Research Design for Analyzing Impact of a 230 MW AI Data Center on Electricity prices and Consumer behavior in Northern Norway

Laura Kreutz
Dept. of Science and Industrial Systems University of South-Eastern Norway
Kongsberg, Norway
laura.kreutz@uni-a.de

Satyanarayana Kokkula
Dept. of Science and Industrial Systems University of South-Eastern Norway
Kongsberg, Norway
ORCID: 0000-0002-0936-7680

Gerrit Muller
Dept. of Science and Industrial Systems University of South-Eastern Norway
Kongsberg, Norway
ORCID: 0000-0003-1952-8377

Omid Razbani
Dept. of Science and Industrial Systems University of South-Eastern Norway
Kongsberg, Norway
ORCID: 0009-0003-4817-5918

This is a pre-copyedited version of a contribution published in 2026 21th Annual System of Systems Engineering Conference (SoSE) published by IEEE. The definitive authenticated version is available online at IEEE Explore: 10.1109/SoSE69681.2026.11622398

***Abstract*— The growth of artificial intelligence and cloud services drives the need for new large data centers, which significantly raises electricity demand in the regions where companies build and operate them. This paper develops a research design to investigate how the planned 230 MW Stargate Norway AI data center in Narvik may affect electricity prices for end-consumers in the NO4 pricing area of Northern Norway. The purpose of this paper is not to present final results, but to establish a methodological approach. The study proposes a mixed-methods approach that combines quantitative analysis of electricity price data and system information from the Nordic power market with a household survey on expectations, price concerns, and potential changes in electricity use. Scenario-based calculations explore how adding a large new baseload could affect average price levels, prices during peak seasons, and short-term volatility. The main goal is to understand how such a data center might reshape regional electricity systems and household electricity costs in a renewable energy context.**

Keywords*— *Data centers, Energy demand, Electricity prices, Residential consumers, Nordic electricity market

I. Introduction

The rapid growth of cloud computing and artificial intelligence (AI) has triggered new investments in large data centers by major technology firms. According to the International Energy Agency [1], global electricity consumption from data centers could double by 2026, increasing from around 460 terawatt-hours (TWh) in 2022 to more than 1,000 TWh. For reference, this is equivalent to Japan's annual electricity use. Recent analyses suggest that this development could affect electricity prices for households and other end-consumers. For example, Gearino [2] reports that electricity prices in several U.S. states are rising as demand from data centers and other large industrial users grows faster than the expansion of new generation capacity. Data centers can consume as much electricity as small cities and that this imbalance between rapid demand growth and slow infrastructure development is a key reason for higher electricity prices for households. Energy experts cited in the report warn that regulators and lawmakers must act quickly to address these challenges.

From a systems perspective, these impacts emerge because electricity supply, grid infrastructure, market design, regulatory instruments, and end-user behavior function as interacting subsystems that remain operationally independent yet are tightly coupled through physical power flows, price formation mechanisms, and policy responses. In this sense, the introduction of large AI-driven loads can be understood as a system-of-systems challenge: local demand shocks may propagate through interconnected markets and networks, while regulatory measures and consumer adaptation create feedback effects that shape price levels and volatility. These developments raise the central question of how AI-driven data centers will influence household electricity prices. As these global trends evolve, they are likely to affect more national electricity systems. In this context, Norway offers a relevant example of how rising data center demand could impact regional markets and end-consumers in the coming years.

Norway provides a unique case study because almost all its electricity comes from hydropower and it participates in the Nordic electricity market. Electricity prices are determined through the Nord Pool market, which divides Norway into five bidding zones (NO1–NO5) that reflect regional differences in supply and demand [3]. In addition to this market structure, Norway recently introduced the "Norway Price" scheme, which offers households a fixed electricity tariff. The scheme reduces exposure to hourly price fluctuations and gives consumers more predictable costs. However, it also weakens incentives to shift consumption to hours with lower prices [4]. This policy context is important when assessing how households may respond to price increases from new data centers.

One major project illustrating this development is the planned Stargate Norway AI data center, located in Narvik, Northern Norway. The center plans to open in 2026 with a capacity of 230 MW and potential future expansion. Northern Norway has become an attractive location for such projects due to its renewable energy resources, low electricity costs, and industrial base [5]. The project aims to support digital innovation but will also significantly increase regional electricity demand. The data center will add a constant baseload demand of 230 MW in the NO4 bidding zone, which may result in higher electricity bills and greater price fluctuations for households and small and medium-sized enterprises (SMEs). Local economic benefits remain uncertain, and previous studies highlight environmental and infrastructure-related concerns, including land-use implications and pressure on grid capacity in regions hosting large data centers [6, 7].

