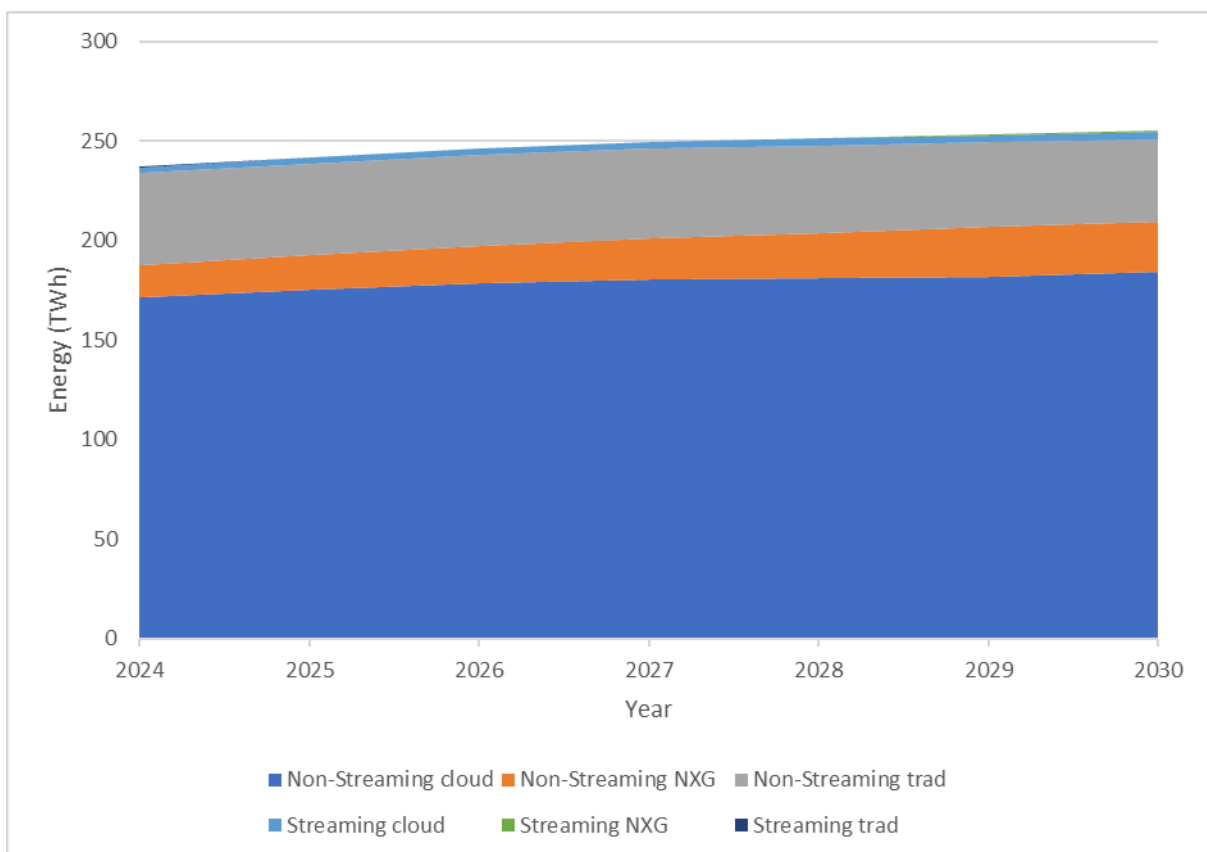
Figure 1 BAU energy use

It is noticeable that the energy use in streaming is low compared to non-streaming.

The TEM models eight different geographic regions. Energy use by region in the original BAU is shown in Figure 2 TEM BAU energy use by region. At the start of and throughout most of the modelled period the Far East and China, North America and Western Europe are projected to use the most energy, with energy use in the Indian subcontinent forecast to just overtake that in North America in 2030.
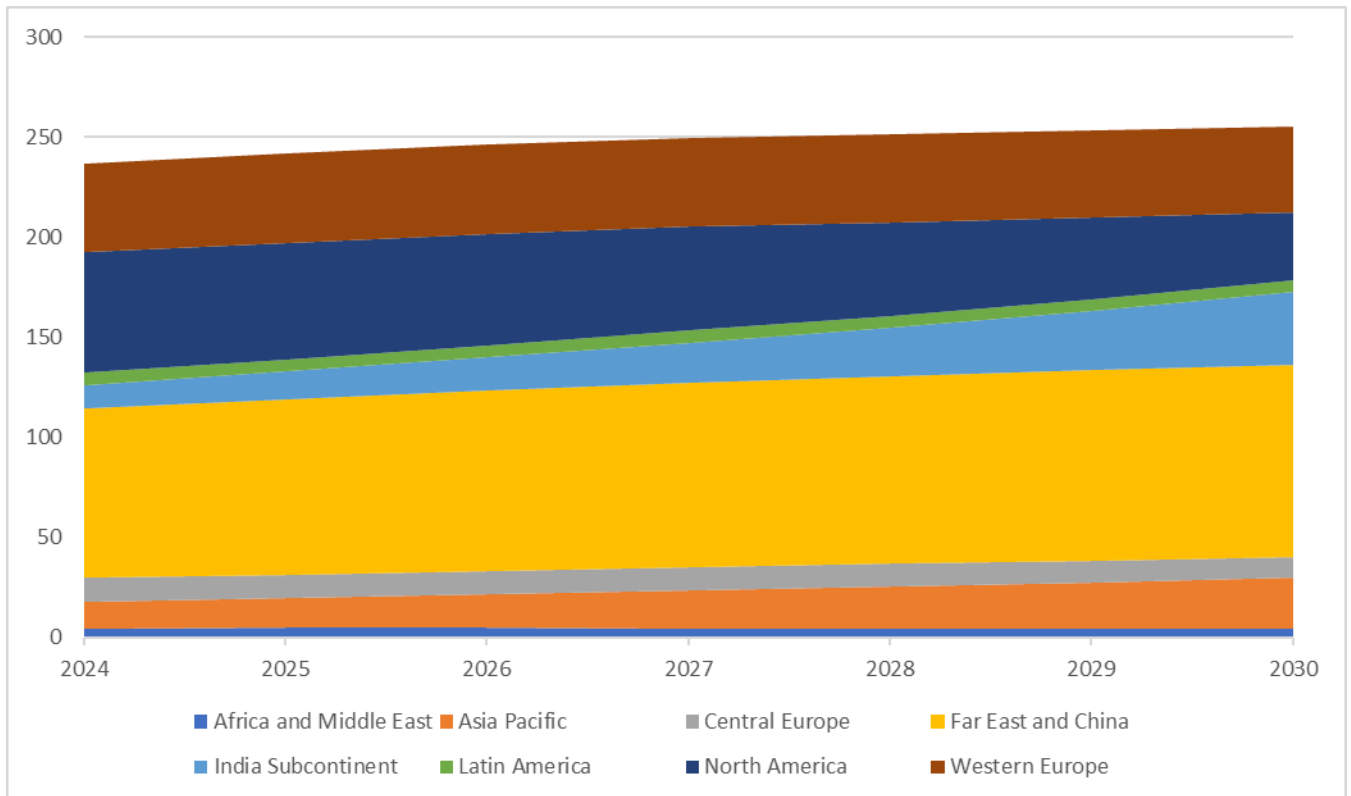
Figure 2 TEM BAU energy use by region

Most data centre policies were found in regions where the TEM expects the greatest data centre energy use to be: the far East and China, North America and Western Europe. It may be that awareness of high energy use is driving policy development. But these regions have a long history of appliance and building energy efficiency policies as do two countries in the Asia Pacific region which also have data centre policies – Australia and Singapore. So it may be due to high energy use or a combination of high energy use and policy experience.

Energy savings in the different scenarios

The energy savings from the BAU in each scenario in TWh/y are shown in Table 12 and in Figure 3.

Table 12 Energy savings by scenario and year

	Energy saving in TWh/y							
scenario	1	2.1	2.2	2.3	3	4	5	6
year	shift to cloud	max PUE1.5	max PUE1.3	max PUE1.2	Utilisation	Server Efficiency	Low utilisation equipment shutdown	Comb of 5
2024	0	0	0	0	0	0	0	0

2025	2	3	6	12	11	45	12	67
2026	4	6	12	22	18	17	12	59
2027	5	9	17	33	25	0	12	69
2028	7	9	15	32	23	0	12	67
2029	8	8	14	30	22	0	12	66
2030	8	8	12	29	21	0	13	64
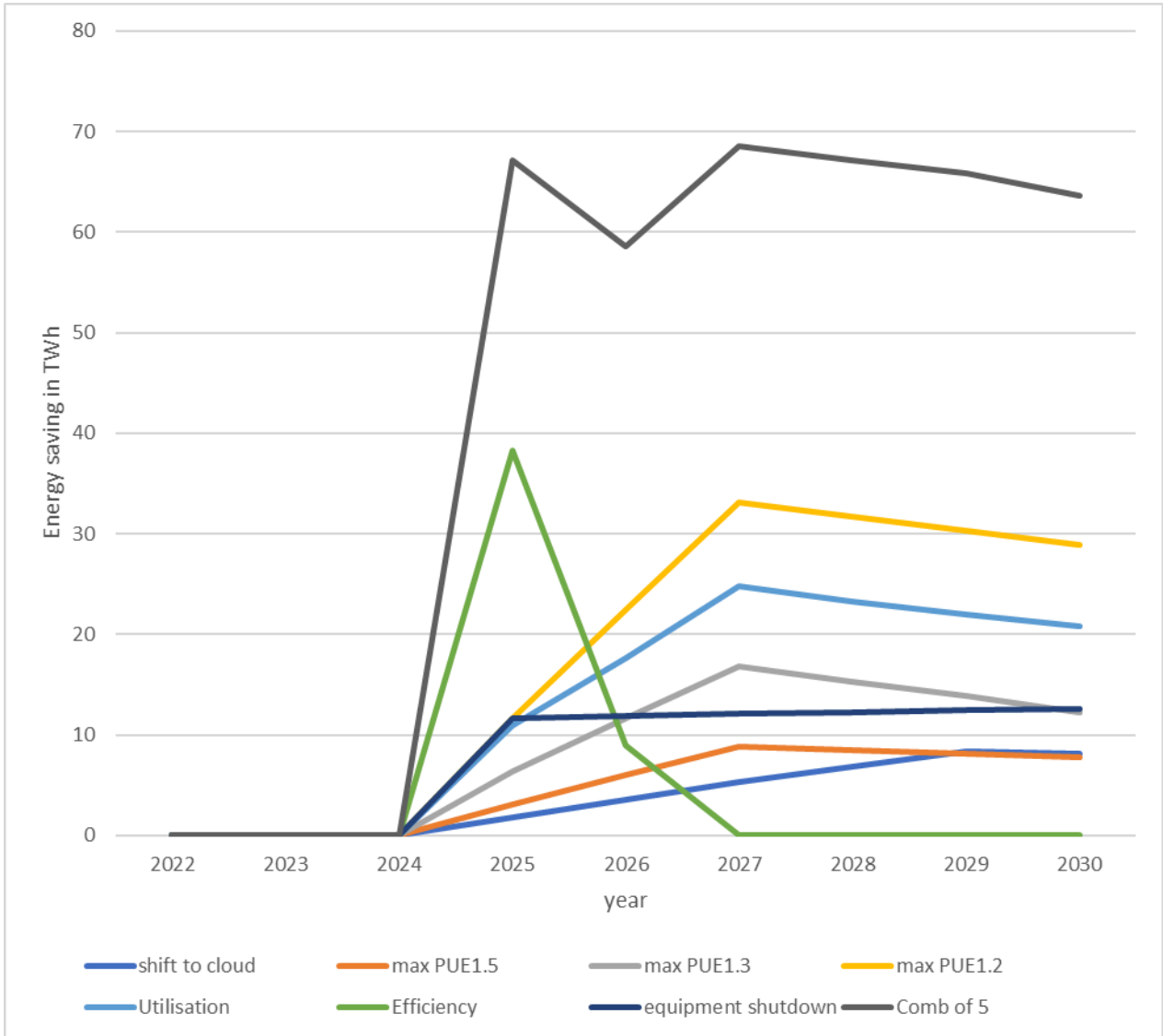
Figure 3 Energy savings by scenario

The scenario 6 energy savings from BAU by region are shown in Figure 4. The savings are broadly in proportion with energy use by region (shown in Figure 2).
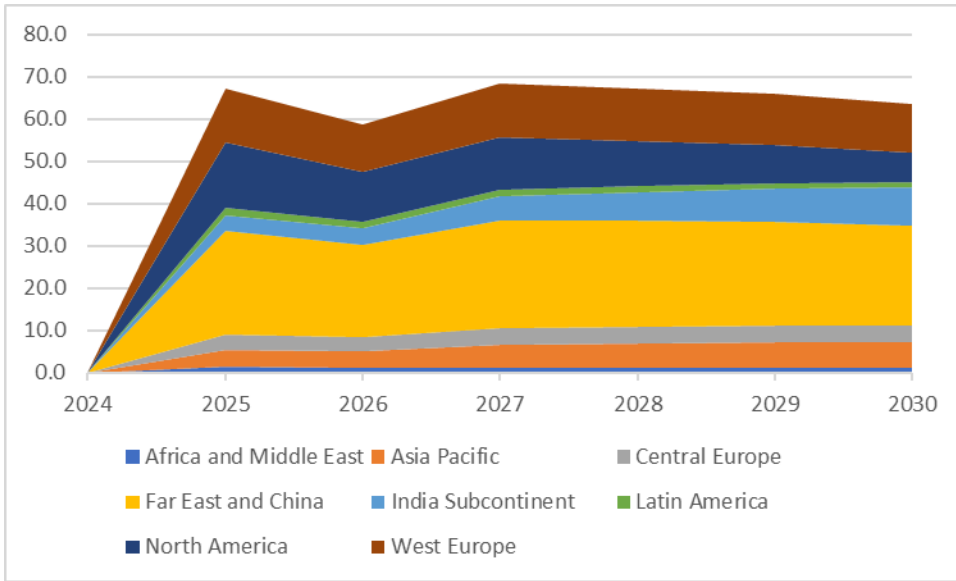
Figure 4 Scenario 6 energy savings by region

The cumulative energy savings from BAU are shown in Table 13.

Table 13 Cumulative energy savings from BAU by scenario

	Energy saving in TWh/y							
scenario	1	2.1	2.2	2.3	3	4	5	6
year	shift to cloud	max PUE1.5	max PUE1.3	max PUE1.2	Utilisation	Server Efficiency	Low utilisation equipment shutdown	Comb of 5
2024	0	0	0	0	0	0	0	0
2025	2	3	6	12	11	38	12	67
2026	5	9	18	34	29	47	24	126
2027	11	18	35	67	53	47	36	194
2028	18	26	50	99	77	47	48	261
2029	26	35	64	129	99	47	60	327
2030	34	42	76	158	119	47	73	391

The energy savings as % of BAU energy use are shown in Table 14.

