ETH Zurich Department of Architecture
ARCHITECTURE OF TERRITORY
Chair of Architecture
and Territorial Planning
Professor Milica Topalović

The Production of Cloud
Fall 2025

Atlas

Energy Demand

Loris Gomez, Lucien Peguiron, Adam Chong, and Thierry Fong

With the rise of new technologies and the rapid development of artificial intelligence, our world is becoming increasingly dependent on energy. Every click, every search, every digital interaction requires energy. As our data consumption explodes, so does our energy demand, leading us to extract, burn, and exploit resources at an unprecedented rate.

If we do not act wisely, we may one day wake up in a world that looks disturbingly similar to the image below: a bleak, post-apocalyptic landscape where nature has been replaced by machines, smoke, and silence. This imagined scenery stands as a warning as it reflects the possible consequences of our insatiable appetite for progress and connectivity. The more we innovate, the more energy we consume and the more production infrastructure we need. How far are we willing to go to sustain our digital lifestyles?

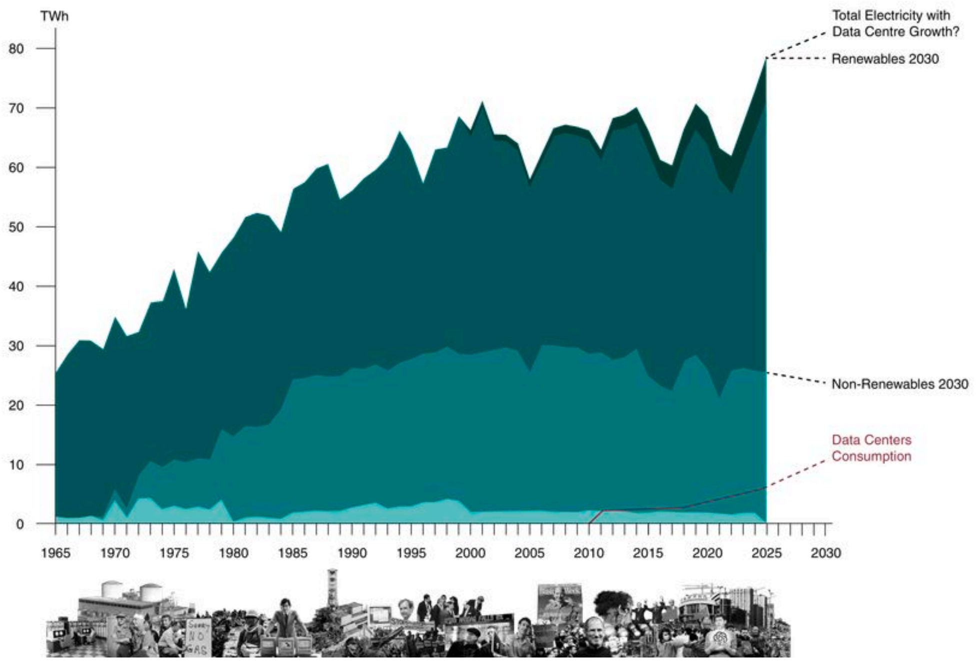
Switzerland 2100 collage. Photograph: Upsmash, 2025. Collage: the authors.

Switzerland today. Photograph: Upsmash, 2025.

A Brief History of Swiss Energy

Switzerland’s energy system has never evolved in isolation. Instead, it has continuously responded to global political events, technological breakthroughs, and shifts in how societies produce and consume information. Each major transformation in energy demand reflects a broader change in the world beyond national borders.

A decisive recent example of this dynamic occurred in 2022 with the public release of generative artificial intelligence systems such as ChatGPT. Almost overnight, global computing demand surged. The widespread adoption of large-scale AI models dramatically increased the workload of data centres, intensifying electricity consumption across interconnected energy grids, including Switzerland’s. Though intangible to users, each AI-generated response requires significant computational power, embedding global technological events directly into national energy demand.



Swiss Electricity Generation Outlook. Source: the authors.

- Other Renewables
- Hydropower
- Nuclear Power
- Fossil Fuels

Several important governmental and industrial events played key roles in the development of the computer, and in relation, the data centre allocation in Switzerland.

MAINFRAME

In 1963, as the computing industry had developed so rapidly, the university purchased a CDC 1604 mainframe and founded a new computing centre. The new machine was 400 times faster than its predecessor, and presented a pivotal moment in the rise of the computer in Switzerland.

NUCLEAR POWER

Beznau 1 is the first commercial nuclear power reactor in Switzerland that began operations in 1969. This was the moment Swiss electricity began relying more on nuclear power as an essential energy source.

FIRST COLOCATION DATA CENTRE IN SWITZERLAND

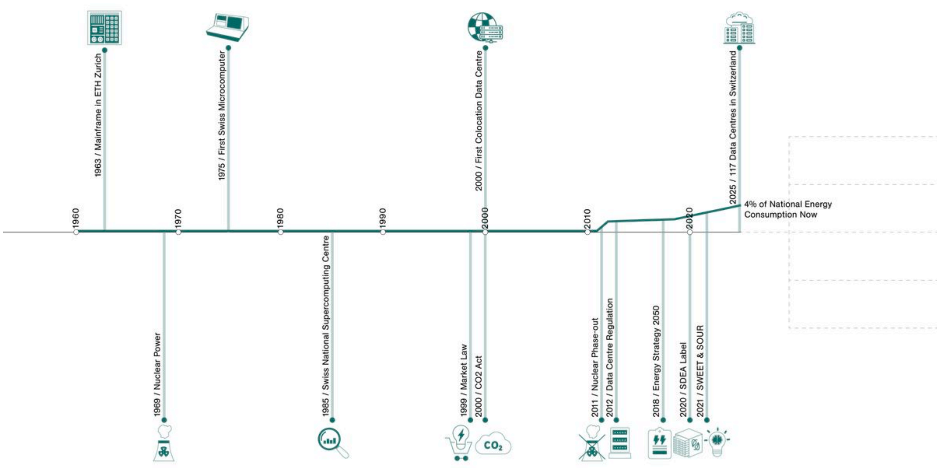
While there is no single authoritative public source that names the “first” colocation data centre in Switzerland, the best, evidence-backed candidate for the earliest purpose- built, carrier-neutral colocation site is likely the Interxion (now Digital Realty) Zurich site in Glattbrugg–also known as ZUR1. We can see this as the rise of the data centre that started roughly in the 2000s.

CO2 ACT

The Federal Act on the Reduction of CO2 Emissions (aka CO2 Act) is a Swiss federal law that regulates carbon dioxide emissions to mitigate climate change. The first CO2 Act was adopted in 1999 and came into force in 2000. The law was totally revised in 2011 and entered into force again in 2013. This represents a focus on the climate that began simultaneously with the entrance of the commercial data centre–signifying an understanding of the environmental impacts of these data centres.

