Digitalization Meets Climate Protection: Legal Framework for Energy-Efficient Data Centres

Michael Denk[a] and Marie-Theres Holzleitner-Senck[b]
Energieinstitut an der Johannes Kepler Universität Linz, Altenberger Straße 6, 4040 Linz, Austria

Keywords: Data Centres, Decarbonization, Digitization, Energy Efficiency, Waste Heat Utilization, District Heating.

Abstract: Data centres serve as a backbone of digitalization, yet consume vast amounts of electricity, particularly for server cooling and uninterrupted power supply. In response, recent EU directives – especially the recast Energy Efficiency Directive and the Renewable Energy Directive – push for transparency, reporting obligations, and reuse of server-generated waste heat. While exemptions (e.g., for economic infeasibility or technical constraints) currently soften mandatory requirements, Germany has adopted ambitious regulations, setting concrete efficiency and waste heat quotas. Still, implementation faces practical obstacles, such as the low-temperature nature of data centre heat, limited district heating infrastructure, and associated costs. As digital services expand, stricter regulations are expected to drive increased energy efficiency and decarbonization across the data centre sector.

1 INTRODUCTION

According to Bitkom's definition, a data centre is "a building—or at least a closed-off area—that, in addition to the IT operations area (space for IT infrastructure), also encompasses all further technical support areas (areas dedicated to data centre infrastructure)" (Bitkom, 2022c). Data centres are regarded as the backbone of digitalization and form the foundational infrastructure for virtually all digital applications (Bitkom, 2022c; Österreichische Energieagentur, 2022). The ongoing digitalization of every aspect of life and the economy requires steadily increasing computing power in order to provide services such as cloud computing, video streaming, smart buildings, the Internet of Things (IoT), and especially applications of artificial intelligence (Bitkom, 2022c; Funke et al, 2019; BMWi, 2019).

At the same time, data centres have a high energy demand, primarily driven by the cooling requirements and the need for uninterrupted power supply for servers and IT components (such as servers, storage, and network infrastructure) (Borderstep, 2022a). According to media reports, the energy consumption of data centres dedicated to AI applications have reached enormous proportions. Tech giants like Microsoft, Google, and Meta are planning to meet the growing energy needs of AI in the future through nuclear power and are even considering acquiring their own power plants (FAZ, 2024).

In contrast to this high energy demand, there is the significant generation of waste heat and the possibility of harnessing this currently untapped source for heating purposes. Legislators have recognized this potential and are increasingly implementing energy efficiency measures targeting data centres and have begun to issue specific regulations to make use of this resource in the future.

This article examines the European and national regulatory frameworks and current approaches to ensuring more sustainable and energy efficient data centres, as well as the barriers that exist.

2 BACKBONE OF DIGITALIZATION AND A VALUABLE SOURCE OF HEAT?

The energy consumption of data centres has risen significantly in recent years. Between 2016 and 2021, the capacity of data centres in Germany grew by 30% (Bitkom/Eco/German Datacenter Association, 2022),

[a] https://orcid.org/0009-0007-5541-6248.
[b] https://orcid.org/0000-0002-8931-6655.

Denk, M. and Holzleitner-Senck, M.-T.
Digitalization Meets Climate Protection: Legal Framework for Energy-Efficient Data Centres.
DOI: 10.5220/0013433100003953

In *Proceedings of the 14th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2025)*, pages 163-171
ISBN: 978-989-758-751-1; ISSN: 2184-4968

while their energy consumption increased from 14 TWh in 2018 to 17.9 TWh in 2022 (Hintemann, 2020; Hintemann/Hinterholzer, 2023).

The latter figure corresponds to 3.7% of Germany's total electricity consumption (Borderstep, 2022a; Österreichische Energieagentur, 2021), surpassing Berlin's energy needs (Borderstep, 2022a). A single mega data centre alone can consume as much electricity as a large city (Hintemann/Hinterholzer, 2023; Funke et al, 2019).

According to Recital 85 EED III in 2018, data centres across Europe consumed 76.8 TWh of electricity (2.7% of the EU-wide electricity demand), with forecasts predicting a rise to 98.5 TWh by 2030 (an increase of 28%) Projections further indicate that data centres will account for 3.21% of the EU's electricity consumption in 2030.

In addition to the high electricity demand, data centres cause further environmental impacts, such as high water demand for cooling and and land use for facilities (Hintemann/Hinterholzer, 2023).

Against this backdrop, data centres are increasingly becoming the focus of legislative measures, particularly in the domain of energy efficiency law (Bitkom/Eco/German Datacenter Association, 2022). In its Digital Strategy, the EU aims to make data centres climate-neutral by 2030 and to introduce transparency measures to record the ecological footprint (Communication from the Commission, 2021).

