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EQUITY RESEARCH | April 29, 2024 | 4:40AM CEST

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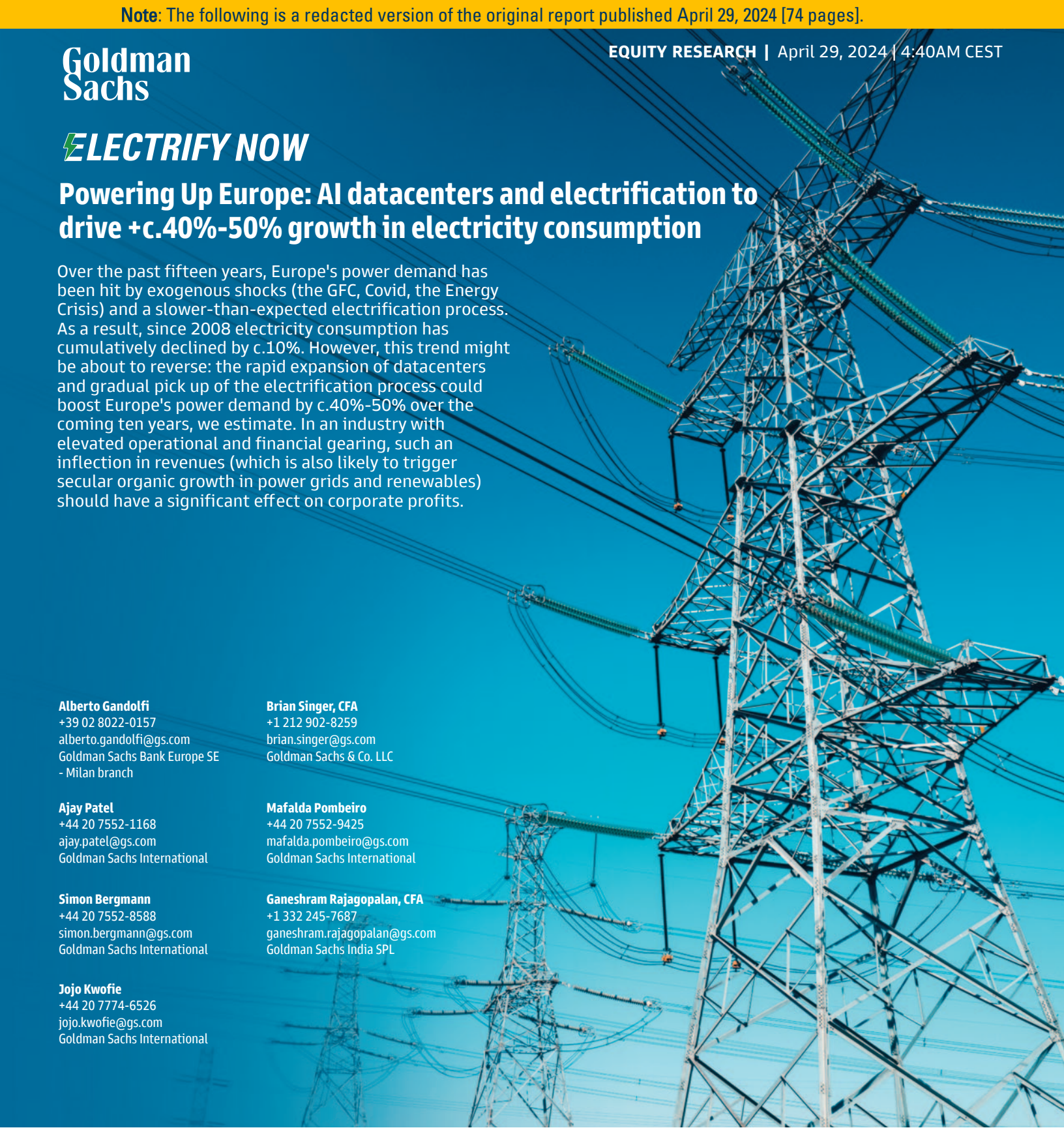
Powering Up Europe: AI datacenters and electrification to drive +c.40%-50% growth in electricity consumption

Over the past fifteen years, Europe's power demand has been hit by exogenous shocks (the GFC, Covid, the Energy Crisis) and a slower-than-expected electrification process. As a result, since 2008 electricity consumption has cumulatively declined by c.10%. However, this trend might be about to reverse: the rapid expansion of datacenters and gradual pick up of the electrification process could boost Europe's power demand by c.40%-50% over the coming ten years, we estimate. In an industry with elevated operational and financial gearing, such an inflection in revenues (which is also likely to trigger secular organic growth in power grids and renewables) should have a significant effect on corporate profits.



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AI datacenters and electrification: +c.40%-50% power consumption. Over the coming three years, we expect the negative trend in electricity demand to inflect. Thanks to the rapid expansion of datacenters (DCs), and owing to a gradual pick up in the electrification process (transport, industrial processes, buildings, etc.), we estimate that Europe's power demand could grow by +c.40% over the coming ten years (2023-33). A bull case for AI datacenters could see cumulative electricity consumption growth at +c.50%.

Datacenters and Europe: benefits could be highly concentrated. We believe power demand from datacenters (8%-14% pa growth in our base-bull case) will be particularly strong in two areas: (1) countries with cheap, abundant baseload power (nuclear, hydro, wind, solar): here we highlight the Nordics, Spain and France; and (2) countries with large financial services and tech companies, willing to offer incentives (e.g., tax breaks) to attract DCs; Germany, the UK and Ireland could be prominent here.

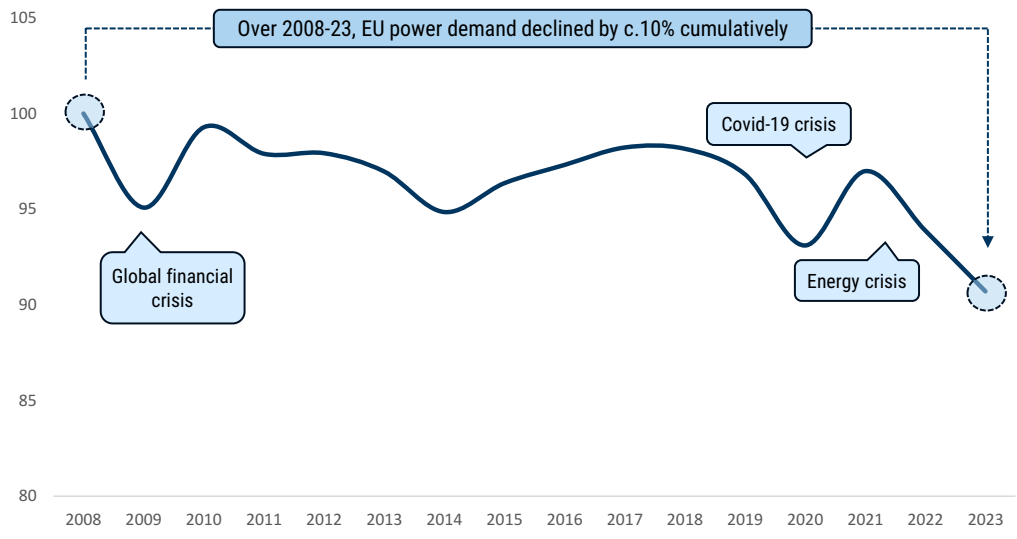
Executive Summary

Over the past fifteen years, Europe's power demand has been hit by exogenous shocks (the GFC, Covid, the Energy Crisis), and a slower-than-expected electrification process. As a result, since 2008, electricity consumption has cumulatively declined by c.10%. However, this trend might be about to reverse: the rapid expansion in datacenters and gradual pick up of the electrification process could boost Europe's power demand by c.40%-50% over the coming ten years, we estimate. In an industry with elevated operational and financial gearing, such an inflection in revenues (which is also likely to trigger secular organic growth in power grids and renewables) should have a significant effect on corporate profits.

Europe's power demand is down 10% over fifteen years

Over the past fifteen years, Europe's power demand has been severely hit by exogenous shocks (the Global Financial Crisis, Covid Crisis, and Energy Crisis), a slower-than-expected pick up in the electrification process, and by ongoing de-industrialization of the European economy. As a result, since the 2008 power consumption peak, electricity demand has cumulatively declined by nearly 10%.

Exhibit 1: Since 2008, the EU's electricity consumption has cumulatively declined by nearly 10%
EU power demand evolution, 2008-23 (rebased, 2008 = 100)



Source: Ember Climate Org

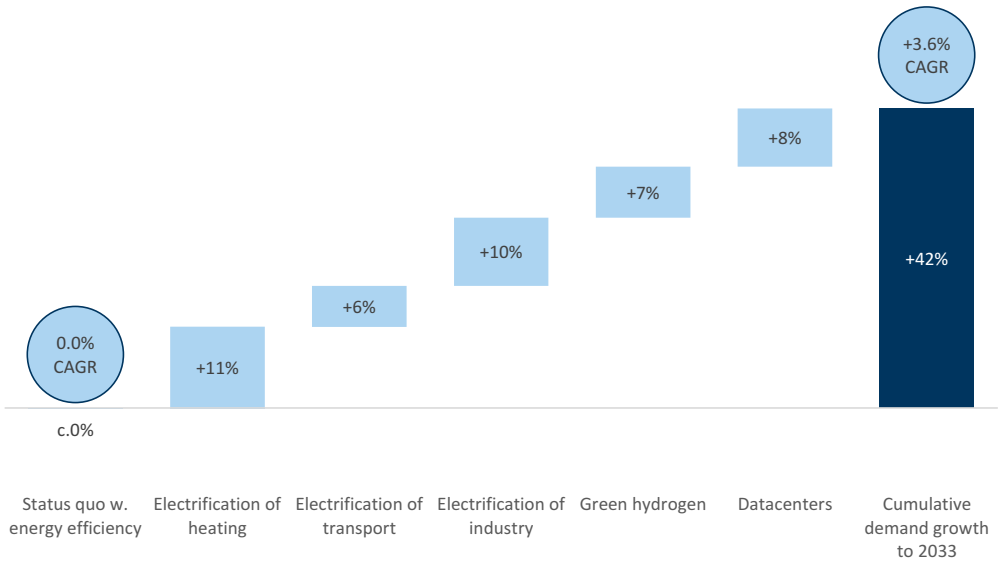
Datacenters and Electrification: +c.40%-50% power consumption

Over the coming three years, we expect the negative trend in electricity demand to inflect. Thanks to the rapid expansion of datacenters (DCs), and owing to a gradual pick

up in the electrification process (transport, industrial processes, buildings, etc.), we estimate that Europe's power demand could grow by +c.40% over the coming ten years (2023-33).

Exhibit 2: We expect c.40% cumulative growth in power consumption, over the coming ten years (base case)

Europe cumulative power demand growth between 2023 and 2033E (%, bars) and CAGR (bubbles)

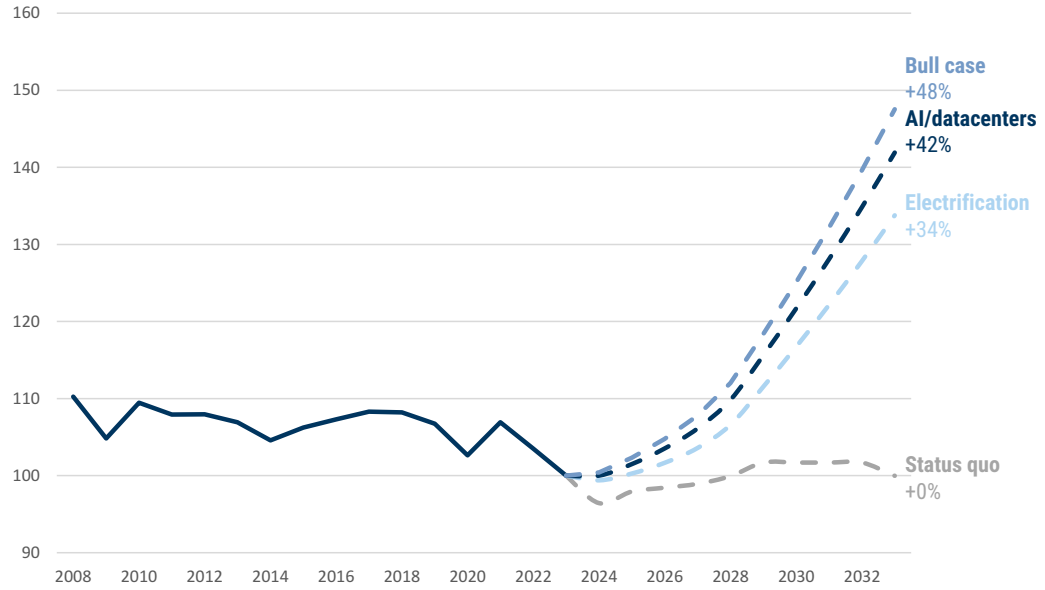


Datacentres includes AI

Source: Goldman Sachs Global Investment Research

A bull case for AI datacenters – which assumes a slightly higher market share for Europe and no efficiency gains on future server deliveries – could see cumulative electricity consumption growth at +c.50%.

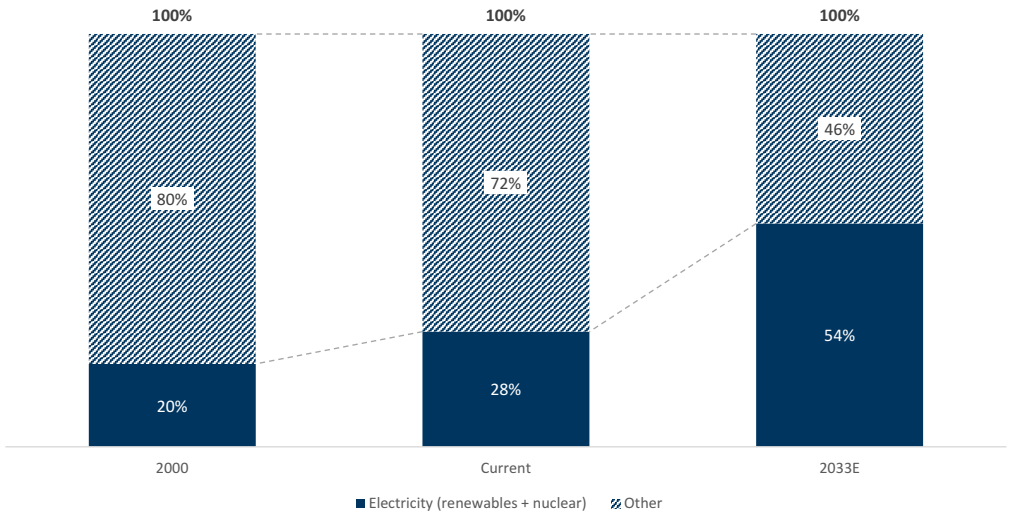
Exhibit 3: In a datacenter/AI bull case, European power consumption could rise by c.50% by 2033
EU-27 power demand scenario analysis (rebased, 2023 = 100)



Source: EMBER, Goldman Sachs Global Investment Research

Europe's electrification process, magnified by the power demand needs of datacenters, is likely to continue to drive a growing role for electricity in the primary energy mix. As a reference, compared to c.20% in 2000, we estimate that electricity could account for more than half of primary energy (c.55%), over the coming ten years.

