



Opinion

Data Centers Expansion in Italy: Energy Considerations and Big Data Analysis

Rocco Morelli^{1,*}

¹ Information Physics Institute, Rome, Italy

*Corresponding author: morelli.rocco@libero.it

Abstract - The need for a Mediterranean hub that allows the spread of artificial intelligence has induced the wind of data center expansion to blow in Italy. Based on public and web data (therefore of only approximate and illustrative reliability), a possible proto-plan is outlined hereinafter that highlights - together with the need for time and cost refinements to reach a real concrete plan - how the construction of data centers should proceed on a broad front in order to optimize the plan objectives. These objectives include, in addition to operational reliability, also the times and costs associated with construction. Some elements of the plan are therefore discussed below from a technical-economic and organizational point of view, but also from a design point of view, useful for localization and for plant optimization, especially for the energy part (in its various technological options) in a European context. After discussing the need for a data center to also operate off-grid, as well as the need for regulation and power factor correction for electrical supplies, the opportunity of an operational index to evaluate performance is highlighted, which should be part of the guaranteed parameters. For this purpose, an estimation index of Normalized Annual Processing Power (NAPP) is provided as a proposal-example to be used in the case of "turn-key" type construction contracts through a "main contractor" or through an "architect-engineer" with managerial functions. Finally, ethical and responsibility aspects are highlighted that concern the ownership of data and the purposes of their use, especially in general cases of experiments that involve a social body worried about generalized social control.

Keywords - Big data; Data lake; Data centers; Big data analyses; Artificial intelligence; Social experiments; Social laser; Social media; Primary regulation; Secondary regulation; Power factor correction; Photovoltaic systems, Data center performance index.

1 Background

There is still talk in various public venues of a Mediterranean hub as a nerve center for the diffusion of Artificial Intelligence (AI) systems. Certainly there is a plan for the expansion of data centers in Italy, a plan that the individual major operators will implement. There is news of it through various associations, the press, social media, universities, but there is always the risk of a partial vision. Unless you are in high institutional positions (and therefore bound by confidentiality obligations!) it is difficult to judge with an external eye and without being involved in the processes in the field, how focused and reliable the numbers and estimates that circulate on the WEB are and that are or should be part of an overall development program planned for new data centers in Italy. In these cases AI can certainly

have a higher power of resolution and discernment, if questioned appropriately, but this does not exempt you from taking the data that is provided, with caution and a critical spirit. Therefore, when AI is questioned - in this case ChatGPT - the picture that emerges (with only approximate and illustrative reliability) is the following:

Question 1: I think there is a lot of confusion on the web about the expansion plans of new data centers in Italy. Can you give me a summary plan emerging from reliable data on: 1) how many new data centers are planned in a 10-year time frame, specifying where possible potential (e.g. total MWe for each data center) and location; 2) how many, instead, should be planned in your opinion according to a growth trend based on data from the last decade; 3) provide a reference for the source of the data used?

Answer 1: Here is a reliable summary of data center expansion plans in Italy and forecasts based on current trends.

1) Expansion plan envisaged for the next 10 years. In recent years, Italy has attracted significant investment in the data center sector, especially in the areas of Milan and Rome. According to a study by the Observatory of the Polytechnic University of Milan, over 80 new data centers have been announced by 2025, with an overall investment that could reach 15 billion euros. By 2030, the national installed energy capacity is expected to exceed 1.3 GW. The Data4 Campus in Cornaredo and Vittuone alone, for example, will reach around 300 MW, with an investment of 2 billion euros to expand infrastructure also intended to support artificial intelligence (AI).

2) Future projections based on trends of the last 10 years. Based on recent data, an even faster expansion is expected in the next decade. If current growth rates are maintained, especially with the growing interest in AI and cloud, we could expect over 200 data centers in Italy by 2035. Italy, in fact, is chosen for its strategic location and relatively low operating costs compared to other areas of Europe. However, the market will require targeted investments in electrical infrastructure and more efficient regulations to support future power and sustainability needs.

3) Sources [1] This information comes from recent studies by the Data Center Observatory of the Milan Polytechnic, from the expansion plan of Data4 in Italy, and from sector analyses by experts in the sector reported on Agenda Digitale, Ansa and TechFromTheNet.

Question 2: Can you provide the indications of investment estimate in the two cases, point 1) and point 2)?

Answer 2: Here are the estimates of investments for the expansion of data centers in Italy in the two cases:

1) Investments planned in current plans for the next 10 years 2023-2025: A total investment of approximately 15 billion euros is planned by 2025 for the construction of 83 new data centers. Of these, a large part will be concentrated in Northern Italy, particularly in the areas of Milan and Rome, where a growing demand for capacity is expected, with numerous hyper-scale data center projects, i.e. with a power greater than 10 MW. Through 2030: With the growth of the market and international interest in Italy, investment is likely to continue to increase. Projections indicate that it could exceed 30 billion euros by 2030, supporting a total capacity of over 1.3 GW, necessary to support cloud, AI and other advanced technologies.

2) Estimated investment based on a growth trend projected to 2035 Considering the current rate of expansion and the increasing demand for digital infrastructure, a conservative estimate could suggest cumulative investments of €50-60 billion by 2035. This projection would also include infrastructure needed to support sustainability and increase energy efficiency, such as self-generation of energy from renewable sources for partial self-sufficiency of data centers. These data provide a picture that, if maintained over the next decade, could position Italy as one of the major European hubs for data centers, particularly in collocation and

hyperscale technologies.

With all due respect for AI systems, it is not possible to avoid assuming this framework only putatively, for the purpose of reasoning, given the overall size of the investment, the average implementation times and the number of data centers (which will be discussed below) that do not seem to leave sufficient margins in the programs and plans established, in a manner compatible with the needs expressed at EU level. Many international newspapers have repeatedly underlined that the intrinsically energy-intensive configuration of data centers can alter the local energy market (see the cases that occurred in American states), to the point that the resulting price increases are suffered by small and medium-sized businesses and families. But the need for data center power continuity also entails the need to provide, in the design phase, for off-grid operability. Since the consumption of essential services represents a large portion of total consumption, it is clear that it is necessary to equip data centers with their own power generation plants that allow for off-grid operations and therefore entry into the local electricity market for the possible delivery to the grid of excess electricity produced and not consumed. In this perspective, the Data Center Expansion Plan in Italy becomes an opportunity to reflect and express some comments on aspects regarding, for example:

- the electricity production technologies needed in a European regulatory context aimed at the ETS (Emission Trading System) and the energy transition;
- the organization and structuring of a large industrial project aimed at data acquisition (e.g. also from social media) and the spread of AI systems;
- the possibility that AI systems can be aimed at social control or even more at experimentation involving individual social agents, i.e. individuals or groups of a given economic-social system, through social media;
- other aspects, for example of development, in the conventional sense, or human development, which may emerge during the analysis.

However, it seems appropriate to provide a mental image of what the outside and inside of a data center might look like. Fig. 1 shows a glimpse of the inside of the operational “core” of an imaginary data center; that is, rows of racks in a cooled and temperature-controlled environment, where the lack of electrical power can turn into a disaster.



Figure 1: A glimpse inside the “core” of an imaginary Data Center.

For the external part, as an example, the rendering with an overall aerial view of what a new data center project under construction in central-southern Italy could look like, can be obtained by referring to a recent article published on WIRED [2]. In this project the

total power (cooling systems + processors) amounts to approximately 30 MW for the entire site. The total land area, however, including roads, services and appurtenances, reaches sixty thousand square meters: that is 6 hectares. As a first estimation under *Standard Test Conditions* (STC) the peak power of a photovoltaic power plant can be calculated as follows:

$$W_p = A \cdot I_s \cdot \eta \cdot f \quad (1)$$

Where:

- A = total available land area (in m²)
- I_s = standard solar irradiance (W/m²)
- η = panel efficiency (that may be assumed on average 21% for modern panels)
- f = shape coefficient, which represents the efficiency of use of the area (from 0 to 1) depending on the deployment of the panels to avoid shading, ensure operation and maintenance. It is generally assumed that $f = 0.65 - 0.70$ on average.

Based on the above, 1 hectare (= 10,000 m²) of land can generate with such a technology about 1.365 MWp.

Therefore, a surface area that at the latitudes of central-southern Italy, with the best photovoltaic technologies, if entirely covered by panels, could give a peak power certainly not greater than $(6 \times 1.365) = \sim 8.19$ MWp. A value that is completely insufficient compared to the 30 MW needed, if one wanted to make the data center self-sufficient, operable off-grid and green from an energy point of view. In the example considered, this would force to:

- separate the electricity generation part from the more clearly IT part (processing and cooling), procuring land ($\sim 70 - 90$ hectares) elsewhere for a photovoltaic system with adequate power, in the order of $100 \div 120$ MWp (the ratio between peak power and continuous power required being $3 \div 4$, depending on location, insolation, etc.).
- deliver the energy produced by a power site to the grid and take it back to the site where the "core" of the data center is located, thus inducing energy losses in the production process.
- carry out operation, maintenance and control on two different sites (the power site and the IT site), inducing organizational and economic losses in the production process.

Ultimately, a project set up in this way would be poorly optimized from an economic, energy and environmental point of view. From this, it is clear how important the decisions of location, layout, and organization of the project are, even before those of project design (basic-design and engineering), given that the conceptual choices made in these initial phases are then reflected in the operation of the data centers throughout their life cycle, which in this case is tied to the evolution even more than to the aging of the information technologies adopted today. Furthermore, a life cycle for similar projects can have a time horizon of 20-30 years, during which the technologies can certainly change and the storage and transfer of data represents another aspect to be analyzed in the initial design phase. In particular, in the risk analysis. On this occasion it is worth highlighting that the distribution of total energy consumption between the different services of a data center is believed to be on average the following:

TYPE OF SERVICE	% of Energy consumed compared to Total
1)-IT Services (IT Equipment: servers, storage and network devices, etc.)	40-50%
2)-Cooling and temperature control	30-50%
3)-Auxiliary services (emergency power, lighting and other non-IT systems)	10-20%
Total	100%

Table 1: Average Allocation of Energy Consumption in a Data Center.

Values that change depending on the efficiency of the cooling systems and local climate conditions. Furthermore, there is a parameter used to measure the energy efficiency of data centers. This is the PUE (Power Usage Effectiveness). The ideal PUE is 1.0 (energy exclusively for IT), but in reality it varies between 1.5 and 2.0 in modern data centers. The data in Table 1 show that an emergency power supply for emergency services does not allow off-grid operation, which must be considered very seriously in the risk analysis when designing a data center. Off-grid operation practically requires an installed power capable of generating almost 100% of energy consumption. The data reported above also indicate very clearly that the energy costs for operating a data center are a significant portion of the total and being able to use the photovoltaic energy potential which in Italy (and in the Mediterranean regions) is naturally abundant, this would make the data center business very attractive and privileged in this country.