A central approach to improving the sustainability of data centres lies in harnessing the (server) waste heat they generate. According to the German digital association Bitkom, a medium-sized data centre with a 5 MW IT-capacity could provide heating for approximately 1,000 residential units (Bitkom, 2022b). Across Germany, it is estimated that the waste heat from the 90 existing large-scale data centres could supply 350,000 apartments (Bitkom, 2022a).

The recast Renewable Energy Directive (RED III, Directive [EU] 2018/2001) highlights the underutilization of waste heat, despite its widespread availability. This underutilization results in squandered resources, insufficient energy efficiency in national energy systems, and unnecessarily high energy consumption throughout the EU (Recital 70 RED III).

At the same time, employing waste heat can make a crucial contribution to decarbonizing heating supply systems by replacing fossil fuels (Holzleitner-Senck/Moser/Denk, 2025).

Although data centre waste heat remains largely underutilized, initial projects demonstrate its feasibility. In Stockholm, for instance, 30 data centres have been connected to the district heating network since 2018 (Ostler, 2018; Funke et al, 2019; Borderstep, 2022b). Stockholm City Administration has also set itself the ambitious goal of completely eliminating fossil fuels by 2040 and thus taking on a pioneering role in the implementation of sustainable energy policy. A key pillar of this strategy is systematically integrating data centres into the municipal energy system, in particular through the use of their waste heat (Ostler, 2018). To support this endeavor, the city aims to attract additional data centres to contribute their waste heat into the district heating network. Current planning suggests that by 2035, the waste heat from these data centres alone will meet around 10% of the entire metropolitan area's heating needs, thus making a substantial contribution to decarbonizing the city's heating supply (Deutsch-Schwedische Handelskammer / AHK Schweden, 2018). Austria also offers an example: in Vienna, waste heat from a data centre is used to heat a hospital located in close proximity (Wien Energie, 2024).

In order to take advantage of these potential benefits and to contribute to a transition towards sustainable heating as well as more sustainable digitalization, recent EU legislation includes regulations governing the use of waste heat.

While these directives have (in part) been transposed into national law by the various European Member States, Germany has adopted the most comprehensive regulations regarding data centres.

The following sections present the relevant EU-level and national regulations.

3 REQUIREMENTS UNDER EU LAW

3.1 Energy Efficiency Directive

3.1.1 General Considerations

The Energy Efficiency Directive (EED III, Directive (EU) 2023/1791) was recast in 2023 and sets out, as a key objective, a reduction in EU-wide energy consumption by 11.7% by 2030 (Article 4(1) EED III). The principle of "energy efficiency first" is at the core of EED III, and Member States are obligated to consider this principle in all policy areas (Recital 15 EED III). In line with this principle and in view of the increasing digitalization described above—along with its energy-intensive infrastructure—EED III imposes certain obligations on data centres.

Pursuant to Article 2(49) EED III, the term "data centre" is understood according to Annex A Nr. 2.6.3.1.16 of the EU-Energy-Statistics-Regulation (Regulation (EC) No 1099/2008). Under this definition, a data centre is "a structure or a group of structures used to house, connect and operate computer systems/ servers and associated equipment for data storage, processing and/or distribution, as well as related activities."

3.1.2 Disclosure and Reporting Obligations

To foster sustainable development in the ICT sector, Article 12(1) EED III lays down reporting requirements for operators and owners of data centres (Recital 85 EED III).

These obligations apply to data centres with an electricity demand of at least 500kW for installed IT capacity. According to Recital 85 EED III, such data centres have a significant footprint and present opportunities for substantial reductions in energy and water consumption, increases in system efficiency to promote decarbonization of the grid, or reuse of waste heat in nearby facilities and heating networks (Recital 85 EED III).

By 15 May 2024, and annually thereafter, the obligated undertakings must publish the information listed in Annex VII. This includes the name of the data centre and of its owner or operator, the date the data centre was commissioned, the municipality in which it is located, the total area of the data centre, its installed capacity, annual incoming and outgoing data traffic, the volume of data stored and processed in the data centre, and the data centres' efficiency in the preceding calendar year based on key performance indicators. These indicators cover, *inter alia*, energy consumption, power utilization, temperature set points, waste heat utilization, water usage, and the use of renewable energy sources. The Delegated Regulation (EU) 2024/1364 on the rating scheme for data centres (Commission Delegated Regulation (EU) 2024/1364) serves as the basis for evaluating these performance indicators (cf. Annex VII Nr. 3(c) EED III).