Exhibit 4: Electricity could account for more than 50% of Europe's primary energy consumption by 2033E
EU-27 primary energy mix (TWh and %): 2000, current (2021) and 2033E (base case)



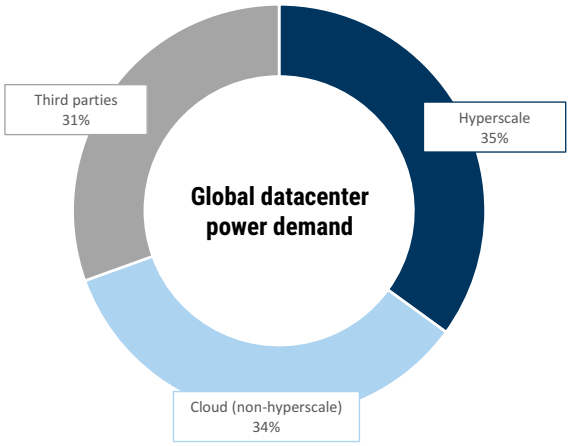
Source: OurWorldInData, BP, Goldman Sachs Global Investment Research

Datacenters: A new driver of power demand

Traditional datacenters have been rapidly expanding as a result of higher demand from

retail customers (cloud storage, social media, movie streaming), growing computational requirements (and storage) from the service industry, and the growing needs of large tech companies such as Google, Amazon, Meta and Microsoft. However, datacenters currently account for only a little over 1% of power demand globally. Our base-case scenario assumes that the expansion of traditional DCs will drive a c.6% boost to Europe's 2023 power demand.

Exhibit 5: Hyperscalers represent about 35% of global datacenter power demand
Global datacenter power demand (% of total), 2023



Source: International Energy Agency

A datacenter is a physical room, building or facility that houses computing infrastructure, including servers, storage systems, networking equipment and cooling mechanisms. Servers are responsible for executing computational tasks, storage systems provide capacity for storing data and applications, and networking equipment enables communication and data transfer between servers, storage systems and external networks. Owing to the high-density nature of computing equipment and the consequent generation of heat, efficient cooling mechanisms are essential to prevent overheating and ensure the reliability and longevity of the hardware components. Cooling solutions may involve air conditioning units, liquid cooling systems or specialised airflow management techniques.

Exhibit 6: AI servers are a lot more energy-intensive than traditional servers
Traditional x86 server rack load (kW per rack)

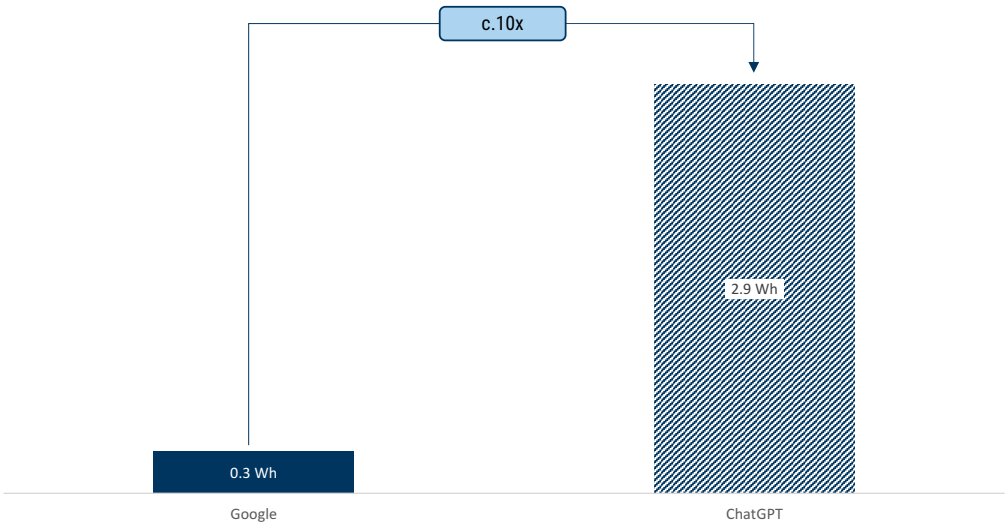
	Server rack type	
	Traditional x86 (5-15 kW)	**AI (50-100 kW)**
Cooling	35%	45%
Servers	25%	35%
Storage	15%	7%
Networking	10%	5%
Other	15%	8%
Total power consumption	**100%**	**100%**

Source: 650 Group

AI datacenters: Booming, more energy-intensive growth

The rise of artificial intelligence (AI) datacenters has sparked much debate over the possibility of these driving much higher power demand. Academic studies (e.g. here) show that AI datacenters can consume up to c.10x more energy than traditional DCs. AI servers are particularly energy-intensive during their training (learning) phase.

Exhibit 7: ChatGPT queries are 10x as power-intensive as traditional Google searches
Power consumption per query/search (Wh)



Source: Google, SemiAnalysis

Datacenters and Europe: The benefits may be highly concentrated

We believe power demand from datacenters (8%-14% pa growth in our base-bull case) will be particularly strong in two areas: (1) countries with cheap, abundant baseload power (nuclear, hydro, wind, solar): here we highlight the Nordics, Spain and France; and (2) countries with large financial services and tech companies, willing to offer incentives (e.g., tax breaks) to attract DCs; Germany, the UK and Ireland could be prominent here.

Exhibit 8: Traditional datacenters and AI could lift power demand in some countriesby as much as +13% in our base case
Traditional datacenters and AI power demand growth to 2033E

	85% allocation scenario					
	Nordics	Spain	Ireland	France	Germany	UK
Power consumption 2023 (TWh)	392	256	35	464	514	317
Traditional datacenter + AI demand growth to 2033 (TWh)	44	29	4	39	43	27
Implied consumption growth vs. 2023 (%)	**11%**	**11%**	**11%**	**8%**	**8%**	**8%**

	95% allocation scenario					
	Nordics	Spain	Ireland	France	Germany	UK
Power consumption 2023 (TWh)	392	256	35	464	514	317
Traditional datacenter + AI demand growth to 2033 (TWh)	50	32	4	44	48	30
Implied consumption growth vs. 2023 (%)	**13%**	**13%**	**13%**	**9%**	**9%**	**9%**

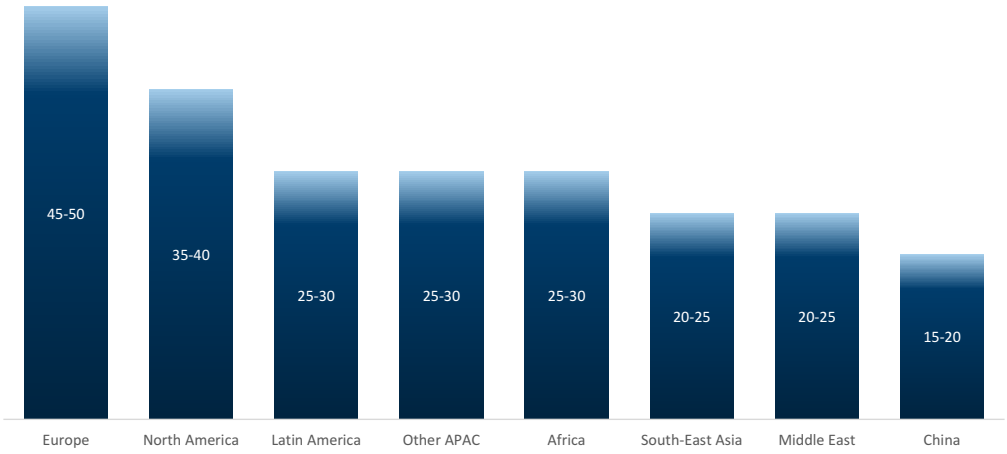
Source: Ember, Goldman Sachs Global Investment Research

We favour 'Electrification Compounders': Power grids

After years of under-investment (Europe currently has the oldest power grid in the

world), we estimate that European investment in power grids (transmission and distribution - T&D) will accelerate by 80%-100% over the coming ten years, depending on the region.

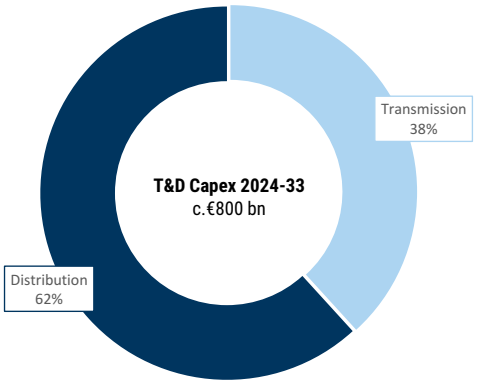
Exhibit 9: Europe has the oldest power grid in the world
Estimated average age of grid by region (years)



Source: Nexans Presentation

In aggregate, this should result in €800 bn of spending on power T&D for Europe as a whole, as a result of : (1) structural under-investment; (2) the need to cope with electrification; and (3) the need to manage an increasingly complex energy system.

Exhibit 10: European T&D power grids will attract nearly €800 bn of investment over 2024-33, we estimate
EU + UK Transmission and Distribution capex breakdown, 2024-33E (€ bn, percentage)



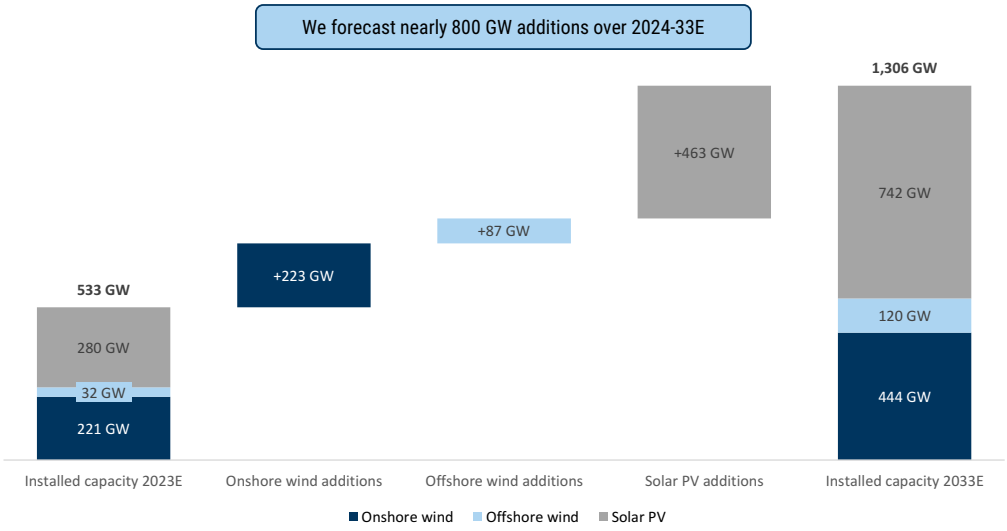
Source: Goldman Sachs Global Investment Research

We favour 'Electrification Compounders': Renewables

On our estimates, which assume 4-5 years of delays in accomplishing the REPowerEU goals, Europe will nearly triple the amount of wind and solar installed in the region

within ten years.

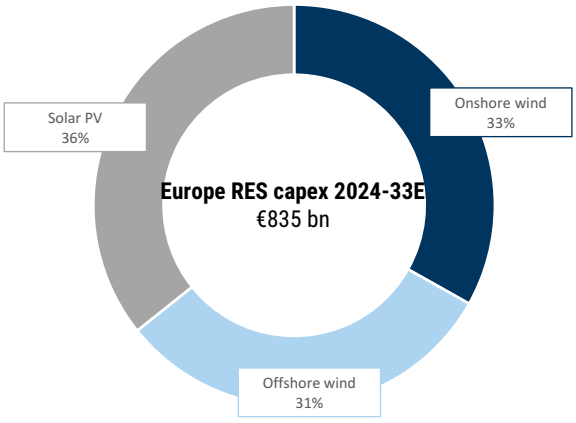
Exhibit 11: We expect Europe to add nearly 800 GW of wind and solar over the coming decade
Europe wind and solar installed capacity and additions, 2024-33E (GW)



Source: Goldman Sachs Global Investment Research

The near-800 GW of additions that we forecast through to 2033 implies an investment of nearly €850 bn over the coming ten years, broadly evenly split between solar, onshore wind and offshore wind.

Exhibit 12: Europe will invest more than €800 bn in wind and solar over 2024-33, we estimate
Europe wind and solar capex 2024-33 (€ bn)



Source: Goldman Sachs Global Investment Research

The share price performance of the European RES stocks since early 2021 suggests that the market remains quite negatively biased towards the renewables developers. The following exhibit shows the considerable (c.35%-75%) compression in the EV/EBITDA multiples of these stocks.

