

# Machine Learning Playbook for Utilities

🞽 info@mosaicdatascience.com 🍈 https://mosaicdatascience.com





### Mosaic helps utilities from all sectors make machine learning actionable, explainable, and scalable.

The energy industry segment has long been regarded as conservative when it comes to deploying digital technology. But the recent explosion of available data has forced several industry players to rethink how they operate as machine learning is reshaping everything from customer engagement to inspection operations.

The <u>Utility Analytics Institute</u> surveyed 42 major utilities focused on assessing the analytics maturity taking place within the utility. UAI asked the utilities to rate their company's ability to process data with the available tools and technologies. After reviewing the results, UAI said, "In terms of whether analytics toolsets meet enterprise needs, most responses fell in the poor/limited and good categories." Clearly, there is a need for user-friendly methods for managing data.



Utilities have a tremendous opportunity to be more efficient by using embracing data-driven decisionmaking. To power those insights, machine learning is a must-have to remain competitive & relevant.

### Why Mosaic?

Our data science team is adept at developing machine learning models across the advanced analytics spectrum, especially for utilities and energy companies. We have worked multiple client engagements where we develop a suite of tools and capabilities that facilitate ongoing learning from data to bring continuous value through machine learning and artificial intelligence.

In the following pages we will explore areas we think Machine Learning can be most impactful.





Machine Learning allows utilities to predict future customer behavior and align their decisions accordingly.



1. Customer Segmentation



https://mosaicdatascience.com

2. Customer Churn & Retention



3. Consumption Forecasting



© Mosaic Data Science

🖌 info@mosaicdatascience.com

3



### **Customer Segmentation**

#### Why this use case matters

Customers (residential, commercial, professional) all expect a certain level of service these days, thanks in large part to advancements in Machine Learning driven by the big five tech giants. If you aren't attracting highvalue customers, your competition is.

### Techniques

Unsupervised Learning - clustering

### Algorithms

K Means, Hierarchical Clustering, DBSCAN, Gaussian Mixture Models, MeanShift, Autoencoder & k-means, Deep Embedding Clustering, Deep Adaptive Clustering

### Outcome

Fortify marketing decisions with predictions on consumer buying behavior, identify which consumers bring in the most value, and optimize the marketing mix with data-derived evidence.





Dashboard that identifies high-value potential customers by zip code.



Mosaic helped a leading national residential energy supplier accomplish this.

https://mosaicdatascience.com







### Geo-Targeted Marketing

Mosaic deployed unsupervised learning to customer segmentation for a leading retail energy company.

### Industry Retail

case Unsuper on Alg Control Contro

© Mosaic Data Science

🞽 <u>info@mosaicdatascience.com</u>



### **Customer Churn & Retention**

### Why this use case matters

You work hard and spend valuable resources to acquire customers, losing them to factors that are in your control is simply unacceptable. ML not only can predict when a customer might leave but uncover why they left.

### Techniques

5

Supervised Learning - classification, customer lifetime value

#### Algorithms

Support Vector Machine (SVM), Logistics Regression, Tree-Based Models (XGBOOST, LightGBM, Random Forest), Deep Neural Networks, Bayes Networks

#### Outcome

Predicting churn not only shaves dollars off the top & bottom line, but it provides any organization with valuable insights on their consumer, which if harnessed properly can inform new product & service decisions.





Dashboard that returns churn scores by pre-identified regions.



<u>We utilized several ML</u> <u>approaches to help this retail</u> <u>energy company combat</u> <u>customer churn.</u>





Mosaic utilized different machine learning approaches to help this retail energy company combat customer churn. This case study builds off segmentation work Mosaic. performed for the same customer.

Industry Retail & Propane ction Classificat Adoption 8 Outcome Targeted Retention fforts, Less Churn, and Market Intelligence



https://mosaicdatascience.com





### **Consumption Forecasting**

### Why this use case matters

Machine learning provides an excellent avenue for predicting future energy consumption. Accurate insights can provide critical insights into variables affecting the demand, providing decisionmakers with an opportunity to address these levers. Forecasts also provide a benchmark to identify anomalous behavior, either high/low consumption, and alert managers to faults within the building.

### Techniques

Supervised Learning - demand forecasting, time-series

### Algorithms

Dynamic Linear Models (DLM), Classical Time-Series Forecasts, ARIMAX, Multilayer Perceptrons (MLP), Long Short-Term Memory (LSTM), NeuralProphet

### Outcome

Draw a complete picture of consumption drivers by isolating the effects of multiple relevant variables over time, these insights can fuel other progressive analytics goals, such as improved customer experience, workforce schedules, and maintenance operations.





Hourly consumption forecasts and actuals for five London households.



We lay out a hands-on approach to detecting consumption patterns using DLMs.





Machine Learning Mosaic data scientists collaborate with customers, digging deep into the data to inform design and deployment of custom ML tools that make a difference.

