Great Lakes: Opportunities and Obstacles for Data Centers With a Renewable Energy Mix

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The exponential expansion of data is triggering a surge in demand for data centers. Rapid advancements in emerging technologies, including content streaming, cloud computing, machine learning (ML), Internet of Things (IoT), ecommerce, and various other developments, are intensifying the necessity for increased data center capacity.[1] As a result, current projections indicate that energy consumption within data centers is poised to escalate to 35GW by the decade's conclusion, nearly doubling its 2022 level.[2]

In response to this pressing demand, accelerating renewable energy solutions for data centers present a promising avenue. Leveraging sustainable sources, such as solar and wind-power, renewable energy offers the opportunity to construct an energy-supply profile that more closely aligns with customer demand patterns. By integrating renewable energy into data center operations, there is the potential to not only meet rising energy needs sustainably, but also contribute to the reduction of greenhouse gas emissions, thereby advancing environmental conservation efforts. Nevertheless, this shift towards renewables presents both significant opportunities and formidable obstacles.

The research prompted a focus on investigating the Great Lakes region, particularly Ohio, Minnesota, and Illinois, as potential sites for data centers, which posed an interesting opportunity. The choice to concentrate on this area was driven by its distinctive mix of challenges and prospects in incorporating renewable energy into the data center industry. The Great Lakes region boasts a diverse renewable energy mix, including wind, solar, hydroelectric, and nuclear power, making it conducive to sustainable data center operations. A major advantage is the region's ample fresh water supply, crucial for the water-intensive cooling processes of data centers. Ohio, with its growing renewable energy initiatives and industrial infrastructure, emerged as a promising candidate. Minnesota's abundant wind resources and commitment to clean energy showcased its potential for hosting environmentally friendly data centers. Meanwhile, Illinois offered a strategic location with access to renewable energy sources and a robust technology ecosystem. However, despite these opportunities, challenges such as regulatory complexities, extreme weather, and grid reliability issues require thorough examination. The research will aim to navigate these complexities, highlighting the Great Lakes region's potential while addressing the obstacles to establishing efficient and sustainable data centers powered by renewable energy.

Great Lakes Birds Eye View
The Great Lakes contain about 18% of the Earth's fresh water, making them the largest collective body of fresh water on the planet.[3]

NASA | 30 August, 2010

Arrey Bate | 12 December, 2023[4]

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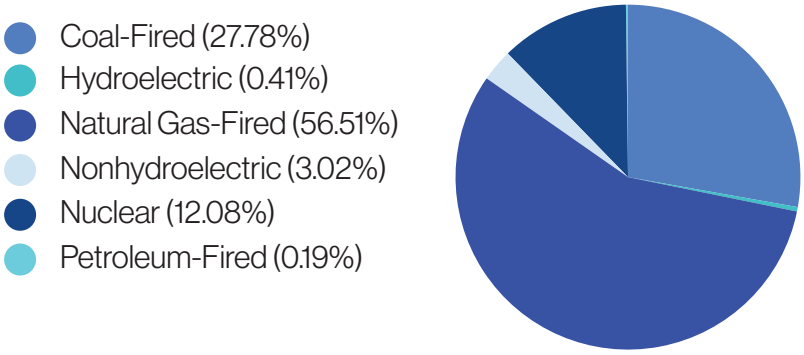
Ohio

Ohio's data center landscape has seen significant growth in recent years, substantially impacting the state's economy and tech industry. The state is home to 85 facilities covering 3,914,990 square feet and offering a power capacity of 407 megawatts.[5] Cities like Columbus, Cleveland, and Cincinnati have become key hubs for these data centers, with Columbus standing out for having the third-largest expansion in the past decade.[6] With close proximity to a significant portion of the U.S. population, approximately 47% within a 10-hour drive, Columbus offers easy access to major markets, making it an attractive choice for companies seeking a centralized location.[7] The industry's growth is also evident in the 23% rise in total annual employment and the 47% increase in total annual labor income from 2017 to 2021. Furthermore, the data center industry has greatly contributed to state and local tax revenues, generating $2.6 billion from 2017 to 2021.[8]

Net Electricity Generation by Source[19]



Columbus Data Center Boom[20]

A new report by researches at JILL, reveals that data center space in central Ohio has grown by 146% over the past decade.

