Reporting requirements on the energy performance and sustainability of data centres for the Energy Efficiency Directive

Task B report: Labelling and minimum performance standards schemes for data centres

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1 Introduction

Data centres are estimated to have the fastest growing energy consumption and carbon footprint across the whole ICT sector, mainly due to technological advances such as cloud computing and the rapid growth of the use of Internet services. In the EU, from 2010 to 2018 data centre energy consumption increased by 42% and is forecast to further increase by 28.2% by 2030[1], representing about 3.2% of the EU final electricity demand. Reducing the energy demand of ICT, including data centres, is an important step in achieving the ambitious climate targets of the EU – a reduction of overall GHG emissions of 55% by 2030 compared to 1990 levels.

The European Green Deal and the Climate Law (Regulation (EU) 2021/1119) represents a major leap in that direction. As a part of the 'Fit for 55' package, the recast Energy Efficiency Directive[2] (EED recast), includes new obligations that target data centres.

To support sustainable development in the ICT sector, the Article 12 of the EED recast asks data centres to make information about their energy performance publicly available. These reporting requirements would apply to all DCs, old and new, whose IT installed power demand is above a threshold.

2 Objectives

In line with the EED recast, the Commission will adopt a delegated act to establish a common EU scheme for the reporting of the sustainability of data centres within EU.

While the negotiations were ongoing and within the frame of uncertainty about its final outcome, the Commission started preparing the necessary evidence by means of this study and whose specific objectives are to:

- Organise a consultation with relevant stakeholders and Member State representatives.
- Assess and propose the main elements that will define the scope of reporting on the energy performance and sustainability of data centres: how are data centres defined, which data centres will be required to report and possible exceptions to this obligation
- Assess and propose the main elements of the reporting scheme: which entities will be responsible to fulfil the reporting obligation for each data centre, access to data and ways to ensure the consistency and quality of the reported data
- Identify, assess and propose the possible key performance indicators that can be used to report the energy performance and sustainability of data centres, as well as their respective calculation methodologies
- Identify, assess and propose the possible data and information, which data centres will need to report along with the key performance indicators
- Propose options for an EU-wide repository that will be used to gather, keep and publish the reported data

3 Structure and objectives of this document

Data gathering and reporting (Task A) is expected to be the first step in a process of incentivising sustainability in data centres as explained in Recitals 66 and 67 of the proposal for an EED recast. Two potential longer-term outcomes of this reporting, according to Article 12(5), could be the introduction of

[1] Own calculations based on figures provided in European Commission (2020b). Energy-efficient cloud computing technologies and policies for an eco-friendly cloud market.
[2] OJ L 231, 20.9.2023, p. 1–111 EUR-Lex - 32023L1791 - EN - EUR-Lex (europa.eu)

an EU-wide labelling scheme for the sustainability of data centres and/or the introduction of minimum performance standards for data centres, especially new and significantly refurbished ones.

To support the development of these policy instrument, Task B will identify, assess and propose possible ways to use the reported data and introduce a labelling or "minimum performance standard" for data centres across EU.

Task B report is structured in the following sections, according to the sub-tasks:

- Evidence of existing policy instruments and potential instruments
- First evaluation of different options
- Identify a small number of most promising options
- Groundwork to select and implement future scheme

4 Evidence of existing policy instruments and potential instruments

In this section, existing policy instruments, or policy instruments under development worldwide are identified and described, as first step to determine possible policy options to be further analysed. The section distinguishes among national and regional legislation, voluntary initiatives, voluntary certification schemes, building certification schemes and self-regulation initiatives. It is based on desk research, stakeholder feedback and the information of the report *International review of energy efficiency in data centres* (Ballarat Consulting, 2021)[3], produced for the Australian Government.

4.1 National and regional legislation

4.1.1 French Decree n° 2019-771 relating to obligations for actions to reduce final energy consumption in buildings for tertiary use

France is exploring the option of setting consumption reference values per data centre size, which would be implemented by means of the decree n° 2019-771 of 23 July 2019. This decree sets reduction of energy consumption tiers for buildings of the tertiary sector until 2050 in respect to a reference year not before 2010. The scope is defined by floor area, with a threshold of 1000 m^2. For data centres, there will be reference values in terms of IT power density (W/m2), utilisation and PUE for each range of size, to calculate the reference energy consumption used to compare the real energy consumption of a data centre.

4.1.2 German Energy Efficiency Act proposal

On 18 October 2022, the Federal Ministry for Economic Affairs and Climate Action (BMWK) presented a draft bill for an Energy Efficiency Act. The Draft Bill proposes efficiency requirements for data centres, in particular to data centres that start operations from 1 January 2025.

According to the information found in the media[4], data centres will be required to cover 50% of energy demand with unsubsidised electricity from renewable energy sources from January 2024, and 100% from January 2025. Data centres starting operation from 1 January 2025 will have to demonstrate a PUE value of at least 1.3 and a utilisation rate of at least 30%. There is also a minimum cooling air intake temperature of 27 degrees for new data centres with air cooling, which will apply from 1 January 2028. These requirements are complemented with an energy or environmental management system and the publication of efficiency indicators of the data centre.

[3] https://www.energy.gov.au/publications/international-review-energy-efficiency-data-centres
[4] https://www.theworldlawgroup.com/news/germany-challenges-for-data-centre-operators

4.1.3 North Holland Region

The province of Noord-Holland, the municipality of Amsterdam, Haarlemmermeer and Hollands Kroon have developed minimum establishment conditions for new data centres and expansions of existing ones. The data centres in the scope have at least a gross floor area of more than 2,000 m2 and an electrical connected load of more than 5 MVA.

The minimum establishment conditions consist of:

- Energy efficiency requirements, among others:
  - Being participant of the EU Code of Conduct for data centres
  - Cold gear temperature
  - Energy registration and monitoring system accessible by the Competent Authority
  - Design PUE has a maximum of 1.16
- Energy generation
  - Installation of solar panels
  - Purchase of green electricity
  - Waste heat reuse
- Water usage, among others
  - Ban on the use of groundwater
  - Where applicable, storage capacity in the form of a rainwater buffer or groundwater
  - Calculation of the WUE (Water Usage Efficiency) in accordance with ISO/IEC 30134-9 and its registration per calendar year

4.1.4 New South Wales requirement for minimum NABERS rating for owned or operated data centres

The New South Wales (NSW), Australia, Government Resource Efficiency Policy (State of NSW and Office of Environment and Heritage 2019) sets requirement that data centres owned or leased by government agencies must achieve NABERS (section 4.4.8) Infrastructure and IT Equipment rating of at least 4.5 stars. This requisite was to be achieved and maintained by June 2020 or within 18 months of first occupancy.

