Powering the Digital Age - Energy Perspective

Introduction

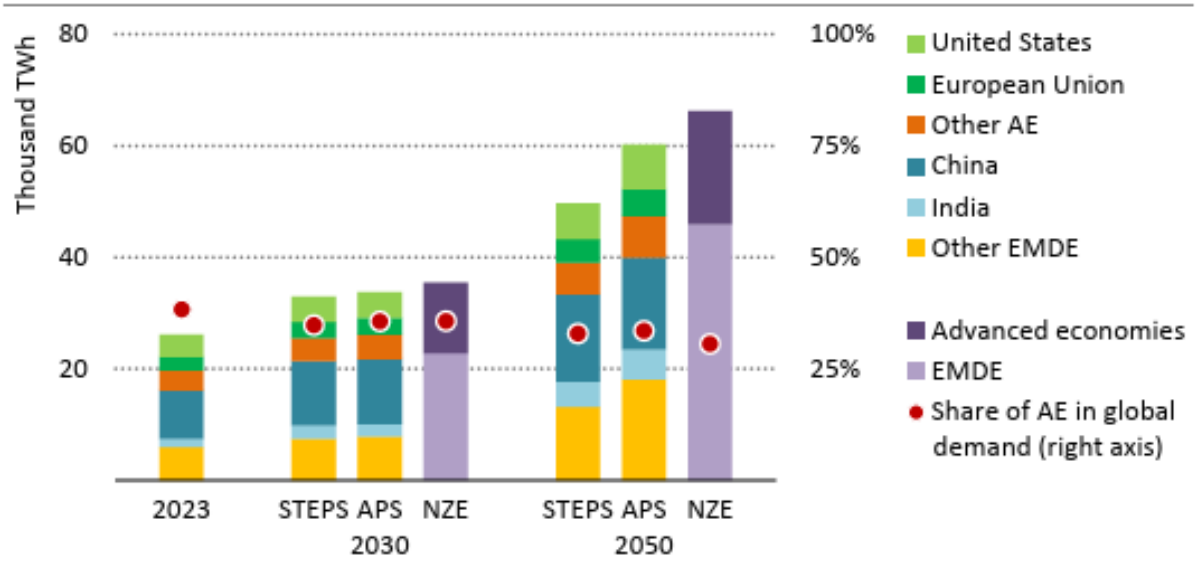
Fueled by the exponential growth of data and the rise of artificial intelligence [AI], data centers are rapidly becoming major energy consumers, accounting for approximately 1.5% of global electricity usage in 2024. This demand is driven by the need for substantial computing power and cooling systems, which form the core of a data center's energy footprint. As AI applications necessitate specialized, power-intensive hardware like GPUs [graphics processing units] and TPUs [tensor processing units], AI data center energy consumption is projected to grow at a compound annual growth rate of 44.7% through 2027.

As we mentioned in our recent article reviewing the CERAWeek 2025 event, several prominent industry names highlighted the strength of secular AI trend. To illustrate, NextEra, one of the largest energy providers in the U.S., anticipates that AI will account for one-third of the total increase in energy demand. Against this backdrop of escalating global energy demand and a shifting energy landscape, Kazakhstan is strategically positioning itself to capitalize on the AI revolution, leveraging its energy resources and strategic location to become a visible player in the data center market.

Global Energy Balance

Global electricity demand experienced a robust increase of over 2.5% in 2023, mirroring the average growth rate of the previous decade. China accounted for two-thirds of this surge, driven by industrial electrification and increased demand for appliances and cooling. India, the Middle East, and parts of Southeast Asia also saw rapid growth, particularly in the building sector. Looking ahead, average annual electricity demand growth is projected by the International Energy Agency [IEA] to accelerate, ranging from 2.4% to 4.5% across different scenarios [STEPS, APS, and NZE] between 2023 and 2050. Emerging market and developing economies are expected to contribute approximately 70% of the additional electricity demand through 2050, with China and India playing pivotal roles.