Article 12(3) EED III mandates the creation of a European database for data centres by the European Commission, which is to compile the information provided by obligated data centres in accordance with Article 12(1) and make it publicly available in aggregated form. Under Article 5 of the Delegated Regulation (EU) 2024/1364, a common user interface will be set up to ensure uniform data submission.

As indicated in Recital 87 EED III, the Union legislator assumes that the collected data and sustainability indicators will help raise awareness among operators, owners, manufacturers, software developers, and users of data centre services regarding the importance of sustainable practices (Recital 87 EED III). The collected data will form the basis for transparent, fact-based planning and decision-making (Recital 87 EED III). Consequently, by 15 May 2025, the Commission will review the collected data on data centre energy efficiency and present a report that may include legislative proposals for additional measures. These further measures may concern regulations aimed at enhancing energy efficiency, introducing minimum performance standards, or transitioning to net-zero-emission data centres (Article 12(5) EED III).

3.1.3 Mandatory Use of Waste Heat

EED III recognizes data centres as a potentially valuable source of waste heat (cf. Recital 105 EED III). Accordingly, Article 26(6) EED III stipulates that data centres with a total rated energy input exceeding 1 MW must either utilize their waste heat or adopt alternative heat recovery methods. Data centres can be exempted if they demonstrate economic or technical infeasibility. Article 26(7) EED III outlines the criteria for such exemptions (see Section 3.1.4. of this article).

3.1.4 Cost-Benefit Analysis for Waste Heat Utilization

Pursuant to Article 26(7)(d) EED III, newly planned or substantially modernized data centres with a nominal total energy input exceeding 1 MW must conduct a cost-benefit analysis regarding the potential use of waste heat. In doing so, they must assess the feasibility of employing waste heat to meet a justified economic demand and the possibility of connecting such facilities to a district heating network or to an efficient or renewable-based district cooling system, or to other means of heat recovery.

This analysis includes, *inter alia*, considerations of technical feasibility, cost-effectiveness, and the effects on energy efficiency and local heat demand, including potential seasonal fluctuations.

Under Article 26(8)(c) EED III, Member States may exempt certain data centres from the obligations set forth in Article 26(7) EED III. This primarily concerns data centres whose waste heat is already being used—or is planned to be used—in a district heating network or directly for space heating, domestic hot water preparation, or other purposes within the building or group of buildings in which the data centre is located.

According to Article 26(12) EED III, Member States must record and publish the findings of these cost-benefit analyses.

3.2 Renewable Energy Directive

3.2.1 General Considerations

The RED III is the primary legislative act for the expansion of renewable energy sources. Under Article 3(1) RED III, Member States are required to pursue the ambitious goal of covering at least 42.5% of their gross final energy consumption from renewable sources by 2030 (an additional indicative target of 2.5% supplements this main target).

In addition to this overarching expansion target and other sector-specific objectives (cf. section 3.2.2. of this article), RED III also contains provisions concerning waste heat—along with a definition that extends beyond the directive itself. By virtue of a reference in Article 2(128c) of the GBER, the definition is also relevant for State aid purposes.

It is, therefore, pertinent to examine this set of regulations in the context of waste heat utilization from data centres.

3.2.2 Creditability Regime Regarding Waste Heat for Sector-Specific Expansion Targets

In order to achieve the long-term decarbonization target, the share of renewable energy must be increased across multiple sectors, including buildings (Article 15a), industry (Article 22a), heating and cooling (Article 23), and the district heating sector (Article 24). It is noteworthy that waste heat is not included in the exhaustive list of renewable energy (sources) under Article 2(1) RED III and therefore does not qualify as such.

Nevertheless, RED III allows Member States to partially include waste heat to meet their expansion targets in the building, industrial, and heating and cooling sectors. For example, in the building sector, under Article 15a(2) RED III, up to 20% of the target may be achieved by using waste heat. With regard to the district heating sector, renewable energy and waste heat are considered equivalent (Holzleitner-Senck/Moser/Denk, 2025).

3.2.3 Definition of Waste Heat Under Article 2(9) RED III

Under Article 2(9) RED III, “waste heat” is defined as “unavoidable heat […] generated as by-product in industrial or power generation installations, or in the tertiary sector, which would be dissipated unused in air or water without access to a district heating […], where a cogeneration process has been used or will be used or where cogeneration is not feasible.”