This development affects different stakeholders, including households, SMEs, regulators, data center operators, and local communities, each with different interests in electricity prices and system stability. From a systems perspective, AI data centers, regional electricity markets, grid infrastructure, and end-consumers form a system-of-systems, where independent subsystems interact through electricity flows, market mechanisms, and regulatory frameworks. Given these dynamics, this study focuses on the Stargate Norway AI data center as a case to analyze how large AI-driven electricity demand could influence prices and consumer behavior in the NO4 region.

This study defines the following problem statement: *How might the introduction of a 230 MW AI data center in NO4 influence local electricity price formation, volatility and consumer impacts?*

Most existing studies focus on the energy efficiency of data centers, their overall electricity consumption, or their environmental sustainability. However, only a few examine their potential effects on end-consumer electricity prices, price volatility, or regional equity in the local area.

This research combines quantitative electricity price analysis with qualitative household data, allowing the study to analyze both market dynamics and consumer adaptation. Because the data center is not yet operational, the analysis uses scenario-based modeling, which estimates potential price effects of a 230 MW additional baseload in the NO4 region. AI data centers not only have a large constant baseload but also show load variations. Such variations arise, for example, from human-activity cycles and from cooling demand that depends on ambient temperature [8, 9]. These dynamic patterns increase the complexity of electricity demand. However, this study considers only a constant 230 MW baseload and excludes the variable load component from the modelling approach. The study combines the modelling results with a household survey capturing acceptance, perceived risks, and behavioral responses. This provides a holistic understanding of how energy demand related to AI data centers interacts with renewable-based energy systems and local consumers.

To answer both technical and social aspects, we define the following research questions:

RQ1: How will the planned Stargate Norway AI data center influence electricity prices for end-consumers in the NO4 region, particularly during peak demand periods?

RQ2: How do households in NO4 adapt their electricity use in response to different levels of price increases?

RQ3: What can the case of NO4 teach about how large-scale data centers influence regional electricity markets and energy systems in renewable-based countries?

This paper has the following structure. Section II reviews the literature on data centers, electricity markets, and consumer impacts, while Section III presents the research design, data collection and analysis, and discusses limitations. Section IV examines risks and uncertainty, and Section V concludes the paper.

II. Literature Review

This literature survey examines academic research and selected reports that analyze the relationship between data centers, electricity demand, market dynamics, and consumer impacts. The search concentrated on five main themes: energy demand and baseload behavior, grid impacts and capacity constraints, market volatility mechanisms in Nordic electricity markets, household behavior, and social acceptance, while a final subsection highlights recent developments linked to AI-driven power use.

A. Energy Demand and Baseload Behavior

Recent research suggests that AI technologies, especially large language models such as ChatGPT, could significantly raise electricity demand in the coming years. Much of this additional electricity demand will likely come from large-scale data centers that host AI workloads [10].

Large-scale data centers are not only technical infrastructures, but also the foundation of many digital services. They are central drivers for cloud services, Big Data, telecommunications, banking, and social media, which explains why their operation has become critical for modern societies. At the same time, this role makes them extremely energy intensive. A single large data center can consume as much electricity as 25,000 households and requires 100 to 200 times more energy per square meter than an office building [9]. Their high electricity demand results from different major load components.

In the Norwegian context, large data centers may influence power systems in different ways. They can operate under different load patterns, including flat-load and mixed-load centers. Flat-load centers operate with load factors close to 100%, meaning that their electricity use is steady and independent of the time of day. Mixed-load centers, in contrast, have lower load factors, around 80%, and show peaks during the middle of the day, but they remain relatively stable compared to household demand. A significant share of data center demand functions as firm baseload, operating throughout the year. At the same time, daily and seasonal variations can occur, for example due to cooling needs and workload patterns. Seasonal differences are also visible in electricity use because cooling systems require more energy in warmer periods, even if Norway's cold climate could reduce this effect. The load characteristics of AI data centers may differ from those of more traditional data centers, as AI workloads can lead to more dynamic operational patterns. Nevertheless, a substantial baseload component remains economically and technically relevant in modern data center operation [8].

In addition to load characteristics, researchers introduce an economic modelling approach to calculate the Levelized Cost of Computation (LCOC) as a new metric to assess the cost efficiency of AI data centers. Using this model, they examine whether future data center infrastructures will mainly operate as baseload consumers or whether they could also create economic opportunities for flexible demand and load shifting. Their results show that higher load factors are economically preferred, while electricity price levels and variations play a smaller role. These findings suggest that AI data centers will likely operate at high utilization rates and therefore contribute to firm baseload demand. The study provides valuable insight into how economic factors shape data center operation. However, the authors do not examine how these developments may influence regional electricity markets, consumer prices, or grid stability [8].

