Begonia

USE CASE 2:

Digitalisation of energy storage and reuse in Data Centers

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Use case identification

Table 1. Identification of use case 2.

ID	Name of Use Case	Geographical scope	Cross-sector domains			Interoperability layers
			Electric	Mobility	Data	
BEG.02	Digitalisation of energy storage and reuse in data centers	☐ Local ☐ Regional ☒ National ☐Cross-border ☐ Outermost	☒ Customer ☐DER ☐Distribution ☐ Transmission ☐ Generation	☐ Customer information ☐Vehicle ☒ Energy station ☐ Infrastructure ☐ Traffic and logistic	☐ Edge ☒ Fog ☒ Cloud	☒ Component ☒ Communication ☒ Information ☒ Function ☒ Business

The scope and objectives of the use case

Table 2. Scope and objectives of use case 2.

Scope and Objectives of the Use Case	
Scope	DCs require a significant amount of electricity to cool down the servers and almost all of this energy is wasted as heat. As solutions to increase the energy efficiency of DCs, it is suggested to equip them with cold-storage units, RESs, power storage units, and waste heat reuse technologies. Adding all these technologies increases the flexibility capacity of DCs and enables them to provide ancillary services for the grids and reduce their operation costs. However, several services should be developed to make the most optimal decisions on the size of the above-mentioned technologies and their operation. This use case proposes an ODP that provides all required services for monitoring and managing DCs to reduce their expenses and make their business more sustainable through flexible coordination of RESs, energy storage, waste heat reuse, and provision of ancillary services.
Objective	Objectives of digitalisation of energy storage and reuse in DCs: • Developing an ODP for monitoring, operation, and planning of DCs, • Developing operational services for cost-effective operation of DCs considering different combinations of technologies such as heat, cool, and electricity storage technologies, and RESs, • Developing planning services for decision-making on using different technologies for reducing costs and increasing efficiency, • Developing services for providing ancillary services for the power system.
Reference country(ies)	Denmark
Related Business Case	Data center operation, energy management, energy trading, carbon neutrality, Auxiliary service,
Possible stakeholders	Data centers, TSO.

Narrative of the use case

DCs are growing rapidly across Europe. According to a recent report by Data Economy, the European DC market is expected to grow by a compound annual growth rate of 11.4% between 2021 and 2026. Furthermore, according to a report by the EC's Joint Research Centre, DCs consume around 3% of the total electricity consumption in the EU. However, in some individual cities or regions, DCs can consume much higher shares of the total electricity, particularly if the area has a high concentration of DCs providing large flexible capacity to transmission system operators (TSOs). As this share is expected to grow, DCs will contribute to the energy transition toward the carbon-zero energy system. Hence, it is necessary to make the DC industry a more proactive contributor to sustainable energy systems.

Figure 1 shows the data center, its related technologies, and possible opportunities for investment to improve energy efficiency and reduce operational costs. In conventional structures, cooling devices consume electricity to cool down the data center servers, there is an auxiliary energy resource such as an uninterruptible power supply (UPS) as a backup in the cases of power grid failure, and the heat generated by servers is dispersed into the environment (walls, air, ground, etc.) and lost forever. New designs suggest equipping the DCs with new electrical and thermal technologies. On the electrical side, it is suggested to add batteries, RESs, and EV charging points to the system to increase flexibility in operation. On the thermal side, it is suggested to have a cool storage and waste heat reuse system.