NUCLEAR PHASE-OUT

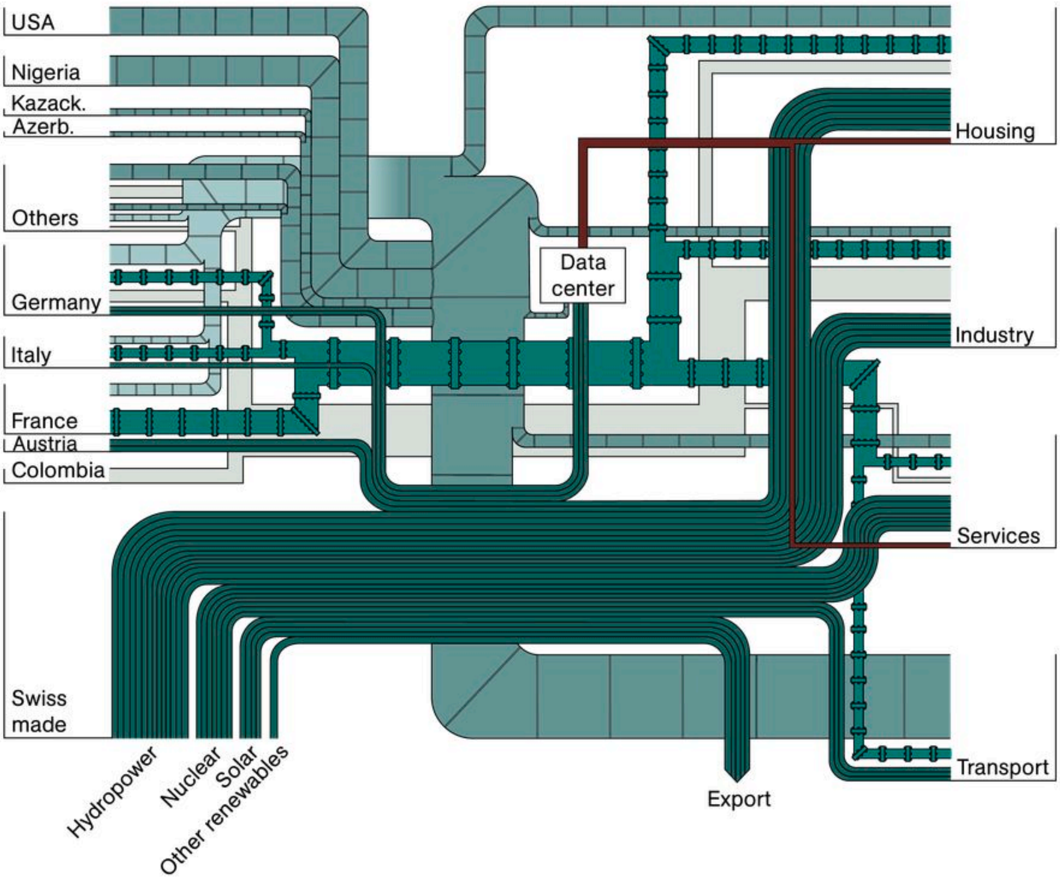
Switzerland is in the process of a nuclear phase-out, which was decided in 2011 and confirmed by a 2017 referendum, after the Fukushima Power Plant Disaster. This sparked an urgency to ensure the stability and capacity of renewable energy to replace the energy supply generated by nuclear power plants.



Timeline of governmental and industrial events that played key roles in the development of the data centre allocation in Switzerland.

Today, data centres account for roughly 7 % of Switzerland’s total electricity consumption, a figure projected to rise to 15 % by 2030. This growth is not driven solely by domestic choices, but by global developments in technology, communication, and automation. Switzerland’s energy system thus reflects a broader reality: local infrastructures increasingly bear the energetic consequences of worldwide digital transformation.

The flow diagram that follows situates data centres within this evolving system, tracing how global events translate into national energy demand and how electricity ultimately powers the digital services shaping contemporary life.



Swiss energy flow diagram. Source: BFE Admin.

Heat	Refined Oil	Electricity
Raw Oil	Gas	Others

70 % of energy is imported and 30 % is produced domestically. Oil is the most commonly imported resource. Accounting for 35 % of Swiss consumption, it makes up 60 % of imports, mostly due to the transport industry. The only significant resource produced in Switzerland is electricity. More precisely, this is broken down as follows: 62 % hydropower, 29 % nuclear, 8 % solar and 1 % other renewables. As data centres consume 7 % of the country's electricity, it is important that they are efficient in transforming this electricity into heat for neighbourhoods.

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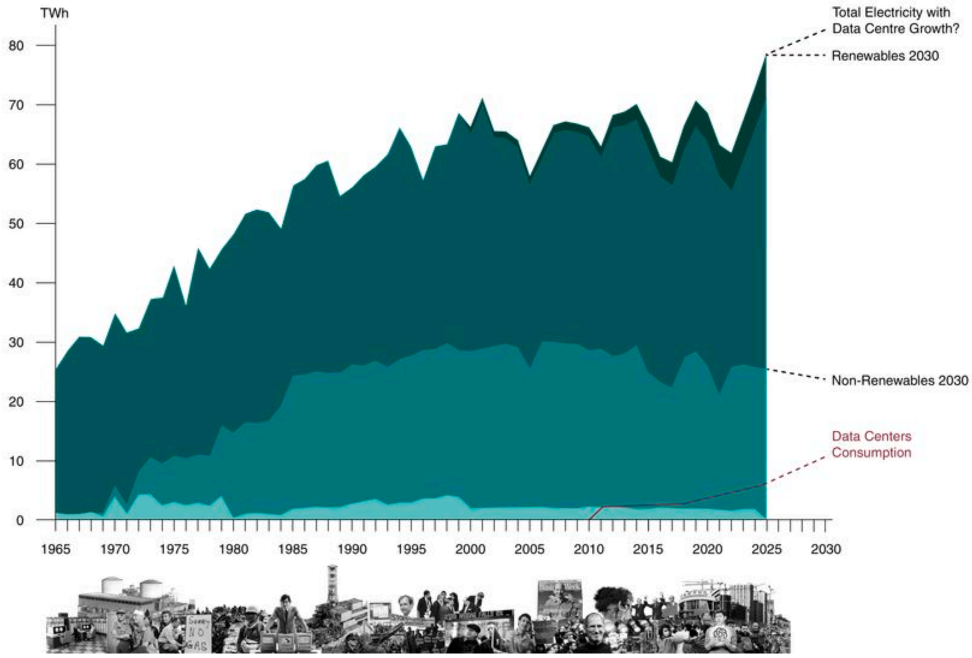

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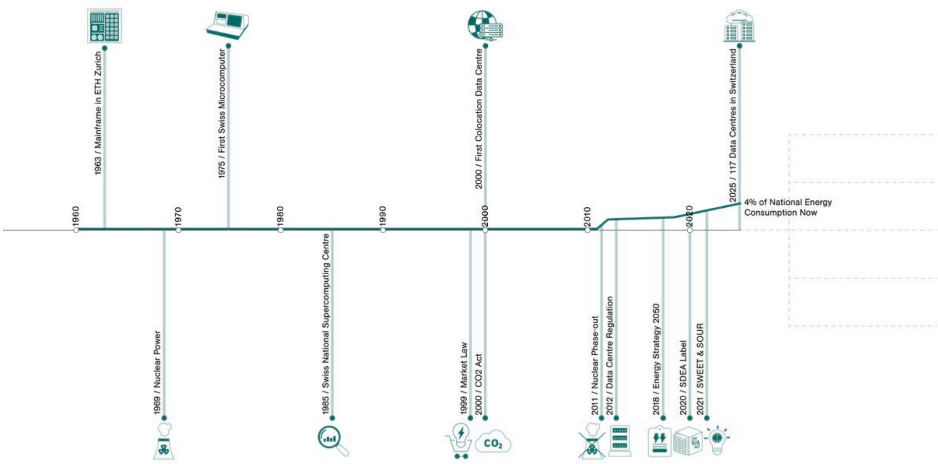