2 Connections between Social Media, Big Data, Data Centers, Cloud Computing, Artificial Intelligence (AI)

The great progress made by Science and Technology, especially by Computer Science, seems to worry a part of the world, which has come to discuss the establishment of a global society equipped with totalizing control systems, thanks also to the increasingly widespread and used Social Media. In fact, there are more than logical connections between Social Media, Big Data, Data Center, Cloud Computing and more recently AI. But this is not the topic to focus on by this work, but to be kept in mind to understand some contents hereinafter. Big data is a huge amount of data that is generated by Social Media, Research, Working Activities, etc. as well as by connected devices and digital applications. Companies are trying to take advantage of this data by developing their big data analytics (BDA) capabilities. However, the issues of energy required and data ownership are crucial, as data are stored in data lakes and used for previously unknown purposes. A data lake is a centralized repository that stores and processes large volumes of data in its original form. This data can come from a variety of sources and include raw copies of system data, sensor data, social data, and more. The key feature of a data lake is its ability to accommodate all types of data, from structured (such as database tables and Excel spread-sheets) to semi-structured (such as XML files and web pages) and unstructured (such as images, audio files, and tweets), without compromising data "fidelity". Data files are typically divided into storage zones: raw, clean, and curated, to allow different users to use the data in its different forms to meet their needs. Data lakes provide basic data consistency for a variety of applications, supporting big data analytics, machine learning, predictive analytics, and other forms of intelligent action. Big Data requires storage, processing, and analysis resources, which can be handled by Data Centers or Cloud platforms. Data Centers are physical facilities traditionally used for housing Big Data infrastructure but can be limited in terms of flexibility and scalability. Cloud Computing offers a more dynamic and scalable environment for Big Data, enabling companies to process and store massive amounts of data without needing to invest in physical infrastructure.

3 "The Information Catastrophe" and the Precautionary Principle

In his 2020 work "The information catastrophe" Vopson clearly described the trend - and provided the logical basis according to the Information Theory - due to the exponential production of data and the respective energy consumption, which would grow in a worrying way [3]. But, such a topic, contrary to what could be expected, is not yet sufficiently considered with the due care and urgency after four years from the first drafts of the work itself. An outcome completely contrary to the expected habits, at least in the EU, which in its constitutional provision has inserted the "Precautionary Principle", on the basis of which relevant decisions are taken in equally problematic occasions, as has already happened. See in this regard the need to adopt vaccines during the COVID-19 pandemic or that of the energy transition to limit anthropogenic greenhouse gas emissions and combat, as far as possible, climate change. Emergencies that today seem to be subject to a downsizing, despite the concerns and emphasis with which they were initially proposed and adopted, with significant repercussions for the entire Western European population and beyond. Therefore, it could appear superfluous to underline in this context IPI - Information Physics Institute the close connection existing between Social Media, Big-Data, Artificial Intelligence (AI) and Energy needed in these processes. We could take it for granted! It is however intention to expose here some recent facts and points of view on these topics, which may have some relevance in evaluations and choices that might produce awareness and have any impact on such an important topic. The production, storage and analysis of data are energy-intensive processes and may require, also for safety and security reasons, data centers with real dedicated power generation plants in addition to the connection to the medium voltage distribution grid ($> 3\text{kV}$); or transmission, in high voltage ($> 110\text{kV}$), delivering any excess produced to the grid or requesting the grid for the surplus necessary to cover the peaks compared to its normal production base-load. Renewable energy sources, in particular wind and photovoltaic, affected by great variability and unpredictability of production (see in this regard figures b) and c) of Fig.4), are not considered the most suitable to ensure primary and secondary regulation (in frequency, voltage and power) on the grid, since all operating conditions are highly variable, if not through accumulation and regulation. Although photovoltaic systems may also have some storage capacity through batteries, it is always much more limited than the peak power and the maximum instantaneous power that can be delivered by the photovoltaic system. Furthermore, many wind and photovoltaic systems, of low or even medium power, are often connected to a medium voltage network, while the regulation of the actual network usually operates through the high voltage network. And between the high and medium voltage networks there are transformers (i.e. inductors) and the equipment of numerous transformation and distribution substations (i.e. inductors and capacitances).

4 Explanatory simplification of the electrical grid regulation

The variability and unpredictability of the production of generation plants of all types, as a whole, and of the loads on the same electrical grid, at whatever voltage level they are operated, require a regulation system to keep the voltage and frequency of the entire network almost constant, in order to avoid fluctuations that would cause malfunctions and damage to user equipment. The meaning of this paragraph can be understood by referring to the intrinsic variability and unpredictability of the production of photovoltaic and wind plants and of the loads on the network at whatever voltage operated, which will be discussed later, to justify that wind and photovoltaic systems do not constitute the optimal typology for a data center. This is especially true in the case of poorly interconnected or even isolated electrical networks, where auxiliary emergency and backup systems become mandatory to ensure continuity of service. The European high voltage transmission grid, except for some isolated residual cases, is strongly interconnected [4] to the point that it is believed that an anomaly

in the Balkans could even be reflected in the Pyrenees. As an explanatory measure, we can think of schematizing the grid with simple interconnection nodes (electrical connection, transformation and exchange substations) and with nodes like the previous ones but with the addition of energy withdrawal or injection possibilities (i.e. large users operating power plants and generation plants).

As an extreme simplification for explanatory purposes, the entire electricity grid (or parts of it) can be considered as a single electric generator that within a certain time reaches a point of equilibrium with its load, which can be represented on a usual Voltage (V), Current (I) diagram. On a purely conceptual level, the grid can actually be modeled as a single system that reaches an equilibrium between generation and load. However, this simplified representation is valid only within certain limits, considering that:

i. The power grid constantly tries to maintain a balance between the energy input from generators and the energy demanded by loads. If the generation is less than the load, the frequency drops (below 50 Hz in Europe); if the generation is more, the frequency increases.

ii. In theory, a voltage-current diagram (V, I) can represent the state of the grid, and the ratio.

$$Z = \frac{V}{I} \quad (2)$$

defines the apparent impedance of the load. However, this is an extreme simplification, since the network is enormously dynamic and involves aspects such as resistances, inductive reactances, and capacitances that influence the power distribution (e.g. between active and reactive).

iii. Although the grid can be imagined as a single "equivalent generator" at a very high level, in practice there are many distributed generators that interact with each other in real time. Collective behavior is what leads to the equilibrium between energy supply and demand.

Primary regulation is the first automatic response mechanism of generators to frequency variations. If demand exceeds supply (i.e. there is less energy generated than requested), the frequency drops. Conversely, excess generation will cause the frequency to increase. This regulation occurs within a few seconds and involves all generators connected to the grid that participate in this control. The following can be assumed as the basic equation of primary regulation:

$$\Delta f = -R\Delta P \quad (3)$$

where:

- Δf is the variation of the frequency with respect to the nominal value (in Europe 50 Hz).
- R is the regulation coefficient of the generator, also known as "droop" (typical value between 2% and 5%).
- ΔP is the variation (increase or decrease) of power supplied by the generator to compensate for the imbalance.

The primary regulation intervenes in a proportional manner: the greater the frequency variation, the more the generator contributes by modifying its power. Ultimately, the primary one is the regulation of the power obtained based on the frequency variation. The constant R expresses the link between the variation of the power output from the generator, and the variation of the frequency due to a changed load. It manifests itself with a certain delay with respect to the load variation and its entity depends on the characteristics of the group and the calibration of the regulation system. With the previous regulation at the end of the

transient there is a variation of the frequency, but to bring it back to its original value it is necessary to intervene on the regulation systems, obtaining the secondary regulation. In this way there is a further variation of the power.

Secondary regulation occurs over a longer time frame (seconds to minutes) and is responsible for restoring the frequency to the nominal value (50 Hz) and managing power exchanges between the control areas.

The following can be taken as the basic equation of the secondary regulation:

$$\Delta P_{reg} = K \cdot \Delta f \quad (4)$$

where:

- ΔP_{reg} is the corrected power to be supplied or subtracted from the grid.
- K is the gain of the secondary control system.
- Δf is the frequency variation from the nominal 50 Hz.

Secondary regulation uses an automatic control system (Automatic Generation Control - AGC), which slowly restores the nominal frequency and also corrects the power flows between the interconnected areas of the network. The two formulas (3) and (4) although having a certain similarity are representative of different regulation interventions, which are implemented with distinct timing. Voltage regulation is managed locally in each substation or node of the network. The voltage is regulated by varying the production of reactive power Q , since the voltage is influenced by the injections of reactive power. The following can be assumed as the basic equation of voltage regulation:

$$\Delta V = K_V \cdot \Delta Q \quad (5)$$

where:

- ΔV is the voltage variation.
- K_V is the voltage regulation coefficient of the system.
- ΔQ is the variation of reactive power supplied or absorbed by generators or static compensators.

Voltage regulation occurs through devices such as synchronous compensators, capacitor banks or adjustments on the transformer windings. In reality, what also varies during regulation is the phase and this, to avoid excessive differences between active and reactive power, requires localized "re-phasing" (power factor correction aims) at appropriate points of the network. Since we are dealing with alternating current (AC), the phase of the current plays a crucial role in the regulation of the electrical network, in particular when it comes to active and reactive power. The overall power in an AC system is defined as apparent power (S), which has an active component (P) and a reactive component (Q). These components form a right-angled triangle in the so-called power triangle:

$$S = \sqrt{P^2 + Q^2} \quad (6)$$

where:

- S is the apparent power (in volt-amperes, VA).
- P is the active power (in watts, W).
- Q is the reactive power (in volt-amperes reactive, VAR).

Power factor correction aims to reduce Q to increase the power factor $\cos(\phi)$, which is given by the relationship:

$$\cos(\phi) = \frac{P}{S} \quad (7)$$

where ϕ is the phase angle between voltage and current.

The phase angle between voltage and current is related to the power factor, which determines the distribution between these two components. Power factor correction is a fundamental operation to reduce losses and improve the efficiency of the network. Power factor correction can be obtained by adding capacitors (or inductors in the case of capacitive reactive power). The aim is to compensate for the reactive power, thus reducing the phase angle between voltage and current. If a system has an initial power factor $\cos(\phi_1)$ and you want to re-phase to a new value $\cos(\phi_2)$, the amount of reactive power that must be compensated, Q_{Comp} is given by the following equation:

$$Q_{Comp} = P \cdot (\tan(\phi_1) - \tan(\phi_2)) \quad (8)$$

where:

- P is the active power (W).
- ϕ_1 is the initial phase angle, related to $\cos(\phi_1)$.
- ϕ_2 is the initial phase angle, related to $\cos(\phi_2)$.

Once Q_{Comp} has been calculated, we can determine the value of the necessary capacitance C (or inductance L in the opposite case) for the power factor correction. If we use capacitors to correct an inductive load, the necessary capacitance C is calculated with the formula:

$$C = \frac{Q_{Comp}}{V^2\omega} \quad (9)$$

where:

- Q_{Comp} is the reactive power to be compensated (VAR).
- V is the operating voltage (in volts).
- $\omega = 2\pi f$ is the system pulsation (where f is the network frequency, typically 50 Hz in Europe).

In practice, the power factor correction is not performed on individual loads, but on specific points of the electrical network, such as substations. The installation of capacitor banks (or in some cases inductors) occurs in these nodes to maintain a stable voltage profile and reduce the flow of reactive power between the different areas of the network, improving the overall efficiency. In conclusion, the main objective of power factor correction is to optimize the network to reduce the circulating reactive power and maintain a good power factor. Although the ideal power factor for a network is 1, since it maximizes energy efficiency and reduces power losses, however, in current practice, maintaining a power factor around 0.95 is considered optimal and realistic for most networks and industrial systems, ensuring good efficiency without excessive costs for power factor correction. Among the technologies for electricity generation most used to date for accumulation and regulation (in power, frequency and voltage) of an AC network, in high or medium voltage, and with a frequency of 50 or 60 Hz, are:

- hydroelectric plants: if necessary equipped with appropriate pumping using the same hydraulic turbines supplied, but reversing the direction of rotation to make them also work as pumps.
- turbo gas groups in quick-start-up configuration; that is, remote-controlled and with a ramp-up to reach maximum power in the order of 30 seconds.

- high-power diesel-generator groups remote-controlled, but which imply the use of fossil fuels, anything but “low-carbon”.
- expansion of the interconnection of the local network, with other nearby networks, where necessary for stability and longer intervention times: but this system, if on the one hand increases the inertia of the available rotating powers and therefore stability, allowing longer times, on the other hand exposes its plants not only to adverse events of its own interconnection network, but also to those of the other networks to which its own is connected.