Taken together, these studies show that large-scale data centers create a large and often inflexible electricity demand, while AI data centers may show similar demand patterns due to their intensive computational workloads. Rapid growth in AI can increase electricity use and electricity prices when energy supply and grid capacity do not expand fast enough [10]. Research also highlights the high energy intensity of data centers and their large electricity consumption [9]. In the Nordic context, data centers are likely to operate at high load factors throughout the year because this is economically more efficient, even though it can reduce flexibility in the power system [8]. These findings indicate that the growing demand from data centers may create new challenges for electricity systems, particularly in regions with limited flexibility.

B. Grid Impacts and Capacity Constraints

Beyond their electricity demand, large-scale data centers can also influence energy systems and grid infrastructure. Large data centers in Denmark could, for example, account for up to 33% of national electricity demand by 2040, which would require an additional 3-6 GW of offshore wind capacity. At the same time, excess heat from data centers can be reused for district heating. Estimates show that this heat could cover between 4 and 27% of Denmark's district heating after 2040 [12]. Studies also discuss the role of data centers in future European energy systems and stress the importance of integrating them through waste heat utilization. They further point out that data centers have the potential to provide demand response. However, this possibility has so far received little attention in European energy policies [13].

Google and Facebook, for example, invested in large facilities in Finland and Sweden because of their climate, renewable energy, and stable humidity conditions. Estimates suggest that investments in the Nordic region will reach between 2 and 4 billion euros by 2025 [11]. This development underlines that Northern Norway, with similar conditions, is a relevant and realistic site for future projects such as Stargate.

Experiences from other regions also highlight that data center growth can create challenges for local electricity grids. Data center clusters in West London created significant difficulties for managing grid capacity. Many facilities reserve large amounts of electrical capacity for future expansion, even if they do not use it immediately. This blocks available grid connections for other users. To address this, Microsoft and UK regulators have suggested reforms such as reservations or locational pricing, which would make capacity allocation more efficient. However, they note that regulators have not implemented these proposals yet and managing grid capacity remains a continuing challenge in regions with concentrated data center growth [7].

Data centers can also support energy integration through waste heat use and demand response, but researchers note that policymakers still rarely use these options in energy policy and planning [12, 13]. The example of West London further illustrates how concentrated data center growth can strain grid capacity and affect other users [7]. Together, these studies show that large data center projects influence the infrastructure and operational constraints of regional power systems. These grid-related challenges are particularly relevant in regions with limited transmission capacity, which makes it important to examine how such developments influence electricity market dynamics.

C. Market Volatility Mechanisms

In the Nordic power market Nord Pool, supply and demand bids determine electricity prices. Long-term electricity prices usually reflect production costs, while external changes in supply and demand create short-term volatility. These changes can cause ordinary fluctuations, but also strong price jumps triggered by unexpected events such as sudden temperature changes or outages in generation. Price jumps become more likely when the production system operates close to its capacity [14]. This is important when considering new data centers because they can add a substantial baseload component that may reduce flexibility in the market and therefore make sudden price changes more likely.

More recent research confirms that volatility remains a key topic of the Nordic market. Price shocks in Nordic electricity markets do not remain isolated but spill over between interconnected countries and price zones, especially during periods of renewable energy uncertainty. The analysis also identifies Northern Norway as a net transmitter of volatility, which means that shocks originating in this zone can spread to other parts of the Nordic system [15]. This underlines that additional demand in NO4, like the one from the new AI data center, could further enhance volatility risk not only locally but also across the Nord Pool market. In addition to these volatility dynamics, large electricity consumers such as data centers have become increasingly visible in European electricity systems. In several countries, data centers already account for a substantial share of national electricity consumption, including 18% in Ireland, 5.2% in the Netherlands, and 4.5% in Denmark [16]. Such high shares mean that concentrated demand from data centers can affect market dynamics and increase pressure on the grid, especially during peak periods. This also suggests that even a single large facility can influence price formation in regions where limited grid capacity restricts market flexibility and weather conditions strongly shape electricity production.

The Northern Norway region (NO4), where Narvik is located, is normally a surplus area with much hydropower and an export capacity of about 1,500 to 1,800 MW. However, in situations with low production and high local consumption in the northern part of NO4, the available export capacity can be lower [18]. When transmission capacity through the interconnecting cables towards southern Norway becomes constrained, NO4 cannot fully export its surplus electricity to other bidding zones. In zonal electricity markets, grid constraints prevent price convergence between areas and create regional price differences [3]. As a result, electricity prices in NO4 can fall below those in southern bidding zones.