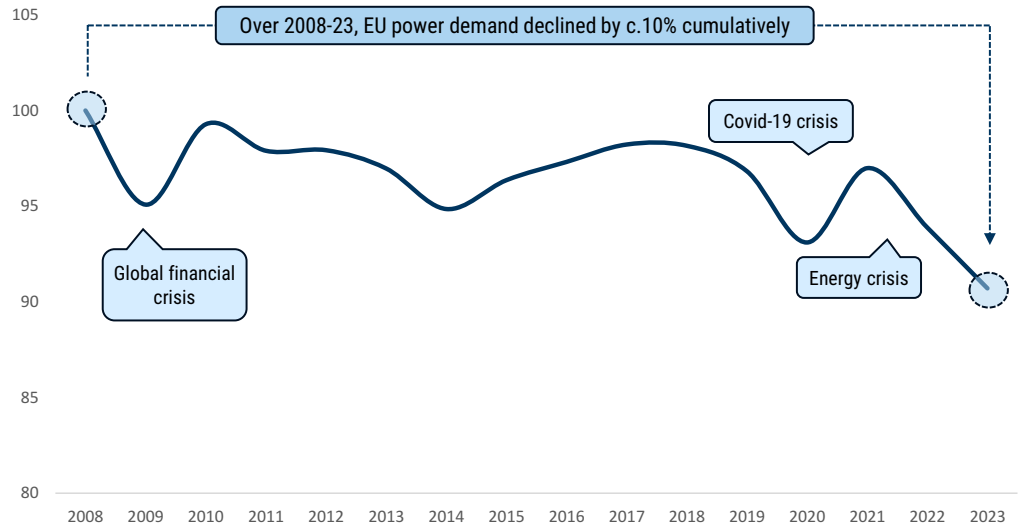
Europe's power demand nearly 10% below the 2008 level

Over the past fifteen years, Europe's power demand has been hit by exogenous shocks (the GFC, Covid, the Energy Crisis), and a slower-than-expected electrification process. As a result, since 2008, electricity consumption has cumulatively declined by c.10%.

Power demand down nearly 10% cumulatively since 2008

Europe's power demand peaked in 2008. Since then, three major episodes (the Global Financial Crisis in 2009, the Covid pandemic in 2020, and the Energy Crisis in 2022) have driven a prolonged period of weak consumption. Currently, electricity demand is nearly 10% lower than in 2008.

Exhibit 20: Since 2008, the EU's electricity consumption has cumulatively declined by nearly 10%
EU power demand evolution, 2008-23 (rebased, 2008 = 100)

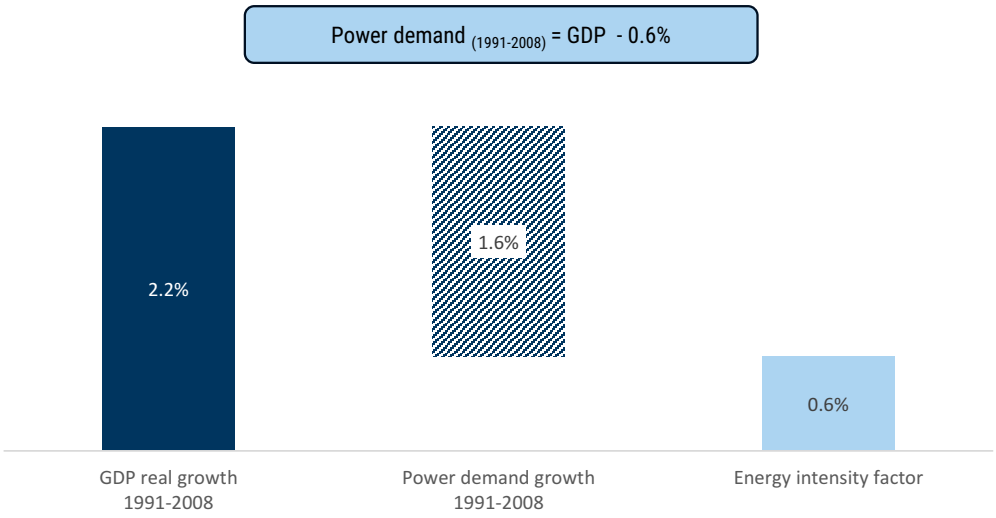


Source: Ember Climate Org

Energy intensity in the European economy has been falling

We have analyzed GDP growth and power demand growth in Europe since 1990. While GDP grew at an average of +2.2% per year through 1991-2008, power demand grew at an average of +1.6% pa, representing an energy intensity factor of 0.6% (e.g., 'GDP – 0.6%').

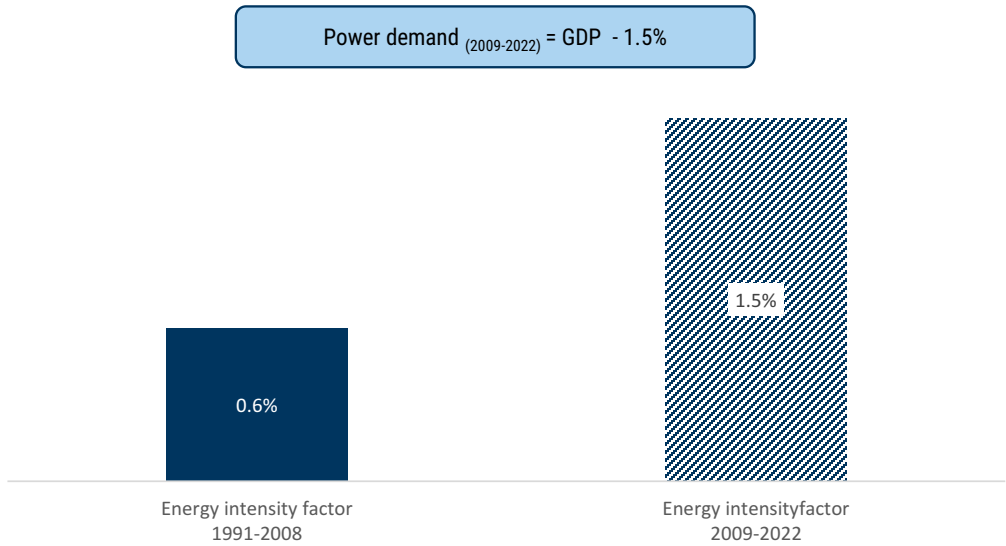
Exhibit 21: Between 1992 and 2008, EU power demand grew by GDP - 0.6% on average
EU-27 GDP and power demand average growth rate, 1991-2008 (percentage)



Source: Eurostat, IMF

However, through 2009-22 this relationship changed significantly: over this period, power demand in Europe grew at 'GDP – 1.5%', on average. We believe this decline has been caused by an acceleration in the process of de-industrialization, leading to a decline in the region's energy intensity.

Exhibit 22: Since the GFC, Europe's energy intensity has significantly fallen: power demand has grown at 'GDP - 1.5%'
EU-27 power demand factor: GDP growth - power demand growth (%)



Source: Eurostat, IMF

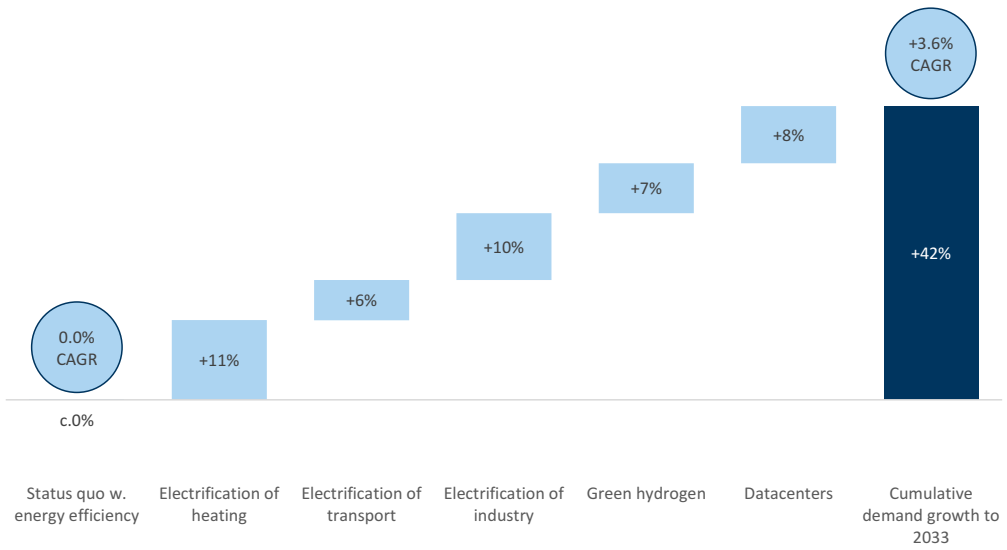
AI/datacenters and electrification: +c.40%-50% boost to power demand

We believe the negative trend in electricity demand is set to change. Thanks to the rapid expansion in AI and traditional datacenters, and owing to a gradual acceleration in the electrification process (mobility, industrial processes, heating, etc), we estimate that Europe's power demand will grow by +c.40% over the coming ten years (2023-33). Our bull case for AI datacenters implies consumption growth of +c.50%. Our analysis is based on a global datacenters model that forecasts the development of traditional DCs by projecting the number of computational queries, and which forecasts the future supply/demand for AI servers. This was developed together with our colleagues in GS SUSTAIN (ESG), Utilities, Clean Tech and – clearly – Technology, across all regions.

Power demand set to inflect: AI/datacenters and electrification imply +c.40% growth

Based on the electrification goals included in the REPowerEU plan, and considering the rapid expansion in AI-powered and traditional datacenters, we conclude that over the coming ten years European power consumption will cumulatively grow by +c.40%. This equates to +c.3.5% pa using a straight line CAGR calculation.

Exhibit 23: We expect c.40% cumulative growth in power consumption, over the coming ten years
Europe cumulative power demand growth, 2023-33E (%, bars) and CAGR (bubbles)

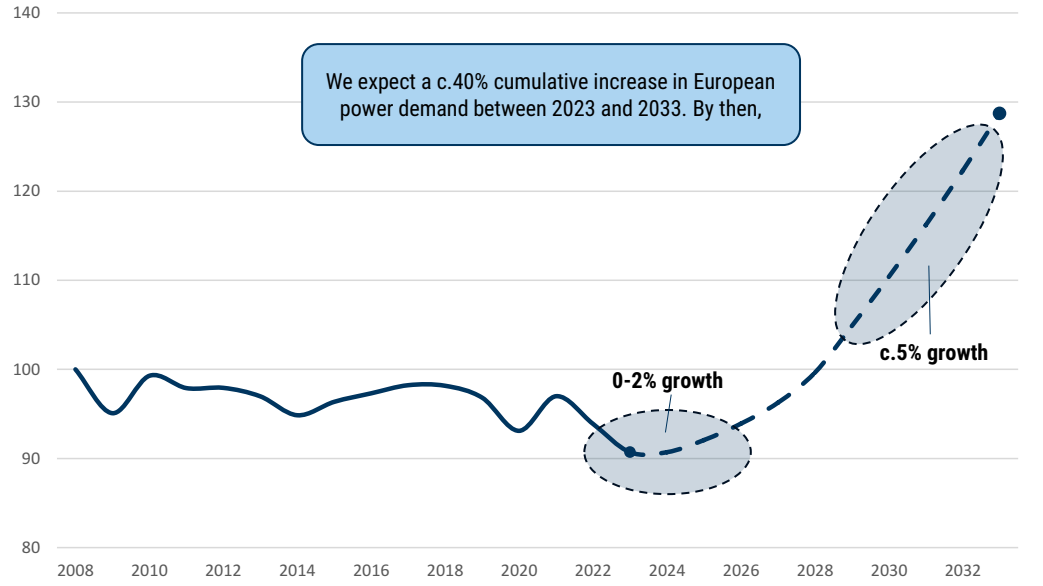


Datacentres includes AI

Source: Goldman Sachs Global Investment Research

Although it is hard to estimate the precise shape of the development of power demand over the coming 3-5 years, we believe that consumption will steadily accelerate from a low-single-digit pa rate to a peak of c.5% pa towards the end of the decade (or in the early 2030s).

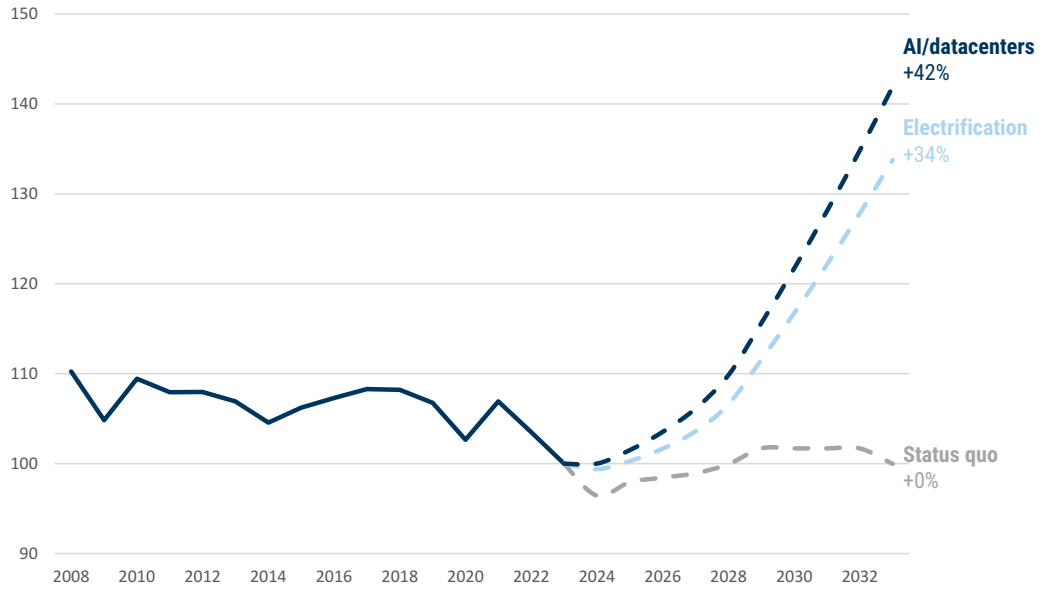
Exhibit 24: We expect European power demand growth to peak in 2028-33 at c.5% pa
EU-27 power demand (rebased, 2008=100)



Source: EMBER, Goldman Sachs Global Investment Research

We assess the potential evolution in power demand vs. the status quo (e.g., essentially zero growth), assuming ongoing energy efficiency. In our electrification scenario, power demand could increase by c.35%, vs. the 2023 level. Incremental demand from datacenters would lift consumption growth to more than +40%, we estimate, in our base case.

