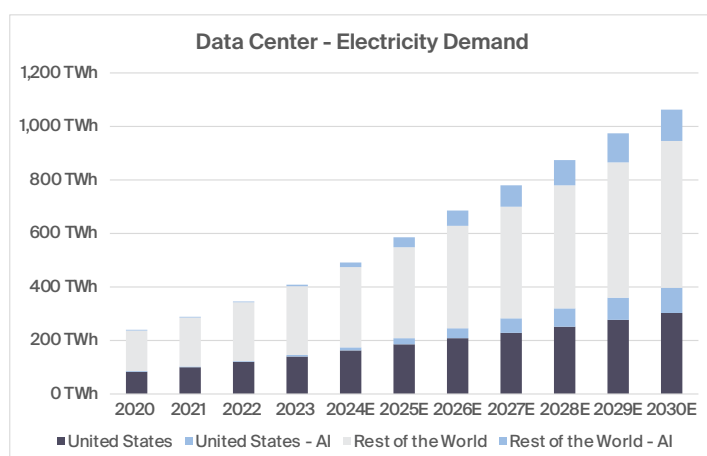
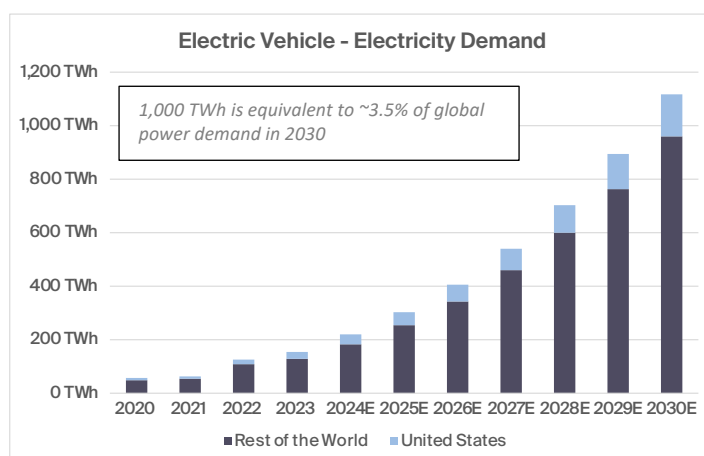


Executive Summary

The era of flat power demand is over. Data center load growth super-charged with the use of artificial intelligence (AI) and an acceleration in electric vehicle (EV) adoption are driving electricity demand. This growth in demand combined with several emerging megatrends is anticipated to cause global power generation to increase by more than 90% by 2050 under current government policies and potentially by almost 110%¹ if stricter decarbonization policies are put into place. These megatrends include energy transition, electrification, digitalization and reindustrialization, all of which represent a powerful investment thematic, particularly for the electrical equipment companies making mission-critical gear that enhance and harden the grid. The implication for many of those companies is they appear to be in the early innings of a multi-decade manufacturing super-cycle that should drive annual revenue growth that's nearly double historical industry rates. This paper explores the potential impacts of these megatrends on electricity consumption and our strategy for earning outsized returns on investment.