4.1.5 Strengthening the construction of green data centres, China

In 2019 the Chinese Government (National Energy Administration of the Ministry of Industry and Information Technology) announced requirements that may affect data centres.[5] The translation of the text suggests that:

- newly built large and ultra-large data centres will reach PUE of 1.4 or less
- high-energy-consuming and old equipment will be basically eliminated
- the utilisation efficiency of water resources and the proportion of clean energy applications will be greatly increased
- waste electrical and electronic products are effectively recycled

[5] http://www.gov.cn/xinwen/2019-02/14/content_5365516.htm

4.1.6 GB 40879-2021 Maximum allowable values of energy efficiency and energy efficiency grades for data centres

This Chinese standard applies to all new and expanded data centres with independent power and cooling. There is no minimum size limit but it excludes edge DCs. The regulation requires the design PUE and operating efficiency to meet specific values that are calculated from the local climate conditions. The operating efficiency is similar to PUE but provides alternative measurements that do not require continuous annual monitoring of the DC energy consumption (although annual measurements are acceptable).

There are 3 grades, and the maximum allowable value is 1.50.

4.1.7 USA Federal Data Center Optimization initiative (DCOI)

The initial Federal Data Center Consolidation Initiative was launched in 2010 and it has reduced energy use by consolidating and closing (less efficient) Federal data centres. The DCOI was established in 2016 and then revised in 2019 (Executive Office of the President Office of Management and Budget 2019). The policy consists of performance metrics on virtualization; advanced energy metering; server utilisation and availability. It removed metrics on energy efficiency as measured by PUE, since it was not deemed as "always appropriate for comparison across multiple facilities or agencies". However, "Improvement in PUE over time should be included in the agencies' approach to their data center management" and facility utilisation.

4.2 Voluntary initiatives

4.2.1 EU: Green Public Procurement criteria for data centres

The European Commission has developed green public procurement (GPP)[6] criteria in recognition of the fact that Europe's public authorities are major consumers and so can influence the market for goods and services. By using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production.

GPP for data centres were published in 2020 (European Commission, 2020) alongside the technical report describing their development (Dodd et al 2020). Criteria can be either technical specifications (TS, i.e., products must meet these requirements to be eligible for purchase) or award criteria (AC, which allocates points according to certain rating; products with higher scores are selected for purchase). In addition, selection criteria establish requisite on the technical capacity and competencies of the supplier. Further, criteria are differentiated in two levels of ambition: 'core criteria' as basic level of ambition and 'comprehensive criteria' as higher level of ambition. Public authorities can choose to use either core criteria or comprehensive criteria depending on the environmental performance of the suppliers available in their territory.

Energy related criteria included in the EU GPP are:

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

Technical capacities and competencies (all SC) are:

- Relevant competencies and experience in optimising a server's utilisation

[6] https://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm

- Relevant competencies and experience in minimising cooling energy use, identifying opportunities to reduce energy use and to use any remaining waste heat
- Demonstrate waste heat reuse readiness (if there is ready demand on or near site for the heat)

There are also contract performance clauses. If the contractor operates the data centre they must:

- Undertake periodical reporting of optimisation analysis and the achievement of utilisation targets.
- Measure and report monthly the utilisation rate of the servers in the data centre based on ISO 30134-5
- Provide an annual report containing the year's average and monthly disaggregated data for the total metered energy consumption of the data centre and the sub-metered electricity consumption for the mechanical & electric systems and the IT equipment (to allow robust calculation of PUE)
- Provide monthly data for the renewable energy purchased or the renewable energy generated (if relevant)

4.2.2 EU Code of Conduct on Data Centre Energy efficiency

The EU Code of Conduct (CoC) started in 2008 and is operated by the Joint Research Centre (JRC), part of the European Commission[7]. 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) (JRC 2021b).

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 overtime progress in the energy efficiency indicator related to the data centre. All Participants are required to follow the best practice guidelines (Acton et al 2021) which are updated annually, and to report annually. They have an obligation to continuously monitor energy consumption and adopt energy management in order to look for continuous improvement in energy efficiency. One of the key objectives of the CoC is that each participant benchmarks their efficiency over time, using the CoC metrics in order to produce evidence of continuous improvement in efficiency.

In addition, every year data centres that have adopted innovative technologies to improve their energy efficiency and have demonstrated outstanding improvements are given the Code of Conduct Data Centre Award. The criteria for the winners are the reduced need for mechanical cooling of the data centre for most of the time and raised indoor temperature. These are among the most important measures to improve efficiency and reduce energy consumption.

Energy efficiency targets expressed as PUE are complemented by general commitments to monitor power and energy consumption, adopt good management practices, increasing IT utilisation, switching off components not needed, and reducing energy consumption where possible.

4.2.3 Taxonomy Regulation and delegated act

The EU taxonomy is a classification system, establishing a list of environmentally sustainable economic activities. It is aimed at helping the EU scale up sustainable investment and implement the European green deal. The EU taxonomy would provide companies, investors and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable. In this way, it would contribute to create security for investors, protect private investors from greenwashing, help

[7] https://e3p.jrc.ec.europa.eu/communities/data-centres-code-conduct

companies to become more climate-friendly, mitigate market fragmentation and help shift investments where they are most needed.

The EU Taxonomy Climate Delegated Act defines which economic activities most contribute to meeting the EU's environmental objectives. It includes the activity storage, manipulation, management, movement, control, display, switching, interchange, transmission or processing of data through data centres, including edge computing, providing it complies with the EU Code of Conduct on Data Centre Energy efficiency.

4.2.4 Climate Change Agreement for The Data Centres Sector, UK

The Climate Change Agreements (CCA)[8] is a voluntary scheme that 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. The scheme is operated by the Environment Agency for the UK Government (Department for Business, Energy and industrial Strategy). Organisations participate in the agreement via the relevant trade association, in this case techUK, via an Umbrella Agreement (Environment Agency 2017). The Agreement is only open to co-location data centres. The sector target for data centres is a 15% reduction in PUE by 2020 from the base year (techUK 2017).

