Powering the future:
Artificial intelligence, grid modernization, and electrification

AI has a voracious appetite for electricity.

Before the rise of generative artificial intelligence (AI), the average data center required an estimated 5 to 10 megawatts of electricity. But hyperscale technology companies increasingly are turning to AI-focused data centers – which use more powerful semiconductors and require much more cooling – that can require 100 megawatts of electricity, according to the International Energy Agency. These new data centers can consume as much electricity annually as 350,000 to 400,000 electric vehicles.[1] And in three years, U.S. data-center power demand could triple to an estimated 12% of U.S. total electricity consumption.[2]

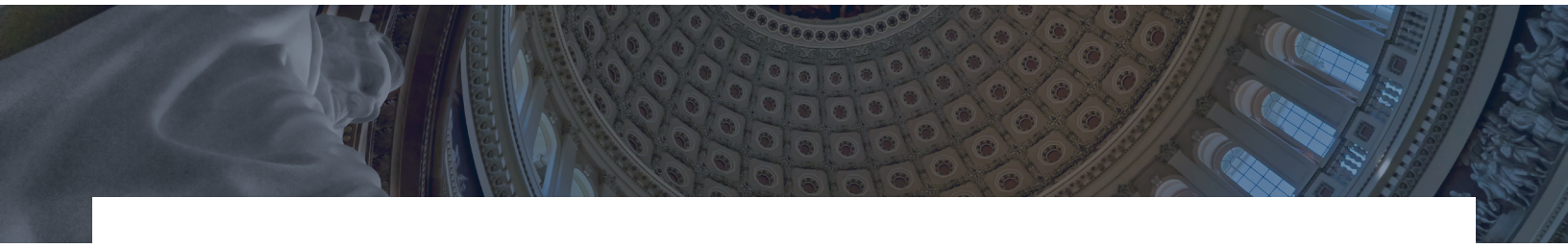
An industry panel convened by Raymond James Investment Management recently outlined how this explosive growth presents:

Challenges	Risks	Investment opportunities
To the U.S grid, a not always interconnected network of power plants, distribution lines, and customer-side resources.	Via snarled supply chains, project delays, unpredictable labor availability, and fluctuating interest rates.	In areas such as utilities; manufacturers of power equipment and components; and suppliers of key metals.

"We can't rely on old playbooks" to meet these challenges, said panelist Louise White, senior consultant for loan programs and tech transitions at the U.S. Department of Energy. "We need new, innovative approaches."

[1] International Energy Agency, Paris, Oct. 18, 2024, "What the data centre and AI boom could mean for the energy sector," available at: https://www.iea.org/commentaries/what-the-data-centre-and-ai-boom-could-mean-for-the-energy-sector, License: CC BY 4.0

[2] US data-center power use could nearly triple by 2028, DOE-backed report says, Reuters, Dec. 20, 2024, available at: https://www.reuters.com/business/energy/us-data-center-power-use-could-nearly-triple-by-2028-doe-backed-report-says-2024-12-20/



The fight for resources

Shahar Levi
Co-Founder and CEO
LocusView

Today data centers already use more electricity in the aggregate than some entire countries, Levi said. And for the first time in three decades the demand for power in the U.S. is growing, driven by:

- Data centers and AI.
- The return of manufacturing via reshoring.
- Broad economic growth and growth in electric vehicles.

"We are seeing a lot of demand and regulators and politicians pushing utilities to make the investment to keep up with the pace and win the AI race, which we all understand is going to decide how the markets and how the U.S. economy is going to play out for the next 20 years," said Shahar Levi, co-founder and CEO of LocusView.

"We're working probably with the top 30 largest players in the U.S. It's clear to everyone that we need to invest, but the big question, is how to do it? What is the balance between what you're putting into the rate case versus maybe other sources of capital? There is going to be a lot of discussion and debate around it.

"The fight for resources is there. And I think utilities will have to leverage tools to help manage the construction process end to end. We have issues across the board from financing at the beginning and on the execution side in terms of getting the permits, then having the needed materials, labor, and ability to manage ambitious projects that use a lot of subcontractors."

$200 billion

Estimated **new investment** in the U.S. power market next year.

$6 trillion

2050 estimate of **annual global spending** on power grid expansion and improvement

Source: Shahar Levi, LocusView, as of 12/18/24.