Table 14 Energy savings by scenario as a % of BAU energy

	Energy savings as a % of BAU energy							
scenario	1	2.1	2.2	2.3	3	4	5	6
year	shift to cloud	max PUE1.5	max PUE1.3	max PUE1.2	Utilisation	Server Efficiency	Low utilisation equipment shutdown	Comb of 5
2024	0%	0%	0%	0%	0%	0%	0%	0%
2025	1%	1%	3%	5%	5%	16%	5%	28%

2026	1%	2%	5%	9%	7%	4%	5%	24%
2027	2%	4%	7%	13%	10%	0%	5%	27%
2028	3%	3%	6%	13%	9%	0%	5%	27%
2029	3%	3%	5%	12%	9%	0%	5%	26%
2030	3%	3%	5%	11%	8%	0%	5%	25%

The savings from the combination of policies applied together, in scenario 6 is less than the sum of savings from applying each policy separately as shown in Table 15.

Table 15 Difference between sum of energy savings from scenarios 1-5 and those from scenario 6

Year	TWh/y	% (of sum of savings from scenarios 1-5)
2025	7	10%
2026	6	9%
2027	7	9%
2028	7	10%
2029	7	10%
2030	7	10%

4.4 Discussion of initial results

The savings from most of the measures decline after the year of full effect in both absolute terms (TWh) and as a percentage of energy use. This is because they are an acceleration of energy efficiency trends that are already present in BAU, with the exception of low utilisation shutdown. This is most noticeable in scenario 4, increasing server efficiency, where the effect of the measure is overtaken by the high rate of efficiency improvement in the BAU after two years, in 2027. The savings from the combination of all the measures declines from 2027, the year when all the measures have taken full effect, due to the effect of measures gradually being overtaken by BAU.

Cumulative savings (Table 13) are greatest from scenario 2.3, maximum PUE of 1.2, followed by increasing utilisation (scenario 3), equipment shutdown (scenario 5) and server efficiency (scenario 4).

The savings from combining all the measures is less than the sum of each measure applied individually (Table 15). This is because there is overlap in the mechanisms for energy savings, for example increasing server efficiency and reducing PUE (if the IT energy use is lower then for the same PUE the infrastructure energy use will also be lower).

Caveats

Examples of values for most of the parameters used to calculate the energy use of data centres is sparse. This presented a challenge when extending the TEM to include data centres and in selecting appropriate values when modelling different measures[19]. This means that the values selected have been relatively arbitrary and may well not be representative of practicable values. They should however give an indication of the types of savings that may be available.

A more general point is that the BAU of the TEM is quite optimistic about the adoption of higher efficiency equipment and practices (Figure 1). This is also evident in the BAU values for each parameter presented in Appendix 10 and discussed above. This results in a modest increase in energy use between 2024 and 2030 – 18TWh or 8% of the 2024 value despite the TEM predicting the volume of data processed increasing substantially over this period, with non-streaming data increasing by over three times and streaming data increasing by over four times. There is a possible precedent for this; Masanet et al (2020) estimated that the worldwide data flow through data centres increased by a factor of 11 between 2010 and 2018 while energy use increased by 6%. However Bashroush and Lawrence (2020) question whether the historic increases in server efficiencies can continue, meaning that increases in overall data centre efficiencies will slow.

It was decided to produce an 'alternative' BAU scenario with a slower increase in server efficiency to see what difference this made to the results. This is described in section 4.5, below.

Match between modelled measures and example policies

Section 4.2 lists the example of policies which **are known** to apply the modelled measures, where they exist.

Table 16 maps the measures against policies which **could** mandate them or encourage their adoption.

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[19] The exception to this is PUE which is widely reported and has been incorporated into a number of policies, as shown by the examples in this report.

Table 16 Mapping measures against policies

Scenario/measure	Policies that could mandate adoption	Policies that could encourage adoption
1: Flow switching	Cloud first	Public procurement
2: Reducing average PUE	Government permitting, MEPS, public procurement, voluntary agreements	Obligations, incentives
3: Increasing utilisation	Government permitting, public procurement	MEPS, Obligations, incentives
4. Increasing server efficiency	Government permitting, public procurement	MEPS, Obligations, incentives
5: Low utilisation shutdown	Public procurement	Government permitting, MEPS, Obligations, incentives
6: Combination	Public procurement	Government permitting, MEPS, Obligations, incentives

4.5 Alternative BAU and results

Approach for an alternative BAU

As noted above the TEM assumes continuing significant efficiency improvements, particularly in server efficiency. It was decided to model an alternative BAU, with slower improvements in server energy efficiency and to see what difference this made to the energy use overall and to the savings from the measures. This was done by adjusting the % improvement in server efficiency as a proportion of the original BAU scenario by 60% (that is, if the original BAU scenario energy intensity improved by 10% each year, in the alternative the energy intensity would improve by 6% each year) from 2024. This was applied to traditional and cloud data centres only - the next generation data centres are expected to adopt the most efficient technology as soon as it is available and so are left unchanged. The alternative values for server intensity are presented in Appendix 10.

The energy use in the revised BAU is shown in Figure 5. The difference in energy use between the two BAU scenarios in energy and percentage terms is shown in Table 17.
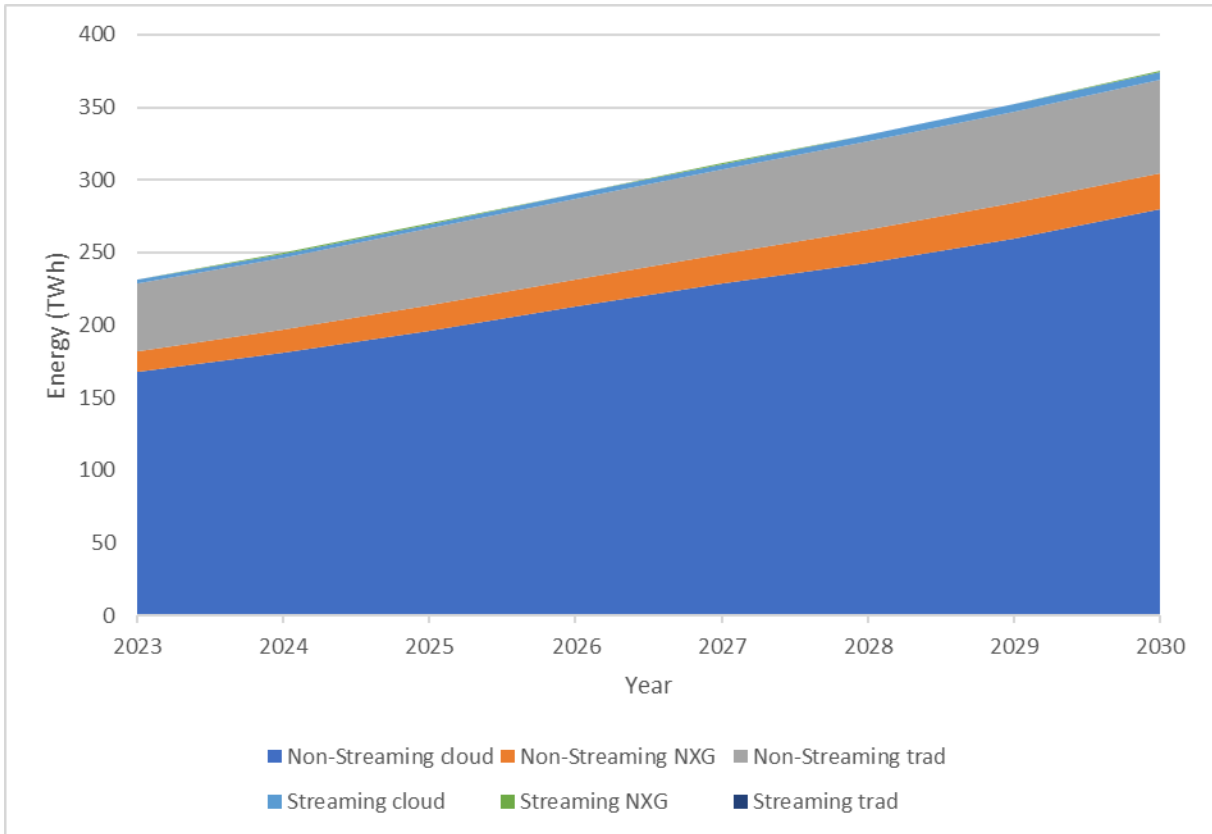
Figure 5 Energy use in alternative BAU

Table 17 Difference in energy use between original and alternative BAU

Year	Difference in energy use between original and alternative BAU in TWh/y	Difference in energy use between original and alternative BAU as % of original BAU
2024	13	5%
2025	28	11%
2026	44	18%
2027	62	25%
2028	80	32%
2029	99	39%
2030	120	47%

In the alternative BAU the energy use increases considerably.

The measures for each scenario are the same as for the original analysis, except for scenario 4 – increasing server efficiency. In this case the measure has the same proportion of increase in server efficiency (reduction in energy intensity) as in the original case but as the starting point is different, resulting in different values. Also as the rate of increase in server efficiency in the alternative BAU scenario is lower the effect of the measure lasts longer – three years instead of two. The revised values are in Appendix 10.

Energy savings in the different scenarios with alternative BAU

The energy savings from the alternative BAU in each scenario in TWh/y are shown in Table 18 and in Figure 6.

Table 18 Energy savings by scenario and year (alternative BAU)

	Energy saving in TWh/y							
scenario	1	2.1	2.2	2.3	3	4	5	6
year	shift to cloud	max PUE1.5	max PUE1.3	max PUE1.2	Utilisation	Server Efficiency	Low utilisation equipment shutdown	Comb of 5
2024	0	0	0	0	0	0	0	0
2025	2	4	7	13	12	50	13	77
2026	4	7	14	27	21	35	14	79
2027	7	11	22	42	31	15	15	81
2028	9	12	21	43	31	0	16	72
2029	12	12	20	44	31	0	17	74
2030	13	12	19	44	32	0	18	75
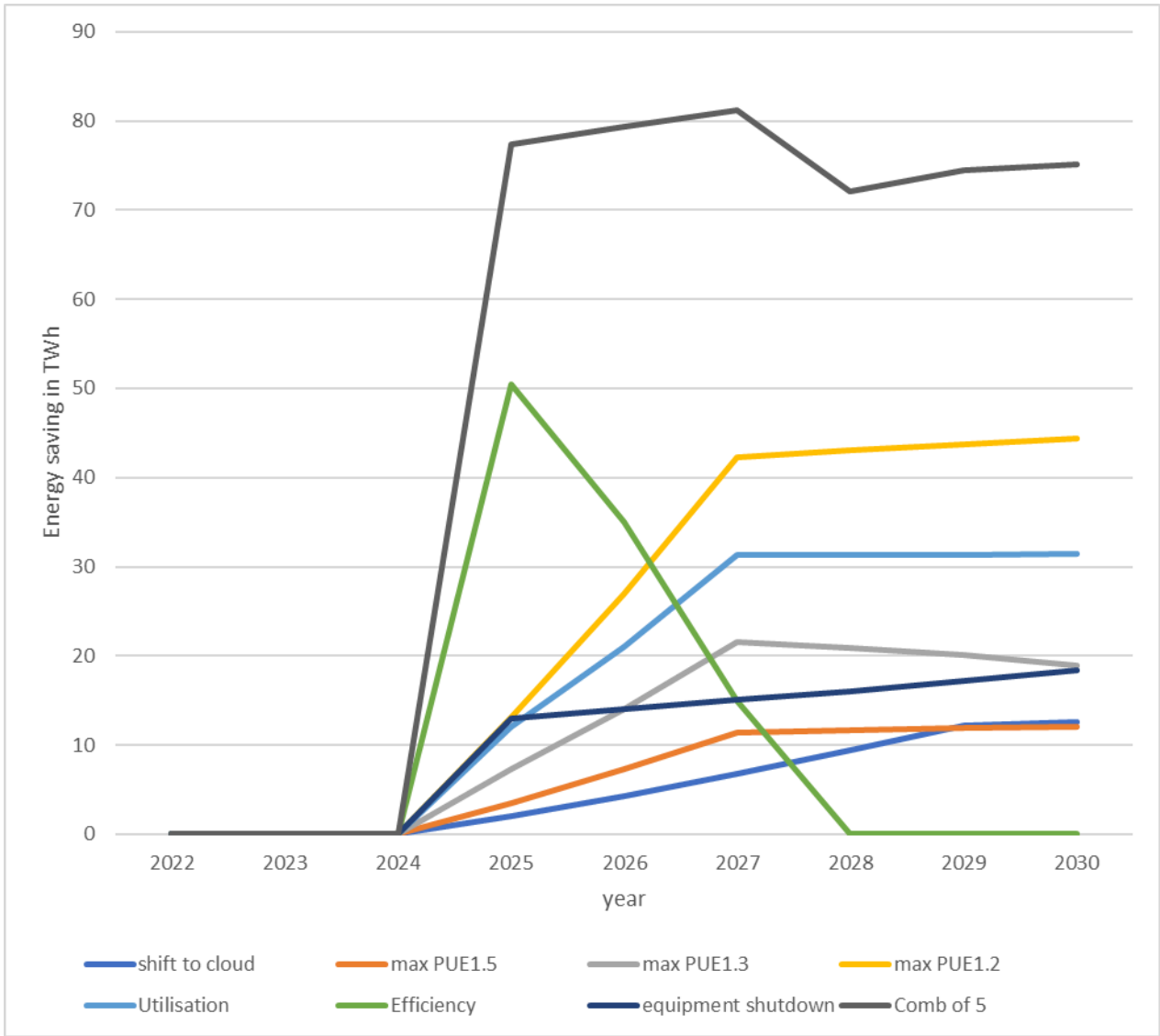
Figure 6 Energy savings from alternative BAU by scenario

The cumulative energy savings from the alternative BAU are shown in Table 19.

Table 19 Cumulative energy savings from alternative BAU by scenario

scenario	Energy saving in TWh/y							
	1	2.1	2.2	2.3	3	4	5	6
year	shift to cloud	max PUE1.5	max PUE1.3	max PUE1.2	Utilisation	Server Efficiency	Low utilisation equipment shutdown	Comb of 5
2024	0	0	0	0	0	0	0	0
2025	2	4	7	13	12	50	13	77
2026	6	11	21	40	33	86	27	157
2027	13	22	43	82	65	100	42	238
2028	23	34	64	125	96	100	58	310
2029	35	46	84	169	127	100	75	384
2030	48	58	103	213	159	100	94	460

The energy savings as % of energy use for the alternative BAU are shown in Table 20.

Table 20 Energy savings by scenario as a % of alternative BAU energy

scenario	1	2.1	2.2	2.3	3	4	5	6
year	shift to cloud	max PUE1.5	max PUE1.3	max PUE1.2	Utilisation	Server Efficiency	Low utilisation equipment shutdown	Comb of 5
2024	0%	0%	0%	0%	0%	0%	0%	0%
2025	1%	1%	3%	5%	4%	19%	5%	29%
2026	1%	2%	5%	9%	7%	12%	5%	27%
2027	2%	4%	7%	14%	10%	5%	5%	26%
2028	3%	4%	6%	13%	9%	0%	5%	22%
2029	3%	3%	6%	12%	9%	0%	5%	21%
2030	3%	3%	5%	12%	8%	0%	5%	20%

4.6 Discussion of results with alternative BAU

The main observations comparing the results from the original and alternative BAUs are:

- The effect of a MEPS on server efficiency are overtaken more slowly by the increase in the BAU and so save energy over three years rather than two as in the original case.
- The absolute energy savings from the alternative BAU are greater than from the original BAU.
- However in most years (comparing Table 14 and Table 20) the savings as a percentage of BAU are lower.
- The relative impact of each measure in cumulative savings is the same as in the original case except that the cumulative savings from the increase in server energy efficiency (scenario 4) is higher than the shutdown in low utilisation (scenario 5) in the alternative case (comparing Table 13 and Table 19).

