Hawai'i Natural Energy Institute Research Highlights

Grid Integration

Real-Time Health Assessment of Distribution Transformers

OBJECTIVE AND SIGNIFICANCE: The goal of this project was to develop a near real-time monitoring algorithm on an advanced grid energy monitor device using non-intrusive sensors and environmental data to assess the health of distribution (service) transformers. A simple, low-cost monitoring system for service transformers will not only help operators better manage transformers and make proper maintenance and replacement decisions in a reasonable way, but it will also contribute to reducing damage and increasing grid reliability. This is especially crucial in light of the additional challenges posed by the rapid integration of distributed photovoltaic (PV) systems, electric vehicles, and other alternative energy resources.

BACKGROUND: Transformers are vital components in the electrical distribution network, playing a crucial role in ensuring the efficient and reliable delivery of electricity to end-users. However, these transformers are susceptible to various operational challenges and failures, such as oil leakage, thermal stress resulting from overload, harmonics, and unbalanced loading. The real-time monitoring system developed by HNEI Grid***START*** could help utilities revolutionize the way managing their distribution transformer assets automatically and continuously at a low cost. By proactively identifying potential failures and assessing transformer health, it empowers utilities to reduce downtime, extend the operational life of distribution transformers, and enhance the reliability of electrical service. The system schematic diagram is shown in Figure 1.

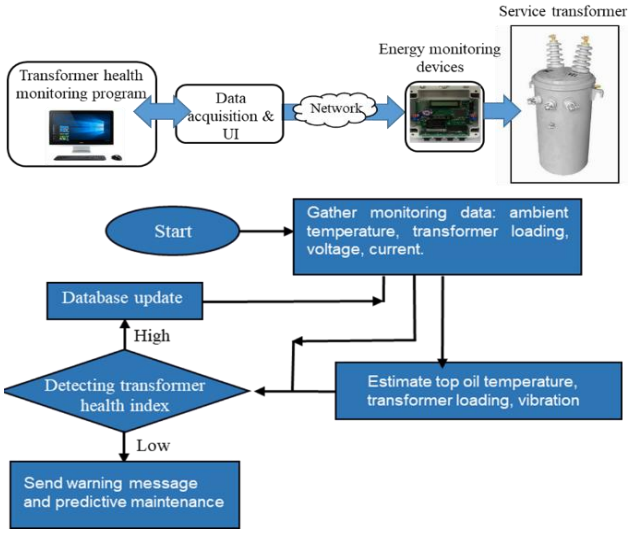

Figure 1. Conceptual schematic diagram.

PROJECT STATUS/RESULTS: HNEI Grid***START*** developed a real-time assessment algorithm implemented on an advanced grid energy monitoring device using fuzzy logic method to evaluate the conditions of distribution (service) transformers. Three main parameters, including top oil temperature, vibration, and transformer loading, are selected to assess the transformer's condition. Transformer indicators are approximated based on the current, voltage, and ambient temperature measured at the transformer. The system model is described in Figure 2.

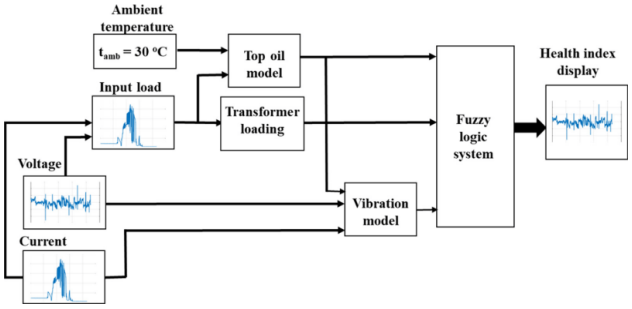

Figure 2. The model of the assessment system.

Data collection to support the assessment of transformer health presents a considerable challenge, as it frequently requires costly sensors and extensive experimentation or field observation. HNEI Grid***START*** has utilized the aforementioned assessment model to construct an initial dataset for implementing a machine learning approach in the oil-immersed service transformer's condition evaluation. This approach is characterized by its simplicity and lack of reliance on expensive sensors, which may not be practically installed due to the low cost of service transformers compared to other transformers within the electric power system.

The project has contributed to the academic community and knowledge dissemination by successfully publishing a total of two peer-reviewed journal papers and two conference proceedings papers. The project was completed in December 2022. HNEI Grid***START*** finalized reporting in October 2023.

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