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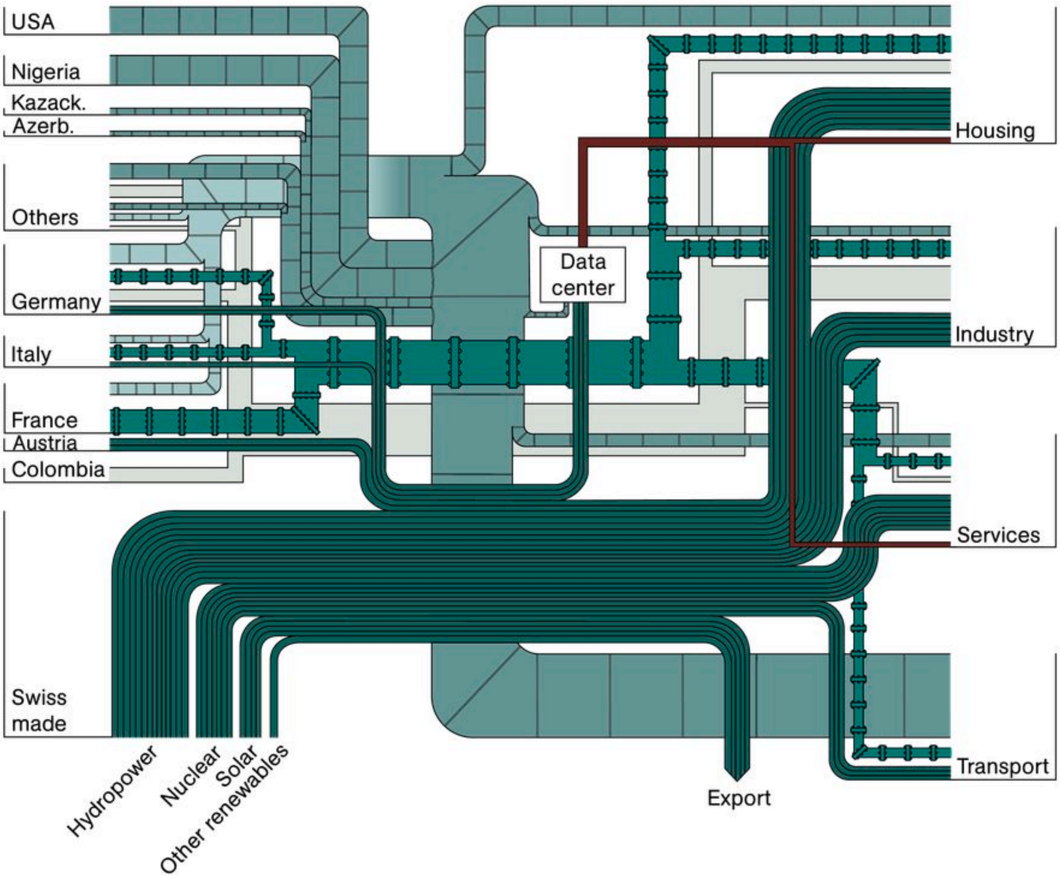

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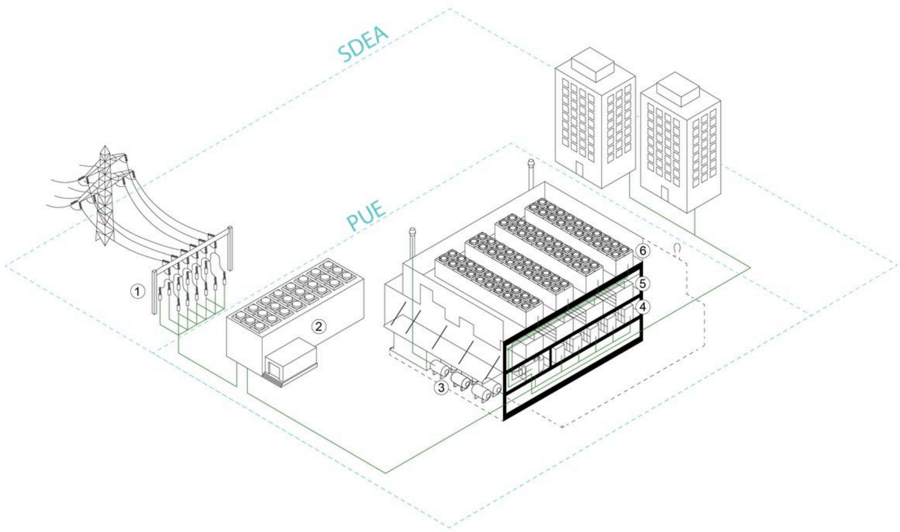
Wired for Power: How Electricity Powers a Modern Data Center

and Its Surrounding Infrastructure

Electricity reaches a data centre through the public grid, typically via high-voltage transmission lines that shift underground before arriving at the site. On-site substations transform this power from transmission levels (110–220kV) down to medium and low voltages suitable for servers and cooling systems.
To ensure uninterrupted operation, data centres rely on layered redundancy. Uninterruptible power supplies and battery systems respond instantly to outages, while diesel generators provide long-term backup during extended failures.
Once inside the facility, electricity flows primarily to IT equipment: servers, storage units, and networking devices. Nearly all of this energy is converted into heat, making cooling one of the most energy-intensive processes within a data centre. In many facilities, cooling accounts for 30–40% of total electricity use.



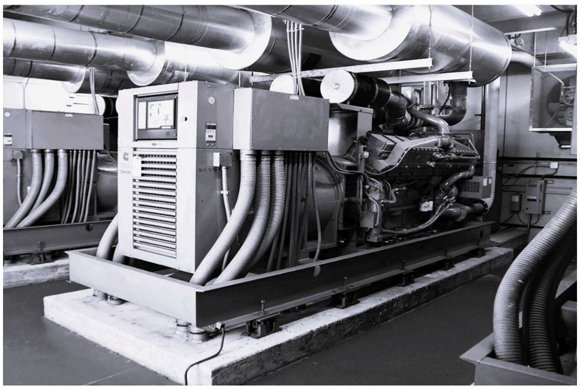
Data center cut axonometric. Source: the authors.

In Switzerland, efficiency is measured not only through Power Usage Effectiveness (PUE), but also through broader frameworks promoted by organisations such as the Swiss Data Center Energy Association (SDEA), which track energy flows, heat reuse, and environmental impact.

The following images break down the physical elements that make up this system:

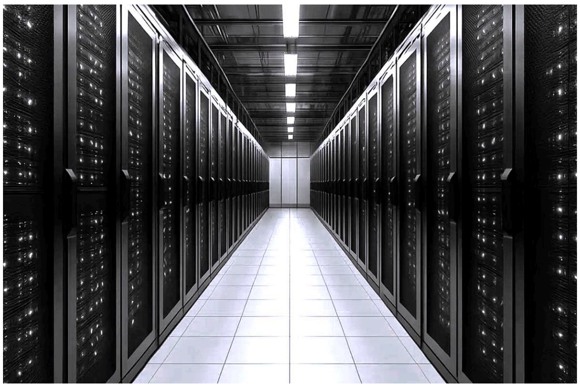
Overhead to underground transition. Source: LHOON, 2008.

Power transformer. Source: CAT, 2017.



Diesel Backup Generator. Source: CSDG, 2020.

UPS batteries. Source: Kim Otte, 2010.



IT equipment. Source: Eolios.

Rooftop air cooling system. Source: Area.