Source: Goldman Sachs



Source: IEA and Rithm Capital estimates

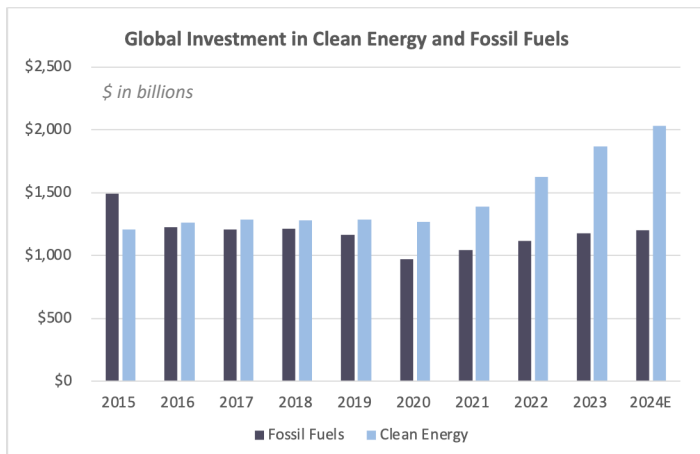
Emerging Megatrends

Energy Transition

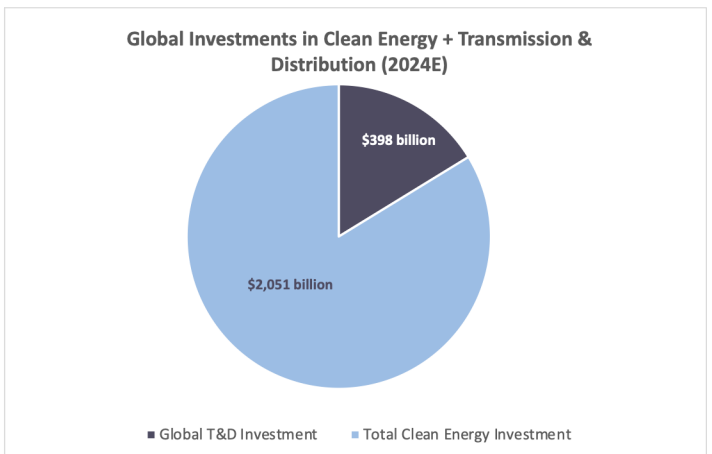
Energy transition is the move away from fossil fuel-based generation such as coal, natural gas and oil to cleaner, renewable sources like hydro, wind and solar energy. Energy transition also involves reducing the consumption of fossil fuels to decrease greenhouse gas emissions. The share of renewable energy in electricity generation has been increasing globally and in the United States. Renewable energy currently accounts for ~30% of the world's power generation, up from 10% in 2010. In the United States, renewable energy accounts for ~20% of electricity generation and by more than 40% when nuclear energy is included in the mix. Renewable energy has become the fastest growing energy source primarily because of its rapidly declining costs that have made it increasingly competitive with traditional fossil fuel generation. Technological improvements have enabled the cost of electricity from solar power to fall by almost 90% between 2010 and 2020 and the cost of onshore and offshore wind to fall by ~50%² over the same time-period. As a result, the world now invests almost twice as much in clean energy as it does fossil fuels with the expected spend reaching almost \$2 trillion annually. These investments are expected to continue to increase the share of renewable energy as a percent of the world's electricity generation mix to as much as 70-90% by 2050^{1,2}.

1. International Energy Agency (IEA) – World Energy Outlook, 2024

2. United Nations and International Renewable Energy Agency (IRENA)



Source: IEA – World Energy Investment 2024



Source: IEA – World Energy Investment 2024

Electrification

Electrification means replacing technologies or processes that use fossil fuels, like internal combustion engines (ICEs) and gas furnaces, with electric-powered equivalents, such as electric vehicles (EVs) or heat pumps. These replacements are typically more efficient, reducing energy demand, and have a beneficial impact on emissions as electricity generation is decarbonized. For example, the rise in EV sales not only shifts demand from petroleum to electricity, but it also reduces the total amount of energy required for road transportation since electric motors for passenger cars require less than one-third the energy as ICEs for every mile driven. The increasing adoption of electric motors in household appliances and industrial applications also offers the potential for substantial energy savings over time. Today, electricity accounts for ~20% of total final global energy consumption and is projected to increase to at least 30% and potentially to more than 50% by 2050³ depending on the world's commitment toward eliminating greenhouse gas emissions. A single EV driven 13,500 miles a year consumes roughly 3.8 MWh, about one-third of the average U.S. household's annual electricity use. The harder constraint is not energy but coincident peak: a home Level 2 charger draws 7-11 kW, rivaling the diversified load of all the homes a single pad-mount transformer was sized to serve. Electrification therefore pulls through distribution transformers, service upgrades and secondary conductor long before it strains generation.

Digitalization

Digitalization is the increasing application of information and communication technology (ICT) throughout the economy and society. ICT includes any technology, component, or device that enables communications, data sharing and global connectivity. The internet, internet of things (IoT), metaverse, virtual reality, cloud computing, AI, 5G/6G networks, Web3, and quantum computing all fall into the ICT universe. The computing requirements to perform these tasks, related cooling needs, and power for associated IT infrastructure has caused electricity demand to soar with projections suggesting that consumption could nearly double by the end of the decade⁴. The ICT sector currently accounts for ~7% of global electricity consumption, and it is forecast to rise to 13% by 2030⁵. This energy footprint currently represents 3-5% of global carbon emissions, putting it on a par with the aviation sector. Data centers alone represent less than 2% of global power consumption today, a share expected to approach 4% by 2030, and more than 8% of U.S. electricity demand by the end of the decade according to Goldman Sachs projections. Rack densities have climbed from 10-15 kW to over 100 kW in AI deployments, forcing liquid cooling, medium-voltage UPS and busway, so the electrical content per megawatt is rising faster than capacity itself.

