I chose to analyze the energy sector, with an emphasis on the use of smart meters in residents and businesses. Initially, smart meters were touted as a cost reduction for utilities, since they cut down on the cost of readers needing to drive and read each meter. As the electrical energy ecosystem has become more complex, the need to predict and plan for the availability of electrical energy has crucial for energy providers. The increased complexity is driven by deregulation in energy markets, by existing energy providers adding less-predictable energy sources (solar and wind), by new energy providers supplying wind-generated and solar-generated power, and by prosumers who add power generation capabilities to their homes and want the opportunity to sell their excess power. Smart meters are in increasing use across the world, with 2.9 million in the UK, 70 million in the US, and 96 million in China as of 2016 (per Wang, Chen, Hong, and Kang, 2018, page 1). To capture the value of smart meters, the need for big data analytics in the energy market sector is expected to grow from 2019 to 2024 at a 10% CAGR (Big Data Analytics In Energy Sector Market - Growth, Trends, And Forecast (2019 - 2024) from ResearchAndMarkets.com.

There are numerous use cases for data analytics involving smart meters. There are five different categories of users on the demand side for electrical power (some of whom sell power to others): consumers, retailers, aggregators, distribution system operators (DSOs), and data service providers. To explain the terms: consumers are residential occupants, governments, and businesses who use power. Retailers sell electrical power, but do not necessarily generate it. Aggregators bring together a number of consumers (and often prosumers – individuals who have wind or solar power generation capabilities) and purchase or sell power on behalf of their members. Distribution system operators are the companies who operate the electrical transmission infrastructure. Data service providers gather and sell smart meter data and analytics to these other groups – and to energy generators.

For consumers, the greatest usage is in load analysis. Load analysis tracks and analyzes the power usage of the user. This can help consumers manage and prioritize their power usage. Many of us are accustomed to billing statements with comparisons to last month and the same month last year in our usage and billing. Anomaly detection is a valuable feature for consumers here, determining if some appliance or piece of equipment is suddenly drawing more power, for example. Per Wang et al (page 5), anomaly detection in power consumption can be divided into probabilistic, statistical, and machine learning methods. Smart meter data is essentially a time series, so the typical time-series anomaly detection methods can be used: seasonal trend decomposition, classification and regression trees, ARIMA, and Holt-Winter seasonal method, among others. The challenge here is to optimize the anomaly detection and then communicate timely, actionable information to the consumer. Methods involving spatiotemporal correlation (what’s going on at neighboring users at the same time) can help detect anomalies in power usage, as can supervised classification methods. At this point, no particular method has been settled upon by analysts as optimal for anomaly detection (Wang, et al page 7).

For the other demand users (retailers, aggregators, DSOs, and data service providers), smart meters provide data for all three stages of analytics: descriptive, predictive, and prescriptive. Load analytics are part of the descriptive stage, as described in the previous paragraph. The predictive stage involves load profiling and load forecasting. Load profiling involves classifying consumers based upon their consumption behaviors: clustering techniques like K-means, hierarchical clustering, and self-organizing maps are used here. Load forecasting takes into account consumer attrition, power demand, and weather. The prescriptive phase of analytics is used in load management to guide capital purchases, pricing, and marketing.

One area of great challenge involves what are called prosumers. These are individuals who have invested in power generation (typically, rooftop photovoltaic systems) and storage systems and from time to time generate more power than they consumer. As electrical energy markets become more and more deregulated, these prosumers have the capability of selling their excess power in a consumer-to-consumer or peer-to-peer model. Analytics need to address this situation to help enable a rational market for this sellable power. This is more much more open-ended situation where pricing and availability are volatile and individuals and aggregators, and DSOs must find a way to agree to do business. Data analytics can have a large role in helping build a market to allow demand, supply, availability, and capacity to be understood by the participants.

References:

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