4.3 Voluntary certification schemes

4.3.1 Data Centers (DE-UZ 228)- Blauer Engel

The German Ministry of Environment and the German Federal Environment Agency have developed voluntary ecolabels for energy efficient data centres: the environmental labels "Energy Efficient Data Center Operation" (DE-UZ-161) and "Climate Friendly Colocation Data Centers" (DE-UZ 214). These two sets of criteria have been consolidated into "Data Centers" (DE-UZ 228)[9], which covers existing operator models but also those operators who manage their information technology at a colocation data centre that has been awarded the Blue Angel.

In order to be awarded the Blue Angel, operators of data centres and information technology must comply with minimum requirements, and this must be verified by an independent auditor (mandated by the German Environment Agency). The environmental label for "Data Centers" may be awarded to those data centres that comply with criteria:

- Requirements for all applicants
    - Energy management system
    - Energy Efficiency Report at the time of application
    - Energy Efficiency Report for final evaluation
- Requirements for data center operators
    - Measurement concept for the technical building equipment
    - Monitoring energy, air conditioning and water
    - Inventory list for the cooling technology and energy provision
    - Renewable energies
    - Publicly accessible information
    - Requirements for data center service providers
        - Obligation to provide information to IT customers

[8] https://www.gov.uk/guidance/climate-change-agreements--2
[9] https://www.blauer-engel.de/en/productworld/data-centers

        - Financial incentives for using more energy efficient information technology
        - Advisory services for improving energy efficiency
    - Power Usage Effectiveness (PUE target depends on date of and length of time since commissioning)
    - Cooling Efficiency Ratio (CER)
    - Refrigerant
    - Use of waste heat (ERF, Energy Reuse Factor, >0)
    - Electrical switching systems
    - Efficient use of floor space
    - New acquisitions during the term of the contract
- Requirements for IT operators
    - IT inventory list
    - Monitoring the IT load
    - Minimum utilisation of the servers ($ITEU_{sv}$ ≥ 20%)
    - Reuse management
    - Outlook on future requirements for IT operators

4.3.2 Certified Energy Efficient Data center award (CEEDA)

CEEDA[10] was launched by BCS (The Chartered Institute for IT) and consist of three classes (bronze, silver and gold) for four categories of award, three for existing data centres: enterprise, Colo, Telco and design/operate for new data centres.

It incorporates best practices, standards and metrics from: ENERGY STAR Server Specification 2.0 (or above), SERT V1.1.1, EU COC 2016 Guidelines V7.1.2, Green Grid: PUE, WUE onsite, WUE source, Energy Reuse Effectiveness (ERE),7 CUE, Green Energy Co-efficient (GEC); ETSI EN 3.1; EN 300 019, ASHRAE TC 9.9, Classes, 2, 3, 4; ISO: 55000, 14001, 50001, 55000; IEC 30134, 14040 and ITU TL1300, L.1310-201408

4.3.3 DCA certification scheme

This is a voluntary certification standard developed and operated by the DCA (Data Centre Alliance) an international trade association for the data centre sector[11]. The scheme started in 2013; the current guidelines were updated in 2020 (DCA, 2020). The certification criteria cover resilience class, operational integrity, and site physical security as well as energy efficiency. PUE value is not used as a criterion but it is required to be reported as a useful indicator of performance. Certification requires the operator to demonstrate that they are following one of three energy efficiency strategies: Green Grid Maturity Model (level 3 or better); EU Code of Conduct Ver10 or later or ITU (International Telecommunications Union) L 13.

[10] https://www.datacenterdynamics.com/en/ceeda/
[11] https://dca-global.org/about-the-dca

4.3.4 Green Data Centre Standard SS 564 Singapore

This certification standard[12] was developed by Infocomm Media Development Authority of Singapore partnered with other government agencies and industry, first published in 2011 and revised in 2013. It is based on the ISO 50001 standard on energy management and tailored to meet the needs of DCs in Singapore. The standard adopts the Plan-Do-Check-Act methodology, an iterative, four step-problem-solving process used for continuous process improvement.

SS 564 requires a number of sustainability indicators to be measured including:

- PUE
- Energy distribution factors (similar to partial PUEs)
- Air supply and return temperatures
- Relative humidity
- Carbon usage effectiveness

Optional sustainability indicators relating to the efficiency of the power and cooling infrastructure, as well as WUE, REF, and recycling are also listed. There are no requirements on the IT equipment.

4.3.5 Swiss Data Center Efficiency Label

The Swiss industry association digitalswitzerland and Hewlett Packard Enterprise (HPE) founded the Swiss Datacenter Efficiency Association,[13] which owns this voluntary label launched in 2020. The initiative is supported by the Swiss Federal Office of Energy through the programme SwissEnergy. The label has three grades for efficiency (bronze, silver and gold); in case of compliance with the environmental sustainability criteria, the carbon footprint, (the end-to-end carbon emissions of the DC reported in grams per kWh of consumed electricity) a “plus” tag is added to the awarded level. The label is valid for three years.

The two efficiency criteria (Swiss Datacenter Efficiency Association, 2020) are IT infrastructure efficiency and DC infrastructure efficiency. The former captures the efficiency of the primary IT components including compute, storage, network and their utilisation. The latter takes into account PUE and recycling capabilities.

4.4 Building focused data centre certification schemes

4.4.1 ENERGY STAR Score for DC

The ENERGY STAR Score for Data Centres[14] is a voluntary scheme that applies to spaces specifically designed and equipped to meet the needs of high-density computing equipment such as server racks, used for data storage and processing. The objective of the ENERGY STAR score is to provide a fair assessment of the energy performance of a property, taking into account the climate, weather, and business activities. The aspects of building activity that are significant drivers of energy use are identified by means of a statistical analysis of the peer building population. The result of this analysis is an equation that will predict the energy use of a property, based on its experienced business activities. The energy use prediction for a building is compared to its actual energy use to yield a 1 to 100 percentile ranking of performance, relative to the national building population.

The reference data used to establish the peer building population in the United States is based on survey data collected by EPA. To this purpose, EPA coordinated with major industry associations,

[12] https://www.imda.gov.sg/regulations-and-licensing-listing/ict-standards-and-quality-of-service/IT-Standards-and-Frameworks/Green-Data-Centre-Standard
[13] https://www.sdea.ch/the-association
[14] ENERGY STAR Score for Data Centres
https://www.energystar.gov/sites/default/files/tools/Data_Centre_August_2018_EN_508.pdf

including Uptime Institute, Green Grid, 7x24 Exchange, and AFCOM, to inform their members and encourage participation.