Figure 7 compares the energy use in the original BAU and the alternative case scenario 6 (all measures combined). It shows that by 2028 the effect of all the measures in reducing energy use is less than the effect of faster improvements in server efficiency assumed in the original BAU, and the energy use continues to increase from then. This suggests that at least some of Governments' attention should be focused on technology innovation in servers, so that a high rate of increase in server efficiency continues to be available. Other policies can then be applied to encourage these higher efficiency servers to be used in data centres.
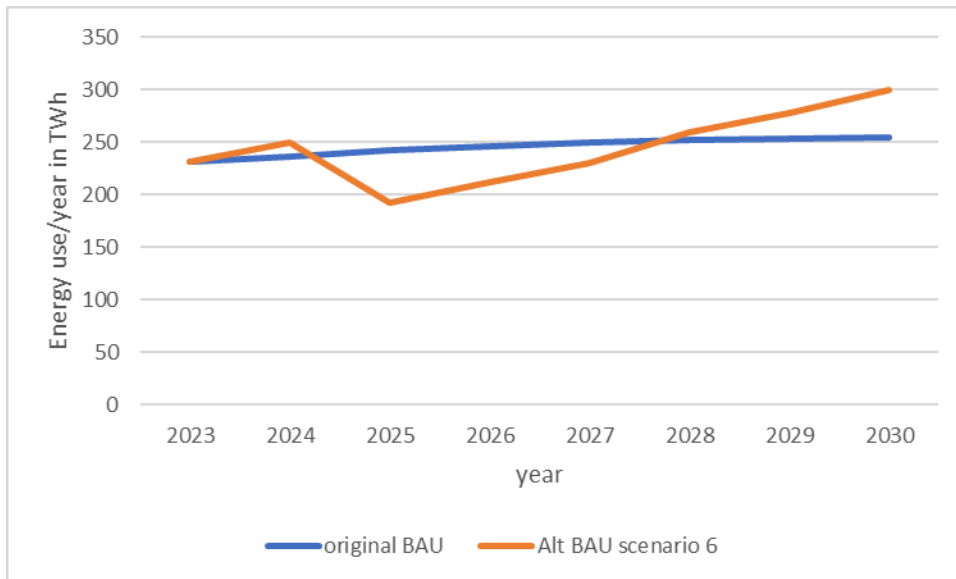
Figure 7 Energy use per year in the original BAU and alternative scenario 6 (combined measures)

6 Issues for policy makers to consider

Challenges

Data centres are an energy sector which are challenging to regulate for energy use for a number of reasons:

1. a wide range of size and type of applications
2. with rapidly changing dynamics
3. fast moving technology
4. some of the market for cloud services is international; this means that there is global competition with potential for 'leakage' if regulation in one jurisdiction is considered too restrictive
5. high requirements for reliability and availability in some applications (although these are not mutually exclusive with improved energy performance / reduced environmental impact).
6. data centres are complex systems with components being added or replaced over time which can radically affect utility and energy use
7. a lack of suitable metrics for some aspects of data centre performance[20]
8. the paucity of data on some of the parameters for which there are metrics are available. This has made selecting suitable values for modelling the measures difficult and would also inhibit policy making
9. to date Governments have not known how many data centres there are, where they are or how much energy they use (unlike 'simple' products whose performance can be measured in a test labs and whose sales can be tracked)

The policies which require reporting of data centre energy related metrics will start to address the final two points. If new metrics are developed and adopted these can be incorporated into

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[20] Several policies (for example the EU's Energy Efficiency Directive and Japan's Energy Conservation Act) express the intention to develop more metrics to enable regulating further aspects of data centre performance or different sections of the market (traditional in addition to colos).

mandatory reporting. Once a robust evidence base is established policy makers will be in a stronger position to make more effective policies – whether regulations, incentives or guidance.

Policy options

We have identified a number of existing policies in different jurisdictions. Most of these have been adopted recently and we have not found evaluations or estimates of effect of the others. While relatively few Governments are in a position to grant permits for each new data centre (the policy option where Governments have the greatest control of specifications) there are other options.

The complexity of data centres can mean that there is a greater knowledge gap between suppliers and customers for data centres than for other energy using products/services. This can make it harder for customers to negotiate with suppliers suggesting that procurement guidance and/or certification schemes could be particularly helpful. Developing these or promoting existing schemes may be a worthwhile investment by Governments.

As identified in this research there are a growing number of policies whereby organisations or building owners or occupiers are obliged to meet greenhouse gas emission reductions, These can include data centres but these are not a 'short cut' to regulating data centre energy efficiency – their complexity and the fact that they are expected to keep growing in size and number[21] mean that to be effective these policies need to be customised to fit them (as for example the Japanese and French obligations - section 2.2 and Appendix 2).

As shown by the mapping of measures against policies (Table 16) public procurement has the potential to address many different aspects in a single policy. This means that these policies have the potential to be transformative, while possibly complex to adopt and enforce. There is also scope for a multiplier effect – once suppliers have found ways of meeting public sector requirements they can offer higher efficiency services to private clients.

The largest (cloud) service providers claim to already be very energy efficient. This is thought to be driven by the need to reduce running costs and to defend their reputations against accusations of high emissions from environmental NGOs (for example Greenpeace 2017). It is also enabled by their access to resources – both expert employees and capital to buy equipment. It will be interesting to see if the figures that they are obliged to report in future will support their claims.

Finally considering voluntary agreements; a review for 4E (Klinckenberg and Harmelink 2017) found that they may achieve modest energy savings when regulatory approaches are not practicable. It will be interesting to see the results of the one known example for data centres, the EU Climate Neutral Data Center Pact, when participants start reporting in 2025.

Modelled measures

The modelling suggests that there are still considerable energy savings to be made by reducing infrastructure use, as measured by PUE. While this is not simple there are tried and tested ways of doing this. Supporting smaller data centres to do this by offering grants or technical support are possible means of accelerating this, separate from MEPS or obligations which may be challenging to apply to smaller data centres.

The modelling results also suggest that increasing shut down of equipment when in low utilisation may be an effective way of saving energy. Conceptually this appears to be relatively easy and could

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[21] With associated benefits of energy efficiency and reduced emissions from increased digitalisation.

provide a 'quick win'. We have not found any policies or voluntary agreements which refer to this[22] but it would seem worthwhile to explore this with industry experts.

The modelling of the alternative BAU shows the importance of the development and adoption of servers whose energy efficiency increases at similar rates to those experienced to date. Increasing energy efficiency has been a side effect of the concentration of computer power. Experts have questioned whether continuing this trend is possible with existing technology and consider that major innovations will be necessary to achieve this (Rotman 2020). This suggests that encouraging continued innovation and improvement in computer power and efficiency may be the single most effective energy efficiency policy for data centres.

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[22] Although the EU Code of Conduct practice 4.3.6 "Shut down and consider removal of idle equipment" has some similarities.

Appendix 1 Description of Government permitting schemes

In alphabetical order of country or jurisdiction.

A1.1 Three-Year (2021-2023) Action Plan on New Data Centres (China)

Type of policy

Effective Minimum Energy Performance Standard

Scope

Large scale data centres – defined 3000 standard rack sizes (2.5 kilowatt per rack, i.e. 7.5MW).

Status and date of introduction (actual or proposed)

Plan published in July 2021.

Listing of the metrics used

PUE and utilisation rate.

Listing of levels set

For new large data centres: minimum (efficiency) requirements:

- PUE less than 1.3 and the PUE of new data centres in extremely cold areas should be below 1.25

- utilisation rate of 55% by the end of 2021 and more than 60% by the end of 2023.

References:

- Sino-German Cooperation on Industrie 4.0 National New Data Centre Development Policy Briefing | September 2022, GiZ
- Data centres in mainland China. Four points to process in 2022, Greater China Research Cushman & Wakefield, April 2022

A1.2 Pilot Data Centre Call for Application (Singapore)

Type of policy

Competition for right to build new data centres - effective MEPS.

Scope

Not stated. From context, at least bigger than server rooms.

Status and date of introduction (actual or proposed)

The Government informed the industry of a temporary pause in the growth of DCs in 2019. In July 2022 the Economic Development Board (EDB) and Infocomm Media Development Authority (IMDA) announced the Launch of pilot Data Centre Call for Application. Bids were invited by a deadline of November 2022. In July 2023 they announced that four data centres with a combined capacity of about 80 MW had been awarded the right to be built. They also stated that they aimed to allocate more capacity in the next 12 to 18 months.

The awarded proposals were reported as:

- "Delivering best-in-class energy efficient performance through comprehensive adoption of liquid cooling and energy efficient core-IT equipment. This includes meeting Green Mark DC Platinum Certification.

- Significantly expanding international connectivity, including through facilitating an increase in submarine cable capacity and setting up new carrier neutral exchanges.
- Anchoring key compute capacities, including AI/ML compute, and High-Performance Compute in Singapore, while linking with offshore DCs to complement Singapore's capacity.
- Significant economic commitments to Singapore beyond the direct DC investments."

Listing of the metrics used

- PUE

- Green Mark for DC Platinum Certification.
  Criteria include (in addition to PUE):

    o Peak Data Centre Cooling Load (expressed as kW/Refrigerated Ton).
    o air handling system efficiency (if relevant);
    o minimum IT power chain efficiency;
    o use of ENERGY STAR related servers, storage devices and network systems
    o water efficiency
    o sustainable construction & management
    o indoor environmental quality
    o other green features
- Contribution to meeting Singapore's decarbonisation, strategic and economic goals (as described for awarded proposals, above)

Listing of levels set

PUE ≤ 1.3. Also achieving a Green Mark Platinum rating (an overall score of > 90 (out of 125) with thresholds for each group of criteria (e.g. 60 out of 83 for energy efficiency)).

References:

- Press release "Four data centre proposals selected as part of pilot Data Centre Call for Application" IMDA and EDB, July 2023
  https://www.imda.gov.sg/resources/press-releases-factsheets-and-speeches/press-releases/2023/four-data-centre-proposals-selected-as-part-of-pilot-data-centre-call-for-application
- Press release "Launch of pilot Data Centre Call for Application to support the sustainable growth of DCs" IMDA and EDB July 2022
  https://www.imda.gov.sg/resources/press-releases-factsheets-and-speeches/press-releases/2022/launch-of-pilot-data-centre---call-for-application-to-support-sustainable-growth-of-dcs
- ANNEX A: Summary of Pilot DC-CFA Key Parameters & Criteria, IMDA and DEA, July 2022
- BCA-IMDA Green Mark for New Data Centres Version NDC/1.1 2012

Appendix 2 Descriptions of MEPS and Obligations

In alphabetical order of country or jurisdiction.

A2.1 Minimum Energy Performance Standard (China)

Type of policy
Minimum Energy Performance Standard and energy label

Scope
Newly built, renovated and expanded data centres, individual or modular units of data centre buildings with independent power distribution, air cooling, and electric air-conditioning. This standard does not apply to edge data centres. Data centres using other non-electric air-conditioning equipment are under the scope of this standard.

Status and date of introduction (actual or proposed)
On 11 October 2021, the China Standardization Administration (SAC) and the China State Administration for Market Regulation (SAMR) approved and published a new standard on Maximum Allowable Values of Energy Efficiency and Energy Efficiency Grades for Data Centers, GB 40879–2021. This standard specifies the technical regulation on energy efficiency rating, energy consumption measurement, energy efficiency calculation and assessment of data centres. It applies from 1 November 2022. The standard has three grades so also functions as an energy label.

Listing of the metrics used
PUE

Listing of levels set
There are three grades of data centre energy efficiency.:

- Grade 1: ≤ 1.2
- Grade 2: ≤ 1.3
- Grade 3: ≤ 1.5

References:
- China: Maximum allowable values of energy efficiency and energy efficiency grades for data centers, Standard GB 40879-2021
  https://www.tuvsud.com/en/e-ssentials-newsletter/consumer-products-and-retail-essentials/e-ssentials-17-2021/china-maximum-allowable-values-of-energy-efficiency-and-energy-efficiency-grades-for-data-centers
- UPS S-ECO Technology White Paper, Huawei

A2.2 Decree n° 2019-771 relating to obligations for actions to reduce final energy consumption in buildings for tertiary use (ELAN) (France)

Type of policy
Energy reduction obligation.

Scope
The scope is defined by floor area, with a minimum threshold of 1000 m^2. This applies to all tertiary buildings. Building operators will need to report data centre energy use whether this is for a dedicated data centre or a building with an IT (server) room (which could be smaller than 20m^2)

Status and date of introduction (actual or proposed)

The decree was adopted in 2019 and the deadline for entering data for was 30 September 2022. 31 December 2031/2041/2051 are the deadlines for OPERAT to verify the 2030, 2040 and 2050 targets have been met.

The target PUE values for data centres (below) were published in December 2023.

Listing of the metrics used

There will be reference values of energy intensity, in $kWh/m^{2.}/year$, for each size range of data centre, adjusted for climate and altitude (PUE_zone[23]), where:

● The energy is that used by the IT equipment

● the area is that occupied by IT equipment if occupying part of a building or the total floor area of a self-contained data centre.

For the 2030 target data centres can choose to meet a PUE target instead of energy intensity.

Listing of levels set

The decree sets a requirement to reduce energy consumption tiers for tertiary sector buildings compared to a reference year between 2010 and 2018 by:

• 40% by 2030
• 50% by 2040
• 60% by 2050

Data centre usage is expected to rise over this period so data centre operators can choose to measure meet a target value of PUE rather than achieve absolute reductions in energy consumption. The target values for PUE for 2030 are as shown in Table 21 (where the area is that occupied by IT equipment if occupying part of a building or the total floor area of a self-contained data centre).

Table 21 Elan 2030 target PUE values by data centre floor area

Data centre size	Basic Target	Adjusted target (depending on PUE_zone)
Local server (area < 20m^2)	2.0	xxx
Server rooms (area between 20 and 100m^2)	1.8	xxx
Mini data centres (area between 100 and 500 m^2)	1.6	1.72
Small data centre (area between 500 and 1000 m^2)	1.6	1.72
Medium data centre (area between 1000 and 5000 m^2)	1.4	1.51
Large data centre (area between 5000 and 10,000 m^2)	1.4	1.51
Very large data centre (area > 10,000 m^2)	1.2	1.29

The targets will be reviewed and may be tightened if new evidence suggests that there is scope to do so.

References:

● Order of November 28, 2023 amending the order of April 10, 2020 relating to obligations to take action to reduce final energy consumption in buildings for tertiary use (Arrêté du 28 novembre 2023 modifiant l'arrêté du 10 avril 2020 relatif aux obligations d'actions de réduction des consommations d'énergie finale dans des bâtiments à usage tertiaire) https://www.legifrance.gouv.fr/loda/id/JORFTEXT000048543601

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[23] Uses existing climate and altitude zones defined in existing building regulations.

