GREEN & RESILIENT DATA CENTER

Data centers with low environmental impact and high resilience that support critical infrastructures.

Developed by Clust-ER Innovate and Greentech.

COESIONE ITALIA 21-27 EMILIA-ROMAGNA
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SUMMARY

Introduction to Energy

Digitalization represents a solution for enhancing energy efficiency and lesse ning the environmental impact across various economic sectors.
The digital sector, in particular, faces the challenge of maintaining energy efficiency due to the continuous growth in computing power, cloud resources, and data storage demands. The magnitude of this expansion becomes evident when observing that globally, from 2010 to the present, internet users have more than doubled, and internet traffic has increased by 25 times.

From an energy perspective, on a global scale, according to a report issued by the International Energy Agency (IEA[1]), data centers in 2022 employed between 1% and 1.3% of final electricity consumption (excluding the cryptocurrency mining sector). This corresponds to a 1% contribution to global greenhouse gas emissions from data centers and data transmission networks. Future prospects, moreover, suggest that this incidence is expected to increase, at least in the short term. In fact, although the growth in energy requirements in data centers is being mitigated by a steady improvement in efficiency, the IEA has reported in recent years an increase in this sector's energy requirements of 20- 40% per year, caused by the rapid increase in workloads in large data centers.

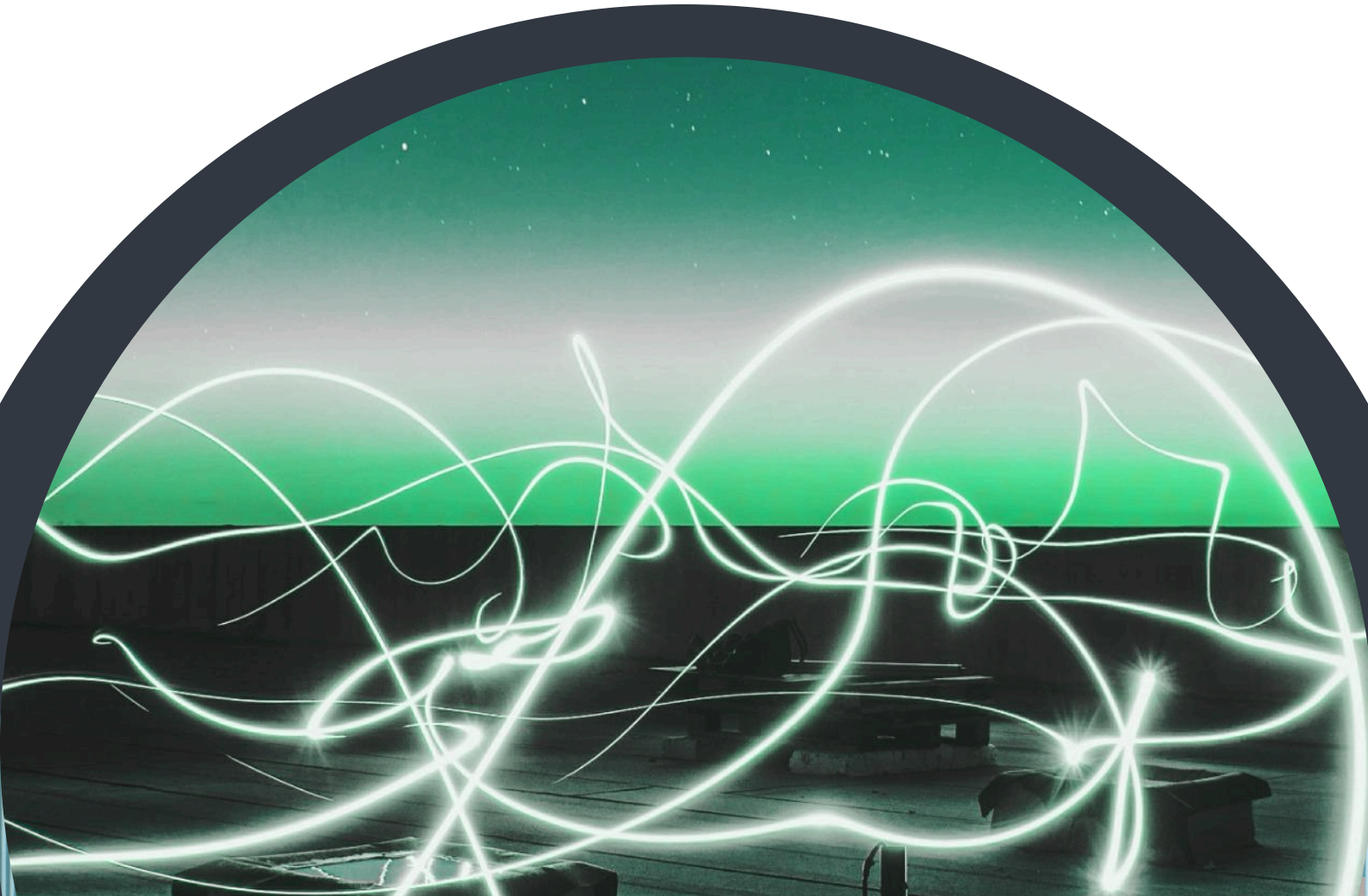
Within the innovation ecosystem of the Emilia-Romagna region and, in particular, within the framework of the regional Data Valley implementation strategy, understood as the complex of investments in supercomputing infrastructures, skills and dedicated research, there are some already acquired experiences and some projects in start-up focused precisely on the issues of energy efficiency and reduction of the environmental impact of data centers. The purpose of this paper is to present a concise review of these best practices and projects and also to describe their implementers in order to provide a complete picture of the articulation and capabilities of the ecosystem itself.

[1] IEA (2023), Data Centres and Data Transmission Networks, IEA, Paris https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networkshttps

The overview of these actions includes interventions and projects on systems for the management and automation of data centers, on the programming of software marked by the optimized use of energy (“green coding”), on the use of increasingly efficient and latest-generation cooling systems, on the efficiency of buildings that house data centers, with the extensive use of renewable energy, passive cooling systems and, in general, with the acquisition of the most advanced energy certifications. In addition, the review considers solutions for the use of thermal waste (“waste heat”), also with a view to industrial symbiosis and increasing the circularity of the whole system.

Alberto Sogni

Senior Expert e Project Manager @ Clust-ER Greentech



RESILIENCE OVERVIEW

Natural disasters and terrorist attacks can cause high casualties, devastating damage and destruction, not only in urban areas but also in critical infrastructure. For example, earthquakes globally have caused more than 30 percent of casualties from natural disasters in the past thirty years. Telecommunications systems and networks usually have to meet certain technical specifications in order to ensure at least voice communications in these emergency scenarios.

Public Safety Organizations and Institutions play a delicate and critical role in dealing with emergencies in disaster scenarios. Lack of or intermittent communication not only among emergency workers, such as firefighters or law enforcement, but also among civilians affected by the disaster can dramatically worsen the effects of the disaster itself.

It is therefore crucial to improve information and communication systems not only during the emergency but also before any possible disaster event in order to increase the resilience of both the technological infrastructure and local communities, possible victims of the event.

The term robustness refers to the ability of an information system to effectively handle responses to known and foreseeable failures while maintaining system uptime. By resilience, on the other hand, is meant the ability to continue to operate properly in the face of unpredictable failures and adversity, adapting to different situations, including wear and tear, that may arise during operation.

These definitions and criticalities can evidently also be applied to a particular and fundamental critical infrastructure of recent decades, namely the data center.This white paper presents several contributions from notable experts i n the management and planning of resilient and low-impact small and large data centers within the Emilia- Romagna Region.

CRIF's contribution concerns the presentation of the Business Continuity Management System (BCMS) they implemented to provide continuity of service delivery in the face of damaging and unforeseen events, as well as the design, structuring, and management of utilities to support the operation of ICT components.

Rekeep's contribution concerns the description of the “Resolve” Platform, which employs tools for criticality and failure analysis, preventive and predictive rather than corrective.

The company Tekni Post presents their Building Energy Management System (BEMS) for managing technology systems with, among others, the goal of maximizing the resilience of those systems.

CINECA presents its approach to the management, maintenance, design and development of one of Europe's largest supercomputing centers, obviously a lso from the point of view of techniques for the analysis and prevention of potential failures.

The solutions presented and proposed here represent a key contribution of regional excellence to improving the reliability, security and resilience of regi onal critical infrastructures, including data centers.

Maurizio Casoni

Associate Professor at the University of Modena and Reggio Emilia.

Green Coding and Performance: the CINECA case

Interview conducted by Elisabetta Bracci, Manager of Clust-ER Innovate, with Mirko Cestari, HPC and Cloud architect at CINECA.

Mirko Cesari HPC and Cloud technology coordinator at CINECA

GREENCODING AVAILABILITY HPC

In an age characterized by widespread technological integration and empow erment, even seemingly intangible activities, like software development, leave a mark: "responsible programming" enables us to minimize the energy required for executing algorithms. Consequently, the environmental impact of a data center is also influenced by coding practices, and adhering to fundamental guidelines is essential for navigating the dual shift effectively, merging digital and ecological transformations. The German Federal Environment Agency offers a notable illustration by outlining a set of standards for categorizing software as "sustainable." These criteria can be condensed into three overarching categories, encompassing environmental sustainability and user experience:

- User autonomy aligns with usage patterns that should be as "efficient" as possible in terms of energy.
- Non-simplified default configuration and options that specifically cater to users' needs
- Efficient resource management features

Let's explore this subject further with Mirko Cestari, HPC and Cloud architect at CINECA.

I would like to begin our chat by starting with the concept of supercomputing: how much does Leonardo consume and what is the most important parameter for you in terms of environmental impact?

During peak usage, Leonardo consumes as much energy as a small town with 50,000 inhabitants. Its successor is projected to consume three times as much energy, equivalent to the energy consumption of the city of Modena. It must hence be worthwhile. Our systems are engineered to last for 5 years before becoming obsolete, and the metric we employ to gauge their performance is the volume of scientific research generated during this timeframe: the greater the output within 5 years, the more effective the system. This is why in HPC (High Performance Computing) systems, performance, defined as the quantity of research over time, is the primary focus.

To increase research output within a specific timeframe, it is essential to maintain a high level of uptime. What is your current uptime percentage?

Availability serves as a metric representing the system's operational time for research production, excluding maintenance. With a monthly service interruption allowance of 10 hours, our IT [1]uptime stands at approximately 98%.

What about a non-HPC data center?

The standard workload typically utilizes over 80% of the server's load capacity, unlike those hosted by conventional cloud providers. In these scenarios, resources are often "overcommitted" to enable allocation of more concurrent workloads and enhance load capacity for improved energy efficiency.

It is important to note that a single server running consumes approximately 20% of its full capacity power, which should be minimized through optimal machine utilization. When servers are idle, 20% of energy is being expended without generating any output.

[1]Uptime refers to the percentage of time during which a system or appliance is operational or capable of operating

Let's draw a comparison with a bus on a highway. Suppose that during the uptime, you need to travel at 300km/h, and if you decrease your speed, you will no longer be able to make up for that 20%.

A 20% consumption is necessary even during idle system periods, as we aim to allocate 100% of the energy for research purposes. Operating within these constraints allows us to strive for optimal efficiency, highlighting the significance of greencoding. This involves adjusting programming methods to minimize effects on execution time and the total number of machine lifecycles. For instance, reducing accelerator frequency from 1400 MHz to 1000 MHz can cut consumption by 20% while only slightly decreasing performance by 5%.

What distinguishes energy consumption the most between a supercomputing system and a traditional data center?

To revisit the previous query, our aim is to achieve a speed of 300 miles per hour with minimal fuel consumption, whereas a conventional data center likely aims to maximize passenger capacity on buses to reduce fuel costs.

In the field of HPC, numerous simulations entail a high volume of processing units operating simultaneously, facilitating information exchanges and continuous updates. While awaiting updated data during these intervals, the processing units remain idle[2].

Consequently, there is no need for CPUs to operate at 3GHz during these periods; a lower frequency suffices for the task of data retrieval.

How would you describe green coding in layman's terms?

In our field, holistic thinking about energy consumption involves utilizing energyefficient software techniques to achieve optimal performance, resulting in a reduction of consumption by 10% - 15% compared to conventional methods, and maximizing the efficiency of system hardware. This poses a challenge in highperformance computing environments, characterized by diverse and increasingly specialized hardware.

[2]Idle: The period in which a CPU, transmission medium, server, etc., is not engaged in any activity and is in a state of waiting.

What are the tips you would give to a colleague to program in a more “Green” way?

We consistently strive to minimize execution times by leveraging the programmer's expertise in optimizing system performance. This goal is accomplished through reducing unnecessary messages and idle time during communications, as well as optimizing task distribution for improved load balancing. Conducting this analysis is crucial, and I recommend all colleagues to prioritize it, as it also enhances response times.

CINECA's facilities accommodate the work of international research groups with varying levels of proficiency and awareness of sustainable practices. How do you provide assistance to your users?

