


# Utility Load Profiling

## History, Strategies & Applications

Curt D Puckett, Vice President

31 January 2023

# What is Load Research?

## Simply put, the foundation for interval load analytics…

**By Definition**

An activity embracing the measurement and study of the characteristics of electric loads to provide a thorough & reliable knowledge of trends, and general behavior of the load characteristics of the customers serviced by the electrical industry

**In Practice**

Load Research allows utilities to study the ways their customers use electricity, gas, and water, either in total or by individual end uses

**Mission**

Builds the foundation allowing the corporation to leverage knowledge of customer usage patterns to enhance or protect shareholder value

AEIC – The Association of Edison Illuminating Companies – Load Research

Load Research & Analytics Committee

Load Research and Analytics - AEIC

# Load Research – A Look at our Past

history

Curt Puckett and Craig Williamson

## utility load research

*a look at our past*

UTILITIES STUDY HOW THEIR customers use electricity across time through load research. The outcomes of load research play an important role in cost-of-service studies and rate design as well as many other activities, such as transformer sizing, demand-side management, load settlement, load forecasting, and distribution and resource planning. Despite its existence for nearly a century, load research is not a well-known subject in the power engineering community. Here, we discuss the history of load research and its current practice and applications. In another article in this issue of *IEEE Power & Energy Magazine*, "Utility Load Research: The Future of Load Research Is Now," we provide a look into the future of load research as utilities increase their interval load data-collection capabilities through the use of automated metering infrastructure (AMI).

Load research allows utilities to examine their customers' use of electricity, either in total or by individual end uses, and requires numerous disciplines including engineering, statistics, computer programming, and marketing. In this issue's "History" column, we examine utility load research, with a look at the past from the first days of load research in the 1930s up to the rapidly advancing future with automated metering infrastructure.

We welcome Curt Puckett and Craig Williamson, both with DNV GL, to these "History" pages of *IEEE Power & Electronics Magazine*.

John Paserba
Associate Editor, "History"

**Association of Edison Illuminating Companies Load Research Committee**

Load research got its start in the United States in the late 1930s as a way to better understand electric customers and their contribution to an ever-expanding base and unprecedented growth. Interestingly, the Association of Edison Illuminating Companies (AEIC) has had a Special Committee on Load Studies dating back to 1938. Table 1 lists those who were members of this committee from

table 1. The members of the AEIC Special Committee on Load Studies (1938–1943).

- S.W. Andrews, American Gas and Electric Service Corporation
- W.E. Barbour Jr., Boston Edison Company
- C.W. Bary, chairman, Philadelphia Electric Company
- A.D. Caskey, Public Service of Northern Illinois
- H.A. Enos, American Gas and Electric Service Corporation
- E.J. Fowler, Commonwealth Edison Company
- J.R. Gardner, Central Hudson Gas and Electric Corporation
- R.E. Ginna, Rochester Gas and Electric Corporation
- H.L. Harrington, Niagara Hudson Power Corporation
- L.V. Nelson, Union Electric Company
- E.H. Schmidtman, Wisconsin Electric Power Company
- H.A. Snow, Detroit Edison Company
- E.T. Steel, Potomac Electric Power Company
- A.H. Sweetnam, Boston Edison Company
- F.M. Terry, Consolidated Edison of New York
- C.M. Turner, Ebasco Services
- W.R. Waggoner, Commonwealth and Southern Corporation
- R.R. Hermann, correspondent member, Northern States Power Company

Digital Object Identifier 10.1109/MPE.2020.2973845
Date of current version: 17 April 2020





