Energy Efficiency of Data Centers in Finland

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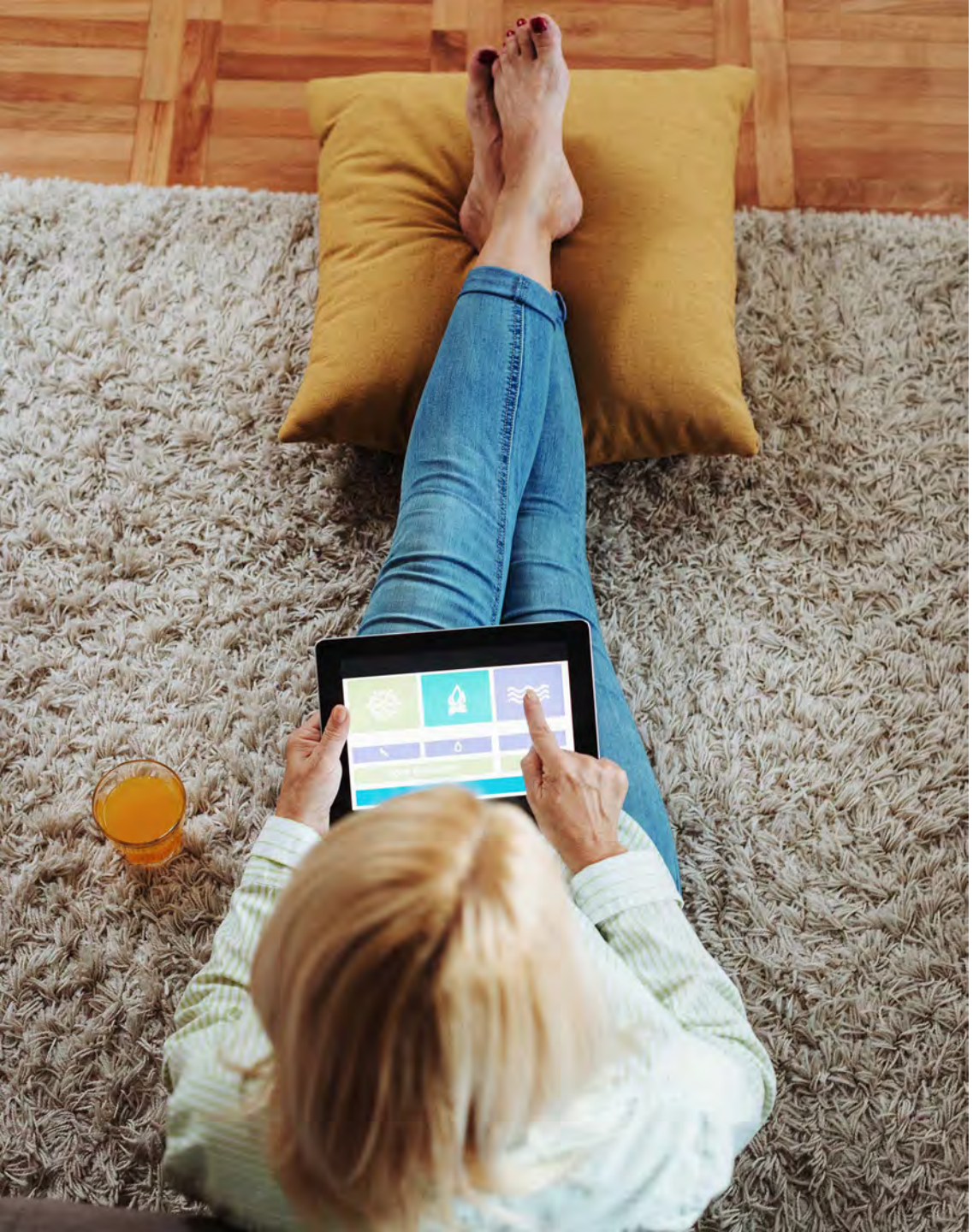

Table of Contents

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Introduction

- Study financed by the Finnish Energy Authority.
- Steering group: Johanna Kirkinen (Finnish Energy Authority); Veijo Terho, Sami Holopainen, Eero Lindqvist, Sami Niiranen and Timo Ranne (Finnish Data Center Association)
- Study carried out by the government owned sustainable development company Motiva Oy in 2022.
- Report available at: Motiva_Energy_efficiency_studies

energy authority

FDCA

Objectives

How are energy and resource efficiencies measured in the data center industry?