You accurately identified an area we are diligently focusing on to comprehend how to effectively communicate to users the importance of resource conservation.

It is crucial for us to offer training to enhance user knowledge and improve their ability to adjust their performance.

Moreover, we offer users applications that are pre-optimized for the infrastructure, handling the fundamental tasks to enhance performance.

Another step involves supporting and raising awareness among users to help them find the optimal balance between the quantity of processes and the collaborating units for their execution.

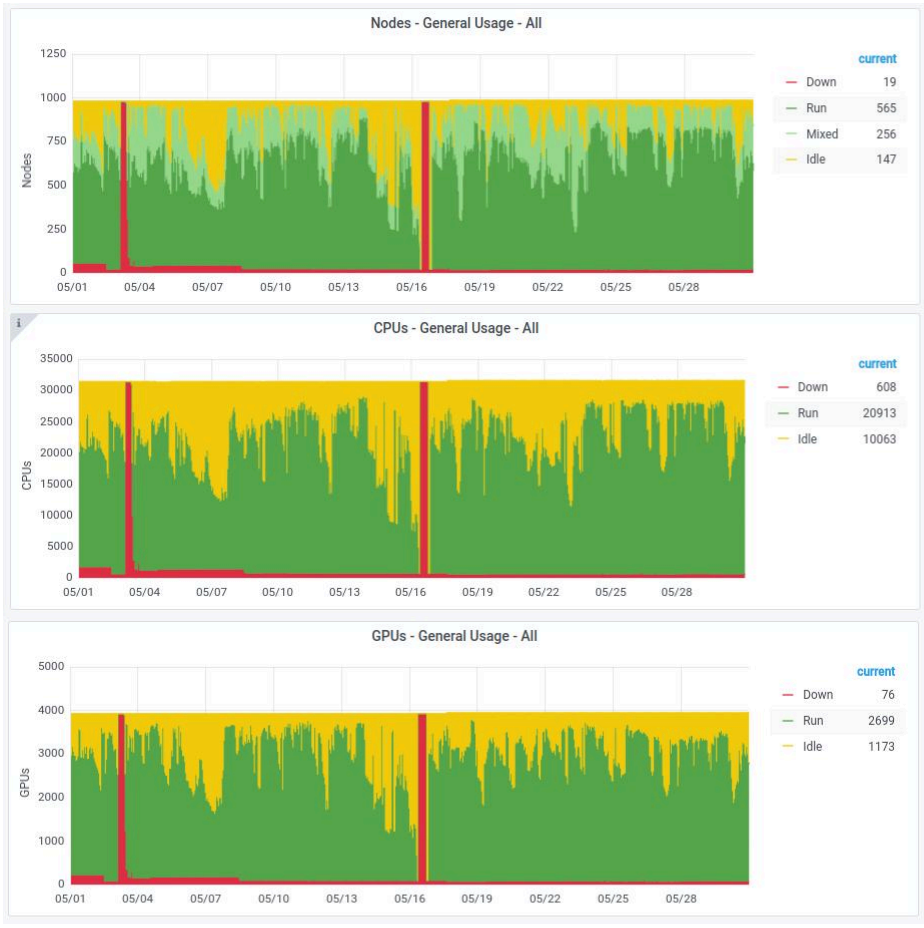
Awareness is the key focus. Have you considered incentives for your environmentally conscious users as well?

It is crucial to inform users about the quality of their usage, potentially by recognizing top users in terms of energy efficiency. Moreover, rewarding them with specialized resources and additional power could be considered. For instance, each project is allocated a specific resource budget: users who consume less may receive a greater share of resources in terms of space and power.

If you spend 20% less to accomplish your goal, you will have 20% more to allocate towards your desires.

Finally, could you provide an illustration of an energy-intensive process and an efficiency solution?

With real-time consumption readings and statistics, it became apparent that the machine assigned to a research project on docking was operating at approximately 20% above the average usage rate. This is primarily due to the significantly high volume of operations involved in such projects. By implementing green coding techniques and thereby enhancing the efficiency of the operations, we managed to optimize consumption, resulting in an increase of just 10%.



Docking in the pharmaceutical field involves a system utilized to predict the binding orientation of a pharmacologically active molecule to its target protein.

Integration of facility and IT: utilizing the ExaMon framework and the BIM model to achieve the Digital Twin

Massimo Mauri, Facility and Energy Area Manager - CINECA

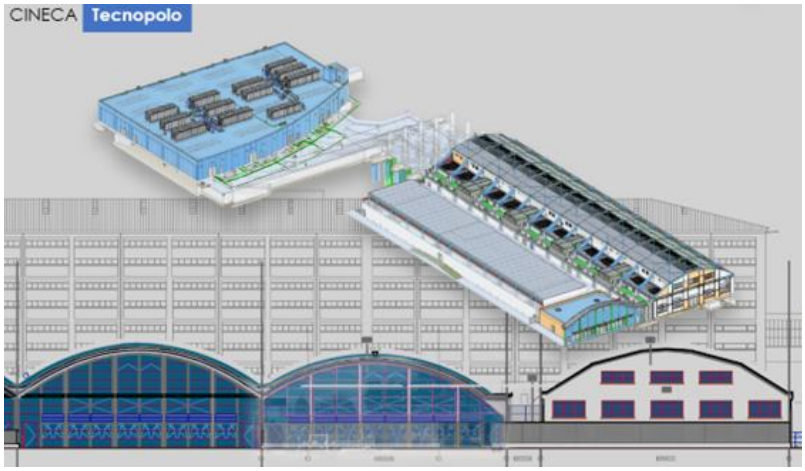
ENERGETIC EFFICIENCY | MAINTENANCE | INTEGRATED MONITORING

Cineca's Data Center (DC) maintenance strategy at the Tecnopolo di Bologna is informed by the experience gained at the Casalecchio di Reno DC, taking into account the specific requirements of an High-Performance Computing (HPC) data center. Through collaboration with supplier companies and the Department of Electrical Energy and Information (DEI) of the University of Bologna, Cineca has established an integrated monitoring system. This system facilitates the communication of diverse metrics, bridging the gap between field data from the facility and the operation of HPC systems, thereby overcoming linguistic and ideological differences.

The subsequent phase involves leveraging Machine Learning and IoT technologies to enhance analytics and proactively avert potential failures or adjust the infrastructure to computing conditions, with the aim of dynamically optimizing the data center while circumventing emergency or reactive measures. Our strategy entails employing a scalable software framework to monitor the performance and energy consumption of HPC servers, aggregating data from various systems, integrating it with real-time information from DCIM systems, and storing it in a data lake to support forecasting and predictive analytics.

BIM and Digital Twin

We believe the natural progression of the undertaken path is to oversee the Tecnopolo di Bologna facility "holistically," engaging all supply chain stakeholders. The objective is to establish a team with versatile expertise that consistently oversees the MEP (Mechanical, Electrical, and Plumbing) systems, network, and computational infrastructure via an integrated platform. This platform will incorporate BIM (Building Information Modeling), autonomously learning and presenting information in a user-friendly manner.



The Digital Twin represents the organic progression of the fusion between the facility and IT, akin to the renowned babel fish of Douglas Adams.

The practical implication is that inserting one into your ear will result in immediate comprehension of any language.

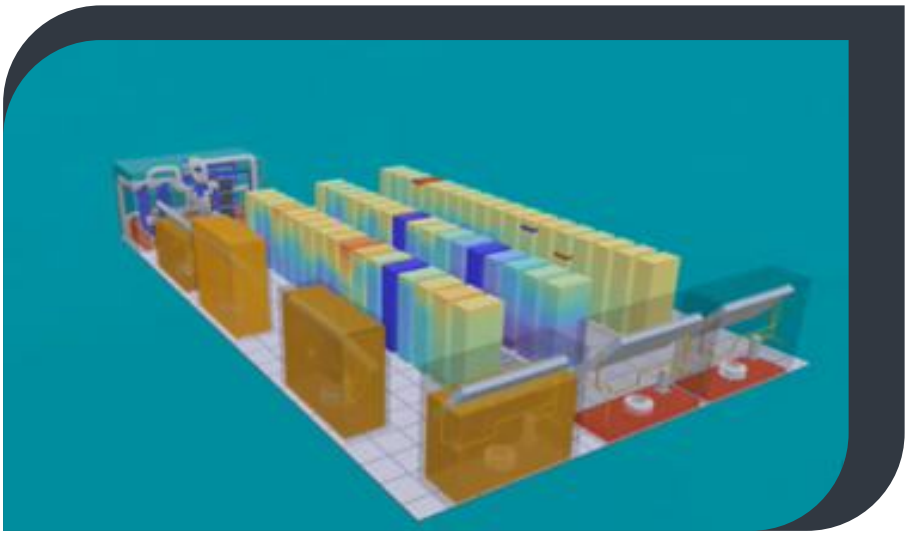
This is the desired functionality of our framework, even if limited to our scope, using digital twins.

ExaMoon

The comprehensive monitoring framework, created in partnership with the University of Bologna (1-4) and named ExaMon, comprises a versatile and expandable platform that can gather 70 GB/day of telemetry data from the entire CINECA datacenter. This data is then integrated with machine learning and artificial intelligence methodologies and resources.

In the realm of Exascale Computing, attaining such elevated performance poses various engineering challenges concerning power consumption, cooling, and reliability.

Model-based optimization is crucial for the design and control of energy-efficient and thermally constrained systems.



[1] An exascale system can execute a quintillion floating point operations per second (flops).

[2] Stream processing involves acting on data as it is generated, assuming it is organized into streams for processing through a series of operations

[3] In-memory computing, or in-memory processing (IMC), stores data in RAM instead of on disk in a database.

In the exascale realm, model learning techniques necessitate the management and analysis of vast data from the HPC monitoring infrastructure. The conventional method of storing and later analyzing the data has become impractical due to elevated expenses and absence of immediate support. Conversely, cloud and edge-based machine learning methods concentrate on constructing models in realtime through approaches like stream processing and in-memory computing, facilitating swift data processing without storage expenses.

By utilizing scalable and lightweight IoT technologies, it is feasible to construct a highly scalable HPC monitoring infrastructure for overseeing sensor data generated by upcoming HPC components.

Within Tecnopolo's maintenance management, the ExaMon framework and the BIM model will serve as the foundation for developing the digital twin of the existing systems, encompassing both the facility and IT aspects. This involves gathering and scrutinizing data, providing a user-friendly management solution, and establishing a unified interface for accessibility.

The digital twin, leveraging machine learning and artificial intelligence methods utilizing data collected and managed by ExaMon, can facilitate tasks like real-time anomaly detection, predictive maintenance, and effective resource and energy management. Due to its scalable and distributed characteristics, it is readily applicable to HPC systems, particularly those of exascale magnitude.

In collaboration with the University of Bologna, a prototype was developed on the Marconi 100 system at the Casalecchio di Reno Data Center. A dashboard was set up to display metrics gathered by ExaMon on a 3D model of the facility. Special "widgets" were utilized for the cooling equipment to visualize real-time data on the 3D object using 3D bars. The height of the bars indicates the heat absorbed, while the color reflects the efficiency based on the COP of the unit. For the computing nodes, temperature or power data can be chromatically displayed for each node individually or in an aggregated manner.

Next step...

In the near future, CINECA will oversee the management of the quantum computer arriving in Italy and housed at the Tecnopolo. Given this fresh challenge, it is evident that energy efficiency and datacenter automation are pivotal goals of CINECA's research and implementation strategy.

1. F. Beneventi, A. Bartolini, C. Cavazzoni, and L. Benini, “Continuous learning of HPC infrastructure models using big data analytics and in-memory processing tools,” in 2017 Design, Automation & Test in Europe Conference & Exhibition (DATE), 2017, pp. 1038–1043.

2. Bartolini, A., Beneventi, F., Borghesi, A., Cesarini, D., Libri, A., Benini, L., & Cavazzoni, C. (2019, August). Paving the way toward energy-aware and automated datacentre. In Proceedings of the 48th International Conference on Parallel Processing: Workshops (pp. 1-8).

3. Borghesi, A., Di Santi, C., Molan, M. et al. M100 ExaData: a data collection campaign on the CINECA’s Marconi100 Tier-0 supercomputer. Sci Data 10, 288 (2023). https://doi.org/10.1038/s41597-023-02174-3

4. A. Borghesi, A. Burrello and A. Bartolini, "ExaMon-X: A Predictive Maintenance Framework for Automatic Monitoring in Industrial IoT Systems," in IEEE Internet of Things Journal, vol. 10, no. 4, pp. 2995-3005, 15 Feb.15, 2023, doi: 10.1109/JIOT.2021.3125885.

Data lakes enhancing critical infrastructure resilience - The PRECINCT case

DATA LAKE | BIG DATA | 3C COORDINATION CENTER | RESILIENCE | DIGITAL TWIN

The PRECINCT[1] project, supported by the EU HORIZON 2020 program, sought to develop a suite of digital tools to enhance the resilience of critical infrastructures in four distinct European cities, establishing a global data-sharing network to raise awareness of infrastructures in handling extreme events.

