FUTURE-PROOFING NORTH DAKOTA'S ELECTRICAL INFRASTRUCTURE TO ENABLE EXPANSION IN AN EVOLVING ENERGY LANDSCAPE

Summary

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FUTURE-PROOFING NORTH DAKOTA'S ELECTRICAL INFRASTURCTURE SUMMARY REPORT

OVERVIEW

North Dakota is experiencing rapid growth in large loads that present both economic opportunities and significant challenges to the transmission network, potentially requiring major reinforcements to maintain reliability and meet demand.

The Energy & Environmental Research Center and Power System Engineering, Inc. Future conducted this study on behalf of the North Dakota Transmission Authority (NDTA) to evaluate the ability of the existing electric transmission system to serve current and future demand across North Dakota.

Through integrated reliability and economic analyses, this study evaluated how large-load additions influence transmission loading, system reliability, transmission congestion, electricity market prices, generation dispatch, and renewable generation and curtailment. Detailed results of the study can be found in the final report available through the NDIC website.[1]

METHODOLOGY/APPROACH

- Summer/winter seasonal power flow and hourly production cost models from the Southwest Power Pool (SPP) 2025 Integrated Transmission Plan covering Year 2 (2026), Year 5 (2029), and Year 10 (2034) forecasts were used for this study.

- Several large loads were added at high-voltage locations in North Dakota. Three scenarios were evaluated for large loads: East, Central, and West, including 600–1400 MW (Table 1, Figure 1).

Table 1. Large-Load Scenarios with Interconnecting Substations

East 1400 MW	Central 1100 MW	West 600 MW
• Coal Creek 230 kV, 200 MW	• Coal Creek 230 kV, 500 MW*	• Coal Creek 230 kV, 200 MW
• Bison 345 kV, 200 MW	• Center 345 kV, 300 MW	• Judson 345 kV, 200 MW
• Buffalo 345 kV, 200 MW	• Leland 345 kV, 300 MW	• Pioneer 345 kV, 200 MW
• Ellendale 345 kV, 200 MW		
• Jamestown 345 kV, 200 MW		
• Maple 345 kV, 200 MW		
• Prairie 345 kV, 200 MW	*Total	

[1] Selvaraj et al. 2025. *Future-proofing North Dakota's Electrical Infrastructure to Enable Expansion in an Evolving Energy Landscape.* Final Report https://www.ndic.nd.gov/sites/www/files/documents/Transmission-Authority/Publications/Transmission%20Capacity%20Study/2025-Final-Report-Future-Proofing-NDs-Electrical.pdf