Implications of the proposed Energy Efficiency Directive Recast for the data center industry: indicator collection and waste heat issues

What policies and measures are in place internationally, in Europe and in Finland?

What is the level of energy efficiency efforts in the data center sector in Finland?

2.
Background

Sector Structure

Hyperscale (HSDC)

- Owned by companies operating in the internet
- Installed power 50-300 MW
- Most energy efficient units
- Volume has grown

Co-location/Cloud (CDC)

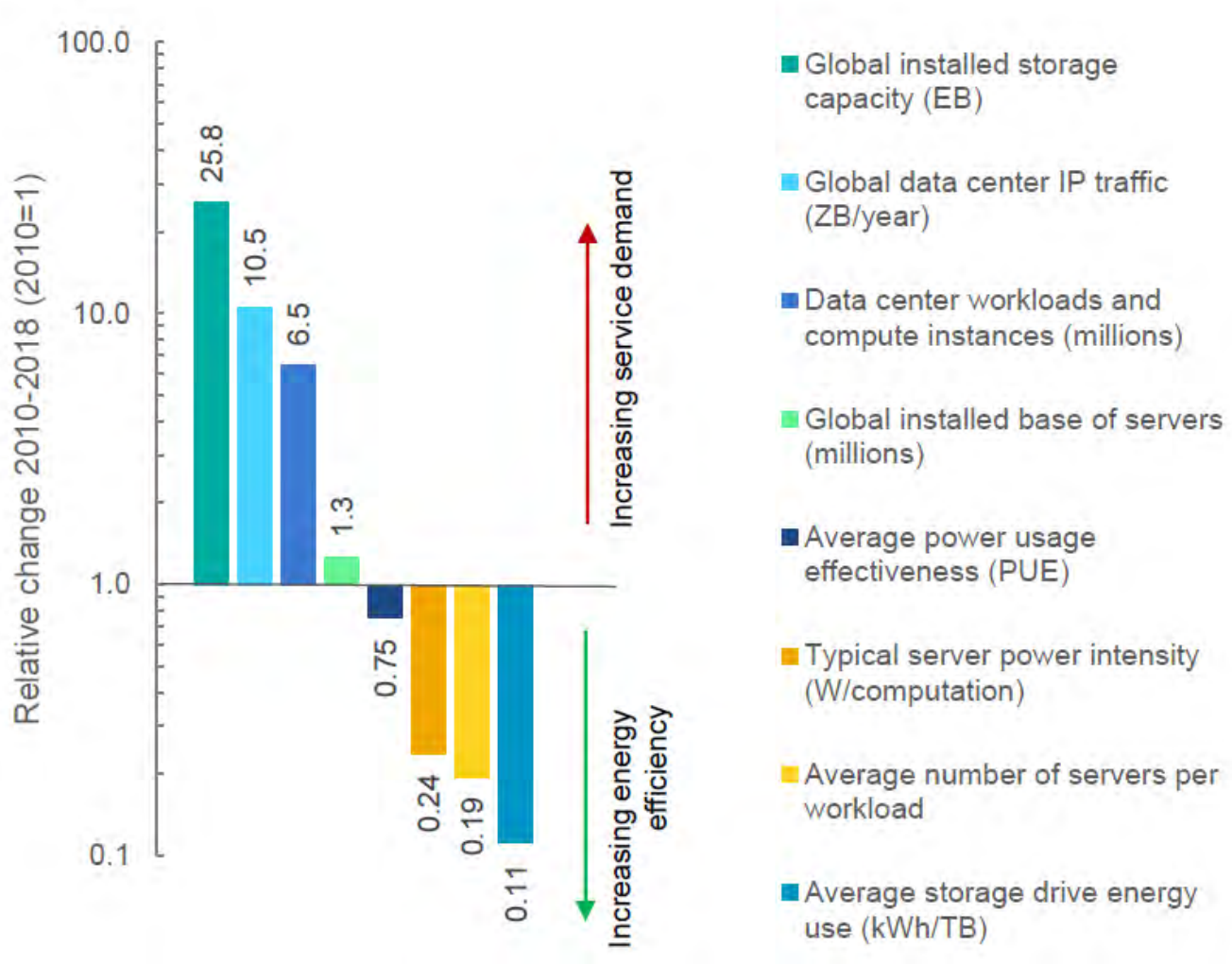
- Owned by companies offering cloud services to others
- Installed power under 50 MW
- Volume has grown and is still growing