Above all this, there is an indisputable fact: Artificial Intelligence (AI) requires a great deal of energy and it would seem that the World is slowly realizing it. But, perhaps, the spirit of the times is not the best for those responsible for the choices to be made to make decisions in this regard in the context of wars that involve us without being able to find the way to peace. So now there is talk (and it does not seem to be just media and social media voices, as we will see below) of the need for data centers for the entire Mediterranean area, and not only, as well as the shortage of energy infrastructure needed to power them. All this will presumably lead to the revaluation, restructuring, re-qualification and reuse of fossil fuel power plants closed and put into disuse, or even decommissioned, in an attempt to speed up the penetration of renewables and try to truly give life to the planned energy transition. It is clear, however, based on the above, that a center for the production, transmission and storage of data should rely on its own power supply system, which is stable, reliable, redundant and safe, as well as possibly for its own exclusive use. Therefore, a photovoltaic or wind system serving a data center (although economically convenient) would seem at first glance inadvisable due to their typical characteristics, even with a stable connection to the grid in case of emergency. Yet this seems to be denied by the fact that the largest data center in the world - which is located in northern Nevada, the Citadel Campus; and belongs to the global technology company Switch - is powered by 100% renewable energy, up to 650 megawatts (MW). It is good to know that it can be done, but one should understand the configurations, measures and redundancies adopted. In any case, an electricity generation plant of any type, served by a data center and owned by it, requires management for operation and maintenance (e.g. also entrusted to third parties), which on the one hand can be a burden for the core business of the data center, on the other hand can configure locally a new, green and integrated electricity and IT utility, serving the territory that hosts it. Such an industrial strategy, however, having verified that the host country is an importer of electricity that can ensure demand, would require the installation of double the electrical power[5] compared to that strictly necessary for the data center and would also constitute an element of mitigating resilience for the unpredictable and unexpected variations in demand that can be recorded on the core business of the data center. Naturally, to have double the electrical power, it is necessary to face a higher investment according to the characteristic scale factor of the technology adopted. By keeping the two most important aspects of a data center separate, that is, the information technology (IT) part and the energy part, it is possible to try to develop an evaluation scheme useful for industrial planning regarding data centers, which will be conceptually exposed, in its fundamental lines, in the following paragraph 5.1.

5 Is the wind of data center expansion really blowing in Italy?

AI seems to have answered affirmatively to the question posed above and from news available on the Web and in the Italian press, which has given much emphasis to this topic, it is known that:

- according to a recent study by CBRE Italia, based on data published by Eurostat in 2022, a total of approximately 17,000 people are employed in Italian data centers and in companies that are part of the sector’s supply chain. And there are also those who estimate that the total remuneration as a Data Center Technician (DCT) is €37,000 per year, with an average

base salary of €35,000 per year.

- according to Scholarship IDA a DCT profile is the following: « The DCT credential is aimed at both electrical and mechanical engineers in data centers, as well as individuals looking to start a new career. Earning this credential will demonstrate to employers that you have a thorough understanding of the concepts that underpin the discipline of mission-critical operations and that you are aware of all major design considerations. To earn the DCT credential, students must complete the required 16 e-learning modules/approximately 56 hours of learning.

- if we take as a reference what Data Centers Map reports, as of Sep 19, 2024, there are already 138 structures present in Italy.

IDA is the Italian association of Data Center builders and operators, born from the partnership between Microsoft, Equinix, Rai Way, Data4, STACK Infrastructure, Digital Realty, Vantage Data Centers and CBRE Data Centers, which aims to bring together all the players in the ecosystem in Italy. The most relevant companies in the sector, together, in building a common space to represent and ensure the promotion of Data Centers as a pillar for the digital economy. In a recent article published by La Repubblica, IDA President Sherif Rizkalla discussed the growing interest in the data center sector in Italy. According to the Milan Polytechnic Observatory, by 2025 estimated investments in the sector could reach 15 billion euros. During the interview, Rizkalla highlighted three key factors that are driving this evolution:

- Digitization of Europe's third largest economy: more and more Italian companies are moving servers outside and adopting cloud solutions.
- Localization of data centers: in order to guarantee greater speed and data security, it is preferred to locate these centers close to customers, whether public or private.
- Strategic location of Italy: our country enjoys submarine connections connecting it to both Africa and the East, making it a strategic point for data centers.

On October 22, 2024, in Rome, the IDA Data Center Symposium held, has been focusing on digital infrastructure, regulation, and sustainability. According to estimates by an involved Observatory, in addition to the 138 existing ones, the construction of 83 new Data centers could be foreseen, which could lead to an overall investment (including, therefore, the purchase of land, construction of structures and plants) of 15 billion euros. It is estimated that these investments could have a significant impact, stimulating local supply chains and improving services to citizens. The new infrastructures are also fundamental for the development of national digital markets and would position Italy as a reference point in the European computing network. Currently, the majority of Italian Data centers have a medium (2 - 10 MW) or small (~ 2 MW) power, while high-power ones (> 10 MW) are less common, requiring high-voltage connections. But it is precisely in this last segment that there should be a significant growth in new structures, i.e. Data centers with a power greater than 10MW. Expected to increase in the coming years, they require a high-voltage connection, which is not always available. This will entail the need to strengthen the national electricity grid, requiring close collaboration between the market and institutions to align growth expectations with the infrastructure reality.

5.1 Proposal of some evaluation schemes for planning

An industrial plan estimated at 15 billion euros is not a game and it is reasonable to think that it will be managed by looking at a life cycle program of the various infrastructures and plants according to modern TCM (Total Cost Management) techniques and assigning to one or more structured teams the responsibilities of managing and controlling the program itself and the projects that compose it, perhaps based on a territorial division (north, center,

south). As with any industrial plan or new installation, there are planning aspects linked to the international market and aspects linked instead to the internal market of the country that hosts the installation. The related data should be available in the local or central offices of the same data centers already operating (for example annual reports or balance sheets, old contracts, etc.). It seems obvious that the significant number of 138 existing data centers can be seen as an appropriate sample from which to search in the most complete way possible for elements useful for evaluations and planning of the new 83 data centers; also in the attempt to identify a more general evaluation model. However, it is necessary to keep the two most important aspects of a data center's systems separate, that is, the information technology (IT) part and the energy part, as already mentioned above, perhaps by planning them separately and then harmonizing their planning with respect to a general plan.

5.1.1 General time planning

The overall time for planning, designing, building, testing, and commercial commissioning of a large industrial project varies depending on the types of projects and the productivity of the economic systems in which they are carried out, as well as the scale of the project. A reference for the average value of the overall time required for the construction of projects with a scale of approximately 100 to 500 million euros for the following types of projects; 1) photovoltaic systems; 2) thermoelectric power plants (including combined cycle gas-steam plants); 3) large buildings; 4) data centers proper; to be built in an EU country such as Italy can be summarized in the following Table 2:

Item	Description	Average construction time (years)	Note
1	Photovoltaic Plants	1,5 - 3	A large PV plant (capable of generating between 50 and 200 MW) can take up to 36 months to build. The permitting and environmental impact assessment phase can take up to a year, followed by design (4-6 months) and actual construction, which can last from 6 to 18 months. The timeframe can be reduced if the permitting and construction processes are expedited
2	Thermoelectric power plants (also combined gas-steam cycle)	4 - 6	The complexity of thermal power plants, which may include combined cycle gas-steam, requires significantly more time. The permitting and planning phases, including environmental impact assessment and emissions permits, can take up to two years. The construction phase can take 2 to 3 years, while the testing and commissioning phase can last another 6 months or more.
3	Large buildings	3 - 5	Large buildings, depending on their function (e.g. offices, operations centres, logistics services, etc.), can vary greatly in time. On average, design and obtaining permits can take up to 1-2 years, while the construction phase can last between 2 and 3 years. The times for commissioning also vary depending on the size and specifications of the building.
4	Data center	2 - 4	Building a large data centre typically takes 2 to 4 years, depending on the size and complexity of the infrastructure. The initial planning and design phases, including energy sustainability assessments, can take 6 months to a year. The construction and configuration phase of the IT infrastructure (servers, cooling systems, and power backup) can take 18 to 24 months.

Table 2: Average construction times.

It must be taken into account that these timeframes - average values, which can vary significantly depending on the size and specific complexity of each project - reflect an average scenario for projects carried out in EU countries, but may be shorter or longer depending on the project management capacity, regulatory constraints and available resources, but above all they depend greatly on the rules and regulations of the country in which the project is carried out, especially in environmental and urban planning matters. And Italy, which with its companies has excellent technical and management references in the construction field throughout the world, certainly does not excel in these authorization aspects on its territory.

Knowing that we are talking about 15 billion for 83 new data centers, which, taking into account the energy and cooling systems served, could be structured into an overall program of 30 ÷ 150 separate projects, depending on the organizational choices, it is clear that if the overall time horizon were even ten years, the program could not be realized without opening several work fronts simultaneously and carrying them forward in sequence at a very fast pace. It is therefore quite obvious that if in the country hosting these plants there were industrial sites, already in some way infra-structurally served, with old industrial plants that could be reused and already equipped with electrical and road connections, buildings, energy production plants to be rehabilitated, etc., it would be almost an obligatory choice, not only to avoid further land consumption (especially agricultural), but also an economically and ecologically necessary choice for the purposes of sustainability criteria.

5.1.2 Information technology structures

Surely professionals in the field have the technical-managerial planning and control indexes for the design, construction and control activities of a data center or a set of them, but thinking about how a typical index for data centers could be structured, the following reflection emerged. The index that is proposed below (still rough and possibly to be refined in the course of work) is an attempt to comprehensively measure the computational, storage and energy use capacities of any data center. A data center produces, stores and manages data. These are very different processes. But if one wanted to measure the capacity and at the same time the potential of a data center with a single all-encompassing parameter, one could think of an index of Normalized Annual Processing Power (NAPP) alongside any others that the applicable standard regulations might prescribe. This would result in a multifactorial formula of the type:

$$NAPP = k \frac{C_C \cdot S_C}{E_C} \quad (10)$$

composed of:

C_C = Compute capacity which measures how much the data center is able to process data, is expressed in Giga FLOPS, operations per second (FLOPS) which measures the performance of a computer, based on the number of floating point arithmetic calculations that the processor can perform in one second.

S_C = which measures the total storage capacity in Gigabytes of the data center.

E_C = data center energy consumption in GigaWh/year.

k = a utilization factor that represents the efficiency in using resources and can be a percentage or an index derived from the average workload (percentage of CPU time, network throughput, and storage usage). For example, a data center that uses its resources efficiently will have a higher utilization factor than one that has a low occupancy rate or energy inefficiencies. It should be possible in this way to compare different data centers (already existing, to be upgraded, or to be built), as long as the same measurement criteria are used. In this way it should be possible to analyze the congestion points on the current basis and therefore upgrade the existing ones or proceed with the construction of new ones.

5.1.3 Electric energy structures

For the energy part, it is useful to know that recently the Italian government institutions are reopening the possibility of resorting to the production of electricity through the most recent generations of SMR (Small Nuclear Reactors, generally based on Generation III+ pressurized water reactor technologies which are relatively close to commercial readiness) and AMR (Advanced Modular Reactors a variety of Generation IV reactor technologies which are under development). But a new data center that used these technologies would presumably have a more troubled authorization process at regional/local level compared to

renewable energy plants.