Heat generated in industrial, commercial, or power generation processes is classified as a “by-product” because it is not the primary objective of those processes. Generally, the objective is the production of a specific product, the delivery of a service, or the generation of electricity. The production of heat is merely an unintended consequence. In the context of data centres, waste heat also qualifies as a “by-product,” since the primary objective of these facilities is to process, store, and transmit data rather than generate heat.

According to the definition, the process that produces waste heat must take place in an industrial installation, in a power generation facility, or in the tertiary sector. This covers a wide range of processes, from manufacturing and processing in factories to electricity production in power plants, as well as services and activities in the tertiary sector, such as hospitals and shopping areas (cf. Annex IV, Commission Recommendation (EU) 2019/1659). In any case, data centres are part of this group of facilities, particularly because they fall under the “tertiary sector” (cf. Annex IV, Commission Recommendation (EU) 2019/1659).

Furthermore, heat is only deemed “waste heat” if “access to a district heating system is available, in which a cogeneration process has been used or will be used or where cogeneration is not feasible.”

The wording suggests that, unlike the purely technical understanding of the term, “waste heat” does not qualify as such without additional structural measures (i.e., establishing access to a district heating system).

For the use of server heat generated by a data centre, this implies that some of the utilization methods (cf. Art 26 EED III) addressed in the EED III or considered within the cost-benefit analysis do not fully align with the understanding of “waste heat” under Article 2(9) RED III.

Article 26(6) and (7)(d) EED III also address on-site and alternative methods of utilizing waste heat, extending beyond its integration into district heating networks (cf. Annex XI EED III). However, on-site usage conflicts with the requirement in Article 2(9) RED III for access to a district heating system and, as a result, would not qualify as waste heat under the definition provided in Article 2(9) RED III. Therefore, in-house utilization of waste heat would not qualify for recognition or credit under these provisions.

4 NATIONAL PROVISIONS

4.1 Austria

4.1.1 Federal Energy Efficiency Act

In transposing EED III into national law, the Austrian Federal Energy Efficiency Act (*Bundes-Energieeffizienzgesetz*, EEffG) imposes information obligations on data centres.

§ 72a EEffG obliges owners and operators of data centres with an installed nominal electrical capacity of at least 500 kW for information technology to publish specific minimum information about their operating data on an annual basis. These reporting obligations, which take effect on 15 May 2024, are intended to enhance transparency concerning the energy consumption and efficiency of data centres.

The scope of the required information is already set forth in Annex VII of EED III (cf. section 3.1.2. of this article).

This includes basic information such as the name of the data centre, the name of its owner or operator, the date of commissioning, and the municipality in which it is located. Additionally, the data centres' floor area must be reported, along with its installed capacity, annual incoming and outgoing data traffic, and the volume of data stored and processed. Furthermore, the data centres' efficiency indicators for the most recent full calendar year must be disclosed. These cover key performance metrics such as energy consumption, electricity usage, temperature setpoints, waste heat utilization, water consumption, and the share of renewable energy.

These items of information must be made available on the website of the respective data centre and must be regularly updated (§ 72a(3) EEffG).

Furthermore, the national energy supervisory authority E-Control must be notified of the publication of minimum information pursuant to § 72a(1), including its transmission as required by § 72a(3). This includes, *inter alia*, the name of the data centre and efficiency of the data centre in the last full calendar year in accordance with the key performance indicators, in particular for energy consumption, electricity use, waste heat utilization, water consumption and use of renewable energies.

4.1.2 Energy Efficiency Standardised Abridged Reports Regulation

The EEff-SKV (*Energieeffizienz-Standardisierte-Kurzberichte-Verordnung*) imposes reporting obligations in the form of a standardized short report pursuant to § 43 EEffG, focusing on the potential for waste heat recovery from technical installations in businesses.

§ 5 EEff-SKV requires data to be reported as thermal output (in kW) and full-load hours, categorized into the following temperature ranges:

1. Cooling temperatures below 0 °C,
2. Low temperatures between 0 °C and 50 °C,
3. Medium temperatures between 50 °C and 200 °C and
4. High temperatures at or above 200 °C.

4.2 Germany

4.2.1 Energy Efficiency Act

According to the German Federal Government's energy efficiency strategy, the use of waste heat in the economy illustrates the "energy efficiency first" principle more effectively than any other area (BMWi, 2019). For this reason, the German federal legislator has introduced comprehensive regulations for data centres in the form of the Energy Efficiency Act (*Energieeffizienzgesetz,* EnEfG). The relevant provisions apply to operators of data centres with a non-redundant nominal connection capacity of 300 kilowatts or more. According to Bitkom, a "non-redundant nominal electrical connection capacity" means "the total of the maximum electrical capacity required for operation" (Bitkom, 2024) This encompasses both IT system capacity and auxiliary systems like cooling and lighting (Bitkom, 2024).