The city of Bologna has integrated three primary critical infrastructures into a Living Lab (LL): the Metropolitan Area Network of fiber managed by Lepida, the “G. Marconi” airport, and the people mover connecting the airport with the railway station.

Among the digital tools developed for the project, including the Interdependency Graph, Serious Game, Data Mining Tool, and Resilience Index Tool, a Digital Twin (DT) tool was specifically created for LL. It focuses on real-time management of critical infrastructures and enhancing communication resilience among involved parties.

[1] https://www.precinct.info/en/

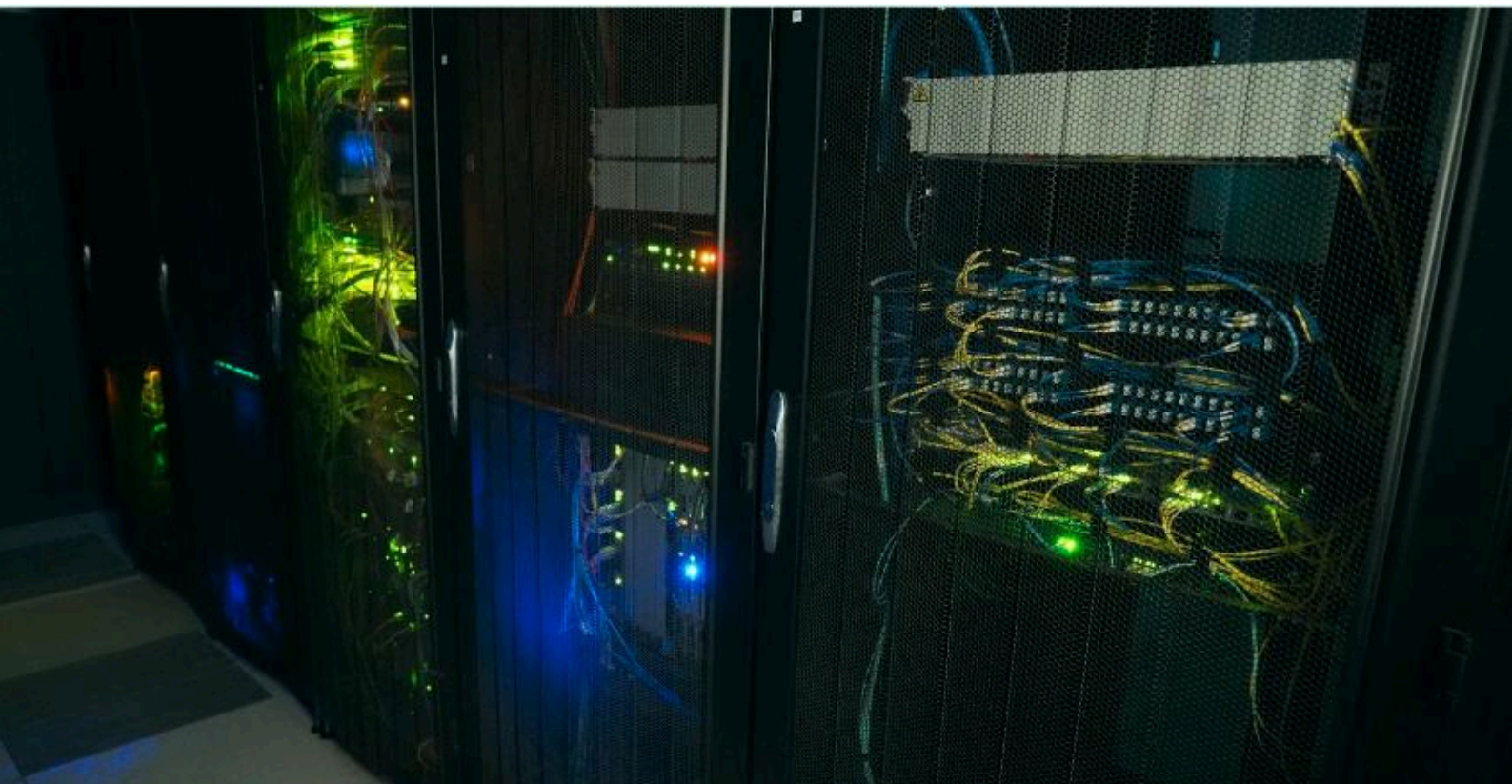
[2] Prevention, detection, response and mitigation of combined physical and cyber threats to critical infrastructure in Europe (europa.eu)

[3] Example of Lepida data definitions for the PRECINCT project: Dashboard.md - Google Drive

Lepida has established an experimental data lake named "Margie" to gather data from various critical infrastructures, enabling the Decision Tree to access historical and real-time data.

- MAN network status monitoring data;
- Airport passenger traffic data (actual);
- MEX passenger traffic data (actual);
- Airport area occupancy data;
- MEX platform occupancy data, identified through the deployment of multiple probes to monitor queue lengths.

All data are gathered anonymously and safeguarded by an NDA. Establishing a data lake enhances resilience in managing data for critical infrastructures by facilitating well-organized handling of big data. The data lake enables the storage of a vast amounts of data, maintainig data in their original state, conducting specific analyses without time constraints, producing predictions, and eliminating the need to relocate data for usage, as it ensures the staying in one centralized location.



The data lake established by Lepida enables real-time feeding of the Digital Twin with data from critical infrastructures while safeguarding against Data Breaches in a centralized storage location. This data lake is backed by a physical data center that optimizes data storage consumption and enhances data resilience through the "Castle Model," which erects digital barriers to safeguard all data within the data lake.

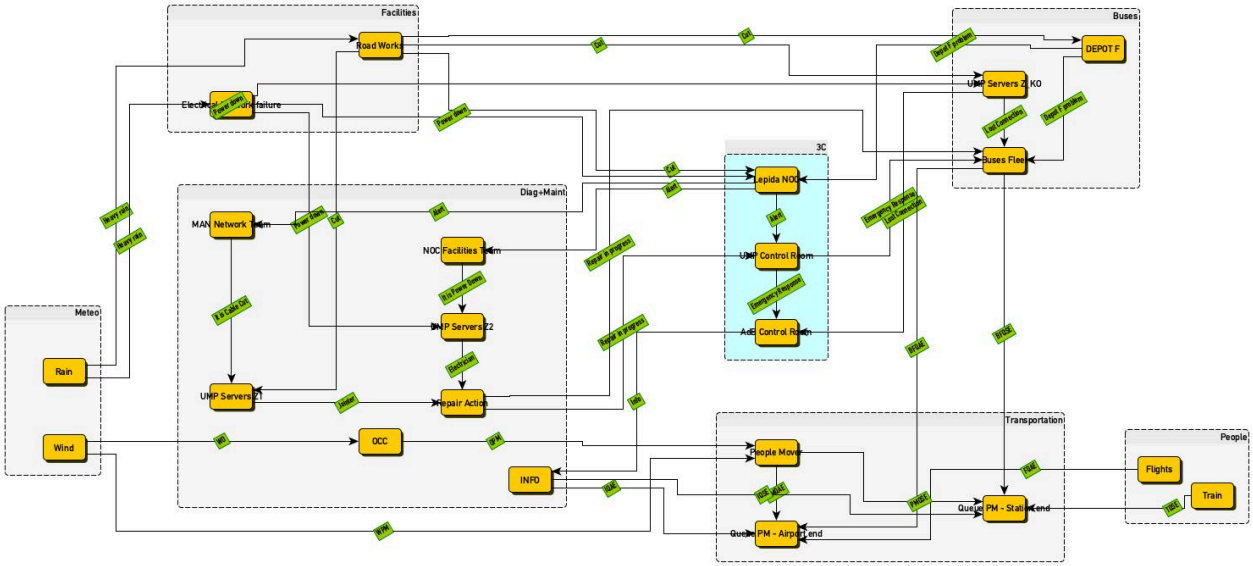
The data lake enables enhanced scalability to incorporate data from additional critical infrastructures beyond those in the LL, facilitating the establishment of a broader network of critical infrastructures. This permits the achievements of both the goal of in depthe scaling within the geographical region of Bologna and the goal of effectively expanding geographically to encompass larger areas.

The concept of enhancing the resilience of critical infrastructures in the LL has been elaborated through the establishment of the Critical Infrastructure Coordination Center (3C). The 3C, initially planned as part of PRECINCT, has been implemented in the LL to facilitate the sharing of data related to critical infrastructures. This initiative aims to improve the promptness of deploying mitigation measures during critical events, thereby enhancing the resilience of key centers.

3C comprises four subjects, each representing a critical infrastructure or a connected service.

- The Lepida Network Operation Center (NOC);
- The Bologna Airport Mobility Manager (to be renamed APOC – Airport Operation Center);
- The control room of the Marconi Express people mover;
- The control room of the local public service provider (Tper).

The envisioned 3C is also a critical infrastructure, currently hosted by Lepida. An information architecture (Information Architecture, modeled after NIST's Business Architecture) was envisioned for the 3C with the purpose of directly managing the sharing of critical infrastructure data between them.



In this way, in addition to ensuring greater data security, since in a single storage location, as Lepida is the provider of the TLC infrastructure for most of the public services, the coordination of rescue or emergency activities would be much faster, since the data can be used to communicate during extreme events, with all the actors involved.

The outlined 3C thus has the main objective of presenting to individual critical infrastructure resilience coordination actors a single point of production and consumption of critical infrastructure data. Its characterization goes beyond the description of a data lake, because it can enable the dynamic creation of data production/consumption flows for critical infrastructure protection, increasing efficiency in the response to extreme events by all actors involved.

PRECINCT's Digital Twin, with the assistance of the data lake and the 3C Coordination Center, has developed a novel tool to establish fundamental components for safeguarding critical infrastructures across the city of Bologna, enhancing its cyber resilience. Physical mobility positively impacts the population in both routine and crisis scenarios.

BEMS in the airport industry: footprint, resiliency, and redundant systems.

Oscar Covato Tekni Post Sales

ENERGY RESLIENCY INTEROPERABILITY SAFETY WARM REDUNDANCY GREENDATACENTER

The case study focuses on intermodal and airport logistics nodes, aiming to develop a plant supervision system enabling real-time monitoring, interaction, and remote management of operational parameters.

The customer's technical team (airport), with whom we have had a longstanding collaboration, recognized the necessity to enhance digitalization in plant management. Familiar with the redundant PLC products we provide for critical infrastructures, they reached out to us to develop an interface dashboard for the plant data of utilities and RACKs in one of their Data Centers.

During the initial 6 months of operation, we developed a BEMS (Building Energy Management System) to oversee various technological systems including HVAC (Heating Ventilation Air Conditioning), Electrical, Fire Safety, Intrusion Security, and Video Surveillance. In the seventh month, we provided training and assistance to the client's personnel to guarantee proper utilization of the platform.

A BEMS platform enables the integration of remote plant management and consumption monitoring for the entire infrastructure. The customer selected the Niagara software platform by HONEYWELL Centraline, which includes the Suite Dashboard Data Center. This solution enables:

- **Intervene on obsolescence and business continuity:** optimizing plant management enables significant reduction of machine downtime and wear on systems.

- **Enhance resilience to critical events:** facilitate plant switches using technology in cases of plant downtime from internal (e.g., breakdowns) and external (e.g., voltage drops) factors.

- **Maintain precise cost control:** by allocating costs to external and internal customers utilizing Data Center services through monitoring individual servers and grouping them by cost center.

- **Avoiding all forms of vulnerability:** by utilizing a system crafted and certified to adhere to stringent cybersecurity protocols, the highest level of security is attained for a non-governmental industrial facility. In this instance, an SL3[1] certification was selected

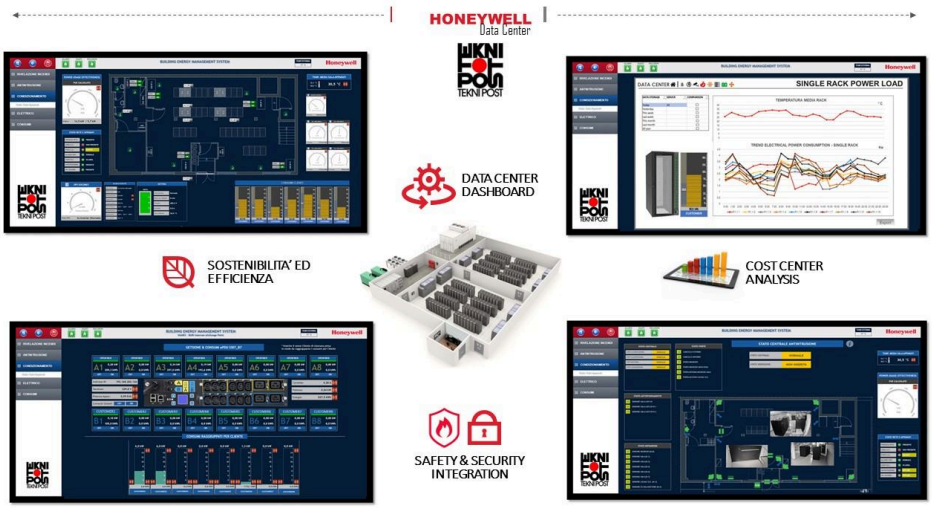
Footprint

The utilization of SAIA BURGESS PLCs in the Hot Standby redundant version, along with their fast calculation speed, enabled the development of a tailored algorithm for establishing a dynamic optimized energy baseline. This baseline is designed to identify the operational logics that guarantee optimal performance of the PLCs supporting the refrigeration system, maximizing the efficiency of both the internal CRAC units and the refrigeration plant.