Enterprise data centers (EDC)

- Owned and operated by companies and the public sector
- Installed power under 2 MW
- Volume has declined and further decline is expected

Source: COWI (2020)

Drivers of Energy Consumption in Data Centers



Source: IEA ref. Masanet et al. (2020)

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Market Structure in Finland

Data available is limited. E.g., there is no data on enterprise data centers.

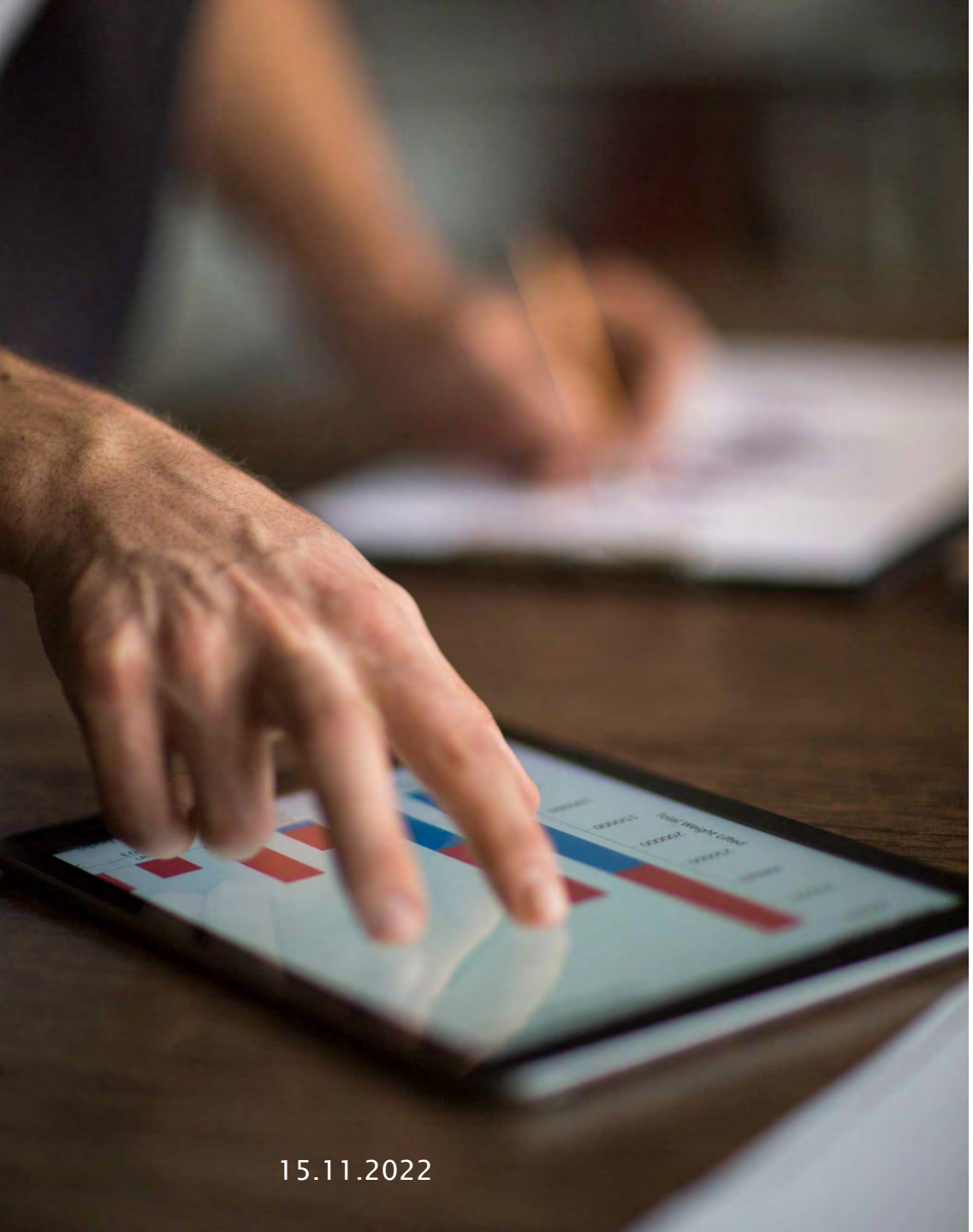
Data from different listing services (Baxtel, Cloudscene and Data Center Map) suggest that there are max. about 35 co-location and hyperscale data centers.