Under § 11(5), these data centres must ensure that, 50% of the electricity is covered by renewable energy sources on a balance sheet basis starting 1 January 2024. From 1 January 2027 onward, the data centres' electricity consumption must be supplied entirely (i.e., 100%) by renewable energy sources.

With regard to additional requirements, the legislation differentiates between data centres that begin—or have begun—operations before 1 July 2026 (subsection 1) and those that begin operations on or after 1 July 2026 (subsection 2).

The former must be designed, built, and operated so that they permanently achieve an average annual Power Usage Effectiveness (PUE) of less than or equal to 1.5 starting 1 July 2027, and less than or equal to 1.3 starting 1 July 2030. Under § 3(15) EnEfG, PUE is defined as "a metric for the energy efficiency of a data centres' infrastructure, describing the ratio of the data centres' total annual energy demand to the IT energy demand, in accordance with DIN EN 50600-4-2."

New data centres, i.e. those that go into operation from 1 July 2026, must be set up and operated in such a way that they achieve an energy efficiency of less than or equal to 1.2.

From the perspective of the German legislator, data centres' waste heat offers the potential to meet at least some of the future demand for heating (Deutscher Bundestag, 2023).

With this in mind, the just mentioned "new" data centres must have a proportion of reused energy of at least 10%. This percentage increases with later commissioning. Therefore, data centres that beginning operations on or after 1 July 2027 must have a planned share of reused energy of at least 15%; data centres that commence operations from 1 July 2028 must have a planned share of reused energy of at least 20%.

The term "reused energy" is understood in accordance with DIN EN 50600-4-6. Under that technical standard, only reuse outside the boundary of the data centre is considered. Consequently, any use of waste heat within the same facility does not fulfill the requirements of § 11 EnEfG (Bitkom, 2024).

Data centres that begin operations before 1 July 2026 are thus not subject to any legal provisions on energy reuse or waste heat utilization. For (new) data centres subject to a mandatory waste heat utilization requirement, exceptions apply under § 11(3) EnEfG. According to this provision, waste heat utilization requirements do not apply if the operator of the data centre can prove that the share of reused energy fails to meet the requirements under subsection 2 Nr. 2 due to unforeseen events, without any fault on the part of the operator. Such unforeseen events might include failed construction projects for the necessary infrastructure (Bitkom, 2024).

Likewise, the requirements do not apply if there is an agreement with a nearby municipality or a district heating network operator that legally binds them to establish a district heating network within ten years. This agreement must include an investment plan, clarify the cost allocation for the connection infrastructure, and determine the price for supplying waste heat. Furthermore, the obligation lapses if a nearby district heating network operator declines an offer to use the waste heat at cost price, even though the data centre provides the necessary infrastructure—particularly a heat transfer station—while the network operator is required, upon the data centre operator's request, to disclose the heating network's available capacity.

Operators of data centres are also subject to several disclosure obligations. Pursuant to § 13 EnEfG, data centre operators are required to publish information regarding their facilities for the preceding calendar year by 31 March each year, in accordance with Annex 3, and submit this information to the federal government. This includes details on the quantity and average temperature of waste heat discharged into air, water, or ground, as well as the quantity of waste heat delivered by the data centre to heat consumers (in kWh per year) and its average temperature in °C.

For this purpose, § 14 EnEfG obliges the German Federal Government to establish an "Energy Efficiency Register for Data Centres," in which the transmitted data is stored and forwarded to a European database for data centres.

In addition to these data centre specific provisions, § 16 EnEfG includes general requirements on the "avoidance and use of waste heat," which also apply to data centre operators.

According to § 16(1) EnEfG, certain companies are obligated to avoid the waste heat generated in their operations in accordance with the state of the art and to reduce the waste heat generated to the proportion of technically unavoidable waste heat, insofar as this is feasible and reasonable. Feasibility (or "reasonableness") is assessed by taking into account technical, economic, and operational factors.

Pursuant to § 16(2) EnEfG, any unavoidable waste heat must be reused to the greatest possible extent through energy-saving measures and techniques, insofar as this is feasible and reasonable. Again, feasibility is determined by technical, economic and operational factors. Under § 16(2) EnEfG, such waste heat should not only be reused within the particular installation but also be made available on the company's premises and to potential external customers. For maximum efficiency gains, the recovered waste heat should be reused multiple times in a so-called cascade process based on its exergy content, or in successive temperature steps.