The statistical analysis is also used to understand what aspects of building activity are significant with respect to energy use. The filtered reference data is analysed using a weighted ordinary least squares regression, which evaluates energy use relative to business activity (e.g. IT energy). This linear regression provides an equation that is used to calculate energy use (also called the dependent variable) based on a series of characteristics that describe the business activities (also called independent variables).

The dependent variable is power usage effectiveness (PUE) and the independent variables come from the reference survey, and are:

- Building Square Footage
- Data Centre Square Footage
- Tier Level (four levels denoting increasing equipment redundant capacity)
- Number of racks
- UPS Utilization
- Annual IT Energy
- Building Type (stand-alone data centre vs. enclosed in another building)
- Data Centre type (options included Hosting, Hybrid, Internet, Traditional, and Telecom)
- HDD (heating degree days)
- CDD (cooling degree days)

PUE variations are analysed against the independent variables, producing a regression equation used to calculate the predicted PUE of a specific data centre. The energy efficiency ratio is the ratio between the actual PUE of a specific data centre and its predicted PUE.

4.4.2 BCA-IDA Green Mark For Data Centres, Singapore

This label was jointly developed by Building and Construction Authority (BCA) and the Infocomm Development Authority (IDA) of Singapore (BCAIDA, 2012). There are four levels of certification (certified, gold, gold plus and platinum) depending on points scored. The major energy related criteria are: PUE and Peak Data Centre Cooling Load (expressed as kW/Refrigerated Ton).

4.4.3 BREEAM SD 5068 Data centres 2010

BREEAM certification consists of five benchmark levels based on points scored across a range of criteria. BRREAM Data centres (BREEAM, 2012) covers new builds, extensions and major refurbishment and building fit-out (i.e. it is not suitable for operational data centres). Points related to energy are awarded based on PUE and CO2 index taken from the Energy Performance Certificate.

BRE Global announced the launch of the BREEAM Data Centres Annex Pilot in November 2019 which is to be used alongside the BREEAM New Construction International manual. The Annex provides data centre buildings with the ability to assess and improve their sustainability and environmental performance against the current BREEAM New Construction International manual for new-build projects around the world.

4.4.4 Energy Conservation Building Code (ECBC) In Data Centers, India

The Confederation of Indian Industry (CII), Indian Green Building Council, and the Lawrence Berkeley National Laboratory have been developing the code for data centres over several years and released a final draft User Guide for Implementing ECBC in data centres in December 2020 (CII et al 2020).

There are three efficiency levels: ECBC Compliant, ECBC+ and SuperECBC. PUE is used as the overall measure of energy performance. Points are also awarded against the efficiency of: room cooling; chiller plant; electrical system and IT hardware and IT system management (including mean CPU Utilisation)

4.4.5 Green Building Index (GBI) For Data Center, Malaysia

GBI is a wholly owned subsidiary of Pertubuhan Akitek Malaysia[15] (PAM) and the Association of Consulting Engineers Malaysia (ACEM). GBI assessment criteria for data centres were published in 2013 (GBI, 2013). There are four classifications: certified, silver, gold and platinum. Data centre specific energy efficiency related points are awarded on the basis of PUE or Building Energy Index (BEI) or a combination of achieved PUE/BEI and improvement in performance over the last three years. Renewable energy supply is awarded additional points.

4.4.6 Indian Green Building Council Data Center Rating System

The Indian Green Building Council (IGBC) issued a Rating System Pilot Version, Abridged Reference Guide for data centres in 2016 (IGBC 2016). Four levels of rating are awarded: certified, silver, gold and platinum. New and existing data centres can be rated. Minimum energy efficiency requirements are set on PUE; PUE below these thresholds are awarded points. Renewable energy supply is awarded additional points.

4.4.7 USGBC LEED for data centres

Developed by the U.S. Green Building Council, LEED[16] is a framework for identifying, implementing, and measuring green building and neighbourhood design, construction, operations, and maintenance which operates internationally. Four levels of rating are awarded: certified, silver, gold, and platinum.

New data centres can be rated against BD+C (Building Design and Construction) criteria; existing data centres against O+M (operation and Maintenance) criteria. A review of the BD+C criteria shortly after its introduction (Izadi Moud et al 2018) found that relatively few of the criteria had been made specific to data centres, only energy performance and thermal comfort. The Moud et al paper implies that PUE is used as the main energy performance metric.

4.4.8 NABERS For Data Centres, Australia

NABERS is a rating system whose rules were issued in 2014 (NABERS, 2014). Three types of NABERS Energy for data centres ratings are available: IT equipment rating; infrastructure rating and whole facility rating. NABERS is suitable for data centres of any age with IT equipment average power demand above approximately 10kW and must have independent cooling for infrastructure and whole facility rating. A star rating 1-6 is issued, valid for one year, based on the energy performance relative to other data centres.

A recent fact sheet (NABERS, 2020) indicates that the infrastructure rating is on PUE. The IT equipment rating assesses the energy efficiency of the storage, processing, and network equipment of the data centre (expressed as kWh per unit storage/processing capacity), the whole facility rating combines both IT Equipment and Infrastructure. The processing capacity is based on the aggregate clock speed of all CPU cores and the storage capacity is calculated from the unformatted (RAW) storage capacity of all storage units.

NABERS uses trained and accredited assessors, auditors and assessment software with extensive guidance for assessing and auditing measurements[17]

[15] http://www.pam.org.my/
[16] https://support.usgbc.org/hc/en-us/articles/12154267763987-Applying-LEED-to-data-center-projects#advantages
[17] https://www.nabers.gov.au/sites/default/files/2022-11/Energy%20for%20Data%20Centres%20Rules.pdf

4.5 Self-regulation

4.5.1 Climate Neutral Data Centre Pact

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. Signatories to the Pact may be trade associations representing data centre operators or companies[18] that own or operate data centres within the European Union. 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.