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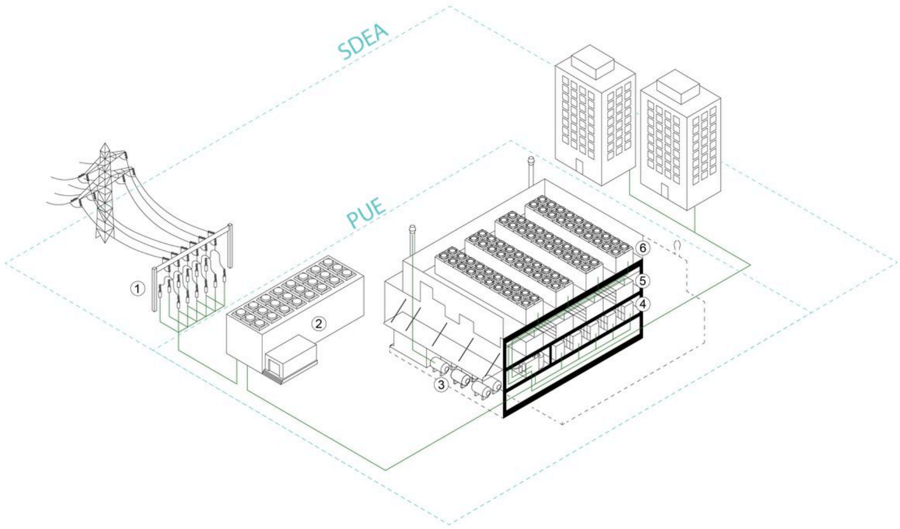

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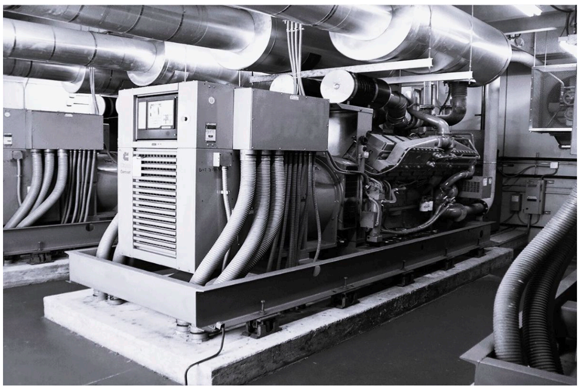

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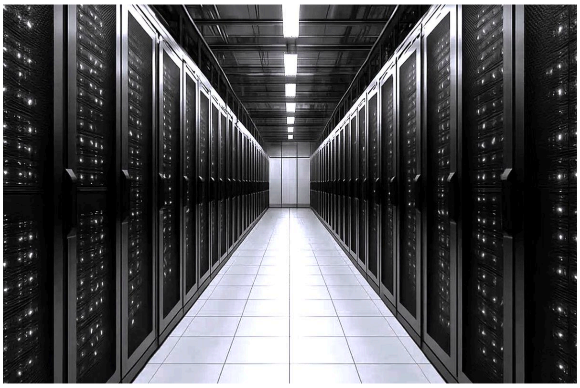

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The Power-Hungry Machine

At a smaller scale, data centres are composed of numerous components, each drawing power continuously:

SERVERS

Servers take up the largest share of energy demand with 56 %. They store the plethora of data that is fed into these data centres for safekeeping.

INFRASTRUCTURE

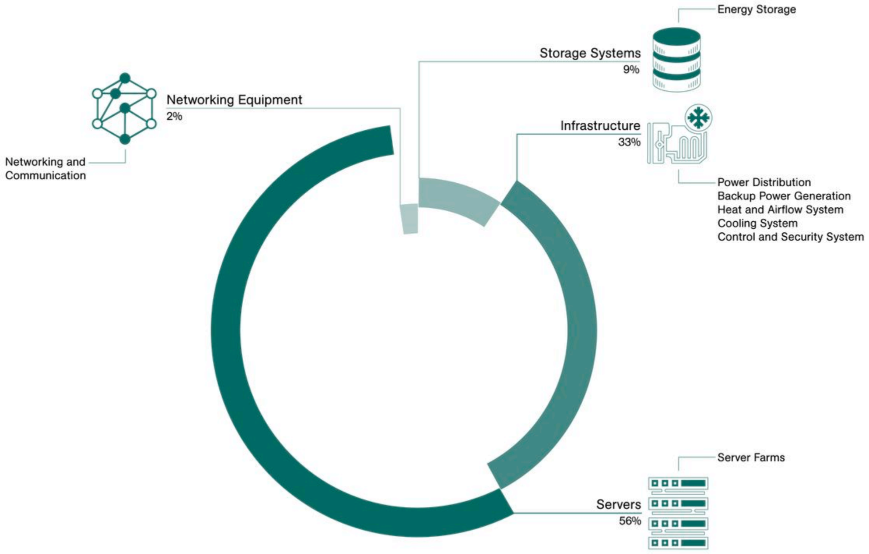
This consists of equipment for cooling, power distribution, lighting and security, backup batteries and generators. Infrastructure takes up the second highest spot for energy used, especially for cooling, which is significant for servers to run.

STORAGE SYSTEMS

Battery systems that provide electricity instantaneously when there is a delay in the start-up of backup power generation.

NETWORKING EQUIPMENT

Taking the lowest share of energy demand, networking equipment includes routers, switches and cabling that help maintain high-bandwidth communication of data.



Share of energy demand by different data centre components globally.

The most power-hungry of these machines will be the SINES Data Campus in Portugal. When completed, the campus will operate at a 1.2 GWh capacity, with a theoretical maximum annual electricity consumption of 10,512 GWh. The immense capacity of the centre is owing to its strategic location along the Atlantic Ocean, enabling fibre-optic connectivity with four continents. In comparative terms, the annual electricity consumption of the SINES Data Campus is nearly equivalent to the entire annual electricity generation of Norway.

SINES Data Campus. Source: startcampus.pt, 2025.

Norway Map. Source: simplemaps.com, 2025.

With the rise of technology and the Internet came the rise of data centres. Switzerland has seen a drastic increase in the number of data centres within its borders, especially from the 21st century, and this number will continue to grow. With plans to build larger and “better” data centres in the near future, data centres are no longer just increasing in number, but also in scale—which will result in an exponential rise in energy demand.

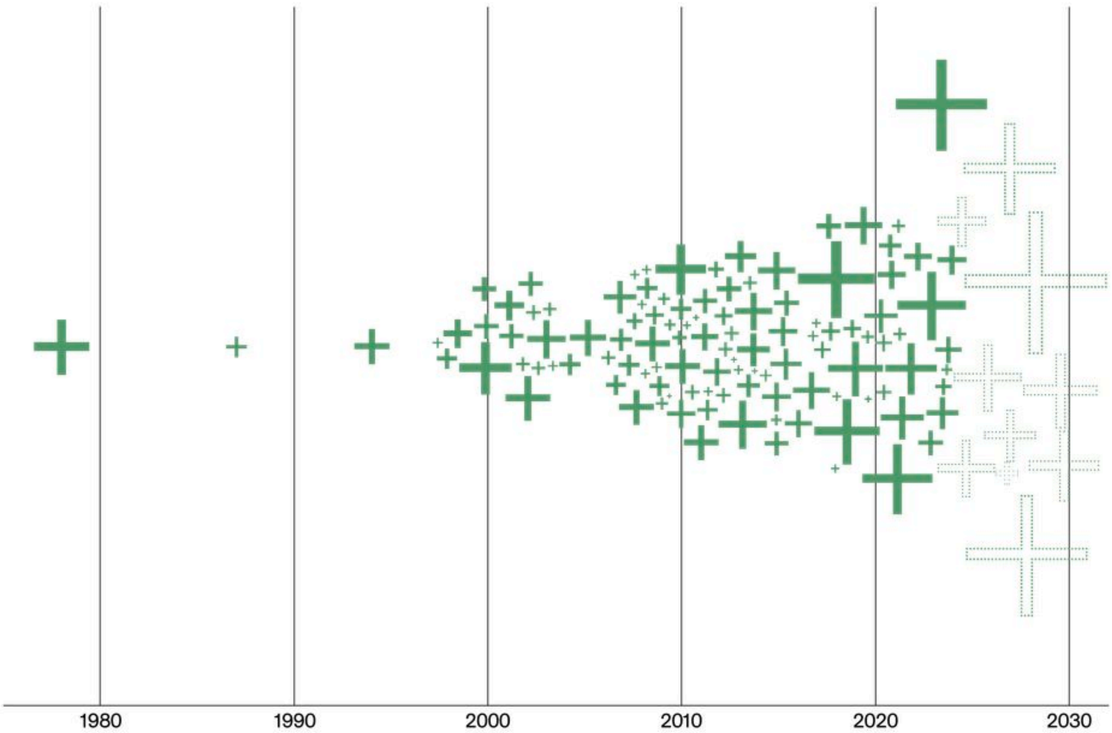
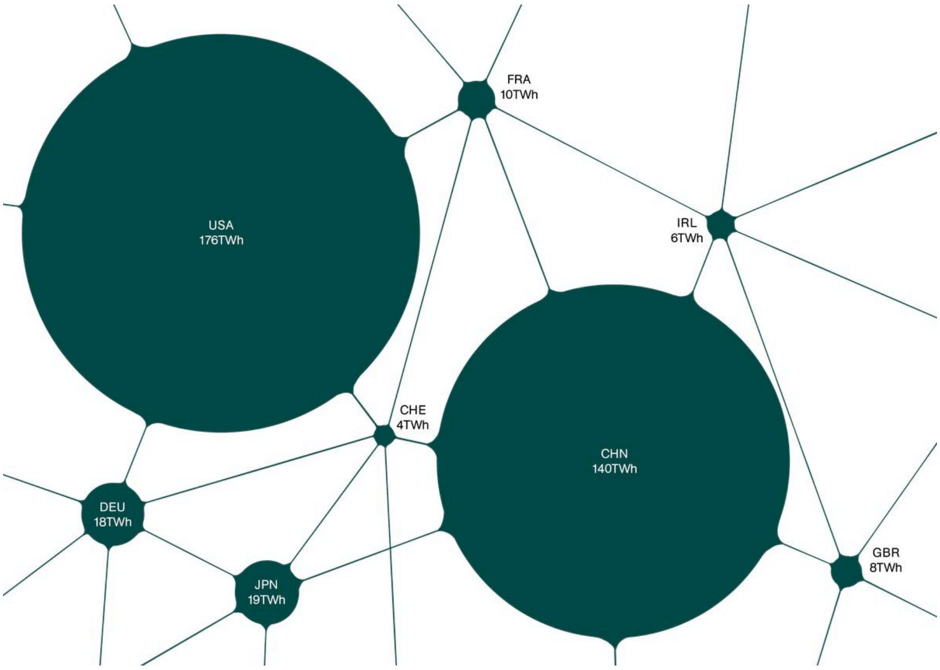