Mosaic integrates powerful Al tools into clients' existing technology stack to solve complex business challenges

Data Science White Paper

Probabilistic Electricity Consumption Forecasting

Machine learning provides an excellent avenue for predicting future energy consumption. Accurate insights can provide critical insights into variables offecting the demand, providing decision-makers with an apportunity to address these levers. Forecasts also provide a benchmark to identify anomalous behavior, either high/low consumption, and alert managers to faults within the building.

> Business Analytic Mosaic helps corporations of all shapes and sizes take advantage of their data, transforming their decision-



With an estimated 143M smart meters to hit the US & Canada, utilities need to understand & manage their load now before the size & scope of data overwhelms.



1. Inspection Automation





https://mosaicdatascience.com

**3.** Grid Balancing



© Mosaic Data Science

8

7



### Inspection Automation

### Why this use case matters

Automating & improving human tasks is the most significant promise of machine learning. Deep learning models are excellent at processing image, video, and text data, classifying what they see, and feeding these insights into custom predictions. ML insights take the guesswork out of inspection.

 $\otimes \diamond \checkmark$ 

### Techniques

8

**Computer Vision - classification** 

### Algorithms

Single-Shot Detection (SSD), Faster Regionbased Convolutional Neural Nets (FR-CNN), Mask-R CNN, ResNet50, Retinanet, YOLO, RanSaC, Filtering, Auto-Encoders

### Outcome

Utilities can feed new images into apps powered by ML and have a machine accurately tag different parts of their infrastructure, saving them valuable time and identifying components that might need to be replaced or repaired.



Mosaic designed a machine learning tool to annotate the numerous asset classes on a pole.

 $\langle \mathfrak{X} \rangle$ 



Mosaic designed and deployed a custom computer vision solution for a leading utility to automate their inspection decisions.



https://mosaicdatascience.com





Data Science Case Study Automating Utility Pole **Recognition & Inspection** with Computer Vision

Mosaic designed and deployed custom computer vision models to automate asset recognition & inform inspection decisions.





### **Asset Intelligence**

#### Why this use case matters

Keeping your grid running optimally while meeting sustainability and customer satisfaction objectives is challenging. Data generated by smart meters and other sensors can help identify anomalies in your network to automate & improve the inspection process.

### Techniques

Anomaly Detection

### Algorithms

k-nearest neighbor (k-NN), Local Outlier Factor (LOF), k-means, Support Vector Machine (SVM), Neural Network-based Detection, Isolation Forest, XGBOD (Extreme Boosting Based Outlier Detection)

### Outcome

Design and deploy robust ML solutions that empower decision-makers to monitor the grid in real-time, route appropriate resources to the correct locations, identify components that may need to be replaced or repaired, and keep customers powered up.

 $\otimes \diamond$ 



Mosaic identified a voltage anomaly and correlated it with a deteriorating transformer at tens of thousands of locations.

Mosaic developed a data-driven alerting solution powered by unsupervised learning to assist a leading energy utility in detecting voltage anomalies & informing optimal grid health decisions.





DATA SCIENCE MILLING

Data Science Case Study
Detecting Voltage Anomalies

Mosaic developed a data-driven alerting solution powered by unsupervised learning to assist a leading energy utility in detecting voltage anomalies & informing optimal grid health decisions.

Industry Itilities

Unuspervised L

Operating Cost Reduction & Outage Prevention



https://mosaicdatascience.com





## **Grid Balancing**

#### Why this use case matters

Supply and demand fluctuations are becoming more extreme and difficult to anticipate. Renewable sources, weather, and consumption patterns are all factors that make accurate projections hard to make.

### Techniques

Supervised Learning - demand forecasting/ yield forecasting, time-series

### Algorithms

Dynamic Linear Models (DLM), Classical Time-Series Forecasts, ARIMAX, Long Short-Term Memory (LSTM), DLMs, Neural-Networks, Prophet, Time Series Classification

### Outcome

Using data sources, modeling techniques, and knowledge from outside of traditional utility use cases helps energy operators balance grid frequency and achieve cost savings. For example, the integration of weather data can save utilities valuable resources in matching supply with demand.

 $\otimes \diamond \heartsuit$ 



Utilities can fortify their demand forecasts & yield decisions by integrating third-party sources such as weather.





Machine Learning Mosaic data scientists collaborate with customers, digging deep into the data to inform design and deployment of custom ML tools that make a difference.

Mosaic integrates powerful Al tools into clients' existing technology stack to solve complex business challenges

Data Science White Paper

effects in their decision making.

Fusing Weather Data into Machine Learning Predictions

Mosaic delves into how businesses can integrate weather

Mosaic helps corporations of all shapes and sizes take advantage of their data, transforming their decisionmaking engengengen

https://mosaicdatascience.com







### **Renewable Portfolio Integration**

#### Why this use case matters

Recent initiatives by leaders across all industries have brought numerous new commitments to zero carbon emission goals and an accompanying surge in the construction of wind and solar generation over the next few decades. Not surprisingly, machine learning & advanced analytics can play a prominent role in assisting utilities and their customers

with insights and recommendations on meeting these targets.



### Techniques

Mathematical Optimization

### Algorithms

Gradient Descent, RMSProp, Stochastic Forecasting, Simulation, Cross-Entropy Method, Bracketing Mosaic forecasts corporate customers' annual GHG emissions (orange line) and yearly GHG targets after implementing our green policies.

