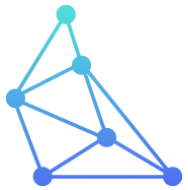
Forecasting Loads and Distributed Energy Resources

PUC peer-sharing webinars on integrated distribution system planning - Hosted by NARUC, Berkeley Lab and PNNL

20 March 2023



TELOS ENERGY

Sean Morash

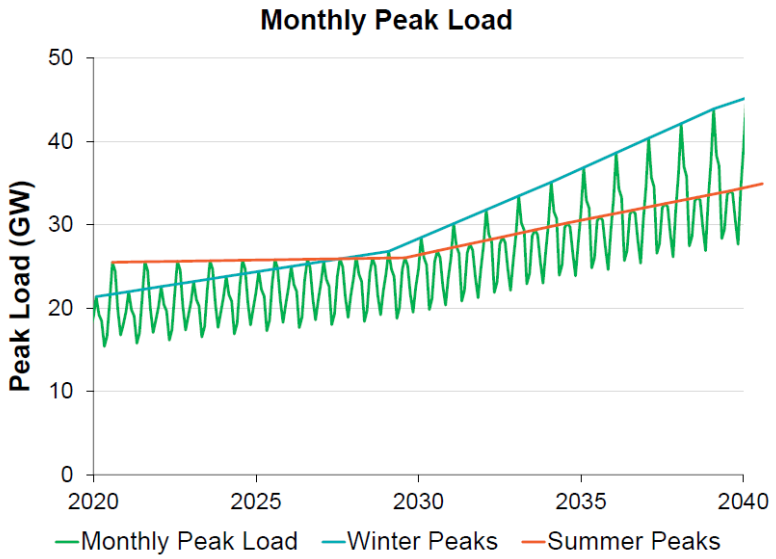
sean.morash@telos.energy

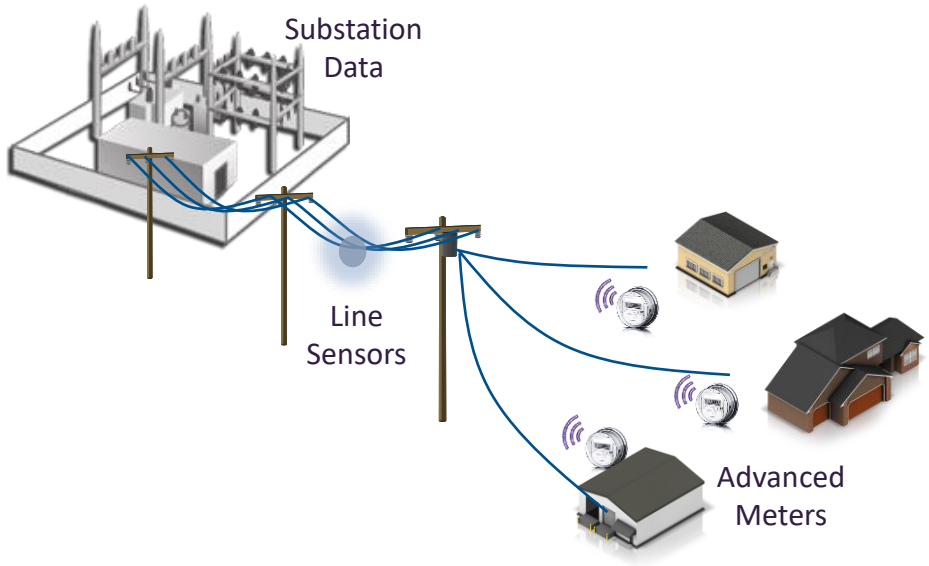
Overview

- Set the stage
- Why forecasting matters
- Some in-practice examples
- Forecasting in the context of scenarios

IDP Forecasting

Incorporate high-level projections, granular data, and local knowledge





METRO NEWS

Mayor Frank Jackson unveils $15 million development as first project in his plan for revitalizing struggling neighborhoods

Updated Mar 29, 2018; Posted Mar 28, 2018

Cleveland Mayor Frank Jackson unveiled details Wednesday for his plan to revitalize struggling city neighborhoods. This rendering shows a building planned for East 105th Street in Glenville that will have shops at street level and apartments in upper floors. The hope is this project will spark other development in the neighborhood. (City of Cleveland)

Source:
Pathways Study, Evaluation of Pathways to a Future Grid (ISO-NE Pathways Study)
https://www.iso-ne.com/static-assets/documents/2022/02/pathways-study-report.pdf
https://www.cleveland.com/metro/index.ssf/2018/03/mayor_frank_jackson_unveils_15.html