Climate Neutral Data Centre Pact (2021) states the requirements are:

- Energy efficiency, using PUE as a metric
- Matching electricity use by purchasing clean energy (clean energy)
- Setting and meeting ambitious targets for water usage effectiveness
- Increasing the quantity of server materials repaired or reused and creating a target percentage for repair and reuse (circular economy)
- Exploring possibilities to interconnect with district heating systems and other users of heat

The Climate Neutral Data Centre Pact is supported by a third party certification system to ensure that the signatories comply with the requirements on the pact. The first certification cycle was carried out in 2023[19]

4.6 CLC/TS 50600-5-1 Maturity model for Energy management and Environmental sustainability

The Green Grid firstly developed a data centre maturity model (DCMM) on energy and resource efficiency that was handed over to CENELEC in 2018, to be integrated in the EN 50600 framework. In 2021, CENELEC published the first edition of the standardised DCMM as Technical Specification CLC/TS 50600-5-1. It covers different elements whose scope or topic are as shown in Table 1.

[18] https://www.climateneutraldatacentre.net/
[19] https://www.climateneutraldatacentre.net/wp-content/uploads/2023/07/2023_07_06-Certification-Open-Letter.pdf

Table 1: Maturity model elements

Element	Topic
Management	Data centre management and operational information
Infrastructure building	Building infrastructure
Infrastructure power	Power supply and distribution infrastructure
Infrastructure Environmental control	Cooling infrastructure
ICT Software	Software and applications
ICT Compute	Server
ICT Storage	Storage
ICT Network	Networking

The DCMM defines five levels of maturity, with increasing requirements for levels 3 to 5, while the first 2 levels set a share of requirements of level 3 to be fulfilled. Levels 1 to 3 require practices related to technical facilities and minimum ICT practices. The incorporation of ICT becomes significant in Level 4 and in Level 5 there are limit values on PUE to be complied with.

Best practices prescribed are the recommended ones in Technical report CLC/TR 50600-99-1 and CLC/TR 50600-99-2, and there are different criteria for data centres in operation and new data centres.

5 Identification of policy options based on existing policies

5.1 Analysis of existing policies

From the analysis of the existing legislation and initiatives for sustainability in data centres, different measures can be identified as follows:

- Requirements on operation or design, usually in the form of best practices: this measure prescribes that data centres are operated (or designed, for new ones) in certain conditions or equipped with specific technologies.
- Minimum performance of metrics, usually PUE.
- Rating depending on the metrics or compliance with best practices: in this case, data centres are graded according to their performance and/or compliance with best practices.
- Information requirements: the data centre is required to disclose its performance, either the result of a metric such PUE or ERF or their score in a rating system.
- Targets or benchmarks: this is usually implemented together with best practices and management systems. The targets are not mandatory but guide the operators to improve the data centre performance.

These measures apply to different aspects of the data centre:

- Management and operation of infrastructure and ICT equipment
- Energy consumption metrics
- Cooling temperature or EER

- Water consumption metrics
- Waste heat metrics
- Renewable energy metrics
- Carbon metrics
- ICT metrics

Table 2 shows the number of legislation and initiatives for each measure applying to specific aspects. As can be observed, a very frequent measure is rating, sometimes in combination with minimum performance, in particular for energy consumption metrics (PUE mostly).

Minimum performance in energy consumption is the most used measure among the initiative identified. From the five national and regional legislative initiatives, the North Holland region sets minimum performance on PUE, cooling temperature and REF, while the German Energy Efficiency Act proposal may establish a combination of minimum performance and information for PUE and cooling temperature, and information requirements on ERF. US has apparently abandoned the use of PUE as metric for minimum requirements on their federal data centres and recommends it as target metric. Server utilisation is one of the performance metrics now applied to US federal data centres. The regions with MEPS tend to be geographically small but the calculations used for the Chinese minimum performance targets demonstrate the potential complexity of determining targets over a wide range of climate conditions such as the EU.

The existing policies all show variations in the scope of data centres, particularly the size of data centre and whether new or existing data centres are included. There are also unknowns about how frequently targets would need to be revised, particularly for ICT capacity but also PUE and infrastructure.

Table 2: Number of legislation and initiatives for each measure applying to specific aspects

Measure **DC aspect**	**Requirements on management and best practices**	**Minimum performance**	**Rating**	**Information**	**Targets**
Management and operation of infrastructure and ICT equipment	9		2 (1 together with requirements)		
Energy consumption metrics		11	7 (6 together with minimum performance)	1 (together with minimum performance)	2
Cooling temperature		3	2	1 (together with minimum performance)	1

Water consumption metrics		1			1
Waste heat metrics			1	1	
Renewable energy metrics		3	1 (together with minimum performance)		
Carbon metrics			2		
ICT utilisation		1	1		1
Server idle		1	1 (with minimum requirements)		
ICT equipment		1	1 (with minimum requirements)		

6 First evaluation of different options

This section gathers the policy options identified from the review and applies a set of criteria for a first qualitative evaluation. The objective is to single out which options are the most suitable for achieving the EED objectives, taking into account the current landscape of the data centre sector in the EU.

It is important to highlight that any policy option that would be developed should be in line with the information and sustainability indicators reported by data centres in the frame of the EED recast, since the reporting scheme will be the basis for any potential measure. A second option could be that the reporting scheme under the EED recast is amended or complemented (at some limited extent) to provide the necessary indicators for such a policy option.

Some of the existing instruments described in the previous section cover carbon emissions. Since carbon emissions are not considered in any form in the reporting scheme, carbon usage effectiveness or any similar metric related to “carbon-free” energy will not be analysed in the following sections. In addition, most of the carbon emissions from data centres are indirect emissions due to the electricity consumption from the grid, on which data centres operators cannot have any influence.

6.1 Criteria

The criteria used for this evaluation are the following:

- Does the policy have clear objectives defined?
- How effective is it concerning energy efficiency?
- How much information is required by policymakers for its development?
- Is it technically feasible for companies?
- How much is it accepted or supported by stakeholders?
- What is expected level of impact?

6.2 Evaluation of policy options

For each policy option, a fiche is produced gathering the results of its evaluation against the criteria defined in the previous point.