https://ieeexplore.ieee.org/document/9069973

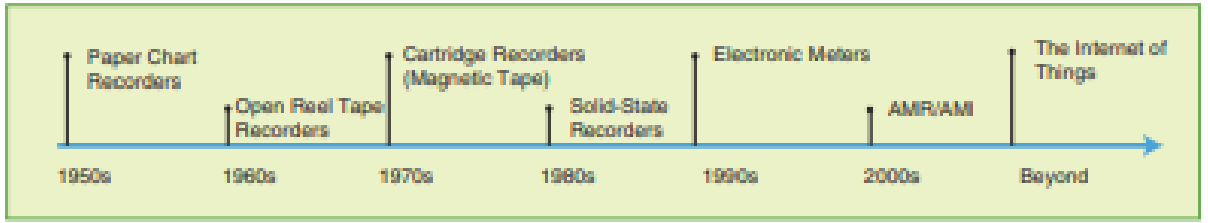
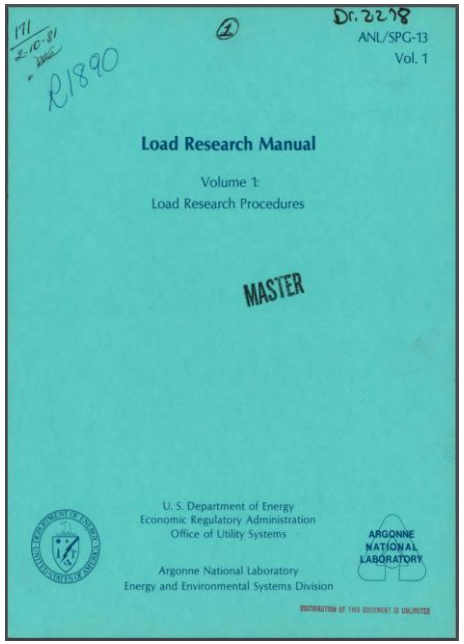
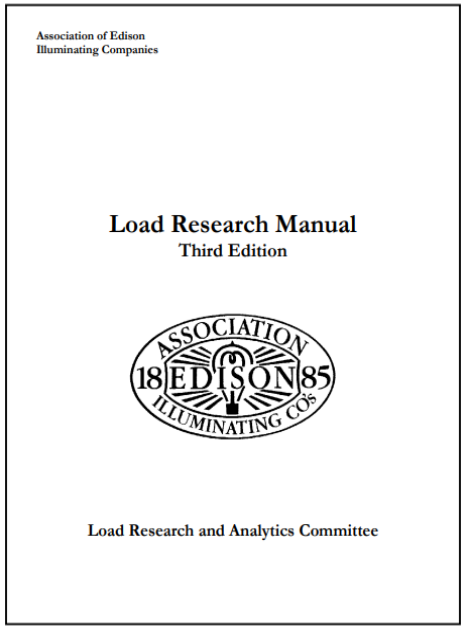



figure 1. The evolution of metering technologies since the 1950s. AMR: automatic meter reading.




AEIC

Load Research Manual

First Published

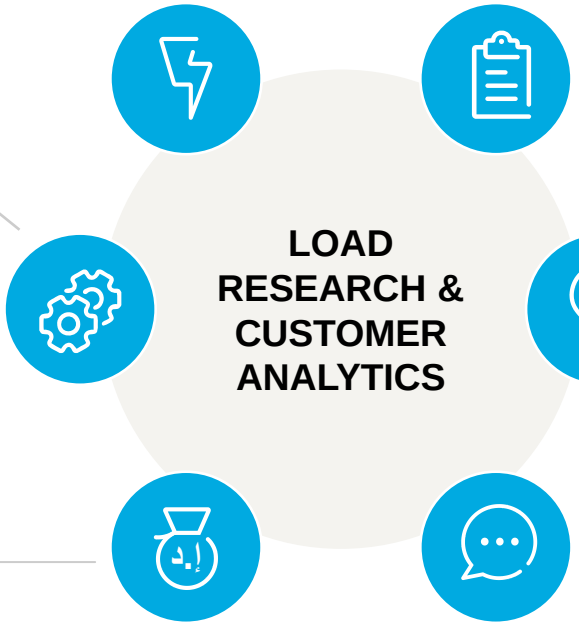
November 1980

Latest Update

3rd Edition

August 2017

# Supports Many Functions within a Utility




## ELECTRIC CHOICE

- Load Profiling
- Settlement
- Evaluation

## DISTRIBUTION PLANNING

- Substation Load Analysis
- Transformer sizing
- Load management
- Loss Studies
- Circuit Load Studies

## GENERATION PLANNING

- Forecasting
- Model Development
- Load Duration Curves
- Net System Output Analysis
- Capacity Planning

## MARKETING

- DR performance
- Contribution/Impacts on Peak
- Demographics Studies
- End-Use Load Studies
- Market Targeting & Segmentation
- Major Account Analysis
- Customer Analytics

## RATES/PRICING

- 8,760 Class Demand Studies
- Allocation schedules
- Sample Design & Management
- Billing Determinants
- Class & System Peak Analysis
- Major Account Demand Analysis