- ANNEX - FINAL ENERGY CONSUMPTION LEVELS SET IN ABSOLUTE VALUE – CABS (ANNEXE - NIVEAUX DE CONSOMMATION D'ÉNERGIE FINALE FIXÉS EN VALEUR ABSOLUE – CABS)

  https://www.bulletin-officiel.developpement-durable.gouv.fr/documents/Bulletinofficiel -0033250/TREL2307517A_Annexe.pdf

A2.3 Energy Efficiency Law (Germany)

Type of policy

MEPS

Scope

For most requirements the scope for data centres is:

a) a structure or group of structures for the central housing, central connection and central operation of information technology and network telecommunications equipment to provide data storage, data processing and data transport services with a non-redundant rated electrical connected load from 300 kilowatts and up

b) All facilities and infrastructure for power distribution, for environmental control and for the required level of resilience and security required to provide the desired service availability, with a non-redundant nominal electrical connected load of 300 kilowatts or more.

Data centres that serve to connect or connect other data centres and which predominantly do not have any data processing are exempt.

Larger data centres, with a non-redundant nominal connected load of 1 megawatt or more and data centres owned or operated by public bodies with a non-redundant nominal connected load of 200 kilowatts, need to have their energy and environmental management systems certified.

Data centres that are scheduled to be decommissioned before 1 July 2027 are excluded.

Status and date of introduction (actual or proposed)

In July the Committee for Climate Protection and Energy published a Resolution recommendation and report. On 21 September 2023 the German Parliament passed the bill, which it is understood incorporated the changes in this report. The act needs to be reviewed by the Second Chamber of the German Parliament (Bundesrat) and enter into force in course of November at the latest[24].

Listing of the metrics used

- PUE (termed energy consumption effectiveness in the law)

- Consumption of unsubsidised electricity from renewable energies

- Energy reuse

- Requirement to establish an energy or environmental management system (larger data centres only)

Listing of levels set

Data centres which commence or have commenced operations before 1 July 2026 shall be constructed and operated in such a way that they:

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[24]

https://www.allenovery.com/en-gb/global/news-and-insights/publications/update-germany-tightens-energy-ef ficiency-requirements-new-challenges-for-companies-and-data-centers

1. from 1 July 2027, have an energy consumption effectiveness of less than or equal to 1.5, and

2. from 1 July 2030 permanently achieve an energy consumption effectiveness of less than or equal to 1.3 on an annual average.

Data centres that commence operations on or after 1 July 2026 shall be constructed and operated in such a way that they:

1. achieve an energy consumption effectiveness of less than or equal to 1.2, and

2. have a proportion of reused energy according to DIN EN 50600-4-6, November 2020 edition 7) of at least 10 percent;

Data centres starting operations in July 1st 2027 must have a planned proportion of at least 15 percent reused energy;

Data centres operating after July 1, 2028 must have a planned percentage of at least 20 percent reused energy.

Data centre operators shall cover the electricity consumption in their data centres on a balance sheet:

1. from 1 January 2024, 50 per cent of unsubsidised electricity from renewable energies and

2. from 1 January 2027, 100 per cent of unsubsidised electricity from renewable energies

Operators of data centres are obliged to establish an energy or environmental management system by 1 July 2025. As part of the implementation of the energy or environmental management system they need to:

1. carry out continuous measurements of the electrical power and energy requirements of the essential components of the data centre, and

2. Take measures that continuously improve the energy efficiency of the data centre

References:

- Germany Draft of a law to increase energy efficiency and to change the Energy Services Act May 2023
  https://www.bmwk.de/Redaktion/DE/Downloads/Gesetz/entwurf-enefg.pdf?__blob=publicationFile&v=6

- German Bundestag 20th electoral term Resolution recommendation and report of the Committee on Climate Protection and Energy (25th Committee) on the federal government's draft law to increase energy efficiency and to amend the Energy Services Act, 20/7632, 5th July 2023
  https://dserver.bundestag.de/btd/20/076/2007632.pdf

- Energy Efficiency Act (EnEfG) – Bundestag decides on draft bill, Lars Reubekeul and Christopher Ollech, DLA Piper, September 2023

A2.4 Energy Conservation Act (Japan)

Type of policy

Annual reporting, and making progress towards benchmark target value.

If companies do not make satisfactory progress towards the target the Government may (in order of occurrence):

1. Provide guidance

2. Inspect the business

3. Give instructions to develop a plan to increase energy efficiency to meet the benchmark

Then, if still failing:

- Name them publicly

- Impose fines

Businesses that have met the target may be published on the government web site as excellent companies and offered energy efficiency subsidies.

Scope

Server rooms with an area of 300m^2 or greater for traditional and colo datacentres.

(2021 METI survey found that this threshold regulation covered 78.9% of operators and covered 98.9% of data centre energy consumption)

There is the intention to develop a metric for IT energy efficiency and when this has been established to include tenants of colo data centres in the scheme.

Status and date of introduction (actual or proposed)

First took effect 1 April 2022 (first reporting April 2023)

Listing of the metrics used

PUE

The intention is to develop an indicator which reflects IT energy efficiency in future.

Listing of levels set

The benchmark target is a PUE of 1.4 (value achieved or surpassed by the top 15% of the 72 data centres which reported PUE values in the 2021 METI survey).

A new target value should be considered when more than 50% of business operators in the industry have achieved the benchmark target.

References:

- Interim Report by working Group on Judgment Standards for Factories, Energy Conservation Subcommittee (2022) https://www.meti.go.jp/shingikai/enecho/shoene_shinene/sho_energy/kojo_handan/pdf/20220324_1.pdf

- Overview Energy Conservation Law for Data center https://www.enecho.meti.go.jp/category/saving_and_new/saving/enterprise/factory/support-tools/data/2022_01benchmark.pdf

- Presentation by Masana Ezawa, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, given March 17, 2021. accessed via

A2.5 Energy Saving Obligation and the Energy Saving Notification Obligation (Netherlands)

Type of policy
Energy saving obligation on businesses

Scope
Commercial data centre business locations which consume more than 50,000 kWh of electricity or 25,000 m³ of natural gas (equivalent) per year.

Status and date of introduction (actual or proposed)
Both Obligations had applied to other sectors previously and were extended to include data centres in 2019.

The Netherlands Enterprise Agency, on behalf of the Ministry of Economic Affairs and Climate, produces lists of 'recognised measures'. Businesses are required to adopt relevant measures with a payback period of five years or less (the Energy Saving Obligation).

There are three data centre-specific and six server room-specific measures. There are also broader measures, on topics such as lighting and using energy efficient fans in ventilation, which are also relevant to data centres.

Businesses are also required to report which of the measures they have adopted every four years. (the Energy Saving Notification Obligation).

Listing of the metrics used
The three data centre-specific measures are:

- PH1 Set a higher cooling temperature for cooling servers
- PH2 Use a frequency converter to control the power of room coolers
- PH3 Apply free cooling to the cooling installation in the data centre

The six server room-specific measures are:
- FI1 Apply virtualization and consolidation to servers.
- FI2 Set up automated power management on servers
- FI3. Take low-load Uninterrupted Power Supplies (UPS) out of service.
- FI4 Use an outside air damper to cool the server room
- FI5 Use an energy-efficient cooling system for cooling of server rooms
- FI6 Separate hot and cold air streams in the server room

Listing of levels set
All measures above to be adopted if they are expected to payback within five years.

References:
- Energy Saving Obligation
  https://english.rvo.nl/topics/energiebesparingsplicht-2023/energy-saving-obligation

- Energy Saving Notification Obligation
https://english.rvo.nl/topics/energiebesparingsplicht-2023/energy-saving-notification-obligation

- Recognized List of Measures (EML) Netherlands Enterprise Agency August 2023,

Appendix 3 Descriptions of Cloud first and data consolidation policies

In alphabetical order of country or jurisdiction.

A3.1 Canada Cloud Smart

Type of policy
Move to cloud

Scope
Federal Government digital supply.

Status and date of introduction
The Canada Cloud Adoption strategy (2023) states that:

"In 2018, the Government of Canada (GC) renewed its cloud adoption strategy in response to the introduction of the Cloud First policy requirement. Since that time departments and agencies have grown their use of cloud.

• As legacy data centres are closed, departments can migrate their applications to Enterprise Data Centres (EDC) or modernize their applications using public cloud services.

• Departments and agencies also turned to cloud services during the pandemic to provide rapid, secure, and stable access to new digital services.

The cloud first policy requirement was meant to challenge departmental CIOs to consider cloud as their preferred delivery model for IT. Departments and agencies responded and it has become clear that 'cloud first' does not mean 'cloud at all costs'. While Cloud remains a preferred choice for new applications, the decisions are more complex for existing applications."

"While the government is still in the early stages of its adoption of cloud it continues to make improvements to polices and tools to support organizations with secure cloud adoption, processes and best practices."

The web page includes seven Cloud Adoption Principles of which the first is relevant:

Cloud Smart, The GC will rationalize application portfolios and align to the most appropriate hosting model.

Listing of the metrics used and levels set
No targets listed

References:
● Canada Cloud Adoption Strategy: 2023 Update
https://www.canada.ca/en/government/system/digital-government/digital-government-innovations/cloud-services/cloud-adoption-strategy-2023-update.html

A3.2 Canada Data centre consolidation

Type of policy
Data centre consolidation

Scope

Federal Government enterprise data centres.

Status and date of introduction

Ongoing. Work started in 2016. Unable to find recent reports of progress.

Listing of the metrics used and levels set

Old data centres closed:– a 2016 update stated 485 operational data centres, down from 543.

Performance of new centrally owned/operated data centres: four operational of which one, EDC Borden, was LEED silver certified in 2022.

References:

- Data centre consolidation
  https://www.canada.ca/en/shared-services/corporate/data-centre-consolidation.html
- Enterprise Data Centre (EDC) Borden achieves LEED Silver certification
  https://www.canada.ca/en/shared-services/campaigns/stories/leed-silver-certification.html

A3.3 France Cloud au centre

Type of policy

Cloud migration

Scope

All State digital services

Status and date of introduction

Ongoing. "In July 2021, France adopted a doctrine for the use of cloud computing technology by the French State, called "Cloud au centre". With this doctrine, cloud computing has become the default hosting and production mode for the State's digital services, for all new digital products and for products undergoing a substantial evolution. The State's digital services must now be hosted on one of the two internal interministerial public clouds or on cloud solutions provided by private companies that satisfy strict security criteria."

The interministerial digital department (DINUM), placed under the authority of the Minister of Transformation and the Public Service, is responsible for developing the digital strategy of the State and steering its implementation, including the Cloud policy.

Listing of the metrics used and levels set

The rules to follow are listed online at
https://www.numerique.gouv.fr/services/cloud/regles-doctrine/#contenu, but none of these relate to technical specifics.

References:

- Doctrine « cloud au centre » sur l'usage de l'informatique en nuage au sein de l'État
  Version du 25 mai 2023
  ("Cloud at the center" doctrine - on the use of cloud computing within the State; the Prime Minister, May 2023)
- The cloud for administrations
  https://www.numerique.gouv.fr/services/cloud/doctrine/

- Digital Public Administration factsheet 2022 France, prepared for the European Commission by Wavestone

A3.4 Singapore Digital Government Blueprint (DGB)

Type of policy

Cloud migration (as part of wider strategy, https://www.tech.gov.sg/digital-government-blueprint/)

Scope

Government digital systems

Status and date of introduction

Introduced initially in 2018, updated December 2020.

The DGB includes a six-fold strategy to build a Digital Government one aspect of this is "Re-engineering the Government's ICT infrastructure" which includes "A systematic shift of less sensitive Government systems and data onto the commercial cloud, enabling the use of leading-edge cloud tools to develop digital services". The 2020 update included a new Key Performance Indicator (KPI) for % of eligible Government systems to be on commercial cloud.

Listing of the metrics used and levels set

KPI of at least 70% of eligible Government systems to be on commercial cloud by 2023. (2023 is the delivery date for all the KPIs in the DGB)

References:

- Digital Government Blueprint Dec 2020

A3.5 UK Cloud first

Type of policy

Data centre consolidation and move to cloud

Scope

UK central government and other public sector organisation (local authorities, health authorities etc)

Status and date of introduction

A Cloud strategy was announced in 2011, with a target of 50% of central government new ICT spend on public cloud computing services by 2015 (not met) and data centre consolidation. The key measures of data centre consolidation were to be:

- Number of data centres and associated hosting services
- Cost per server
- Percentage of servers virtualised
- Utilisation of servers

The formal introduction of a 'Cloud First' policy followed in 2013. Guidance has been published and updated, most recently in 2022
https://www.gov.uk/guidance/use-cloud-first
and the strategy was updated in June 2023
https://www.gov.uk/guidance/government-cloud-first-policy

Listing of the metrics used and levels set

"When procuring new or existing services, public sector organisations should default to Public Cloud first, using other solutions only where this is not possible".

"Organisations should use Cloud managed services, avoiding simply using the Cloud for infrastructure hosting. Solutions should use higher level Cloud services available from the vendor…. As legacy workloads are migrated to Cloud, organisations should aim to modernise solutions by using Cloud services, rather than simply rehosting."

References:
- Guidance: Use cloud first
  https://www.gov.uk/guidance/use-cloud-first

- Guidance: Government Cloud First policy
  https://www.gov.uk/guidance/government-cloud-first-policy

A3.6 US Cloud Smart Strategy

Type of policy
Move to cloud

Scope
Federal Government and their agencies

Status and date of introduction
The Federal Government introduced a Cloud First strategy in 2010. This was replaced in 2019 by a 'Cloud Smart' policy, "

Listing of the metrics used and levels set
The Cloud Smart policy offers practical implementation guidance for Government missions to fully actualize the promise and potential of cloud-based technologies while ensuring thoughtful execution that incorporates practical realities. The Cloud Smart Strategy is a long-term strategy for the adoption of the cloud by Federal agencies in order to build a path for migrating to a safe and secure cloud infrastructure.
https://cloud.cio.gov/strategy/
It is lead by the U.S. Federal Chief Information Officer, Office of Management and Budget (OMB).

Who produced a list of 22 actions to be completed in order to support the policy
https://cloud.cio.gov/strategy/actions/

When accessed in August 2023 the webpage showed that 17 of the actions were completed and 5 were in progress.

References:
- Federal Cloud Computing Strategy, Suzette Kent, U.S. Federal Chief Information Officer, June 24, 2019
  (file name: US Federal Cloud-Strategy Jun 2019.pdf

A3.7 US Federal Data Center Optimization Initiative (DCOI)

Type of policy
Data centre consolidation and optimisation

Scope
Data centres operated for 24 Federal departments and agencies

Status and date of introduction

This is a continuation policy from initial Federal Data Center Consolidation Initiative, which was launched in 2010 and which reduced energy use by consolidating and closing (less efficient) Federal data centres. The DCOI was established in 2016 and then revised in 2019. The initiative operates under the framework of the Federal Information Technology Acquisition Reform Act (FITARA) (however this lapsed on 1 October 2022).

Listing of the metrics used and levels set

Agencies are obliged to plan and report in several ways under the initiative:

- A full inventory quarterly

- An annual strategic plan

- Five milestones per fiscal year at a minimum

The US GAO (Government Accountability Office) then report on progress annually against the required metrics of:

- Virtualization
- Availability
- Advanced energy metering
- Underutilized servers

Seven of the agencies are listed as being "not applicable" for reporting these metrics. The February 2023 report of the year to October 2022 was that all the agencies hit their availability target, 13 or 14 hit the targets for the other metrics.

The target values for these metrics do not appear to be published.