The planned 230 MW Stargate data center would use an amount of electricity comparable to around 13 to 15% of the total export capacity of NO4. Although export capacity and electricity consumption are not directly comparable, this comparison highlights the relative scale of the project within a regional grid with limited transmission flexibility. In such a setting, additional demand of this size could become relevant for local market dynamics, particularly during periods of constrained transmission capacity or high system utilization.

Overall, prices in the Nordic market reflect how supply and demand, system flexibility, and regional grid constraints interact. Price jumps occur when the system operates close to its capacity, and volatility can spread across interconnected bidding zones [14, 15]. Data centers already account for a visible share of national electricity consumption in several European countries, which increases their influence on price formation during periods of high demand [16]. In Norway, the structure of bidding zones and the varying transmission capacity in NO4 can restrict the ability to balance regional differences. The planned 230 MW baseload will add a significant new load to a region that depends on seasonal hydropower and weather conditions. The literature shows that capacity limits and new demand shocks can influence price levels and volatility in the Nordic market.

D. Household Behavior

Most research on data centers and electricity markets focuses on system integration and efficiency rather than on how end-consumers experience these changes. In Norway, almost all households are directly exposed to wholesale price fluctuations, about 95% of their electricity consumption is covered by spot price contracts [19]. Rising demand from large consumers, such as new AI data centers, therefore, reaches end-consumer electricity bills. However, households that have adopted the "Norway Price" scheme are not affected by short-term price volatility, as the scheme provides a fixed tariff while it remains in effect [4]. This makes it relevant to examine how different groups of households respond when prices rise or fluctuate over longer periods.

During the 2021/22 energy crisis, Norwegian households faced extremely high spot prices. On average, households reduced their electricity consumption during winter months by 11.4%, mainly by lowering indoor temperatures, reducing hot water use, or switching to alternative heating. Almost 80% of households reported active measures to save energy. However, the average household did not react significantly to hourly price volatility but rather to sustained high price levels over longer periods. Only certain groups, such as households using mobile apps to monitor prices or those with automated electric vehicle charging, managed to shift their demand during peak hours. For example, households with smart charging reduced peak load by up to 15.7% by shifting their charging sessions. This shows that while consumers respond to price levels, their ability to buffer short-term volatility remains limited [20]. These findings are important for this study because they show that households react to persistent high prices, not to short-term volatility. This limited flexibility may become relevant if a new data center increases local price levels or contributes to longer periods of high prices.

E. Social Acceptance

Beyond household electricity consumption, recent research has also examined how data center development is perceived by local communities and how these perceptions influence the social acceptance of such projects. Research on Arctic and Nordic regions, including Greenland, Iceland, and Norway, shows that these locations have become hotspots for large-scale data center facilities. The study examines the sustainability impacts of data centers on local communities using a mixed-methods design that combines corporate data, expert interviews, focus groups, and site visits. Across these interviews and discussions, many participants described data centers as necessary for digital progress and modern life, but they also expected only modest benefits for the local population. Some interviewees also reported that data centers create limited employment opportunities and that external staff handle most operational tasks, while others expressed concern that preferential electricity contracts for data centers could negatively affect other consumers. As a result, the study identifies both positive and negative side effects of data center development for consumers. On the positive side, participants linked data center development to a more efficient and resilient global data network, improved digital connectivity, and stronger infrastructural integration. On the negative side, they raised concerns about electronic waste, environmental impacts, and increased vulnerability to digital and cyber risks [6]. These findings relate to large-scale data center development in general and not specifically to AI-focused facilities. While AI data centers also require significant infrastructure, they primarily provide computational capacity for AI-related workloads, which may involve different local effects. The study also emphasizes that the impacts of data center development are not limited to electricity prices but include broader aspects of social and digital sustainability, which are important when evaluating the overall effects of new data center projects [6]. It also contributes to the literature by highlighting local, social, and environmental perspectives that are often missing in research on data centers. However, the findings rely primarily on perceptions from interviews and focus groups, which makes it difficult to generalize them or link them directly to measured market outcomes such as electricity prices or grid stability. The analysis, therefore, provides an important qualitative perspective on the social implications of data center development, but further research must connect these insights with quantitative evidence on energy market effects.

F. Recent Developments and Trends

Recent reports and media publications show how artificial intelligence is already increasing electricity demand and putting pressure on energy systems. While these sources are not peer-reviewed, they give useful background on ongoing developments that academic research has not covered yet.

In Norway, public debate increasingly describes data centers as a "bottomless power drain" that could reshape the national energy sector. Electricity use from data centers may double by 2030 and could reach around two percent of total power consumption by 2050. The discussion raises political and ethical questions about whether Norway should allocate clean energy and natural resources to large AI facilities and about who should have access to electricity and under what conditions. It also highlights the importance of considering the consequences this development may have for Norway's energy security, emergency preparedness, and value creation, while noting that AI could also become part of the solution through smarter energy management [21].