#### Outcome

Saving the world, just kidding, but kind of...integrate renewable energy sources into your existing portfolio with minimum disruptive effects to the existing customer base. ML automates & recommends optimal energy policies to current accounts, ensuring a smooth transition and reducing Greenhouse Gas emissions.



Mosaic developed an innovative optimization app for a leading energy company, helping them recommend suites of renewable energy products to meet corporate carbon footprint reduction goals within budgetary constraints.





Data Science Case Study Reducing Greenhouse Gas Emissions with Data Science

Mosaic developed an innovative optimization app for a leading energy company, helping them recommend suites of renewable energy products to meet corporate carbon footprint reduction goals within budgetary constraints.



ction in Corporate reenhouse Gas Emissions



https://mosaicdatascience.com



### **Workforce Planning**

### Why this use case matters

Optimizing seasonal staffing and resourcing is a crucial challenge for utilities, especially when the exact timing of high-volume activity can change based on complex factors. Augmenting the workforce too early means diverting profit to unnecessary personnel costs while waiting until high-volume demand is already underway, risking operating below capacity and decreasing customer satisfaction (e.g., if there are long wait times).

### Techniques

Supervised Learning – regression, classification, time-series

### Algorithms

Linear Regression, Tree-Based Models (XGBOOST, LightGBM, Random Forest), Neural Nets, ARIMAX, SARIMA, Holt-Winters, LSTM, Prophet, DeepAR, N-BEATS, Temporal Fusion Transformer

### Outcome

Predictive workforce insights allow utilities to proactively plan for peak demand events well before a spike, allowing organizations to manage their workforce to meet customer expectations while maintaining necessary slack in the schedule. Happy employees are an absolute must in a tight labor economy.





Mosaic visualized our ML outputs in this dot plot showing predicted vs. actual maintenance events that required human attention.



A utility operator in a chilly climate came to Mosaic with a request to build a model that predicts when customers will reactivate or service their heating systems.



Mosaic data scientists collaborat with customers, digging deep int the data to inform design and deployment of custom ML tools that make a difference

Artificial Intelligence Assaic integrates powerful a tools into clients' existing echnology stack to solve omplex business challenges

Data Science White Paper Workforce Planning

Prediction

Mosaic helps corporations of all shapes and sizes take advantage of their data, transforming their decisionmaking norcesses



13

https://mosaicdatascience.com





## **Repair Routing**

#### Why this use case matters

Repair scheduling optimization is possible by integrating thirdparty weather data, and grid asset prioritization into the decision process. Machine learning enables more relevant routing objectives when developing inspection and repair schedules.

### Techniques

Optimization, Supervised Learning – regression, classification

### Algorithms

Tabu search, Tree-Based Models (XGBOOST, LightGBM, Random Forest), Neural Nets, LSTM, Stochastic Forecasting, Bracketing

### Outcome

An ML-based solution can help dispatchers make better decisions about scheduling inspections and repairs to more effectively ensure grid health and prevent outages for customers. Save valuable time, money, and resources that drive operational efficiency and dollar savings.





Mosaic recommends optimal repair routes using a unique blend of machine learning & mathematical optimization expertise.



<u>Mosaic lays out</u> <u>an approach in our</u> <u>whitepaper</u>





Machine Learning Mosaic data scientists collaborat with customers, digging deep int the data to inform design and deployment of custom ML tools that make a difference.

Artificial Intelligence Mosaic integrates powerful Al tools into clients' existing technology stack to solve complex business challenges

Data Science White Paper

inspection and repair schedules.

Grid Inspection & Repair

Scheduling Optimization

prioritization into the decision process enables more relevant routing objectives when developing

> Business Analytic Mosaic helps corporations of all shapes and sizes take advantage of their data, transforming their decision-

https://mosaicdatascience.com



### Machine learning is not done in a vacuum; employing a model monitoring plan, refreshing with new data, and *using* the insights are absolutely critical to ongoing success and cost savings.

Mosaic preaches **actionable**, **scalable**, & **explainable** machine learning. It is a must to include as many utility-specific heuristics into the model. We view each engagement as an opportunity to build powerful tools custom to your data & processes.

Mosaic is keenly aware of the common ML Adoption Barriers, and we address these in several engagements.



#### ML Adoption Barrier #1 | Skills Shortage

Since 2004 we have been designing & deploying machine learning solutions that deliver value for our customers. Over 90% of clients come back to Mosaic after the first engagement, and we strive for mutually beneficial, longterm relationships.



#### ML Adoption Barrier #2 | Fear of the Unknown

Mosaic could not survive without staying on top of the latest and greatest computer vision algorithm or NLP deep learning model. Not only do we stay current with the latest trends, but we know how and when these are appropriate to deploy.



#### ML Adoption Barrier #3 | Finding a Starting Point

It is critical to start machine learning projects with the end in mind. Machine learning is not a magic wand that bakes your bread and butters your toast. It is a mathematical process of inference on a set of data and improvement on each model run.