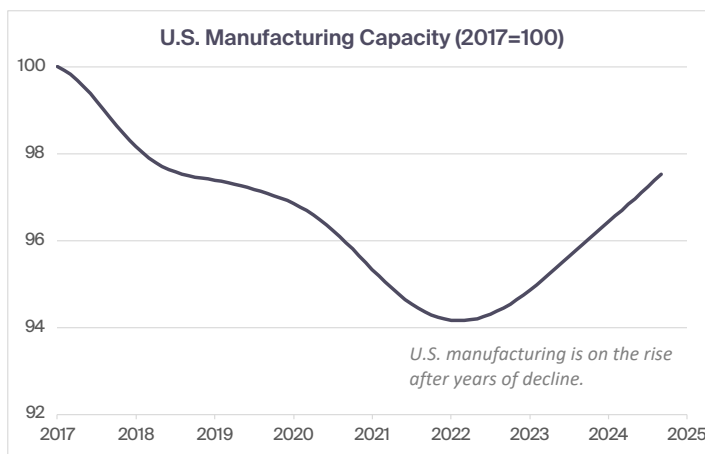
3. International Energy Agency (IEA) – World Energy Outlook, 2024

4. A single ChatGPT query requires nearly 10x as much electricity to process as compared to a Google search, on average (IEA).

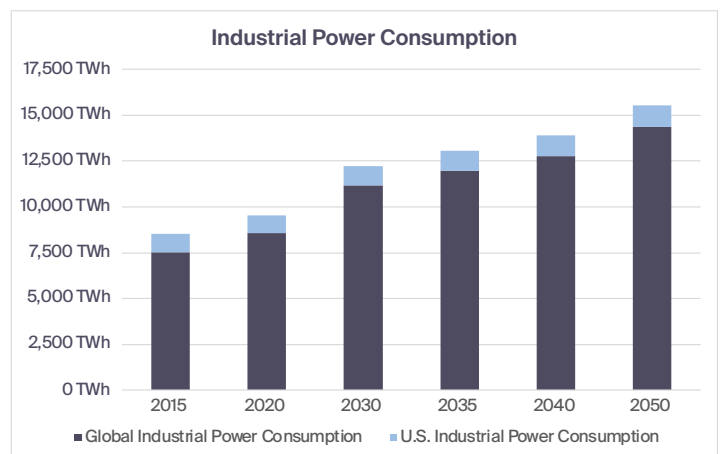
5. European Commission

Reindustrialization

Reindustrialization, which includes reshoring, is the process of strengthening the industrial sector by moving manufacturing and production back inside a country's border. The goal is to create jobs, boost production, and reduce dependency on foreign sources. Reindustrialization is happening in the United States and Europe and is being driven by several factors including the need for greater supply chain flexibility and resilience; escalating geopolitical concerns such as U.S.-China tensions; tariffs on imported goods; increasing demand for locally produced goods among consumers; and government incentives, such as tax breaks, grants, and infrastructure investment to encourage businesses to bring manufacturing back to its origin. This resurgence in manufacturing is driving up electricity demand, primarily due to the increased need for power to operate production facilities. Sectors like semiconductor production and EV manufacturing are particularly energy intensive. Industrial electricity demand in the United States, which accounts for about one-quarter of total electricity consumption, is anticipated to grow by at least 15% through 2050⁶. Throughout the rest of the world, industrial power demand is expected to grow by nearly 50% by 2050⁷. But if manufacturing switches to more electric-powered machinery, electricity demand could more than double, while total energy used declines by ~5% since the increased electricity usage should lead to a reduction in the use of fossil fuels for heating and other non-electric energy needs.



