Final Report

Lakeland Electric Revenue and Load Modeling

Capstone

12/11/24

**Introduction**:

Lakeland Electric has a lot of unique challenges when it comes to forecasting electricity usage and revenue. Standard industry models work as a solid baseline, but they do not capture Lakeland’s specific behavior. This project is designed to create a model for improving the revenue and load modeling relating to Residential customers and then expand if time permits. The current Lakeland Electric models focus on monthly aggregates and then create a 1 year short-term forecast and a 10 year long-term forecast. Our goal is to create models that utilize hourly/daily data to obtain more specific forecasts. From there, if the models work well, they can be expanded and modified in future iterations to eventually handle real-time forecasting and other building classes. Lakeland Electric plans on this being a multiple year project so our goal is to create a solid starting point that can be built upon by future work. The priority is creating something reliable and scalable that can grow and adapt as Lakeland Electric’s needs change.

**Customer Needs/Requirements**:

Lakeland Electric needs models that can accurately predict electricity load and revenue to improve resource planning and pricing.

* Key Needs:
  + More specific forecasting models that utilize daily/hourly data and local patterns.
  + Initial focus of residential customers since they are by far the biggest new business.
  + Pipeline for expanding into other building classes/customers.
  + Utilizing hourly/daily data in the forecasts to obtain more specificity.
* Functional Requirements:
  + Capable of processing hourly and daily data for energy usage, peak demand, and revenue prediction.
  + Use of historical weather and demographic data.
  + Implementation of the various residential rate structures (RS, RSX-1, RSD)[1].
  + Clear, interpretable outputs.
  + Accurate models when compared to ITRON and available Lakeland Electric data.

**Problem Decomposition/Constraints**:

1. Problem Decomposition:
   * Load Model:
     + Analyze and predict hourly/daily electricity load for residential customers.
     + Use weather (HDD/CDD)[1], customer, and time of day trend variables.
   * Revenue Model:
     + Forecast revenue based on rate classes and customer usage patterns.
     + Account for various residential rate structures within the model.
2. Constraints:
   * Data Availability:
     + Data is obtained directly from Lakeland Electric – we can’t obtain some of it ourselves.
     + Will need to fill any missing data with external data sources – e.g weather.gov.
   * Scope:
     + Residential customers/classes only initially – look to expand once this model is capable.
   * Accuracy vs. Understandability:
     + Models need to have interpretable and reliable output.

This approach helps the project move forward step by step, focusing on immediate needs while staying flexible for future growth.

**Potential Solutions/Analysis**:

We have identified multiple potential models to start out with. Initially, we will be focusing on multiple regression models like the ITRON standard Lakeland Electric currently uses. From there we can look to feature engineering and other model improvements.

1. Literature Review:
   * Examined existing energy forecasting methods, including:
     + Itron's SAE econometric approach for understanding residential energy consumption trends [1][2].
     + Modeling techniques like multiple regression, ARIMA, and exponential smoothing.
   * Incorporates Lakeland data, but doesn’t adapt the models to utilize it best.
2. Proposed Modeling Approaches:
   * Load Model:
     + Start with multiple regression to establish basic relationships between variables such as weather, time-of-day, and load.
     + Incorporate time series methods (e.g., exponential smoothing, ARIMA) for capturing trends and seasonality.

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Figure 1: Current Load Model (WIP)

* + Revenue Model:
    - Use regression-based approaches to link load predictions to revenue.
    - Test additional features (X below) to try and identify ways to improve the models.

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Figure 2: Current Revenue Model (WIP)

1. Alternatives Considered:
   * Machine learning models (e.g., Random Forests, Gradient Boosting) seem promising as well, but time and initial data constraints will make them more of a future work goal.
   * Smart-grid data integration was also identified as a longer-term goal.
2. Initial Focus:
   * Simpler models (multiple regression) to start with and then expand via feature engineering and various forecasting methods (exponential smoothing vs ARIMA).

**Applicable Codes/Standards**:

There is no safety code or standard required for this project. However, Lakeland Electric uses Itron’s forecasting tools, widely recognized as an industry standard for energy forecasting[1][2]. We will be using their current model and practices as a baseline to initially create and compare our model to.

Industry Standards:

1. Itron Methodologies:
   * The SAE model provides a benchmark for comparing the residential load and revenue models developed in this project.
   * We will utilize their way of handling weather data and add to it (HDD/CDD)[1].
2. Best Practices for Data-Driven Forecasting:
   * Proper obtaining and cleaning of the data will be performed.
   * Models created will follow the rules learned within our classes here at Florida Poly.

This project aligns with how ITRON performs their industry standard analysis. By building on these methodologies and incorporating them into the model design, this project ensures that standard practices are followed.

**Conclusions/Future Work:**

This project focuses on tackling the distinctive challenges of forecasting electricity usage and revenue for Lakeland Electric, beginning with residential customers. This allows us to create models for the customer section they most need it for, and then expanding when/if time allows. Our models will incorporate the Lakeland weather, customer behavior, and usage obtained directly from Lakeland Electric. From there we will investigate potential features that could be useful that are not currently included. Initial efforts emphasize scalable and interpretable methods, with the option to expand into more advanced techniques and additional customer classes in the future

Future Work:

1. Data Acquisition/Cleaning:
   * Obtain data from Lakeland Electric (currently in process).
   * Ensure the data is clean and ready to use in modeling.
2. Model Creation:
   * Start with multiple regression as shown in Figures 1 and 2, and then expand the features and interactions between features as we continue.
3. Evaluation/Benchmarking:
   * Compare our model outputs to ITRON’s to see how well our models are performing.
   * Cross-validation to ensure our models are consistent.
4. Expand Feature Set:
   * Additional variables such as some of the smart-grid data will be explored.
   * Nonlinear feature engineering to try to identify any interactions not captured by the initial model.
5. Scalability Planning:
   * Pipeline will be created to help Lakeland Electric have an idea of how to proceed with the other customer classes if we don’t have time to get to it.
6. Final Deliverables:
   * A complete report will be provided to Lakeland Electric outlining our entire process along with any code or models created.
   * This plan will also include any pipelines created for expansion for the other customer classes or real-time implementation.

Future work will be focused on expanding the models to the other customer types along with trying to identify ways to scale this further into the future for real-time data use.

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Figure 3: GANNT Chart: Spring 25’ Project Timeline

**Citations**

**1) Tariff Document:**

Lakeland Electric. (2024). *Residential Service Rate Schedules RS, RSX-1, and RSD.* Lakeland Electric Tariff Documents. Retrieved from the Lakeland Electric utility services on December 1st, 2024.

2) **ITRON Information:**

Itron. *Itron Energy Forecasting and Analytics.* Retrieved November 16, 2024, from <https://na.itron.com/>