Challenges to the American Grid (The Grid, part one)

Newspapers are reporting a surge in demand for electricity, driven by data centers and artificial intelligence (AI), new factories, EVs, and electric heating and cooling. The grid has a new energy mix, with solar and wind resources. Our grid is quite reliable, despite aging infrastructure; much of it was built in the 1950s and 1960s. But greater resiliency is now needed, to be able to plan and prepare for, respond to, and recover rapidly from severe storms and wildfires, physical and cyber attacks, and other hazards.

What is the grid? Briefly, it is the transmission and distribution system that moves electricity. From central energy generating sources, transformers step-up or convert electricity to high voltage for long distance transmission, and step-down electricity to lower voltage distribution feeder lines to customers. Electricity generation must balance electricity consumption, moment by moment. There is no single national US grid, but three large grids: the Eastern and Western Interconnections that span the eastern and western US, large parts of Canada (except Quebec), and a small part of Mexico, and the largely independent Texas grid. Transmission systems are run by regional organizations and distribution is handled by investor-owned, cooperative, and municipal utilities.

Half the world's data centers are in the US, where they accounted for150 terawatt-hours (TWh) or about 4% of total US electricity consumption in 2022. Although efficiency gains tempered electricity use in the past, computationally intense AI applications need more and more energy. Electricity consumption by Meta, Amazon, Microsoft, and Google more than doubled between 2017 and 2021. Future needs are uncertain, as are AI trends. A ChatGPT request requires 2.9 watt-hours or ten times the electricity of a traditional Google query that uses 0.3 watt-hours. Do we need every search to be AI-assisted? Separately, energy use by cryptocurrencies has grown very rapidly over the last several years and now represents 0.6-2.3% of US electricity consumption. The mining mechanism makes a difference; Ethereum changed in 2022 to a proof of stake mechanism that has 0.005% the power demand of Bitcoin, which uses a proof-of-work consensus mechanism based on extensive computational effort.

To bring low-carbon energy sources on board and support the electrification of buildings and transport, (to meet our climate goals), the grid must expand 60% by 2030, according to one study. Issues raised by solar and wind resources include distance, intermittency, and distribution. Where it is windy or sunny may not be close to population centers. Solar and wind are intermittent making it harder for the grid to balance electricity generation and consumption. Proliferating home solar and battery installations at the distribution end don't fit the traditional grid's centralized power to users, one-way flow.

Right now, there's a backlog of solar, storage, and wind energy projects on the interconnection queue, but wait times to join the grid average 4 years. The Federal Energy Regulatory Commission (FERC) lacks siting authority for interstate transmission lines (which it has for natural gas pipelines), so approval requires review by each state. Land acquisition, environmental reviews, and negotiations on who pays are other hurdles. FERC ruled in May to require transmission operators to develop long term plans in the consumers' interest and to allocate costs according to benefits. At the distribution end, investor-owned utilities, which supply two thirds of electricity, are regulated by public utility commissioners (PUCs) on behalf of the public. Utilities that earn a return based on capital expenditures make money by building and will have a financial bias for new power plant or transmission line construction over sharing resources or efficiency. Are utilities prioritizing grid resilience, cleaner electricity, and cost-effectiveness? PUCs do resource planning and approve utility rates. Electricity generation costs are declining, but transmission and distribution costs (about 40% of the price of electricity in 2022) continue to increase. Planning, permitting, and payment are challenges to progress on the grid.

Part two will be about strategies to meet growing demand, utilize more renewable energy, and make a smarter, more flexible and resilient, modern grid.

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General

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Data Centers, AI, Cryptocurrency

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