Previous targets for server utilisation and efficiency (as measured by PUE) were withdrawn although PUE values are collected as part of the inventory reporting for statistical purposes and "Improvement in PUE over time should be included in the agencies' approach to their data center management".

GAO also report against goals on:

- Data centre closures (for example 20 were closed and a further 58 scheduled to close in fiscal year 2022) and
- Cost savings (for example $612.326 million in cost savings in fiscal year 2021)

A further requirement is that agencies should consider EPEAT-registered servers when upgrading or replacing hardware to maximize efficiency. EPEAT-registered servers must be ENERGY STAR certified and should support ASHRAE Class A2 (or higher) allowable operating range.

References:
- Memorandum for Chief Information Officers of executive departments and agencies, Executive Office of the President Office of Management and Budget, June 2019

- Data Center Optimization, United States Government Accountability Office Report to Congressional Committees, Feb 2023

A3.8 US California state Cloud first

Type of policy
Move to cloud

Scope

California agencies and state entities.

Status and date of introduction

In place since 2014, current version adopted in 2020.

Listing of the metrics used and levels set

Each Agency/state entity is required to:

- Evaluate, in consultation with their IT organization, secure cloud computing alternatives for all IT projects and infrastructure initiatives (e.g., storage, servers, and Wide Area Network equipment).
- Use a cloud service model, i.e., Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), whenever a feasible and cost effective solution is available. The use of cloud services must take into account the full range of significant factors which will influence the success of the application during its operational life.
- Use IaaS or PaaS solutions for new, expansion or refresh initiatives
- Use IaaS, PaaS and SaaS solutions that are provided through the California Department of Technology where available

References:

- California POLICY - 4983.1 August 2020
  https://www.dgs.ca.gov/Resources/SAM/TOC/4900/4983-1#:~:text=Maintain%20an%20effective%20incident%20response,other%20applicable%20laws%20and%20regulations.

Appendix 4 Descriptions of public sector procurement policies

In alphabetical order of country or jurisdiction.

A4.1 Resource Efficiency Policy, Australia (New South Wales)

Type of policy

Mandatory procurement policy.

Scope

Data centres owned or leased by government agencies

Status and date of introduction (actual or proposed)

Policy adopted in 2019. This was required to be achieved and maintained by June 2020 or within 18 months of first occupancy.

Listing of the metrics used

NABERS data centre rating

Listing of levels set

NABERS Infrastructure and IT Equipment rating of at least 4.5 stars.

References:

- NSW Government Resource Efficiency Policy 2019

A4.2 Green public procurement guidelines (EU)

Type of policy

Voluntary guidelines. (Although the recast Energy Efficiency Directive 2023 requires authorities to "make best efforts to purchase only products and services that respect at least the technical specifications set at 'core' level in the relevant Union green public procurement criteria" (Annex IV para c)).

Scope

Data centres, server rooms and cloud services

Status and date of introduction (actual or proposed)

Published in 2020.

Listing of the metrics used

Criteria can be a selection criteria (SC, that is products not meeting these requirements are not eligible for purchase) or award criteria (AC that is points are awarded against these; products with higher scores are selected for purchase). Further, there are 'core criteria' that must be included and more demanding ambitious 'comprehensive criteria' that public authorities can choose to use.

Energy related technical specifications include:

- Server active state efficiency, SC
- Where air cooling is used, ICT Operating range – temperature and humidity, SC
- Demonstrating that the facility has environmental control facilities and infrastructures that are in line with the requirements and recommendation of standard EN 50600-2-3, SC
- Server idle state power, AC
- Renewable energy factor, AC

Listing of levels set

For each server model deployed in the data centre the calculated active state efficiency score must be greater than or equal to the minimum active state efficiency thresholds as listed in Table 22 based on the EN 303470 measurement methodology.

Table 22 Server efficiency in EU GPP by criteria and product type.

Product type	Core criteria	Comprehensive criteria
1 socket – rack	11.0	13.0
1 socket - tower	9.4	11.0
2 sockets – rack	13.0	18.0
2 sockets – tower	12.0	12.0
2 sockets – blade or multi-node	14.0	20.0
4 sockets – rack	16.0	16.0
4 sockets – blade or multi-node	9.6	9.6

References:

- EU green public procurement criteria for data centres, server rooms and cloud services, European Commission (2020)

A4.3 Resource Efficiency Programme III (Germany)

Type of policy

Voluntary procurement with the intention of becoming mandatory.

Scope

All IT procurement by the federal government.

Status and date of introduction (actual or proposed)

Goal that the German government's data centres should be operated in a more environmentally friendly manner and comply with the Blue Angel criteria for data centres. Set in the German Resource Efficiency Program III, (passed by the Federal Cabinet on June 17, 2020 and runs to 2023), measure 111.

There is also included in the coalition agreement of the current German government.

Listing of the metrics used

See Blue Angel (Appendix 8)

Listing of levels set

See Blue Angel (Appendix 8)

References:

- German Federal Data Centres as Trailblazers, "Blue Angel" quality ecolabel for data centres, 2023
  https://www.tuvsud.com/en-gb/press-and-media/2023/june/german-federal-data-centres-as-trailblazers

- Green IT: sustainability for the public sector, Lynn Nguyen, 2023
  https://www.adesso.de/en/news/blog/green-it-sustainability-for-the-public-sector-2.jsp

- German Resource Efficiency Program III – 2020 to 2023 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, June 2020

A4.4 Sustainable Public Procurement guidance for Networks, Telephone Services and Telephone Equipment (the Netherlands)

Type of policy
Voluntary guidelines provided by a web tool.

Scope
Includes data centres.

Status and date of introduction (actual or proposed)
Operational (date of introduction not stated)

Listing of the metrics used
There are different types of criteria:

- Minimum requirement
- Award criteria
- Suitability requirement
- Suggestion
- Contract Provision.

which may be basic, significant or ambitious.

An environmental management system is mandatory. Energy efficiency criteria are:

- PUE
- A history of PUE measurements
- An action plan for energy savings
- Supercomputers with Green500 or comparable power-performance ratios are rated higher

Listing of levels set
For new data centres the basic requirement for PUE is 1.3, the significant value is 1.2.

References:
- SPP-criteria tool
  https://www.mvicriteria.nl/en/webtool?cluster=1#//9/1//en

A4.5 California Green Building Action Plan (data centers) (US)

Type of policy
Procurement/effective MEPS for state-owned and leased data centres

Scope
California state-owned and leased data centres. One requirement applies to data centres or server rooms with an area ≥ 18.6m^2. All requirements apply to data centres with a floor area ≥ 92.9 m^2 (1000 square feet)

Status and date of introduction (actual or proposed)
Introduced in 2014 as required in the Green Building Action Plan Section 10.7.

These data centre specific requirements are in addition to the more general building requirements which include:

- All new State buildings and major renovations beginning design after 2025 shall be constructed as Zero Net Energy facilities

- State agencies shall continue taking measures to reduce grid-based energy purchases for State-owned buildings by at least 20% by 2018, as compared to a 2003 baseline, and reduce other non-building, grid-based retail energy purchases by 20% by 2018, as compared to a 2003 baseline.

- State agencies shall reduce water use at the facilities they operate by 10% by 2015 and by 20% by 2020, as measured against a 2010 baseline

Listing of the metrics used

- PUE

- Virtualisation

- Temperature and humidity range

Listing of levels set

All data centres or server rooms with an area ≥ 18.6m^2:

- must be operated within the 2011 ASHRAE - TC 9.9, Class A1 – A4, recommended guidelines for temperature and humidity

All data centres with a floor area ≥ 92.9 m^2 (1000 square feet):

- that exceed a PUE of 1.5 shall reduce their PUE by a minimum 10 percent per year until they achieve a 1.5 or lower PUE.

- all state agencies must consider virtualization options when refreshing equipment or standing up new systems.

References:

- Management Memo MM 14-09 Energy Efficiency in Data Centers and Server Rooms, Department of General Services, Oct 2014
- Green Building Action Plan – For Implementation of Executive Order B-18-12

Appendix 5 Descriptions of incentive schemes

In alphabetical order of country or jurisdiction.

A5.1 Corporate Sustainability Reporting Directive (CSRD) (EU)

Type of policy

Mandatory disclosure of whether companies have taxonomy aligned activities. The European Commission consider that this constitutes an incentive for companies to undertake these activities as "Companies with Taxonomy-aligned activities will benefit from institutional investors, retail investors and banks interested in green investments, as they will be looking to finance Taxonomy-aligned economic activities."

Scope

The scope expands progressively from 2024 to 2028, requirement starts with large and listed EU companies, then to large third country companies which do substantial business in the EU or have securities listed on EU regulated markets. It is estimated that more than 50,000 companies will be covered by the new CSRD obligations.

When in full force it will apply to all listed and non-listed companies with at least two of the following criteria:

a. more than 250 employees;
b. €40 million turnover or more;
c. €20 million or more in total assets.
It will also apply to non-EU parent companies with: (i) an EU-established large subsidiary or a listed SME subsidiary; or (ii) a large EU branch

Status and date of introduction (actual or proposed)

The CSRD took effect in January 2023 and sets requirements on progressively more companies from 2024 to 2028 (see above).

Listing of the metrics used

The EU Taxonomy provides a classification system for sustainable economic activities that is applied within the CSRD. Data centres can be assessed as meeting the Taxonomy requirements if they are certified as following the EU Code of Conduct (see separate listing for details)

Listing of levels set

As EU Code of Conduct.

References:

- Corporate sustainability reporting
  https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

- Corporate Sustainability Reporting: New EU rules for large companies and listed SMEs, White & Case, 2022
  https://www.whitecase.com/insight-alert/corporate-sustainability-reporting-new-eu-rules-large-companies-and-listed-smes

- EU Taxonomy Navigator FAQs
  https://ec.europa.eu/sustainable-finance-taxonomy/faq

- DIRECTIVE (EU) 2022/2464 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting
- Assessment Framework for Data Centres in the Context of Activity 8.1 in the Taxonomy Climate Delegated Act, JRC131733, JRC 2023

A5.2 Finance Law 2020 and REEN 2021 (France)

Type of policy

Tax incentive. Data centre operators who meet the scheme requirements receive a rebate from the carbon tax on electricity.

Scope

Unclear.

Status and date of introduction (actual or proposed)

The incentive was first included in the finance law of December 2020, taking effect in 2021. This was amended, with additional requirements added in November 2021, with effect from January 2022.

Listing of the metrics used

The requirements are:

- To implement an energy management system
- To adhere to a programme, recognized by a public, national or international authority, for sharing good practices in energy management of data centres[25] including:
  - The eco-design of data storage centres;
  - Optimization of energy efficiency;
  - Monitoring energy consumption and producing periodic reports on this;
  - The implementation of cooling technologies meeting performance criteria
- To reuse waste heat through a heating or cooling network, or meet a target of efficiency in the use of energy[26]
- To limit the use of water for cooling purposes.
- To carry out a cost-benefit analysis in order to assess the opportunity to recover waste heat, particularly through a heating or cooling network.

Listing of levels set

Not stated.

References:

- LOI n° 2020-1721 du 29 décembre 2020 de finances pour 2021 (1) article 266
  LAW no. 2020-1721 of 29 December 2020 on finances for 2021 (1): article 266
- LOI no 2021-1485 du 15 novembre 2021 visant à réduire l'empreinte environnementale du numérique en France (1), article 28
  LAW no. 2021-1485 of 15 November 2021 aimed at reducing the environmental footprint of digital technology in France (1), article 28

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[25] It has been suggested that the EU Code of Conduct meets these requirements.
[26] Possibly PUE?

A5.3 Climate Change Agreement (UK)

Type of policy

Voluntary agreement and tax incentive. The scheme offers companies with energy intensive processes significant discounts on the Climate Change Levy (a carbon tax) in return for meeting energy or carbon efficiency targets agreed between Government and sectors.

Scope

Colocation data centres with a minimum power supply of 240kW, a floor area of over 200m^2 and emergency back-up power to allow continuous running (not just batteries to allow controlled shutdown).

Status and date of introduction (actual or proposed)

Organisations participate in the agreement via the relevant trade association, in this case techUK. Target periods are for two years. The first period applicable for data centres was 2013-2014. The most recent target period was for 2021-2022; the tax incentive applies until March 2024. The scheme was extended in March 2023 with a target period of 2024-2025 and the tax incentive applicable until March 2027. In a 2020 publication techUk stated that there were over 150 participating sites.

Listing of the metrics used

PUE

Listing of levels set

A target reduction in PUE as shown in Table 23.

Table 23 UK Climate Change Agreements commitments by target period

Target Period	Sector Commitment (percentage reduction from base year)
1 January 2013 to 31 December 2014	1.000%
1 January 2015 to 31 December 2016	8.333%
1 January 2017 to 31 December 2018	13.750%
1 January 2019 to 31 December 2020	15.000%
1 January 2021 to 31 December 2022	4.539%

References:

- The UK Data Centre Sector: The most important industry you've never heard of, techUK and SLR, 2020
- UMBRELLA CLIMATE CHANGE AGREEMENT FOR THE DATA CENTRES SECTOR Agreement dated 14 February 2022, Environment Agency
- Note 05: Timetable of techUK CCA Activities, techUK and SLR, July 2017

Appendix 6 Descriptions of voluntary agreements

In alphabetical order of country or jurisdiction.

A6.1 Climate Neutral Data Center Pact (EU)

Type of policy
Industry voluntary agreement

Scope
Signatories to the Pact may be trade associations representing data centre operators or companies that own or operate data centres within the European Union. Targets apply to all data centres larger than 50kW of maximum IT power demand.

Status and date of introduction (actual or proposed)
Two organisations: the Cloud Infrastructure Service Providers in Europe (CISPE) and the European Data Centre Alliance (EUDCA) have created a governance coalition known as the Climate Neutral Data Centre Pact. The overall aim is for data centres which are signatories to the Pact to be climate neutral by 2030.

Beginning January 1, 2021 representatives from the data centre trade associations and companies that have signed the initiative, and the European Commission will meet twice annually to review the status of this initiative. By no later than July 1, 2023, signatories will certify adherence. The initial period of measurement will cover January 1, 2022 through December 31, 2022. Following the first certification, adherence will be reported every four years.

In December 2022 the Pact announced an audit framework for signatories[27] and required them to use accredited third party auditors to certify adherence. The Audit Framework is said to be aligned with the EU Taxonomy Regulation 2020/852 (see separate description of this for details).

Table 24 shows the signatories on the public register of the Pact as of 3rd October 2023:

Table 24 Number of signatories to the Climate Neutral Data Center Pact as at October 2023

Status	Number
Lapsed	3
Signed	21
Self-Certified	46
Certification - Pending	7
Certified	11
Total	**88**

Listing of the metrics used
PUE for energy efficiency. (There are other requirements on to water use effectiveness, use of clean energy and connecting with district heating systems).

In recognition of the European Commission's interest in creating a new efficiency metric, the trade associations have stated that they will work with the appropriate agencies or organizations toward

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[27]

https://www.climateneutraldatacentre.net/2022/12/08/audit-framework-launched-to-verify-data-centre-progress-to-climate-neutrality-by-2030-2/

the creation of a new data centre efficiency metric. Once defined, the trade associations will consider setting a 2030 goal based on this metric.