A grid in flux

Louise White
Senior Consultant
Loan Programs and
Tech Transitions
U.S. Department of Energy

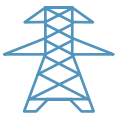
"The grid is starting to change dramatically because of distributed-energy resources like home solar and batteries, which can create two-way power flows," said Louise White, senior consultant for loan programs and tech transitions at the U.S. Department of Energy. "The U.S. Department of Energy (DOE) talks about 'virtual power plants' – how do we aggregate customer-sited, home-sited, home solar battery, and smart thermostats to help serve demand and manage the system more effectively? Home solar batteries might not meet data center needs but could free up capacity on the bulk power side to help address data center needs.

"With AI, the demand story is very different depending on where you are in the U.S. I think particularly for savvy investors, it helps to look geographically at the local context for the utility in a particular area. Data centers are certainly huge in many regions – particularly Virginia, California, and Texas – but not all regions of the U.S. In other areas the driver could be the growth of electrification, electric vehicles, or manufacturing."

Financing resources include:

- Through the Inflation Reduction Act and Bipartisan Infrastructure Law, a $400 billion loan authority to help fund investment into the grid.
- DOE grants, including a $10.5 billion program to help finance upgrades and expansions to the transmission and distribution grid to get more value out of the existing grid and to support expansion.
- Emerging new tariff models so that data centers potentially pay a larger portion than they historically have to support upgrades needed in the near term.

Due for replacement soon:



30%
of large, high-voltage power lines

60%
of smaller, neighborhood-serving distribution lines

Source: Louise White, U.S. Department of Energy, as of 12/18/24.

Addressing growing data center electricity demand

Examples of potential technology solutions

Grid-scale clean energy deployment	Grid infrastructure enhancement and expansion	Energy efficiency and demand-side flexibility	Maximizing data center efficiency and operational flexibility
Expand existing supply (including repurposing existing infrastructure) • Solar • Onshore wind • Storage (batteries) • Hydroelectric power • Conventional geothermal (hydrothermal) • Nuclear (including power uprates and relicensing) • Offshore wind	**Enhance existing transmission and distribution** • Advanced reconductoring • Grid-enhancing technologies • Distribution automation • Point-to-point high-voltage direct current • Advanced flexible transformers	**Improve energy efficiency** • Building efficiency • Geothermal heating and cooling	**Improve data center efficiency** • Hardware efficiency • Al algorithm efficiency • Building automation • Building efficiency • Geothermal heating and cooling
Scale emerging solutions • Advanced nuclear • Next-generation geothermal • Long-duration energy storage (LDES) • Carbon capture and storage (CCS) on power plants • Clean hydrogen • Concentrated solar power	**Expand transmission and distribution** • Advanced conductors • Inter-regional and regional high voltage direct current / alternating current (DC / AC) transmission • Distribution system	**Manage and flex demand** • Virtual power plants • Distributed energy resources • Microgrids • Fuel cells	**Enhance operational flexibility and efficiency** • Flexible operational processes • On-site power generation and facility design optimization

Source: U.S. Department of Energy, as of 2/20/25. Accessed at: https://www.energy.gov/gdo/clean-energy-resources-meet-data-center-electricity-demand

An all-of-the-above strategy

Pavel Molchanov
Managing Director and Equity Research Analyst
Renewable Energy and Clean Technology
Raymond James

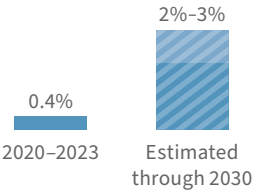
U.S. electricity sources, 2024

44% – natural gas
18% – nuclear
17% – non-hydroelectric power renewables
15% – coal*
6% – conventional hydroelectric power**

Source: U.S. Energy Information Administration Monthly Energy Review, p. 135, data for the first nine months of 2024, as of 12/23/24. Available at: https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf
* And shrinking. Coal accounted for nearly 52% of U.S. electricity generation 20 years ago.
** Also shrinking because of worsening drought conditions.

"It's important to look at this through the lens of all of the above," said Pavel Molchanov, managing director and equity research analyst for renewable energy and clean technology at Raymond James. "We will need more natural gas, more wind, more solar, and a little bit of nuclear if we go out far enough in time. If somebody starts building a new U.S. reactor over the next couple of years, it will be sometime in the next decade before that reactor generates electricity. Because of that, it will be overwhelmingly natural gas, wind, and solar that support the growth of power demand between now and 2030."

Growth per year in U.S. electricity demand



Source: Pavel Molchanov, Raymond James, as of 12/18/24.

The economics are always case by case, project by project, Molchanov said:

Solar – Arizona/Utah: Lots of sunlight and low-cost land for solar farms.