In the United States, data centers use an increasing share of national electricity, currently around two to three percent, which may double by 2030. Their location depends on factors such as access to affordable power, cooling water, and fibre infrastructure. This development puts increasing pressure on utilities and policymakers to expand grid capacity and highlights the growing relevance of AI-driven electricity demand [22]. These reports underline that the growth of AI infrastructure is already visible in real energy systems and support the relevance of studying potential effects in Northern Norway.

Overall, the literature highlights several key factors that are relevant for analyzing the impact of large data centers on electricity systems and consumers. These include baseload demand characteristics, grid capacity constraints, market volatility mechanisms, household behavioral responses, and social acceptance aspects. Together, these factors shape the main dimensions of the planned study on the Stargate Norway AI data center.

III. Research Design

This section describes the research design, including the overall approach, data collection, and methods that examine possible impacts from the planned data center in NO4. The goal is to understand how the planned Stargate Norway AI data center could influence electricity prices and consumers in

Northern Norway. Fig. 1 provides an overview of the research design and shows how the steps connect to each other.

A. *Research Approach*

Proposed research approach makes it possible to analyze market dynamics and to understand how consumers adjust their behavior when electricity prices change. Because the Stargate Norway data center has not yet started operation, the study uses a scenario-based logic. It adds a 230 MW baseload to the existing demand profile of NO4 to estimate how such a demand increase could influence electricity prices during normal and high-demand periods. The quantitative analysis applies descriptive price analysis, correlation analysis with weather and hydropower indicators, and a scenario-based demand adjustment to examine electricity price patterns in NO4 and their sensitivity to external factors. It also evaluates how an additional 230 MW baseload could affect average prices, volatility, and extreme price events.

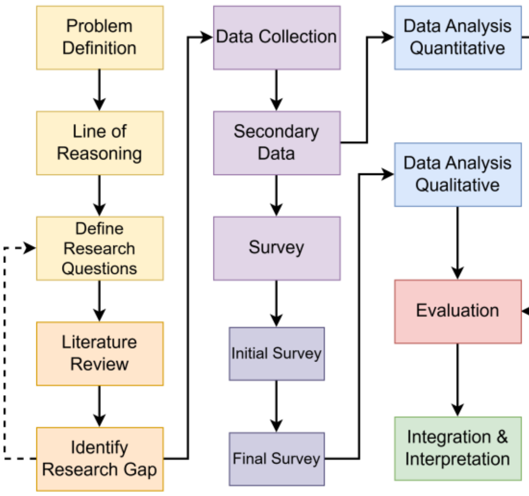

Fig. 1. Research Design.

The qualitative analysis examines how Norwegian households relate to new data centers, how they perceive risks, and how they adjust their behavior to higher electricity prices. Together, these methods build a broader understanding of how large AI data centers affect both the electricity system and local consumers in Northern Norway. These methods directly support the research questions. The quantitative analysis answers RQ1 and RQ2, by studying price changes and the system factors behind them, while both the quantitative and qualitative insights contribute to RQ3 by showing how market effects and consumer perspectives interact in a renewable-based energy system.

B. *Data Collection*

The study uses secondary electricity market data and survey data from Norwegian households. For the secondary data, the study relies on market operators and statistical agencies. Nord Pool provides hourly day-ahead and intraday energy prices for all Norwegian bidding zones. This data makes it possible to analyze differences between NO4 and other zones and to study seasonal patterns, extreme values, and volatility levels. The ENTSO-E Transparency Platform contributes information on demand, generation, and interconnector flows, as well as day-ahead prices for all European bidding zones. These datasets help to understand how NO4 interacts with neighboring regions and how shocks may spread across the Nordic system. Statnett offers technical data on transmission capacity and congestion, which support the analysis of local flexibility limits in Northern Norway. Statistics Norway (SSB) and the Norwegian Water Resources and Energy Directorate (NVE) provide information on household consumption, electricity contracts, and environmental statistics. These sources make it possible to link wholesale market movements to end-consumer bills.

The study also uses survey data to understand how residents perceive electricity prices and new data centers. At the beginning of this research, the study conducted an initial survey to identify which factors residents in Norway are most concerned about when they think about changing electricity prices caused by new AI data centers. The survey included fourteen Likert-scale questions, ranging from “strongly agree” to “strongly disagree”, and two open text fields. The survey covered concerns about higher bills, price volatility, price peaks during peak seasons, trust in government protection, acceptance of new data centers, local economic expectations, environmental risks, and behavioral changes when prices increase by more than ten percent. The survey was distributed using a convenience snowball approach: students in the ITM4400 Research Methods for Systems Engineering course (2025) were asked to share the survey link within their personal networks. This recruitment strategy yielded 78 responses and is treated as exploratory rather than statistically representative.