Exhibit 25: Electrification and datacenters could lift consumption by more than 40% (vs. 2023, base case)
EU-27 power demand scenario analysis (rebased, 2023 = 100)

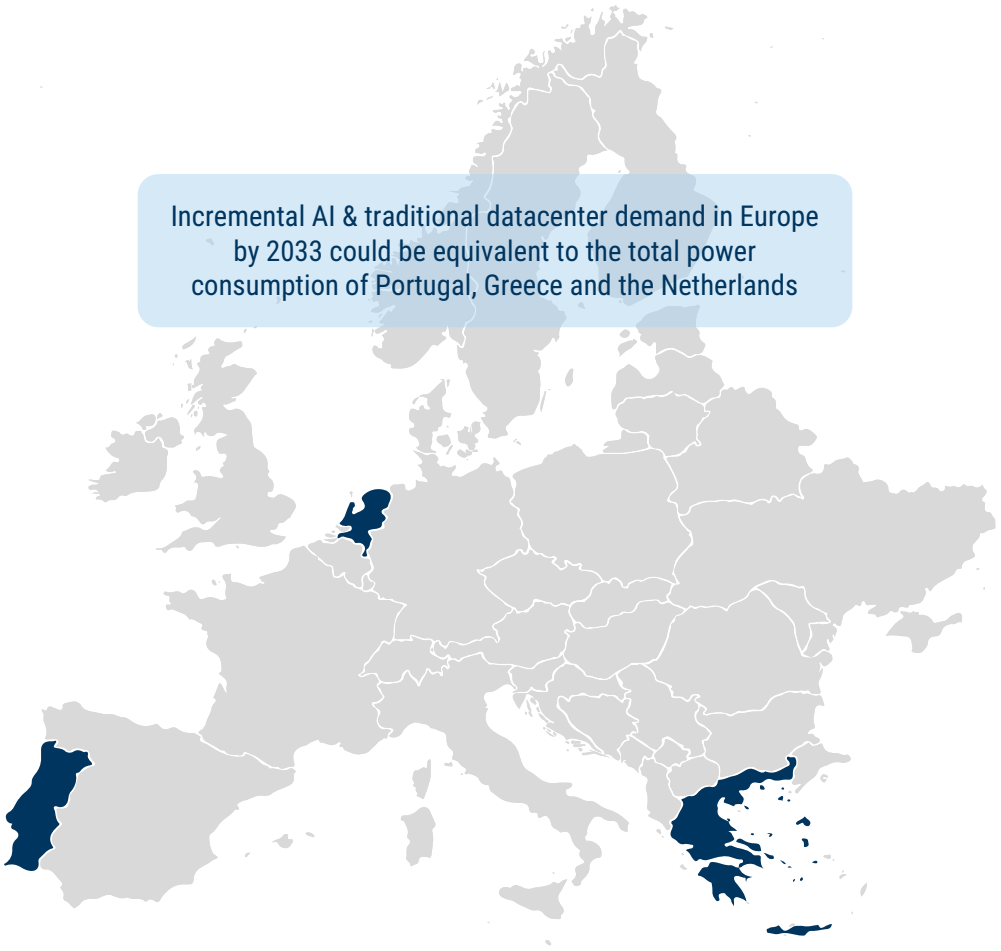


Source: EMBER, Goldman Sachs Global Investment Research

The impact on European demand from Datacenters

Currently, datacenters account for just over 1% of European power demand. Besides organic growth in traditional DCs, academic studies show that AI datacenters can consume up to c.10x more energy than traditional ones – AI servers are particularly energy-intensive during their training phase. Given the strong growth in traditional datacenters, and the expected exponential growth in AI servers (per our Tech analysts), we estimate that datacenters will boost European electricity demand by +8% over the coming ten years (our base case). In other words, AI-driven consumption will add some c.220TWh to European electricity demand. This is broadly equivalent to the current consumption of the Netherlands, Portugal and Greece combined.

Exhibit 26: By 2033, AI and traditional datacenter demand would match the current consumption of Portugal, Greece and the Netherlands



Source: Goldman Sachs Global Investment Research

Currently, about 20% of the world's data centers are located in Europe (c.15% in absolute terms, c.25% in terms of energy requirements). European data center capacity is relatively concentrated, and is mostly located in the Nordics and FLAP-D (Frankfurt, London, Amsterdam, Paris and Dublin), as we detail later in the report. By using our Tech team's global estimates for AI server sales and DCs (see here, and holding Europe's share constant at c.20% of global expected consumption, we conclude that that power

demand from Traditional and AI datacenters will increase by +8% in Europe over the coming ten years. In other words, AI-driven consumption adds to European electricity demand a total equivalent to the current consumption of Portugal, the Netherlands and Greece combined.

Exhibit 27: Incremental demand from traditional datacenters and AI could, by 2033E, be equivalent to +8% of current consumption
AI power demand analysis

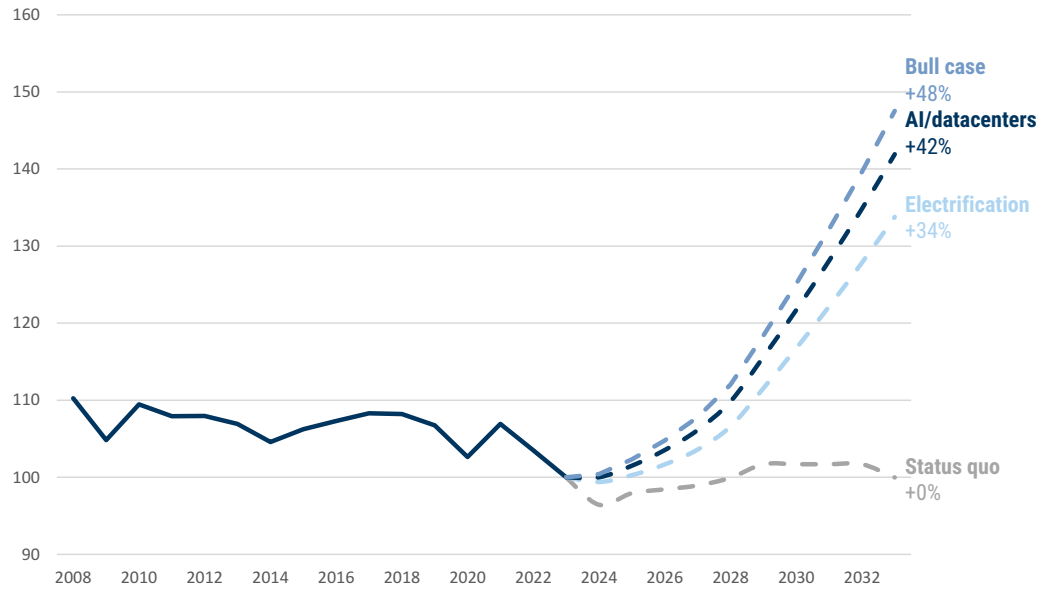
	Base case			
	2024E	2027E	2030E	2033E
Global AI server sales (mn)	0.8	2.4	4.4	7.2
Global AI server sales (mn), cumulative	0.8	6.4	15.0	26.4
Average energy consumption per server (kW)	5.0	3.6	2.7	1.9
Global demand from AI servers (TWh), cumulative increase	**21**	**136**	**203**	**359**
EU share of AI demand (%)	20%	20%	20%	20%
European demand from AI servers (TWh), cumulative increase	**4**	**27**	**41**	**72**
European demand from traditional datacenters (TWh), cumulative increase	**13**	**50**	**91**	**148**
European demand from AI/traditional datacenters (TWh), cumulative increase	**17**	**77**	**132**	**220**
% of total 2023 power demand	**1%**	**3%**	**5%**	**8%**

Source: Ember, Goldman Sachs Global Investment Research

The bull case: Datacenters could add up to +c.15% of power demand

As detailed above, over the coming ten years we believe that datacenters will add +8% to power consumption, vs. Europe's 2023 level. However, we also investigate a bull case, in which power demand from DCs is +c.15%.

Exhibit 28: In a datacenter/AI bull case, European power consumption rises by c.50% by 2033E
EU-27 power demand scenario analysis (rebased, 2023 = 100)



Source: EMBER, Goldman Sachs Global Investment Research

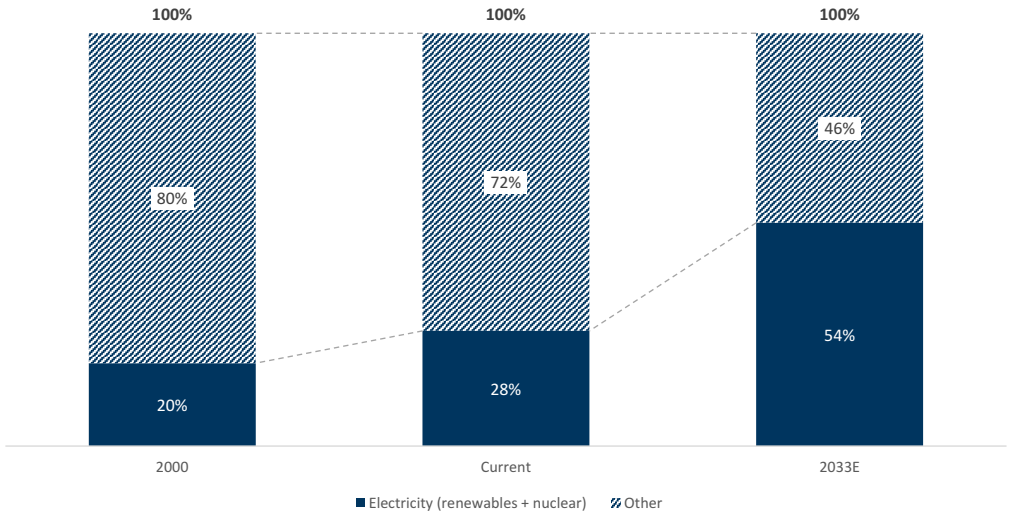
Our bull case assumes the same number of servers shipped, but with zero energy efficiency gains and higher European market share (25%, vs. 20% in our base case).

Electricity may account for more than half of primary energy within ten years

Europe's electrification process, magnified by the power demand needs of datacenters,

is likely to continue to drive a growing role for electricity in the primary energy mix. As a reference, compared to c.20% in 2000, we estimate that electricity could account for more than half of primary energy (c.55%) over the coming ten years.

Exhibit 29: Electricity could account for more than 50% of Europe's primary energy consumption by 2033E
EU-27 primary energy mix (TWh and %): 2000, current (2021) and 2033E (base case)



Source: OurWorldInData, BP, Goldman Sachs Global Investment Research

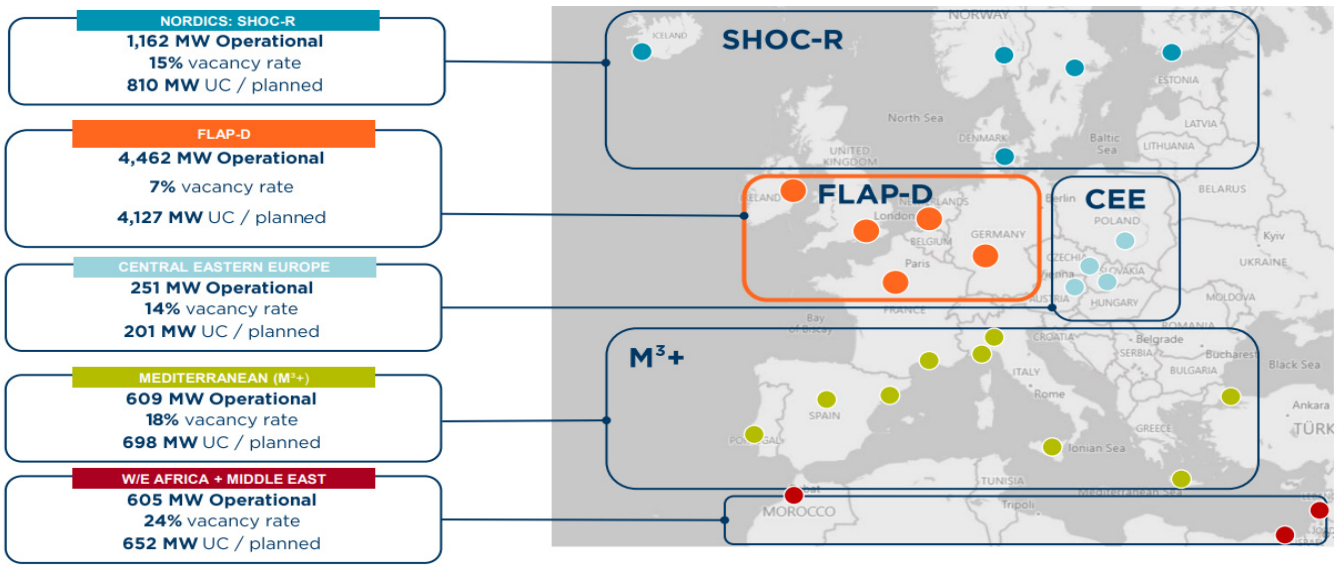
Datacenters: A new driver of power demand

Traditional datacenters have been rapidly expanding to reflect: higher demand from retail customers (cloud storage, social media, movie streaming), a rising number of computational requirements (and storage) by the service industry, and the growing needs of large tech companies such as Google, Amazon, Meta and Microsoft. However, datacenters currently account for only a little over 1% of power demand globally. Our base case assumes that the expansion of traditional DCs will account for some +150 TWh of incremental demand across Europe over the coming ten years. This implies a c.6% boost to Europe's 2023 power demand.

Datacenters in Europe

Currently, about 1% of power consumption is from datacenters. European datacenters are quite concentrated in the FLAP-D region (Frankfurt, London, Amsterdam, Paris, Dublin), as seen in the following map.

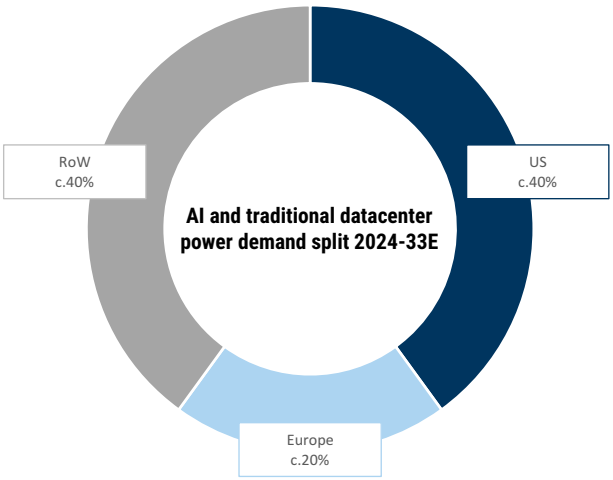
Exhibit 30: European data center capacity is relatively concentrated
EMEA data center capacity (MW)



Source: Cushman & Wakefield

Based on IEA data, Europe is host to c.15% of all global datacenters. However, in terms of power capacity, Europe accounts for as much as 25%. Conservatively, we assume European market share somewhere in the middle (i.e., 20%) in the future.

