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Energy consumption of data centres in Slovenia

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Abstract. Data centers are specialized facilities designed to computing resources such as servers, storage, and networking equipment. They provide the infrastructure needed to store, process, and distribute large amounts of data efficiently and securely. Data centres are large electricity consumers, so monitoring their consumption is important for studying and monitoring the environmental impacts of digitalization. Such an industry is evolving rapidly, driven by demand for faster, more efficient, and sustainable solutions. A results of survey on the energy consumption of data centres in Slovenia for year 2023 were dealt within a paper. The survey, identification of the reporting units and questionnaire testing are presented, as well.

Key words. Data centres, energy consumption, survey, digitalization.

1. Introduction

Energy statistics in Slovenia (SURS) have been recently developed to meet the needs of both national and international users. The development resulted in the compilation of annual national energy balance, commodities balances, the fulfilment of monthly and annual reporting obligations to international institutions, and the dissemination of energy statistics for the use of scientific institutions, policymakers, students and other users in Slovenia and abroad.

In the framework of energy statistics SURS collects data on the production, export and import, stocks, transformation and consumption of all types of energy products in line with the provisions of Energy Statistics Regulation 1099/2008 [1]. It is important to provide energy data and statistics to support policy planning and actions for the energy-related sectors. Energy statistics are, for example, one of the inputs for the calculation of greenhouse gas emissions and are regularly used by the Slovenian Environment Agency. They are used for evaluating the implementation of the National Action Plan for Renewable Energy Sources and for monitoring the Integrated National Energy and Climate Plan of Slovenia. Furthermore, they are important in developing probabilistic models for decision-making in sustainable energy transition.

However, currently available energy statistics are still incomplete, especially after the European Commission (EC) adopted the most encompassing amendment of the energy statistics regulation conducted so far (No. 2022/132, [2]). In that sense SURS needs to develop and upgrade the statistics to fulfil present and future data requirements related to the mentioned amendment as well.

The activities within the paper were focused on new data about the electricity consumption of data centres. Commission Regulation on energy statistics requires the reporting of data on energy use of data centres with a total power capacity of 1 MW or more [2]; however, in this research we have also focused on the smaller ones.

Data centres could represent a large energy consumers, while new data will be important for monitoring the environmental impact of digitalisation, as well [3-4].

The main objectives were:
- to develop the methodology and set up the procedures and technical solutions for the collection of data on energy consumption of data centres,
- to identify the reporting units,
- to design a questionnaire for the collection of data on energy consumption of data centres,
- to conduct the pilot data collection in order to test the new methodology and

- to analyse the results of data collection.

Work at SURS is process-oriented, meaning that different sections carry out different processes. Every process has a special monitoring system. The project leader additionally oversees all phases of the survey. The team of colleagues from the Environment and Energy Statistics Section has prepared the questionnaire (Tables I-III) in cooperation with the methodologist responsible for questionnaire design and the methodologist responsible for questionnaire programming. The reporting units (Tables IV-V) were selected by the team from the Environment and Energy Statistics Section in close cooperation with an expert on sampling methodology. Data were collected with the help of the Enterprise Cooperation Section. To achieve a high response rate and to verify the provided data, additional time was allocated for contacting the reporting units. All actions were undertaken under the close supervision of the project leader. The final validation and editing of microdata were also done by the team from the Environment and Energy Statistics Section.

2. Conducting the survey

A pilot survey on the energy consumption of data centres for year 2023 was carried out. For the purpose of the project, a new set of questions (Tables I-III) was designed as part of the existing questionnaire on energy consumption in the services sector. The new set of questions was prepared based on experiences from the aforementioned questionnaire, which had already included some basic questions on energy consumption of data centres. The questions were designed in order to meet specific requirements of the current project obligations. In that sense, reporting units are encouraged to complete the electronic version of the questionnaire.

Basically, if the reporting unit reported that they have their own data centre and/or they offer collocation and/or cloud services, they were asked more detailed information about their data centres (Tables I-III):
- number of locations of their data centres,
- surfaces of their data centres,
- rated electric power of their data centres,
- electricity consumption of their data centres and
- electricity consumption of their data centres by end use (cooling, data storage, network infrastructure, servers, other end uses).