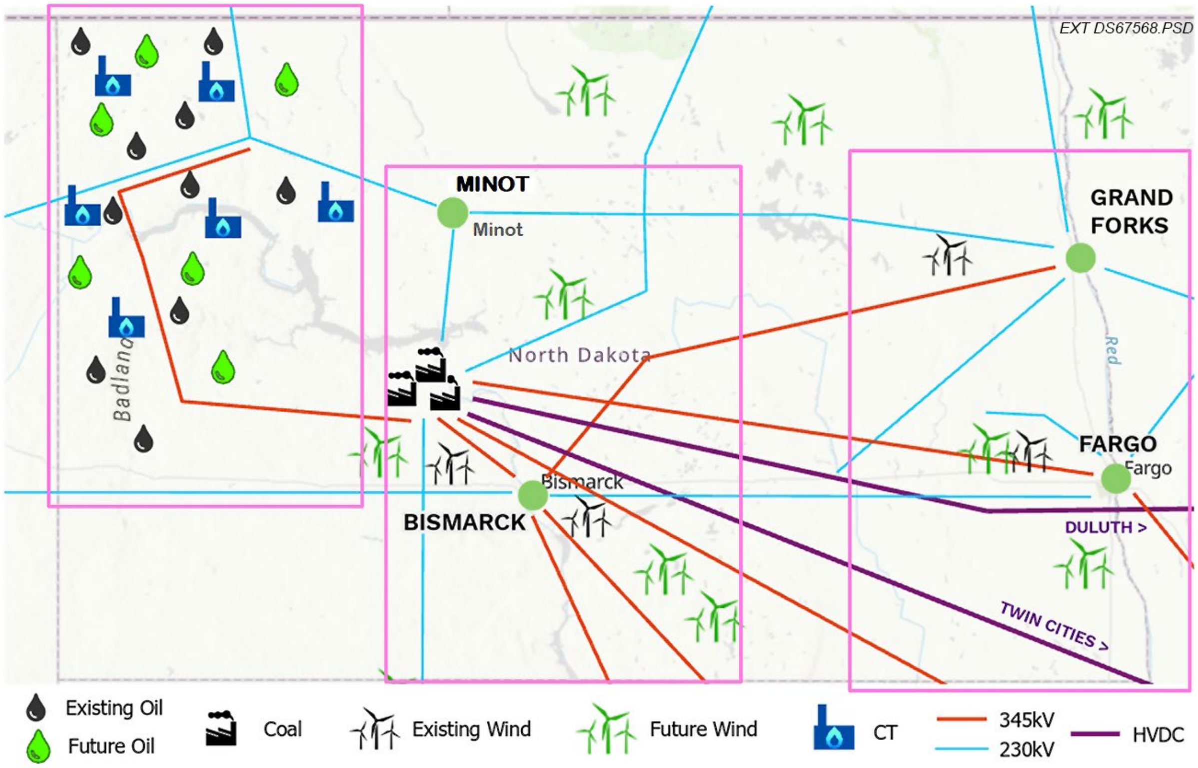

Figure 1. North Dakota system map.

SUMMARY OF KEY FINDINGS

- System Performance under Base Conditions – The existing North Dakota transmission system demonstrates adequate performance under current conditions, with only a limited number of thermal and voltage violations observed in the base models.

- Impacts of Large Loads – When additional large-load scenarios (600–1400 MW) were introduced into the study models, the number of thermal and voltage violations increased significantly (Figure 2). Voltage issues were concentrated primarily on the 115-kV network, particularly in western North Dakota, where voltages dropped below transmission owner (TO) criteria during N-1 contingencies.

- Thermal Overloads and Equipment Stress – Under large-load scenarios, 22–75 miles of transmission lines exceeded thermal limits during summer peaks, and 75–198 miles of transmission lines exceeded thermal limits during winter peaks. Four transformer overloads were also identified, indicating potential substation capacity constraints.