Doral Chenoweth / The Columbus Dispatch

85	3.9+	407
facilities	million sq ft	MW

Opportunities + Obstacles

Ohio is recognized as an ideal location for data centers due to its excellent connectivity, favorable climate, and attractive tax incentives. Since the enactment of Senate Bill 3 in 2001, Ohio has been one of 26 states with a deregulated electricity market.[9] Deregulation has led to greater availability and reliability of electricity, providing consumers with energy savings, uninterrupted service, and flexible rate plans.[10] Additionally, the Ohio Tax Abatement offers substantial tax breaks to data centers that make significant investments, requiring at least $100 million in expenditure and an annual payroll of over $1.5 million.[11] This incentive framework promotes significant capital investment and job growth.

Furthermore, according to the U.S. EIA, Ohio ranked 46th in the nation for renewable energy consumption in 2021, with renewables comprising only 4.7% of its total energy use.[12] This low performance stems largely from House Bill 6, which subsidized coal and nuclear plants and weakened renewable energy and efficiency standards for investor-owned utilities. Initially, Ohio's utilities were required to generate 12.5% of their energy from renewable sources by 2022, but this target was reduced to 8.5% by 2026, the lowest among U.S. states with renewable portfolio standards.[13]

Ohio ranks high in solar energy, placing 5th in 2023,[1415] with major companies like Amazon going fully solar.[16] The state generated 1,735 gigawatt-hours (GWh) of electricity from solar power in 2023, marking the ninth consecutive year of growth.[17] Wind energy production has generally increased over the past decade, though it saw a slight decline from 3,154 GWh in 2022 to 2,828 GWh in 2023 due to unfavorable conditions.[18]

This scenario presents data centers with opportunities to invest in renewable energy projects, ensuring a sustainable power supply and taking advantage of potential incentives to boost Ohio's renewable energy capacity. Additionally, the need for infrastructure upgrades to handle rising demand could result in a more reliable power supply for data center operations.

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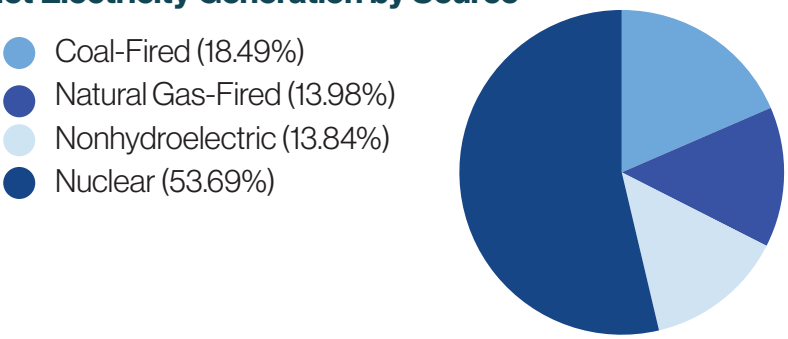
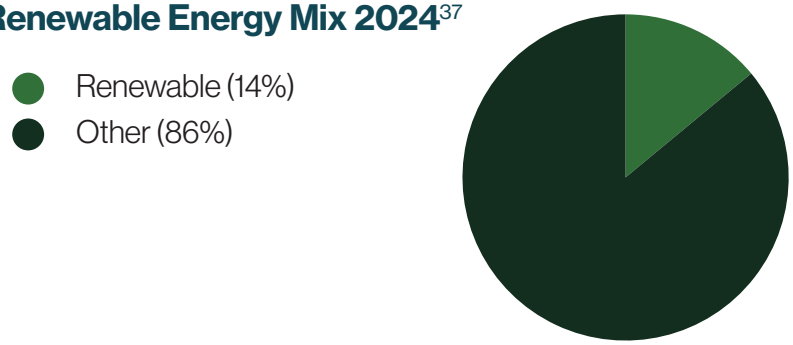
Illinois