The industry association the Finnish Data Center Forum (FDCF) has over 90 data center companies as members, which is one indication on the sector volume.

The Finnish government owns about 30 data centers.

Municipalities have mainly outsourced their data center services.

3.
Energy and Resource Efficiency Indicators



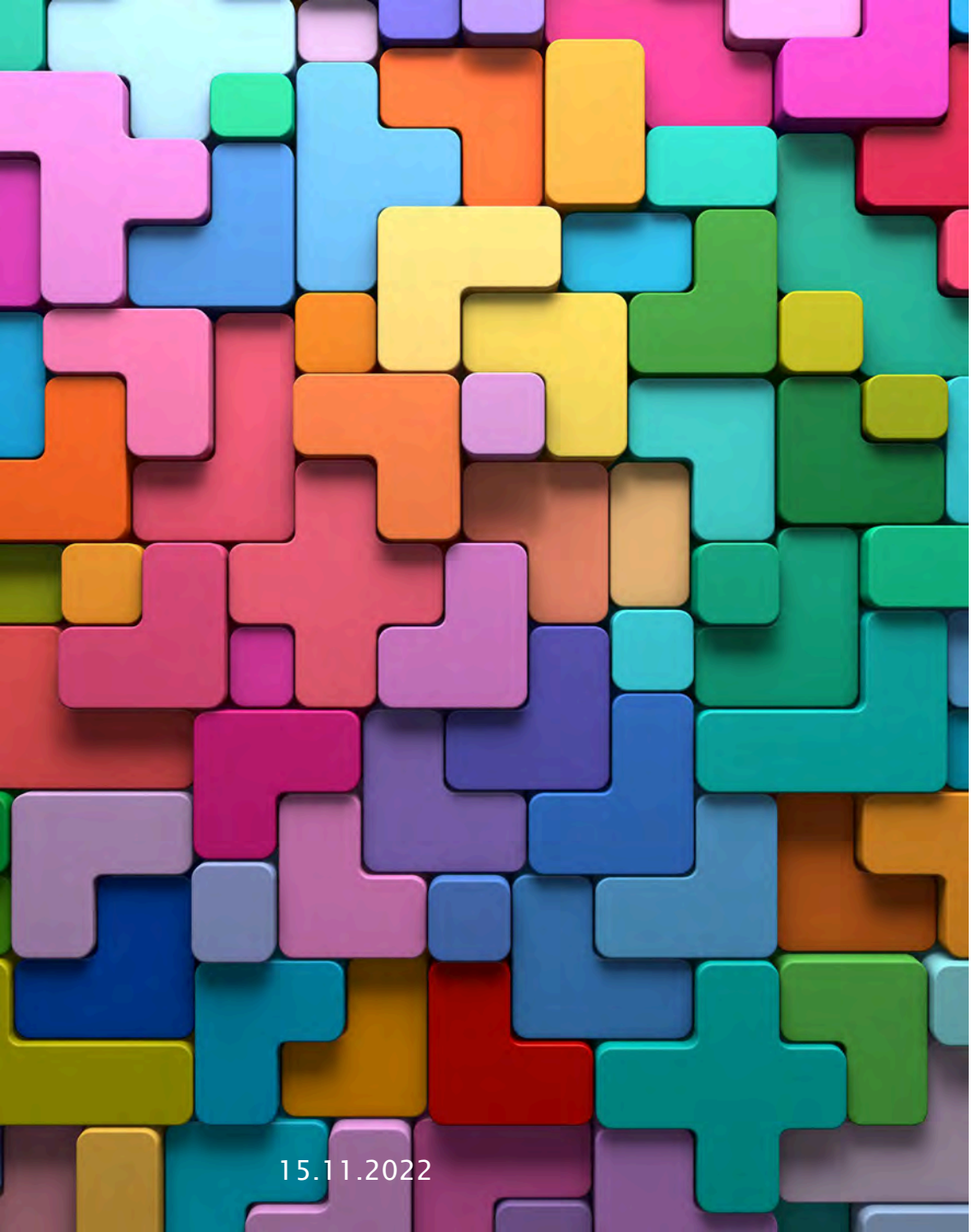
Indicator Issues

Energy efficiency of a data center depends on the system's performance including equipment design, software architecture, resource allocation and operational set points. The systems are complex, and it is difficult to define what is useful work. (Koronen et al 2020)

Multiple indicators are needed and used but which ones are most important?

- PUE only measures the "overhead" energy consumption of the building and auxiliary systems. Good levels are relatively easy to achieve in new facilities.
- What is the impact of electricity used by heat pumps in heat recovery on the indicators? Care needs to be applied in setting the evaluation boundaries.
- Are there trade-offs between objectives (e.g., between use of energy and water) affecting interpretation of indicators?

Calculations have been standardized but it is not adequate to ensure harmonization.



Energy and Resource Efficiency Indicators for Data Centers

Power Usage Effectiveness (PUE) / Data Centre Infrastructure Efficiency (DCiE)

Renewable Energy Factor (REF/RES)

Energy Reuse Factor (ERF) / Energy Reuse Effectiveness (ERE)*

Cooling Effectiveness Ratio (CER)

Carbon Usage Effectiveness (CUE)

Water Usage Effectiveness (WUE)

Cooling Effectiveness Ratio (CER)

Power to Performance Effectiveness (PPE)

Data Centre Energy Productivity (DCeP)

Data Center Performance Per Energy (DPPE)

Bold = defined in standards ISO/IEC 30134 and EN 50600

* Used in Finnish tax legislation

4.
Energy Efficiency Policies and Measures Addressing the Sector

EU Policy for Energy Efficiency of Data Centers