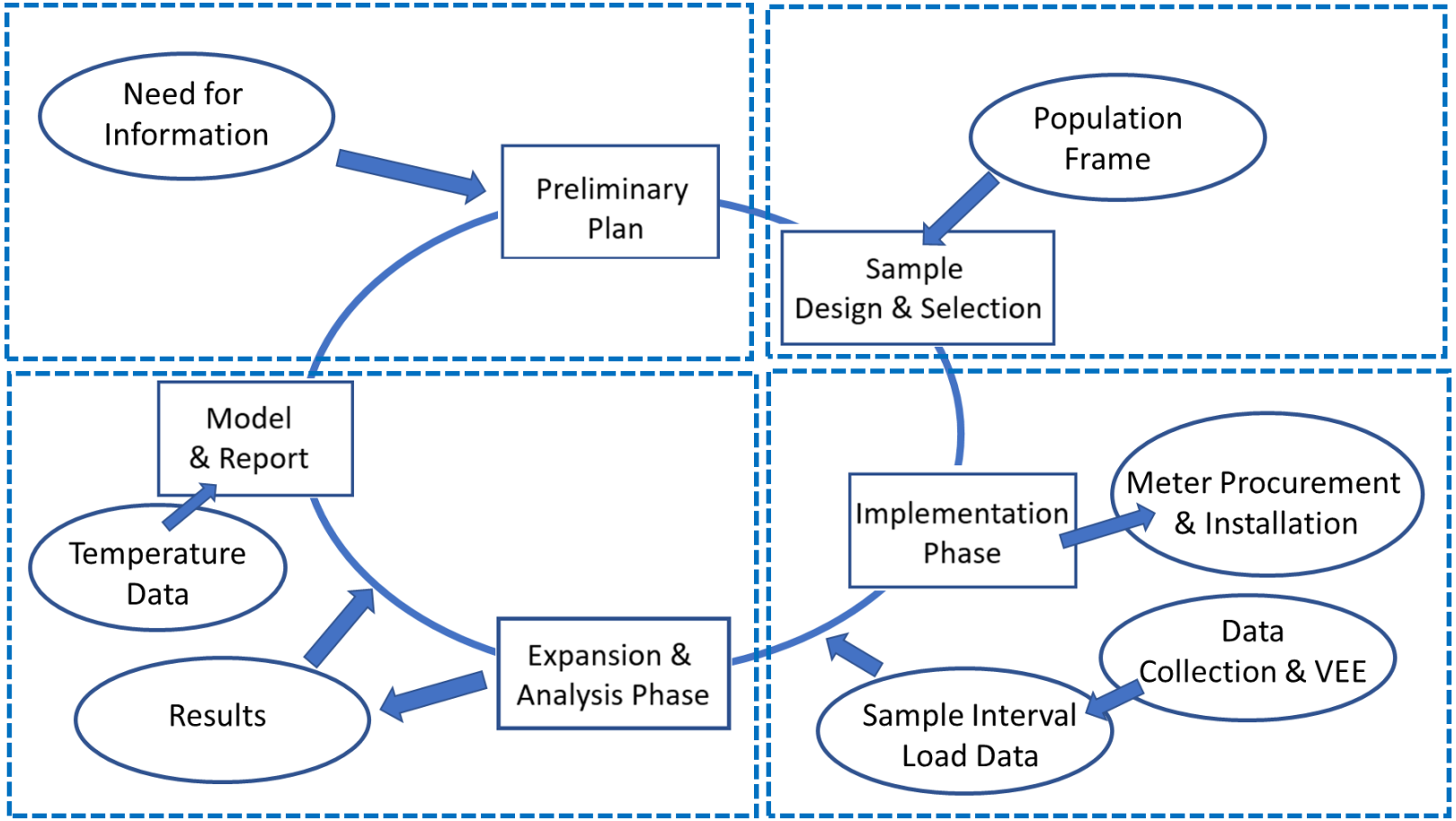
## OTHER

- Demand Side Management
- Distributed Renewables
- Electric Mobility
- Micro Grids / Smart City
- Product Development
- Weather Normalization

Most Public Services Commissions require that rate case Cost-of-Service studies are based on Load Research demand allocations - $165B of investment allocated using Load Research