Exhibit 31: We assume c.20% of future global power demand from AI and traditional datacenters will be in Europe
AI and traditional datacenter power demand split, 2024-33E (%)

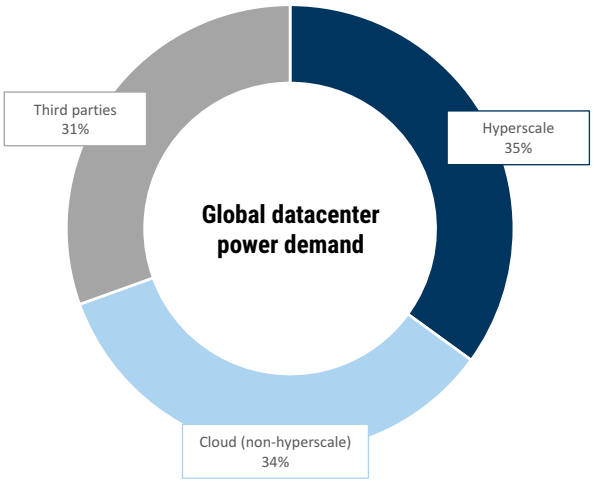


Source: Goldman Sachs Global Investment Research

How a datacenter works

For simplicity, we have classified datacenters (DCs) into three categories: (1) enterprise DCs ("Hyperscale" typically) which are usually owned by large users and have a high utilisation rate - Google, Amazon, Meta and Microsoft account for about half of this segment; (2) third-party servers, which are usually rented by corporates (e.g., financial services, smaller tech firms etc.); and (3) cloud retail datacenters, which largely service demand from smartphones and personal computers (storage, social media, Netflix, etc).

Exhibit 32: Hyperscalers represent about 35% of global datacenter power demand
Global datacenter power demand (% of total)



Source: IEA

A datacenter is a physical room, building or facility that houses computing infrastructure, including servers, storage systems, networking equipment and cooling mechanisms. Servers are responsible for executing computational tasks, storage systems provide capacity for storing data and applications, and networking equipment enables communication and data transfer between servers, storage systems and external networks. Owing to the high-density nature of computing equipment and the consequent generation of heat, efficient cooling mechanisms are essential to prevent overheating and ensure the reliability and longevity of the hardware components. Cooling solutions may involve air conditioning units, liquid cooling systems or specialised airflow management techniques.

Exhibit 33: AI servers are far more energy-intensive than traditional servers
Traditional x86 server rack load (kW per rack)

	Server rack type	
	Traditional x86 (5-15 kW)	**AI (50-100 kW)**
Cooling	35%	45%
Servers	25%	35%
Storage	15%	7%
Networking	10%	5%
Other	15%	8%
Total consumption	**100%**	**100%**

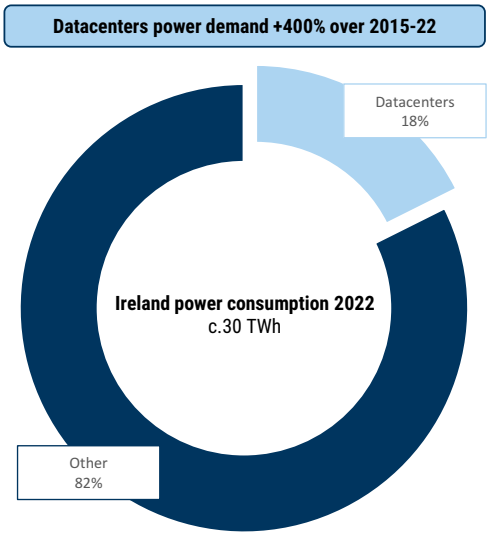
Source: 650 Group

Traditional datacenters: the Irish example

Ireland is an extreme example of datacenter concentration and the effect that DCs can have on power demand. According to the Central Statistics Office (CSO), datacenters in Ireland accounted for c.20% of total power demand in Ireland in 2022. This share is likely to continue to grow: between 2015 and 2022, power consumption by datacenters

in the country rose by c.400% vs. an overall increase in demand of only c.2% pa over the same period.

Exhibit 34: Datacenters account for c.20% of total Irish power demand
Ireland power consumption 2022 (TWh)

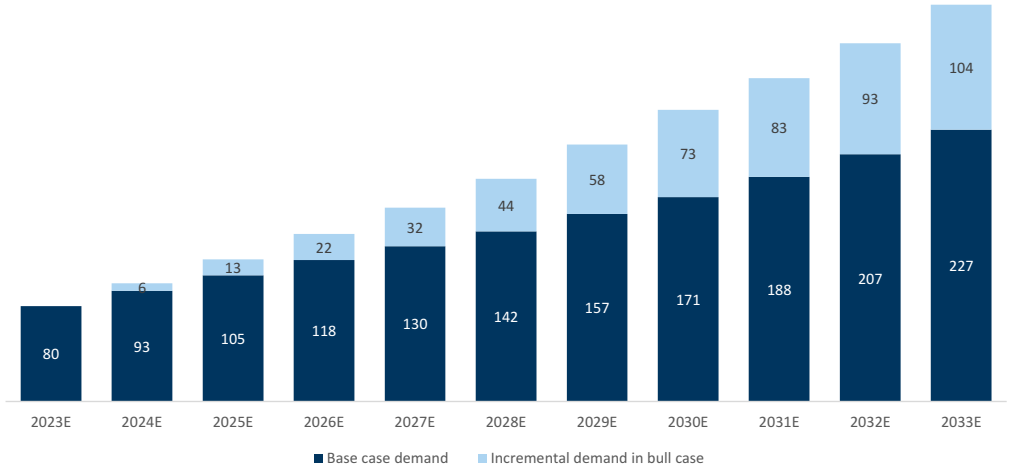


Source: Central Statistics Office (CSO)

Traditional datacenters could add 5%-9% to Europe's power demand

Based on the evolution of traditional servers globally (as estimated by our global tech analysts; see here, and estimating their power consumption (kWh per compute instance), we estimate that traditional DCs will add +c.150 TWh to Europe's power demand (+c.5%) by 2033, vs. 2023. In our bull case (Europe's market share up to 25%, no efficiency gains in servers), we estimate would demand increase by +c.250 TWh.

Exhibit 35: European power demand from traditional centers will reach >200 TWh within the next decade in our base case
Europe traditional datacenter power demand (TWh): base and bull case



Source: Goldman Sachs Global Investment Research

The key assumptions underpinning our forecast for Europe, include: (1) c.11% average annual growth in traditional datacenters; (2) c.8% annual efficiency gains per DC; and (3) 20% market share for Europe, on a global basis.

AI datacenters: Booming, more energy intensive growth

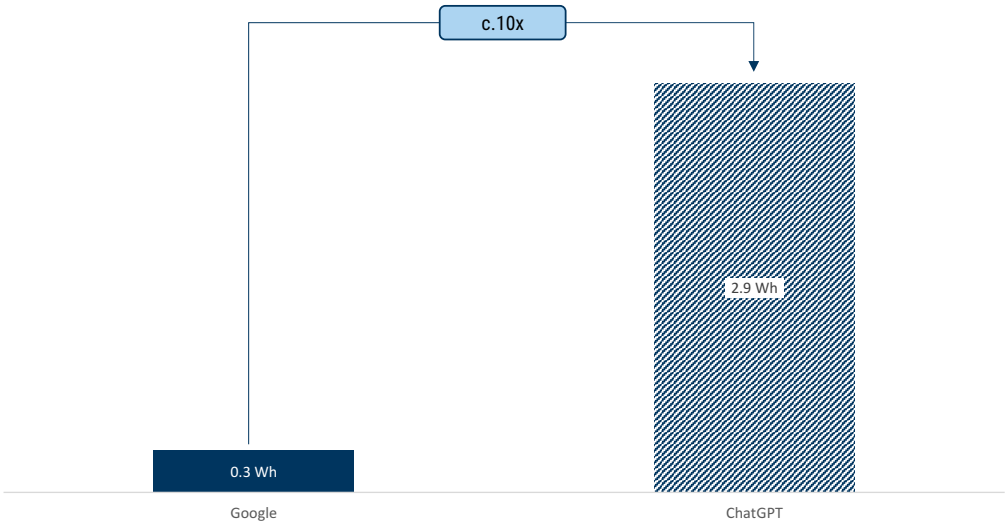
The rise of artificial intelligence (AI) datacenters has sparked much debate over the possibility of these driving much higher power demand. Academic studies show that AI datacenters can consume up to c.10x more energy than traditional DCs. AI servers are particularly energy-intensive during their training (learning) phase. In our base case, AI datacenters alone add c.2.5% to Europe's power demand over the coming ten years. However, given the significant uncertainty over the number of applications that AI will be used for across the entire economy, we also present a bull case. This suggests up to +c.5% power demand boost for Europe, by 2033.

What is an AI datacenter

An AI datacenter is datacenter designed to accommodate the intense computational needs of artificial intelligence. AI servers are optimised to process large amounts of data and run complex algorithms efficiently. Compared to traditional centers, AI datacenters are very energy-intensive: academic studies show that AI datacenters can consume up to c.10x as much power as traditional DCs (link).

As a simple illustration of how power-intensive AI is compared to traditional computing, a ChatGPT search consumes c.10x as much electricity as a standard Google search.

Exhibit 36: ChatGPT queries are 10x as power intensive as traditional Google searches
Power consumption per query/search (Wh)



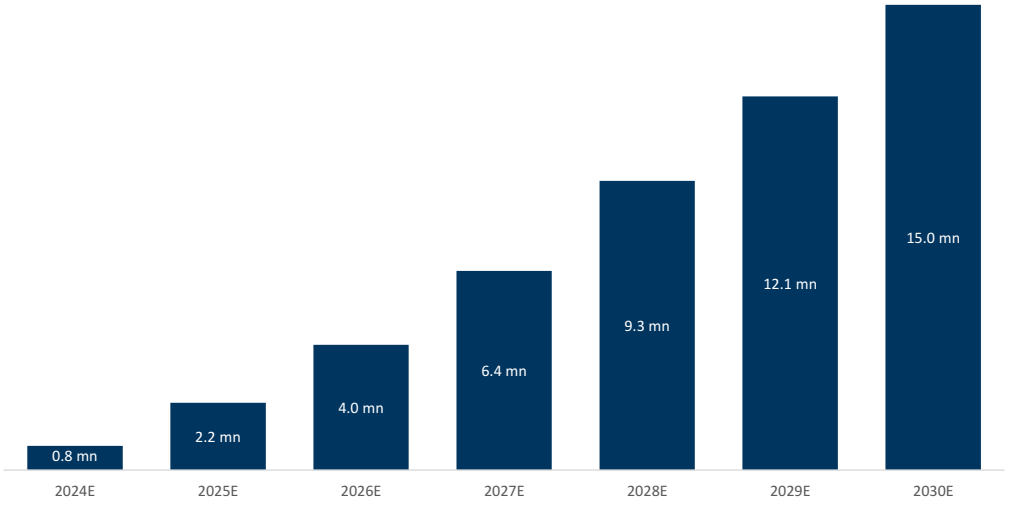
Source: Google, SemiAnalysis

AI datacenters set to add +c.70 TWh to Europe over the coming ten years

NVIDIA is the market leader in AI hardware, with estimated market share of c.75% (4Q 2023) of the Data Center Compute market (here). Based on the estimates of our technology analysts, global AI (new) server shipments could increase more than ten-fold 2030, to nearly 4.5 mn units. Assuming a five-year useful life for this equipment, we

show our projections for the total number of AI servers in operation to 2030E.

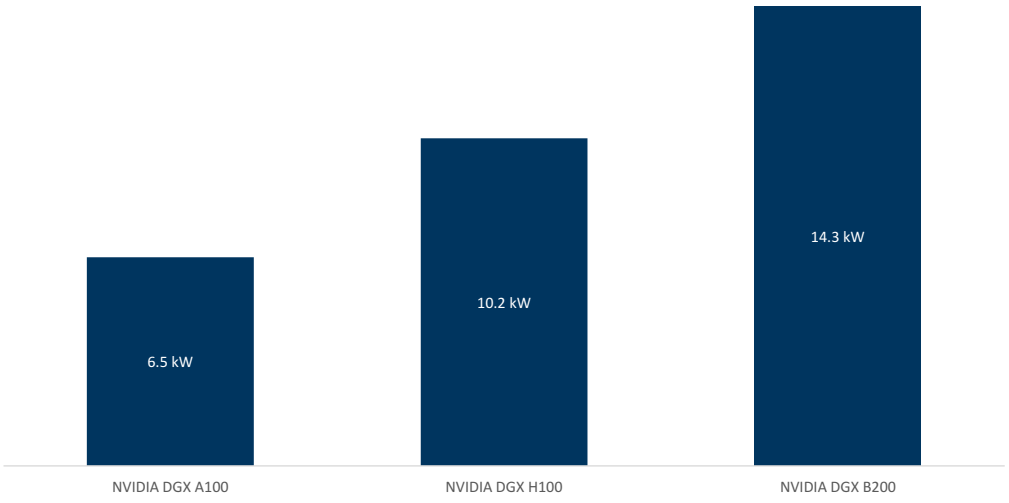
Exhibit 37: By 2030, we expect an incremental 15 mn AI servers to be in use globally
Incremental AI servers in use globally, 2024-30E (mn)



Source: Goldman Sachs Global Investment Research

Next, we estimate load per server, which currently ranges at c.6.5-14 kW. Our tech analysts highlight that while overall power consumption per server has increased over time, the consumption per computation has fallen (see here).