6.2.1 Management and operation of infrastructure and ICT equipment

Description policy option	Management requirements linked to internal targets, best practices
Clear objectives defined	Management requirement together with targets are usually designed for internal continuous improvement, which is the objective of these measures, so no clear objectives are defined.
Effectiveness concerning energy efficiency	The integration of best practices is the way to go beyond an internal effectiveness. However, the effectiveness is linked to specific techniques (no technology/practice-neutral) so it does not promote new solutions. This is a drawback in a highly innovative sector.
Information required by policymakers for its development (market and technological analysis, DC operation information)	Plenty of information available from current initiatives such CoC, however it requires a frequent revision period to reflect changes in best practices and technologies.
Technical feasibility (for companies)	This is feasible for DCs with over 500kW of installed IT power.
Acceptance and support of stakeholders	Data centre sector is not in favour in general of mandatory requirements, but it accepts requirements on energy management.
Impact	As any mandatory measure, the prescription of certain best practices may have a significant impact potential depending on the ambition level.

6.2.2 Energy consumption metrics and ancillary metrics

Description policy option	Minimum performance
Clear objectives defined	The objective of this measure is ensuring a minimum energy efficiency performance that discard the least energy efficient data centres, so the objective is clearly defined. The scope of the requirements may be new data centres or existing ones.
Effectiveness concerning energy-efficiency	This measure if very effective for renewable energy integration. PUE may have the effect to promote the consolidation of data centres, that is, small data centres to be clients of colocation data centres, but it is an effective metric for energy efficiency. WUE and PUE are related since water cooling improves the efficiency of data centre. Hence minimum requirements on WUE are difficult to establish. ERF requirements can be effective if waste heat consumers a near the data centre, so it is also difficult to establish a threshold.

	The effectiveness also depends greatly on how much of the market is regulated. Most policies only set PUE targets on new data centres, leaving the much larger proportion of older, less efficient DCs unaffected.
Information required by policymakers for its development (market and technological analysis, DC operation information)	Mandatory requirements always require a thorough understanding of the sector and its performance, to the detail of different types and sizes of data centres. In case of WUE and ERF, the location of the data centre must be factored in. It is also necessary to understand how the measure will affect new entries in the market, particularly in a highly innovative sector.
Technical feasibility (for companies)	The feasibility for companies will depend on the size, probably a system with different levels of compliance is needed.
Acceptance and support of stakeholders	Data centre sector in general is not in favour of mandatory requirements, but it is more open to REF requirements.
Impact	Depending on the level of ambition and its scope (new or existing), a requirement on PUE may have a high impact. REF requirements will hardly have an impact, as the purchase of renewable electricity seems to be a common practice in the sector. WUE and ERF have a significant impact potential.

Description policy option	**Information in the form of the metric**
Clear objectives defined	The objective is to inform the public about the energy and water usage performance of the data centre, so the sector is driven by clients and corporate responsibility to best performance.
Effectiveness concerning energy-efficiency	The effectiveness of information requirements is not so certain as mandatory requirements as it depends on the level of sensitiveness and awareness of data centre clients and society. It may benefit large data centres.
Information required by policymakers for its development (market and technological analysis, DC operation information)	As information will be in the form of metric, and there is not a threshold to be established, little information is needed.
Technical feasibility (for companies)	Feasible.
Acceptance and support of stakeholders	Supported by stakeholders.
Impact	It depends on the response of clients and other stakeholders with influence to drive the data centre sector.

Description policy option	**Information in the form of rating, labelling**
Clear objectives defined	The effectiveness of information requirements is not so certain as mandatory requirements as it depends on the level of sensitiveness and awareness of data centre clients and society. It may benefit large data centres.

Effectiveness concerning energy-efficiency	Labelling can improve the effectiveness of information requirements as it is meant to enable comparability among data centres and more accessible information for laypeople.
Information required by policymakers for its development (market and technological analysis, DC operation information)	The development of a rating or labelling system requires information on the performance of different types and sizes of data centres, to ensure that the labelling captures the complexity of the sector and disclose the performance level is an understandable and fair way.
Technical feasibility (for companies)	Feasible
Acceptance and support of stakeholders	Supported by stakeholders
Impact	It depends on the response of clients and other stakeholders with influence to drive the data centre sector

6.2.3 ICT utilisation, server idle

Description policy option	**Information in the form of the metric**
Clear objectives defined	The objective is to inform the public about the performance of the data centre in terms of work delivered per resource consumed. The goal is that the resources consumed for processing, storage and network are minimised.
Effectiveness concerning energy-efficiency	The effectiveness of information requirements is not so certain as mandatory requirements as it depends on the level of sensitiveness and awareness of data centre clients and society. In case of utilisation, the information may not be completely understood as it may largely vary depending on the type of data centre.
Information required by policymakers for its development (market and technological analysis, DC operation information)	As information will be in the form of metric, and there is not a threshold to be established, little information is needed.
Technical feasibility (for companies)	Depending on the metric, some data centres may not have the means to measure utilisation.
Acceptance and support of stakeholders	Data centre sector does not support utilisation metrics.
Impact	It depends on the response of clients and other stakeholders with influence to drive the data centre sector.

Description policy option	**Information in the form of rating, labelling**
Clear objectives defined	The effectiveness of information requirements is not so certain as mandatory requirements as it depends on the level of sensitiveness and awareness of data centre clients and society. In case of utilisation, the information may not be completely understood as it may largely vary depending on the type of data centre.

Effectiveness concerning energy-efficiency	Labelling can improve the effectiveness of information requirements as it is meant to enable comparability among data centres and more accessible information for laypeople.
Information required by policymakers for its development (market and technological analysis, DC operation information)	The development of a rating or labelling system requires information on the performance of different types and sizes of data centres, to ensure that the labelling captures the complexity of the sector and disclose the performance level is an understandable and fair way.
Technical feasibility (for companies)	Same as previous.
Acceptance and support of stakeholders	Supported by stakeholders.
Impact	It depends on the response of clients and other stakeholders with influence to drive the data centre sector.

7 Identify a small number of most promising options

From the different options analysed in the previous section, there is a set that can be singled out and ordered from high to low effectiveness and impact, taking into account relevant criteria for development and implementation, i.e., information required by policymakers and technical feasibility for data centre companies:

- Minimum performance on energy metrics: PUE, REF, ERF
    - High effectiveness and impact
    - Medium information required by policymakers
    - Dependent on the ambition levels for each segment of data centres
- Information requirements in the form of labelling based on a rating system according to performance of metrics and the compliance with requirements on management and best practices:
    - Medium or uncertain effectiveness and impact
    - Large information required by policymakers
    - Feasible for companies
- Labelling based on voluntary pass-or-fail criteria on performance of different metrics and the compliance with requirements on management and best practices:
    - Medium or uncertain effectiveness and impact
    - Medium information required by policymakers
    - Feasible for companies
- Information requirements in the form of metrics
    - Medium/low or uncertain effectiveness and impact
    - No information required by policymakers
    - Feasible for companies

Different combinations of these policy options can be further defined including different tiers similar to the maturity model of CLC/TS 50600-5-1. It could be rolled-out over a time period to better adapt to the information needs of each option that will be provided by the reporting scheme. Table 3 shows a possible combination using all options along a 6 year period.