# The Load Research Life Cycle

Conventional Metering: 18-24 Month Cycle




AMI Metering: 18-24 Day Cycle

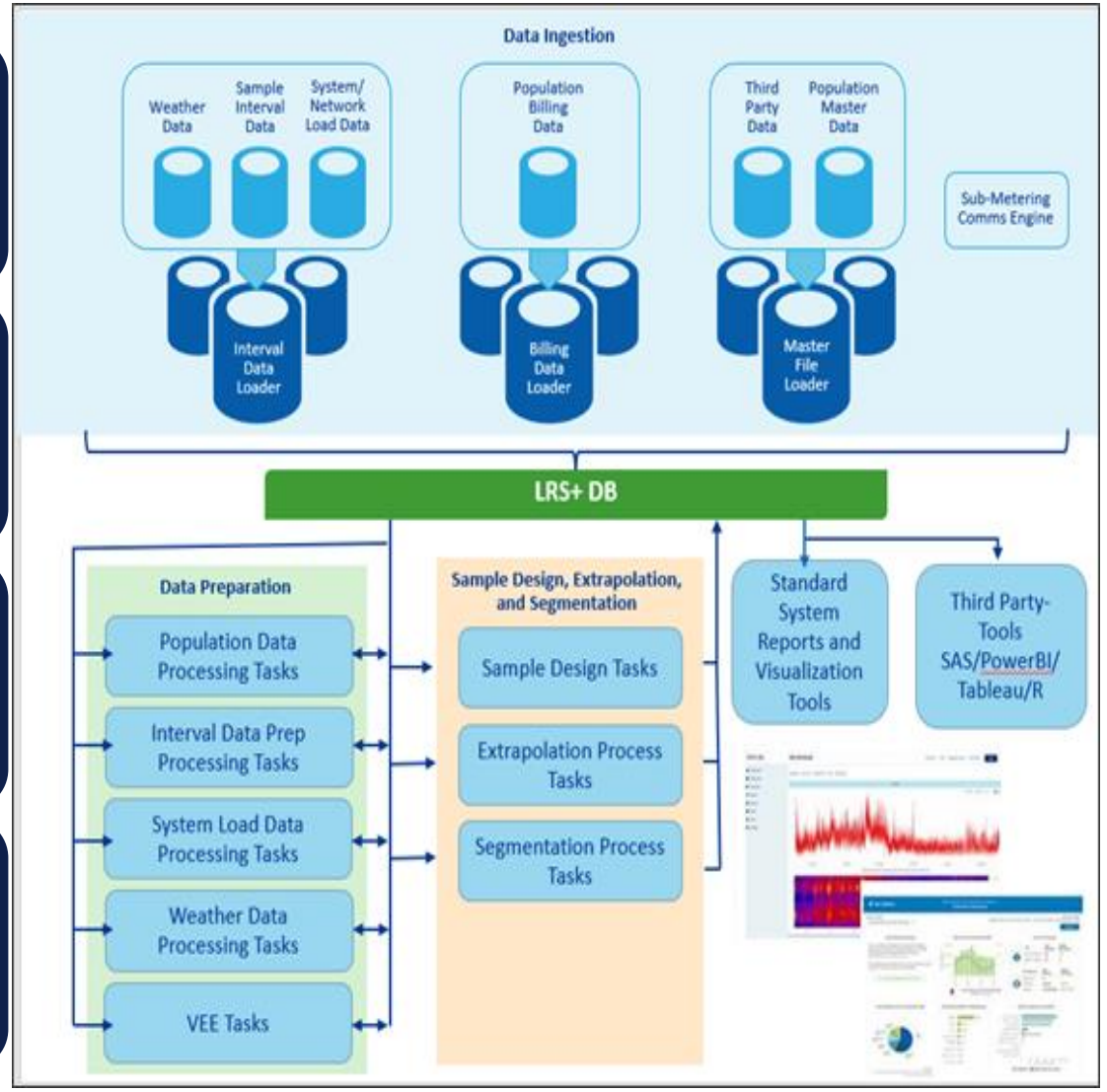
# DNV Interval Load Analytics

DNV's Load Research System has been at the forefront of interval load analytics for decades providing comprehensive sample design, statistical analysis and reporting capabilities…

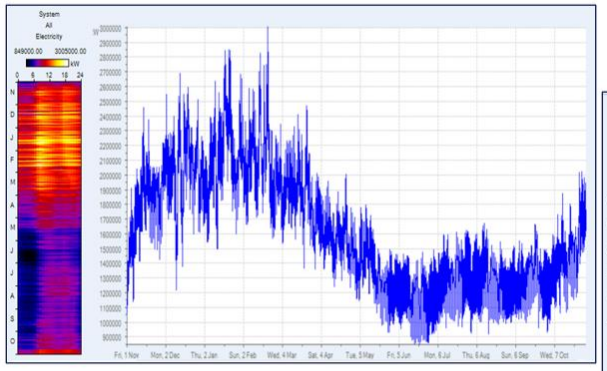
DNV's new SQL based platform was built to serve the new world of AMI load analytics by providing low-cost, highly responsive load analytical services on large data streams including advanced validation, editing and estimation algorithms to ensure the integrity of the data and analytical results…

DNV's decades of interval load analytics experience and deep analytical bench can be leveraged for on-going analytical support including rate case review and testimony…

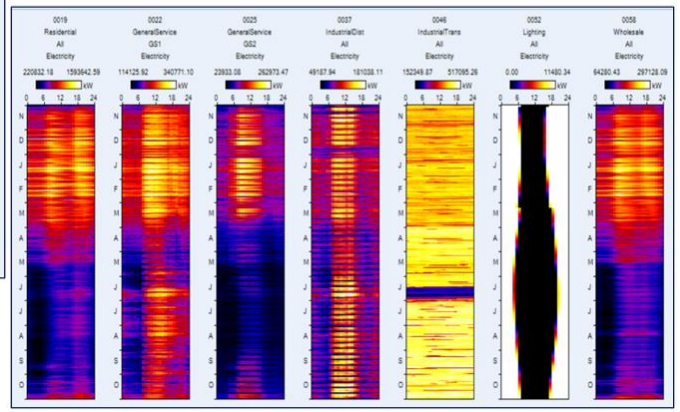
DNV trainers can provide training on sampling, analysis, use case development, and software applications



# Breaking Down the System Load (Peeling Back the Onion)



Class Load Estimation





DNV

# Our Bread & Butter: Cost of Service, Cost Allocation & Rate Design

**1. Gather and Assemble Study Data**
- Financial, system, customer, billing, load data

**2. Analyze Electric System**
- Types of generation, voltage levels, dedicated facilities

**3. Functionalize Electrical Plant Investment**
- Generation
- Transmission (> 115 kV)
- Sub-transmission (33 – 66 kV & Radial Transmission Lines)
- Distribution plant
- Customer service