Listing of levels set

By January 1, 2025 new data centres operating at full capacity in cool climates will meet an annual PUE target of 1.3, and 1.4 for new data centres operating at full capacity in warm climates. Existing data centres will achieve these same targets by January 1, 2030.

References:

- Climate Neutral Data Centre Pact
  https://www.climateneutraldatacentre.net/

- Climate Neutral Data Center Pact – Self Regulatory Initiative 2021

- EU climate neutral data centre pact audit framework announcement December 2022

- Climate Neutral Data Centre Pact Public Register
  https://www.climateneutraldatacentre.net/public-register/
  (file ref: EU climate neutral data centre pact signatories 2023.xls)

Appendix 7 Descriptions of labels and certification schemes

In alphabetical order of country or jurisdiction.

A7.1 NABERS (Australia)

Type of policy

Voluntary label/rating. Three types of rating are available: infrastructure, IT equipment, whole facility.

Scope

- 10,000 kWh for a 40 day period for IT Equipment ratings;
- 87,600 kWh for 1 year or with IT equipment greater than 10 kW for Infrastructure ratings;
- 175,000kWh for 1 year or with IT equipment greater than 10 kW for Whole Facility ratings.

Status and date of introduction (actual or proposed)

Introduced in 2014. A certified NABERS Energy for data centres rating is valid for 12 months.

Selected information on rated schemes NABERS are publicly listed on a web site https://www.nabers.gov.au/ratings/find-a-current-rating.

Information listed for data centres include:

- Premises name
- Customer
- Address
- Rating type
- Date certificated valid to
- Star rating
- GHG emissions
- PUE

As of 10 January 2024 14 data centres with infrastructure ratings were listed.

Listing of the metrics used

In all cases rating is based on GHG emissions using a customised benchmark. For infrastructure ratings this is related to PUE.

Listing of levels set

Not published

References:

- NABERS Energy for data centres, Rules for collecting and using data, VERSION 1.1 JULY 2014
- https://www.nabers.gov.au/ratings/find-a-current-rating

A7.2 Code of conduct for data centres (EU)

Type of policy

Initially a commitment to follow a set of procedures to increase energy efficiency; latterly can also be used as an assessment tool for the EU taxonomy.

Scope
Not known

Status and date of introduction (actual or proposed)
Started in 2008, operated by the Joint Research Council (JRC), part of the European Commission. Organisations can apply to join the CoC as participants (owners and operators of data centres) or as endorsers (committing to support the Code and participants through the development of products, information, services, education or other programs) Signatories follow best practice and increase energy efficiency over time.

Participants sign a registration form, through which they commit to conduct an initial energy audit to identify the major energy saving opportunities, prepare and submit an action plan and implement this plan according to the agreed timetable. Energy consumption must be monitored regularly to see over time progress in the energy efficiency indicator related to the data centre. All Participants are required to follow the best practice guidelines which are updated annually, and to report against these guidelines annually. They have an obligation to continuously monitor energy consumption and adopt energy management in order to look for continuous improvement in energy efficiency.

The Assessment Framework[28], complements the Best Practices document by making it more requirement driven rather than recommendation based. This provides auditors with the necessary tools to assess if data centres apply the Practices correctly and it allows market players to complete their disclosures for EU Taxonomy[29] alignment as part of their non-financial reporting without any ambiguity.

Listing of the metrics used
PUE is known to be reported.

Certified organisations are publicly listed https://e3p.jrc.ec.europa.eu/node/575. As at September 2023 there were 168 participants many of which operated more than one data centre.

Listing of levels set
Not applicable. There are dozens of practices in the CoC, with different values, scored from 1 to 5. Some of these are 'Expected' (that is to be followed by all participants) or apply in particular circumstances (e.g. New build or retrofit), others are optional.

References:
- JRC Data Centres code of conduct
  https://e3p.jrc.ec.europa.eu/communities/data-centres-code-conduct
- Acton M, Bertoldi P, and Booth J (2021) Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency, Joint Research Council
- EU Science Hub European Code of Conduct for Energy Efficiency in Data Centres
  https://joint-research-centre.ec.europa.eu/scientific-activities-z/energy-efficiency/energy-efficiency-products/code-conduct-ict/european-code-conduct-energy-efficiency-data-centres_en
- Assessment Framework for Data Centres in the Context of Activity 8.1 in the Taxonomy Climate Delegated Act, JRC131733, JRC 2023

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[28] Alternatively the scheme can meet the requirements in CEN-CENELEC document CLC TR50600-99-1 "Data centre facilities and infrastructures - Part 99-1: Recommended practices for energy management"
[29] See separate policy description for EU Taxonomy

A7.3 EU taxonomy (EU)

Type of policy
Certification scheme. Certification used in the EU for the Corporate Sustainability Reporting Directive (CSRD) and the Sustainable Finance Disclosure Regulation (SFDR). See separate listings in incentives policies.

Scope
as EU Code of Conduct

Status and date of introduction (actual or proposed)
The EU taxonomy allows financial and non-financial companies to share a common definition of economic activities that can be considered environmentally sustainable. The Taxonomy Regulation entered into force on 12 July 2020. It established the basis for the EU taxonomy by setting out four overarching conditions that an economic activity has to meet in order to qualify as environmentally sustainable.

Under the Taxonomy Regulation, the Commission was obliged to develop a list of environmentally sustainable activities by defining technical screening criteria for each environmental objective through delegated and implementing acts. For data centres the implementing act is C(2021) 2800, with the details in Annex 1, section 8.1. Data processing, hosting and related activities. According to a draft commission notice published December 2022 data centres can be certified as meeting the screening criteria by being assessed as following the EU Code of Conduct using the assessment framework.

Listing of the metrics used
 as EU Code of Conduct

Listing of levels set
as EU Code of Conduct

References:
- EU taxonomy navigator
  https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en#eu-taxonomy-navigator

- EU taxonomy navigator Data processing, hosting and related activities
  https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity/230/view

- COMMISSION DELEGATED REGULATION (EU) C(2021) 2800 of 4.6.2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives

- As above Annex 1 – relating to climate change mitigation

- DRAFT COMMISSION NOTICE on the interpretation and implementation of certain legal provisions of the EU Taxonomy Climate Delegated Act establishing technical screening criteria for economic activities that contribute substantially to climate change mitigation or climate change adaptation and do no significant harm to other environmental objective

https://ec.europa.eu/finance/docs/law/221219-draft-commission-notice-eu-taxonomy-climate.pdf
- Assessment Framework for Data Centres in the Context of Activity 8.1 in the Taxonomy Climate Delegated Act, JRC131733, JRC 2023

A7.4 Blue Angel (Germany)

Type of policy

Voluntary label/rating. Note Only certified data centres can be used by German central government under the German Federal government IT strategy[30].

Scope

Size threshold not stated

Status and date of introduction (actual or proposed)

In 2012, the DE-UZ-161 environmental label set out the requirements for energy-efficient data centres have to fulfil; 2020 then saw the introduction of the supplementary DE-UZ-214 label for climate-friendly co-location data centres. The 2023 update combined those two labels in a single environmental label, "Data Centres" (DE-UZ 228).

Listing of the metrics used

Include:

- PUE
- cooling efficiency ratio (CER) ,
- energy reuse factor (ERF)
- water usage effectiveness (WUE).
- total IT output per square metre of gross floor area [kWel/m²GFA]
- total IT output per square metre of constructed area [kWel/m²CA]
- total IT output per square metre of white space [kWel/m²white space]
- for all servers: Average CPU utilisation per server, as an average figure for a period of one month
- for all storage systems: Average storage space utilised per storage system, as an average figure for a period of one month
- Minimum utilisation of the servers $ITEU_{SV}$
- Renewable energy use

Listing of levels set

- the establishment of an energy management system in accordance with DIN EN 50600-3-1, DIN EN ISO 50001 or EMAS III;
- use of waste heat in both the centre's own and external buildings or facilities;
- reuse management of hardware, i.e. servers and storage devices, after the end of their service life in the data centre;
- regular publication of key energy efficiency performance indicators such as power usage effectiveness (PUE), cooling efficiency ratio (CER) , energy reuse factor (ERF) and water usage effectiveness (WUE).
- The data centre must cover 100% of its electricity consumption using renewable energies such as hydroelectric power, photovoltaic power, wind power or biomass power.

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[30] See separate policy description for the German Federal government IT strategy

Minimum requirement for Power Usage Effectiveness (PUE) are shown in Table 25.

Table 25 Blue Angel minimum requirement for Power Usage Effectiveness

Date the data centre was commissioned	PUE
01/01/2024 or later	PUE ≤ 1.25
Between 01/01/2019 and 31/12/2023	PUE ≤ 1.30
Between 01/01/2015 and 31/12/2018	PUE ≤ 1.50
31/12/2014 or earlier	PUE ≤ 1.60

Minimum requirement for the Cooling Efficiency Ratio (CER) are shown in Table 26.

Table 26 Blue Angel minimum requirement for the Cooling Efficiency Ratio

Date the data centre was commissioned	PUE
01/01/2024 or later	CER > 9
Between 01/01/2019 and 31/12/2023	CER > 8
Between 01/01/2015 and 31/12/2018	CER > 7
31/12/2014 or earlier	CER > 5

The servers used in the data centre must have an average CPU utilisation of at least 20 percent over a period of 12 months

References:

- Data Centers (DE-UZ 228)
  https://www.blauer-engel.de/en/productworld/data-centers
- BLUE ANGEL The German Ecolabel Data Centers DE-UZ 228 Basic Award Criteria Edition January 2023 Version 1
- German Federal Data Centres as Trailblazers, "Blue Angel" quality ecolabel for data centres, 2023
  https://www.tuvsud.com/en-gb/press-and-media/2023/june/german-federal-data-centres-as-trailblazers

A7.5 BCA-IDA Green Mark for Data Centres (Singapore)

Type of policy
Voluntary label/rating.

Scope
Not known

Status and date of introduction (actual or proposed)
This label was jointly developed by Building and Construction Authority (BCA) and the Infocomm Media Development Authority (IMDA) of Singapore. The BCA-IMDA Green Mark for Existing Data Centre was first launched in October 2012 and was followed by the launch of BCA-IMDA Green Mark for New Data Centre in March 2013. Updated criteria came into effect in October 2020.

There are four levels of certification:

- Certified,

- Gold,
- Gold plus
- Platinum

depending on points scored.

Listing of the metrics used

The major energy related criteria are:

- PUE (25 out of 110 points)
- Peak Data Centre Cooling Load (expressed as kW/Refrigerated Ton). (20 out of 110 points)

Other, lower scoring criteria include:

- on the air handling system;
- minimum IT power chain efficiency;
- use of ENERGY STAR related servers, storage devices and network systems
- energy management

The scheme also scores parameters which are not directly energy related including:

- water efficiency
- sustainable construction & management (materials, commissioning)
- Smart and Healthy Building (air quality, lighting quality)

Listing of levels set

The minimum requirements for PUE for each label rating are shown in Table 27.

Table 27 BCA-IDA Green Mark for Data Centres minimum requirements for PUE

Certification level	PUE at 25% load[31]
Certified	< 1.7
Gold	< 1.6
Gold Plus	< 1.55
Platinum	< 1.5

Full points scores for each parameter are in the scheme description.

As of October 2023 there were four new and four existing certified data centres listed on the IMDA web page.

References:
- BCA-IMDA Green Mark for Data Centres Scheme
  https://www.imda.gov.sg/how-we-can-help/bca-imda-green-mark-for-data-centres-scheme
- Green Mark Assessment Criteria and Online Application
  https://www1.bca.gov.sg/buildsg/sustainability/green-mark-certification-scheme/green-mark-assessment-criteria-and-online-application
- BCA-IMDA Green Mark for New Data Centres 2019

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[31] There are curves of PUE at different IT loads. The PUE at 25% IT load is used for base point calculation; However, if PUEs at 50% or 75% cannot meet the reference PUE curve of respective ratings, points will be deducted.

A7.6 ENERGY STAR (US)

Type of policy
Voluntary label/rating.

Scope
Data centres **typically** include:

- high density computing equipment (such as server racks used for data storage and processing)
- dedicated power and cooling systems
- a constant power load of 75 kW or more
- uninterruptible power supplies (UPS)
- raised floors

Status and date of introduction (actual or proposed)
This was first introduced in 2010. Scored against the median value of a sample taken periodically.

Buildings with an ENERGY STAR score of 75 or higher are certified.

ENERGY STAR certified data centres are listed at
https://www.energystar.gov/buildings/certified_data_centers. Published data includes:

- Facility name
- Facility owner
- The years of certification
- Total floor space
- The year of construction

As of 25th September 2021 234 facilities were listed.

Listing of the metrics used
PUE.

The software used to collect energy data is the ENERGY STAR Portfolio manager. To calculate the ENERGY STAR score for stand alone data centres this requires an annual value of the IT energy use measured at the UPS outlet.

Listing of levels set
The Environmental Protection Agency (EPA) collected survey data, in coordination with major industry associations, including Uptime Institute, Green Grid, 7x24 Exchange, and AFCOM. Of the data collected that used by 61 stand alone data centres were used to develop a correlation equation of PUE and IT power. This was used to generate a distribution curve of efficiency ratio ((actual PUE/predicted PUE) and a look up table of ENERGY STAR score against efficiency ratio, with the score ranging from 1 (efficiency ratio of 1.3315 or greater) to 99 (efficiency ratio ≥ 0.6569).

References:
- Portfolio Manager FAQs, Property Types, Data Center, What is the definition of Data Center?
  https://energystar.my.site.com/PortfolioManager/s/article/What-is-the-definition-of-Data-Center-1600088539138
- Technical reference ENERGY STAR Score for Data Centers in the United States, EPA, August 2018

Appendix 8 National and supranational data collection schemes

In alphabetical order of country or jurisdiction.

A8.1 EU Energy Efficiency Directive 2023, data centre registry (EU)

Short description

Article 12 of the recast EED, 2023/955, (entered into force September 2023) places an obligation on Member States to require owners and operators of eligible data centres in their territory to make a set of information publicly available, except for information subject to Union and national law protecting trade and business secrets and confidentiality.

There is also a requirement for data centres with a total rated energy input > 1MW to utilise the waste heat or other waste heat recovery applications unless they can show that it is not technically or economically feasible[32].

Scope

Data centres with a power demand of the installed information technology (IT) of at least 500kW,

Data centres used for, or providing their services exclusively with the final aim of, defence and civil protection are excluded.

Data collected (published)

The data to be gathered[33] annually is:

- the name of the data centre,
- the name of the owner and operators of the data centre,
- the date on which the data centre started its operations
- the municipality where the data centre is based;
- the floor area
- the installed power,
- the annual incoming and outgoing data traffic,
- and the amount of data stored and processed within the data centre;
- the performance, during the last full calendar year, of the data centre in accordance with key performance indicators about, among other things :
  - energy consumption,
  - power utilisation (actual, average power consumption),
  - temperature set points,
  - waste heat utilisation,
  - water usage
  - and use of renewable energy,

initially using as a basis, where applicable, CEN/CENELEC EN 50600-4 'Information technology - Data centre facilities and infrastructures',

The intention is to introduce, by 31 December 2023, via a delegated act, a common rating scheme for data centres, defining data centre sustainability indicators, key performance indicators and the methodology to measure them[34].

The European database shall be publicly available but only at an aggregate level. The degree of aggregation (Member State, region?) is not specified in the act.