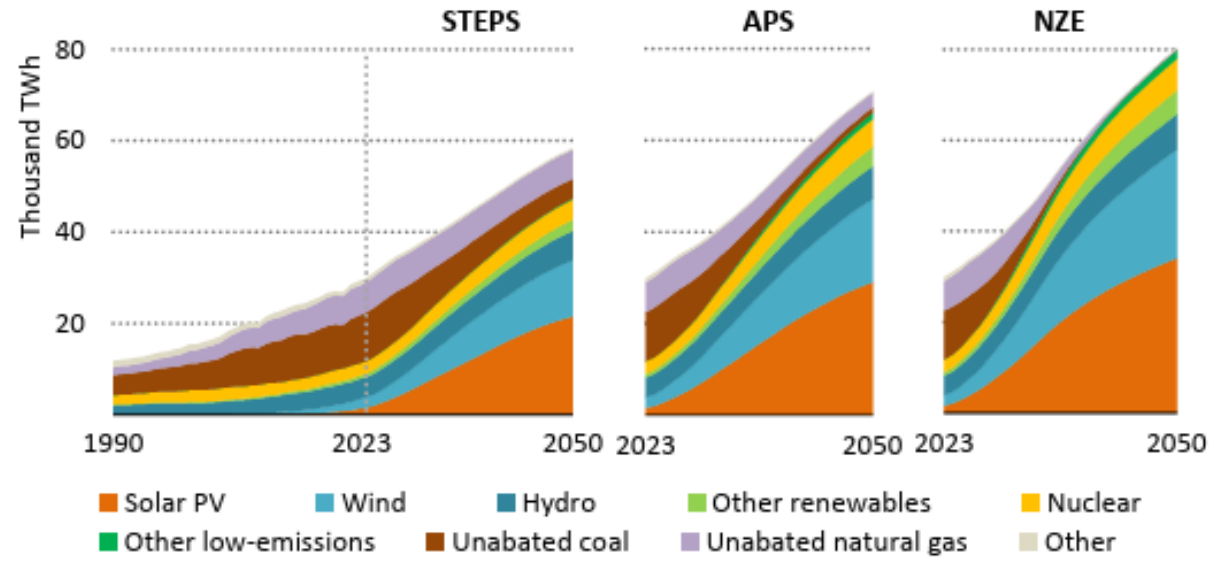
Figure 3.18 ▷ Electricity demand by country/region and scenario, 2023, 2030 and 2050



Source: International Energy Agency, "World Energy Outlook 2024"

While advanced economies currently account for nearly 40% of global electricity demand, their share is expected to decrease over time. The share of electricity in total final consumption is set to rise, reaching 23% in the STEPS by 2030 and even higher in more ambitious scenarios. This growth is fueled by factors such as the adoption of EVs [electric vehicles], heat pumps, and the increasing power demands of AI and data centers.

Figure 3.21 ▷ Global electricity generation by source and scenario, 1990-2050



Source: International Energy Agency, "World Energy Outlook 2024"

In terms of electricity supply, fossil fuels accounted for 60% of global electricity generation in 2023, the lowest share in the past 50 years. Renewables, led by solar PV and wind, reached 30% of global electricity generation. The future energy mix is expected to shift significantly towards renewables, with solar PV and wind projected to play a much larger role. Coal-fired power generation is expected to peak around 2025 and decline thereafter, while nuclear power is also expected to increase steadily. Many governments are implementing policies to support clean energy transitions in the power sector, including targets for renewable energy expansion and the phase-out of unabated coal-fired power generation. Energy storage, particularly battery storage, is also gaining increasing policy support.