**4. Functionalize Operating Expenses**
- Finance expense (incl. capital tax and rate of return)
- Depreciation expense
- Operating/maintenance costs

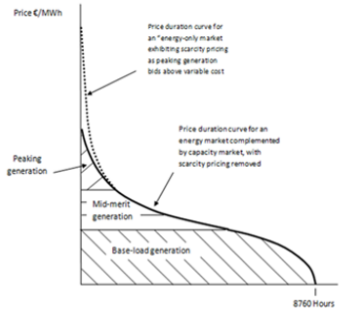
**5. Classification of Operating Costs to Cost Components**
- Fixed Costs, usually based on Coincident Demand(s) – consumption at a specific point in time and the maximum size needed to serve that demand (expressed as kW or MW)
- Variable Costs, usually based on Energy – consumption over a period of time (kWh)
- Customer Costs

**6. Allocate Expenses to Customer Classes**
- Allocations based on classified costs

**7. Identify Revenues by Customer Class**
- Residential, Commercial, Govt, Industrial

**8. Determine Revenue Adjustments**
- Revenue Cost Coverage by customer class
- Cost components of classified costs

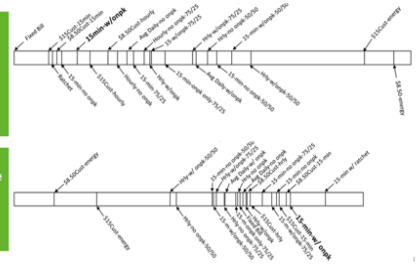
- Load Research/Interval Load Data provides the basis for developing time-of-use (TOU) responsibilities and classifications and demand rates
- Investigating structural winners and losers given a particular rate design
- Estimation of total billing determinants when not already available (i.e. demand rates, TOU rates)




| Description | Annual | Month1 | Month2 | Month3 |
|---|---|---|---|---|
| | | 2017 | 2017 | 2017 |
| | | 3 | 4 | 5 |
| Accounts in Population | 1,681 | 1,681 | 1,681 | 1,681 |
| Total Energy Use | 42,441,209 | 3,158,195 | 2,586,269 | 2,894,806 |
| Energy Use per Account | 25,248 | 1,879 | 1,539 | 1,722 |
| Number of Days | 365 | 31 | 30 | 31 |
| Minimum Number of Accounts in Sample with Valid Data | 1,633 | 1,633 | 1,633 | 1,633 |
| Maximum Number of Accounts in Sample with Valid Data | 1,633 | 1,633 | 1,633 | 1,633 |
| Day of System Peak Demand | 1/18/2018 | 3/16/2017 | 4/29/2017 | 5/19/2017 |
| Hour of System Peak Demand | 8 | 8 | 16 | 17 |
| Total Energy Use | 42,441,209 | 3,158,195 | 2,586,269 | 2,894,806 |
| Total Demand at System Peak Hour | 15,174 | 10,664 | 7,056 | 7,702 |
| Error Bound for Total Demand | 6.25 | 5.05 | 3.31 | 3.36 |
| Energy Use per Account | 25,248 | 1,879 | 1,539 | 1,722 |
| Demand per Account at System Peak Hour | 9.03 | 6.34 | 4.20 | 4.58 |
| Error Bound for Demand per Account | 0.00 | 0.00 | 0.00 | 0.00 |
| Relative Precision of Demand at System Peak | 0.04% | 0.05% | 0.05% | 0.04% |
| Number of Days | 365 | 31 | 30 | 31 |
| Load Factor at System Peak | 0.32 | 0.40 | 0.51 | 0.51 |
| Error Ratio | 0.45 | 0.50 | 0.48 | 0.38 |