For photovoltaic systems in particular, the results may be useful – barring specific in-depth studies – of a recent preliminary survey conducted on the Italian market regarding small, medium and large photovoltaic plants [6]. Ignoring the peculiarities of the individual system (diversity of panels, layout, configuration, etc.) and assuming the cost as a function of peak power as the only variable, the graph shown in Fig. 2 can be considered.

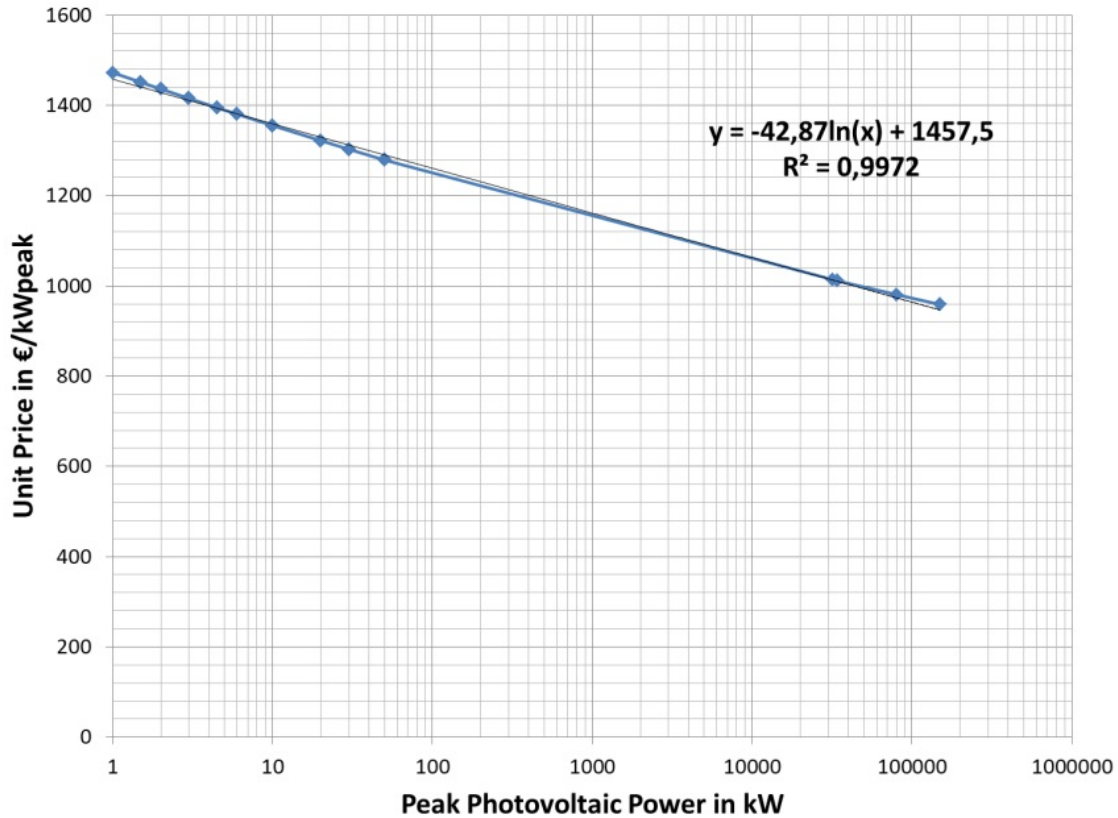


Figure 2: Market Survey 2023 in Italy.

The data relating to the large photovoltaic plants that ENEL is building in Sicily and which have been made public (see references below) during the licensing procedures [7] may also be interesting, allowing us to draw up the following Table 3 for Large Power Plants, presumably of the average size needed for a new data center. These are reliable data from a large electric utility regarding plants actually under construction.

MWp	M€	Media MWp	Media M€	Item
32	33			
34	30	33	31,5	1
80	60	80	60	2
		K	C	

Table 3: Large PV Power Plants.

It is evident that when the power varies there is a scale effect on costs of the type $(C = hK^S)$, where the exponent is characteristic of a technology or a type of plant that can assume different capacity and therefore different cost. Having the data for plant (1) and plant (2) which are of the same typology / technology and therefore being able to assume $(h_1 = h_2)$ we have for each of them that:

$$C_1 = hK_1^s \quad (11)$$

$$C_2 = hK_2^s \quad (12)$$

and dividing member by member (starting from C_1), h disappears and we get:

$$\frac{C_1}{C_2} = \left(\frac{K_1}{K_2}\right)^s \quad (13)$$

from which we have the following equations:

$$\log\left(\frac{C_1}{C_2}\right) = s \cdot \log\left(\frac{K_1}{K_2}\right) \quad (14)$$

$$C_1 = C_2 \cdot \left(\frac{K_1}{K_2}\right)^s \quad (15)$$

and solving according to s we get:

$$s = \frac{\log\left(\frac{C_1}{C_2}\right)}{\log\left(\frac{K_1}{K_2}\right)} \quad (16)$$

and then we can calculate s , $s = 0.728$. Instead, if in the member-by-member division of the two initial equations we started from C_2 we calculate the same value of s , indicating that the the exponent remains the same, as expected. In practice, for any installation, if the systems involved are of the same technology/type, the scale factor can be easily calculated using historical data, or even derived from the market, by calculating the characteristic exponent in the specific case. This does not only apply to electricity generation systems, but also to other types of systems. The warning to be taken into account in any case is that the costs or prices, subject to variations over time, due to market factors or even simple inflation, must be reported to the same reference date to be compared and this can be done (through historical series) using ratios between statistical indices of variation in the cost of goods over time (for example the "Goods and Services" Index published periodically over time by ISTAT in Italy, or those of the Chambers of Commerce, or those of relevant Industrial Associations). The most suitable alternative for an update and price revision is however to use the cost structure of a "conventional" project in the Energy Sector (or even in the IT sector if this is the case). Even before the copious economic and contractual engineering literature on the subject "price revision" (and in any case before the historic general conditions[8] of Enel), in the Energy Sector contracts and for conventional projects (thermoelectric or nuclear power plants, gas turbines or combined cycles, power lines and stations, etc.) reference has been made for a long time to the "General conditions for the supply and installation of plants and equipment for import and export - No. 188 A" of March 1957" [9] drawn up by the Economic Commission for Europe at the United Nations, which felt the need to regulate the matter. Such approach constituted, from then on, a reference for international trade. Although the notion of this reference has now been lost, commercial and especially contractual practice (specifications, general supply or procurement standards), continue - in fact - to share that original approach which has now become consolidated practice. Therefore, for commercial purposes, but especially for the revision of prices (or costs) in contractual occasions of various types, the total cost of a project (C_t) can be traced back to: a fixed and invariable share (a); a

share (b) variable with the cost of materials (M_x) (i.e. according to prices, quantity and type of materials); a share (c) variable with the cost of labor (W_x) (i.e. type, quantity and wages of the labor employed); in such a way that the sum of the three shares constitutes the entire price:

$$a + b + c = 1 \quad (17)$$

$$C_t = a + b \cdot M_x + c \cdot W_x \quad (18)$$

Typical average reference values for large energy sector contracts have long been the following: $a = 0.1$, $b = 0.45$ and $c = 0.45$ [10], for which it was necessary that $M_x = 0.45 \cdot C_t$ and $W_x = 0.45 \cdot C_t$. This gives overall: $C_t = 0.1 + 0.45 \cdot C_t + 0.45 \cdot C_t$, which thus provide the total cost structure in the case under consideration. Now it is evident that, where in a project it is possible to identify further variables on which the total cost depends, it is possible to have a more articulated structure linked to the identified variables, even if in a different number to the case taken as an example above. The revision coefficient $\varepsilon_x \geq 1$ that links the cost C_{t_0} at time 0 to a cost C_{t_x} increased at time x – where the cost structure has not changed – will be given by:

$$C_{t_x} = \varepsilon_x \cdot C_{t_0} \quad (19)$$

from which the price revision coefficient ε is determined, according to the cost structure, as follows:

$$\varepsilon_x = \frac{0.1 + a \cdot C_{t_x} + b \cdot C_{t_x}}{0.1 + a \cdot C_{t_0} + b \cdot C_{t_0}} \quad (20)$$

5.1.4 Possible location of new data centers

When considering the possible location of new data centers, one cannot help but think that in Italy, and in its islands, industrial sites that are no longer productive (also “thanks” to the structural crises that have occurred since 2008) abound. It is to be expected that the licensing processes for their reuse would be welcomed by central and local authorities and would possibly be facilitated if they were data centers with serving plants for the production of the necessary electrical energy. The sites of some thermoelectric power plants of ENEL Holding that have been definitively closed after completing their productive life cycle immediately come to mind, but which have buildings and services, still in good condition, that can be renovated and adapted to accommodate data centers; as well as having spaces to accommodate the necessary new plants for the production of the necessary electrical energy. These are sites close to the national backbones of the high-voltage transmission grid, equipped with an electrical transformation and transmission substation.

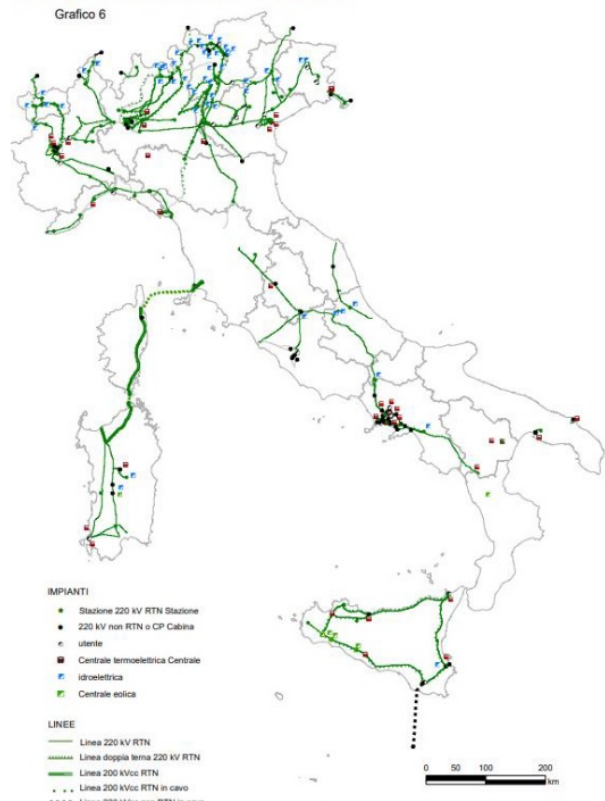
Rete italiana a 380 kV al 31 Dicembre 2022

Grafico 5



Rete italiana a 220 kV al 31 Dicembre 2022

Grafico 6



The entire high voltage network (380 in red and 220 kV in green) is strongly interconnected to the European network, but the hydraulic pumping power has remained substantially at ~1.5 GWe, or less than 1% of the Italian gross efficient power of 123.3 GWe. All this while the intermittent photovoltaic and wind power is strongly expanding. Sicily, an offshoot of the network interconnected at only one point to the peninsula, deserves attention for network regulation and stability of the electrical service.

Figure 3: The Italian HV Grid.

Then there are some of these plants that have been stopped and put into conservation conditions, awaiting further decisions regarding their use, which has become problematic following the EU's green plans regarding the use of fossil fuels (There is a need for green certificates generated by emissions avoided by plants with renewable energy in quantities equivalent to the CO₂ that the thermoelectric plants in operation would produce, according to the schemes envisaged by ETS). The sites of the old nuclear plants (NPP) in Piemonte, Lombardia and Lazio also come to mind (Trino Vercellese NPP and Caorso NPP, Bosco Marengo Lab, Garigliano NPP, Latina NPP) entrusted to SOGIN Spa for definitive decommissioning (which is currently underway), together with approximately 500 hectares of land in total, useful for the installation of photovoltaic systems.