The results show a strong concern about electricity price increases and volatility. Around 75% of respondents agreed or strongly agreed that they expect prices to fluctuate significantly during winter periods. Similarly, approximately 58% of respondents expressed concern about higher electricity costs, while about 18% disagreed or strongly disagreed. Trust in government measures appears weakly consolidated. While 45% of valid respondents expressed trust (agree/strongly agree), a substantial share selected neutral (29%), and 26% expressed distrust (disagree/strongly disagree). Overall, the findings show that households are particularly concerned about rising and volatile electricity prices, while trust in government measures remains limited.

In addition to the initial survey, the research conducts a second and more detailed household survey that provides the main qualitative dataset. The survey targets households in Northern Norway, with a focus on residents in the NO4 bidding zone. A purposive sampling strategy distributes the questionnaire through regional networks and social media channels. The survey aims to collect approximately 100 to 150 responses. Although the sample does not statistically represent the entire population, it allows the identification of general patterns in consumer perceptions and behavioral responses. The questionnaire collects information on behavioral responses to different electricity price levels, household flexibility during high-price periods, the type of electricity contracts households use, and expectations about future costs. It also includes questions on the acceptance of AI data centers, perceived risks, and trust in political measures. The survey uses Likert-scale questions and open-text responses.

C. *Data Analysis*

The quantitative analysis examines electricity prices in NO4 by studying long price tails, the frequency and duration of extreme values, and overall volatility. It also analyzes how often and how strongly prices deviate from more typical levels. To understand the role of external factors, the study examines correlations between electricity prices and variables such as temperature, precipitation, hydropower indicators, hour of the day, weekday, and season. These relationships help to identify how weather conditions, hydropower availability, and daily demand patterns influence price formation in the NO4 pricing area.

The qualitative analysis examines how households perceive and adapt to potential electricity price changes. The study summarizes the survey results using aggregated Likert-scale responses and a Net Promoter Score (NPS). These insights help to understand how households experience higher electricity prices, how they react to different price scenarios, and how flexible they are when electricity becomes more expensive. Together, the quantitative and qualitative analyses provide a complete picture of how the planned data center affects energy prices and end-consumers in NO4.

D. Validity and Limitations

The analysis requires careful consideration of how the chosen methods influence the reliability of the results. The quantitative data from Nord Pool, Statnett, and ENTSO-E provide a consistent foundation, but they may not capture all local dynamics in NO4. Correlation analysis identifies statistical relationships, yet it cannot show causal links or isolate the impact of a single new consumer. The scenario-based approach, which adds a 230 MW baseload to historical demand patterns, helps to explore possible price effects, but it cannot reflect future market conditions, operational behavior, or policy changes. The qualitative survey also faces limitations related to sample size, self-selection, and differences in how participants interpret questions. As the data center is not yet operational, the survey captures expectations rather than observed reactions. Taken together, these methodological limitations define the boundaries of this study and lead directly to the following discussion of potential risks and expected outcomes.

E. Method Evaluation

It is important to verify whether the results produced by the research approach are reliable and meaningful. The quantitative part evaluates this by comparing the scenario outcomes with historical electricity price patterns in NO4, which shows whether the modelled 230 MW baseload behaves realistically under different hydrological and seasonal conditions. Additional sensitivity checks, such as varying inflow levels or adjusting transmission constraints, can further test the robustness of the scenario results. The qualitative part evaluates the method by reviewing the clarity and consistency of the survey instrument and by comparing responses across different household groups to identify stable patterns rather than isolated outliers. These steps demonstrate whether the approach captures the main dynamics of electricity prices and consumer behavior in a renewable-based region.

IV. Discussion

The chosen mixed-methods approach makes it possible to explore potential price effects and consumer reactions in the NO4 pricing area, but it also introduces uncertainties that should be kept in mind. One central risk is the timing of the project. The planned 230 MW facility will only start operation in 2026, which means that no direct data on its electricity use or load profile exists yet. Future technological, grid, or policy developments may alter the final impact.

There are also important risks related to how the Nordic electricity system behaves. Prices in NO4 depend strongly on hydropower availability, weather conditions, and interconnector flows. These factors can dominate price movements in ways that are difficult to predict. As a result, the impact of a new baseload may appear stronger in some years and weaker in others. In dry years or during winter peaks, the system becomes more stressed, which increases the risk of higher prices and stronger volatility. When hydropower reservoirs are full, or inflow is high, the expected effects are likely smaller.