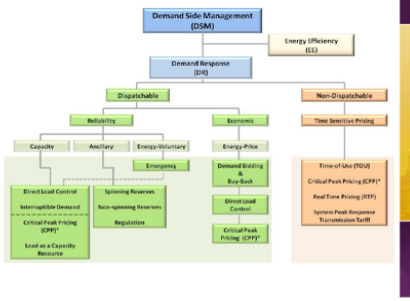
**Revenue Stability**

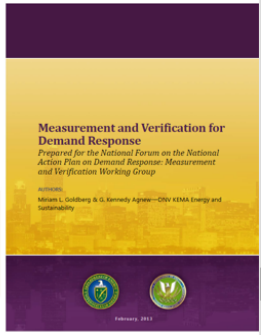
**Customer Acceptance**

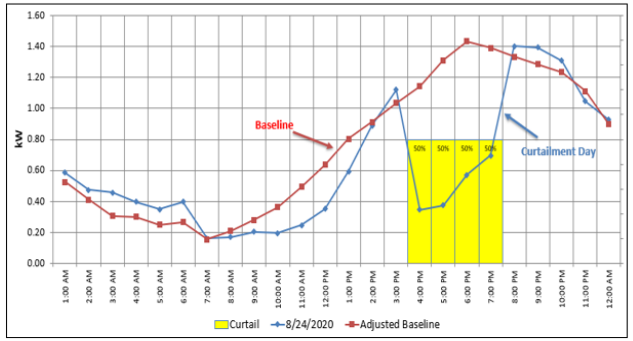


# Demand Response Impact Analysis

- Estimating the load that would have occurred absent the call for curtailment (unknown) and compare that to the load that was observed (known) is *an interesting **statistical modeling** challenge!*
  - *Settlement:* Measuring and reporting the load reductions of an individual participant
  - *Program Evaluation:* Measuring and reporting the load reduction of all participants taken together
- Impact evaluation is all about *Baselines!*



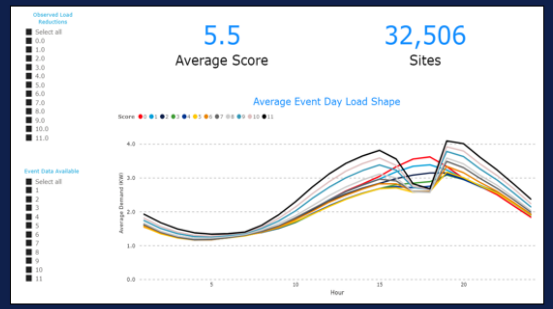



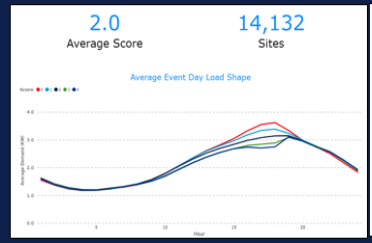


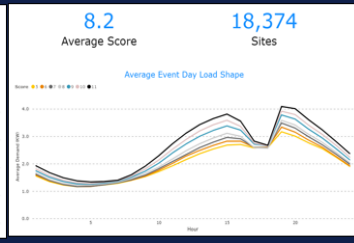

DNV

# Identification of Underperforming DR Assets (Client Project)

- Using AMI Data
  - Create simple algorithm to exam each event day for each participant
  - Compare pre/event/post performance
  - Score the participants based on their event day performance
  - Examine the aggregate load curves for each "scored" event
  - Geographically map all participants considered underperforming, e.g., event score <5 to see if there is a systematic reason