Furthermore, the law contains a right of information for district heating network operators and other potential companies interested in purchasing waste heat. According to § 17(1) EnEfG, businesses—including data centres—must, upon request, provide operators of district heating networks, district heating suppliers, or other potential heat purchasers with comprehensive information about the waste heat generated in their facilities. This includes, *inter alia*, the name of the business, the address of the site(s) where waste heat arises, the annual quantity of available waste heat, and the maximum thermal capacity. In addition, information on the temporal availability of the waste heat—e.g., in the form of performance profiles throughout the year—and on options for adjusting temperature, pressure, and grid injection must be supplied. The average temperature level in °C must also be disclosed.

To alleviate information gaps regarding waste heat availability (Deutscher Bundestag, 2023), businesses must annually by 31 March, irrespective of specific inquiries, submit the aforementioned information to the Federal Office for Energy Efficiency (*Bundesstelle für Energieeffizienz*) and update it immediately whenever changes occur. This data must be submitted using a federal government-provided electronic template. Under § 7(2)(6) EnEfG, the Federal Office for Energy Efficiency must establish a "Platform for Waste Heat" for this purpose. The Federal Office makes the collected information available on this platform while safeguarding trade and business secrets.

Exemptions from the reporting and disclosure requirements apply to businesses with an average total final energy consumption of 2.5 GWh or less over the last three completed calendar years (§ 17(4) EnEfG).

4.3 Portugal

4.3.1 Decreto-Lei n.º 84/2024

The *Decreto-Lei* n.º 84/2024 aims to implement the EED III and Delegated Regulation (EU) 2024/1364 in Portugal and primarily establishes information obligations.

Article 2 specifies that this law applies to data centres with a minimum installed IT capacity of 500 kW. The term "data centre" ("*centros de dados*") follows the interpretation in Article 2(49) EED III, referring to the definition in Annex A of the Energy-Statistics-Regulation (Article 3).

Article 4 requires the operators and owners of data centres to make information about their energy consumption publicly available on their website. This includes, among other details, the data centres' location, its annual data traffic, the use of waste heat and renewable energy sources, as well as water consumption (cf. the Annex to the act). These details must be updated annually by 15 May and must also be submitted in digital form to the national energy authority (DGEG) (Article 4(4)).

5 5 WASTE HEAT UTILIZATION CHALLENGES (IN DISTRICT HEATING SYSTEMS)

5.1 Low Temperature Level

Transferring waste heat from data centres to district heating systems presents several technical challenges. A key challenge is the relatively low temperature of the waste heat. While data centres typically produce waste heat with temperatures of around 30–40 °C, district heating networks require significantly higher temperatures, in the range of 60–70 °C (Funke et al, 2019; Ostler, 2018). This temperature gap necessitates an additional heating process. In practice, heat pumps are used to address this issue. They not only ensure the required temperature boost, but can also compensate for fluctuations in waste heat production (Funke et al, 2019; Bitkom, 2022a; Waldhauser, 2019). However, the economic feasibility of these systems heavily depends on electricity costs (Funke et al, 2019).

Liquid cooling of servers offers a promising alternative that remains economically viable even if electricity prices increase while heat prices stay low (Borderstep, 2022b). This approach allows the data centre to directly produce water at around 60 °C, thereby enabling immediate heat utilization without the use of additional heat pumps (Borderstep, 2022b).

5.2 Lack of Off-Takers and Infrastructure

Many data centre operators are reportedly willing to provide their waste heat at no or low cost, but they often struggle to find potential off-takers (Bitkom/Eco/German Datacenter Association, 2022).

Moreover, the necessary district heating network infrastructure is still insufficiently developed (Hintemann/Hinterholzer, 2023).

In addition to expanding infrastructure, district heating network operators should face greater obligations to accept waste heat (Bitkom/Eco/German Datacenter Association, 2022). Thus, alongside mandatory waste heat utilization or its provision, energy utilities should be required to accept that heat and provide nondiscriminatory access to district heating networks and feed-in options (Bitkom/Eco/German Datacenter Association, 2022).

The revised RED III mandates regulated "Third Party Access" to district heating systems with capacities exceeding 25 MWh.

Article 24(4)(b) RED III requires operators to either integrate renewable energy and waste heat from third parties into the network or offer to purchase it for feed-in.

The directive mandates Member States to define non-discriminatory criteria for this purpose; Article 24(4), (i) to (iii) restricts these criteria to covering additional demand from new customers, replacing existing heating capacities, or expanding current generation capacities.

Network access must be granted if demand from new users grows, if less efficient or fossil-based sources can be replaced by renewable ones, or if third-party feed-in increases overall supply capacity.