Exhibit 38: AI server capacity range c.6.5 kW to 14 kW
Load per AI server (kW)

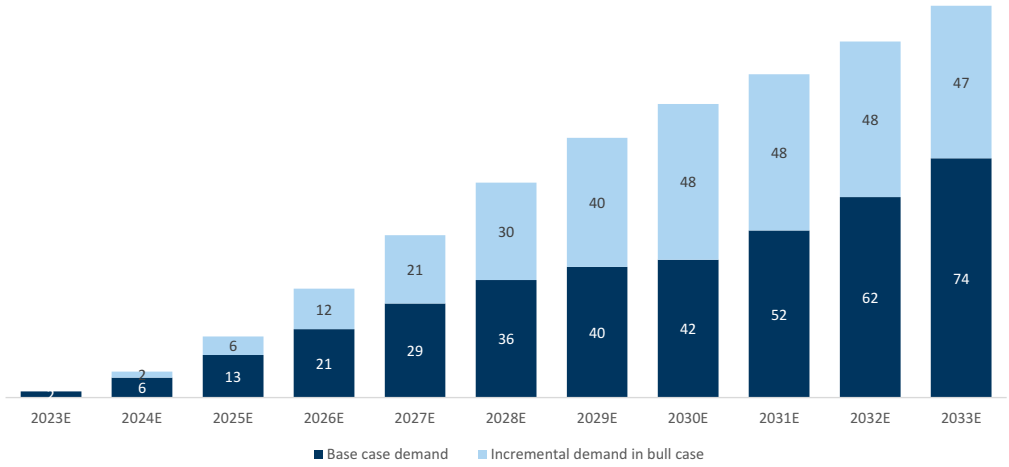


Source: NVIDIA

Our base case forecasts for AI demand are based on our Tech analysts' expectations for AI shipments globally, an assumed average load per server (adjusted for efficiency gains

and utilization) and a flat 20% market share for Europe (in our bull case, we assume 25% market share for Europe and a stable average load per server).

Exhibit 39: AI looks set to add c.70 TWh to European power demand by 2033 in our base case (+120 TWh in a bull case)
Europe AI server demand (TWh)



Source: Goldman Sachs Global Investment Research

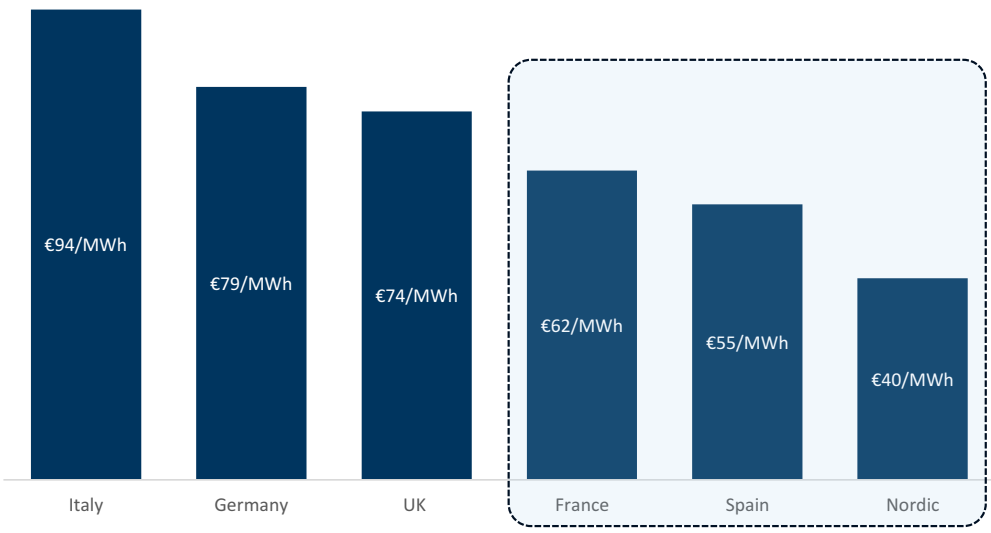
Europe and datacenters: Material regional nuances

We believe power demand from datacenters will be particularly strong in two areas: (1) countries with cheap, abundant baseload power (nuclear, hydro, wind, solar): here we highlight the Nordics, Spain and France; and (2) countries with large financial services and tech companies, willing to offer incentives (e.g., tax breaks) to attract DCs; Germany, the UK and Ireland could be prominent here.

Low power price regions to attract incremental power demand

Countries with cheap, abundant baseload power could attract incremental power demand from datacenters, we believe. Exhibit 40 shows that the Nordic region, Spain and (to a lesser degree) France are the areas with the lowest power prices across Europe, currently averaging c.€50/MWh.

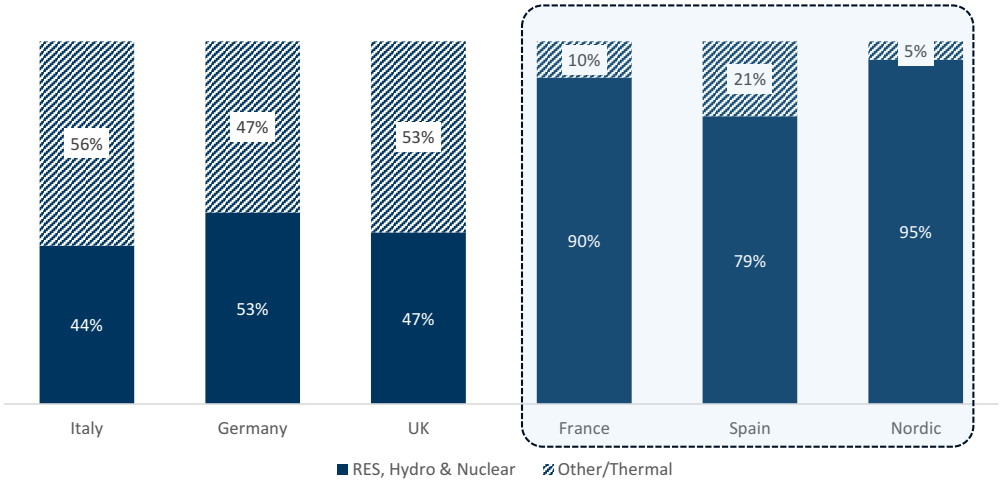
Exhibit 40: Nordic, Spain and France have the lowest power prices in Europe currently
Forward power prices by region, 2026 (€/MWh)



Source: OMIP, EEX, Bloomberg

Low power prices are associated with markets enjoying a higher proportion of fixed-cost technologies, namely: wind/solar, hydro and nuclear. Interestingly, the Nordics, Spain and France show the highest share of RES, hydro and nuclear production in the mix.

Exhibit 41: Typically, lower power prices are associated with a higher share of fixed cost technologies in the generation mix
Countries' power production breakdown by technology, 2025E (percentage)

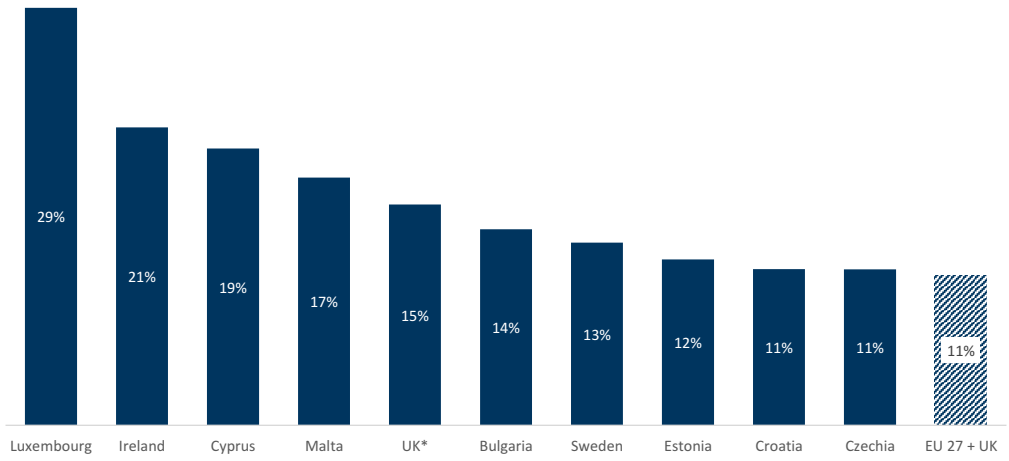


Source: Goldman Sachs Global Investment Research

Big financial services and tech centers should also benefit

We believe that regions with a strong presence in financial services and acting as big tech hubs could also take a larger share of the datacenters pie. Additionally, and as previously stated, countries offering incentives (e.g., tax breaks, LT PPAs) to attract datacenters, and to support a faster adoption of electrification technologies could benefit from a larger share. In this subgroup, we believe Germany, the UK and Ireland could play a larger role.

Exhibit 42: UK and Ireland have economies with larger than average exposure to financial services and ICT
Gross valued added by financial services and ICT, by country (%) (2022)



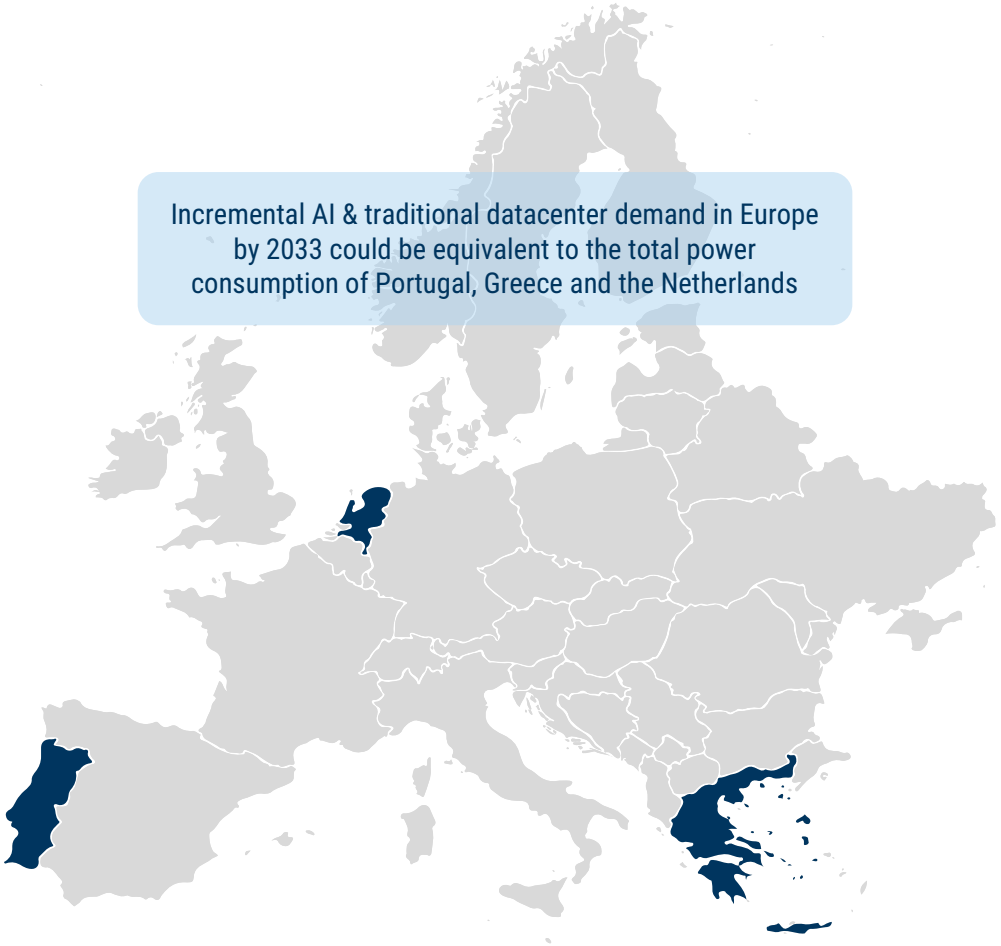
*2021

Source: Goldman Sachs Global Investment Research, Office of National Statistics, Eurostat

The impact will be highly regional

As explained earlier, over the coming ten years we project c.220 TWh of incremental consumption from AI and traditional datacenters in Europe alone, in our base case. This would be equivalent to the current consumption of the Netherlands, Portugal and Greece, combined.

Exhibit 43: By 2033, AI and traditional datacenter demand should match the current consumption of Portugal, Greece and the Netherlands



Source: Goldman Sachs Global Investment Research

If we assume that the Nordics, Spain, France, Germany, the UK and Ireland (which currently account for nearly 75% of Europe's total power consumption) absorb 85%-95% of the total incremental demand from data centers, then electricity consumption in these regions could benefit from a (cumulative) c.10%-15% boost, by 2033E.

Exhibit 44: Traditional datacenters and AI could lift power demand in some countriesby as much as +13% (base case)
Traditional datacenters and AI power demand growth to 2033 analysis

	85% allocation scenario					
	Nordics	**Spain**	**Ireland**	**France**	**Germany**	**UK**
Power consumption 2023 (TWh)	392	256	35	464	514	317
Traditional datacenter + AI demand growth to 2033 (TWh)	44	29	4	39	43	27
Implied consumption growth vs. 2023 (%)	**11%**	**11%**	**11%**	**8%**	**8%**	**8%**

	95% allocation scenario					
	Nordics	**Spain**	**Ireland**	**France**	**Germany**	**UK**
Power consumption 2023 (TWh)	392	256	35	464	514	317
Traditional datacenter + AI demand growth to 2033 (TWh)	50	32	4	44	48	30
Implied consumption growth vs. 2023 (%)	**13%**	**13%**	**13%**	**9%**	**9%**	**9%**

Source: Ember, Goldman Sachs Global Investment Research

REPowerEU plan set to kickstart a major electrification process in Europe

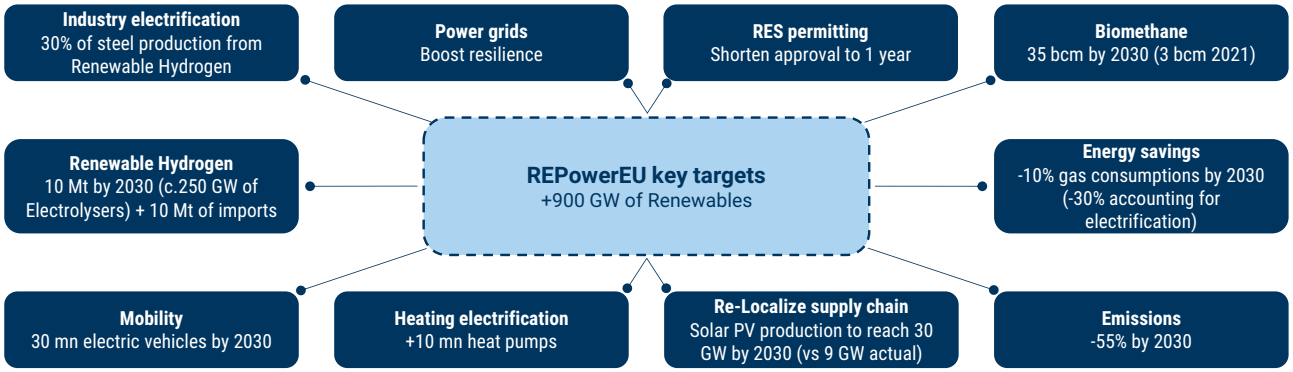
We detail our assumptions for heating, mobility, manufacturing and hydrogen supporting our c.35% power demand upside scenario from electrification, over the coming ten years, as laid out in this report. We note that, from prudence, our analysis assumes that the EU targets on electrification (as expressed in the REPowerEU plan) are achieved only in 2033-35, three to five later than the original plan.