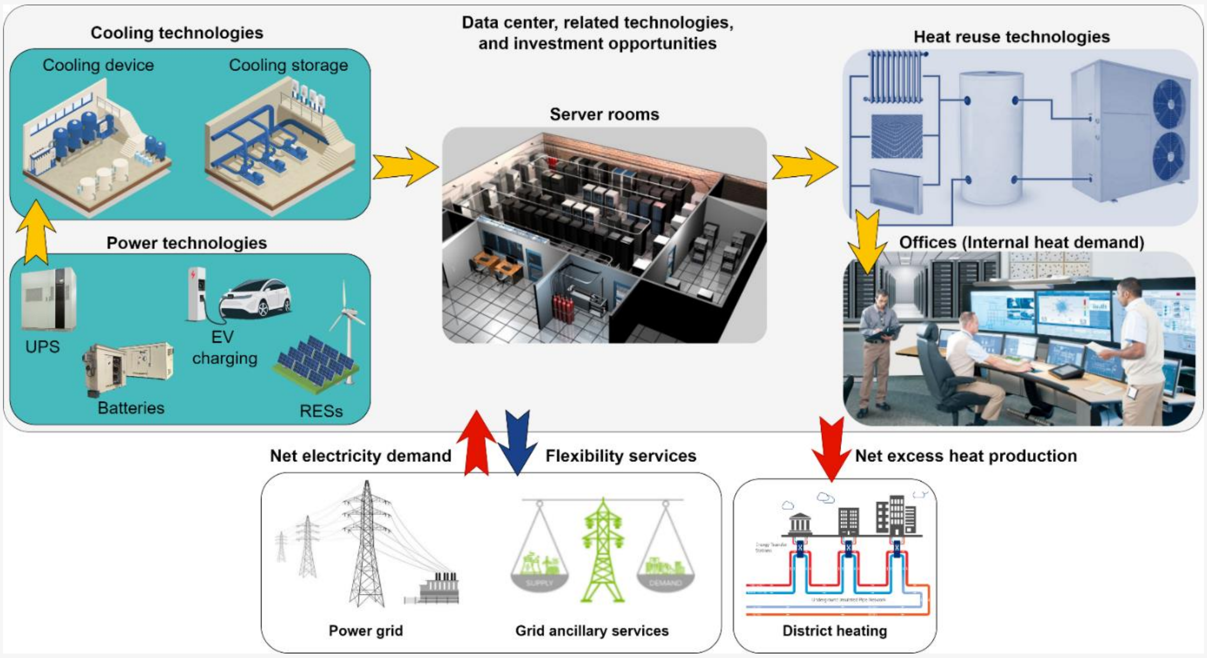

Figure 1. Data center, related technologies, and investment opportunities.

The storage of "cold" happens when the cold-water storage tank is charged during lower chiller cost periods and discharged during higher chiller cost periods. Similarly, waste heat reuse utilizes heat storage and more efficient heating technologies such as heat pumps to benefit from the heat produced by the DC to supply the heat demand of the DC offices and the external demand for heat in district heating. The flexibility provided in the operation of the DC by all these technologies enables the DC to participate in the ancillary service market and provide services such as balancing and voltage regulations for TSO or DSO.

It is worth noting that the reliable operation of DCs is a critical task. A failed test with a new design can lead to overheating and damage to servers as well as costly downtimes. Therefore, safe off-site hardware tests are necessary before integrating new technologies and accompanying controllers in the DC control system. To this end, a digital twin of the DC and related technologies should be developed using advanced AI algorithms to test any planning or operational solution before applying it to the real system.

This use case proposes developing an ODP for flexible coordination and testing of different technologies for DCs. This ODP should have a tool for developing digital twins of the DCs and evaluating_different technologies that can be used to improve efficiency and reduce costs. It should be generic enough to be applied to different DCs and technologies. This ODP is expected to provide the following services:

- **Monitoring service:** The data received from different sensors and smart meters can be visualized and presented to the DC operators,
- **Planning service:** This service provides testing capabilities within ODP on a technology or a group of technologies that the DC manager would like to integrate into the existing system. To this end, the developed digital twin is tested with new technologies, and the results are evaluated from technical and economic perspectives,
- **Operation service**: Receives the real-time data, forecasted parameters, and status of different devices (UPS, EV charger, RES, cool storage, etc) and schedules the operation of devices considering technical and reliability constraints,
- **Grid flexibility service:** Advanced methods and the latest measurements are used to forecast the flexibility of the DC system and offer it to the TSO or DSO taking into account the rules and regulations,
- **Emergency response and recovery:** Since the reliable operation of DCs is a very important task, an emergency response and recovery strategy should be defined to ensure the reliability of the DC's operation.