Wind – The middle of the U.S.: Iowa, South Dakota, Kansas, and Texas (the No. 1 wind-producing state).

Natural gas – Texas and Oklahoma, but mostly the Marcellus gas field in the Appalachian Basin: Virginia, West Virginia, Pennsylvania. If you build a data center near Washington D.C., natural gas is right next door.

Opportunities and risks

An all-of-the-above strategy applies not only to the sources of electricity, Molchanov said, but also as a framework for investing in the energy transition.

Potential areas of opportunity include:

- Utilities: Both regulated power-generating utilities and unregulated independent power producers.
- Infrastructure manufacturers: Equipment manufacturers and suppliers of transformers, power cables, batteries, solar panels, etc.
- Industrial metals: Precious and industrial metals: steel, copper, lithium, and graphite, plus materials like uranium and natural gas for the actual power generation. Over the last five years, global demand has risen 145% for lithium, 51% for graphite, and 10% for copper.

Risk factors:

- Delays: Infrastructure projects tend to take longer than expected and to cost more than budgeted.
- Regulatory risk: Varies by geography. Europe has very strict environmental rules. In the United States, it tends to be state by state, because utilities are generally regulated by state agencies.
- Interest rates: Pre-COVID the 10-year U.S. Treasury yield was 3%. If it's 4.5% in the future, that increases the cost of building projects and ultimately the cost of the electricity.

Growing demand for precious and industrial metals

Global production (thousands of metric tons)

	2024	Change, 2019 to 2024
Precious metals		
Gold	3.0	-8%
Platinum	0.2	1%
Silver	27.0	-2%
Industrial metals: batteries		
Cobalt	265.0	89%
Graphite	1,664.0	51%
Lithium	211.0	145%
Manganese	20,800.0	9%
Nickel	3,888.0	44%
Industrial Metals: Other		
Aluminum	71,400.0	12%
Chromium	41,820.0	-5%
Coper	22,440.0	10%
Iron ore	2,550,000.0	2%
Rare earths	389.0	78%
Silicon	9,270.0	32%
Steel	1,881,000.0	-1%

Source: U.S. Geological Survey, Trading Economics, Business Analytiq, as of 12/18/24.

Key takeaways

Addressing aging systems: With 60% of U.S. distribution lines and 30% of high-voltage transmission lines nearing the end of their useful life, modernization is a critical priority for reliability and meeting rising demand.

Opportunity: Utilities leading grid expansion are positioned to benefit from steady capital flows. Engineering firms and technology providers specializing in advanced grid solutions are poised for growth.

Data centers: AI-focused data centers are driving energy consumption, with total data-center demand already exceeding that of some countries and projected to double in the United States by 2030.

Opportunity: Distributed energy resource (DER) providers, grid developers, and energy suppliers supporting these facilities and the grid generally are positioned for growth as demand continues to rise.

The fight for resources: Lithium, copper, graphite and other industrial metals are critical to renewable energy and storage technologies. As global electrification advances, demand for these materials continues to rise, creating supply challenges that require innovative solutions.

Opportunity: Companies involved in processing these materials and innovators addressing supply bottlenecks play a critical role in ensuring resource availability.

Government incentives: DOE-backed initiatives, including a $400 billion loan authority and $10.5 billion in grid modernization grants, are driving investment and mitigating financial risk. These programs, supported by the Inflation Reduction Act, accelerate renewable energy adoption and grid expansion.

Opportunity: Companies participating in DOE-funded projects or collaborating with federal programs can leverage these resources for growth.

Watch the full discussion now
Full webinar replay available online

Risk Information:

Investing involves risk, including risk of loss.

Diversification does not ensure a profit or guarantee against loss.

Disclosures:

Index or benchmark performance presented in this document does not reflect the deduction of advisory fees, transaction charges, or other expenses, which would reduce performance. Indexes are unmanaged. It is not possible to invest directly in an index. Any investor who attempts to mimic the performance of an index would incur fees and expenses that would reduce return.

As with all equity investing, there is the risk that an unexpected change in the market or within the company itself may have an adverse effect on its stock. The biggest risk of equity investing is that returns can fluctuate and investors can lose money.

Investing in commodities is generally considered speculative because of the significant potential for investment loss. Their markets are likely to be volatile and there may be sharp price fluctuations even during periods when prices overall are rising.