In the first case, district heating operators are required to grant network access to third parties when there is additional demand from new customers. In other words, they must accept heat from third parties if it can be used to meet that increased demand (cf. Article 24(4)(b)(i) RED III).

Second, access for third-party providers is facilitated if the heat they supply replaces existing, potentially less efficient or fossil-fuel-based heat generation capacities. This promotes the use of renewable or more efficient energy sources in the district heating network (cf. Article 24(4b)(ii) RED III).

Third, access must also be allowed if feed-in by third parties serves to expand existing heat generation capacities. This means that third parties are permitted to deliver heat if doing so increases the overall supply capacity of the network—for instance, to meet growing demand in the future (cf. Article 24(4)(b)(iii) RED III).

At the same time, Article 24(5) RED III allows district heating operators to refuse access or the purchase of heat if the system does not have sufficient capacity due to other renewable or waste-heat inputs, if the heat fails to meet technical requirements for safe and reliable feed-in, if granting access would cause disproportionate cost increases for end consumers, or if the operator's system qualifies as an efficient district heating system

5.3 Value Added Tax Liability

In order to comply with existing and likely future requirements regarding the use of waste heat, data centre operators might be inclined to supply it to off-takers without charge. However, it should be noted that such transactions are generally subject to VAT and therefore may not be profitable.

The Court of Justice of the European Union ruled that under Article 16(1) of the VAT Directive (Council Directive 2006/112/EC), surplus heat provided free of charge is taxable if the generating facility (or its components) was eligible for input tax deductions and the heat is supplied for economic activities (cf. ECJ, 25 April 2024, Case C-207/23, *Finanzamt X*, ECLI:EU:C:2024:352, para. 48). The Court based its decision on preventing untaxed final consumption (of the supplied heat) (ECJ, 25 April 2024, Case C-207/23, *Finanzamt X*, ECLI:EU:C:2024:352, para. 39.). As a result, data centre operators remain liable for VAT even when providing waste heat free of charge (Bitkom, 2024).

Regarding the taxable amount under Article 74 VAT Directive, the CJEU held that it corresponds to the purchase price of the good or, if no such price exists—as in the present case—the cost price at the time of application (ECJ, 25 April 2024, Case C-207/23, *Finanzamt X*, ECLI:EU:C:2024:352, para. 50 and 59). In addition to direct production or generation costs, this calculation must also take into account indirectly attributable costs, such as financing costs (ECJ, 25 April 2024, Case C-207/23, *Finanzamt X*, ECLI:EU:C:2024:352, para. 59). It remains unclear to the authors how exactly these production costs should be determined in the case of unavoidable waste heat.

6 CONCLUSIONS

European and national regulations are reacting to the growing number of data centres, although the current measures largely consist of publication and reporting obligations. For the time being, the EU legislature appears to be relying on economic stakeholders to use this information to take their own initiatives and voluntarily implement more energy-efficient solutions. Nevertheless, it is likely that the Commission will use the reported data to draft more comprehensive legislation in the future.

Although data centres offer significant potential for reducing overall energy consumption through their waste heat, technical barriers (such as the need for temperature elevation) and infrastructural shortcomings currently impede broad-scale implementation.

While third-party providers are now afforded non-discriminatory access to district heating systems under the principle of "Third Party Access," the right to feed into these systems can be denied under certain conditions (e.g., capacity constraints, disproportionate cost increases).

Overall, current regulations focus heavily on information obligations aimed at making data on energy efficiency and waste heat usage more readily available. This transparency will enable policymakers, businesses, and researchers to gain a clearer understanding of data centres' efficiency potential and to prepare more far-reaching regulations if necessary. Additionally, providing waste heat is associated with tax implications. In particular, the Court of Justice of the European Union's ruling on the VAT liability of freely supplied surplus heat

demonstrates that even free provision may not always be financially viable for operators.

While current EU legislation relies on industry-led voluntary measures, it is expected that more stringent regulations will be introduced once the newly mandated transparency and reporting requirements have been thoroughly evaluated.

ACKNOWLEDGEMENTS

This contribution was developed as part of the research project „ReduzAb“ - CO2-Emissionen REDUZieren durch Abwärme“ FFG-Nr.: FO999903330) funded by the Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.

REFERENCES

Bitkom, (2022a). Abwärme von Rechenzentren für Heizung und Warmwasser einsetzen, <https://www.bitkom.org/Presse/Presseinformation/Abwaerme-Rechenzentren-fuer-Heizung-Warmwasser-einsetzen\>.

