Modeling Heat Pump Adoption Propensity and Simulating the Distribution-Level Effects

nationalgrid

BUSINESS PROBLEM

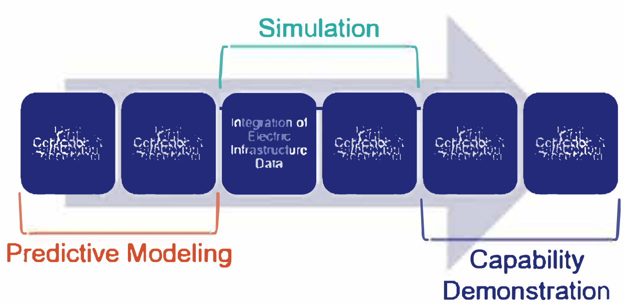
National Grid, like many utilities in the energy sector, finds itself at a critical juncture for decarbonization. To maintain alignment with regional carbon reduction goals, it must find innovative ways to reduce greenhouse gas emissions in its service territories. For the heating sector in particular, air source heat pumps (ASHP) represent a promising opportunity to decarbonize the residential space conditioning market through electrification. However, in order to meet its goals, the company must accelerate the current rate of customer adoption – utilizing data and tools at its current disposal.

APPROACH

(1) Collect data relevant to modeling the propensity of utility customers to adopt ASHPs. (2) Develop a machine learning (ML) pipeline to build predictive models using a variety of pre-processing, feature selection, hyperparameter, and training algorithm options. (3) Deploy best-performing ML model. (4) Use propensity modeling results to simulate distribution system impacts from ASHP adoption.

DATA SOURCES

Internal sources of data included: (1) Customer account data (e.g. electricity usage) (2) Energy efficiency program participation data (e.g. previous rebates) (3) Electricity and natural gas infrastructure data (e.g. feeder ratings) External sources of data included: (1) Customer demographics (e.g. household income) (2) Housing data (e.g. square footage) (3) Survey data (e.g. heating fuel type)



Data Types and Format

Data was collected at the household/account level. Data types were a combination of continuous, binary, and categorical.

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The business impacts of having household-level ASHP propensity data fall into two general categories: (1) Program Strategy & Execution and (2) Business Strategy. From a program strategy and execution perspective, high-accuracy ASHP propensity models provide a capability to "geotarget" customers — improving the yield of marketing efforts and using resources more efficiently. Understanding who the most likely customers are to adopt an ASHP, and customizing marketing efforts to encourage these customers to adopt will help to greatly accelerate the early adoption of ASHPs. Additionally, utilities have an opportunity to use ASHP adoption propensity data to match high potential customers with certified contractors in their local area — which helps accelerate the growth of an ASHP market for contractors as well. From a business strategy perspective, this capability allows for more granular planning capabilities with regards to zonal electrification and alleviating natural gas system supply constraints. For example, if a utility has a natural gas supply constraint that prevents is from providing enough gas supply to meet demand — they can utilize knowledge of ASHP adoption propensity to strategically shift customers from gas to electricity for home space conditioning. Finally, this information can be used to better understand the location and timing of future distribution system upgrades.

DRIVERS

decarbonization has become a major driver across many industries. ASHPs present a huge opportunity for decarbonization — and stakeholders such as utilities are trying to accelerate adoption. Second, with their vast amounts of available data, utilities have become increasingly interested in deploying digital solutions to traditional problems.

BARRIERS

The primary barriers impacting this project included: (1) The desired data was housed in various internal databases, owned by various teams. As such, integrating all data sources was at times cumbersome. (2) Databases contained sensitive customer information, so care was necessary to respect all company data privacy policies. (3) Developing a tool that met the needs of various stakeholders and teams — and was useable by all.

ENABLERS

The enablers of this work included: (1) Management team, and coworkers, that were invested in the outcome of the project. (2) National Grid's desire to deploy digital solutions — of which this was a perfect example. (3) Complete access to relevant data, and to relevant stakeholders (both internal and external) (4) Partnership with advanced data analytics team for mentorship.

ACTIONS

(1) Collected and processed all relevant data for ASHP predictive modeling. (2) Developed an "ASHP Propensity Modeling & Simulation Tool" — a Python based program with an Excel front-end user interface. This tool provided capabilities to train a new propensity models and to run various distribution system simulations. (3) Created state-level Microsoft Power BI dashboards to visualize results. (4) Created feeder map visualizations using ArcGIS.

INNOVATION

The primary innovations associated with this solution include: (1) Deployment of a Python program (unknown to many employees) via an excel-based interface to improve end-user adoption likelihood. (2) Application of gradient-boosted decision trees in the context of utility — delivering superior results to more traditional methods such as logistic regression. (3) Development of an improved load forecasting technique that relies on propensity data.

IMPROVEMENT

The final improvement of this project is not yet quantifiable. Once the solution is validated, there will be an opportunity to quantify improvement in terms of marketing spend ($) per ASHP adoption, as well as the overall rate of ASHP adoption through National Grid sponsored programs.

BEST PRACTICES

Best practices include: (1) Leverage existing Python libraries to the maximum extent possible. (2) Involve end users in user-interface development from the very beginning. Ask them to "paint the picture" of their perfect solution. (3) Take the time to understand what/who is needed to continue updating and using your solution in the future. Try to automate as much as possible.

OTHER APPLICATIONS

The methods of propensity modeling used in this solution can be utilized for any "product adoption" scenario — in various industries.