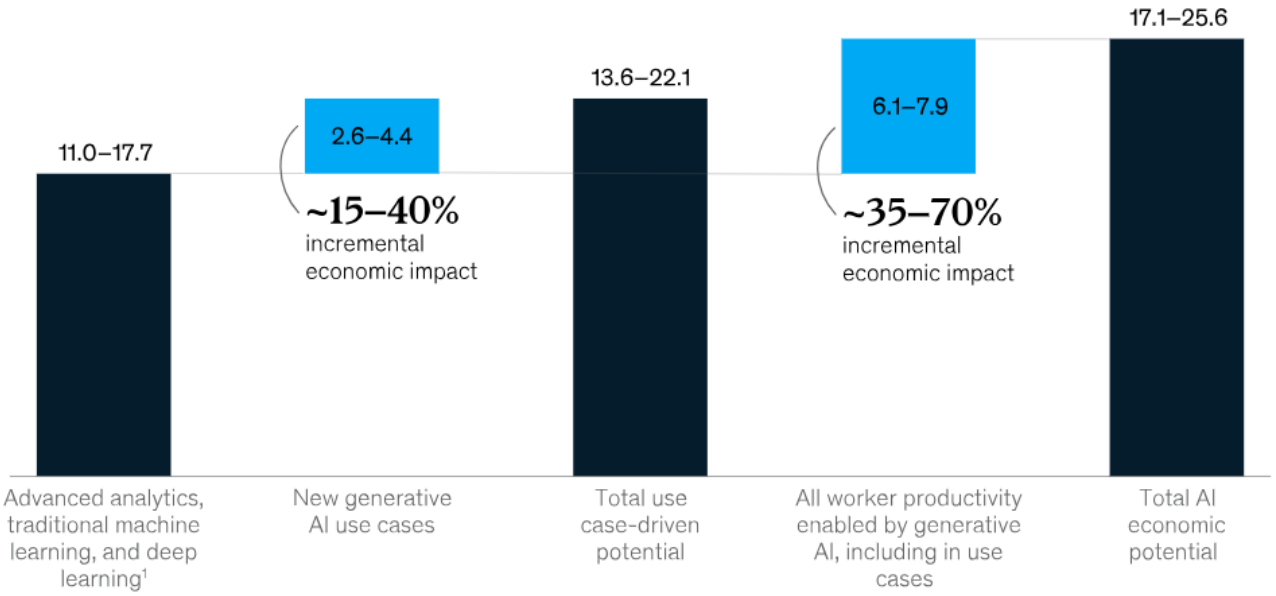
Data Centers, AI, and Energy Supply/Demand

Data centers are rapidly becoming one of the world's largest energy consumers, accounting for approximately 1.5% of global electricity usage in 2024. This consumption is primarily driven by the need for substantial computing power and the cooling systems required to maintain optimal operating temperatures. These two elements form the core of a data center's energy footprint.

Data centers are not a new phenomenon for the world as they have their roots tracing back to the 1940s. If we speak about the modern digital age, there was a spike in data center buildout with the broader adoption of cloud-native solutions. However, the new wave of digital revolution, powered AI, took demand for data centers to another level. For example, the largest U.S. tech companies are set to invest in high-performance data centers more than $300 billion in 2025 alone. A staggering $500 billion "Project Stargate" was one of the very first announcements made by President Trump during his inauguration, also aims to expand the AI infrastructure of the U.S. As a result of such massive investments in AI, the energy profile of data centers is poised to undergo significant transformation over the next few years.

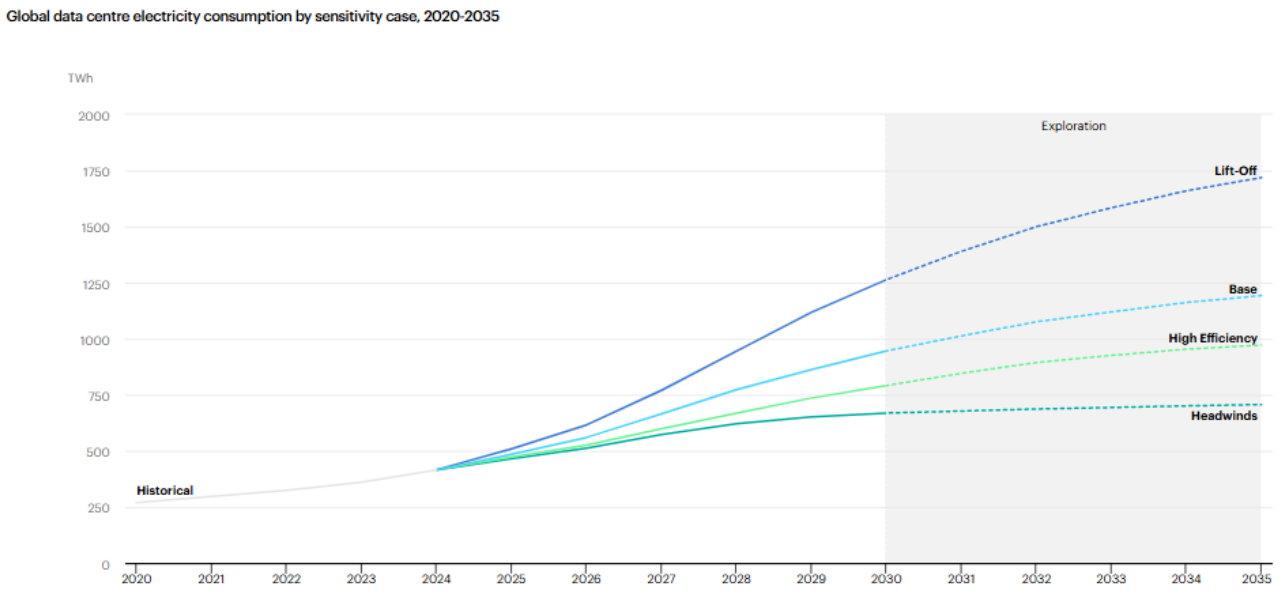
Generative AI could create additional value potential above what could be unlocked by other AI and analytics.