Bitkom, (2022b). Position zur Legislaturperiode 2021 – 2025: Deutschland zum führenden Standort für Rechenzentren in Europa machen, <https://www.bitkom.org/sites/main/files/2022-02/Policy-Paper_2022_Rechenzentren.pdf\>.

Bitkom, (2022c). Rechenzentren in Deutschland, <https://www.bitkom.org/sites/main/files/2022-02/10.02.22-studie-rechenzentren.pdf\>.

Bitkom, (2024). Energieeffizienzgesetz für Rechenzentren <https://www.bitkom.org/sites/main/files/2024-01/bitkom-leitfaden-energieeffizienzgesetz-fuer-rechenzentren.pdf\>.

Bitkom/Eco/German Datacenter Association, (2022). Perspektiven für eine nachhaltige Rechenzentren-Wirtschaft bis 2030, <https://www.bitkom.org/sites/main/files/2022-10/2210-Positionspapier-Nachhaltige-Rechenzentren.pdf\>.

BMWi, (2019). Energieeffizienz-Strategie 2050.

Borderstep, (2022a). Rechenzentren 2022, Stromverbrauch von Rechenzentren in Deutschland nimmt weiter zu, <https://www.borderstep.de/facts-and-figures/rechenzentren-2022/\>#:~:text=Die%20Digitalisierung%20von%20Wirtschaft%20und,Deutschland%202022%20fast%20eine%20Mrd.

Borderstep, (2022b). Wirtschaftlichkeit der Abwärmenutzung aus Rechenzentren in Deutschland, <https://www.borderstep.de/wp-content/uploads/2022/08/Abwaermenutzung_Rechenzentren_Update_2022.pdf\>.

Commission Recommendation (EU) 2019/1659 of 25 September 2019 on the content of the comprehensive assessment of the potential for efficient heating and cooling under Article 14 of Directive 2012/27/EU, OJ L 275/2019.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 2030 Digital Compass: the European way for the Digital Decade (2021).

Deutsch-Schwedische Handelskammer / AHK Schweden, (2018). Stockholm will bis 2040 die „smarteste“ Stadt der Welt sein, <https://www.handelskammer.se/de/nyheter/stockholm-will-bis-2040-die-smarteste-stadt-der-welt-sein\>.

Deutscher Bundestag, (2023). Drucksache 20/6872.

FAZ, (2024). Meta will Atommeiler für Rechenzentren bauen, <https://www.faz.net/aktuell/wirtschaft/unternehmen/atomstrom-fuer-ki-meta-zieht-mit-plaenen-nach-110152401.html\>.

Funke, T et al., (2019). Abwärmenutzung im Rechenzentrum.

Hintemann, R. Hinterholzer, S. (2023). Rechenzentren 2022, < https://www.borderstep.de/publikation/hintemann-r-hinterholzer-s-2023-rechenzentren-2022-steigender-energie-und-ressourcenbedarf-der-rechenzentrumsbranche-berlin-borderstep-institut/#:~:text=Mit%2017%2C9%20Mrd.,zunehmend%20mit%20der%20Rechenzentrumsbranche%20befassen.>.

Holzleitner-Senck, M. T., Moser, S., Denk, M. (2025). Waste heat inconsistences in the EU's energy legislation, Utilities Policy 2025, Vol 93, 101880.

Holzleitner, M. T., Moser, S. (2020). Rechtliche Möglichkeiten für die Einspeisung von Abwärme in ein bestehendes Fernwärmenetz – eine Analyse der Neuerungen durch das „Clean Energy Package“, ZTR 2020, 63.

Österreichische Energieagentur, (2021). Auswirkungen der Digitalisierung auf Energieverbrauch und Klima in Österreich, <https://www.energyagency.at/fileadmin/1_energyagency/projekte/digitalisierung/digat/digat2040_d2.1_ikt-verbrauch_in_oe_2019_final.pdf\>.

Ostler, U. (2018). Datacenter in Schweden und in Deutschland – best Practices versus Ignoranz, <https://www.datacenter-insider.de/datacentre-in-schweden-und-in-deutschland-best-practices-versus-ignoranz-a-718973/\>.

Waldhauser, B. (2019). Heat Recovery from Data Centers: a Win-Win Situation, <https://www.dotmagazine.online/issues/on-the-edge-building-the-foundations-for-the-future/heat-recovery-from-data-centers\>.

Wien Energie, (2024). Lokal und klimaneutral: Rechenzentrum heizt Klinik Floridsdorf, https://www.wienenergie.at/pressrelease/lokal-und-klimaneutral-rechenzentrum-heizt-klinik-floridsdorf/\.