The Ecodesign Directive was extended to servers and storage devices in 2019.

The European Green Deal started in 2020. It is a voluntary agreement promoting efficient use of energy and water, use of clean energy and circular economy.

The European Code of Conduct is a voluntary agreement for the sector launched in 2008.

New measures are proposed in the recast Energy Efficiency Directive (EED) for energy efficiency improvements and for monitoring development in sustainability, including energy efficiency (see next slide for details).

The EED Recast Proposal – European Parliament on 14 September 2022

By 15 March 2024, and annually thereafter, Member States shall require owners and operators of every data centre (with installed IT power demand ≥100 kW) to make information publicly available (an EU database will be established):

- the name of the data center; the name of the owner and operators of the data center; the municipality where the data center is based
- the floor area of the data center; the installed power; the annual incoming and outgoing data traffic (if available); and the amount of data stored and processed within the data center when this affects the energy consumption
- Power Usage Effectiveness (PUE), Renewable Energy Factor (REF), Energy Re-use Factor (ERF), Cooling Effectiveness Ratio (CER), Carbon Usage Effectiveness (CUE) and Water Usage Effectiveness (WUE).

Cost-benefit analysis for the use of waste heat in district heating or cooling shall be carried out for data centers with a total rated energy input exceeding 100 kW level.

Requirements are established for energy management of data centers with installed IT power demand ≥1 MW

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Energy Efficiency Policies in Finland Relevant to Data Centers

National Climate and Environmental ICT Strategy (2021).

Lower energy tax rate is available for energy efficient data centers (with requirements for Power Usage Effectiveness PUE and Energy Reuse Effectiveness ERE).