Machine learning technology supports system logic to evaluate functional trends, enabling timely management of the footprint to define the plant as a "Green Data Center" accurately.

The project involves monitoring each electrical alarm and fully integrating the PDU (Power Distribution Unit) to enable remote server restarts via the On-Off function of the individual power supply. The electrical consumption of each server is monitored, recorded, and aggregated, automatically allocating the cost of the entire Data Center infrastructure.

Customers can customize cost centers to track real-time consumption, daily, monthly, and annually, through intuitive trend visualization and graphs. This feature eliminates manual Excel file management, reducing time spent on low-value tasks and minimizing the risk of human errors.



Resilience Impacts

In the realm of logical security, an SL3 certification level helps guarantee protection against deliberate cyber security breaches created using advanced methods. It is crucial for such systems to possess top-tier certifications to prevent intrusions via vulnerabilities in utility tele-monitoring subsystems

In the realm of physical security, this application ensures superb interoperability by integrating all Safety & Security subsystems that transmit data using standard protocols. Even the supervision of occasional entries involves video analysis with dynamic opening of video streams to notify and engage remote operators effectively.

Within the maintenance sector, a dedicated study was conducted focusing on the operational and uptime patterns of individual electrical and mechanical equipment that can issue predictive maintenance notifications. The assessment was carried out collaboratively with the Facility team, examining potential system malfunction scenarios within the entire Data Center.

The system's most significant impact is associated with the concept of hot redundancy, enabling seamless switches between redundant plant groups through electronic controllers ensuring continuous alignment among the plants.

User Team and Parameters

Thanks to a dynamic interface with user-friendly graphics, the Suite Data Center system is now utilized by all company functions involved in Data Center management: IT Manager, Energy Manager, Facility Manager, and Safety/Security Manager.

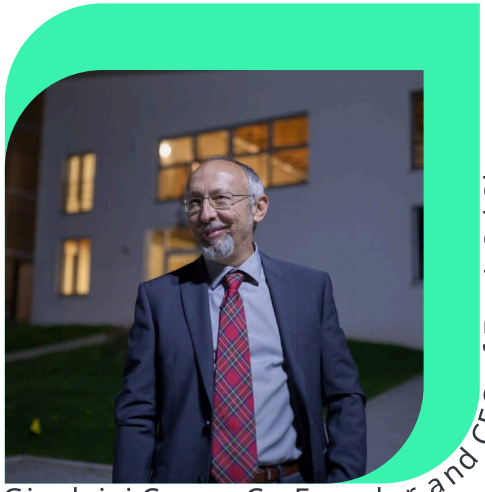
The range of monitored parameters caters to the requirements of all technical roles, encompassing consumption, performance, PUE, available electrical and cooling resources, performance and efficiency analysis, functional statuses of Cooling and UPS, air quality, and dashboards dedicated to the detailed consumption of individual IT devices. Additionally, it includes the seamless integration of smoke detection and fire extinguishing control units with monitoring of dirt levels on the detectors

[1] Security Level 3 as per ANSI ISA IEC 62443

[2] CRAC (Computer Room Air Conditioner) units are sophisticated cooling systems created to regulate the temperature of a Data Center. They continuously monitor the temperature, humidity, and heat distribution parameters across the room.

[3] Uptime: operational availability

Il Progetto 00GATE by Exe.it



Gianluigi Capra, Co-Founder and CEO of Exe.it Srl Sb

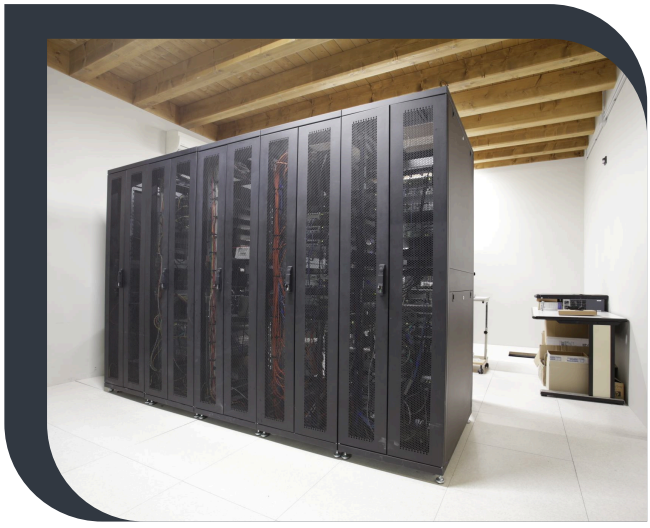
SUSTAINABILITY GREEN DATA CENTER SOLAR ENERGY

Exe.it Srl Sb has consistently prioritized offering prompt, accessible solutions to assist companies in their transition towards more sustainable production and operational practices. Sustainability has always been at the heart of this vision and led, in 2012, to the birth of the 00GATE projec. This innovative Data Center emphasizes sustainability and harnesses solar energy to diminish energy and cooling expenses.

The framework and infrastructure

The inauguration of the new headquarters, which houses the Data Center, took place in 2015. The development of 00GATE is rooted in an eco-conscious methodology that prioritizes power, flexibility, and security. This initiative entailed a substantial financial investment and a thorough reassessment of operational procedures.

The structure consisted solely of wood to reduce heat transfer, featuring a low rack space density and a high operating temperature of approximately 28°C.



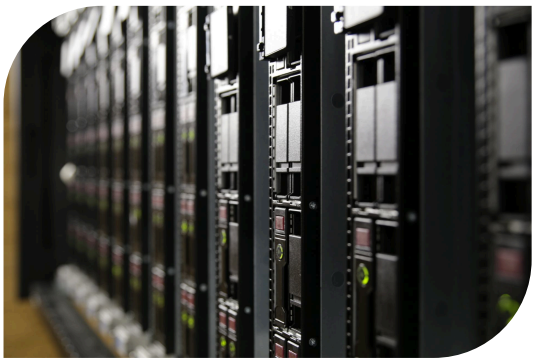
Utilizing Free Cooling for the majority of the year, air conditioning is only utilized for 2 summer months, with a closed-loop water conditioning system in the floors offering supplementary assistance. 75 kW of photovoltaic panels have been integrated into the building, producing approximately 35% of total energy requirements.

The innovative solutions implemented by 00GATE have led to an 80% reduction in air conditioning costs and a decrease of approximately 100 tons of CO2 emissions. This achievement establishes it as the first Data Center in Southern Europe to attain such remarkable results.

Considering the scale of the infrastructure, it is evident that this project is not intended to rival Hyperscale. 00GATE was specifically developed to facilitate rapid technological initiatives necessitating intensive data processing on robust CPUs and GPUs, including artificial intelligence, blockchain, machine learning, IoT, and video computing.

Certifications

The selection of certifications was made to ensure users the transparency and accuracy of the proposed sustainability. It is crucial to be certified by third-party entities so that the commitment to value can be conveyed to the customer.



00GATE has acquired the Certification of Electricity Origin from TÜV, with the assistance of its exclusive provider Repower, for its energy provision and from Bioagricert for zero emissions due to the utilization of self-generated solar energy and sources that are not only generally renewable but also devoid of any combustion (such as wind energy from Repower's Lucera Wind Farm in 2023, alongside our self-sufficiency).

These certifications supplement the ISO9001 and ISO27001 standards, validating the existence of quality management and information security systems.

The company has also chosen to qualify as an innovative SME and has recently joined the European Code of Conduct for Data Centres (EU DC CoC), the EU code of conduct on energy efficiency in data centres. A crucial part of its dedication involves allocating a significant portion of its financial earnings to research and development, as an innovative SME, thereby facilitating the ongoing delivery of state-of-the-art, secure, and zeroemission services.

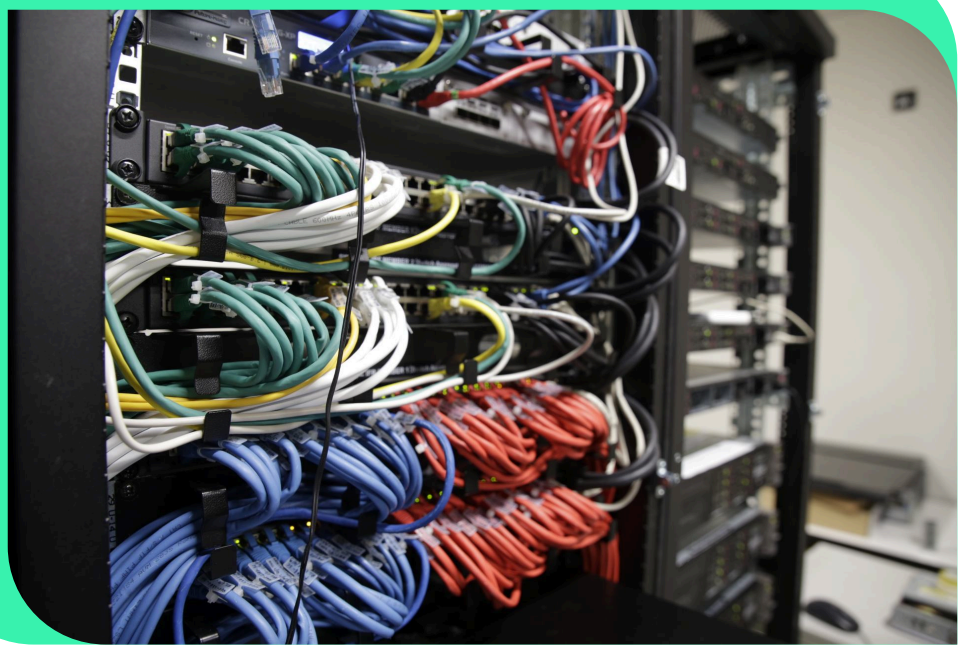
In order to engage and deliver value to end customers, whether companies or individuals, a decision was made to offer a certification directly to the customers themselves: by hosting their servers and data in a Green Data Center like this one, they can acquire the "GREEN CLOUD CERTIFIED®" certification, distinguished by a specific number, provided by the Green Cloud Consortium. This consortium is dedicated to advocating for the implementation of more environmentally friendly solutions. This approach not only raises awareness among customers and engages them in the ethos of sustainable digital evolution but also enables them to showcase their proactive involvement in environmental initiatives to external parties.

Sustainability, not merely technological

Since 2016, Exe has transitioned into a Benefit Corporation/BCorp, strengthening its dedication to inclusivity and ethical business practices. The organizational ethos prioritizes sustainability, particularly concerning individuals, and thus fosters employee welfare by providing specialized internal amenities like a gym for use during breaks, a vegetable garden watered by rain, a music room, and various communal areas.

Partnership

Addressing the challenges of the circular economy in the data center requires establishing strategic collaborations with partners specialized in the reuse and reconditioning of electronic and IT devices. This synergy significantly reduces waste sent to landfills and extends the useful life of these devices, providing tangible benefits to educational institutions and non-profit organizations.



High Efficiency Cooling Systems' Impact on LEED Platinum Certifications: The ECMWF Case

Michele Toni Senior site engineer di ECMWF

SUSTAINABILITY

INDUSTRIAL COOLING

One of the goals of the Data Centre project was to construct buildings with a high energy class, able to meet not only legal requirements but also the quality standards of the voluntary energy certification of the LEED America protocol.

Due to the energy-intensive characteristics of a supercomputing data center, it was crucial to devise highly efficient solutions to reduce energy consumption, environmental impact, and operational expenses.

The objective of this paper is to offer an overview of how this translated into the design and implementation of the cooling system.

The project

The implementation of the LEED system as a design tool resulted in the subsequent solutions.

- Three cooling sources: refrigeration units, dry coolers, geothermal wells
- High-efficiency mechanical systems
- Photovoltaic system of around 352 kW
- Rainwater collection and reuse
- Integration and monitoring of systems in a unified tool
- Automated adjustment of internal comfort using natural lighting, humidity, temperatures, and CO^2 levels
- Material selection based on recycled content percentage and low emissions of VOCs and other pollutants.

The Data Centre has achieved the highest level of certification (Platinum) for design and construction (LEED v4 BD&C).