Illinois hosts 53 data center facilities, all located in the Chicagoland area right along Lake Michigan. These facilities make up a combined 6.6 million square-feet[21] and consume roughly 400 MW of electricity.[22] Due to Chicago's vast milage of railroads, adjacent fiber optic lines, as well as its location at the heart of the Midwest, it is considered the "network hub of the Midwest."[23] Additionally, due to its location between the Eastern and Western United States, Chicago is considered the network connector between East and West.[24] Besides its location, Illinois offers durable electricity infrastructure, a diverse energy mix, and profitable tax benefits for qualifying data centers.

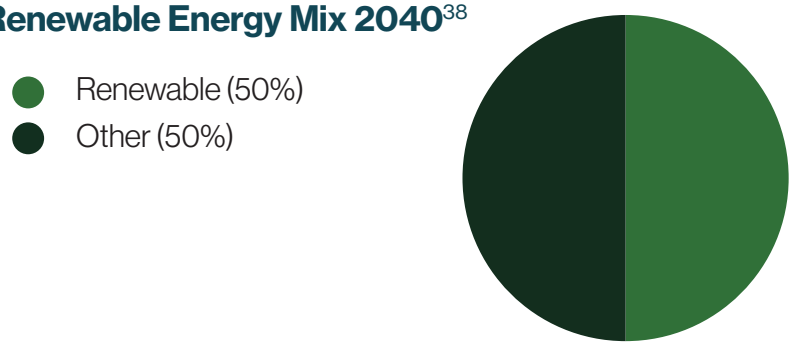
Net Electricity Generation by Source[40]



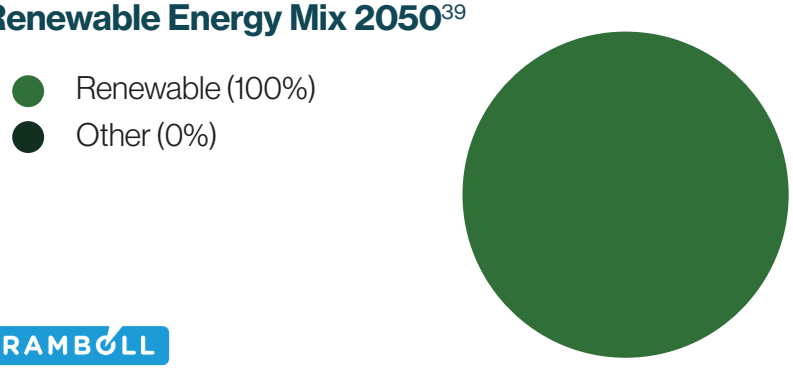
Renewable Energy Mix 2024[37]



Renewable Energy Mix 2040[38]



Renewable Energy Mix 2050[39]



Byron Nuclear Plant servicing Northern Illinois & Chicago[36]

53	6.6	400
facilities	million sq ft	MW

Opportunities + Obstacles

Illinois offers various advantages for data centers over other states. The Data Center Investment Program provides qualifying data centers with tax incentives, such as exemptions from several state and local taxes and a 20% tax credit on wages paid to construction workers if the data center is built in an underserved area.[25] To qualify, data centers must meet investment, job creation, wage, contracting, labor, and reporting criteria, and achieve carbon neutrality or meet green building standards within two years of operation.[26]

Illinois produces approximately 16,475 GW-h of electricity each year, with 54% from nuclear, 18% from coal, 14% from natural gas, and 14% from renewables.[27] As the top nuclear energy producer in the US, Illinois exports about 20% of its electricity to neighboring states[28] and ranks fifth in national energy reliability, boosting its appeal for data center construction.[29]

Illinois' energy sector, while a key strength, faces challenges. Chicago's energy prices are $0.173 per kWh, higher than the Midwest average of $0.156.[30] Data center energy consumption in the Chicago area is also projected to surge from 400 MW to 4 GW.[31] In response to this trend, Governor J. B. Pritzker highlighted the concern of one industry consuming excessive electricity, but reaffirmed Illinois' excess power and status as a net electricity exporter.[32]