The REPowerEU plan

In May 2022, the EU unveiled an ambitious clean energy transition plan, the REPowerEU plan. It represents a major, ground-breaking electrification plan for Europe, that if delivered, will transform the way we consume energy, boost investments in renewables, transform industrial processes, modify the way we heat homes and buildings, and radically change the concept of mobility. Specifically, the plan outlines three main objectives:

- **Boost the supply of clean energy.** The plan was presented in the aftermath of the European energy crisis, with the goal of accelerating clean energy targets and boosting the diversification of energy supplies. This is a major electrification plan, which heavily relies on renewable sources (targeting a c.70%-75% RES share of power production by 2030) to decarbonise power-generation activities, industrial processes, buildings (heating) and mobility. In terms of technology, it targets a major acceleration in the development of wind/solar, heat pumps, renewable hydrogen and biomethane.
- **Achieve meaningful energy savings.** REPowerEU largely focuses on saving energy, mostly gas (10%-30% savings), to counter the reduction in supplies from Russia.
- **Supply chain re-localization.** Currently, Europe accounts for only 2% of global solar manufacturing, which compares with c.80% for China. In other words, only c.10% of the modules added in Europe under the REPowerEU plan (c.75 GW pa over 2023-32) would be endogenously manufactured.

Exhibit 45: The REPower EU plan sets several targets across different technologies to accelerate the energy transition
REPowerEU key targets



Source: European Commission

Electrification: Four main drivers for power consumption

Heating. Our estimate for heating implies +11% power demand upside vs. 2023 levels. We base this upside on an assumption of 40 mn heat pumps by 2033, for residential customers; essentially, we take the Eurelectric estimate for 2030, and assume a three-year delay. For industrial buildings (and offices), we assume that electrified buildings will move from the current 50% level to about 65%.

Mobility. We assume the number of EVs in Europe increases from 8 mn in 2023 to 60 mn by 2033 (= REPowerEU goals, delayed by three years). Based on an electric vehicle's annual consumption of c.3 MWh, we estimate the potential power consumption upside at c.6%, vs. the 2023 level.

Manufacturing. We assume that the electrification rate for industries increases from the current 30% to 40% by 2033, implying power demand upside of c.10% vs. 2023. This is well below the goals implied by REPowerEU, and could potentially provide the largest source of upside to power demand within the electrification process.

Hydrogen. We assume power demand upside of c.7% vs. current power consumption levels, based on a standard load factor of 27.5%, applied to 80 GW of renewables capacity (the capacity needed to run the targeted 40 GW of electrolysers).

Exhibit 46: Our assumptions for heating, mobility, manufacturing and hydrogen supporting the c.45% power demand upside scenario to 2033

Main assumptions supporting the c.45% power demand upside scenario to 2033			
Heating	Mobility	Manufacturing	Hydrogen
About 2/3 of service buildings electrified, and 20% of residential buildings to be electrified	52 mn incremental EVs by 2033, consuming c.3 MWh/year of electricity	An increase in the electrification rate for industry to 40% (from 30% currently)	80 GW of renewables (at a standard load factor of 27.5%) to support 40 GW of electrolysers.

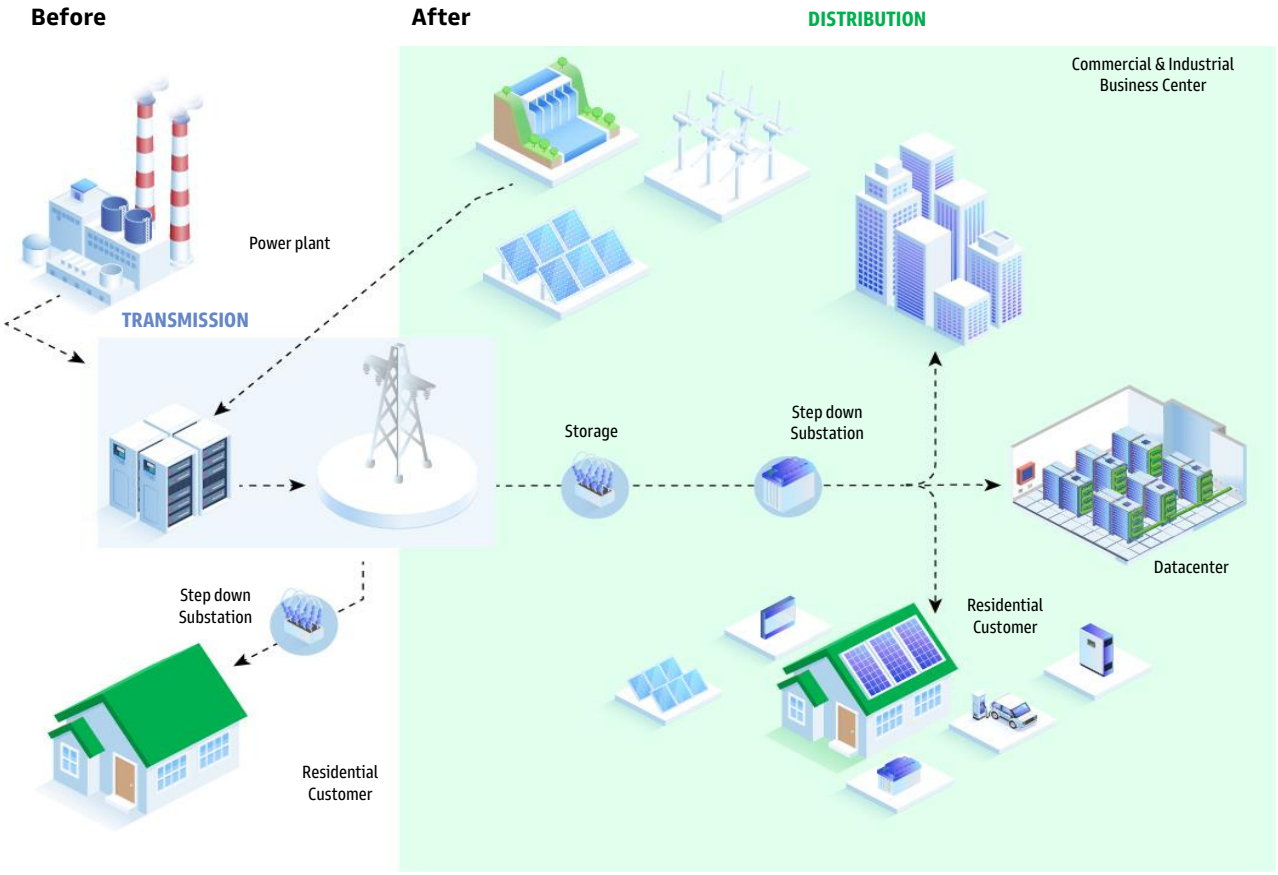
Source: Goldman Sachs Global Investment Research

Power Grids: The urgent need to modernize

We estimate that, over the coming ten years, European investments in power grids (Transmission and Distribution) will accelerate by 80%-100%, depending on the region. In aggregate, this will entail €800 bn of spending in power T&D for Europe as a whole. We believe this secular capex supercycle in power grids reflects three main drivers:

- **Structural under-investment**. For the past two and a half decades, Europe's energy transition policies have largely focused on developing renewable energy (wind, solar). As a result, power grids have been neglected – currently these assets are over 40 years old.
- **Electrification**. The electrification process implies a growing need for: (1) new connections (e.g., distributed generation, datacenters); (2) the development of charging infrastructure for electric vehicles; and (3) the ability to handle much higher loads from electrified buildings and factories.
- **Managing complexity.** The rising share of distributed generation (renewables), electric vehicles, rooftop solar and datacenters has greatly increased the complexity of electricity systems. Power grids will have to rely on big data and algorithms to predictively manage power systems. This in turn will require investment in software, sensors and 'intelligent' hardware.

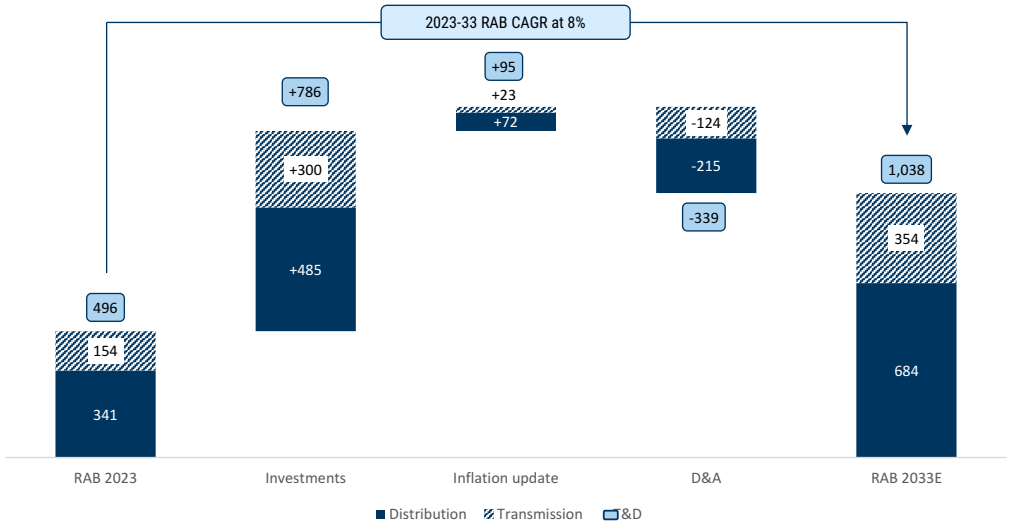
Exhibit 47: The distribution network will need a significant upgrade to cope with rising complexity in the power system brought about by the energy transition
Indicative illustration of distribution network before and after energy transition



Source: Goldman Sachs Global Investment Research

We expect the power grids asset base (regulatory asset base, or RAB) to grow throughout Europe, by c.8%-10% pa, well into the early 2030s. These activities provide an attractive risk-adjusted return in our view, as they operate in the absence of competition (in a regime of natural monopoly) and with fully regulated returns set on a 'cost-plus' basis. We see EON, Enel, SSE and Iberdrola as offering the greatest exposure to this theme.

Exhibit 48: Combined T&D RAB in Europe set to more than double between 2023 and 2033, reaching c.€1 trn by then
EU+UK Power T&D RAB evolution 2023-33E, breakdown by main components (€ bn)

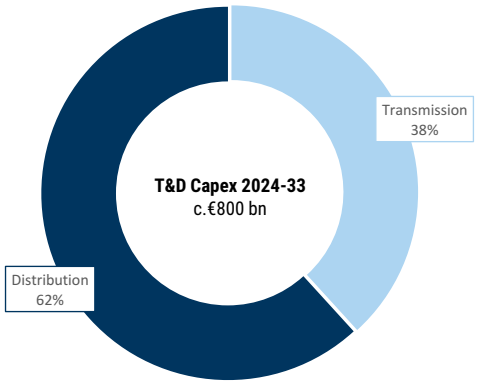


Source: Goldman Sachs Global Investment Research

Nearly €800 bn of investment needed to modernize and expand the European power grid

Besides the need to modernize its ageing power network infrastructure, we believe Europe will need to expand and digitalize its transmisison and distribution grids, to cope with: (1) rising connection requests from renewable energy; (2) deployment of new electrification infrastructure in mobility and heating; and (3) the need to better integrate and interconnect the European power market. Our estimates suggest combined T&D investment of nearly €800 bn over the next ten years.

Exhibit 49: European T&D power grids will attract nearly €800 bn of investments over 2024-33, we estimate
EU + UK Transmission and Distribution capex breakdown, 2024-33E (€ bn, percentage)

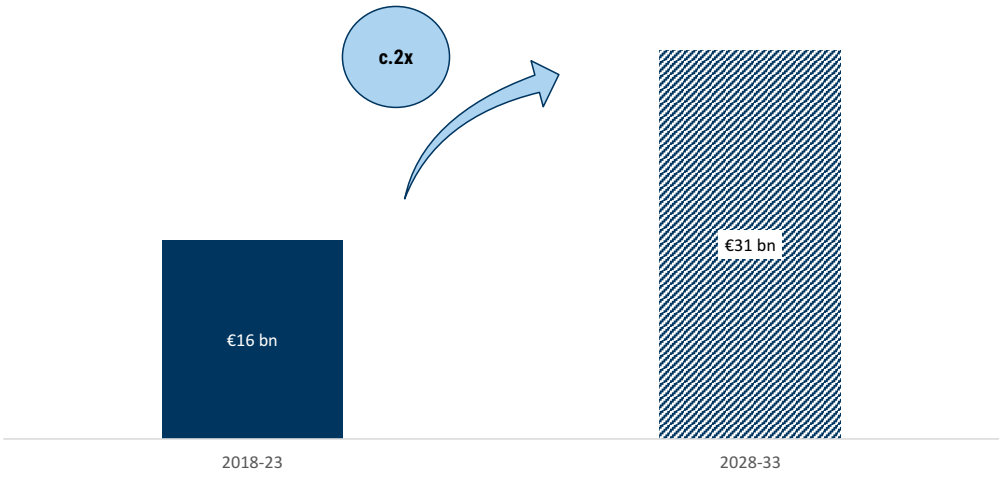


Source: Goldman Sachs Global Investment Research

Transmission: Annual capex to double by end-decade

For Europe as a whole, we estimate that the annual capex run-rate in Power Transmission is set to reach >€30 bn towards end-decade (2028-33E). This implies a doubling from current annual capex level of €16 bn.