Source: Federal Reserve Economic Data (FRED)



Source: IEA – World Energy Investment 2024

Transformation of the Electric Grid

To accommodate the increasing demand for electricity, significant infrastructure investments will need to be made. These investments not only include new generation facilities but also new and upgraded transmission and distribution (T&D) systems, such as substations, transformers, cables, and overhead lines, to handle the increased load. Even without electricity demand on the rise, large investments were going to be needed to replace the existing grid's aging infrastructure⁸. In the United States, most of the electric grid was built in the 1960s and 1970s, and estimates by the Department of Energy indicate that over 70% of the grid is more than 25 years old. To promote greater reliability and resilience, the grid must also be digitalized since the decentralized nature of new energy technologies is disrupting the traditional power delivery model. Electricity no longer follows a one-way path from a generating station to the end-user. Consumers can increasingly produce their own electricity (via solar installations and battery storage), use it locally as needed, and in many cases, export excess power back to the grid. This means a redesign of the entire grid⁹ needs to occur to avoid short circuits. Using automated and interconnected computing and AI will improve the efficiency of electricity management despite having a more complex energy ecosystem.

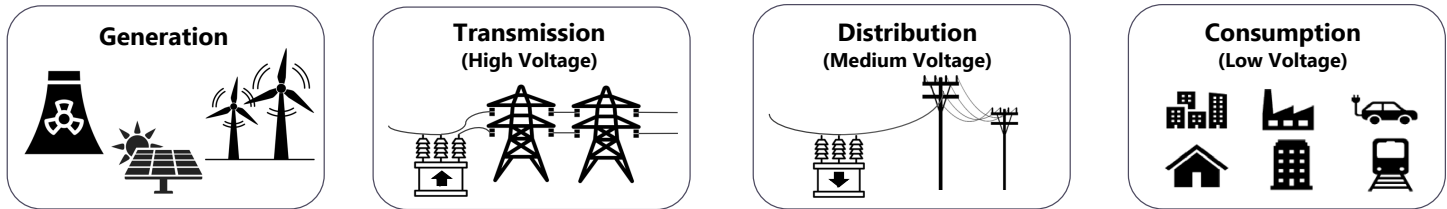
6. U.S. Energy Information Administration (eia) – Annual Energy Outlook, 2023

7. International Energy Agency (IEA) – World Energy Outlook, 2024

8. The total combined length of all transmission and distribution networks globally is close to 55 million miles, a distance long enough to encircle the planet more than 2,100 times. (Rystad Energy)

9. A smart grid is an electricity network that uses digital technologies to monitor and manage the delivery of power from generation to consumers.

Electricity Value Chain



Challenges for the Power Sector

1. **Under-Investment:** Global grid investment (excluding battery storage) is expected to be at least \$2.5 trillion between 2025-30¹⁰ based on current run-rate levels, but that's probably a conservative estimate since concerns over grid-related bottlenecks are already emerging¹¹.
2. **Regulatory Approvals:** The lack of obtaining timely regulatory approvals for permits and interconnections is another contributing factor to potential bottlenecks despite most government agencies around the world generally being in favor of the shift to greater electricity usage.
3. **Cyber-Security:** Another challenge with the migration to the smart grid is cyber-security due to the increasing reliance on digital communication and internet-based technologies.
4. **Data Management:** Smart grids produce a lot of data. Utilities will need to create systems for collecting, storing, analyzing and responding to this data in real time.
5. **Technological Integration:** Smart grids are dependent on a system of sensors, meters, and communication devices – all of which will need to be able to efficiently communicate with each other.

Final Thoughts

The expected growth in electricity consumption that's being driven by energy transition, electrification, digitalization and reindustrialization represents a multi-decade investment thematic, especially for the electrical equipment companies making the equipment to enhance and harden the grid. This is a figurative "pick and shovel" play that provides investors with a lower risk way of gaining exposure to these themes instead of taking on technology, construction and commodity price exposures¹². And these grid-related expenditures are not an elective, they must be made to sustain economic growth and provide long-term energy security. It's not an exaggeration to state that many of these companies are in the early innings of a manufacturing super-cycle that should drive annual revenue growth that's nearly double historical industry rates. The companies driving the "electric revolution" should have the best ability to provide consistent long-term returns to investors.

10. In that scenario, an additional 11.2 million miles of grid network would be needed to keep pace with the electrification underway across cities and counties, including new renewable energy capacity and the rapid adoption of electric vehicles.

11. It can take a year to build a substation and more than ten years to build a high-voltage line, depending on the jurisdiction and length of the line, so thoughtful planning is required to accommodate the anticipated growth in power demand.

12. Favorable legislation from policymakers provides another tailwind that should incentivize continued investment in these initiatives.