Table I. - The questionnaire (energy consumption in the data centres, level 1)

Question (level 1)	Answer
A) Do you use a data centre or are you a colocation or cloud service provider?	Y/N
B) What type of data centre or services do you use?	1) Own 2) We rent colocation services 3) We rent cloud services 4) We offer colocation services 5) We offer cloud services
C) In how many locations are your data centres?	Number [/]
D) What are the areas of individual data centres?	Number [m^2]
E) What is the rated electrical power of individual data centres?	Number [kW]
F) What was the electricity consumption of individual data centres?	Number [MWh]

Table II. - The questionnaire (energy consumption in the data centres, level 2)

Question (level 2)	Answer
B1) Which provider do you rent colocation services from?	Text
B2) Which provider do you rent cloud services from?	Text

Table III. - The questionnaire (share of the electricity of individual data centres by end uses)

Electricity consumption by end uses	Location x
AN1) For cooling	Number [%]
AN2) For data storage	Number [%]
AN3) For network infrastructure	Number [%]
AN4) For servers	Number [%]
AN5) For other end uses	Number [%]
Total	**100%**

3. Identification of the reporting units

Before the data collection, the reporting units should be identified. The identification was very challenging as there is no list of data centres in Slovenia. Some information on the use of data centres was available from the pilot survey on energy consumption in the services sector. The majority of enterprises included were the enterprises that stated in the previous survey (service sector) that they had a data centre and have also reported high electricity consumptions of their data centre. Also included were enterprises that stated that they did not have a data centre, but still reported high data centre electricity consumption. Lastly included were enterprises with the highest returns, as well as telecommunication enterprises and enterprises that offer hosting services/colocation/cloud services and are in general expected to have an internal data centre.

The list of the reporting units thus contained three types of reporting units:
- enterprises that are publicly known to have larger data centres (basic information is available online, from articles and advertising of their services, etc.),
- enterprises from the Information and Communication Technology sector for which we assumed that they could have data centres based on the publicly available descriptions of their activities and their already reported information and
- some of the largest enterprises from the services sector that either have already reported that they have a data centre or we assumed that they could have data centres.

The final list was prepared after the cognitive testing of the questionnaire where we also gathered some additional information on the situation regarding data centres in Slovenia (Tables IV-V).

Table IV. - The number of reporting units by the NACE Rev. 2 section

NACE Rev. 2 section	Number of reporting units
G – wholesale and retail trade, repair of motor vehicles and motorcycles	4
H – transportation and storage	5
J – information and communication	20
K – financial and insurance activities	3
M – professional, scientific and technical activities	c
O – public administration and defence, compulsory social security	c
P – education	c
Q – human health and social work activities	c

c – confidential

Table V. - The number of reporting units by the number of employees

Number of employees	Number of reporting units
<100	15
100–499	7
500–999	c
1000–4999	10
5000+	c

c – confidential

4. Questionnaire testing

The purpose of the questionnaire testing was to find out if the reporting units had the information about the energy consumption of their data centres and other data. It was important to find out if the questionnaire was sufficiently intelligible, transparent, and if the instructions that were provided were clear, and whether enterprises have or can provide the data required.

For the testing, different enterprises were selected. Potential reporting units (11 enterprises) selected for testing were invited to participate via e-mail. Six enterprises responded and were included in testing.

Main findings of questionnaire testing:

- overall, the questionnaire was mostly clear and understandable to the participants,
- in most cases, the participants had no difficulties understanding the questions and information we wanted to obtain from them.

Initially we had two questions about the power of a data centre – rated electrical power and typical input power. There was a lot of misunderstanding regarding the question about typical input power. Since we only needed one piece of information about the centre's power and rated power turned out to be more appropriate, we decided to remove the question about typical input power.

The question about total electricity consumption was clear and participants mostly confirmed that they would not have any problems with this question and could provide the data.

Regarding the question on electricity consumption by end use, participants said that it would be very difficult, if not impossible, to provide these data. Therefore, we changed the question so that we asked them to estimate the share of electricity consumed by different end uses.