Exhibit 50: We expect Transmission annual capex to double in the near future, reaching >€30 bn by 2028-33
EU + UK Power transmission annual average capex evolution (€ bn)



Source: Goldman Sachs Global Investment Research

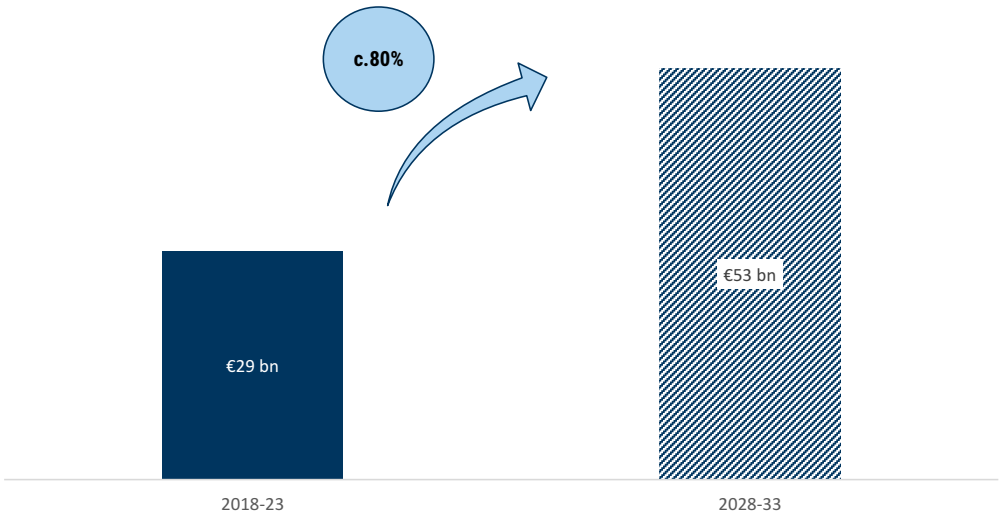
The main drivers of this forecast capex acceleration in Power Transmission are the following:

- **The integration of power markets.** In 2014, the EU set a 2030 interconnection target amongst member states of at least 15%; in other words, each country would need cables capable of transporting 15% of the electricity produced to neighboring countries. A recent report from ENTSO-E highlights the need to double the cross-border interconnection capacity from current levels, for the region to cope with energy transition targets.
- **New corridors.** In light of the structural skew in the development of renewables (more solar in Southern Europe, more offshore wind in Northern Europe, for instance), and given imbalances within countries (e.g. Germany shutting down lignite in the west and the east, and adding offshore in the north), the EU Commission (see here) has identified priority energy corridors to be developed.
- **Offshore wind.** About 15% of the total investment in a new offshore wind farm is for Transmission infrastructure, we estimate. Since Europe is planning to reach 111 GW by 2030 (vs. c.17 GW in 2022), we believe new offshore facilities would be a large driver of Transmission capex.

Distribution investments to accelerate by c.80% over the coming years

Regarding distribution, we expect annual capex (currently c.€30 bn pa) to accelerate by c.80% over the coming years. This should bring annual capex deployment to nearly €55 bn pa by 2028-33E.

Exhibit 51: Distribution annual investments could increase by c.80% and reach nearly €55 bn towards end-decade
EU + UK Power distribution annual average capex evolution (€ bn)

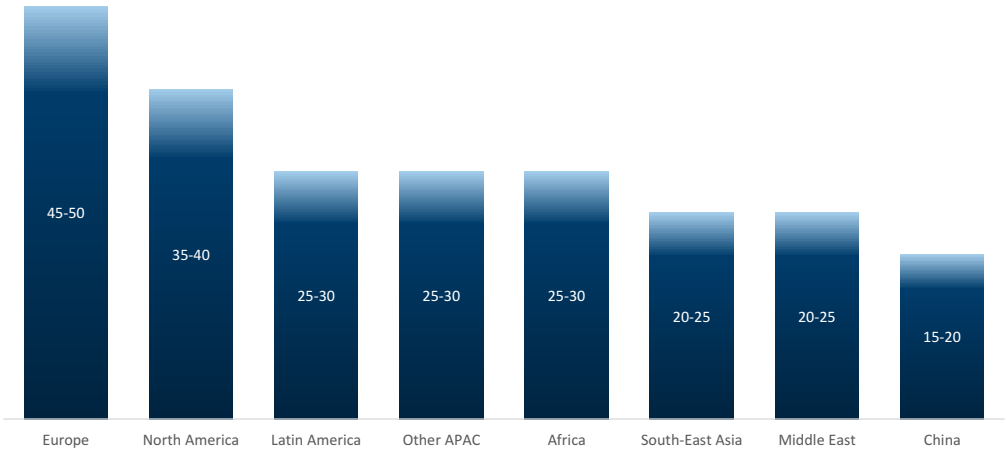


Source: Goldman Sachs Global Investment Research

Besides the structural underinvestment (Europe's power grid is rapidly ageing and >40 years old, according to Nexans), our Power Distribution capex forecasts are supported by three main factors:

- **Renewable connections.** By 2030, Europe is planning to reach an installed RES base (mostly solar, onshore wind, offshore wind) of 1,236 GW; essentially +c.2x more than the 2022 level. As c.70% of all new renewable additions are typically connected to the distribution grids (according to Eurelectric), we believe that RES additions will be a key driver of accelerating capex in distribution grids.
- **Electrification infrastructure.** Mobility infrastructure (new charging points) will also be a key driver: currently (2022), in Europe (+UK) there are 7 mn EVs. According to Eurelectric, this should increase to 50-70 mn by 2030. We believe the electrification of heating will also be a key driver (c.40 mn heat pumps targeted by 2030, vs. c.20 mn installed currently).
- **Digitalization to handle complexity.** The volatility triggered by the rising share of renewable energy in the system, together with the upgrades needed in low-voltage grids (distributed generation, EVs, HPs), will require a significant upgrade of power grids to deal with the rising complexity in the power system. Digitalization (sensors, AI software, upgrades in transformers) will be another key investment driver, in our view.

Exhibit 52: Europe has the oldest power grid in the world
Estimated average age of grid by region (years)



Source: Nexans Presentation

Renewables: Unloved, but pivotal to meeting rising demand

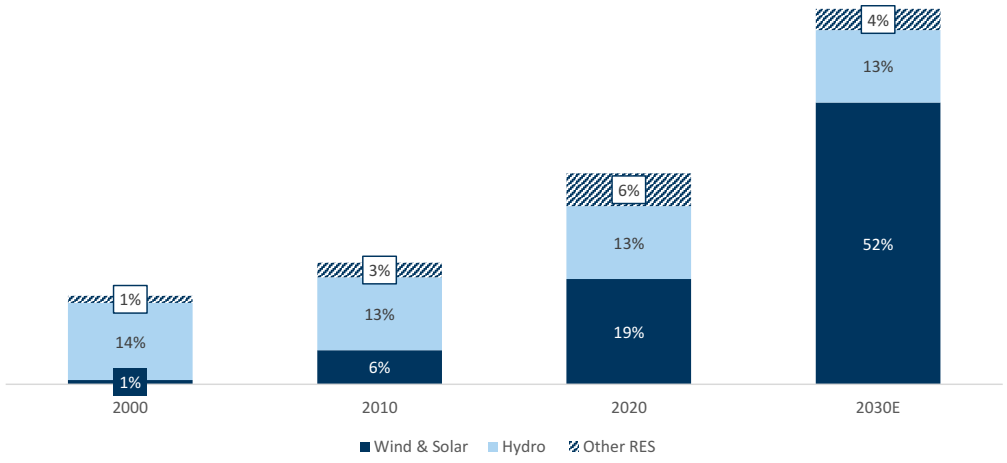
On our estimates, which assume 4-5 years of delays to accomplishing the REPowerEU goals, Europe will nearly triple the amount of wind and solar installed in the region within ten years. This would imply an average 75-80 GW of annual additions, representing c.€850 bn of investment broadly evenly split across solar, onshore wind and offshore wind.

Electrification and datacenters validate the REPowerEU plan

The ongoing deployment of RES is pivotal to Europe's electrification process. In more detail, we see this growth underpinned by three key drivers:

- **Decarbonization**: as consistently seen since 2000, we expect wind and solar to gain market share in the energy mix, to replace production from coal and gas.

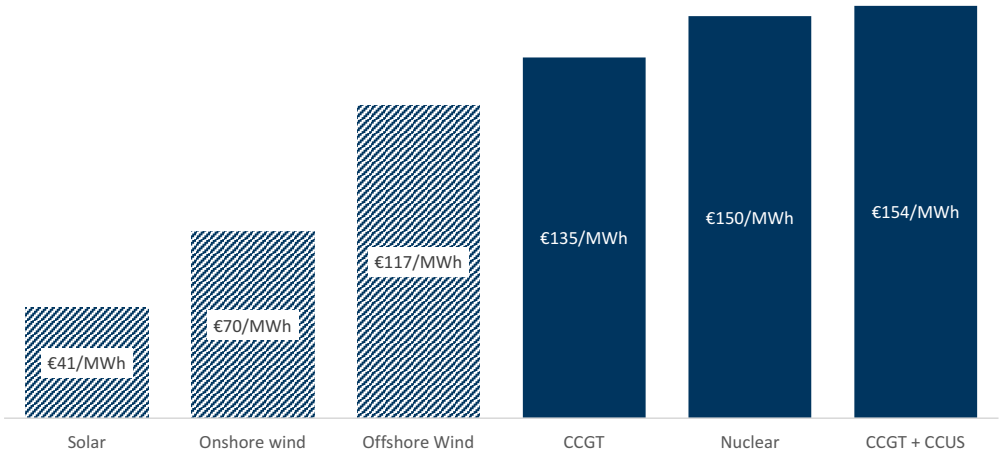
Exhibit 53: Wind and solar have been gaining market share in the EU energy mix since 2000, and we expect this to continue to 2030
EU-27 share of production by RES technology evolution (percentage of total production)



Source: European Commission, Goldman Sachs Global Investment Research

- **Better economics:** despite the increase in rates and in equipment costs, developing (onshore) wind and solar remains cheaper than any other thermal alternative, on a like-for-like comparison (i.e., comparing the costs of new facilities on a 'full-cost' basis).

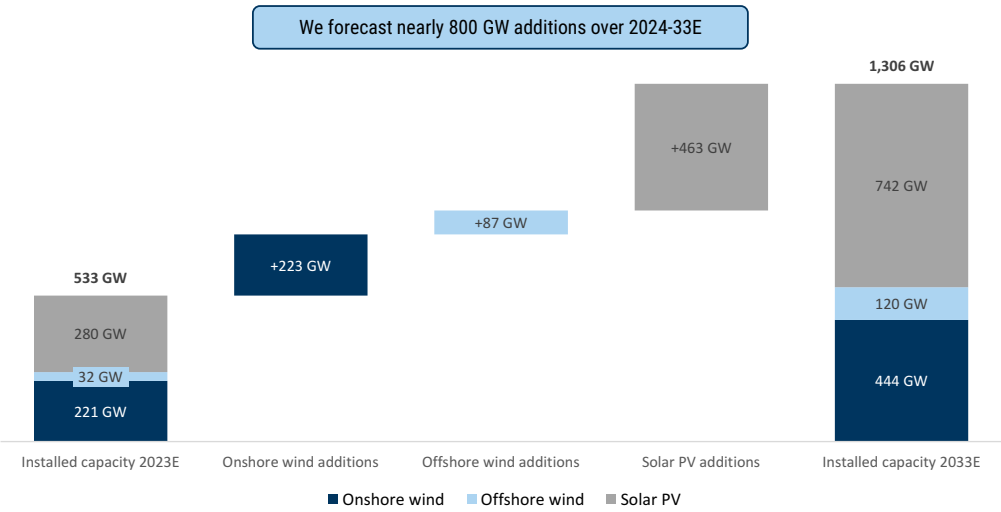
Exhibit 54: Despite higher rates and equipment costs, we estimate wind and solar remain cheaper than any other thermal alternative
European LCOEs by technology, 2025E (€/MWh)



Source: Goldman Sachs Global Investment Research

- **Rising power demand**: new MWs will be needed to support the potential c.40%-50% increase in demand, described throughout this report. All in all, we estimate that over the coming three years the wind and solar installed base in Europe will nearly triple.

Exhibit 55: We expect Europe to add nearly 800 GW of wind and solar over the coming decade
Europe wind and solar installed capacity and additions 2024-33E (GW)

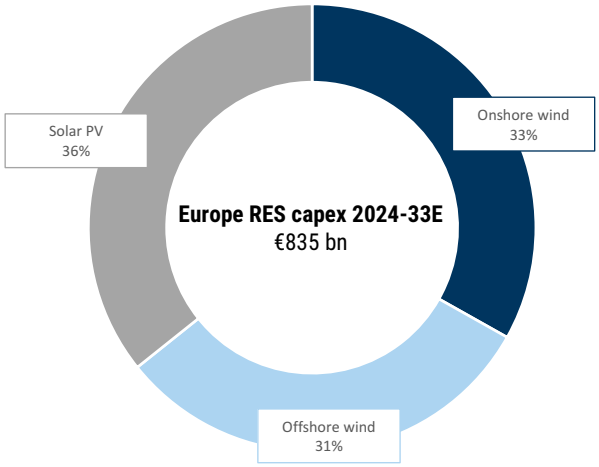


Source: Goldman Sachs Global Investment Research

The near-800 GW of additions that we estimate by 2033 will require investment of nearly €850 bn over the coming ten years, broadly evenly split between solar, onshore

wind and offshore wind.

Exhibit 56: Europe will need to invest more than €800 bn in wind and solar over 2024-33E we believe
Europe wind and solar capex 2024-33E (€ bn)



Source: Goldman Sachs Global Investment Research

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