Multi-Temporal Hierarchical Natural Gas Demand Forecasting Framework for Power Generation Infrastructure: Integrating Variational Mode Decomposition with Deep Learning

CTIPS-073 – UTC Project Information

Recipient/Grant Number:	North Dakota State University Grant No. 69A3552348308
Center Name:	Center for Transformative Infrastructure Preservation and Sustainability
Research Priority:	Preserving the Existing Transportation System
Principal Investigator(s):	Pan Lu, Ph.D. Xinyi Yang, Ph.D.
Project Partners:	USDOT, Office of the Assistant Secretary for Research and Technology – $102,213 North Dakota LTAP – $58,250 Transportation Learning Network – $35,000 Upper Great Plains Transportation Institute – $8,963
Total Project Cost:	$204,426
Project Start and End Date:	8/28/2026 to 11/30/2029

Project Description

This seed project focuses on developing accurate, multi-scale prediction of natural gas demand for power generation—at the generator unit, power plant, and aggregated city and state levels. Its importance lies in both technical innovation and strategic national relevance.

USDOT Priorities

Section left blank until USDOT's new priorities and RD&T strategic goals are available in Spring 2026.

Outputs

This project will advance technology transfer through the publication and dissemination of high-quality, peer-reviewed research. Planned outputs include one to two journal manuscripts targeting Transportation Research Part C, Applied Energy, and Energy, along with one to two peer-reviewed conference papers. Research findings will be communicated through both virtual and in-person mechanisms. Virtual dissemination will include CTIPS-hosted webinars, recorded instructional materials, and online presentations, while in-person outreach will occur through seminars, professional meetings, and topical

workshops. The project team will also actively participate in CTIPS Technology Transfer (T2) programs to engage stakeholders and ensure broad dissemination of results through regional, national, and professional venues.

Outcomes/Impacts

The expected outcomes of this research include:

1) Development of a validated multi-temporal, hierarchical forecasting framework: The framework will operate across four temporal resolutions (yearly, monthly, daily, hourly) and three organizational levels (unit, plant, system), demonstrating how optimal forecasting strategies and feature importance vary systematically across different scales.
2) Improved forecasting accuracy for natural gas demand: The developed models will achieve measurable improvements in prediction accuracy compared to baseline methods, directly supporting operational decisions such as fuel procurement, maintenance scheduling, and dispatch optimization at both facility and system levels.
3) Interpretability analysis identifying critical demand drivers: The SHapley Additive exPlanations (SHAP) analysis will reveal which factors (meteorological variables, operational patterns, cross-unit dependencies) dominate predictions across different temporal scales and organizational levels, guiding data collection priorities and monitoring investments.

The outcomes of this project are expected to enhance natural gas demand forecasting by delivering accurate, multi-scale predictions that serve both regional energy planning and facility-specific operations, thereby improving resource allocation, operational efficiency, and grid reliability for power generation facilities.

Final Report

Upon completion, the final report link will be added to the project page on the CTIPS website.