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[32] Article 26(6)
[33] listed in Annex VII of the directive
[34] Article 33(3)

Hardware and software used for collection

The Commission shall establish a European database to collate all this information. Data will be collected via a central database similar to EPREL (the European Product Registry for Energy Labelling).

There is an EC funded project : "Technical assistance in support of the introduction in the EED provisions (Commission proposal for the EED recast) of reporting requirements on the energy performance and sustainability of data centres" which it is understood is contributing to this.

References:

- DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on energy efficiency and amending Regulation (EU) 2023/955 (recast), July 2023

A8.2 Decree n° 2019-771 relating to obligations for actions to reduce final energy consumption in buildings for tertiary use (ELAN) (France)

Short description

The decree was adopted in 2019 and the first deadline for entering data for was 30 September 2022. (30 September is the deadline for entering data for the previous calendar year.)

Scope

The scope is defined by floor area, with a threshold of 1000 m^2. This applies to all tertiary buildings. Building operators will need to report data centre energy use whether this is for a dedicated data centre or a building with an IT (server) room.

Data collected (published)

Each owner or tenant will have to report their energy consumption data annually for the previous year. The floor area by category or sub-category (data centres are a sub-category) is also reported. Only collated data – the energy performance of a sector for a given year, is published. In addition the online platform allows each organisation to see how their energy performance compare to those made by organisations with buildings in the same category.

Hardware and software used for collection

Data is reported via an online IT platform OPERAT.

References:

- OPERAT presentation 25 January 2023

A8.3 LAW no. 2021-1485 of November 15, 2021 aimed at reducing the environmental footprint of digital technology in France, "REEN"(France)

Short description

The decree was adopted in 2021 – supplementing Section 1 of Chapter II of Title I of Book II of the Postal and Electronic Communications Code.

Scope

This will be set by a decree which will specify the content and methods of application of the obligation and the threshold of annual turnover achieved in France above which electronic communications operators will need to comply. At the time of writing this decree is in development.

Data collected (published)

Energy data is not required to be reported or published. Electronic communications operators are required to publish key indicators on their policies to reduce their environmental footprint, particularly in terms of:

- reducing greenhouse gas emissions,
- renewing and collecting portable mobile terminals,
- eco-design of products and the digital services they offer,
- recycling and reuse of routers and modems,

and raising awareness of responsible digital uses.

The indicators must be consistent with the objectives set by the national low-carbon development strategy.

The frequency of publication is not stated.

Hardware and software used for collection

Not stated.

References:

- LOI no 2021-1485 du 15 novembre 2021 visant à réduire l'empreinte environnementale du numérique en France (1), article 28
LAW no. 2021-1485 of 15 November 2021 aimed at reducing the environmental footprint of digital technology in France (1), article 28

A8.4 Energy efficiency law 2023 (Germany)

Short description

In July the Committee for Climate Protection and Energy published a Resolution recommendation and report on the Bill. On 21 September 2023 the German Parliament passed the bill, which it is understood incorporated the changes in this report. The act needs to be reviewed by the Second Chamber of the German Parliament (Bundesrat) and enter into force in course of November at the latest[35].

The first date of data collection is unclear – context suggests for 2024.

The Federal Government is establishing an energy efficiency register for data centres in which the information transmitted by the data centres is stored and transferred to a European database on data centres.

If operators of data centres offer services to third parties (customers), the operators are obliged to transparently present customers with the energy consumption per year that can be directly attributed to the customers from 1 January 2024.

Data on German data centres is being collected by the Peer-DC project, https://peer-dc.de/. The project developed and circulated a spreadsheet template to gather data[36]

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[35]

https://www.allenovery.com/en-gb/global/news-and-insights/publications/update-germany-tightens-energy-efficiency-requirements-new-challenges-for-companies-and-data-centers

[36] . In a private communication 21 July 2023, Peter Radgen, Stuttgart University, one of the project leaders reported that the register was nearly complete.

Also there is a report - Energy consumption of data centres, published in 2021. This gives broad estimates of energy use but does not provide detail.

Scope

In the law a data centre is defined as:

 a) a structure or group of structures for the central housing, central connection and central operation of information technology and network telecommunications equipment to provide data storage, data processing and data transport services with a non-redundant rated electrical connected load from 300 kilowatts and up

b) All facilities and infrastructure for power distribution, for environmental control and for the required level of resilience and security required to provide the desired service availability, with a non-redundant nominal electrical connected load of 300 kilowatts or more.

Data centres that serve to connect or connect other data centres and which predominantly do not have any data processing are exempt.

Data collected (published)

Operators of data centres are obliged to submit information about their data centre to the Federal Government by the end of 31 March of each year for the previous calendar year.

The data required and data published are:

1. General data centre information for publication
a)   Name of the data centre,
b)   Name of the owner and operator of the data centre
c)   Size class according to information technology connected load (<100kW, <500 kW; < 1MW, < 5MW; <10MW, <50MW; <100 MW; >= 100 MW),
d)   Postcode at which the data centre is located
e)   Total size of the building area (gross floor area and heated net floor area)
f)   area of the room for installation of information technology (white space)
g)   nominal connected load of the information technology and the non-redundant nominal connected load of the data centre
.

2. General data on the operation of the data centre in the last full calendar year for publication:
h)   Total electricity consumption including own generation, total electricity purchase and Power feedback into the supply network
i)   Share of renewable energies in total electricity consumption according to DIN EN 50600-4-3, November 2020 issue 8)
j)   Amount and average temperature of the measurable or estimable waste heat released into air, water or soil
k)   Amount of waste heat delivered by the data centre to heat consumers in kilowatt hours per year and its average temperature in (degrees Celsius)
l)   Amount of data stored and processed in the data centre,
m)   Energy consumption effectiveness according to DIN EN 50600-4-2, August 2019 edition of the entire data centre
n)   Percentage of reused energy according to DIN EN 50600-4-6, November202010 edition
o)   Efficiency of the cooling system according to DIN EN 50600-4-7, August 2020 11 edition
p)   Efficiency index of water use according to DIN EN 50600-9, May edition 202012

Hardware and software used for collection

"The information to be submitted in the electronic template provided by the federal government."

They may use the (spreadsheet) template developed in the [Public Energy Efficiency Register of Data Centres](#) (PEER-DC) project.

References:

- April 2023 draft of act
  https://www.bmwk.de/Redaktion/DE/Downloads/Gesetz/entwurf-enefg.pdf?__blob=publicationFile&v=6

- German Bundestag 20th electoral term Resolution recommendation and report of the Committee on Climate Protection and Energy (25th Committee) on the federal government's draft law to increase energy efficiency and to amend the Energy Services Act, 20/7632, 5th July 2023
  https://dserver.bundestag.de/btd/20/076/2007632.pdf

- News story on the passed Act (September 2023)
  https://www.dlapiper.com/en-pe/insights/publications/2023/09/part-3-energy-efficiency-act-enefg-bundestag-decides-on-draft-bill
  (file name: German Energy Efficiency Act update Sep 2023.doc)

- Energy consumption of data centers, German Bundestag Scientific Services, WD 8 - 3000 - 070/21, August 2021

- Data collection for the public energy efficiency register for data centres, PEER-DC

A8.5 Energy Conservation Act (Japan)

Short description

First took effect for data centres 1 April 2022 (first reporting April 2023).

Scope

Server rooms with an area of 300m^2 or greater for traditional and colo datacentres.

There is the intention to develop a metric for IT energy efficiency and when this has been established to include tenants of colo data centres in the scheme.

Data collected

PUE

The intention is to develop an indicator which reflects IT energy efficiency in future.

Hardware and software used for collection

Not known

References:

- Interim Report by working Group on Judgment Standards for Factories, Energy Conservation Subcommittee (2022)
  https://www.meti.go.jp/shingikai/enecho/shoene_shinene/sho_energy/kojo_handan/pdf/20220324_1.pdf

- Overview Energy Conservation Law for Data centres 2022
  https://www.enecho.meti.go.jp/category/saving_and_new/saving/enterprise/factory/support-tools/data/2022_01benchmark.pdf

- Presentation by Masana Ezawa, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, given March 17, 2021..
  accessed via
  https://iea.blob.core.windows.net/assets/2867cfa4-5184-4d4e-801b-c545de7e8900/2.Mr.MasanaEZAWA%2CMETI17-03BenchmarkingWorkshop.pdf

Appendix 9 Description of North American province, state and city data collection schemes

In order of data centre market significance.

A9.1 California: Building Energy Benchmarking Program

Short description
Introduced in 2018.

[2021 data includes 200 entries including use 'data centres and other use " of which 42 are classified as 'data centres' as primary use.]

NB excludes cities covered by separate city ordinances – see San Jose below.

Scope
Buildings with (1) more than 50,000 square feet (≥ 4645 m^2) of gross floor area and (2) either no residential units or 17+ residential units are required to report energy use annually. Data is published.

Data collected (published)
Includes:

- Address
- Primary Property Type
- All property types
- Weather Normalized Site Energy Use Intensity (EUI) (kBtu/ft²)
- Gross floor area
- Electricity purchased
- Electricity Use – Generated from Onsite Renewable Systems and Used Onsite
- ENERGY STAR score (if applicable)
- Whether ENERGY STAR certified
- Gas purchased

All published.

Hardware and software are used for collection
ENERGY STAR Portfolio Manager (which has a specific data center category) and then online reporting.

References:
- California Energy Commission Building Energy Benchmarking Program
  https://www.energy.ca.gov/programs-and-topics/programs/building-energy-benchmarking-program

A9.2 Massachusetts: Act Driving Clean Energy and Offshore Wind

Short description
The Act was signed in August 2022, the requirement goes into effect on July 1, 2024, but Department of Energy Resources (DOER) has an additional year (until July 1, 2025) to draft implementing regulations and establish the parameters of the reporting program.

Scope

It applies to buildings in the state (except in cities which have adopted their own ordinances – see Boston below) with floor area of 20,000 square feet or more (≥ 1858 m^2) initially but DOER may lower that threshold by regulation.

Data collected (published)

There is no information yet on what energy data will be required. Once the program is up and running, the data will be made publicly available on DOER's website on a building-by-building basis.

Hardware and software are used for collection

Not yet known. Seems likely to use ENERGY STAR Portfolio Manager in line with other US schemes.

References:

- Massachusetts to Require Disclosure of Energy Usage from Large Buildings, Kathleen Brill, Law & the environment, 2022
  https://www.lawandenvironment.com/2022/08/24/massachusetts-to-require-disclosure-of-energy-usage-from-large-buildings/

A9.3 Boston (Massachusetts): Building Energy Reporting and Disclosure Ordinance (BERDO).

Short description

There is a requirement to report energy use from 2019.

[2021 data includes 28 entries including use 'data centres and other use " of which none are classified as 'data centres' as largest property type.]

Third-party verification of buildings' data is required for the first year of reporting.

Emissions requirements are set for five year periods, starting 2025-2029, expressed in kgCO2e/SquareFoot/yr with targets set for 13 different use types developed through a technical analysis process based on existing buildings in Boston.

Scope

This applied to non-residential buildings that are 35,000 square feet or larger (≥ 3252 m^2) from 2019. The 2021 amendment to BERDO gave the City authority to set emissions standards for large existing buildings. The emissions standards will decrease over time, with all buildings achieving net zero emissions by 2050.

Smaller non-residential buildings, that are 20,000 square feet or larger (≥ 1858 m^2) began reporting their energy in 2022. They will not be subject to the emissions standards until 2031, reporting for 2030 emissions.

Buildings owned by the City of Boston and Boston Housing Authority are also required to report.

Data collected (published)
Includes:

- Property owner name
- Address
- Largest property Type
- All property types

- Site Energy Use Intensity (EUI) (kBtu/ft²)
- Gross floor area
- Electricity usage
- Electricity Use – Generated from Onsite Renewable Systems and Used Onsite
- ENERGY STAR score (if applicable)
- Whether ENERGY STAR certified
- Gas usage

All published.

Hardware and software are used for collection

ENERGY STAR Portfolio Manager is used for energy related data. A custom form is available to collect additional data required (presumably related to the emissions requirements.

References:

- BERDO (Building Emissions Reduction and Disclosure Ordinance) 2.0 101 webinar May 2022

A9.4 New Jersey: Clean Energy Act Energy Benchmarking

Short description

Benchmarking is mandatory. The first year's data to be reported is 2022, submission required by October 2023.

Scope

Commercial buildings[37] larger than 25,000 square feet (2323 m^2). Other building operators or owners can choose to report, without charge.

Data collected (published)

The data collected will include water and energy use. As the same collection method is to be used as for other US schemes the parameters will be similar.

Data will be published but the format is to be decided.

Hardware and software are used for collection

ENERGY STAR Portfolio Manager.

References:

- New Jersey's Clean Energy Program CEA Benchmarking
  https://njcleanenergy.com/commercial-industrial/programs/cea-benchmarking
- New Jersey Energy and Water Benchmarking, Stakeholder meeting, NJ Board of Public Utilities, December 2022.

A9.5 Chicago (Illinois): Energy Benchmarking Ordinance

Short description

Adopted 2013. Whole-building energy use is reported to the City annually. In the first year in which buildings benchmark, and every third year thereafter, buildings have to have energy and building data reviewed by an in-house or 3rd-party professional with a license or training credential recognized by the City.

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[37] Data centres are explicitly included, see
https://www.njcleanenergy.com/commercial-industrial/programs/benchmarking/energy-benchmarking-signup/?vs=&r=&b=Data%20Center&s=Commercial

The same ordinance introduced a energy rating system: buildings received a star rating (one to four) based on their ENERGY STAR score or equivalent which they are required to display in a prominent location on the property and to share this information at the time of sale or lease listing.

Scope

This applies to existing commercial, institutional, and residential buildings larger than 50,000 square feet (4645m^2).

Data collected (published)

- Primary property use type;
- Number of buildings on the property;
- Property address;
- Year built;
- Occupancy rate;
- Total gross floor area;
- Gross floor area for each property use type (if more than one).
- Electricity usage
- ENERGY STAR score (if applicable)
- Whether ENERGY STAR certified
- Gas usage

A report is published annually with aggregated data on energy use, ENERGY STAR scores, water use and emissions. Site data is not published.

Hardware and software are used for collection

ENERGY STAR portfolio manager and online portal.

References:

- Chicago Energy Benchmarking Homepage
  https://www.chicago.gov/city/en/progs/env/building-energy-benchmarking---transparency.html
- Chicago Energy Rating System
  https://www.chicago.gov/city/en/progs/env/ChicagoEnergyRating.html
- Chicago Energy Benchmarking Benchmarking Guide v2 2021
- Chicago Energy Benchmarking 2020 Report, City of Chicago

A9.6 Atlanta (Georgia): Commercial Energy Efficiency Ordinance

Short description

From 2019 owners of buildings are required to benchmark their energy and water usage, submit that data to the City on an annual basis, and have an ASHRAE Level 2 energy audit[38] conducted every ten years.

Scope

Commercial buildings, including multifamily, over 25,000 sq. ft. (2333 m^2).

Data collected (published)

Not specified but assume a similar list of parameters to other US schemes which also use ENERGY STAR portfolio manager.

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[38] https://www.betterbuildingsbc.ca/faqs/what-are-ashrae-energy-audits/

Aggregate data for each year is published online
https://public.tableau.com/app/profile/greenlinkanalytics/viz/AtlantaCBEEOBenchmarking2022/Intr
oduction

Hardware and software are used for collection
ENERGY STAR portfolio manager for reporting and online portal.