Chart of the construction of data centres in Switzerland over time.

+ Built

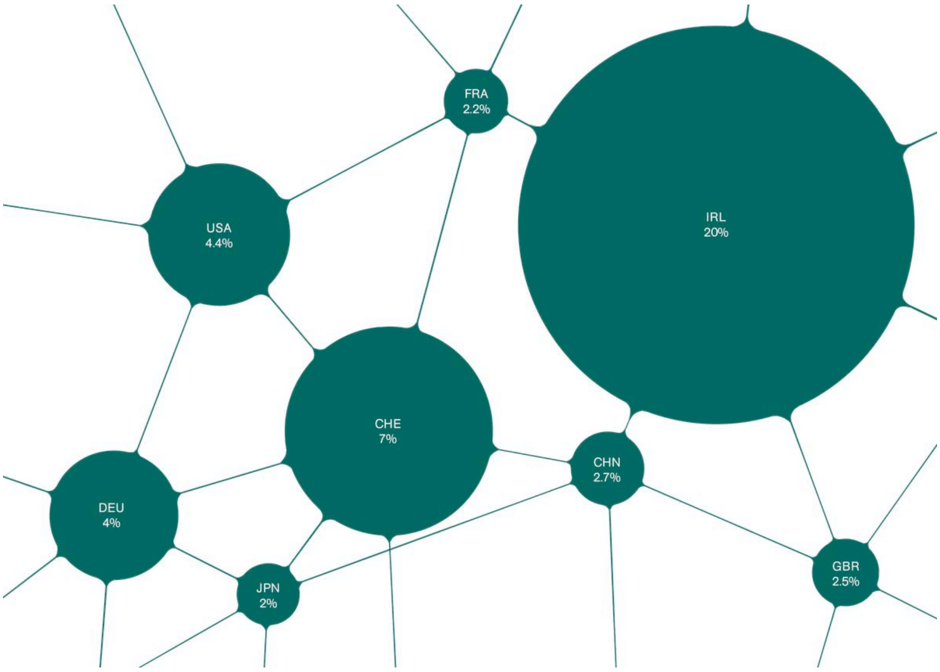
+ Planned

How does Switzerland compare itself to other countries? The US and China have the highest electricity demand for data centers globally, due to their vast territories and high number of data centres.



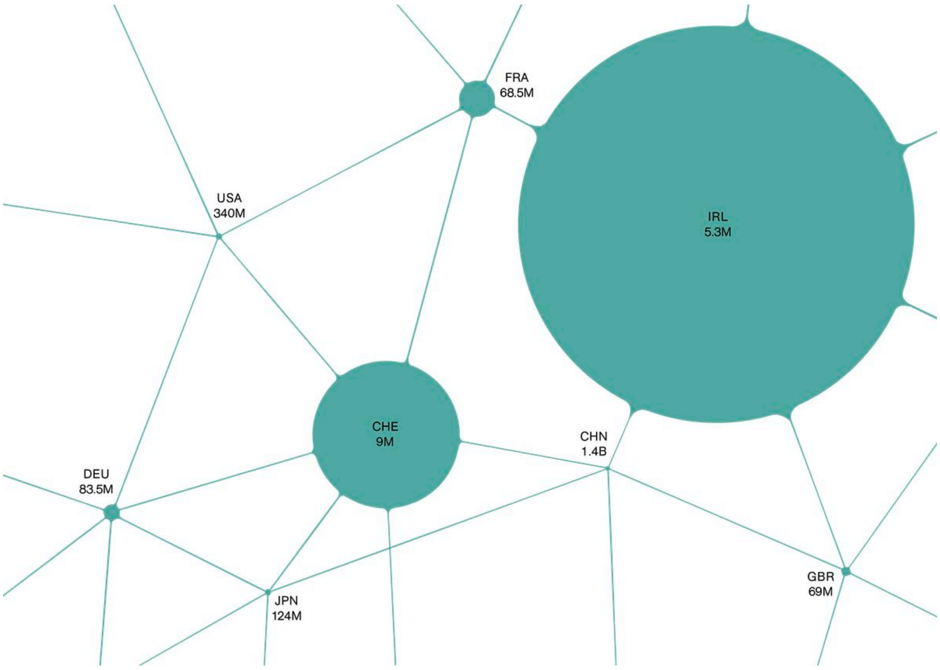
Data centre energy consumption in terawatt hours (TWh).

If we change the point of view and calculate which percentage of the country’s total energy use flows through data centers, we can observe that the balance shifts towards much smaller countries such as Ireland and Switzerland.



Percentage of country's electricity consumed by data centres.