AI's potential impact on the global economy, $ trillion



Source: McKinsey Digital, "Economic Potential of Generative AI", June 2023

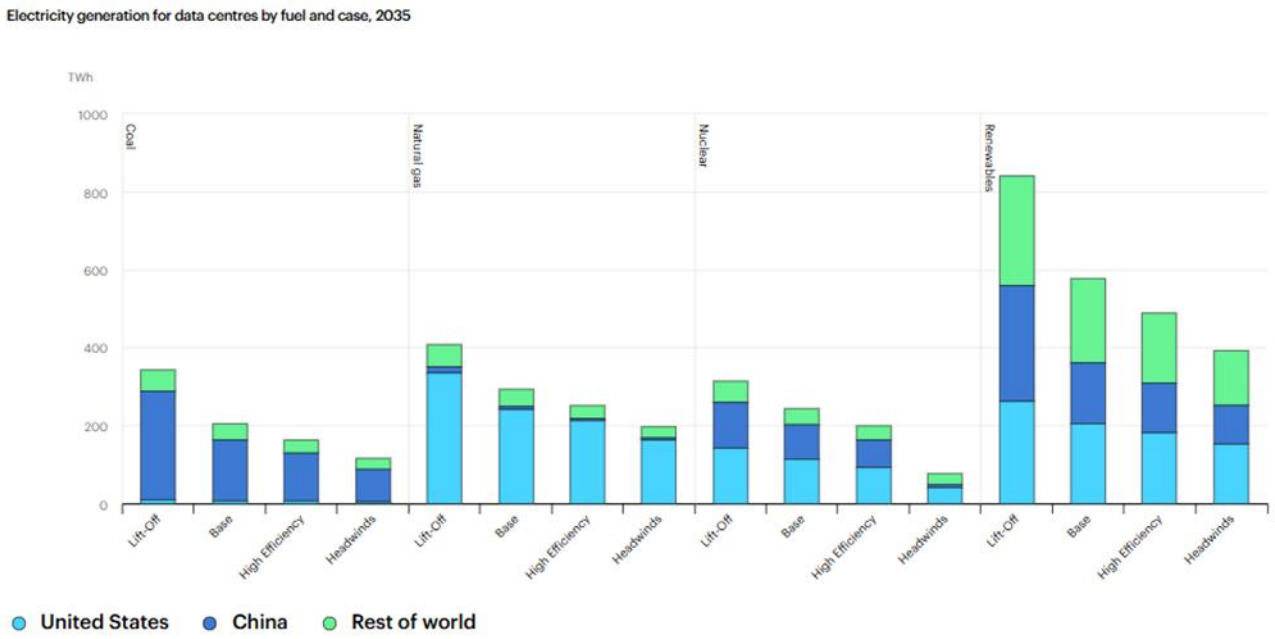
This energy landscape shift is inevitable as AI applications necessitate specialized hardware configurations, such as GPUs and TPUs, which consume significantly more power than traditional computing tasks. According to research from IDC, AI data center energy consumption is projected to grow at a compound annual growth rate [CAGR] of 44.7% through 2027, far exceeding the already rapid growth of general data center energy demand. This stark surge underscores the transformative impact AI is having on infrastructure needs. IEA outlined various data center energy consumption scenarios in a recent report. In a "Lift-Off" case, driven by strong AI adoption, data centers could consume 1,700 TWh in 2035, representing 4.4% of global electricity demand. Conversely, a "High Efficiency" case, emphasizing advancements in energy efficiency, projects a lower demand of 970 TWh, or 2.6% of global electricity. Finally, a "Headwinds" case, characterized by slower AI adoption and infrastructure bottlenecks, forecasts a plateau in energy demand at around 700 TWh, limiting data centers to less than 2% of global electricity consumption.



