Columbia Business School
Climate Knowledge Initiative

Slide Deck | Deep Dive | Key Insights

Powering Grids

Executive Summary

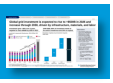
See Slides 1-6 of deck



- Global electricity demand growth is **accelerating across nearly all major regions**, with data centers projected to account for **~50% of U.S. demand growth** by 2030
- Over 40% of global grid assets (**up to 70% in the U.S.**) are reaching the **end of their 50-year design life**, necessitating urgent replacement
- Annual global grid investment is expected to exceed **$500B in 2026** and reach **$600B a year by 2030** in a net zero pathway
- Optimizing (**1-2+ yrs**) unlocks the **lowest-cost grid capacity**, modernizing takes 1-4+ yrs, and expanding (**5-15+ yrs**) is the most capital intensive
- AI-enabled data center flexibility could unlock **~100 GW of dormant capacity** from grid infrastructure that already exists

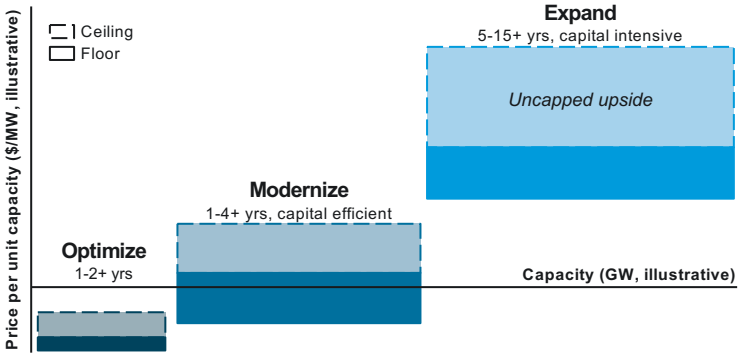
Why invest in power grids?

Slides 4-6



- Grid investment needs reach $800-900B a year in 2040-2050, 80% of it to modernize
- Optimization is an estimated $50-150B+/yr opportunity from 2030-2035
- Modernization and expansion each draw an estimated $200B+/yr from 2030-2035
- Virtual power plants deliver peak capacity at roughly half the cost of a new gas peaker
- Storage and flexibility could defer up to $1.8T in global grid investment through 2050

Grid Capacity Cost Curve by Lever (Illustrative)



Investment Opportunities

Slides 7-26



Expand & Modernize

New T&D and HVDC — 5-15+ yrs

Capital intensive *– Investor type: Infrastructure, Utilities*

Extends the network to new generation; HVDC moves multi-GW power over thousands of kilometers with lower losses. Expansion draws an estimated $200B+/yr from 2030-2035.

Grid-Scale Battery Storage — 1-4+ yrs

Capital efficient *– Project Finance, Utilities*

Batteries firm renewables and reinforce congested nodes; the global market is set to exceed $100B in 2026.

GFM, FACTS, AMI & Digital Twins — 1-4+ yrs

Capital efficient *– Utilities, Growth, Private Equity*

Hardware and digital upgrades at existing nodes; FACTS can increase transmission capacity by ~30-50%.

Optimize

DERMS & Virtual Power Plants — 1-2+ yrs

Asset-light *– Growth, VC*

Tripling U.S. VPP capacity to 80-160 GW by 2030 could save $10B a year; North America already has 30-60 GW of VPPs.

Load Shifting & V2B/V2G — 1-2+ yrs

Asset-light *– VC, Corporate*

Data centers can shift up to 40% of non-critical load in under 40 seconds; EVs can act as flexible storage.

Key Risks

Slide 32



- Interconnection delays, with a >4 yr median from request to commercial operation
- Federal permitting (~4 yr) and cost allocation disputes slow new transmission
- Lead times exceed 2.5 yr for power transformers, with constrained EPC capacity
- Rising grid costs risk customer backlash if they are not fairly allocated

Investment Trends

Slide 17



- Optimize and modernize draw VC, PE and corporate capital, i.e., VC into VPPs and DERMS rose from ~$50M to ~$650M in 10 years
- Expansion relies on infrastructure finance recovered through the rate base, i.e., CHPE ($6B, 87% project debt), TenneT green bonds
- Hyperscalers are financing grid capacity, i.e., Google (Voltus, 1 GW VPP capacity committed across PJM)

About CKI

The Climate Knowledge Initiative (CKI) conducts rigorous techno-economic analyses and turns them into actionable, business-relevant insights. Through research, communication, and stakeholder engagement, CKI bridges the knowledge gap between academia and business leaders. View the full report on power grids.

Credit: Ilayda Tezcan, Ariela Farchi, Pia Doris Morrow, and Gernot Wagner. Share with attribution: Wagner *et al.* "Powering Grids," Columbia Business School Climate Knowledge Initiative (29 October 2026).