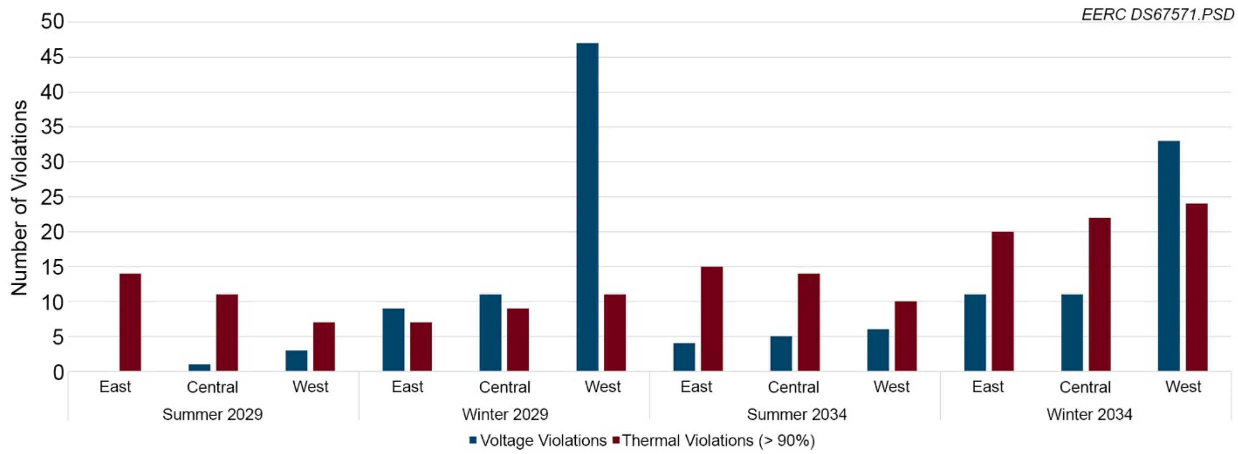

Figure 2. Thermal and voltage violation counts from the seasonal summer/winter peak model by forecast year (2029, 2034).

- Regional and Economic Sensitivities – The western portion of the state exhibited the greatest sensitivity to new industrial load growth. Large loads need to be added to the local utilities load forecast and uploaded into the regional transmission organization's (RTO's) planning database as quickly as possible. This will ensure the RTO's transmission upgrade process will capture the impact of the large loads and implement the required reinforcements. This process has already added hundreds of miles of 345-kV backbone transmission in North Dakota and avoided future congestion or curtailment risks. The potential for transmission investment underscores the need for coordinated planning to balance system reliability, economic growth, and ratepayer impacts.

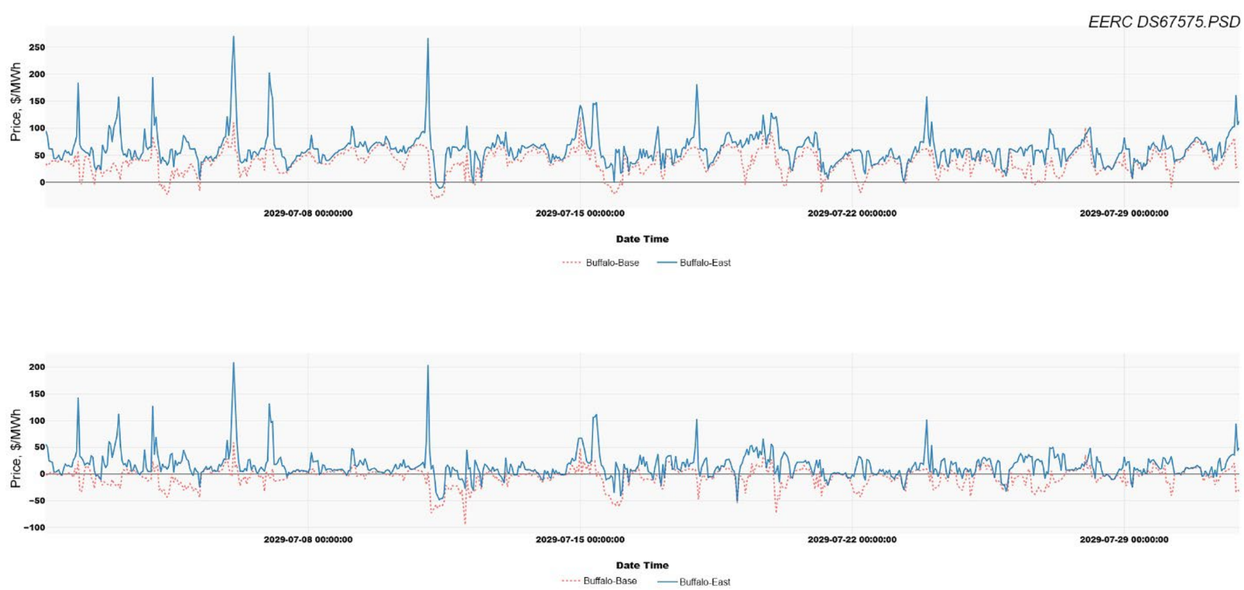

Figure 3. LMP and its congestion component for Buffalo bus under the base case and east scenario – July 2029.