The thermal burden

The thermal load of IT equipment, ranging from 5 to 5.5 MW, can be categorized into 4 primary groups:

- Supercomputing servers (high power density, directly liquid-cooled);
- Auxiliary supercomputing systems (medium-high power density, air-cooled and with liquid cooling doors);
- Network and disk equipment (medium power density, air-cooled);
- Magnetic tape libraries (low power density, high sensitivity to temperature and humidity);

Water is the carrier fluid utilized for heat dissipation, directly for supercomputing and cooling doors, and exchanged with air through the CRAH (Computer Room Air Handler) units for other devices.

To reduce cooling needs, room temperatures are adjusted near the maximum temperatures recommended by IT component manufacturers and ASHRAE guidelines.

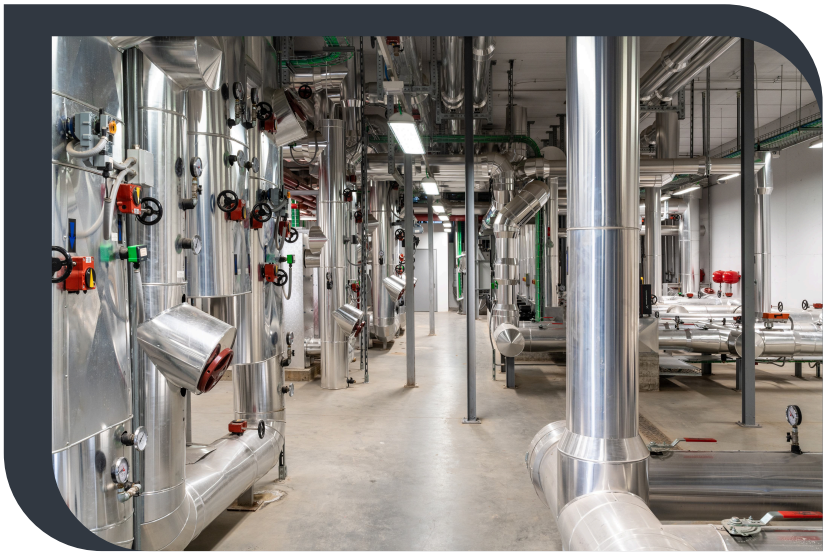
The cooling mechanism

As predicted earlier, two additional sources, dry coolers and geothermal wells, have been incorporated into the conventional refrigeration units to generate chilled water. These three systems operate sequentially, with energy consumption priorities in reverse order. Their functioning is controlled by software that adjusts based on external temperatures and the current thermal load to optimize performance under all conditions.

The primary source consists of dry coolers that sustain the full load during the cold season.

As outdoor temperatures increase, adiabatic panels are added to dry coolers to expand their usability.

This approach enables supercomputing servers to be cooled primarily by dry coolers year-round.



For different loads necessitating lower temperatures, the implementation of geothermal wells will be phased in gradually, adhering to imposed restrictions to avoid substantial changes to aquifer conditions. Chillers will only be utilized on the hottest days.

Some of the heat produced by the IT equipment is utilized to warm the office spaces. Additionally, a project is underway to explore district heating for external users.

Industrial symbiosis paths for waste heat reuse

Valentina Fantin is a researcher at ENEA LEA laboratory.

INDUSTRIAL SYMBIOSIS | SYMBIOSIS FRAMEWORK | RESOURCES VALORISATION

The best practice concerns the implementation of industrial symbiosis pathways, by means of methods developed by ENEA, for reusing waste heat from data centres cooling systems, in alignment with technologies proposed in this document by the consortium RSE-CINECAUNIBO-LEAP-POLIMI. The application of these methods is preparatory for heat recovery and heat exchange projects proposed by the consortium.Industrial symbiosis involves the exchange of resources among two or more distinct industries, including both materials (such as by-products or waste) and energy, services and expertise. Industrial symbiosis[1] allows companies to achieve economic and environmental advantages by waste reduction and primary resources conservation.

Overall, it enables companies to obtain win-win solutions where all stakeholders can profit from collaborative interactions. Moreover, from a holistic point of view, , it is an essential instrument to both guarantee a more efficient resources use in industrial areas and to stimulate territorial and economic competitiveness.

ENEA is involved in several national and international projects (Figure 1) aimed to propose and develop industrial symbiosis pathways, which . have involved several local/regional/national companies. ENEA has also developed specific tools to support and facilitate the adoption of industrial symbiosis pathways within companies, such, for example, a methodology to engage companies, an industrial symbiosis platform (www.industrialsymbiosis.it) for resource matching, and the Italian Industrial Symbiosis Network - SUN (www.sunetwork.it) for exchanging and promoting experiences and projects of industrial symbiosis.

[1] Cecchin, A., Salomone, R., Deutz, P., Raggi, A., Cutaia, L., 2020. Relating Industrial Symbiosis and Circular Economy to the Sustainable Development Debate. In: Salomone, R., Cecchin, A., Deutz, P., Raggi, A., Cutaia, L. (eds) Industrial Symbiosis for the Circular Economy. Strategies for Sustainability. Springer, Cham. https://doi.org/10.1007/978-3-030-36660-5_1

Figure 1. ENEA's Industrial Symbiosis Projects

The ENEA[2] methodology, primarily addressed to companies, consists of three phases. The initial fact-finding phase includes an analysis of the territorial context and its productive sectors, and finally the development of a geo-referenced company database which maps the territory production activities. In the second step, companies are selected and invited to participate in operational workshops. These workshops are round tables (Figure 2), aimed to exchange resource supply and demand and involve the filling in of input-output technical sheets prepared by ENEA, followed by an initial identification of potential synergies among companies.

Afterwards, the collecteddata are uploaded on the symbiosis platform to identify specific industrial symbiosis paths for companies. In this phase regulations, technical standards, administrative obligations and profitability of proposed actions are examined in detail, and then summarized in a first draft of the operating manuals.

The third phase includes consultations among different stakeholders to discuss feasibility, critical issues and potential developments about the implementation of the identified industrial symbiosis pathways. During this step, meetings are organised with trade associations, local authorities and other institutional bodies to debate issues outlined in the manuals and, if needed, update their contents. The observations are then included in the manuals, which are finalized and distributed to the companies.

[2] Cutaia L., Luciano A., Barberio G., Sbaffoni S., Mancuso E., Scagliarino C., La Monica M., 2015. The experience of the first Industrial Symbiosis Platform In Italy. Environmental Engineering and Management Journal. July 2015, Vol.14, No. 7, 1521-1533.

Figure 2. Illustration of operational tables in industrial symbiosis.

The industrial symbiosis platform "Symbiosis" (Figure 3) is a tool for companies and other territorial operators to exchangeresources supply and demand and facilitate their transfer among companies. Its primary goal is to identify and connect companies and operators, according to industrial symbiosis principles.

Figure 3. Industrial Symbiosis Platform

The platform operates through a web interface (www.industrialsymbiosis.it), which enables registered users to geo-reference their organization; to enter and update data about their production site; to input, update, and manage resources by adding input/output sheets; to share resources; to explore potential synergies within the network.

The methodology developed by ENEA can be effectively used to organise round tables with businesses and local organizations to identify potential reuse and recovery of heat from data centres. It also helps to identify possible beneficiaries of this energy flow, aiming to valorise its utilization.

The data collected from the round tables can be uploaded on the Symbiosis Platform, allowing registered users to share and explore further potential symbiosis opportunities. Operating manuals will provide a detailed summary of regulations, technologies, benefits and economic advantages of the identified symbiosis pathways.

Examples of heat recovery from industrial symbiosis pathways include those of the CAP Group, which manages the integrated water service of the Metropolitan City of Milan, and the eco-industrial park of Kalundborg (Denmark), the first example of industrial symbiosis on a worldwide scale.

The CAP Group, with the industrial symbiosis project BioPiattaforma, aims to convert current facilities, including a waste-to-energy plant and a wastewater treatment plant, into a carbon neutral bioplatform focused on circular economy. This bioplatform will handle sludge from water treatment and wet waste to produce heat for district heating, fertilizer and biomethane. Specifically, the sludge processing line will utilize 14,100 tons/year of sludge from CAP Group's wastewater treatment plants, producing 11,120 MWh/year of heat for district heating.

Kalundborg Symbiosis has developed a heat pump system to exploit the waste heat from wastewater, which is then used for town district heating. The wastewater treatment plant in Kalundborg receives around 6 million cubic meters of wastewater annually; the treated wastewater have an average temperature of 24-25 degrees. By a heat exchanger, the wastewater is directed to a heat pump that, powered by electricity, captures the energy and elevates the temperature to 72-87 degrees.

Lowering the wastewater temperature by 10 degrees can produce around 80,000 MWh of heat for district heating, meeting over 30% of city's requirements.

[3] CAP Group, 2021. Industrial Symbiosis Contribution and Potential for Transition. Ecological. Ecomondo 2021.

[4] https://www.symbiosis.dk/en/2022/01/11/gron-energi/

Seasonal heat recovery and storage systems for data center waste heat

Alberto Sogni EU&Industrial Proposal Manager di RSE SpA.

Additional partners involved in this case study proposal include CINECA and CIRI FRAME. University of Bologna, LEAP s.c.a r.l., Polytechnic University of Milan – Piacenza Territorial Campus.

TES - THERMAL ENERGY STORAGE

HEAT PUMPS

WASTE HEAT REUTILIZATION

One area of interest involves the utilization of waste heat generated by extensive data centers via their cooling systems.

A report by the IEA (International Energy Agency) stated that in 2022, data centers globally consumed between 1 and 1.3% of total electricity usage, excluding the cryptocurrency mining industry.

Given that nearly all of this electrical energy converts to heat, this equates to about 6% of the thermal energy demand for district heating (data from 20142).

Despite ongoing enhancements in efficiency, the International Energy Agency (IEA) has documented a 20-40% yearly rise in energy demand within the data center sector due to the escalating workloads in sizable data centers.

This trend appears to be confirmed in short-term predictions, with more uncertainties arising in the long term. The actual potential for recovering waste heat from data centers relies on technical-economic evaluations to be carried out on an individual basis. In some instances, estimates suggest that recoverable heat may exceed two-thirds of the total production in certain case studies. This image depicts a significant potential for interest, particularly in terms of efficient energy resource utilization and thermal waste management.

[1] IEA (2023), Data Centres and Data Transmission Networks, IEA, Paris https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

[2] Recommendation Paper - From Data Centres to District Heating & Cooling: Boosting waste heat recovery to support decarbonization - https://www.codema.ie/publications (Codema - Dublin's Energy Agency).

[3] Huang et al., A review of data centers as prosumers in district energy systems: Renewable energy integration and waste heat reuse for district heating, Applied Energy 258 (2020) 114109.

The primary opportunities for utilizing this waste heat are:

- District heating networks;
- Heating of nearby civil and/or agro-industrial users;
- Heating of buildings within the same data center;
- Heating of buildings within the same data center;

In many instances, a primary challenge to address is the temporal misalignment between the consistent availability of heat from data centers and the concentrated demand profile of potential users, which is typically influenced by various factors, beginning with weather conditions, climatic and specific requirements or behaviors.

This challenge can be addressed by implementing heat storage systems, even across seasonal periods (up to 6 months), which necessitate technical-economic research and development for practical application and integration with data centers, including field experimentation.

Another technical consideration is ensuring alignment between the temperature of the heat source and the operating conditions.

Heat pumps represent a solution that enables the recovery of waste heat in an energyefficient manner by raising its temperatures to the required levels for the user, utilizing various technologies and system configurations.

[4] Utilization of Waste Heat in the Data Center - A white paper by NeRZ in collaboration with eco – Association of the Internet Industry - https://international.eco.de/topics/datacenter/white-paper-utilization-of-waste-heat-in-the-data-center/

[5] Li et al., Energy, economic, and environmental analysis of integration of thermal energy storage into district heating systems using waste heat from data centres, Energy 219 (2021) 119582.

In conclusion, the subjects of interest we aim to explore in a case study are:

- Systems designed to recover waste heat from data centers, focusing on liquid cooling technologies such as two-phase liquid cooling and on-chip liquid cooling, are highly efficient (Power Usage Effectiveness - PUE <1.1) and offer significant potential for utilizing waste heat. This enables the availability of waste heat at higher temperatures compared to air systems (45-60 °C).

- Innovative heat upgrading systems, such as absorption, adsorption, or compression heat pumps with optimized thermodynamic cycles and/or innovative, low environmental impact working fluids.