Source: International Energy Agency, "Energy and AI", April 2025

Electricity costs now represent the largest operational expense for data center operators, accounting for 46% of total spending for enterprise facilities and 60% for service provider data centers. This economic reality positions energy efficiency not merely as an environmental consideration but as a fundamental business imperative that shapes competitive advantage in the sector. Data centers are increasingly seeking locations with access to cheap and reliable power, making energy resources a key factor in site selection.

The global trajectory of data center energy consumption is unmistakably upward, with total electricity usage expected to reach 857 terawatt hours [TWh] by 2028, more than doubling from 2023 levels. This growth is not evenly distributed across regions, with certain markets experiencing particularly concentrated demand growth due to factors such as technological innovation, economic development, and policy incentives. Currently, the largest data center markets by power consumption capacity are located in Virginia, Beijing, and London, which collectively represent over 5.4 gigawatts of capacity. The United States, China, and the European Union lead global data center electricity consumption, collectively accounting for approximately 500 TWh in 2022. These regions benefit from advanced infrastructure, favorable regulatory environments, and strong demand for digital services.



Source: International Energy Agency, "Energy and AI", April 2025

From the supply side, IEA expects renewables to be the global leading energy source that will cover potentially soaring demand from data centers. Renewables are expected to meet nearly half of the additional demand by 2030, driven by wind and solar PV deployment. However, fossil fuels, particularly natural gas and coal, remain crucial in the near term, meeting over 40% of the additional electricity demand until 2030, especially in the United States and China. Nuclear power, particularly through Small Modular Reactors [SMRs], is expected to play an increasingly important role after 2030, leading to a potential decline in coal-fired generation by 2035. This transition results in CO_2 emissions from data center electricity generation peaking around 2030 before a slight decline, highlighting the ongoing need for sustainable energy solutions to mitigate the environmental impact of the AI revolution.

Kazakhstan and the AI Revolution

Against this backdrop of escalating global energy demand, Kazakhstan is strategically positioning itself to capitalize on the AI revolution. The nation has embarked on an ambitious digital transformation journey, highlighted by a landmark agreement with Singapore-based GK Hyperscale Ltd for the construction of two hyperscale data centers with a capacity of 200 MW. Hyperscale refers to the ability of a technology architecture or system to scale in response to increasing demands on a single business process. Hyperscalers typically comprise a large network of data centers located globally, striving for broader coverage and employed for large-scale computing. This $1.5 billion investment will establish facilities

compliant with Tier III standards, positioning Kazakhstan as a competitive player in the regional data services market.

Kazakhstan's data center market is on a strong growth trajectory, with revenue projected to reach approximately $417 million by 2028, according to BBC. This growth is being supported by significant international collaborations, including partnerships with UAE-based companies. Our country's collaboration with Presight for a supercomputer and data-processing center represents a significant step toward establishing advanced computing infrastructure. The initiative is expected to enhance Kazakhstan's capacity for AI development across various sectors including government services, finance, healthcare, and education. Moreover, the project is also crucial for accessing expertise, technology, and investments.