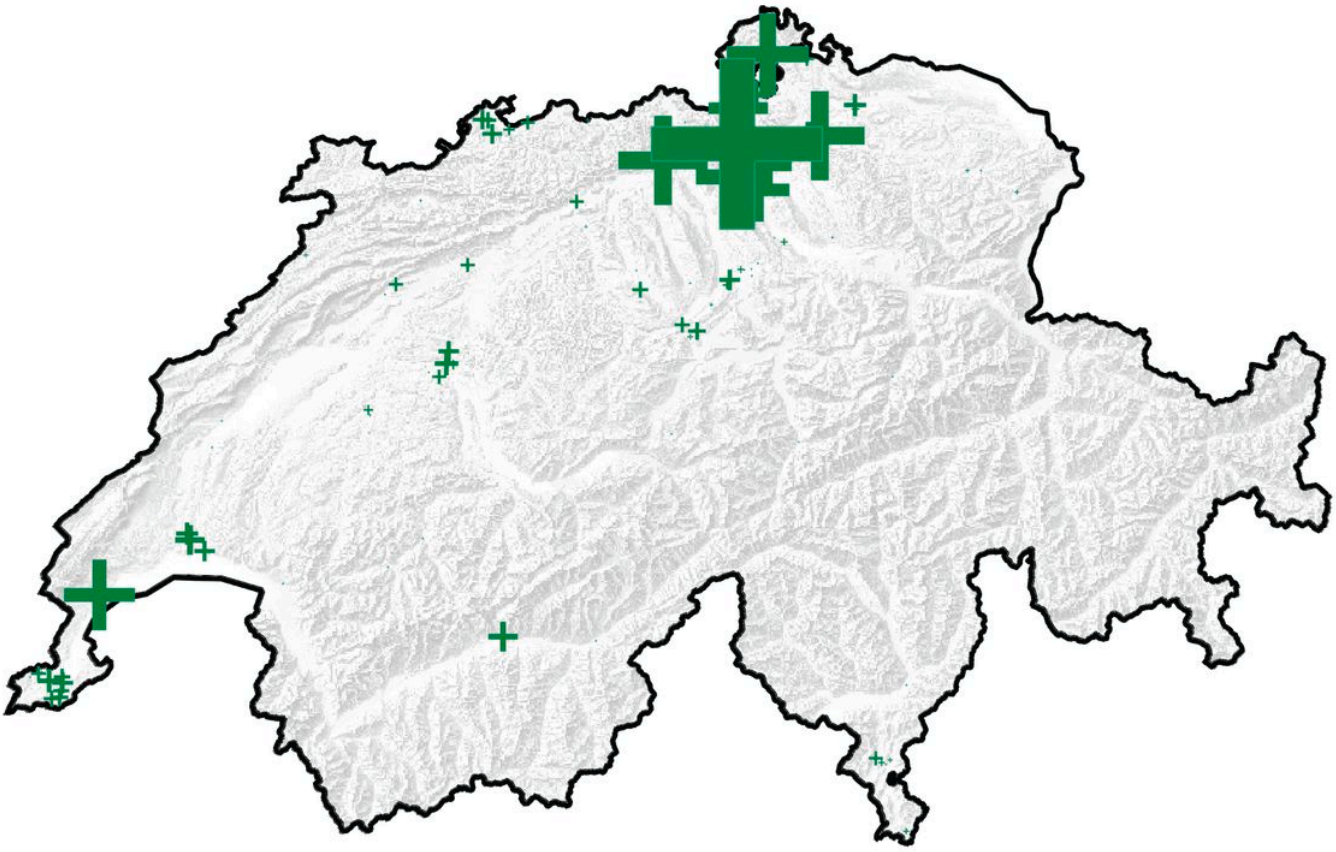
If we consider the population factor, and look at the data centre electricity consumption per capita, the situation completely reverses. The US and China are now the smallest consumers and Ireland and Switzerland the largest.



Data center consumption per capita.

Why are Switzerland and Ireland so attractive for data centres? Ireland is a favourable location because of its mild climate that allows the infrastructure to work on free cooling. The taxation system of this country offers low corporate taxes and data-friendly regulations.

On the other hand, Switzerland is well known for trustable data security and its biggest city, Zurich, has a high density of financial institutions. This also explains why so much of Swiss data centres are located in this region. In addition to that, there are lower cooling needs as the climate is favorable to free cooling more than 6 months a year.



Data centres in Switzerland and their energy demands. The size of the cross indicates the energy consumption.

In a scenario where data centres consume 15 % of the total Swiss electricity consumption in 2030, the country will need to produce or source an additional 4060 gigawatt hours (GWh) of electricity to meet this demand. This amount of electricity is equivalent to 800 trillion lightbulbs, or enough electricity for the entire Swiss population to charge their iPhones for 70 years.

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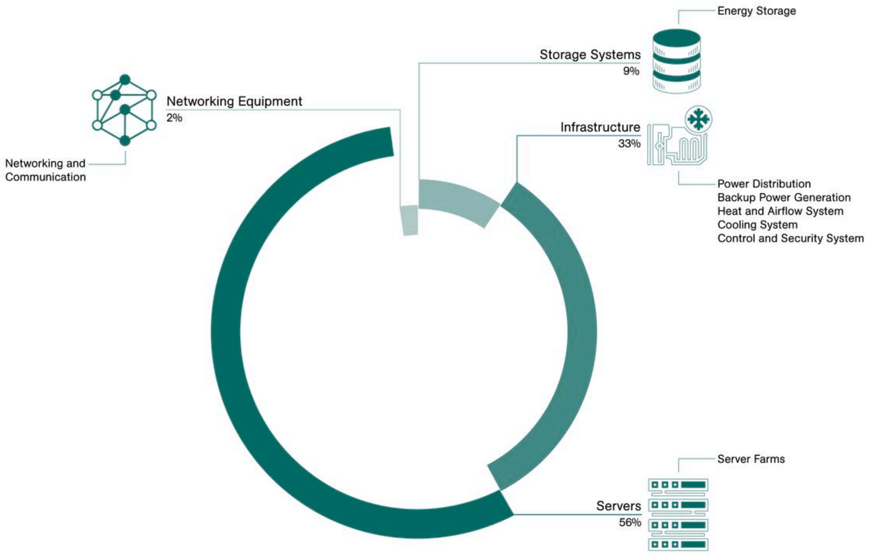

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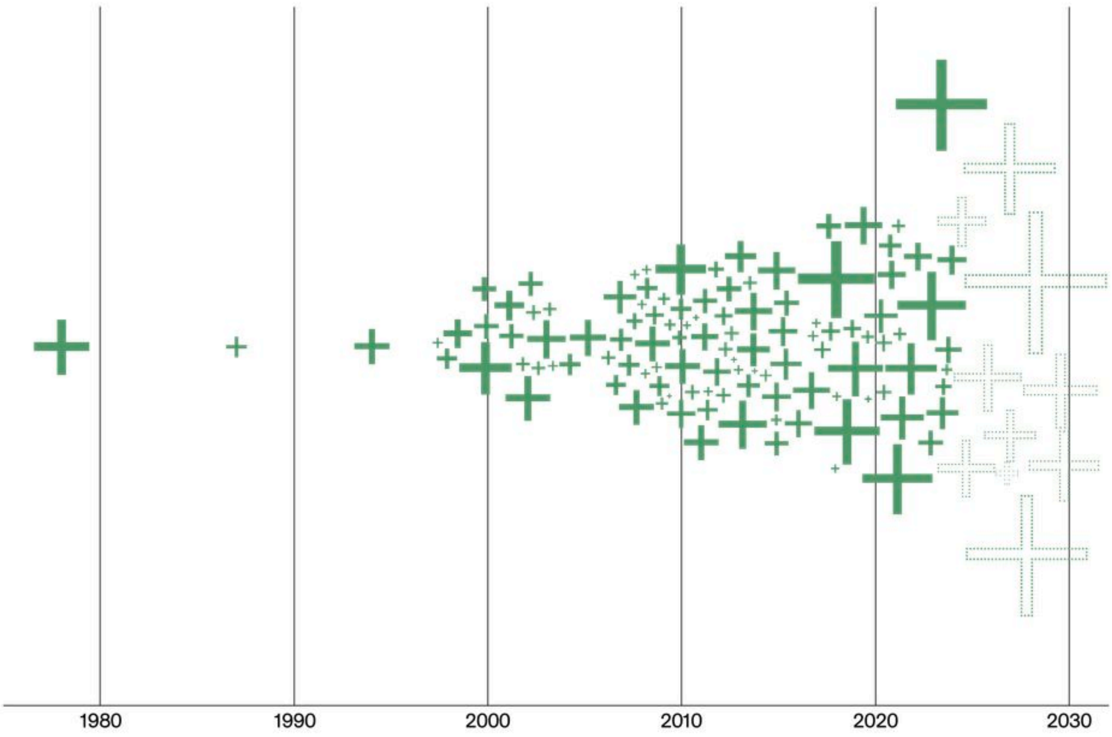