Table 3: Example of combination of policy options for data centres

Tier	Year	Policy option
0	0	Reporting scheme comes into force.
1	1	This would be the most basic level of the sustainability scheme which would entail just Information requirements in the form of metrics.
2	3	This would be a first step in the sustainability scheme where only data centres that voluntarily comply with certain voluntary pass-or-fail criteria on performance of different metrics.
3	5	The basic information requirement would turn into a labelling/rating scheme, improving the comparability and accessibility of information. It may incorporate ICT capacity and utilisation metrics.
4	6	Based on the previous tiers, mandatory requirements on energy metrics or on the labelling scheme would be established.

This is just an example of the different combinations that could be designed, which need to be based on the information provided by the reporting scheme over some years and the groundwork explained in the next section. The natural evolution of the data centre sector is an important factor for the definition of policy drivers, which must be additional to the improvements achieved without policy intervention.

Stakeholders generally supported a gradual development of policy options from the basis of the information collected by the reporting scheme.

8 Groundwork to design the policy options

This section describes the tasks and methodologies that could be used for the definition and design of sustainable policy options for data centres.

8.1 Analysis of data from the reporting scheme

8.1.1 EU stock characterisation

The reporting scheme will provide sufficient information to describe and characterise the EU stock of data centres (data centres located in EU) and their performance in term of energy and water consumption, over a minimum period of time. The analysis will cover all the parameters that affect the performance, such as:

- Size in terms of ICT power demand or floor area
- Type of data centre: enterprise, colocation, co-hosting data centre.
- Redundancy or availability class according to EN 50600-1: 1-4
- Climate conditions, in terms of cooling degree days
- Water availability
- Location (access to waste heat users)
- Year of construction or renovation

It will also investigate any other aspects that could be relevant for policy development, for example, the adherence to voluntary initiatives such as the Code of Conduct or the Climate Neutral Data Centre Pact. This information may help the definition of measures based on management and best practices.

8.1.2 Base cases

The analysis of the data will be the basis for defining base cases for each relevant category of data centres. The base case can be either a real data centre, or an average data centre built on the characteristics of different ones. The aim of the data centre base case is being a reference to compare and quantify the improvement potential of technologies.

8.1.3 Trends of the evolution of EU stock

The projections of the EU stock needed to assess the impacts of policy options require a foresight of trends in data centres in terms of numbers, types, and sizes. For the number of data centres, some assumptions will be needed based on the time series available and the expected evolution in the demand of data centre services and in business models.

8.2 Supplementary technology analysis

This task describes the information that can supplement the analysis of the data from the reporting scheme.

8.2.1 Description of technologies

The task will describe data centres at technical level, not only with the data from the reporting scheme, but with expertise from industry and academia. The aim is to identify and describe:

- Technologies and practices that are commonly used to minimise energy and resource consumption.
- Best available technologies and practices that are used by frontrunners, that is, for those data centres with best performance.
- Best not yet available technologies, that is, technology still not available at commercial scale, but potentially available in the future. They indicate the space for future innovation and differentiation.

The description of these technologies is to be accompanied by data on improvement potential, i.e the capacity of the technology to reduce energy and resource use compared to the base case. Each technology will be characterized in terms of additional costs that a base case data centre will have to invest for implementation.

8.2.2 Cost-benefit and improvement potential analysis

The analysis of the technologies from the perspective of costs and benefits will provide a helpful orientation on the definition of policy options. Costs must be evaluated in terms of total cost of ownership or life-cycle costs of the data centre as a system, meaning that additional costs to implement energy efficiency solutions must consider the costs of the energy saved. Those technologies and practices with lowest costs are usually promoted by minimum performance requirements, as it is the case of Ecodesign measures, which are based on the least life cycle cost option. The definition of labelling or rating systems can be informed by the differentiation of technologies in terms of costs and improvement potential, so those technologies with highest potentials should have the highest rating, regardless their costs.

8.3 Policy options

The outcome of the previous tasks will be the basis to define in detail the policy options to be assessed. This section provides a description of a possible methodology to this purpose, linking the results of the previous tasks to each option.

8.3.1 Voluntary labelling based on pass-or-fail criteria

The reporting scheme will provide information on the performance of data centres, which will be affected at least by the parameters mentioned in section 8.1.1 which are not under the control of the data centre operator.

Some schemes such as Blue Angel and the Maturity model only discriminate by year of commissioning of the building and set the same thresholds to PUE regardless the size or other characteristics. However, it is recommended to analyse how data centres of different sizes and in different locations would comply with the criteria to understand what best practices in data centre operation are being promoted, and whether any specific segment of data centre can comply with the criteria more easily.

Both Blue Angel and the Maturity models incorporate criteria on management and best practices which may be complementary to the criteria on metrics.

Taking into account this differentiation, a voluntary labelling scheme should be focused on the promotion of best available technologies and practices, so its criteria must have the capacity to single out those data centres that implement them, or that achieve an equal performance.

A stakeholder pointed out that a voluntary labelling is not the envisaged policy option in the EED recast, which does not establish a voluntary nature of a possible rating scheme. In their view, a voluntary instrument could induce the proliferation of schemes at national level and thus the fragmentation of the internal market. Other comments also highlighted that there are already EU voluntary instruments such as the Code of Conduct supported by the EU taxonomy for sustainable activities, and they do not help provide robust and complete information on the data centre performance.