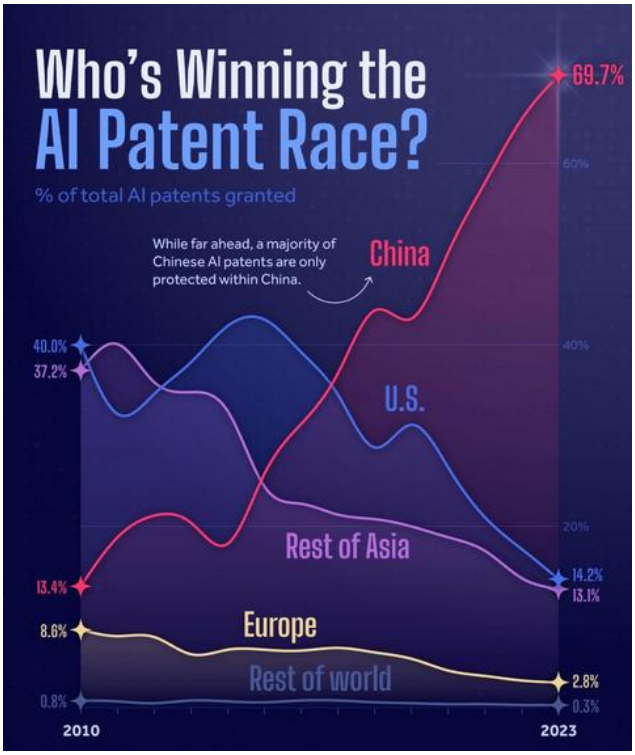
Moreover, there are notable private data center projects advancing in our country. To illustrate, Freedom Telecom Holding is set to establish the West-East fiber-optic hyperhighway, as well as a data processing center [Tier III or higher]. Reportedly, the cost of the hyperhighway construction is estimated at approximately $33.3 million, while two data processing centers in G4 City near Konayev city in the Almaty region and in Aktau are projected to cost roughly $175.5 million. Another significant project is the Akashi data center in Astana, the largest commercial data center in Kazakhstan with Tier IV level reliability. The Akashi data center boasts an unprecedented volume (for our region) of 4096 racks and a power capacity of 43 MW.

The digital infrastructure expansion will create demand for specialized talent, with the GK Hyperscale Ltd project alone expected to generate over 360 highly skilled jobs. Developing this workforce represents both a challenge and an opportunity for Kazakhstan's educational and training institutions. Investing in STEM education, vocational training, and partnerships with international universities is essential for building a skilled workforce capable of supporting the data center industry.

The GK Hyperscale Ltd hyperscale data center project are designed to maximize local economic impact, with at least $1.2 billion of procurement directed toward domestic companies. This approach creates opportunities for developing Kazakhstan's technology supply chain while ensuring that digital infrastructure investments generate broader economic benefits. Supporting local businesses, promoting technology transfer, and fostering innovation are key strategies for maximizing the economic impact of data center investments.

The strategic investments in data center infrastructure are aligned with Kazakhstan's broader ambition to establish itself as Central Asia's digital hub. This positioning is expected to attract international technology companies, with the Minister of Digital Development, Innovations and Aerospace Industry, Zhaslan Madiyev, specifically noting the potential to bring in giants like Microsoft, Google, and Amazon. The country's stable political environment, strategic geographic location, and government support are key factors in attracting these investments.

In addition, Kazakhstan's government is actively entering the rapidly evolving field of AI, signaling a global trend of governmental involvement in AI development. This is evidenced by their legislative efforts to create a legal framework for AI, investments in technological infrastructure like supercomputers, and initiatives such as the National AI Platform, Industrial AI Accelerator, and the International AI center alem.ai.



Source: Visual Capitalist

From the early 1980s, the United States has indisputably dominated information technologies. However, the AI revolution is shaping up to be a fierce technological competition between the U.S. and China. In January 2025, the U.S. tech sector was surprised by the release of DeepSeek's R1 LLM, reportedly much cheaper and technologically close competitor to OpenAI's ChatGPT.

Chinese tech giants like Alibaba and ByteDance [TikTok] are making massive investments in data centers and AI, actively seeking locations to expand their digital infrastructure. Kazakhstan's energy resources and strategic location make it an attractive destination for these companies. Given our country's close proximity to China and historically strong economic ties, Kazakhstan has a unique opportunity in this evolving landscape.

Thirst for Energy

Now, let's mention the drawbacks as well. It is vital to temper enthusiasm with a realistic assessment of the country's energy landscape. The pursuit of AI, with its immense computational demands, hinges significantly on a stable, affordable, and diverse energy supply. Currently, forecasts indicate potential energy deficits in Kazakhstan, raising concerns about the sustainability of energy-intensive initiatives like large-scale AI / data centers deployments. According to Ministry of Energy, Kazakhstan will experience energy deficit in both 2025 and 2026.