We also tested the question on the use of excess heat to heat the premises [5-6]. There were no problems with the question; however, we finally excluded this question from this set of questions, as this information is already obtained in the questionnaire on energy consumption in the services sector.

Based on the results from testing, the questionnaire was slightly updated and additional instructions were provided, for example:

- a data centre is a building or space dedicated to hosting computer equipment. It consists of servers, data storage space, and the network infrastructure to connect the individual components,
- in colocation, an enterprise typically leases space from an external provider, with the servers and network infrastructure used by the enterprise typically being owned and operated by the provider and
- rated electrical power is the highest continuous net electrical power that a data centre can operate normally without time restrictions.

5. Survey data results

The main results on the energy consumption of data centres for year 2023 are presented in this section (Tables VI-VII, Fig. 1). Some reporting units have more than one data centre (up to 5). In total, there were 41 data centres in Slovenia in 2023. Their total surface area was 6,295 m^2, their total rated electrical power 7,554 kW and their total electricity consumption 36,833 MWh.

In 2023, the majority of data centres in Slovenia (61%) were smaller data centres with power size less than 100 kW (Fig. 1). Only three data centres had the power of 1 MW or more.

Table VI. - Data centres in Slovenia by power size class (number and area)

Power size class	Number of data centres	Area (m^2)
Less than 0.1 MW	25	1,727
0.1 MW – 0.999 MW	13	3,548
1 MW and more	3	1,020
Total	**41**	**6,295**

Table VII. - Data centres in Slovenia by power size class (power and consumption)

Power size class	Rated electrical power (kW)	Consumption (MWh)
Less than 0.1 MW	1,057	6,176
0.1 MW – 0.999 MW	3,497	18,116
1 MW and more	3,000	12,541
Total	**7,554**	**36,833**

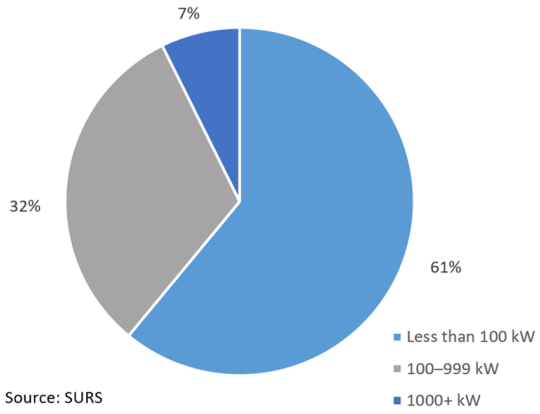

Fig.1. Share of data centres in Slovenia by power size class.

In 2023, the majority of data centres in Slovenia (46%) were owned by enterprises registered in NACE section J – information and communication (Tables VIII-IX).

Table VIII. - Data centres in Slovenia by NACE section J (number and area)

Power size class	Number of data centres	Area (m^2)
J – information and communication	19	3,772

Table IX. - Data centres in Slovenia by NACE section J (power and consumption)

Power size class	Rated electrical power (kW)	Consumption (MWh)
J – information and communication	4,733	22,399

The majority of electricity consumption of data centres (Table X) was consumed for servers (50%), followed by consumption for cooling (28%), data storage (11%), network infrastructure (7%) and other end uses (4%). In the category of other end uses, reporting units listed lighting, ventilation, control system, support infrastructure, etc.

Table X. - Electricity consumption of data centres by end uses (MWh)

Type of end uses	Electricity consumption (MWh)
Cooling	10,306
Data storage	3,852
Network infrastructure	2,722
Servers	18,519
Other end uses	1,434
Total	**36,833**

6. Conclusion

Data centers are among the largest energy consumers worldwide, and their power usage continues to grow as demand for cloud computing, artificial inteligence, and digital services increases. As data centers consume massive amounts of energy, the industry is shifting toward sustainable solutions to reduce carbon footprints while maintaining high performance. The activities within the paper were focused on new data about the electricity consumption of data centres in Slovenia for year 2023. As known, regulation on energy statistics requires the reporting of data on energy use of data centres with a total power capacity of 1 MW or more. Basically, within research we focused on conducting the survey (for present and future applications), identification of the reporting units and questionnaire testing, as well.

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