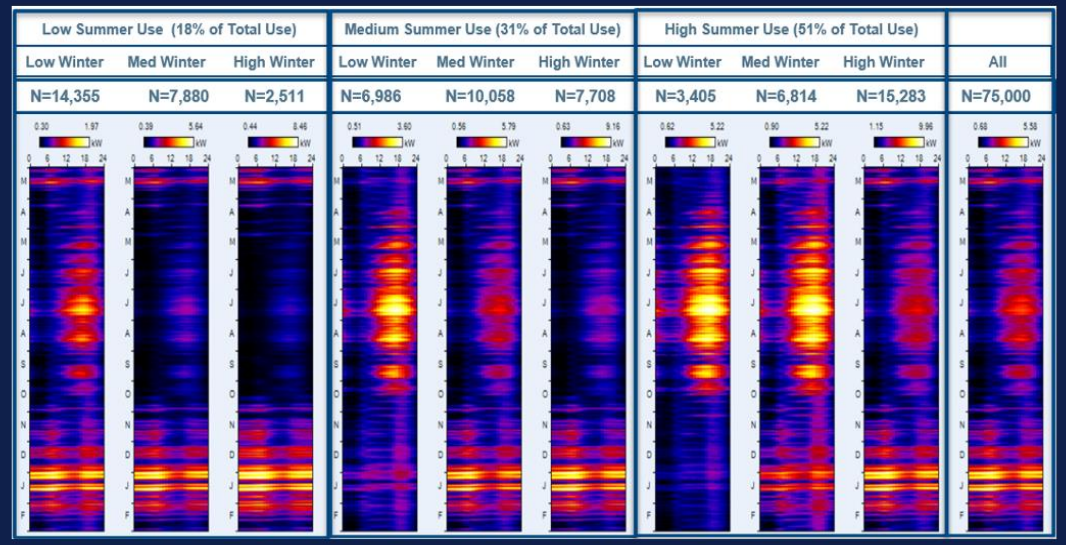





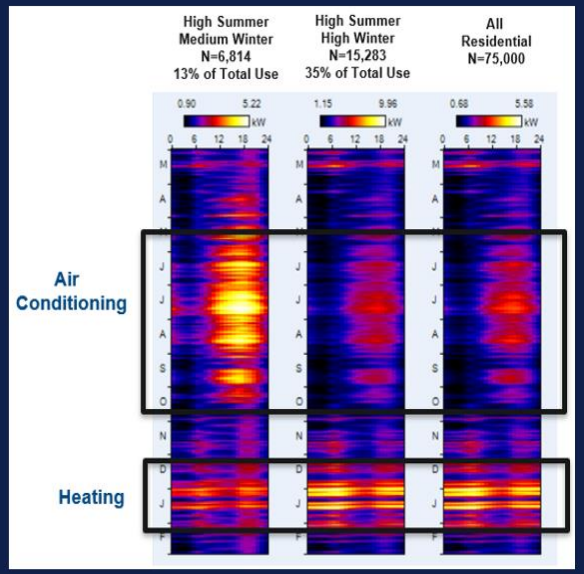

DNV

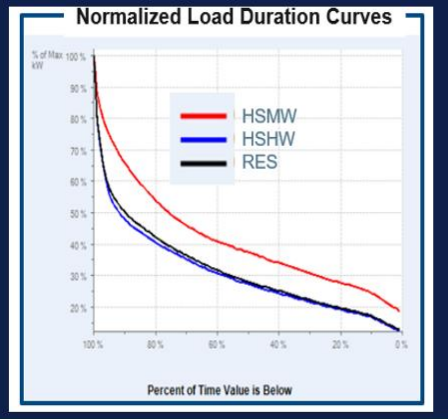
# Customer Segmentations
(Client Project – Based on Billing Determinants)






# Customer Targeting (Electric HVAC Customers)



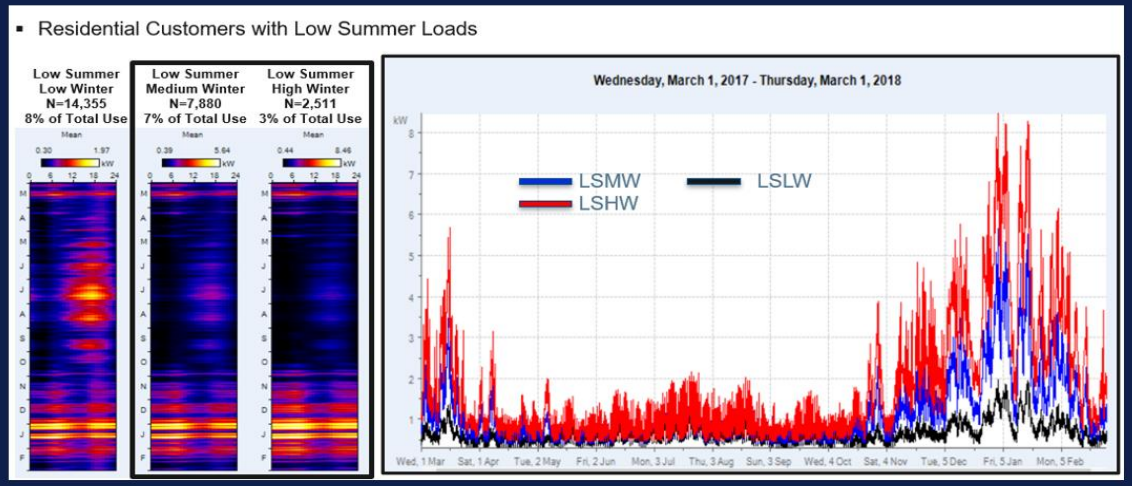




*Residential high winter load customers have a poorer load factor than their medium winter counterparts…this is an indication that they likely have a higher cost-to-serve*



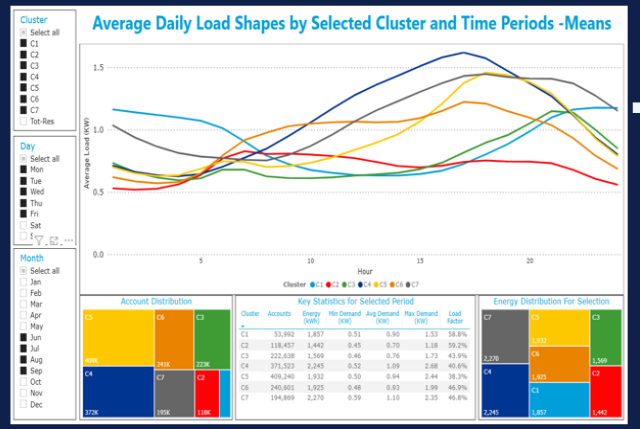
# Customer Targeting (Customers w/o A/C)