Chicago's location along Lake Michigan presents climate challenges. Increased precipitation is expected to raise Lake Michigan's water levels by 0.44m (1.44ft) by 2049, leading to flooding.[33] Higher summer temperatures could also increase drought frequency, straining water supplies for water-cooled data centers.[34] Illinois ranks fourth in the nation for billion-dollar weather and climate events, indicating high susceptibility to climate change impacts.[35]

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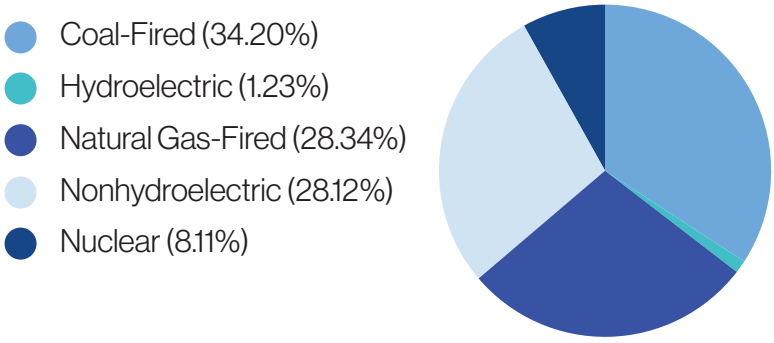
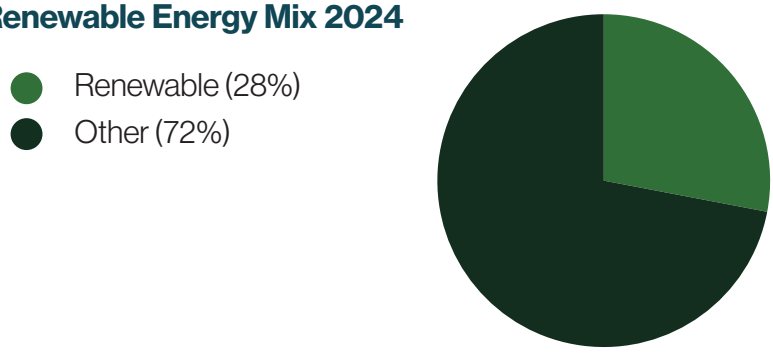
Minnesota

Minnesota provides a distinctive setting that blends substantial opportunities with unique challenges for data centers. The state's dedication to renewable energy, technological advancements, strategic geographical position, and regulatory benefits aligns closely with the data center industry's objectives of sustainability, efficiency, and connectivity. In Minnesota, there are 36 data centers spread across 8 different markets, with the majority located in the Minneapolis - St. Paul area. These facilities are managed by 24 different providers and encompass a total of 1,141,455 square feet with a capacity of 71 Megawatts.[41] Currently, renewable sources generate 28% of Minnesota's electricity, with 52% coming from carbon-free sources like renewables, nuclear, and hydropower. The state aims to reach 100% carbon-free electricity and 55% renewable electricity by 2040.[42] Last year, wind power contributed 18% to the total energy production, solar energy about 3%, nuclear power around 23%, while coal and natural gas provided 25% and 26%, respectively.[43]

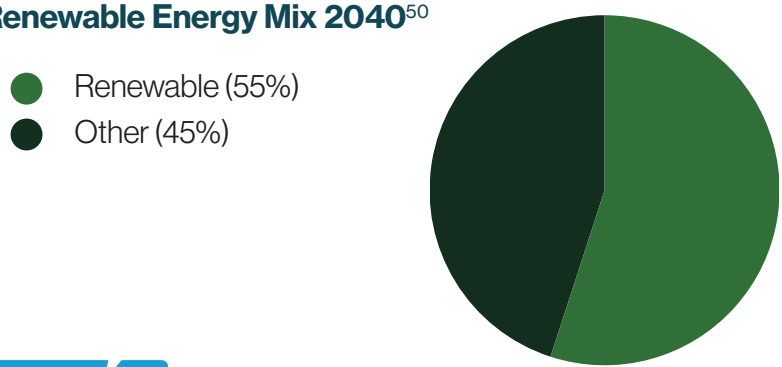
Net Electricity Generation by Source[51]