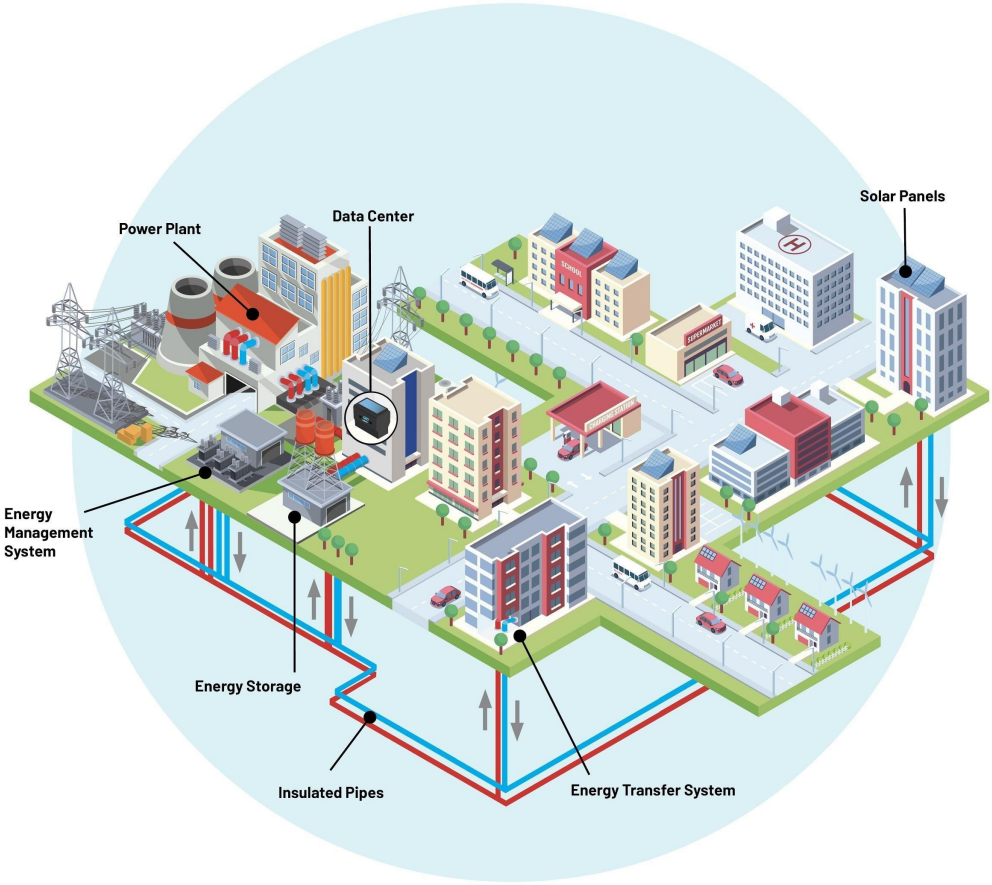
- Seasonal thermal energy storage systems, primarily relying on geological storage methods, involve the transfer of heat into the ground, utilizing appropriate geological structures and favorable hydrogeological circumstances (BTES-Borehole Thermal Energy Storage, ATES-Aquifer TES, PTES-). Utilizing thermal energy storage (TES), etc., to address the temporal misalignment between heat supply and demand.

- Design, integration, management, and optimal control of the technological solutions mentioned above (including any connection with district heating networks), utilizing numerical optimization methods and techniques based on advanced automation, digitalization, and artificial intelligence.

With this case study proposal, we aim to analyze the full-scale development of the technological solutions mentioned above from a modeling perspective. Subsequently, with suitable funding sources, we plan to test them on a pilot and demonstration scale. Our primary reference point will be the data center of Tecnopolo di Bologna Ex Manifattura Tabacchi, specifically focusing on the supercomputer "Leonardo."

The involved organizations have already taken steps in this regard by engaging in European project initiatives related to these matters, with Tecnopolo being featured as a case study. Additionally, they are actively exploring optimal financing options.

Figure 1 illustrates a schematic of a Data Center heat recovery and storage system integrated into the city's energy system https://www.datacenterknowledge.com/industry-perspectives/submer-when-datacenters-really-start-make-sense



Contributors to this work: Elisa Alberti (CINECA), Marco Pellegrini and Francesco Tinti (CIRI FRAME – University of Bologna), Matteo Zatti (LEAP), Manuele Gatti (Polytechnic of Milan)

Business Continuity Management System (BCMS)

Gisella Santandrea B. Continuity e Crisis Management di CRIF

RESILIENCE | STRATEGY | PROCESS SUSTAINABILITY

Established in Bologna in 1988, CRIF is now a worldwide company that specializes in credit and business information systems. It oversees the management and dissemination of information to the financial market and individual enterprises. Safeguarding information and ensuring consistent service levels are pivotal concerns for CRIF, serving as crucial prerequisites for its operations.

For years, CRIF has developed a Business Continuity Management System (BCMS) that considers the continuity requirements of the services offered and formalizes, at strategic, tactical, and organizational levels, the criteria for addressing events that could lead to service interruptions.

The system, developed based on the principles of the ISO 22301 standard and with consistent alignment with the guidelines of the Bank of Italy, addresses various impact scenarios - No Building, No People, No Technology, No Outsourcer - and establishes distinct strategies for restoring operations. It implements varied solutions depending on the location and service affected by the incident. Over time, these solutions have advanced, not only technologically but also in terms of processes, significantly minimizing the organization's impact.

NO BUILDING Scenario: Critical processes being unable to take place for over 48 hours due to the absence of buildings.

The strategies implemented for the No Building scenario initially planned for the relocation of individuals engaged in critical tasks to an alternate corporate building. To guarantee their availability during emergencies, vacant workstations were maintained in each building.

The outcomes of regular assessments and the practical lessons from the Covid-19 pandemic in recent times have prompted us to discard this approach and embrace remote work as the sole remedy for reinstating all essential operations. This shift eliminates the necessity of upkeeping idle spaces and minimizes staff commuting to alternate work sites, streamlining operations. Additionally, it reduces the downtime for resuming activities by obviating the need to set up new workstations, as virtual workstations are already in place, ensuring functionality and efficiency.

NO PEOPLE Scenario: 70% of resources are allocated to critical processes being unavailable for over 48 hours.

Regarding the scenario where there are no people involved, the initially identified strategy resulted in the creation of a "succession plan" outlining backups for the essential individuals responsible for critical processes. Additionally, a periodic training plan was established to ensure their continuous development.

This solution quickly became challenging to handle and unsuitable for a dynamic environment like CRIF's. Backups often found themselves performing tasks they were acquainted with but not accustomed to, utilizing tools that differed from their daily ones. In the best scenarios, they lacked valid authorizations due to irregular usage.

In this manner, the downtime of processes could be considerably prolonged, jeopardizing adherence to the Recovery Time Objectives (RTOs) established with clients. The RTO, denoting the duration necessary for full restoration of a system or organizational process, stands as a pivotal metric in assessing the effectiveness and efficacy of a Business Continuity Management System. When feasible, an alternate approach was adopted, entailing the establishment of diverse teams situated in various geographic regions. These teams collaborate on tools and protocols and can perform identical tasks when needed.

During a crisis, the staff is already operational, familiar with the necessary tools, and prepared to utilize them. Alignment requirements are minimized to pending tasks for the backup teams to handle.

Document Management and Business Continuity

Even at the documentary level, efforts have been undertaken to mitigate the environmental and social impacts on the organization.

The various documents created to uphold the Business Continuity Management System, ensuring that the established procedures remain accessible, familiar, and implemented by all relevant parties, have undergone multiple revisions and streamlined over time to consolidate into a single document for each specific role (Crisis Coordinator, Service Owner, BC Support Group, etc.). These documents feature concise and structured content, providing clear guidance to individuals through crisis scenarios, necessary tasks, and required contacts, supported by straightforward workflows.

Documents are consistently accessible in digital form on the company intranet, reachable from any mobile device, yet conveniently savable for personal access, ensuring readiness for immediate utilization when necessary. This substantial managerial dedication ensures an adaptable and efficient structure, poised to respond promptly to safeguard the services and business of our clientele.

Integrated Facility Management

Anna Lisa Infante Services Planning Tech Rekeep

PEOPLE

FACILITY MANAGEMENT

OPERATION MANAGEMENT

RISK MANAGEMENT

Facility Management firms such as Rekeep, which undertake specific actions affecting both the energy and resilience aspects of a Data Center, possess key factors enabling top-tier performance.

In terms of energy impact, the primary factor guiding this is PUE (Power Usage Effectiveness), which is the ratio of energy utilized by the entire system to that consumed solely by the IT components, ideally approaching 1 in optimal conditions.

In the PUE, a substantial portion of energy consumption comes from cooling technological equipment continuously. This is achieved through ongoing monitoring facilitated by on-site sensors, BMS software, and operators who assess the building's performance using dedicated checklists.

The fusion of conventional and digitalized operations, such as Operations Management, ensures seamless business continuity and optimal system conditions to maximize energy efficiency. A facility manager's responsibility is to ensure peak performance, irrespective of the technological decisions made during the system's initial setup that Rekeep oversees.

Our expertise in resilience has been developed through the management of numerous critical infrastructures, such as hospitals and government agencies. We have established protocols that must be meticulously adhered to, even during emergency scenarios like earthquakes, pandemics, and floods.

The deployment of IT services should be preceded by a precise Risk Management analysis (UNI 11230:2007), focused on categorizing, preventing, or reducing all barriers that impede the accomplishment of a goal, whether strategic, operational, productive, security-related, or economic, following a "risk opportunity" approach rather than "risk mitigation."

In Rekeep, we have detailed Maintenance Operation Procedures (MOPs) that provide step-bystep guidance for our maintenance staff. These procedures aim to accurately outline each operation, including descriptions of steps, necessary tools, materials, and personal protective equipment (PPE). The goal is to ensure that each task is executed with minimal errors and risks of accidents.

With extensive experience, Rekeep has identified that incidents can be categorized into two groups: inadequate MOP details or insufficient professional readiness of operators. Therefore, it is crucial for Data Center service delivery to enhance the quality of human resources possessing specialized skills from both technical and interpersonal perspectives.

At a technical level, a multi-specialized organizational model is implemented, incorporating various integrated professional skills, proficient in diverse system types. Examples of this include certification for live electrical interventions PES according to CEI 11-27 and the F-gas license.

Operator training encompasses safety courses, high-risk fire prevention, and BLSD (Basic Life Support Defibrillation) certification to mitigate the risk of electrocution in settings like Data Centers.

Specific training at a relational level equips resources to handle critical situations with clarity and firmness, along with daily operations, by leveraging soft skills.

Organizing supervision and rotation activities requires implementing a redundancy logic to address potential absences.

This concept, commonly found in IT environments at the plant level (consider all backup systems at the electrical energy level), is integrated into the configuration of Maintenance Plans, established using the "Resolve" Platform.

Utilizing sophisticated BI and Failure Mode, Effects, and Criticality Analysis (FMECA) tools, the maintenance system is steered towards a proactive and anticipatory model, as opposed to a reactive one. The Maintenance Plan integrates an initial risk assessment model, assigning a corresponding level of risk to each maintenance task. Below is a snippet from the Maintenance Plan of a managed Datacenter.

FREQUENZA	COMPONENTE	GENNAIO				FEBBRAIO				MARZO				APRILE				MAGGIO				GRADO DI RISCHIO
		1a	2a	3a	4a	1a	2a	3a	4a	1a	2a	3a	4a	1a	2a	3a	4a	1a	2a	3a	4a	
		1-6	7-13	14-20	21-31	1-10	11-17	18-24	25-28	1-10	11-17	18-24	25-31	1-7	8-14	15-21	22-30	1-12	13-19	20-26	27-31	
GRUPPO FRIGORIFERO																						
Giornaliera	Attività di manutenzione/verifica GF Giornaliera	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	0
Mensile	Attività di manutenzione GF Mensile				X				X				X		X						X	0
Bimestrale	Attività di manutenzione GF Bimestrale								X								X					0
Semestrale	Attività di manutenzione GF Semestrale																					1
Annuale	Attività di manutenzione GF Annuale																					1
CENTRALE FRIGO																						
Giornaliera	Scheda giornaliera di controllo Pompe ed Organi di Tenuta	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	0
Mensile	Attività di manutenzione Mensile			X				X				X					X		X	X		0
Bimestrale	Sistema Filtrante,Valvole, inversione pompe							X								X						1
Semestrale	Attività di manutenzione Semestrale																					1
UTA																						
Mensile	Attività di manutenzione Mensile			X				X				X					X	X				0
Bimestrale	Attività di manutenzione Bimestrale							X									X					1
Semestrale	Attività di manutenzione Semestrale																	X				1
CABINA DI SMISTAMENTO A/C																						
Mensile	Attività di manutenzione MT Mensile				X				X				X				X		X	X		0
Trimestrale	Simulazione Mancanza Rete Cabina MT Trimestrale												X									2
Annuale	Attività di manutenzione MT Annuale																					3
CABINA ELETTRICA 1																						
Giornaliera	Controllo e rilievo temperature trafo	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	0
Mensile	Attività di manutenzione MT Mensile				X				X				X				X		X	X		0
Trimestrale	Simulazione Mancanza Rete Cabina MT Trimestrale												X									2
Annuale	Attività di manutenzione MT Annuale																					3
GRUPPO ELETTROGENO DI EMERGENZA N° 1																						
Settimanale	Attività di controllo e manutenzione GE Settimanale	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	0
Trimestrale	Attività di controllo e manutenzione GE Trimestrale												X									2
Semestrale	Attività di controllo e manutenzione GE Semestrale																		X		X	2
Annuale	Attività di controllo e manutenzione GE Annuale																	X				1
DISTRIBUZIONE ELETTRICA SALA																						
Semestrale	Attività di controllo e manutenzione QEDE Semestrale														X							1
CDZ A SERVIZIO SALA 1																						
Giornaliera	Verifiche su CDZ Sale Dati	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	0
Mensile	Attività di controllo e manutenzione CDZ Mensile	X				X				X				X						X		1
Bimestrale	Attività di controllo e manutenzione CDZ Bimestrale					X								X								1
Semestrale	Attività di controllo e manutenzione CDZ Semestrale																				X	1