Subsidies for energy efficiency investments and non-mandatory energy audits carried out by those not subject to mandatory energy audits.

Voluntary energy efficiency agreement scheme established in 1997 is important in many sectors but only few commercial data center operators participate in it.

Low-carbon road map for the technology industry covers also data centers and recognises their waste heat potential.

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5.
Good Examples from Data Center Industry

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Image Fortum

Microsoft and Fortum Waste Heat Recovery in Espoo

Microsoft construct a new data center campus in the Helsinki Metropolitan Area and Fortum (energy company) will invest in large-scale heat recovery into the district heat network. The transmission network operator Fingrid will make the necessary investments into the power network.

Only zero-emission electricity will be used, and surplus heat from the data centers will cover 40% of the heat demand of 250 000 district heat customers in Espoo, Kauniainen and Kirkkonummi.

Carbon dioxide emission reduction is 400 000 tonnes per year. The project will be globally the largest waste heat recovery project from data centers.

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Image Telia

Telia Helsinki: Waste Heat Recovery and Service Provider for Fast Frequency Reserve

The Helsinki Data Center of Telia (a telecom operator and ICT service company) was commissioned in 2019 and it is the largest co-location data center in the Nordic Countries.

From autumn 2022, excess heat flows into the district heat network of Helen (local energy company) providing heating to over 20 000 dwellings.

The data center uses electricity produced by hydro and wind power.

Balancing service provide with the UPS equipment in the Fast Frequency Reserve in the national transmission grid. Quick balancing is needed, e.g., during interruptions in renewable electricity supply.

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Image CSC

CSC/LUMI, Resource Efficient Supercomputer in Kajaani

LUMI supercomputer, constructed for research computation needs in Kajaani, was taken into use in June 2022. It is Europe's most efficient supercomputer.

Planned PUE value is as low as 1.05.

The data center uses hydro power on site.

Excess heat, equivalent for 20% of district heat demand in Kajaani, is sold to the local district heat company which reduces carbon dioxide emissions by 12 400 tonnes per year.

Building the data center inside a closed paper mill reduced emissions of the construction phase by 80% compared to a green field project.

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Image Kuulea

Kuulea Distributed Server Concept with Waste Heat Recovery

In Kuulea's service concept, specially manufactured servers are distributed in properties that require heating services.

Waste heat is used locally in the heating of the property. Additional benefit is that using heat at the same property helps to avoid heat transmission losses.

The system is at its best in places where heat is needed evenly throughout the year such as hotels, spas, shopping centers, swimming pools, industrial properties, and large housing companies.

Waste Heat Potential from Data Centers in Finland

In 2020, AFRY Management Consulting estimated the utilized waste heat from data centers in Finland at 200 GWh/a, most of which is used in district heating networks.

The total technical waste heat potential was estimated at 2 TWh/a but the potential grows along with sectoral growth.

Study assumptions: There are max. ten over 5 MW and about 50 mid-sized 0.5–5 MW data centers. Waste heat capacity in them totals at about 300 MW. Annual electricity generation is 2 TWh/a production, calculated with peak load utilization time of 6000 h/a.

Situation changes constantly due to sectoral growth and large new projects.

6.
Summary and Conclusions

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Conclusions on Energy Efficiency of Data Centers in Finland

Criteria for lower electricity tax class provides good incentives for commercial data centers.

Many large-scale waste heat utilization projects are underway.

Effective benchmarking is not possible because of lack of data and statistics.

Low PUE and active use of renewables are already common among larger operators and in new facilities. Client requirements for demonstrating sustainability in a reliable way are growing.

There is still room for further improvements in data center management (all data centers are not professionally managed).

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Indicators in the EED Proposal

When implemented, dramatic improvement can be expected in the knowledge base.

National data collection to the Commission's forthcoming database needs to be planned.

- The data center industry should prepare for the new data reporting requirements

New requirements for the data center industry, such as minimum performance standards, may be presented by the Commission in March 2025 following the assessment of the collected data.

The EU Action Plan Digitalising the Energy System (Oct 2022) announces a new environmental labelling scheme for data centers in 2025, building on the collected data.

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Thank you!

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