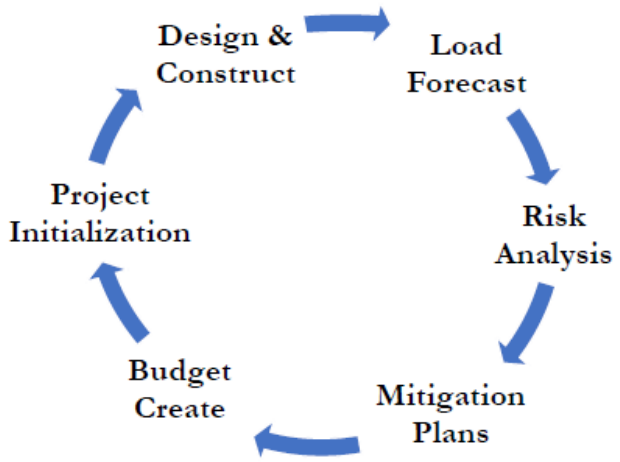
Forecasting: First Step in D-Planning Process

Annual Distribution Planning Process

Most utilities have a roughly annual process to assess the entirety of their distribution system.

The process starts with assessing past performance and incorporating load forecasts to determine risks, plans, and ultimately construct projects.

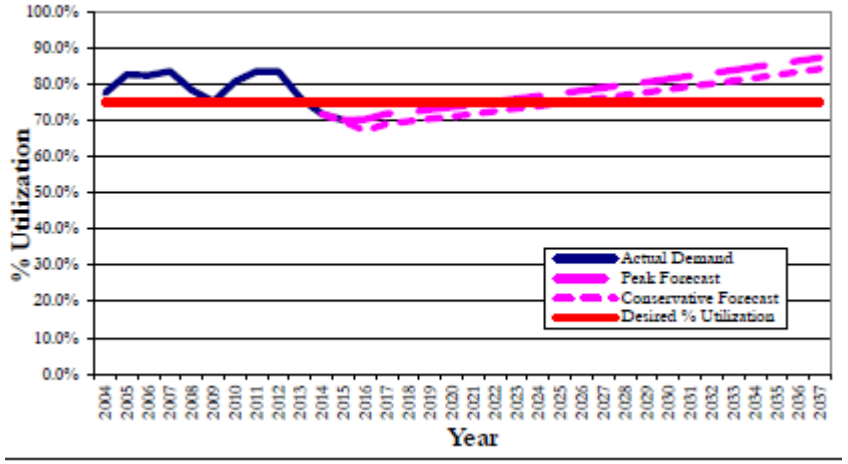
Figure 1: Annual Distribution Planning Process



Capacity Utilization

Distribution planners are historically most concerned with peak demand on infrastructure.

To maintain system flexibility and provide time for construction, many utilities have design standards that prompt more thorough analysis once the peak loading crosses a certain threshold.



Equipment Overloads

When equipment is overloaded, it may fail.

The overload is contextualized, and risk is assessed with respect to costs of mitigation plans.