Regarding flexibility services, an agreement between DCs and TSO/DSO is needed to define the way the DCs can contribute to providing grid services.

The novelty of this use case consists in creating a platform capable of demonstrating how DC would operate under the integration of new energy technologies, in the first place, under an optimized and coordinated heat reuse schedule without actual deployment inside the DC.

Diagram of the use case

The diagram of use case 2 is presented in Figure . Use case actors and scenarios are explained in Table 3 and Table 4., respectively.

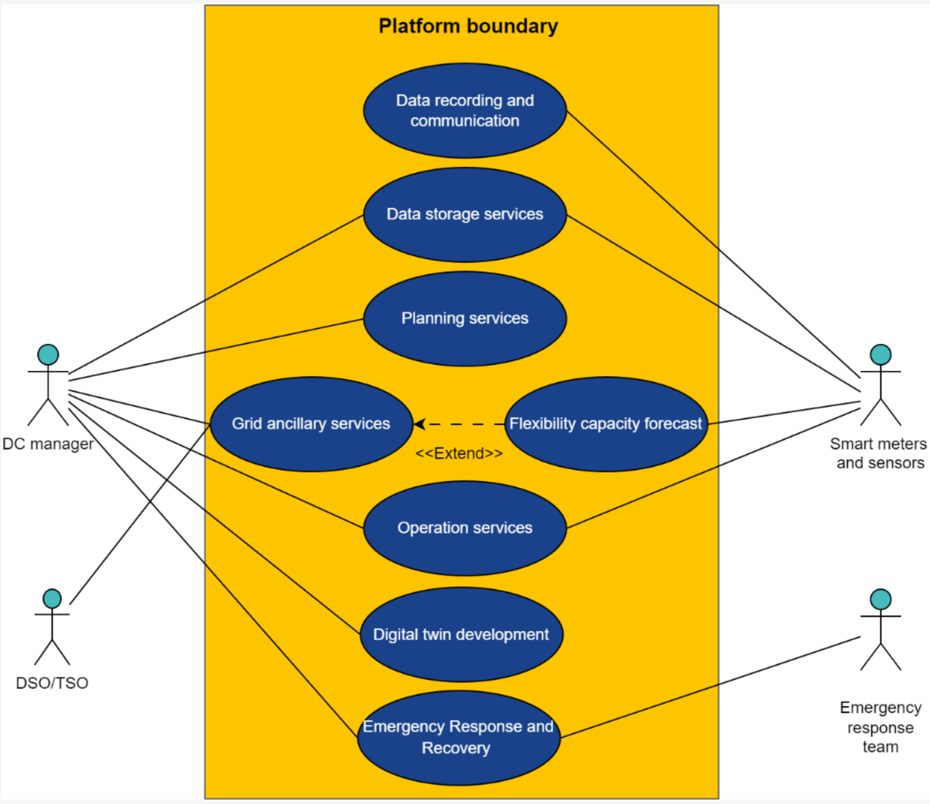

Figure 2. Diagram of use case 2.

Actors of the use case

Table 3. Description of the actions of use case 2 actors.

Actor Name	Actor Type	Actor description	Actions	Standards
Smart meters and sensors	System	Sensors are electronic components that respond to physical or chemical stimuli, that is, they detect variations in the environment in which they are inserted. A smart meter is a digital device that measures and records energy consumption in real-time.	Sensors measure parameters such as temperature in transformer boxes, while meters record electrical measurements like voltage and current. These devices transfer data to the data storage system. If they lack communication capabilities, they should be equipped with appropriate communication devices.	No
DSO	Role	An entity responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	DSO determines the required services for the ODP and uses the ODP to exploit different grid and flexibility services.	No

TSO	Role	An entity responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity.	Defines the requirements and rules for the data center to provide ancillary services.	No
DC manager	Role	Supervise the overall smooth and successful operation of the operational scenarios.	Perform tests on different parts of the digital platform, ensure reliable commutation between the DSO/TSO, meters, and the data center, and ensure that the data center system provides ancillary services within the agreed terms.	No
Emergency response team	Role	A group of people who prepare for and respond to any emergency incident.	They detect system failures, security breaches, or other emergency incidents and react to support the reliability of the DC.	No

Scenarios

Table 4. Description of use case 2 scenarios.