5.1.5 Brief contextualization of the related energy problem in the EU framework

The use of fossil fuels, which is expanding in Eastern economies, is considered problematic in Europe, not very recommendable and, according to some, "penalized" by the ETS (Emission Trading System) for environmental purposes (especially in the EU economies). Except for photovoltaic roofs of individual users and some medium-sized plants (~ 50MW), renewable energies, not only due to a lack of "mega-factories" and adequate regulation, encounter difficulties of various types and struggle to adequately penetrate markets so to replace fossil fuels. That is also because renewable energies have variable producibility and are strictly linked to the location of the plants (see for example Fig.4.a); and if we consider the necessary storage batteries, wind and photovoltaic systems are not as effective in operation and scarcely environmentally friendly as they seem at a superficial glance, particularly in the decommissioning phase.

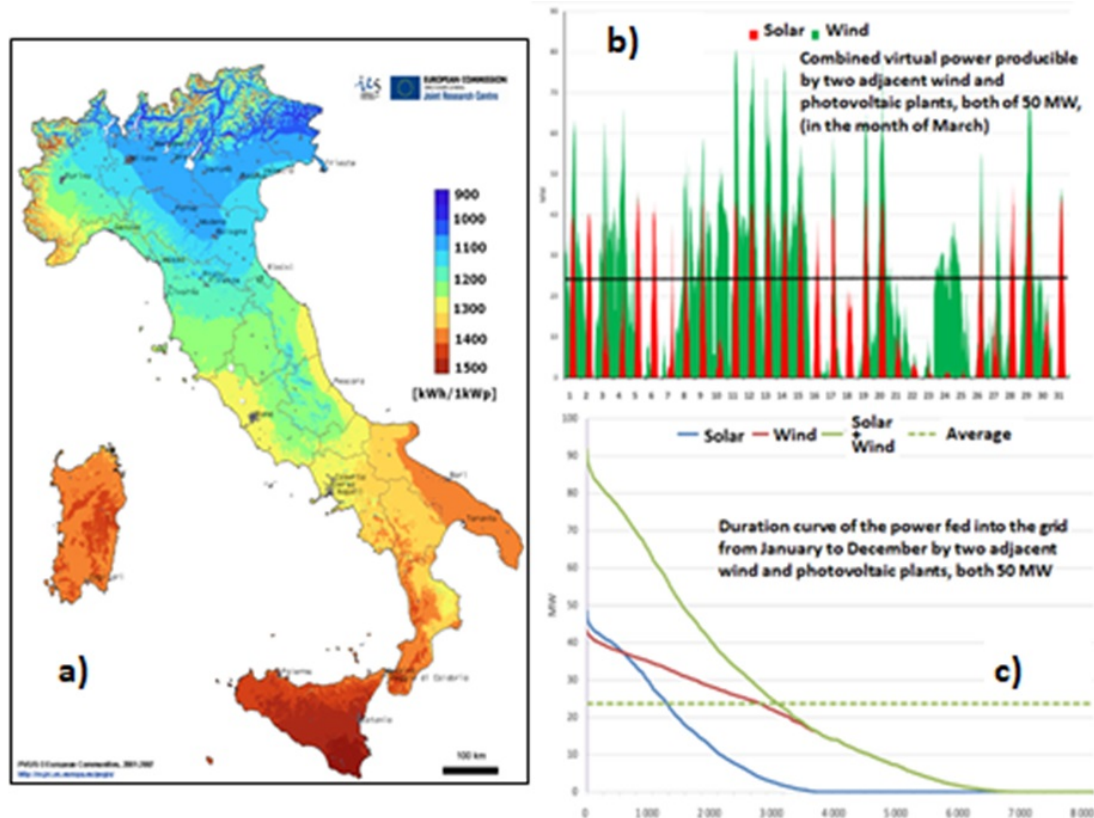


Figure 4: a) annual production in kWh/kWp in different regions; b) and c) variability and unpredictability of production from wind and photovoltaic plants: in tandem wind 50 MW + photovoltaic, with 50MW about 25 MW continuous.

In fact, the need for lithium is not only a resource problem, but also a mining and environmental one; while dismantling, i.e. decommissioning of plants, disposal of batteries, PV panels and wind turbines, are not at all negligible and light-weight operations. If, with regard to photovoltaic and wind power, even combined together as has been attempted to do in order to try to improve the production characteristics, we consider the data coming from experiments and reported in Fig. 4.b) - 4.c) above, we must conclude that at the latitudes of Central-Southern Italy and with the most widespread modern technologies (in 2021) [11] the following is valid:

- In terms of power that can be generated in continuous operation, it has been proven that 100 MW of renewable power (50 MW photovoltaic + 50 MW wind) are equivalent on average in a year (but also monthly, at least in a spring month like March) to an actual 23 MW plant. The ratio $100/23 \cong 4$ is very similar to an old rule of thumb in force at ENEL (Italian electricity utility) at the dawn of photovoltaics, when it was argued that to provide a photovoltaic plant with a continuous power of approximately (x) MW, a plant with a peak power of at least (4x) MWp was needed.

- From each kW of peak photovoltaic power installed it would be difficult to obtain annual values equal to or greater than $1100 \div 1200$ kWh/y of production, as for example in Tuscany or Lazio. To reach values of $1100 \div 1200$ kWh/y it is necessary to go down in latitude to Puglia. In any case the maximum achievable is recorded in Sicily with 1500 kWh/y. Obviously these values are conditioned by the performance of the photovoltaic panels; e.g. monocrystalline silicon assumptions with performances of approximately 21%. This type of panel has recently undergone significant improvements bringing, with different construction techniques, the performance to values between $23 \div 28\%$.

Furthermore, the so-called bifacial panels, whose production was started right here in Sicily by ENEL through its subsidiaries, also exploiting the reflected light coming from behind, seem to promise other significant results in terms of production.

6 General observations on sustainability aspects in the EU and UN context

The return of war in Europe is not considered separate from the problems of the energy crisis, which in a free market context, according to some, has exposed and exposes consumption to speculation, since energy quotas necessary for an economy can be granted at a higher price to other "wealthier" ones, causing de facto shortages and price increases on the internal market of that economy. Historically and until recently, from the point of view of economic planning, a clear linear correlation between energy consumption and the gross domestic product of a given economy in the Western system has always been supported.

To the point that sometimes the development planning of that economy was based on institutional models even for single sectors of activity, which assumed such a correlation as valid. Subsequently, the following factors:

- the recent structural crises that afflict the global economy.
- the liberalization of national energy systems in the Western world.
- the rejection of nuclear energy for peaceful uses of electricity generation in many countries, together with the development of the concept of energy saving as a supplement.
- the reduced power of control and participation by States in economic activity in general, despite the introduction of specific control Authorities (especially in the EU).
- some court rulings (Italian case)[12] that have not recognized energy as a primary good, together with the volatility of prices of primary energy sources (fossil and nuclear in particular) that have facilitated speculative attitudes on the market.
- sanctions and retaliations caused by recent conflicts that have opened in the Western world, etc...

seem to have exposed the free energy market to the breaking of this correlation. If, instead of using the percentage growth of GDP, we used the Human Development Index according to the United Nations formulations, the linear correlation disappears and the link between GDP growth and economic development seems to take on more evanescent forms and certainly less correlated to the current development model, almost calling for its change. (see Fig. 7).

ETS – Emission Trading System - Recent fluctuations in the cost of CO₂ emissions (which can exceed the value of €100/t, although the trend is now reversed). The economic equivalent of the CO₂ avoided in a project compared to the average of the economic system in which it is implemented could constitute a further element of the project's financeability.



Source: © Statista 2024

Figure 5: ETS – CO₂ Emission Cost - Jan. 2022 – Feb. 2024

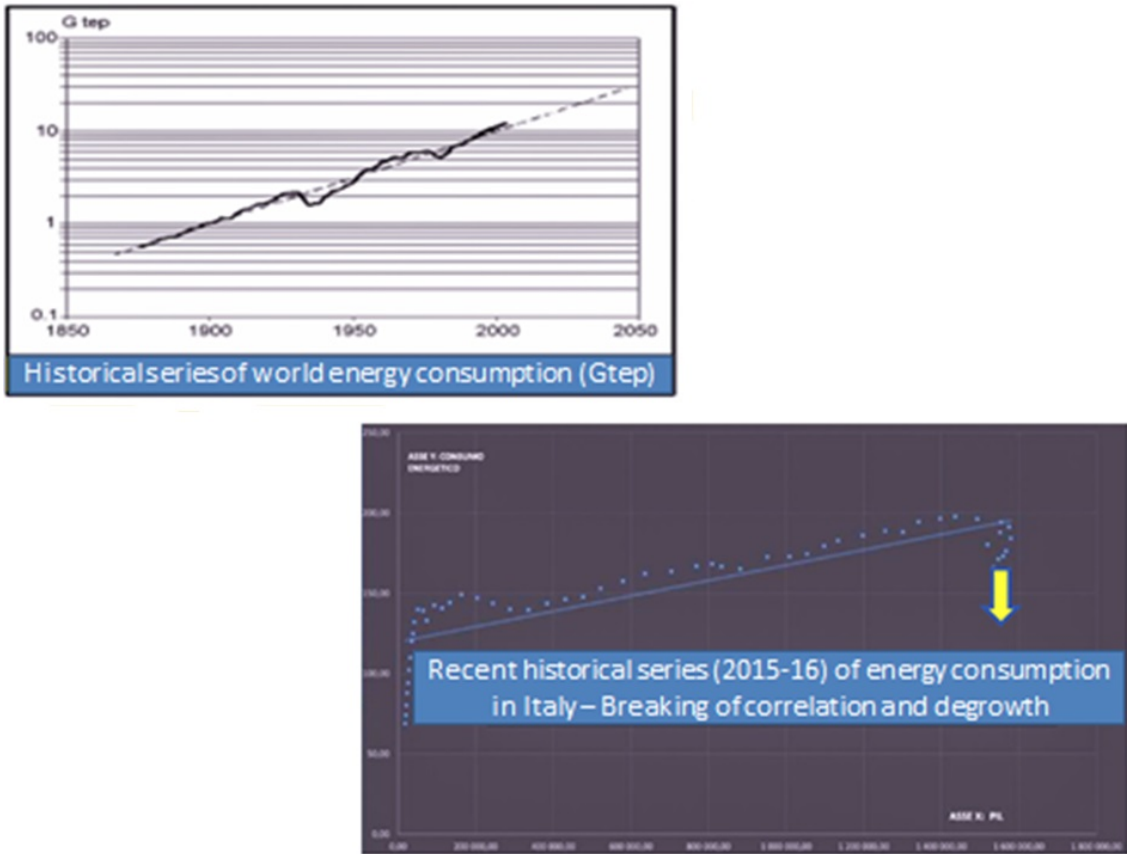


Figure 6: Global energy consumption. Top image - Correlation between energy consumption and GDP in Italy; Bottom image - Points to where there has been a break in the correlation and a decrease.