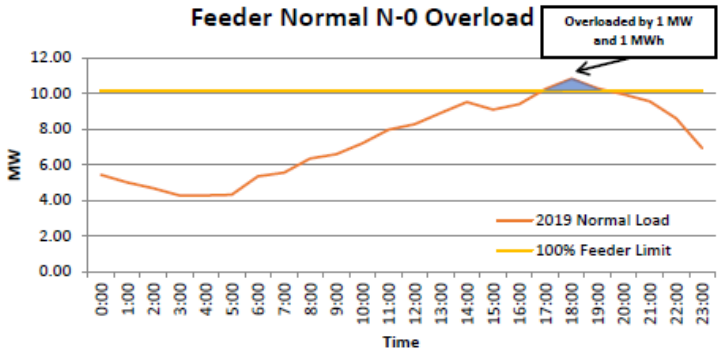
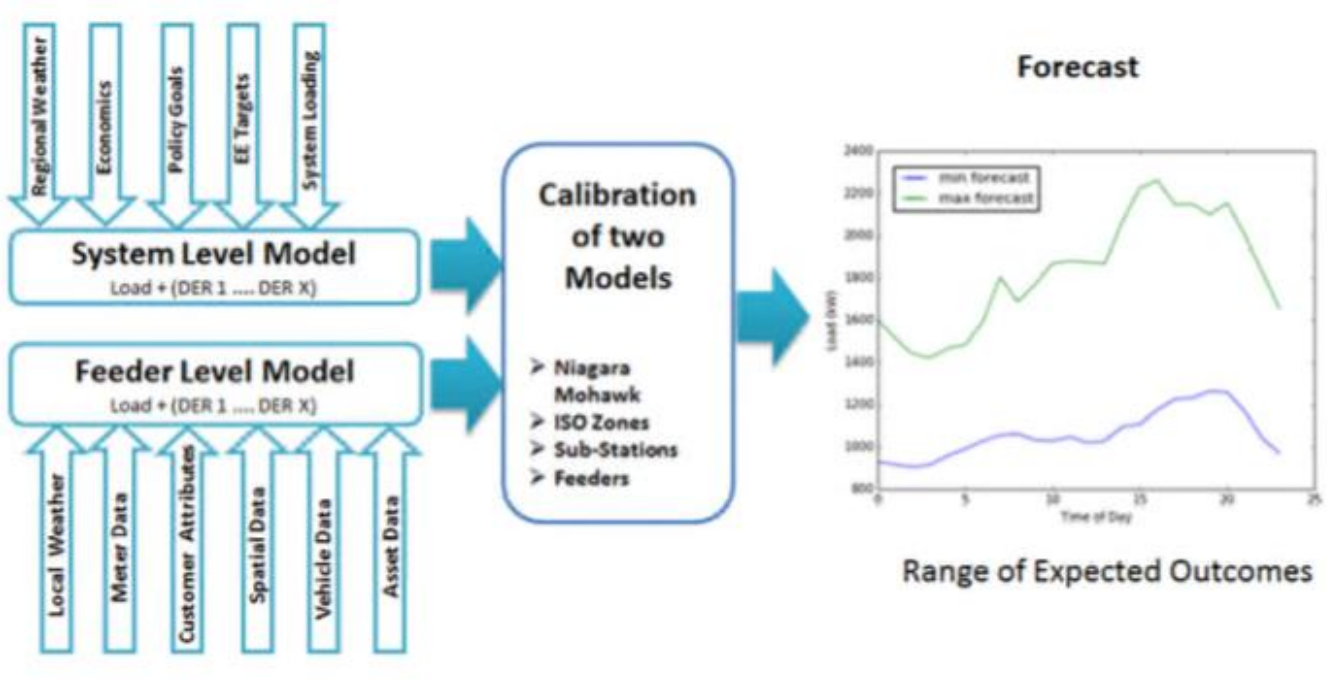


Image Sources:
Xcel Energy 2021 IDP, filed Nov 1, 2021 – MN PUC Docket 21-694

National Grid Example:

Make forecasts spatially granular

- In 2017, created hourly forecasts for each substation and each feeder
- Calibrated with actual peak load for each feeder
- Developed hourly customer load profiles for feeder model
- Used this as an input into distribution planning tool