- The addition of large loads without the addition of equivalent generation increased both congestion and locational marginal prices (LMPs). As shown in Figure 3, congestion costs drive up LMP values and higher LMP values are observed in East Scenario. However, incorporating a price-sensitive load curtailment mechanism for these large loads helped alleviate congestion and reduced the resulting LMP impacts.

- The introduction of large loads consumed energy that was otherwise being curtailed because of transmission limitations on the North Dakota export interface. Consequently, thermal generation dispatch and renewable energy output increased to meet the additional demand.

RECOMMENDATIONS

- Stakeholder Engagement – The RTO's transmission planning processes are dependent on stakeholder input. Engagement in these processes by North Dakota stakeholders will ensure that North Dakota-area reliability issues are addressed and cost-effective transmission additions are implemented.

- Targeted Transmission Reinforcements – Prioritize RTO-identified upgrades to the 115-kV and select 230-kV corridors in western and central North Dakota where large-load growth is most likely and voltage violations were most prevalent.

- Transformer and Substation Expansion – Address observed transformer overloads through proactive capacity expansion or parallel transformer installation at high-risk substations.

- Enhanced Coordination Within Industry – Coordinate enhanced research and analysis efforts related to gathering accurate data regarding the characteristics of large loads. This data should include electrical performance and market response data. Share this data amongst NDTA, the Public Service Commission, utilities, and RTOs (SPP and Midcontinent Independent System Operator) to help inform the existing planning process, align forecasts, model assumptions, large-load interconnection procedures, and project priorities across jurisdictions.

- Load-Siting Guidance for Developers – Encourage early engagement between large-load developers and utilities to align project siting with available capacity, minimizing the need for major network reinforcements and improving project feasibility.

- Integrated Planning of Generation and Transmission – Coordinate with upcoming RTO resource adequacy, generation expansion, and reliability studies to ensure that new generation and transmission upgrades are planned in tandem to maintain system resilience.

- Economic and Cost–Benefit Evaluation – Support the RTO's cost–benefit assessment of candidate reinforcement projects to identify the most cost-effective reliability improvements and inform funding and policy decisions.

- Coordinate the large load's own reliability criteria with what the local TO can reasonably provide. Investigate the large load's ability to curtail during network congestion and/or generation constraints. If the large load has on-site backup generation capability, evaluate whether this resource can be utilized to offset exposure to high LMPs by self-generating power during periods of elevated prices.

- Support RTO and utilities power market impact studies of large-load additions. This is important because the pace of large-load additions is likely to exceed the pace of generation additions. This study showed that the addition of large load without corresponding generation additions and transmission reinforcements has the potential to raise power market prices through increases in congestion and energy costs.

FUTURE STUDY/NEXT STEPS

Future study considerations:

- Large-Load Electrical Characteristics – Investigate the response of large loads under transmission system disturbances, including voltage and frequency trip settings. Examine market behavior to understand how large loads respond during transmission congestion and energy emergencies.

- Refined Load Forecasting – Update and refine the large-load forecast to reflect confirmed data center and industrial development timelines, ensuring realistic modeling for future scenarios.

- Transmission Reinforcement Planning – Identify specific project options (e.g., reconductoring, transformer additions, or new transmission lines) to alleviate thermal and voltage violations under large-load scenarios and analyze those options for use in the RTO planning process.

- Integration with Resource Expansion Studies – Support future RTO ongoing generation and resource adequacy assessments and generator interconnection planning to ensure that both supply and transmission infrastructure evolve in tandem to maintain reliability.

- Power Market Impact Studies – Support RTO and utility market economic analysis with additional large-load scenarios and the latest planning assumptions. Analyze impacts of generation additions and transmission reinforcements on power market prices through congestion and energy costs.

- Follow-On Study – Leverage the analytical framework, datasets, and regional insights from this phase to extend the work in a consistent, data-driven manner, building on established methods, validated assumptions, and stakeholder input.