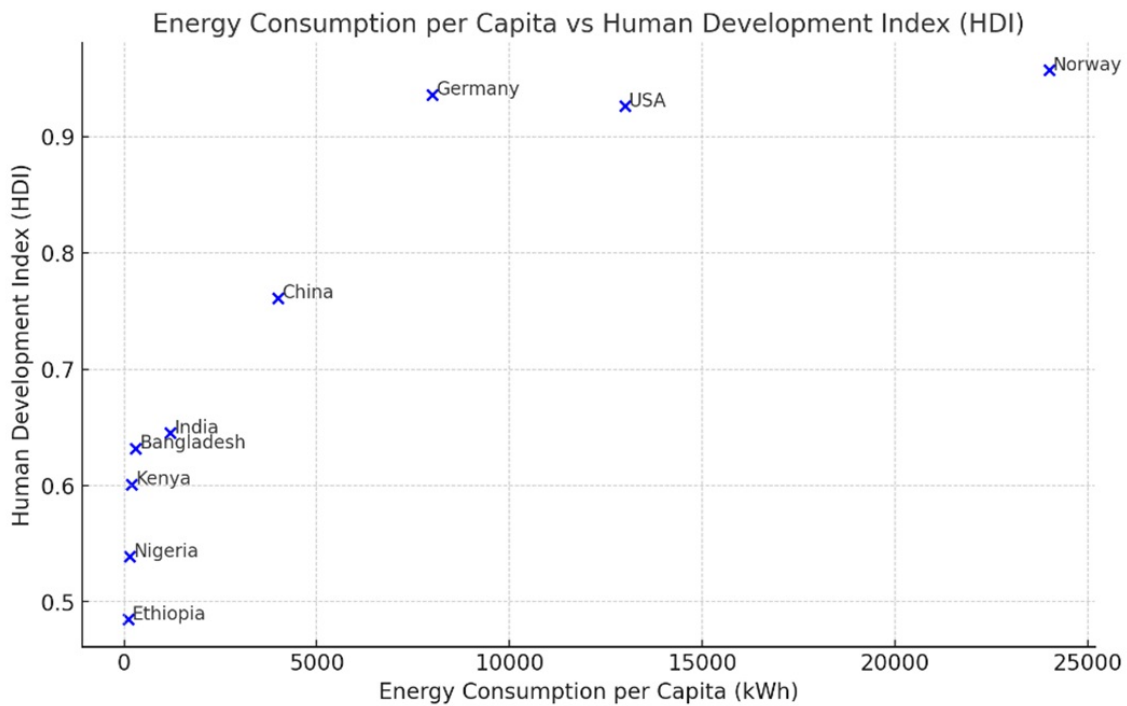


Figure 7

All this seems not to consider the close link between sustainability, especially financial, of an economy and growth of its GDP for the purpose of sustainability of the relative public debt (often forgetting the private one), which today at a global level has reached the value of 313 trillion dollars (Source ISPI 2023) [13] compared to a global GDP of 105 trillion dollars (source World Bank). Therefore with a ratio of approximately 3 between debt and global

GDP. Without taking into account, in this ratio, the derivatives for which:

"Outstanding interest rate and FX derivatives (notional amounts) increased by 17% and 12% during the first half of 2023 to reach \$574 trillion and \$120 trillion, respectively."[14]

In practice, although the large economies are guarantors with the solidity of their respective productions of the value of their currency, in reality the world is sitting on a mountain of paper money that has no collateral to guarantee it. This has been the case since those famous words "dollar is our currency, but it's your problem" were uttered in 1971, after a productive thirty years under the Bretton Woods agreements. Today, there are those who are once again calling for a return to the "Gold Standard" as a necessary collateral in international transactions, just as the countries participating in BRICS seem to be seriously jeopardizing the supremacy of the US dollar.

This little aside is to say that, ultimately, there is not only the "information catastrophe" that can be expected in the long-term future, but also an energetic and monetary one, which could come even earlier, in the short-medium term, if we do not take cover with equanimity and intelligence (where perhaps the artificial one, although highly appreciable, might not be enough!).

And in this climate, it is also true that the West seems to have changed its face and that of the WASP [15] (outlined by Weberian sociological analysis), dedicated to the Protestant ethic and the evolutionary spirit of capitalism, as a tool for growth and global and other people's evolution. A change that seems well perceived by many, by now. And in this context there are those who cannot find anything else - it is difficult to say whether as a proposed remedy! - than:

- The renunciation (particularly in Italy) of the use of nuclear power for peace purposes (electricity generation) and the use only of renewable energy or gas (low-carbon), without having properly taken into account the quantitative human needs, but contradictorily posing the problem of energy poverty of populations in cold or mountainous areas and without paying attention to the growth of plutonium (Pu) and highly enriched uranium (HEU- bomb grade) inventories for military purposes.

- Wars of dominance: which expose, through the "first strike", the entire world to the nuclear danger of annihilation of the planet we live in.

- Great Reset and abolition of private property: for example, one's own house has become the only "expropriable" collateral for one's debt, real or artificially constructed through one's CO₂ footprint, perceived as an enemy and whose price can fluctuate on the ETS (Emission Trading System) market reaching and even exceeding €100/t, knowing that for every kWh of electricity produced by fossil fuels there is an emission that can reach and exceed 0.5 kg/kWh depending on the case. CO₂ is considered an even greater enemy than water vapor for greenhouse effects (Fig.8); vapor that is the greatest forcing in the models that predict climate change, but that we persist in not wanting to consider together with other possible causes of a change that is evident to all. Except for the same ones who refuse to take into account other non-anthropogenic effects, such as solar cycles and high-intensity coronal mass emissions, given that the aurora borealis, once a privilege of Northern Europe, have now come to manifest themselves even as far as Southern Italy (Puglia) in autumn 2024

- change in traditional reference values that have made not only the West grow, but freed a large part of humanity from primary needs.

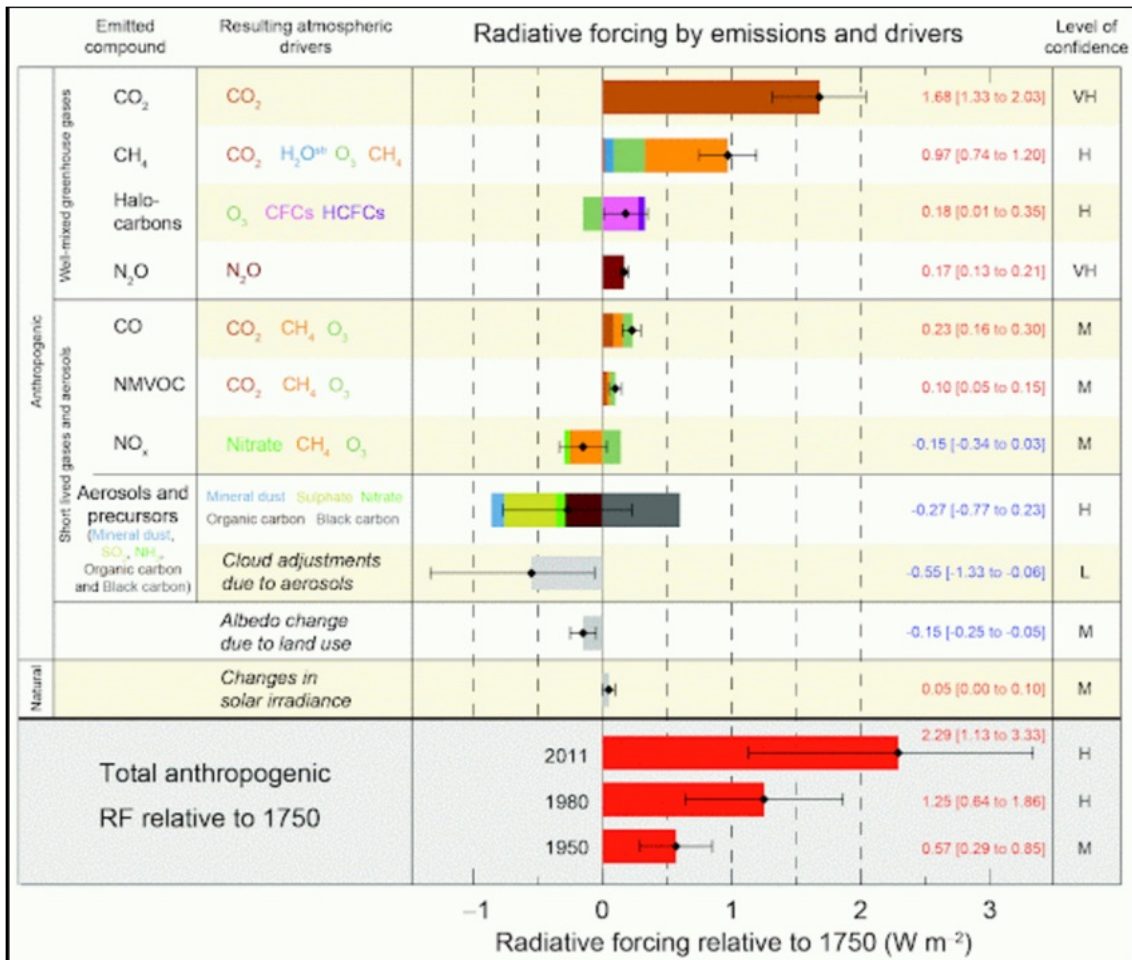


Figure 8: Source NOAA

It should be noted that "water vapor is the greenhouse gas with the highest concentration in the atmosphere (on average 0.33%, reaching 4% in certain periods) and is the one that contributes most to the greenhouse effect (with an estimated contribution of 70%, which reaches 98% if the effect created by clouds is also considered). The greenhouse effect theory itself was born in the early 1800s precisely to explain the decisive role of water vapor in the atmosphere. In the atmosphere, water molecules capture the heat radiated by the Earth, spreading it in all directions, thus heating the surface of the Earth before being radiated back into space" [16]. This is not to deny that CO₂ is an important forcing agent responsible for the greenhouse effect, but rather to highlight that the cancellation of its footprint cannot be achieved with wind and photovoltaic plants alone. In fact, an electrical network formed only by plants of this type would be devoid of regulation and could not perform the function for which it is intended. Yet, paradoxically, "beyond a constant problematic on/off the grid switch", even wind and photovoltaic energy could be accumulated in the form of thermal (molten salts), hydro (pumping) or electrical (batteries) energy and therefore also contribute to the primary and secondary regulation of the network, but so far this has not even been taken into consideration due to the significant economic and environmental costs it would entail. In fact, it would be necessary to have solar thermal mirror systems with storage in very hot and corrosive molten salts, or large UPS with batteries (which would last a short time), or to build pumping hydro-power projects (if the site allows it), where the daily photovoltaic (or wind) production of 350 MWp could power 100 MW hydroelectric pumping groups, with high installation costs and high consumption of land taken away from alternative uses (for example agricultural use). Furthermore, as previously mentioned (in Fig. 4.b,c)) experiences carried out with the coupling of 2 plants of 50 MW each, with overlapping production, one wind and the other photovoltaic, produce together as an ideal plant of another type that operates at a power of about 25 MW continuously (see Rivista

Energia 2021 04). In any case, it should not be forgotten that, due to their intermittency, wind and photovoltaic energy can create problems of availability, regulation and stability of the local network, especially in an interconnected network such as the European one, where "a problem on energy exchanges in the Balkan area has repercussions on the entire continent" (see RSE research cited [11]). So, faced with reasoning of this and other nature regarding the current energy sources available, even at EU level, after a long and troubled debate, as well as assessments on sustainability regarding the environmental impact of each technology, we arrived first at a change in the taxonomy, including nuclear energy among the green ones, and then at the acceptance of nuclear energy (especially if produced by safe SMRs - Small Modular Reactors) in an appropriate mix that varies from country to country. This, also as an objective not only as a fight against climate change through the reduction of greenhouse emissions, but also as an environmental impact generally understood on the basis of different "weighted" parameters. But in this European framework, perhaps the little-known and perhaps most significant thing to consider is that the UNECE, the European Economic Commission at the United Nations, has produced a "Life cycle assessment of electricity generation options – September 2021" [17] which shows that among the most sustainable electricity production technologies in absolute terms, there are hydroelectric (up to 360 MW), nuclear, wind and photovoltaic. In particular, in the following graph extracted from the aforementioned report, it is highlighted that these technologies, to produce 1 kWh of electricity, consume much less than 1 kWh throughout their life cycle. While, on the other hand, all technologies that use fossil fuels (among which uranium cannot be considered, classified as non-renewable) to produce 1 kWh = 3.6 MJ consume no less than 8.4 MJ (>2 kWh). However, it would be a serious mistake (and above all a loss of attractiveness for the business of data centers!) to ignore the recent photovoltaic technologies that use mono crystalline silicon, especially those with high efficiency and that reach efficiency of 28%, or the bifacial ones (which also exploit the energy reflected back) recently developed by ENEL in Sicily, where efficiency of even close to 30% are expected, depending on the operating conditions. The expansion of renewable energy deserves to be promoted in any case for the aspects of minimal energy self-sufficiency and ultimately energy security for individual users, domestic users, small or medium-sized businesses, or even national or international ones as it is the case of data centers.