Another risk concerns data availability and transparency. Large data centers often do not publish detailed information about their electricity use, cooling cycles, or operational flexibility. Without access to this data, the study must assume a constant baseload even though real consumption may be different. Real demand could also vary depending on cooling requirements, seasonal temperature changes, or the type of AI workloads running at a given time. These uncertainties make it difficult to estimate how closely the simulated demand reflects the real behavior of the new Stargate data center.

Integrating household perspectives through a survey also introduces risks. The survey provides valuable insight into how residents think about new data centers and higher electricity prices, but the survey results depend on who takes part in the survey. A limited or uneven sample cannot represent all household types in Northern Norway. The survey captures expectations rather than real behavior since households have not yet experienced price effects from AI data centers. In addition, households differ widely in income levels, heating technologies, and electricity contract types, which influence how strongly they react to price changes. These structural differences mean that some groups may have more flexibility than others, especially during long-lasting periods of high prices. The survey also focuses only on households and does not include other affected groups in the region, such as SMEs, local industries, or public institutions, which reduces the broader scope of the findings.

Beyond methodological considerations, governance and acceptance risks also play a significant role. If households feel that data centers benefit companies more than local residents, acceptance may decline. Concerns about fairness, transparency, and local value creation can influence how people interpret future price changes and how strongly they react to them. In addition, the Norwegian government introduced the “Norway Price” in 2025, which offers households a fixed electricity price. While the scheme reduces short-term financial pressure, it also weakens incentives to shift consumption to cheaper hours. This moves the system away from dynamic pricing. Future changes in market regulation or support schemes could also influence how households experience price signals. Adjustments to the Norway Price or new capacity charges for large consumers may affect consumer flexibility and overall system dynamics.

Another source of uncertainty is how NO4 interacts with other Nordic price zones, where constraints make it difficult to isolate the effect of a single new consumer.

Based on the research design, the expected outcome is that the planned 230 MW baseload will increase electricity prices for residential households in NO4. Recent developments in other countries show similar effects in regions where large data centers are operating. This impact will likely be strongest during periods of high demand or low hydropower availability. The additional load may also reduce system flexibility and contribute to stronger price volatility, particularly in winter or dry seasons. Comparisons with other Norwegian bidding zones will help to show how much prices in NO4 differ from those in other regions. On the consumer side, households are expected to respond mainly to long-lasting periods of high prices rather than to short-term fluctuations. Previous research shows that people reduce their electricity use when prices remain high over several days or weeks, while their flexibility within single hours stays limited. Survey insights will likely show mixed acceptance of new data centers, with some households expecting economic benefits and others worrying about higher electricity bills, environmental effects, or unequal distribution of gains.

V. Conclusion

This study prepares the groundwork for a research project on how the planned 230 MW Stargate Norway AI data center may influence electricity prices and consumers in the NO4 region. We presented with problem statement, established the line of reasoning, and reviewed literature on data center energy demand, the Nordic electricity market system, and consumer impacts.

The paper proposes a clear conceptual and methodological foundation for future research on the impacts of large data centers. The proposed research approach also identifies the next steps, such as validating the scenario assumptions, expanding the survey sample, and integrating real consumption data from the facility. The outcomes from this research can support policymakers and local actors when evaluating the trade-offs between data center development, electricity price stability, and consumer interests. These steps help build a deeper understanding of how the new data center may influence both the regional electricity system and residential consumers in Northern Norway.

Acknowledgment

The author used ChatGPT (OpenAI, 2025) to assist with improving the structure and language of this paper. The authors developed all analysis, interpretations, and conclusions independently.

REFERENCES

[1] International Energy Agency, "Electricity 2024: Analysis and forecast to 2026," IEA, Paris, 2024. Accessed: Dec. 11 2025. [Online]. Available: https://www.iea.org/reports/electricity-2024

[2] B. D. Gearino, *Which States Are Getting Hit Hardest by Electricity Price Increases?* [Online]. Available: https://insideclimatenews.org/news/25092025/inside-clean-energy-electricity-rate-hikes-by-state/ (accessed: Nov. 12 2025).

[3] Statnett, *Why we have bidding zones.* [Online]. Available: https://www.statnett.no/en/about-statnett/The-power-system/why-we-have-bidding-zones/ (accessed: Sep. 10 2025).

[4] Ministry of Energy, *"Norway Price" to Ensure Predictable and Stable Electricity Prices for Consumers.* [Online]. Available: https://www.regjeringen.no/en/whats-new/norgespris-skal-sikre-forutsigbare-og-stabile-strompriser-for-folk/id3090849/ (accessed: Nov. 18 2025).

[5] OpenAI, *Introducing Stargate Norway.* [Online]. Available: https://openai.com/index/introducing-stargate-norway/ (accessed: Sep. 9 2025).