References:
- Atlanta Building Efficiency home page
  https://atlantabuildingbenchmarking.com/
- ATLANTA'S COMMERCIAL BUILDINGS ENERGY EFFICIENCY ORDINANCE, Training Event
  presentation, Kate Taber, August 2020.

A9.7 San Jose (California): Energy and Water Building Performance Ordinance
Short description
Large buildings to benchmark their energy use from June 2018.

Beyond Benchmarking: This additional ordnance places an additional requirement from 2024. A
subset of buildings[39] has to comply in each year and every 5 years thereafter. Building owners must
demonstrate either satisfactory building energy and water efficiency or undergo actions for efficiency
improvement (perform an energy audit, retrocommissioning, or targeted efficiency upgrades to
improve performance). A qualified service provider is required to demonstrate compliant through
either performance or improvement.

Scope
Benchmarking: over 50,000 square feet (4645 m^2), and multifamily from June 2019. Commercial and
multifamily buildings 20,000 square feet (1858 m^2) and over were required to comply from May
2020.

Beyond benchmarking: very large (over 50,000 square feet) from 2023 and large (20,000 to 49,999
square feet) buildings

Data collected (published)
Not specified but assume a similar list of parameters to other US schemes which also use ENERGY
STAR portfolio manager.

Results do not appear to be published.

Hardware and software are used for collection
ENERGY STAR Portfolio Manager

References:
- Energy and Water Building Performance Ordinance home page
  https://www.sanjoseca.gov/your-government/departments-offices/environmental-services/clim
  ate-smart-san-jos/energy-and-water-building-performance-ordinance
- Beyond Benchmarking home page
  https://www.sanjoseca.gov/your-government/departments-offices/environmental-servic
  es/climate-smart-san-jos/energy-and-water-building-performance-ordinance/beyond-be
  nchmarking

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[39] The last digit of a building's Assessor Parcel Number: very large buildings with 0 and 1 report in 2023, with 2
and 3 in 2024 and so on.

- Beyond Benchmarking 101: Overview of the Compliance Process and Pathways City of San José Energy and Water Building Performance Ordinance (BPO), webinar presentation, December 2022

A9.8 New York City (New York): Benchmarking and Energy Efficiency Rating

Short description

Initially introduced in 2009, under current law, large buildings must file annual benchmarking data with the city. In addition buildings are required to display an energy label which includes both a letter grade and the building's energy efficiency score in a conspicuous location near each public entrance.

Scope

Buildings larger than 25,000 square feet (2323 m^2)

Data collected (published)

Not specified but assume that a similar list of parameters to other US schemes which also use ENERGY STAR portfolio manager is collected.

A subset of this data is published annually for each building, namely:

- Identifier
- Street
- Square footage
- ENERGY STAR score
- Energy efficiency grade. (A to D or F if information missing, based on the ENERGY STAR score)

Hardware and software are used for collection

ENERGY STAR Portfolio Manager

References:

- Benchmarking and Energy Efficiency Rating home page
  https://www.nyc.gov/site/buildings/codes/benchmarking.page
- NYC Buildings 2022 Local Law 33 Data Disclosure for CY2021 Reporting

A9.9 Ontario: Energy and water reporting

Short description

Introduced in 2018 the regulations mandate that data about the building and its water and energy consumption be collected. Submissions for buildings 100,000 square feet (9290 m^2) or larger need to be certified by a professional.

[2021 data includes 80 entries including use 'data centres and other use " of which none are classified as 'data centres' as largest property type.]

Scope

Commercial, institutional and industrial buildings more than 50,000 square feet (4645 m^2).

Data collected (published)

1. Building Identifiers
2. Property uses
3. Whether the reporter ran the Data Quality Checker and the date it was run
4. Weather-normalized electricity use intensity (kWh/ft2, GJ/m2)
5. Weather-normalized natural gas use intensity (GJ/m2, m3/m2, m3/ft2)

6. Source energy use intensity (ekWh/ft2, GJ/m2)
7. Weather-normalized source energy use intensity (ekWh/ft2, GJ/m2)
8. Site energy use intensity (ekWh/ft2, GJ/m2)
9. Weather-normalized site energy use intensity (ekWh/ft2, GJ/m2)
10. Indoor water use intensity (m3/m2, m3/ft2)
11. Greenhouse gas emissions intensity (kgCO2/ft2, kgCO2e/m2)
12. Property Gross Floor Area – Self-reported
13. Gross floor area of specific property use types
14. Occupancy rate
15. Property notes
16. Energy use by fuel (electricity, gas, diesel, district heat etc)

Of these parameters numbers 1 to 11 are published annually for each building; the remaining parameters are reported only in aggregate.

Hardware and software are used for collection

ENERGY STAR Portfolio Manager

References:

● Report energy and water use in large buildings – overview page
  https://www.ontario.ca/page/report-energy-water-use-large-buildings
● Guide to energy and water reporting home page
  https://www.ontario.ca/document/guide-energy-and-water-reporting

A9.10 Montreal (Quebec): Disclosure and Rating of Greenhouse Gas Emissions of Large Buildings by-law

Short description

This was adopted in 2021 with annual reporting of energy data. A building GHG emissions performance rating is assigned annually to each building based on the submitted data. This rating has to be posted in the building and will also be published on the City's website.

Scope

● 2022: The by-law applies to any building with a floor area of 15,000 m² or more that is not exclusively residential and to any city-owned building of 2,000 m² or more.

● 2023: The by-law applies to any building with a floor area of 5,000 m² or more or with 50 or more dwelling units.

● 2024: The by-law applies to any building with a floor area of 2,000 m² or more or with 25 or more dwelling units.

Data collected (published)

Data collected includes:
● civic address
● year of construction,
● number of dwelling units (if applicable)
● floor area for each type of use
● building type
● energy use by fuel

There does not seem to be the intention of publishing data beyond the building GHG emissions performance rating mentioned above.

Hardware and software are used for collection
ENERGY STAR Portfolio Manager

References:
- By-law concerning GHG emission disclosures and ratings of large buildings home page https://montreal.ca/en/articles/law-concerning-ghg-emission-disclosures-and-ratings-large-buildings-20548
- Presentation: overview and application of the city of Montreal by-law 21-042 on the disclosure and rating of GHG emissions of large buildings. Geneviève Gauthier, Econoler, January 2022

Appendix 10: Initial values in TEM and model inputs for each scenario

Scenario 1 Data flow switching

BAU values

Table 28 shows the percentage of global data consumed in non-streaming in each data centre type in the BAU scenario.

Table 28 BAU global data consumed, non-streaming by data centre type

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non-streaming	5.3%	5.1%	4.9%	4.7%	4.5%	4.2%	4.0%
Cloud non-streaming	85.2%	84.3%	83.7%	83.0%	81.8%	80.0%	78.8%
Next generation non-streaming	9.4%	10.5%	11.4%	12.3%	13.7%	15.8%	17.3%

Note that TEM assumes that data processed (non-streaming) will increase to more than three times 2024 volume in 2030.

Table 29 shows the percentage of global data consumed in streaming in each data centre type in the BAU scenario

Table 29 BAU global data consumed, streaming by data centre type

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional streaming	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
Cloud streaming	89.7%	88.7%	87.9%	87.1%	85.6%	83.5%	82.0%
Next generation streaming	10.0%	11.1%	12.0%	12.9%	14.4%	16.5%	18.0%

Note that TEM assumes that data streamed will increase to more than four times 2024 volume in 2030.

Scenario values

The initial suggestion is 25% of data flow switched from traditional non-streaming to cloud non-streaming over five years in all regions as shown in Table 30.

Table 30 data flow switching by year scenario 1

Year	2024	2025	2026	2027	2028	2029	2030
Data Switch	0%	5%	10%	15%	20%	25%	25%

Scenario 2 Reducing PUE

BAU values

BAU values of PUE are shown in Table 31.

Table 31 BAU PUE

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	1.885	1.880	1.875	1.87	1.865	1.860	1.855
Traditional streaming	1.885	1.880	1.875	1.87	1.865	1.860	1.855

DC ID							
Cloud non-streaming	1.353	1.345	1.338	1.330	1.323	1.315	1.308
Cloud streaming	1.353	1.345	1.338	1.330	1.323	1.315	1.308
Next generation non-streaming	1.203	1.195	1.188	1.180	1.173	1.165	1.158
Next generation streaming	1.203	1.195	1.188	1.180	1.173	1.165	1.158

2.1) Scenario PUE1 – maximum PUE 1.5 taking effect in three years from 2025

Scenario values are shown Table 32 with the changed values shown in green.

Table 32 Scenario 2.1 PUE

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	1.885	1.750	1.625	1.500	1.500	1.500	1.500
Traditional streaming	1.885	1.750	1.625	1.500	1.500	1.500	1.500
Cloud non-streaming	1.353	1.338	1.330	1.323	1.315	1.308	1.300
Cloud streaming	1.353	1.338	1.330	1.323	1.315	1.308	1.300
Next generation non-streaming	1.203	1.188	1.180	1.173	1.165	1.158	1.150
Next generation streaming	1.203	1.188	1.180	1.173	1.165	1.158	1.150

2.2) Scenario PUE2 – maximum PUE 1.3 taking effect in three years from 2025

Scenario values are shown Table 33 in with the changed values shown in green.

Table 33 Scenario 2.2 PUE

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	1.885	1.683	1.492	1.300	1.300	1.300	1.300
Traditional streaming	1.885	1.683	1.492	1.300	1.300	1.300	1.300
Cloud non-streaming	1.353	1.325	1.313	1.300	1.300	1.300	1.300
Cloud streaming	1.353	1.325	1.313	1.300	1.300	1.300	1.300
Next generation non-streaming	1.203	1.188	1.180	1.173	1.165	1.158	1.150
Next generation streaming	1.203	1.188	1.180	1.173	1.165	1.158	1.150

2.3) Scenario PUE3 – maximum PUE 1.2 taking effect in three years from 2025

Scenario values are shown Table 34 in with the changed values shown in green.

Table 34 Scenario 2.3 PUE

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non-streaming	1.885	1.650	1.425	1.200	1.200	1.200	1.200

Traditional streaming	1.885	1.650	1.425	1.200	1.200	1.200	1.200
Cloud non-streaming	1.353	1.292	1.246	1.200	1.200	1.200	1.200
Cloud streaming	1.353	1.292	1.246	1.200	1.200	1.200	1.200
Next generation non-streaming	1.203	1.188	1.180	1.173	1.165	1.158	1.150
Next generation streaming	1.203	1.188	1.180	1.173	1.165	1.158	1.150

Scenario 3 Increasing utilisation

BAU values

BAU utilisation values are shown in Table 35.

Table 35 BAU utilisation values

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Traditional streaming	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Cloud non-streaming	22.7%	22.9%	23.1%	23.4%	23.6%	23.8%	24.1%
Cloud streaming	22.7%	22.9%	23.1%	23.4%	23.6%	23.8%	24.1%
Next generation non-streaming	25.7%	23.9%	27.1%	28.4%	28.6%	28.8%	29.1%
Next generation streaming	25.7%	23.9%	27.1%	28.4%	28.6%	28.8%	29.1%

Scenario values

Scenario values are shown in Table 36 with the changed values shown in green.

Table 36 Scenario 3 utilisation values

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Traditional streaming	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Cloud non-streaming	22.7%	24.4%	26.0%	27.5%	27.5%	27.5%	27.5%
Cloud streaming	22.7%	24.4%	26.0%	27.5%	27.5%	27.5%	27.5%
Next generation non-streaming	25.7%	25.5%	27.1%	28.7%	28.7%	28.8%	29.1%
Next generation streaming	25.7%	25.5%	27.1%	28.7%	28.7%	28.8%	29.1%

Scenario 4: Increasing Server efficiency (decreasing equipment energy intensity)

The equipment energy intensity is the TWh energy consumed per exabyte of data processed by the equipment when operating in the high utilisation period. The equipment intensity is the inverse of the energy efficiency and is a characteristic of the ICT equipment (and software).

BAU values

The BAU values of equipment intensity x10^3 (to be easier to read) are shown in Table 37.

Table 37 BAU equipment intensity x10^3

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non-streaming	1.346	1.157	0.994	0.857	0.739	0.637	0.549
Traditional streaming	0.135	0.116	0.100	0.086	0.074	0.064	0.055
Cloud non-streaming	1.264	1.093	0.945	0.817	0.707	0.612	0.530
Cloud streaming	0.109	0.093	0.080	0.069	0.059	0.051	0.043
Next generation non-streaming	1.179	0.915	0.846	0.728	0.606	0.505	0.421
Next generation streaming	0.102	0.078	0.072	0.061	0.051	0.042	0.034

NB Multiplied by a thousand to be easier to read.

Scenario values

The scenario values of equipment intensity x10^3 (to be easier to read) are shown in Table 38.

Values in green are changed in the scenario

Table 38 Scenario 4 equipment intensity x10^3

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	1.346	0.926	0.926	0.857	0.739	0.637	0.549
Traditional streaming	0.135	0.093	0.093	0.086	0.074	0.064	0.055
Cloud non-streaming	1.264	0.915	0.915	0.817	0.707	0.612	0.530
Cloud streaming	0.109	0.078	0.078	0.069	0.059	0.051	0.043
Next generation non-streaming	1.179	0.915	0.846	0.728	0.606	0.505	0.421
Next generation streaming	0.102	0.078	0.072	0.061	0.051	0.042	0.034

Scenario 5: Increasing % low utilisation equipment shutdown

The BAU values are % for all years and all data centre types. The scenario values are 20% for all years from 2025 for cloud and next generation data centres.

Alternative BAU scenario 4

BAU values

The server intensity values in the alternative BAU are in Table 39.

Table 39 Alternative BAU equipment intensity x10^3

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non-streaming	1.433	1.313	1.202	1.102	1.011	0.927	0.850

Traditional streaming	0.143	0.131	0.120	0.110	0.101	0.093	0.085
Cloud non-streaming	1.333	1.225	1.126	1.034	0.951	0.874	0.803
Cloud streaming	0.115	0.105	0.096	0.088	0.081	0.074	0.067
Next generation non-streaming	1.179	0.915	0.846	0.728	0.606	0.505	0.421
Next generation streaming	0.102	0.078	0.072	0.061	0.051	0.042	0.034

NB Multiplied by a thousand to be easier to read.

Scenario values

The scenario values of equipment intensity $x10^3$ (to be easier to read) are shown in Table 40.

Values in green are changed in the scenario

Table 40 Alternative BAU Scenario 4 equipment intensity $x10^3$

DC ID	2024	2025	2026	2027	2028	2029	2030
Traditional non streaming	1.433	1.050	1.050	1.050	1.011	0.927	0.850
Traditional streaming	0.143	0.105	0.105	0.105	0.101	0.093	0.085
Cloud non-streaming	1.333	0.980	0.980	0.980	0.951	0.874	0.803
Cloud streaming	0.115	0.084	0.084	0.084	0.081	0.074	0.067
Next generation non-streaming	1.345	0.915	0.846	0.728	0.606	0.505	0.421
Next generation streaming	0.117	0.078	0.072	0.061	0.051	0.042	0.034

References

Note: this list is only of literature references. References to policies are embedded in the policy descriptions in the Annexes.

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