This document is a general communication being provided for informational purposes only. It is educational in nature and not designed to be taken as advice or a recommendation for any specific investment product, strategy, plan feature, or other purpose in any jurisdiction, nor is it a commitment from Raymond James Investment Management or any of its affiliates to participate in any of the transactions mentioned herein. Any examples used are generic, hypothetical, and for illustration purposes only. This material does not contain sufficient information to support an investment decision, and you should not rely on it in evaluating the merits of investing in any securities or products. In addition, users should make an independent assessment of the legal, regulatory, tax, credit, and accounting implications and make their own determinations together with their own professionals in those fields. Any forecasts, figures, opinions, or investment techniques and strategies set out are for information purposes only, based on certain assumptions and current market conditions, and are subject to change without prior notice. All information presented herein is considered to be accurate at the time of production, but no warranty of accuracy is given and no liability in respect of any error or omission is accepted. It should be noted that investment involves risks, the value of investments and the income from them may fluctuate in accordance with market conditions and taxation agreements, and investors may not get back the full amount invested. Both past performance and yields are not reliable indicators of current and future results.

The views and opinions expressed are not necessarily those of the broker/dealer or any affiliates. Nothing discussed or suggested should be construed as permission to supersede or circumvent any broker/dealer policies, procedures, rules, and guidelines.

Link(s) are being provided for informational purposes only. Raymond James Investment Management is not affiliated with and does not endorse, authorize or sponsor any of the listed websites or their respective sponsors. Raymond James Investment Management is not responsible for the content of any website or the collection or use of information regarding any website's users and/or members.

Sector investments are companies engaged in business related to a specific sector. They are subject to fierce competition and their products and services may be subject to rapid obsolescence. There are additional risks associated with investing in an individual sector, including limited diversification.

Definitions

The Bipartisan Infrastructure Law, also known as the Infrastructure Investment and Jobs Act, passed by the U.S. Congress in November 2021, provides funding for a variety of new initiatives, including rebuilding roads and bridges, improving public transit, replacing lead pipes, addressing drinking water contamination, and expanding access to high-speed internet.

Carbon capture and storage (CCS) refers to technologies that reduce carbon dioxide emissions from large producers such as coal- or gas-fired power plants in an effort to mitigate climate change.

Clean hydrogen refers to hydrogen fuel produced using methods with lower emissions than fossil fuel-based methods of producing hydrogen. Green hydrogen, for example, is hydrogen produced by using renewable energy sources such as wind, water, or solar power to fuel an electrolysis process that splits water into oxygen and hydrogen.

Compound annual growth rate (CAGR) is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming that profits were reinvested at the end of each year over the span of the investment.

Distributed energy sources include small-scale technologies such as renewable energy, batteries and other storage, and combined heat and power that can be tapped to provide power to electrical grids.

Generative artificial intelligence (GenAI) is a form of artificial intelligence that can create new content that includes text, audio, code, video, and images.

Hyperscaler refers to the largest cloud computing providers that can provide massive amounts of computing resources and storage at enterprise scale.

The Inflation Reduction Act (IRA) is federal legislation passed in August 2022. It aims to help curb inflation by directing spending toward reducing carbon emissions and lowering health care costs, while also aiming to improve taxpayer compliance through increased funding for the Internal Revenue Service.

A microgrid is a small, self-sufficient, and self-contained electrical system that can generate and distribute electricity to a specific area, such as a business campus or hospital.

A power uprate is a term for the process of increasing the maximum power level at which a commercial nuclear power plant may operate.

Reshoring describes an effort to bring manufacturing and other services back to the United States from overseas operations.

A tariff on electricity is a structured plan that details the charges that a utility collects from customers.

A virtual power plant is a network of smaller sources of electricity whose output is coordinated to provide electricity to the grid.

About Raymond James Investment Management

Raymond James Investment Management is a global asset management company that combines the exceptional insight and agility of individual investment teams with the strength and stability of a full-service firm. Together with our boutique investment managers – Chartwell Investment Partners, ClariVest Asset Management, Cougar Global Investments, Eagle Asset Management, Reams Asset Management (a division of Scout Investments) and Scout Investments – we offer a range of investment strategies and asset classes, each with a focus on risk-adjusted returns and alpha generation. We believe providing a lineup of seasoned, committed portfolio managers – spanning a wide range of disciplines and investing vehicles – is the best way to help investors seek their long-term financial goals.

RAYMOND JAMES | INVESTMENT MANAGEMENT

880 Carillon Parkway, St. Petersburg, FL 33716 | 1.800.521.1195 | RJInvestmentManagement.com