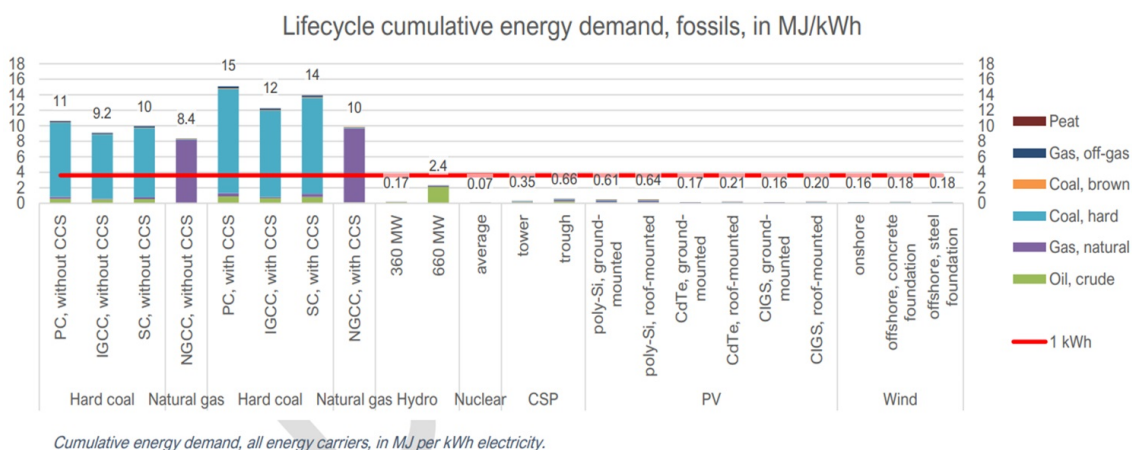


Figure 9: Energy balance on the life cycle of each technology - Extract from the 2021 UNECE report cited

7 Warnings regarding Data and Contents (material and immaterial) in the old and new Italian Data Centers, as well as on their possible Use

There are important aspects to clarify in order to decide on the new (but perhaps also old to be reviewed) Italian data centers that are planned to be built (or strengthened and updated). These aspects concern property rights, concessions, patrimonial, management and purpose

rights, as well as use and benefit rights, as well as safety and security from a military and national security point of view. This is also particularly true for all data, software, information, assets, etc., that can be generated through social media and that involve individual citizens, as well as institutions, not simply for privacy aspects. The experiments and simulations that are now possible through social media also constitute an important point to reflect on before any decision in this regard. Conflict and at least competition, which now seem to be dominant aspects of our time, teach us that the location in which they will inevitably end up taking place will increasingly involve cyberspace first and foremost. Therefore, cyber-security and cyber-safety play a central role. By way of example and certainly not exhaustively, the following aspects regarding big data are cited:

- Data Ownership: which refers to the fundamental rights and responsibilities related to data. For instance it is a critical aspect of BDAs.

- Data Property Types:

- Data ownership: This concerns who owns the data itself.
- Data platform ownership: Refers to who manages the infrastructure (such as data lakes) where the data resides.
- Data Product Ownership: This concerns those who create value from data through analytics and applications.

- Purpose of big data analysis:

- Improve existing processes and products.
- Develop new data-driven business models.
- Enable exploration and experimentation with data for innovation.

It is taken for granted, and worth checking, that there is an ethics to this, also known simply as data ethics, concerns the systematization, defense and recommendation of concepts of right and wrong conduct in relation to data, especially personal and institutional data. With the exponential increase in the quantity and quality of data since the dawn of the Internet, it is essential to consider the ethical aspects of data management. This includes issues such as the use of unbalanced starting data, privacy violations and the pursuit of short-term return on investment at all costs. It should also be remembered that social experiments, such as social lasing, can be conducted through social media, which raise important ethical and legal questions. The theory of social lasing [18], developed by Prof. Andrei Khrennikov, a globally recognized scientist, well known even in IPI, is an interesting area of research that connects quantum physics to social behavior. However, at the moment, we cannot consider it a consolidated scientific theory (and this implies the need to have to experiment with social media, since a theory without experimental verification, although deduced and supported mathematically cannot yet be considered properly Science). Let's see some key points:

- Social Lasing Concept: According to this theory, social atoms (analogous to photons in lasers) can interact through infons (excitations of the quantum social information field). This process could lead to "social lasing", similar to lasing in physical lasers.

- Infons and Social Energy: Infons carry social energy and contain communication information. The idea is that social atoms can reach a state of population inversion (similar to the concept of population inversion in lasers) thanks to infons.

- Experimental Tests: At present, there is no solid experimental evidence to support social lasing. The theory is still under development and requires further research and empirical testing.

- Applications and Implications: Social lasing theory may have interesting implications for

understanding social processes, but it is still a subject of debate and study. In summary, while the theory of social lasing is fascinating, we must await further experimental verification to establish its scientific validity.

It is therefore appropriate to reaffirm the following concepts regarding social media:

- **Informed Consent:** Most laws require informed consent for participation in experiments or research. If social media users are unaware of the experiment and have not given specific consent, this may violate privacy laws and research ethics.
- **Transparency:** Transparency is key. Social experiments should be conducted in a way that clearly informs participants about what is happening and obtains their explicit consent.
- **Local and International Laws:** Laws vary from country to country. However, many jurisdictions have privacy and data protection laws that require compliance with consent and transparency.
- **Ethics and Responsibility:** Just because something is legal, it does not necessarily mean it is ethically acceptable. Companies and researchers should consider the social and moral impact of their actions.

In short, the social experiment - on social media - without informed consent could be illegal and certainly raises ethical concerns. It is important to respect the rights and privacy of social media users. Here are some past examples of controversial social experiments that have sparked debate and concern:

- **The Halo Effect:** This experiment showed that global evaluations of a person (e.g., how likeable they are) also influence judgments of specific traits (such as intelligence). It is also known as the “beautiful is good principle” or “physical attractiveness stereotype.”
- **Cognitive Dissonance:** This experiment explores the mental discomfort people experience when they try to hold two conflicting beliefs in their minds. To resolve this discomfort, people change their thoughts to align with one of the conflicting beliefs and reject the other.
- **The Thieves’ Cave Experiment :** This study examined how prejudice and conflict emerge between two groups of boys. It found that groups naturally develop their own cultures, status structures, and boundaries, and then come into conflict with each other. The key to reconciliation was focusing on higher goals that go beyond the boundaries of the group itself.
- **The Stanford Prison Experiment:** Conducted to explore how people would react to being prisoners or prison guards, it revealed how ordinary, healthy individuals could behave cruelly as prison guards in certain situations, even if it went against their personality.

These experiments have contributed to our understanding of social psychology, but have also raised important ethical and moral questions. Although it is no longer possible to find an adequate reference today, it seems appropriate to recall in this context an experiment on social conformity that was discussed among sociology and psychology students in the 1970s. The experiment was conducted by a majority control group on a single minority group. In identifying a double choice (a white or black billiard ball drawn at random from a container) a specially instructed control group lies by stating the opposite of reality (white when in reality it is black), clearly showing in the results the effects of social conditioning that the pressure of the majority produces on a part of the minority regardless of the truthfulness of the contents stated. The experiment referred to here is also equivalent to the one known as the Asch experiment on social conformity. Solomon Asch, a social psychologist, conducted this study in the 1950s to examine the pressure of hope that influenced individual perception. Here is how it worked:

- **Participants:** Asch involved a group of participants (usually eight) and put them together in a room.

- Visual stimuli: He showed them a series of three segments of different lengths and asked them to indicate which of them was the same length as a standard segment.
- Group bias: However, the other participants were actually complicit in the experiment and deliberately gave incorrect answers. For example, if the segment was clearly black, the group assumed it was white.
- Results: 75% of participants complied with the group's incorrect answers at least once. In absolute terms, participants gave clearly incorrect answers in 32% of cases, while without group pressure, the correct answers rose to 98%.

This experiment demonstrates how social conformity can influence individual perception, leading people to change their minds or deny objective evidence due to group pressure. Now let's imagine all this practiced on social media and try to envision what might happen.

8 Concluding remarks

A data center cannot rely only on the existing electricity grid, but must be able to operate in off-grid conditions through its own electricity generation plant (even for emergency conditions only); a generation plant that must be part of the basic equipment and possibly located close to the data center itself. Where this is not possible, the free market conditions of the electricity sector (where already existing!) can allow production in any location and withdrawal of production where necessary for the data center, covering the transport/distribution costs.

If, for normal (non-emergency) operation, a data center relies on the existing electrical grid, it must necessarily provide power factor correction/regulation equipment and have its own redundancies (e.g. UPS, emergency diesel generators or turbogas in quick start-up configuration) to allow stand-by conditions for a well-defined period while waiting for normal operations to be restored.

It is difficult to deny, especially according to the aforementioned UNECE study, that the most sustainable technologies for electricity generation are essentially hydroelectric up to 360 MW, nuclear (especially SMR and AMR), photovoltaic and wind. All these technologies have advantages and disadvantages to be assessed locally. For example, nuclear and hydroelectric are disadvantageous for long and complex authorization processes above local acceptance consent; renewables are disadvantageous for production variability, land consumption and visual impact).

In spite of possible disadvantages and necessary remedial measures that the photovoltaic technology may imply, a data center equipped with a photovoltaic power plant (on-grid connected) sufficient to cover almost all energy consumption is extremely beneficial from the business point of view. The emissions avoided may also increase such beneficial aspects in case of issuance of tradable "green certificates" through ETS. All this may be verified in the investment analyses and business planning.

In all cases, investment analyses should be based on existing hard data, using appropriate scale effects, and should consider the risk of IT technology change over the life cycle (20 years) before investment break-even, as well as considering all aspects of decommissioning and end-of-life data retention/transfer.