- Residential Customers with Low Summer Loads

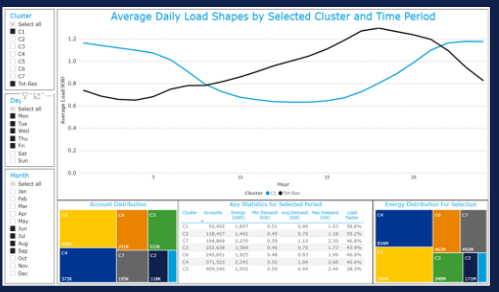





# Clustering (Client Project – Based on Average Summer Weekday)

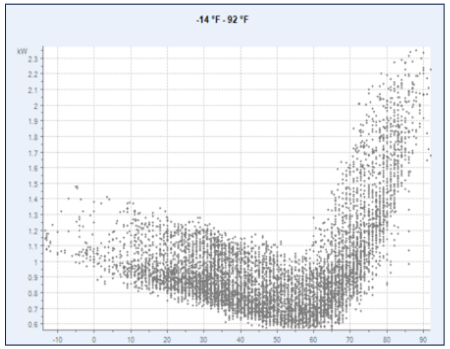


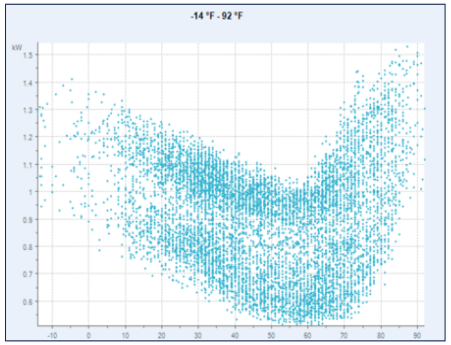

Identifying DER Assets



# Weather Sensitivity
## (PRISM-Like Analysis)

- Disaggregate monthly, daily, or hourly load based on a base load, cooling sensitive component and a heating sensitive component
- Models can be organized by day of week or other relevant attribute
- Fit models to the three segments then consider creating k-means clusters based on the resulting coefficients, e.g., base, heating slope, and cooling slope





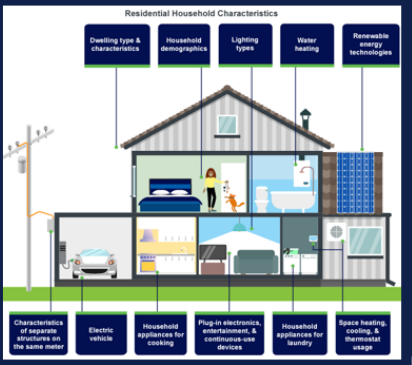

# Distribution Predictive Maintenance

- A visualization that allows users to identify potentially failing distribution assets (transformers, feeders, circuit breakers, surge arrestors, etc.)
- Helps address the issue quickly and possibly prevent equipment failure and/or extend the life of expensive equipment
- Quickly identify meter maintenance issues and provide insight to anticipated meter failures
- Reconcile anomalies with meter outages through machine learning to ensure meters are working and recording use accurately



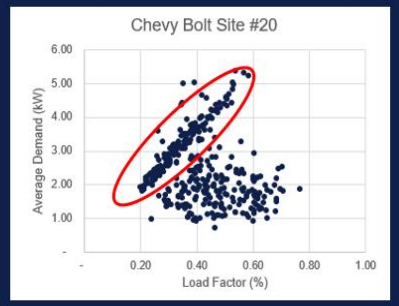
# End-Use Load Estimation

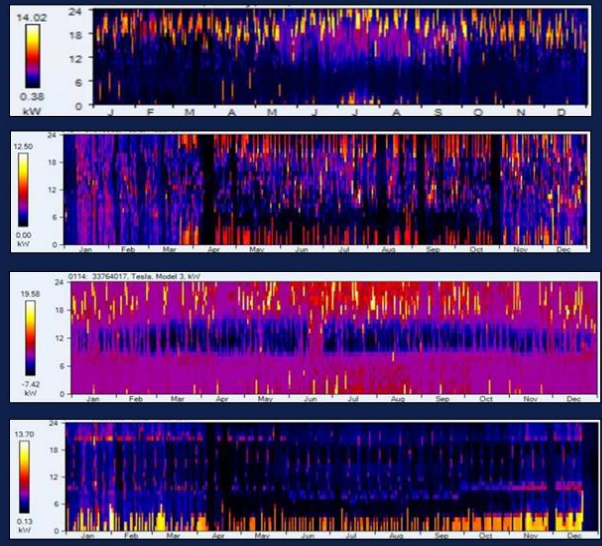
- Demographic survey paired with AMI whole facility load data provide statistical estimates of end-use energy shares and proxy end-use load profiles




# Identification of EV Loads (AI/ML – WIP)

- EV Charge At Home Identification
  - Level 1 Charging – Difficult to isolate
  - Level 2 Charging – Can be evident in total load
- Data Reduction & Patter Recognition Strategies
  - Isolate Daily Load Impacts Average & Maximum Demands versus Load Factor






# Carbon Calculator

- Track carbon performance of various customer classifications
- Track based on cost & rates analysis
- Track based on arbitrary load shape analysis, e.g., clustering




# Renewable Program Integration

- Create visualizations that plots distributed energy resources (DER) assets and their load profiles for an LPC's service territory
- Enhances/improves system forecasting and, eventually, proactive integrated resource planning
- Improves interconnection study processes.

# Thank You

Curt D Puckett

curt.puckett@dnv.com

+1-517-898-7078

**www.dnv.com**