[6] B. K. Sovacool, P. Upham, and C. G. Monyei, "The "whole systems" energy sustainability of digitalization: Humanizing the community risks and benefits of Nordic datacenter development," *Energy Research & Social Science*, vol. 88, p. 102493, 2022, doi: 10.1016/j.erss.2022.102493.

[7] D. Mytton, M. Ashtine, S. Wheeler, and D. Wallom, "Stretched grid? Managing data center energy demand and grid capacity," *Oxf Open Energy*, vol. 2, 2023, doi: 10.1093/ooenergy/oiad014.

[8] J. K. Nøland, M. Hjelmeland, and M. Korpås, "Will Energy-Hungry AI Create a Baseload Power Demand Boom?," *IEEE Access*, vol. 12, pp. 110353–110360, 2024, doi: 10.1109/ACCESS.2024.3440217.

[9] M. Dayarathna, Y. Wen, and R. Fan, "Data Center Energy Consumption Modeling: A Survey," *IEEE Commun. Surv. Tutorials*, vol. 18, no. 1, pp. 732–794, 2016, doi: 10.1109/COMST.2015.2481183.

[10] C. Bogmans, P. Gomez-Gonzalez, G. Ganpurev, G. Melina, A. Pescatori, and S. Thube, "Power Hungry: How AI Will Drive Energy Demand," *IMF Working Papers*, vol. 2025, no. 081, p. 1, 2025, doi: 10.5089/9798229007207.001.

[11] K. M. U. Ahmed, M. H. J. Bollen, and M. Alvarez, "A Review of Data Centers Energy Consumption and Reliability Modeling," *IEEE Access*, vol. 9, pp. 152536–152563, 2021, doi: 10.1109/ACCESS.2021.3125092.

[12] S. Petrović *et al.,* "The role of data centres in the future Danish energy system," *Energy*, vol. 194, p. 116928, 2020, doi: 10.1016/j.energy.2020.116928.

[13] C. Koronen, M. Åhman, and L. J. Nilsson, "Data centres in future European energy systems—energy efficiency, integration and policy," *Energy Efficiency*, vol. 13, no. 1, pp. 129–144, 2020, doi: 10.1007/s12053-019-09833-8.

[14] J. Hellström, J. Lundgren, and H. Yu, "Why do electricity prices jump? Empirical evidence from the Nordic electricity market," *Energy Economics*, vol. 34, no. 6, pp. 1774–1781, 2012, doi: 10.1016/j.eneco.2012.07.006.

[15] C. Lyu, H. X. Do, R. Nepal, and T. Jamasb, "Volatility spillovers and carbon price in the Nordic wholesale electricity markets," *Energy Economics*, vol. 134, p. 107559, 2024, doi: 10.1016/j.eneco.2024.107559.

[16] G. Kamiya and P. Bertoldi, "Energy Consumption in Data Centres and Broadband Communication Networks in the EU," *1831-9424*, 2024, doi: 10.2760/706491.

[17] M. T. Takci, M. Qadrdan, J. Summers, and J. Gustafsson, "Data centres as a source of flexibility for power systems," *Energy Reports*, vol. 13, pp. 3661–3671, 2025, doi: 10.1016/j.egyr.2025.03.020.

[18] Entsoe, "Principles for determining the transfer capacities," 2023. [Online]. Available: https://www.nordpoolgroup.com/493abd/globalassets/download-center/tso/principles-for-determining-the-transfer-capacities-2023-03-23.pdf

[19] Statistics Norway, *Slightly lower electricity price in first quarter.* [Online]. Available: https://www.ssb.no/en/energi-og-industri/energi/statistikk/elektrisitetspriser/article-for-electricity-prices/slightly-lower-electricity-price-in-first-quarter (accessed: Sep. 11 2025).

[20] M. Hofmann and K. B. Lindberg, "Residential demand response and dynamic electricity contracts with hourly prices: A study of Norwegian households during the 2021/22 energy crisis," *Smart Energy*, vol. 13, p. 100126, 2024, doi: 10.1016/j.segy.2023.100126.

[21] S. W. Normannsen, *Datasentrenes umettelige behov for strøm vil endre hele energisektoren.* [Online]. Available: https://gemini.no/2025/09/ki-har-skapt-et-bunnlost-stromsluk-som-vil-endre-hele-energisektoren/?utm_source=RSS+Nyhetsbrev&utm_campaign=3a6be9f6a5-FIKK_DU_MED_DEG_DISSE_COPY_01&utm_medium=email&utm_term=0_de4d883975-3a6be9f6a5-73574461 (accessed: Oct. 9 2025).

[22] Visual Capitalist, *Mapped: The Massive Network Powering U.S. Data Centers.* [Online]. Available: https://www.visualcapitalist.com/map-network-powering-us-data-centers/ (accessed: Oct. 9 2025).