The estimation index of Normalized Annual Processing Power (NAPP) in equation (9) – or similar equivalents – is only a hypothetical proposal to be established and improved during the field research activity (on existing data centers). This is to stimulate the evaluation of past data, formulate historical series and evaluate further parameters of minimum guaranteed operation that can be useful when setting the contractual parameters. However, these are parameters to be established in the purchase contracts and to be measured during the testing phase of the data center (relating them to the established contractual value and any performance penalties), especially in the case in which their construction requires a "main

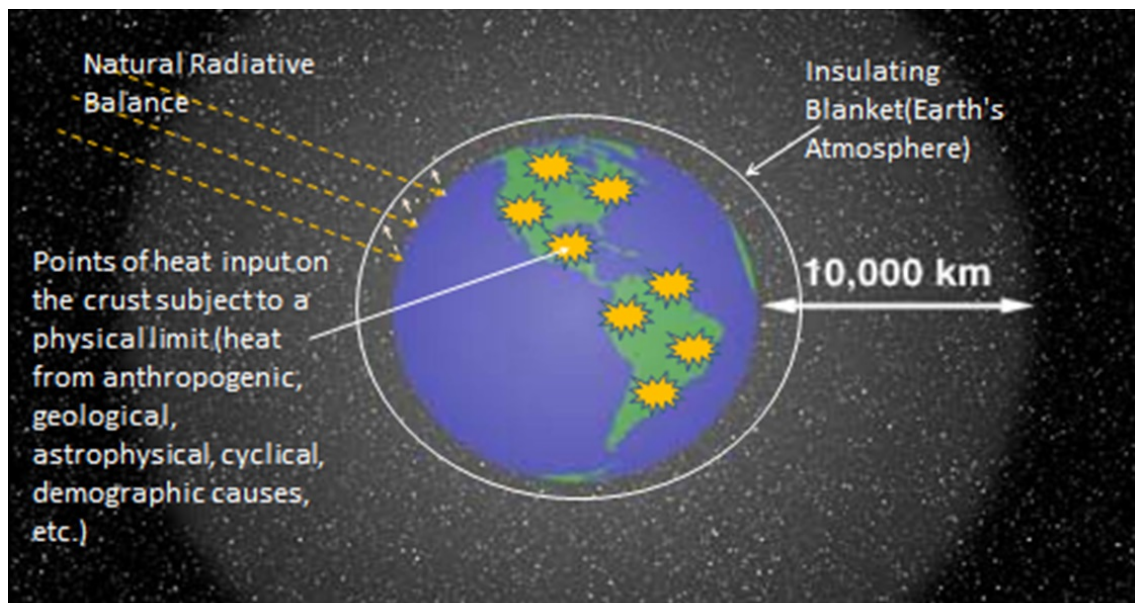
contractor” acting on a “turnkey” basis or an “architect/engineer” with managerial functions responsible for the construction.

The option of equipping a data center with generation plants with self-production of electricity greater than the expected consumption necessarily implies – given the power involved – entry into the local electricity market, with its own typical licensing procedure.

The aspects of data ownership, the purposes of data collection, storage and analysis are covered by principles of ethics and responsibility that are increasingly evolving and could encounter obstacles not only in institutional apparatuses, but also in civil society, where there is an increasing worry of a social control that can be implemented through the WEB by States, but not only.

In the Environmental Impact Assessment of a major project (required at local/European level for the licensing of any major project) the focus is usually on polluting emissions and in particular on greenhouse gas emissions. In reality, beyond the causes, whether anthropic, geophysical, astrophysical, etc., climate change is manifesting itself with undeniable evidence. The possibility of arriving at «The Information Catastrophe» (and similar!) mentioned above, cannot be further underestimated, together with all the other possibilities of global geo-political instability that can be induced by the economic-financial and ecological elements concerning energy and in particular the reserves of primary energy and related resources (rare earths, metals, etc.).

Ultimately, alongside «The Information Catastrophe» which is expected to be longer term, a particular general comment on energy systems, which goes well beyond data centers, seems appropriate to remember on this occasion too. As is well known, all energy, of any kind, consumed on Earth, is ultimately transformed into heat and gives rise to a typically local limit on energy consumption itself. A limit that cannot be the same in all places on the planet in order to guarantee human livability and that of autochthonous eco-systems.



REGARDLESS THE CAUSES, HEAT CAN BE PUT INTO DEEP SPACE IN AN UNLIMITED WAY, BUT NOT ON THE EARTH'S CRUST, TO AVOID THE TEMPERATURE INCREASE CONTAINED BY THE INSULATING BLANKET (ATMOSPHERE)

Figure 10

Even if we assume that CO_2 has a negligible or zero effect on climate change, it is quite clear that making available to humans supposed new technologies[19] that would make unlimited quantities of energy available at very accessible conditions, entails problems of sustainability and education in its use. In fact, it must be remembered that all the energy released onto the Earth's surface under the atmospheric blanket that is “insulating” with respect to the frozen deep space (see Fig. 10), would influence in the long term the local and

non-local climate, beyond the CO₂, despite the fact that in this case it is claimed that these are small quantities (but not the same everywhere). In short: HEAT CAN BE LOCALLY INTRODUCED IN AN UNLIMITED WAY INTO DEEP SPACE, BUT NOT ON THE EARTH'S CRUST, UNDER PENALTY OF AN INCREASE IN TEMPERATURE OF EVERYTHING ENCLOSED BY THE THERMALLY INSULATING BLANKET (ATMOSPHERE). Those who preside over the formation and transmission of Science and Technology, in addition to engaging in research on nuclear fusion, which would obviously be liberating for the needs of all humanity, should at the same time question themselves, research on the subject and identify the "natural" limits for local energy consumption, everywhere, under the canopy of the Earth's sky (and atmosphere). Such limits are not the same everywhere should be publicly known! In addition to what is reported above for illustrative purposes, data centers must comply with international technical standards. It was therefore considered useful, for any technical insights [20], to report in Table 4 below a list of the main international standard regulations applicable to data centers.

Item	International Standard	Applicable to
1	• ISO/IEC 27001	Information Security Management
2	• ISO/IEC 30134-2	Data Center Energy Efficiency (PUE) Measurement
3	• EN 50600	Data Center Infrastructure Design, Construction, and Management
4	• ANSI/TIA-942	Telecommunication Infrastructure in Data Centres, Including Reliability and Security
5	• ASHRAE TC 9.9	Cooling Management (Thermal Guidelines for Data Centres)
6	• Uptime Institute Tier Standards:	Classification to Assess Data Center Reliability and Redundancy

Table 4: List of major international standards for Data centers.

Finally, it should be noted that the first results - mentioned above - of a study to evaluate the possible economic and financial aspects of the use of photovoltaic energy also for hydroelectric pumping, in order to regulating the electricity grid, are reported and available in reference [21].

References

- [1] References: IREFI ; Agenda Digitale ; ANSA.it ; <https://techfromthenet.it/2024/06/24/ida-i-data-center-italiani-sono-in-forte-crescita/>
- [2] Antonio Piemontese-Italia, place of innovation 05.10.2024 - The project of the largest data center in the South - It will be built in Caserta and will serve an area of five million inhabitants. On the table an investment of 300 million - Refer to the following link <https://www.wired.it/article/data-center-caserta-sud-italia>
- [3] M.M. Vopson, The Information Catastrophe, AIP Advances 10, 085014 (2020) - <https://doi.org/10.1063/5.0019941>
- [4] The minimum technical requirements for participation requested by generation plants use as a reference both the guidelines adopted internationally UCTE1, and the local Technical Standards CEI 11-32, (in the Italian case).
- [5] 2023 (Feb 2023)-Reflections for a Possible Research on the Generalizability of the Total Cost Concept - Morelli Rocco Ref. <https://zenodo.org/records/7677250> - A preliminary examination of cases (industrial production plants) with different values of fixed and variable costs, through the consideration of production variations, highlights concepts useful for evaluating production flexibility, partly also for the purpose of greater resilience to market-induced variations.
- [6] R.Morelli - Brief Market Survey On Photovoltaic (In Italy – Summer 2023) <https://zenodo.org/records/8331295> - In such survey, assembly costs for some small domestic plants (i 6-10 kWp) have been omitted because they are usually assembled according to "do-it-yourself" criteria.
- [7] Project of a photovoltaic system called "Blusolar Augusta 2" with a power of 34.62 MW integrated with a 10 MW storage system, located in the Ogliastro district in the municipality of Augusta (SR) within the SIN of Priolo and the related connection works <https://va.mite.gov.it/it-IT/Oggetti/Info/8492>
- [8] General Supply Standards UAA TN1 and TN2 from the 1960s, and General Contract Specifications - from the same period (1963).
- [9] G. Carrà – Price revision in industry – Franco Angeli publisher – ISBN 88-204-1420-. In particular page 60 – Use of price revision formulas for commercial evaluations.
- [10] Usually, the fixed part $a = 0.10$ was considered to include (especially in the presence of a down payment of the same amount) the development and design costs to make the project executable.

- [11] Refer to Poster UE-JRC-Ispra (I) ; Rivista ENERGIA - 2 Aprile 2021- Variabilità e intermittenza di eolico e fotovoltaico - Alessandro Clerici, Samuele Furfari <https://www.rivistaenergia.it/2021/04/variabilita-e-intermittenza-di-eolico-e-fotovoltaico/>
- [12] The Supreme Court of Cassation in Italy has established this, specifying that electricity cannot be considered an indispensable good for life, but rather a "good suitable for providing comforts and opportunities that go beyond the concept of uncontrollable necessity". Sep 8, 2017. See: <https://iusletter.com/dalla-redazione/diritto-e-responsabilita-civile/utilities/energia-elettrica-non-un-bene-primario/#:~:text=Lo%20ha%20stabilito%20la%20Suprema,dal%20concetto%20di%20incoercibile%20necessita%20C3%A0%E2%80%9D>. Come pure: <https://www.avvocatopenalista.org/visualizza/news/2017/sentenza/per-la-cassazione-l-elettricit%C3%A0-non-e-un-bene-primario/13608>.
- [13] Global debt levels hit a new record high of \$313 trillion in 2023, with developing economies scaling a fresh peak for the ratio of debt to their gross domestic product, a study showed [https://www.reuters.com/business/global-debt-hits-new-record-high-313-trillion-iif-2024-02-21/#:~:text=LONDON%2C%20Feb%2021%20\(Reuters\),domestic%20product%2C%20a%20study%20showed](https://www.reuters.com/business/global-debt-hits-new-record-high-313-trillion-iif-2024-02-21/#:~:text=LONDON%2C%20Feb%2021%20(Reuters),domestic%20product%2C%20a%20study%20showed). See also. <https://www.ispionline.it/it/pubblicazione/il-debito-del-mondo-e-tornato-a-creocere-144899>.
- [14] Refer to https://www.bis.org/publ/otc_hy2311.pdf - Bank for International Settlement - 16 November 2023 - OTC derivatives statistics at end-June 2023.
- [15] White Anglo-Saxon Protestant - https://en.wikipedia.org/wiki/White_Anglo-Saxon_Protestants.
- [16] Greenhouse forcing power of water steam https://it.wikipedia.org/wiki/Vapore_acqueo.
- [17] Life cycle assessment of electricity generation options - September 2021- Commissioned by UNECE - Draft 17.09.2021 - Authors: Thomas Gibon, Álvaro Hahn Menacho, Mélanie - Luxembourg Institute of Science and Technology – available at link https://unece.org/sites/default/files/2021-09/202109_UNECE_LCA_1.2_clean.pdf (still branded as "draft").
- [18] See various references below: https://www.youtube.com/watch?v=xQop26MEsG&t=435s&ab_channel=InformationPhysicsInstitute; https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Social+Sciences%2C+andrei+khrennikov&oi=scholar; <https://www.taylorfrancis.com/books/mono/10.1201/9780367817206/social-laser-andrei-khrennikov>.
- [19] For example, nuclear fusion, on which the "G7 Working Group" meeting was recently held to promote research, beyond ITER and Stellarator, which despite everything represent anything but "proven technology".
- [20] ENEA https://www2.enea.it/it/Ricerca_sviluppo/documenti/ricerca-di-sistema-elettrico/elettrotecnologie/5-linee-guida-datacenter-07.09.2010.pdf; KIWA <https://www.kiwa.com/it/it/media/news-eventi/2023/efficienza-energetica-data-center/>; TECHRADAR <https://global.techradar.com/it-it/pro/il-consumo-energetico-dei-data-center-sta-diventando-un-problema-serio>.
- [21] Morelli Rocco. (2023, October 12). Hydro Solar Power Projects> : Why? - Meeting at the University of Rome "La Sapienza" on 10/12/2023. <https://doi.org/10.5281/zenodo.8430982>.