Renewable Energy Mix 2024



Renewable Energy Mix 2040[50]



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36 facilities | **1.14** million sq ft | **71** MW

Opportunities + Obstacles

Minnesota's central location within the U.S. optimizes data transmission to both coasts, thus enhancing service reliability and speed. The state's access to abundant freshwater, from Lake Superior, the largest of the Great Lakes and holder of approximately 10% of the world's surface fresh water, offers sustainable cooling options for data centers.[44] This reduces dependence on energy-intensive mechanical cooling systems significantly. Minnesota's commitment to renewable energy and its current energy mix provides data centers with access to clean energy, boosting operational sustainability and cost efficiency. The state offers substantial economic incentives, including grants, loans, and tax credits, to support the growth and technological upgrades of data centers. For instance, companies that build data or network operation centers covering at least 25,000 square feet and invest a minimum of $30 million within 48 months qualify for significant tax incentives.[45]

Minnesota hosts major data centers, including CenturyLink's campus with over 100,000 square feet of server space that benefits from the state's cold climate to reduce cooling costs.[46] Additionally, Meta is set to open a new $800 million data center in 2026, which will be entirely powered by renewable energy and is expected to create 1,000 construction jobs and 100 long-term jobs on a 280-acre site at the University of Minnesota Outreach, Research, and Education Park.[47]

Despite supportive policies, Minnesota's extreme climate from below freezing temperatures in the frigid winters to hot and humid summers requires robust infrastructure for optimal data center operations. The state faces severe weather like thunderstorms and blizzards, demanding resilient facilities and contingency plans. [48]Moreover, strict environmental regulations and the shift toward renewable energy require significant technological investments and careful management to ensure a reliable power supply. Developing data centers that can withstand harsh conditions and regulatory demands involves substantial capital investment, alongside higher maintenance and updating costs to meet environmental and technological standards.[49]

Key Takeaways and Conclusion

Companies should prioritize Ohio, Illinois, and Minnesota for their strategic locations, which offer excellent connectivity to major U.S. markets, robust fiber optic and transportation infrastructure, and a mix of renewable energy sources such as wind, solar, hydroelectric, and nuclear power. This setup not only reduces carbon footprints, but also enhances energy reliability. Additionally, the regions' significant cloud capacity and unparalleled bandwidth access make them attractive for data center investments.

Local economic incentives such as tax abatements, grants, and energy credits play a crucial role in these decisions. Ohio's deregulated electricity market and tax policies, Illinois's investment programs, and Minnesota's tax exemptions encourage the establishment of data centers, offering substantial financial benefits. However, companies must carefully evaluate the longevity and true value of these incentives, ensuring long-term financial sustainability as these incentives phase out.

Climate change presents significant challenges for data centers in the Great Lakes region, necessitating robust planning for disaster recovery and infrastructure resilience. Minnesota's extreme cold and heavy snowfall, Ohio's rising temperatures, and Illinois's variable weather patterns require meticulous management of cooling demands and operational costs. However, these conditions also offer opportunities. European nations such as The Netherlands and Denmark, which use their cool climates to enhance data center efficiency, the Great Lakes region can similarly benefit. By investing in research and adopting strategies to harness local climate conditions, data centers can improve energy efficiency, reduce cooling costs, and enhance sustainability. This approach not only ensures long-term reliability but also leverages climate change to create operational advantages.

The decision to establish data centers in the Great Lakes region should be a balanced consideration of strategic location benefits, economic and regulatory incentives, sustainable energy integration, environmental and climate considerations and energy reliability. These factors will not only determine the feasibility and resilience of data center operations but also their ability to meet future demands sustainably and responsibly.

Google's data center campus in Eemshaven, Netherlands[52]

Endnotes

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