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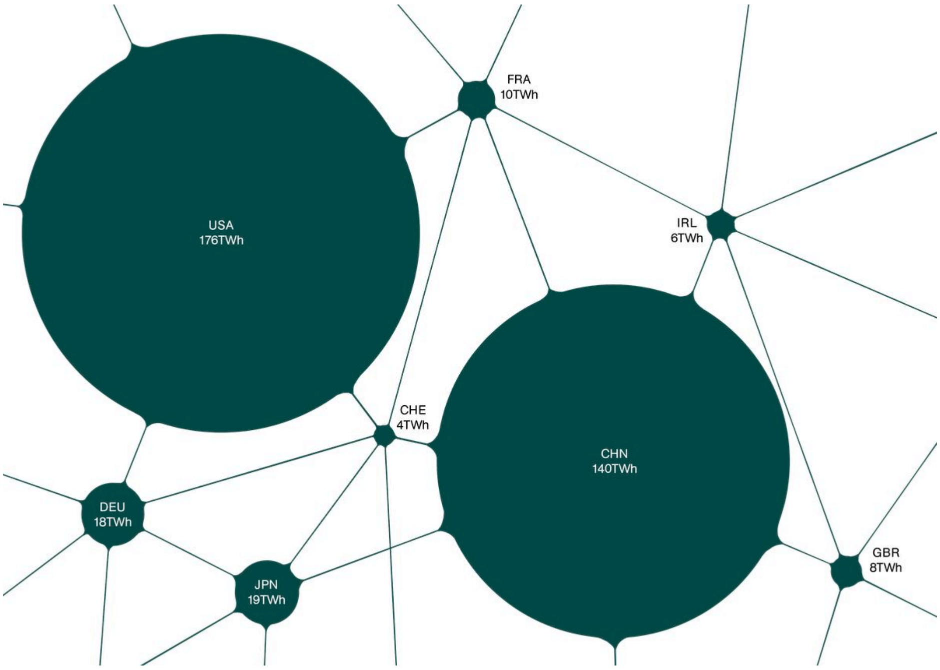

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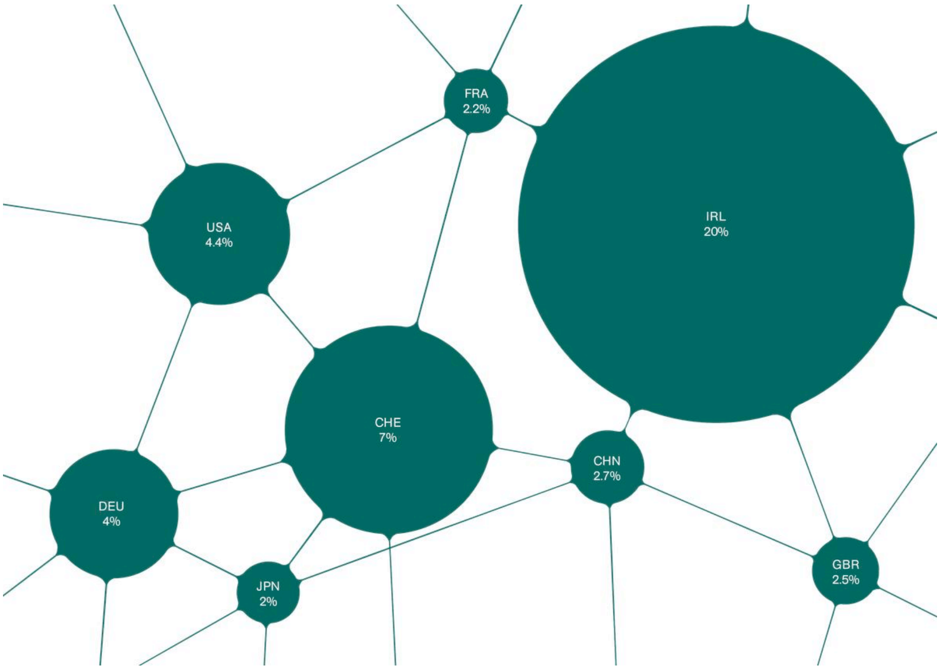

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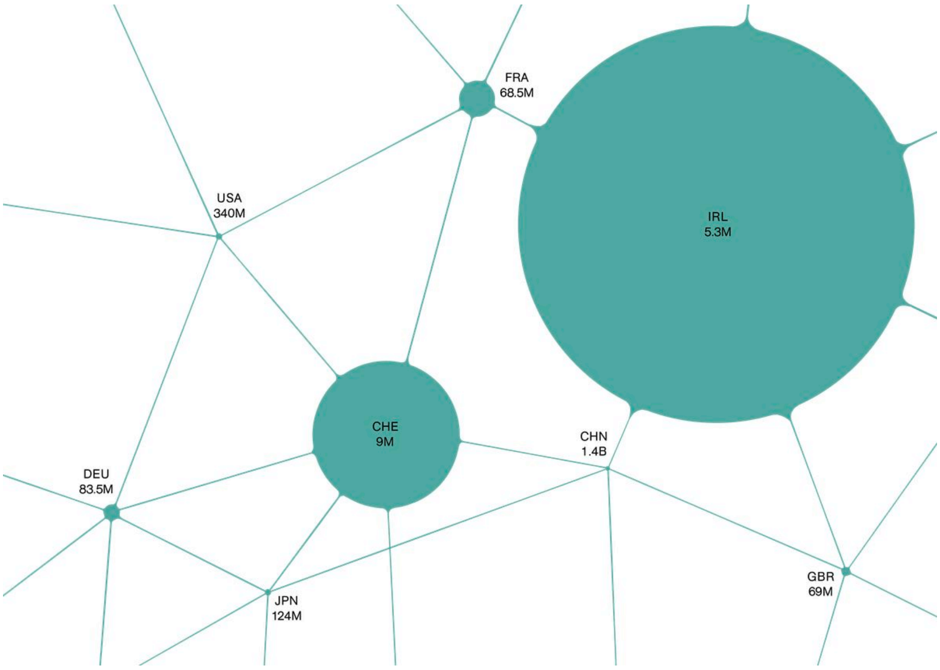