8.3.2 Labelling scheme based on rating or classes

The most complex policy option to be developed is a labelling scheme based on rating. Each metric or criteria must be normalised taking into account all parameters that may affect the performance or level of compliance of a data centre. These parameters are at least the ones listed in the previous section; however, Energy Star Score for DC identifies also identifies:

- Building floor area
- Data Centre floor area
- Number of racks
- UPS Utilization
- Annual IT Energy
- Building Type (standalone data centre vs. enclosed in another building)
- Data Centre type (options included Hosting, Hybrid, Internet, Traditional, and Telecom)

For other metrics than PUE, other parameters may be relevant, for example, ERF depends on the location and the access to waste heat consumers. This also links on how to develop a sustainability label that integrates all relevant metrics. A basic energy efficiency index can be derived from the normalisation of PUE, similarly to Energy Star Score. Additional points would be added upon the results on the other metrics and possibly on whether management and best practices are in place. These points can be in turn the function of other parameters:

- Points allocated to ERF may depend on the access to waste heat consumers.
- Points allocated to WUE may depend on the level of water stress in the territory.
- Points allocated to management and best practices may depend on their improvement potential and their cost of implementation.

- Points allocated to REF and on-site renewable energy may depend on the size of the data centre.
- Points allocated to the electrical grid functions such as peak demand shifting and firm frequency response (FFR). This will depend on the location of the data centre to provide flexibility, given that some locations present better opportunities or are better suited to participate in grid services.
- Points allocated to server utilisation.

For the definition of classes or levels (similar to A-G energy classes or silver, gold and platinum of some certification schemes), the cost-benefit and improvement potential analysis can inform the definition of these classes or levels. The classes should be defined in a way that data centres with technologies and practices with highest improvement potential or with equal performance are placed in the highest classes. In the case of data centres, these best data centres are equipped with a combination of both technologies and best practices, which together are able to achieve a certain level of performance.

Stakeholders supported the development of a rating system, though taking into account the diversity of characteristics in data centres. Some suggested that there should be a rating system for each assessment criteria, that is, one per each parameter evaluated (PUE, REF, etc.), instead of aggregating them into one single indicator.

There was a comment questioning the inclusion of management and best practices in the sustainability rating scheme as a separate metric due to the possible double counting. Such measures aim to improve sustainability performance across the PUE, REF, ERF and WUE metrics, and as such they will implicitly be reflected in the calculation of these values. While this may be a valid argument, the option is not totally discarded at this stage, since management and best practices can be deemed beneficial not only for their impact in the indicators, but as a way to evaluate the engagement of operators with continuous improvement of the data centre as a system. In addition, the improvement potential of some practices such as software efficiency are not captured by indicators. However, it is acknowledged that is not easy to develop as the practices will be specific for each type, size, location and other characteristics of the data centre.

The stakeholder consultation for this study provided a specific proposal for a labelling system by Oeko Institute. The full description of the metrics and the rating can be found here: https://be-rechenzentren.de/wp-content/uploads/2023/06/Oeko-Institut_energy-efficiency-label-for-data-centres_V1.0.pdf, and the description is as follows:

The label and the underlying metrics can be applied to data centres and ICT separately or combined. It awards data centres with low PUE, high CER and high ERF. For ICT, the weighting of components (servers, storage, network) adapts to the actual energy consumption so that it is applicable to all kinds of data centre. The label awards high utilisation and low waste of energy on idling based on a simplified approach.

8.3.3 Mandatory requirements on energy metrics or on the labelling scheme

Mandatory requirements are aimed at excluding worst-performing data centres, which may be seen as a negative measure, compared to labelling. However, they have an evident advantage of “impact certitude” since a well-designed minimum requirement can effectively speed up the adoption of solutions available in the market, to which all players will converge naturally. Nevertheless, it is a restrictive measure hence it is also necessary to understand how the measure will affect new entries in the market, particularly in a highly innovative sector.

The requirement may be based on metrics, that is, setting minimum thresholds for relevant metrics such as PUE, or on the labelling scheme, that is, requiring a minimum level or rating to data centres. In both cases, the definition of the minimum threshold can be supported by the cost-benefit analysis,

which will identify which technologies can be implemented at minimum costs and are therefore economically viable for all data centres in the market.

Within the cost-benefit analysis, the level of business disruption and technical feasibility will need to be considered. There is a risk that mandatory requirements would have very limited impact on existing data centres and will need to be complemented with other options to cover all DC types.

During the stakeholder consultation for this study, a stakeholder provided a specific proposal for minimum thresholds by as follows:

- Design PUE < 1.3 for new DC
- Operational PUE < 1.5 for new DC
- REF > 30% for new DC
- REF > 50% 1 year, REF=100% 3 years after entering into force
- Servers must run in balanced mode instead of power mode

8.4 Scenarios

Once the policy options or their combinations, as the example provided in section 7, are decided, the modelling of different scenarios will provide information on their impacts at EU level. Modelling of future scenarios is a tool used to estimate the impacts of specific measures, based on the comparison with a business as usual scenario, i.e. a scenario where no measures have been implemented.

8.4.1 Business as usual scenario

The results from the previous tasks will enable the modelling of the business as usual scenario. It consists of a projection of EU stock and their impacts without any measure, taking into account that a natural improvement will occur driven by economic or corporate motives.

The first step will build on the data on EU stock of data centres and their performance in terms of energy and water consumption from the reporting scheme. In addition, it will be necessary to understand the future trends on the evolution of number and size of data centres and their performance. The objective of this first step is to estimate the number of data centres, their sizes and their performance in the future, along a certain time horizon.

The second step will calculate the total energy consumption and water consumption of the stock of data centres within the time horizon, based on the information of the first step. Other impacts such as life cycle costs can also be estimated, which would cover the costs of acquisition, the energy and water costs, maintenance costs and end-of-life costs of equipment.

8.4.2 Policy scenarios

On the ground of the business as usual scenario, the policy scenarios are meant to estimate the impacts of the specific measures applied to data centres. For example, a minimum requirement on PUE would improve the least efficient segment of data centres, and this would reduce the energy consumption of the stock, compared to business as usual scenario.

The impact of the different policy options will require some assumptions in the case of voluntary options and information requirements, due to the uncertainty of their impact. Minimum requirements are easier to model since they are to discard worst performing data centre with a high level of certainty.

8.4.3 Conclusions from scenario analysis

The comparison of the impact associated to each policy option or combination will help the policymaker decide which is the most effective and efficient to reach the objectives. It will also provide a prospective analysis taking into account all drivers that can affect the data centres, such as the natural evolution of the technology, business models, energy and water prices, self-regulation, etc. This will enable to

establish the cause-effect link between the policy measure and the positive impact in terms of energy savings.

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