Forecast balance of electric energy in the unified electric power system of the Republic of Kazakhstan for the period from 2025 to 2031

TWh (billion kWh)

#	Item	forecast						
		2025	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
1.	Electricity consumption	122.8	127.7	133.0	138.9	144.9	151.2	157.5
2.	Electricity production	117.1	125.2	134.2	142.1	149.9	150.6	150.6
3.	Existing stations	116.1	113.6	113.4	112.6	113.0	113.0	113.0
4.	Planned stations	1.0	11.5	20.8	29.5	36.9	37.6	37.6
5.	including renewable energy sources	7.7	9.2	10.5	10.5	16.9	16.9	16.9
6.	**Deficit (+), excess (-)**	**5.7**	**2.6**	**-1.1**	**-3.2**	**-5.0**	**0.5**	**6.9**

Source: Ministry of Energy of the Republic of Kazakhstan, adapted from Russian

As a result, Kazakhstan relies on electricity imports from Russia to bridge existing gaps, as noted by KEGOC, which underscores a vulnerability in energy security. The anticipated stagnation of electricity production from existing power plants is a critical warning, suggesting that the energy deficit could worsen if the launch of planned new capacities is delayed. Given the inherent complexities and risks of budget or schedule overruns associated with capacity buildout projects, including generation at nuclear power plants from the middle of the next decade, there is a considerable risk of increased electricity imports from Russian Federation, which would further compromise Kazakhstan's energy independence.

The cryptocurrency mining boom in 2021 exposed the fragility of Kazakhstan's power grid. The surge in electricity demand from energy-intensive mining operations led to energy bottlenecks, as reported by Forbes.kz. This experience serves as a cautionary sign, illustrating how unforeseen energy demands can destabilize the entire system and impact costs and accessibility, especially for energy-sensitive consumers like data centers.

While Kazakhstan's potential is significant, several challenges must be addressed to fully realize its ambitions. A significant challenge for Kazakhstan's renewable energy sector is the development of adequate energy storage systems, as highlighted in an article from The Astana Times. This issue is particularly relevant for data centers, which require uninterrupted power supply and thus depend on stable energy infrastructure. Investing in battery storage,

pumped hydro, and other energy storage technologies is crucial for ensuring the reliability of data center operations.

At the same time, as a major oil and gas producer transitioning toward a more diverse energy portfolio, Kazakhstan faces the challenge of balancing investments in traditional energy infrastructure with the growing demands of the digital economy. This balancing act requires sophisticated policy frameworks and investment strategies that recognize the interconnected nature of energy systems. Diversifying the energy mix, promoting energy efficiency, and investing in renewable energy sources are essential for meeting the energy demands of both traditional industries and the digital economy.

The Bottom Line

Kazakhstan has the potential to become a significant player in the global data center market, leveraging its abundant energy resources and strategic location to attract investment and drive economic growth. However, realizing this potential requires considering key challenges related to energy storage, workforce development, local content, and balancing traditional and digital energy demands.

The nation's electricity balance forecast indicates that successfully meeting increasing demand hinges on the timely and efficient commissioning of new power generation capacities. Given the inherently high execution risks associated with capacity buildout projects, stringent oversight is crucial to safeguarding the country's energy security.

By proactively addressing these challenges and capitalizing on its opportunities, Kazakhstan can power the digital age and secure its place in the global technology landscape.

ENERGY Insights & Analytics

Analytical center "ENERGY" LLP (ENERGY Insight & Analytics) is a joint venture between the KAZENERGY Association and IT company AppStream. The company aims to become a priority source of data, analytical information, and recommendations for Kazakhstan's oil, gas, and electric power industries, allowing decision-makers to analyze and predict the most significant industry indicators with details on leading market players. Activities of ENERGY Insight & Analytics incorporate the whole analytics cycle with consequent stages: Descriptive, Diagnostic, Predictive, and Prescriptive analytics.

The key tool and product of ENERGY Insight & Analytics is internally developed software - the Analytical Platform EXia, aimed to identify, localize, format, and present data most efficiently for the specified use cases.

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