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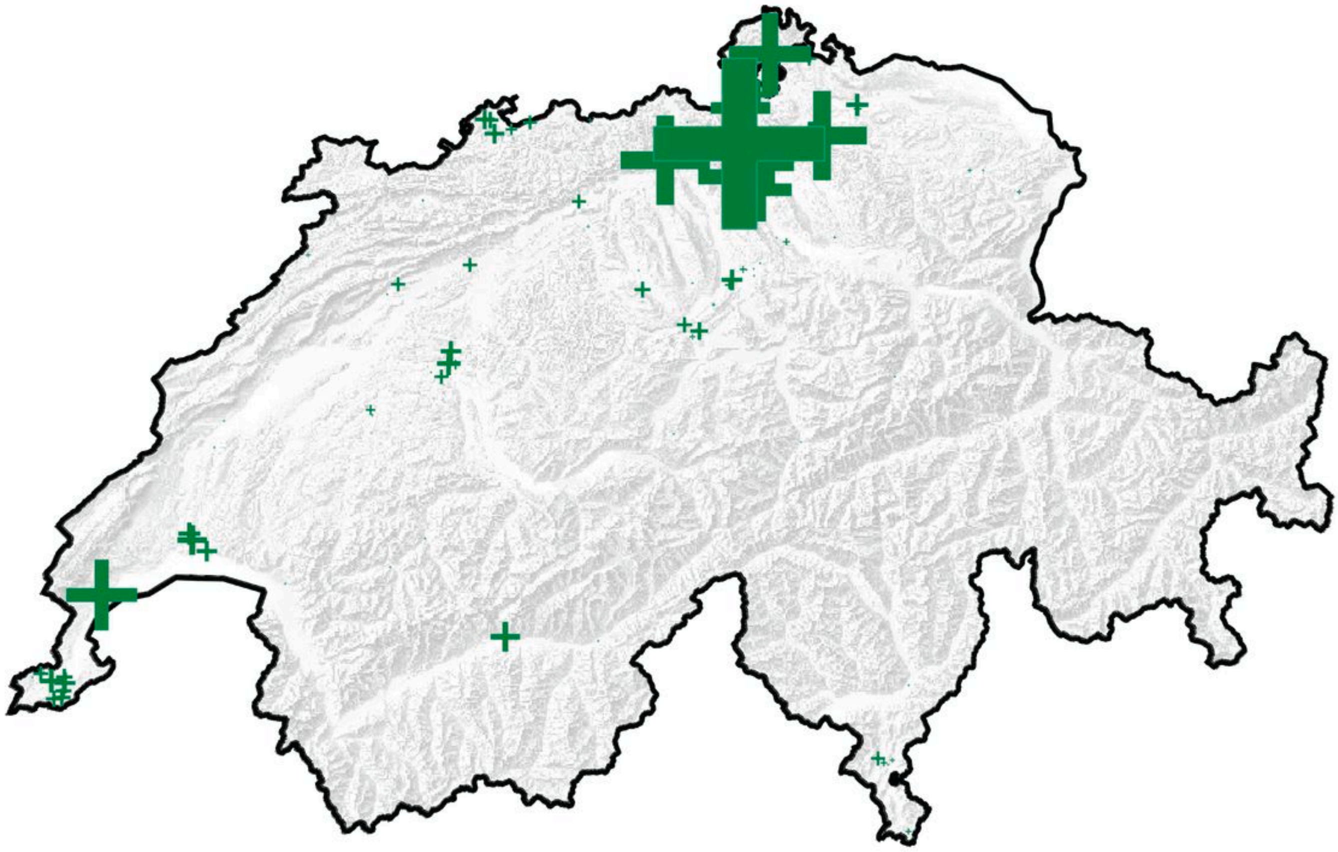

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A Cautionary Projection

Until now, energy demand has largely been discussed in abstract terms: percentages, gigawatt hours, efficiency metrics, and growth curves.
In this final chapter, the focus shifts from numbers to territory. By projecting future data centre electricity demand onto physical space, the consequences of digital infrastructure become tangible.
How does the expansion of data centres reshape Switzerland's landscapes, from alpine valleys to urban peripheries?

Mavoisin and Grande Dixence are two of Switzerland's largest hydroelectric dams, with annual electricity yields of 1072 and 2933 GWh each, respectively. Both are within the ten tallest dams in the world, with Grande Dixence being the tallest dam in Europe. Combined, these two hydropower plants would still be just shy of the surplus electricity needed to meet the additional electricity demand of Swiss data centres in 2030.

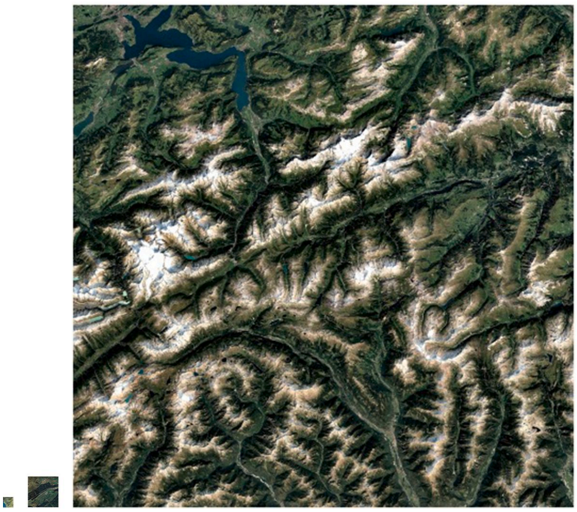
Mavoisin Dam. Source:
Source: Olivier Bruchez, 2006.

Grande Dixence Dam. Source:
Grande Dixence, 2025.

NalpSolar is a planned photovoltaic panel farm in Tujetsch, Grisons. When completed, the 100,000 square metre facility will produce 11 GWh of electricity per year.
To power a data center such as the Green Metro Campus in Dielsdorf, which consumes 307 GWh annual electricity alone, a solar farm with the same density as NalpSolar would need to cover nearly 3 million square metres of land.
For the total additional electricity demand of data centres in Switzerland in 2030, a 37 million square metre solar farm would do the trick.

100'000 m^2 solar farm projected in Tujetsch (GR). Source: Baublatt, 2025.

2,800,000 m^2 solar farm needed to cover annual energy demand of the Green Metro Campus (307 GWh). Source: Google Earth, 2025.



37,000,000 m^2 solar farm needed to cover annual energy demand of data centers in Switzerland in 2030. Source: Google Earth, 2025.

Given the enormous amount of electricity required to meet the growing energy demand of data centres, it is worth considering how this might manifest spatially. In 2030, will data centres be surrounded by photovoltaic fields, with arrays of solar panels covering the roofs, streets and lawns, dwarfing the tiny installations adorning the rooftops of centres such as Green Metro Campus? Will wind turbines scrape the Swiss sky, buffeting air warmed by data centre cooling towers?

Transformation of Dielsdorf by solar and wind.
Image source: Green, Collage: the authors.

Or will Switzerland walk back on its promises of decommissioning nuclear energy in order to appease the public, corporate, and governmental demand for more data and more artificial intelligence? Will a return to nuclear be marked by reactor towers fusing isotopes next door to data centres downloading data?

Return to nuclear collage. Image source: Green.

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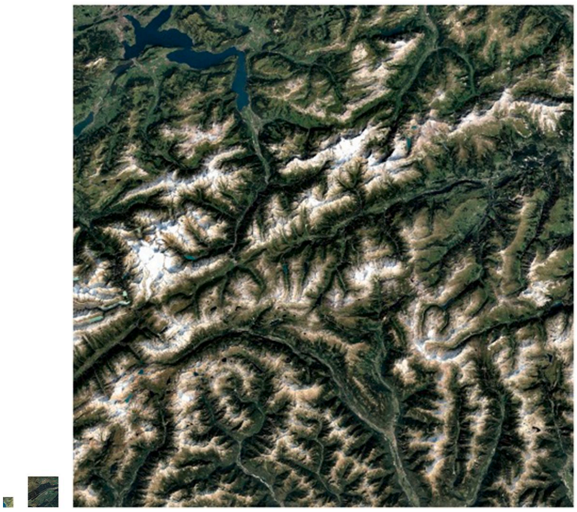
100'000 m^2 solar farm projected in Tujetsch (GR). Source: Baublatt, 2025.

2,800,000 m^2 solar farm needed to cover annual energy demand of the Green Metro Campus (307 GWh). Source: Google Earth, 2025.



37,000,000 m^2 solar farm needed to cover annual energy demand of data centers in Switzerland in 2030. Source: Google Earth, 2025.

Given the enormous amount of electricity required to meet the growing energy demand of data centres, it is worth considering how this might manifest spatially. In 2030, will data centres be surrounded by photovoltaic fields, with arrays of solar panels covering the roofs, streets and lawns, dwarfing the tiny installations adorning the rooftops of centres such as Green Metro Campus? Will wind turbines scrape the Swiss sky, buffeting air warmed by data centre cooling towers?

Transformation of Dielsdorf by solar and wind.
Image source: Green, Collage: the authors.

Or will Switzerland walk back on its promises of decommissioning nuclear energy in order to appease the public, corporate, and governmental demand for more data and more artificial intelligence? Will a return to nuclear be marked by reactor towers fusing isotopes next door to data centres downloading data?

Return to nuclear collage. Image source: Green.

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