S.No	Scenario Name	Triggering Event	Scenario Description	Primary Actor
BEG.02.S1	Data recording and communication	The measurement time interval has elapsed, measurement request is sent by the DC manager/ODP.	The data monitoring service receives the data from different sensors and smart meters, visualizes them, and presents them to the DC managers and TSO. The data is processed in real-time to detect anomalies and generate alerts if thresholds are exceeded. This ensures continuous monitoring and quick response to any issues.	Sensors and smart meter
BEG.02.S2	Data storage services	New data is received	All the data received from smart meters and sensors is stored in the data centers and can be used by digital twin developers and service providers.	Sensors and meters and external data providers.
BEG.02.S3	Planning services	A new device is to be integrated into the DC, new control logic is required or a new	DC manager configures and runs the planning service using digital twin based simulation and forecasting tools to decide which technologies, their configuration, and operation strategy would best serve the purpose of DC	DC manager

		regulation is applied in the DC.	renovation/upgrade with objectives of reducing costs and increasing efficiency of the integrated solution.	
BEG.02.S4	Digital twin development	Based on the results of planning and operational tests, the DC manager decides on the final configuration of the integrated device/control/constraint system.	The data center manager works with the team of engineers to describe a recent design for control logic/device/constraint and integrate it into a digital twin for the updated system. This digital twin is used to simulate the operational behavior of the data center under various conditions to ensure reliability and efficiency before actual implementation.	DC manager
BEG.02.S5	Operation services	Continuous, in specific time intervals.	The operation service receives the real-time data, forecasted parameters, and status of different devices and schedules the operation of devices considering technical and reliability constraints applied to the existing and newly integrated equipment. The developed digital twin is tested with new technologies, and the results are evaluated from technical and economic perspectives. This ensures that the integration of new equipment and control strategies is optimal and reliable before full-scale deployment.	DC manager
BEG.02.S6	Flexibility capacity forecast	Continuous, in specific time intervals.	Taking into account the DC needs and status of the devices, a methodology is used to forecast the flexibility capacity of the DC for providing grid services.	
BEG.02.S7	Grid ancillary services	A grid service required by DSO or TSO	The ODP/DC manager offers the flexibility capacity to the TSO or DSO taking into account the rules and regulations, and provides flexibility when needed.	DC manager
BEG.02.S8	Emergency Response and Recovery	Detection of a system failure, security breach, or other emergency.	The emergency response service activates protocols to mitigate damage, secure data, and restore normal operations. The digital twin helps simulate emergency scenarios and plan recovery strategies.	DC manager, Emergency response team

Policy and digitalisation needs

Table 5. Description of use case 2 policy and digitalisation needs.

Policy needs	• Regulations are needed to facilitate the participation of data centers in the grid services, • Digital platfrom should support regulations established in different countries for DC-TSO interaction,

Digitalisation needs	The technical barriers in this use case come from the necessity to adopt the developed ODP to the properties of a specific infrastructure for cooling, heating, and electrical subsystems that the specific DC exploits: • Design details of storage and production technologies would impose different construction and operation constraints on the cooling system, • Type of DC cooling and heating systems. One has to test all solutions for the correct infrastructure and therefore detailed data is required about the DC to make the digital twin. This leads to the need for an accurate and reconfigurable digital twin that would adapt its behavior based on the change in the DC topology. The interoperability barriers that have to be overcome are: • Identification of standard construction principles for the digital twin to make the solution transferable, • The interoperability layers of the digital twin design must reflect those for the actual DCs under investigation (communication protocols, data handling, functions), • The Scada systems for DCs are not normally constructed in an interoperable way, e.g. transformers between the Scada and ODP communication protocols may be necessary.