GRADO DI RISCHIO	CRITERIO DI ASSEGNAZIONE	ESEMPIO	TEMPO DI PRE AVVISO E RICHIESTA AUTORIZZAZIONE
0	Rientrano in questa categoria tutte le attività che non comportano interazione con le apparecchiature critiche del Datacenter	Controlli di tipo visivo, manutenzioni per le quali non è necessitano mettere fuori servizio componenti di impianto	Nessun preavviso/nessuna richiesta di autorizzazione del Cliente.
1	**PERDITA DI RESILIENZA** Rientrano in questa categoria tutte le attività che prevedono di mettere fuori servizio una delle componenti di impianto senza che si raggiunga il numero critico sotto il quale un eventuale guasto non possa essere più tollerato.	Manutenzione di un chiller dove sono presenti 4 unità e il numero minimo di macchine necessario è 2	Nessun preavviso/nessuna richiesta di autorizzazione del Cliente.
2	**PERDITA DI RIDODANZA** Rientrano in questa categoria tutte le attività che prevedono di mettere fuori servizio una componente di impianto raggiungendo il numero minimo di unità sottto la quale il guasto non è più tollerato.	Manutenzione di un chiller dove sono presenti 2 unità e l'eventuale guasto dell'unità rimanente comporta di dare disservizio	**NECESSARIA AUTORIZZAZIONE DEL CLIENTE** Preavviso di almeno 10 giorni con invio della documentazione necessaria al Cliente.
3	**PERDITA DI RIDODANZA CON POSSIBILE IMPATTO DIRETTO SUL CARICO IT** Rientrano in questa categoria tutte le attività che prevedono di mettere fuori servizio una componente di impianto direttamente impattante sul carico IT	Manutenzione di un UPS che prevede di alimentare il carico IT direttamente da rete	**NECESSARIA AUTORIZZAZIONE** Preavviso di almeno 15 giorni con invio della documentazione necessaria al Cliente.

The objective is consistently to minimize discrepancies between planned and implemented actions, aligning with the provisions of the Integrated System of Quality, Energy, Environment, and Safety to reduce errors and time wastage (e.g. redundant actions) and materials. Every task is structured by evaluating the consequent consumption, conducting a life cycle assessment for all utilized equipment.

An Integrated Facility Management company aiming for high performance in data centers for critical infrastructures must consider the broader impact on the entire territory. This includes ensuring comfort and usability for users while also promoting environmental sustainability.

Dall’High Throughput Computing all’Hight Performance Computing

Luigi Benedetto Scarponi Facility manager at INFN data center

HPC | POWER | DIRECT LIQUID COOLING

The CNAF Data Center

The Tier-1 Data Center was established at CNAF, the INFN's computing and data center, offering computing and storage resources and services to over 40 scientific collaborations (data from 2022) involving the INFN, as well as various scientific communities, applications, and industrial research collaborations with active research agreements.

The Data Center currently operates as an HTC (High Throughput Computing) system, housing around 60,000 computing cores spread across roughly 5,000 servers. It boasts a fast storage capacity of 50PByte online on disk and a long-term archive system of about 130PByte on tape. It stands as one of the 10 Tier-1 centers globally within the WLCG (Worldwide LHC Computing Grid) for managing and analysing data from the LHC experiments.

Approximately 30% of the data center's computing resources are allocated to astroparticle experiments such as VIRGO/Ligo, AMS, CTA, DARKSIDE, KM3NeT, JUNO, EUCLID, and others. CNAF is also engaged in diverse research, development, and innovation initiatives related to distributed computing and emerging information and data networking technologies at national and international levels, in partnership with ICT firms and public authorities.

It is crucial to highlight the Ministry of Health project, Health Big Data, spanning a decade, and the ACC association, Alliance Against Cancer, with the INFN Data Center serving as the technology provider.

Regarding collaborations with companies and technology transfer activities, the coordination of activities in the Emilia-Romagna Region is carried out by the HTN network laboratory, INFN-TTlab, which brings together the industrial research activities of the three INFN sites in the region along with CNAF, the Bologna section, and the Ferrara section.

The growth projections for the resources deployed at the Data Center anticipate a steady annual increase of approximately 15-20% until 2027, followed by a minimum tenfold increase. Additionally, beginning this year, the CNAF data center will accommodate a portion of the resources from ICSC (Italian Center for Super Computing), the newly established National Center for Big Data, HPC, and Quantum Computing, as well as the TERABIT project, a Research Infrastructure supported by the PNRR.

Flexibility and growth

The existing Data Center, constructed in 2009, was planned to provide 1.2 MW of electrical power for computing equipment. The data center's architecture is extremely robust, with a requirement to maintain a 99.9% availability for LHC collaborations.

With the necessity to enhance computing and storage capabilities in the mentioned collaborations significantly beyond current levels, starting from 2020, the INFN, in partnership with CINECA, has undertaken the development of a new data center at the Tecnopolo di Bologna located at the Ex Manifattura Tabacchi in Bologna. This initiative aims to provide ample computing and storage resources to meet demands for the upcoming decade.

The upcoming data center will be situated in a designated area. The technological infrastructure (shared with Cineca) for power provision and cooling will enable the INFN area to accommodate, initially (until 2026), resources consuming up to 3 MW of electricity, with a subsequent increase, in the following phase, to 10 MW. The INFN space offers a functional area exceeding 2000 m2, with a portion (500 m2) reserved for potential future growth.

Power and Durability

The existing computing facility at the University of Bologna, Department of Physics and Astronomy, situated at Viale Berti Pichat 6/2, is designed to support IT equipment consuming 1.2 MW of electrical power.

It covers a total area of around 2000 m 2 of which 600 m 2 allocated to IT equipment and 1400 m 2 to electrical and mechanical systems which include: a medium-voltage delivery cabin (15 kV), a transformation cabin housing 3 transformers of 2500 kVA each in a 2+1 redundancy configuration, the room for continuity groups with two diesel rotary uninterruptible power supply (DRUPS) with capacity of 1700 kVA each, the main power plant room and the refrigeration system.

The refrigeration system comprises six 300 kW refrigeration units with N+2 redundancy.

The data center is powered by two different power lines which provide a dual source of power supply for all IT equipment.

There is additionally a remote control and monitoring system that can be used to intervene remotely and ensure maximum reliability.

The system design logic prioritizes maximum resilience and fault tolerance to achieve optimal uptime.

INFN Data Center located at the Tecnopolo Manifattura in Bologna.

The INFN Data Center is scheduled to relocate to the Tecnopolo Manifattura in Bologna in December 2023, where it will feature shared technological systems with CINECA.

All electrical and mechanical systems are designed with 3+1 redundancy.

It is important to emphasize that the refrigeration plants will supply two circuits operating at different temperatures.

- Chilled water production with operational temperatures 19-26 °C for “traditional” air cooling computer equipment
- Tempered water production with operational temperatures 37-47 °C to allow the installation of IT equipment cooled using Direct Liquid Cooling (DLC) technology, which enhances the energy of the system.

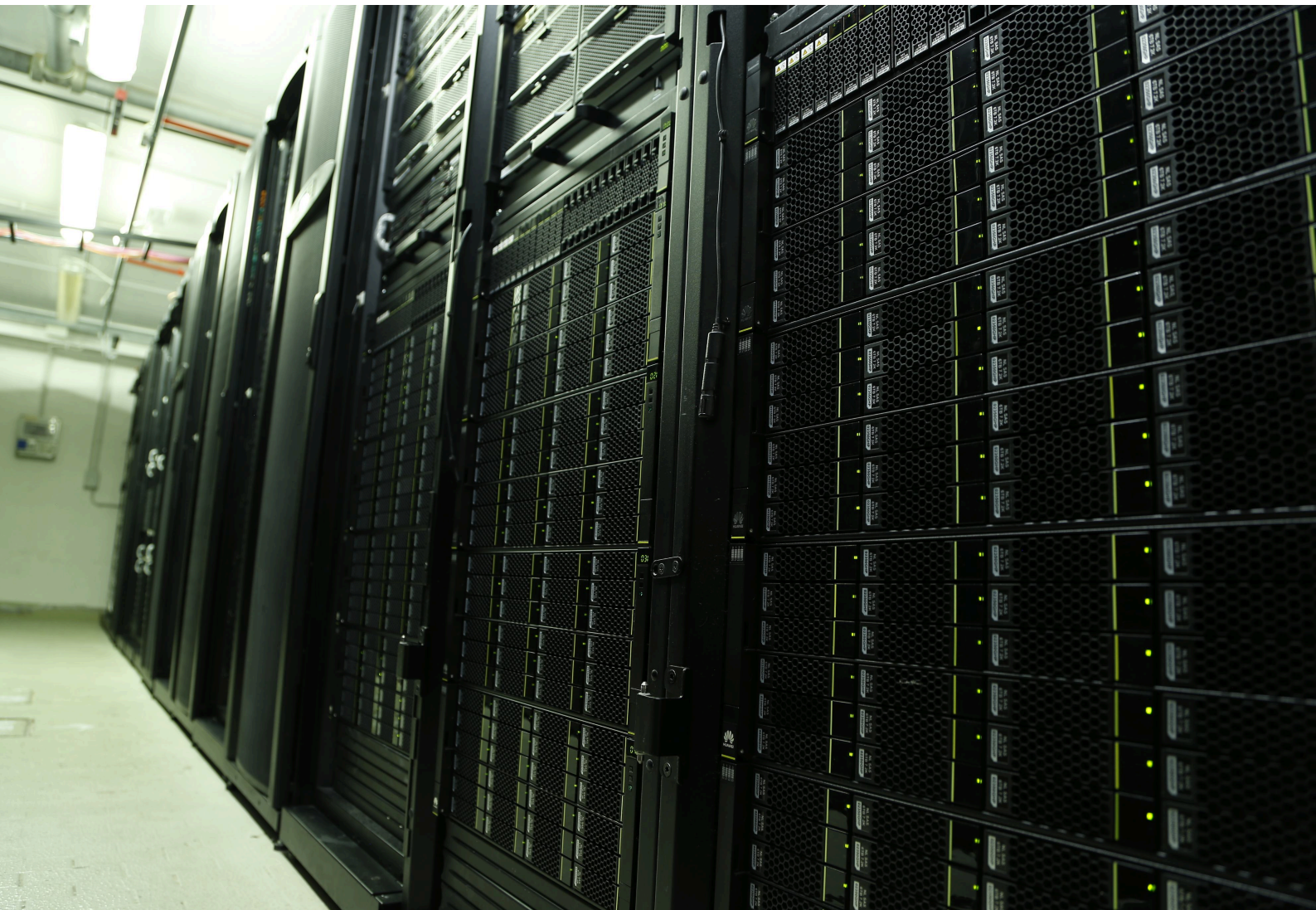
Direct Liquid Cooling (DLC) has significantly advanced in recent years, emerging as a feasible substitute for air cooling systems. In this system, liquid enters a rack to extract heat directly from the source, achieving an efficiency between 50 and 1,000 times higher than conventional air systems.

Three primary liquid cooling categories include direct on-chip cooling, back heat switches, and immersion cooling. Irrespective of the category, liquid cooling substantially decreases energy consumption, enabling reduced usage.

Water cooling, in comparison to air cooling systems, occupies less space and generates lower noise levels than fan cooling systems.

With the aim of energy savings, the temperate water circuits have been readied for potential connection to a forthcoming heat recovery system.

This will enable the reuse of waste heat from IT equipment, such as for heating the buildings within the Tecnopolo Manifattura complex.



Codes of conduct and regulations pertaining to data centers, emphasizing energy efficiency.

- The European Union's Code of Conduct for Data Centres aims to enhance energy efficiency in data centres by offering guidelines for measuring, monitoring, and reducing energy consumption.
- The Green Grid is a non-profit entity dedicated to advancing energy efficiency and sustainability in data centers. It has created various frameworks and metrics for assessing and enhancing data center efficiency.
- The Uptime Institute has established data center performance and operations standards that outline best practices for ensuring data center reliability, availability, and efficiency.
- ASHRAE Datacom Series: The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has established industry-specific guidelines for the data center sector, covering standards for energy efficiency, cooling, air quality, and other relevant aspects.
- The Data Center Alliance (DCA) Code of Conduct: The DCA has formulated a code of conduct that advocates for operational excellence and sustainability in data centers, offering guidance on performance monitoring, energy efficiency, waste management, and other critical areas.
- Data Center Site Infrastructure (DCSI) Certification: This certification program, created by the Uptime Institute, assesses and acknowledges the efficiency and resilience of data center physical infrastructure based on specific criteria and standards set by the Uptime Institute.
- The Certified Data Center Professional (CDCP) is a certification provided by the Data Center Certification Institute (DCCI) that emphasizes the expertise and abilities required to design, construct, and manage a data center efficiently and proficiently.

- BICSI Data Center Design and Best Practices: BICSI (Building Industry Consulting Service International) offers a comprehensive set of best practices for data center design and management. These guidelines encompass various aspects such as structured cabling, power distribution, cooling, and other essential considerations.
- The Open-IX Association: A non-profit entity dedicated to advocating openness, neutrality, and equitable access within data centers and interconnections. It establishes standards and guidelines to enhance transparency, interoperability, and service quality in data center operations.
- ISO 50001 is an international energy management standard. Although not tailored for data centers, it can be utilized to implement an energy management system in a data center, facilitating the monitoring and enhancement of energy efficiency.
- LEED (Leadership in Energy and Environmental Design) is a commonly utilized certification system for sustainable buildings. It includes a particular protocol for data centers, allowing those seeking environmental certification to showcase adherence to stringent sustainability criteria.
- BREEAM (Building Research Establishment Environmental Assessment Method) is a building assessment method that assesses the environmental impact and sustainability of buildings, including energy efficiency, water management, indoor environmental quality, and other factors. It can be applied to assess the sustainability of a data center.
- The ANSI/TIA-942 Standards set forth requirements for the design and construction of data centers, encompassing reliability, availability, physical security, and disaster recovery capability.
- Standard Uptime Institute: The Uptime Institute has created a range of data center availability classifications, including the Tier Standard and the M&O Stamp, to define standards for assessing the dependability and operational oversight of data centers.
- The ANSI/BICSI 002 Standard focuses on the design of data center infrastructure, encompassing structured cabling, power and cooling infrastructure, and asset management.
- The European Energy Efficiency Directive (EED) seeks to enhance energy efficiency within the European Union and is pertinent to data centers regarding energy consumption criteria and energy performance monitoring [Directive 2012/27/EU]

General applicable regulations

- ISO/IEC 27001 is an international standard focusing on information security management. While not tailored specifically for data centers, it serves as a valuable guide for implementing security measures within such facilities.
- ISO/IEC 20000, on the other hand, is an international standard dedicated to IT service management. It sets out best practices for service management, encompassing incident management, problem management, and change management.
- L. 6 December 1971, n.1083 pertains to regulations concerning the safe utilization of combustible gas.
- Legislative Decree 19 August 2005 n.192, along with subsequent revisions, addresses the enforcement of Directive 2002/91/CE on Energy Performance in Buildings Presidentia
- Decree 59/2009 implementing Legislative Decree 19 August 2008, n.192, for Directive 2002/91/EC
- Legislative Decree 28/2011 on Renewable Sources and Energy Certification
- Legislative Decree 4 July 2014, n. 102
- 26 June 2015 Ministerial Decree on Minimum Requirements
- 26 June 2015 Ministerial Decree on Energy Certification
- 26 June 2015 Ministerial Decree on Technical Reports
- Legislative Decree 81/08 on Accident Prevention and Worker Safety (ex 626/94)
- Law 186/68 Obligation of the proper execution of the plants CEI
- DM 37/08 Decree of 22-01-08 (ex 46/90)
- Law 791/77 on Manufacturer Responsibility
- DPR 224/88 on Manufacturer Responsibility
- Legislative Decree of 9 April 2008, n. 81 on Workplace Health and Safety Text
- Consolidated ASL and ISPESEL Recommendations
- Electricity Distribution Company Standards and Regulations
- Telegraph and Telephone Construction Circle Standards
- Territorially Competent Fire Brigade Command Rules and Regulations.

- UNI, CEI, UNEL consolidation tables
- Italian Institute for the Quality Mark regulations for materials and equipment qualified for mark acquisition
- Any additional regulations, standards, or guidelines established by authorities and relevant to electrical systems and their components
- EEC directives transposed into domestic law, notably framework directives 89/391 and 92/57.

BIOGRAFIE

Mirko Cestari

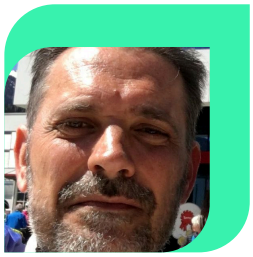
HPC and Cloud technology coordinator of CINECA

Coordinator of the “HPC and Cloud Technologies” group of the high-performance computing department of CINECA, Italy's largest high-performance computing center. He is responsible for the techonological evolution of the computing infrastructure with the aim of making world-class services available to Italian and European research. He is responsible for technology scouting of the main hardware and software solutions in the field of supercomputing and data management, consulting and training.

Massimo Mauri

Responsible for the Facility area and conservation and rational use of energy at Cineca.

With a degree in Architecture, he joined the Cineca team in 1999 and began a multidisciplinary journey of learning about the needs of data centers. He currently holds the position of Facility Area Manager and since 2010 he has also held the role of manager for conservation and rational use of energy at Cineca, developing the Consortium's energy policies. Always interested in the use of energy seen as a strategy for the future, he passionately applies in the field of Data Centers possible strategies for the decrease in a holistic sense of the Consortium's consumption



Cristiano Passerini

Lepida DIH-ER Project Director

Director of Lepida's DIH-ER Project, which focuses, primarily, on the EmiliaRomagna Region's European Digital Innovation Hub, ER2Digit, for innovation on the topics of Data-Driven Governance, Security and Confidentiality, Artificial Intelligence and IoT for PA.

Luca Simone

Project Manager in Lepida

Project Manager, European Projects and Business Development Division.

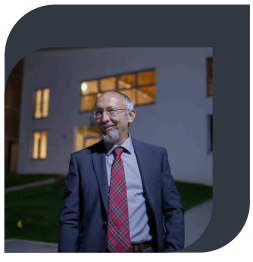
Oscar Covato

Sales in Tekni Post

Oscar Covato, born in 1993, graduated in Energy Engineering in Bologna. He currently serves as a sales technician at Tekni Post, focusing on providing comprehensive customer support.

Gianluigi Capra

Co-founder and Administrator of Exe.it Srl SB



Co-founder and Administrator of Exe.it, a company that has been successfully operating in the IT industry since 1988. He is involved in Financial Management and application development, database administrator and project manager in a wide variety of business applications. Expert in Microsoft Dynamics NAV, Database Data Structures.

Michele Toni

Senior site engineer di ECMWF

Michele Toni has been the senior site engineer at ECMWF since 2019, where she oversees the Data Center infrastructure: electrical, mechanical, security, and communication networks.

Valentina Fantin

ENEA LEA laboratory researcher

Valentina Fantin, Environmental Engineer with a PhD in Environmental Engineering, is a Researcher at the ENEA LEA Laboratory. Her research activities focus on the development of methods and tools to promote circular economy and eco-innovation.

Alberto Sogni

EU&Industrial Proposal Manager di RSE SpA

Alberto Sogni, mechanical engineer, European and Industrial Proposal Manager at RSE and Senior Expert of the Emilia-Romagna Clust-ER Greentech - Energy and Sustainable Development. Elisa Alberti (CINECA), Marco Pellegrini and Francesco Tinti (CIRI FRAME - University of Bologna), Matteo Zatti (LEAP), Manuele Gatti (Politecnico di Milano) contributed to this paper.

Gisella Santandrea

Business continuity e Crisis Management di CRIF

In CRIF since 2002, he has been involved in Business continuity and Crisis management for more than ten years; he has collaborated in the preparation of the Business Continuity plan of the Italian companies of the CRIF Group and currently takes care of its management and constant adaptation to business evolution

Anna Lisa Infante

Services Planning Technician di Rekeep

Anna Lisa Infante has been working for Rekeep Group for 20 years. As Services Planning Technician for the Process Design Department, she puts her many years of experience in designing tenders to design the delivery of energy and maintenance services aimed at public and private clients, especially in the hospital sector.

Luigi Benedetto Scarponi

Head of the infrastructure department in INFN-CNAF

Luigi Benedetto Scarponi graduated in power engineering. Since 2018, he has been working for INFN-CNAF in Bologna, where he serves as head of the infrastructure department that oversees the mechanical, electrical and special systems serving the Tier-1 computing center.

AZIENDE

CINECA

Cineca is a nonprofit Interuniversity Consortium formed by 116 public entities. Established in 1969 (as Consorzio Interuniversitario per il Calcolo Automatico dell'Italia Nord Orientale), today it is the largest computing center in Italy and one of the most important worldwide. Cineca offers support to the activities of the scientific community through supercomputing and its applications, builds management systems for university administrations and the MUR, and designs and develops information systems for public administration, health care and business. Increasingly a unique reference point in Italy for technological innovation, with offices in Bologna, Milan, Rome, Naples, and Chieti, and more than 1,000 employees, Cineca operates at the service of the academic system and national research. Cineca is also one of the Large Scale Facilities in Europe and hosts at the Tecnopolo of Bologna the LEONARDO supercomputing system, a pre-exascale class supercomputer, ranked 4th among the most powerful supercomputers in the world in the Top500 ranking.

LEPIDA

Lepida is an in-house company with total and exclusive instrumental public capital and operates in accordance with the in-house providing model performing, as indicated by LR no. 11/2004 and LR no. 14/2014, the function of an aggregator pole to support the plans in the development of Information & Communication Technology

ITL Foundation

Founded in 2003, the Institute on Transportation and Logistics (ITL) is a publicly held foundation that aims to contribute to the development and promotion of logistics and transportation systems in the Emilia- Romagna region through research, consulting and training activities

Tekni Post

Tekni Post, a company operating in the Building Automation field, is located in Bologna, Italy, at 91L Via Carracci. Founded in 1977, its mission is to form the best team of specialists working to be the reference point in the Building Automation System Integrator market.

Exe.it Srl SB

The company Exe.it Srl Sb is located in Castel San Pietro Terme and was founded in 1988 by Gianni Capra and Assunta Di Francesco. The scope of action impacts the field of cloud services, hosting, housing, hardware & software colocation, infrastructure outsourcing, Saas, Iaas, Paas, software development, test environments, Business Continuity or Disaster Recovery. Its mission is to enable the use of environmentally friendly and zero-emission Data Centers capable of expressing the highest possible energy efficiency for the health of the environment, as well as meeting their expectations through a fair, transparent and comprehensive definition. The 2022 turnover is €1,917,544.24

ECMWF

ECMWF is the European Center for Medium-Range Weather Forecasting. It is an intergovernmental organization created in 1975 by a group of European nations and is now supported by 34 states, mainly in Europe. ECMWF is now a multi-site organization: headquarters in Reading (UK), new offices in Bonn, Germany, and a new data center in the newly established Tecnopolo of Bologna.

INFN - National Institute for Nuclear Physics

INFN is the national public research organization, supervised by the Ministry of Education, University and Research (MIUR), dedicated to the study of the fundamental constituents of matter and the laws that govern them. It conducts research, both theoretical and experimental, in the fields of subnuclear, nuclear and astroparticle physics. In particular, CNAF is INFN's national center dedicated to research and development in the field of computing and telematics disciplines.

ENEA - LEA Laboratory

The LEA Laboratory is internal to ENEA's Department of Sustainability of Productive and Territorial Systems (https://sostenibilita.enea.it/), and aims to develop tools for the analysis and evaluation of environmental policies and the resulting plans and programs, integrating the environmental dimension with the socio-economic dimension in order to provide effective responses in terms of sustainability.

RSE SpA

Energy System Research - RSE SpA is a company founded in 2005, with headquarters in Milan and other offices in Piacenza, Brugherio (MB) and Rome. RSE belongs to the GSE SpA Group, which in turn is controlled by the Ministry of Economy and Finance. RSE's objectives are analysis, study and research applied to the entire energy sector. In 2022, RSE recorded a production value of more than 40 M€, with more than 330 employees.

CRIF S.p.A.

CRIF S.p.A., an Italian multinational in the financial services sector, is headquartered in Bologna and maintains offices in 80 countries globally, with a Group turnover of 714 million euros for 2022. CRIF's mission is to generate value and fresh opportunities for consumers and businesses through the provision of dependable information and solutions. This enables well-informed decisions and drives innovation. Established 35 years ago, CRIF initiated the Business Continuity project in 2009. This initiative concentrated on pinpointing critical business processes and formulating strategies for resuming operations. These strategies have developed over time, significantly minimizing the impact on the organization. Established in Bologna in 1988, CRIF is now a worldwide company that specializes in credit and business information systems, providing information to the financial market and individual companies. Protecting information and maintaining sufficient service continuity are central themes for CRIF and are essential conditions for its operations.

Rekeep S.p.a.

Founded in 1938, Rekeep S.p.A is headquartered in Zola Predosa (BO) and specializes in Integrated Facility Management. The company is dedicated to providing high-quality services to enhance the operational efficiency of public entities and private enterprises, as well as improve their real estate and infrastructure assets.