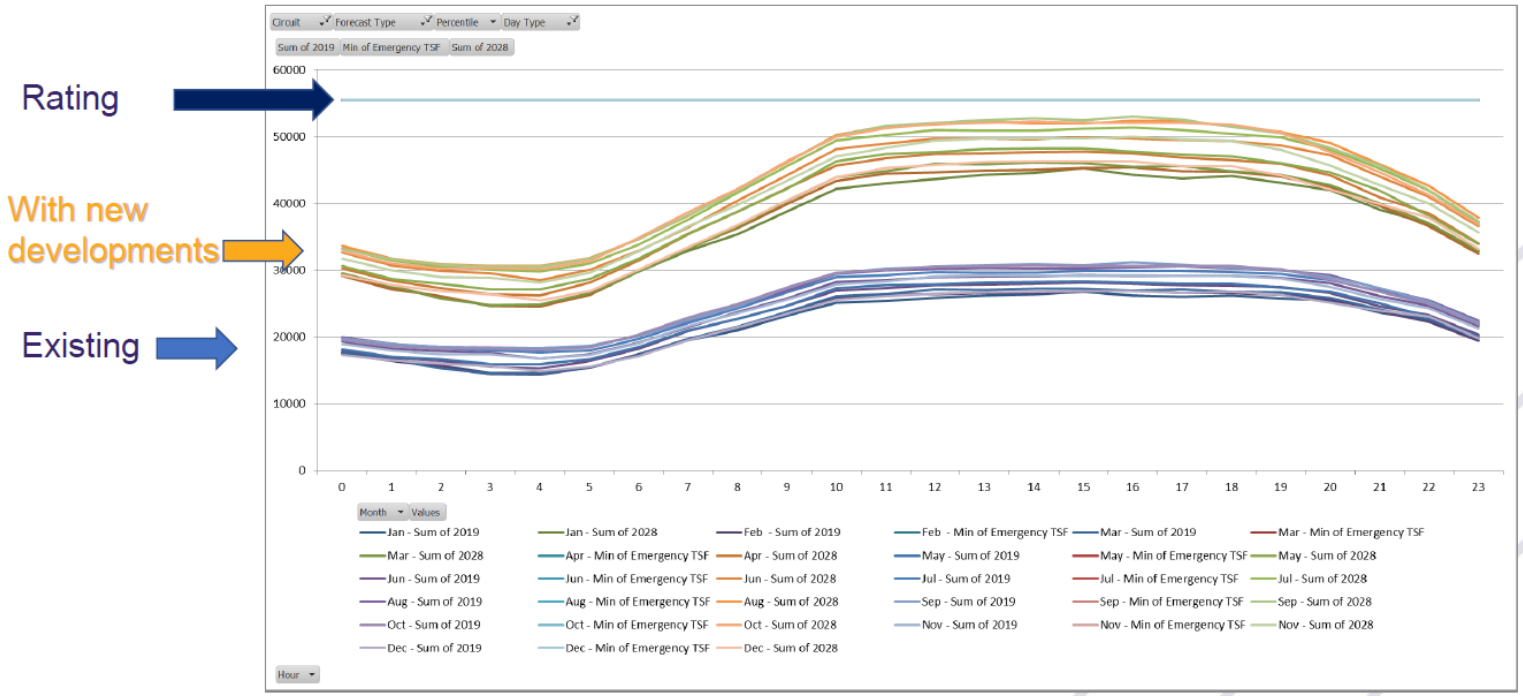


Sources:
Niagara Mohawk Power Company, Distributed System Implementation Plan Update, July 31, 2018

Hawaiian Electric Example:

Building profile for new developments

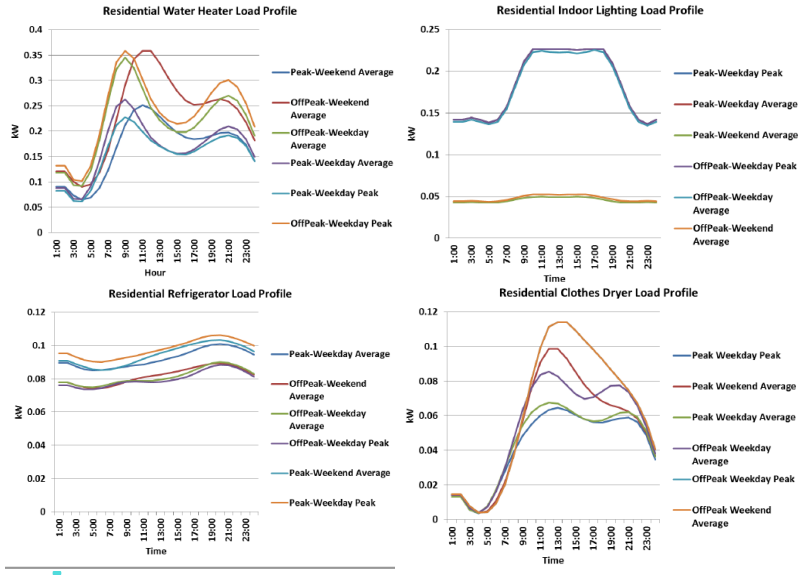
- Software tool incorporates load forecast profiles that include:
  - DER program shapes
  - EV forecasts
  - Economic variables
- Assesses impact of new developments based on their actual profile, rather than simply added to existing peak

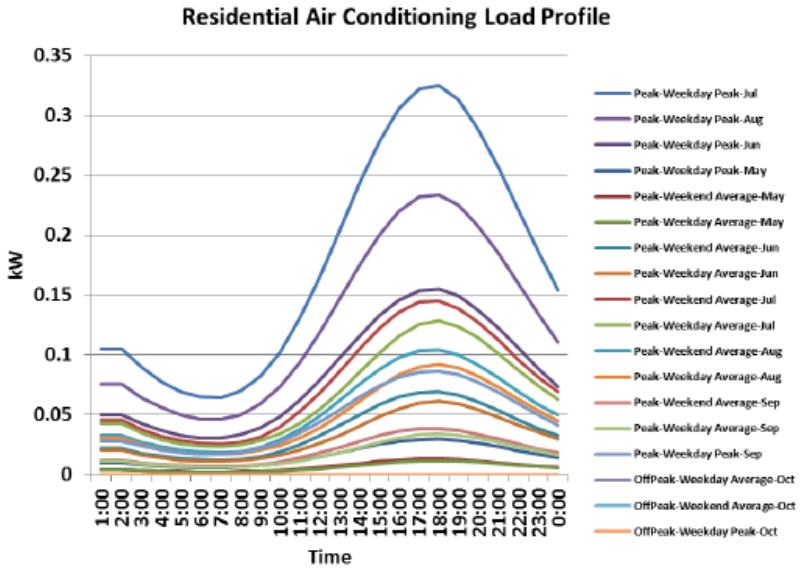


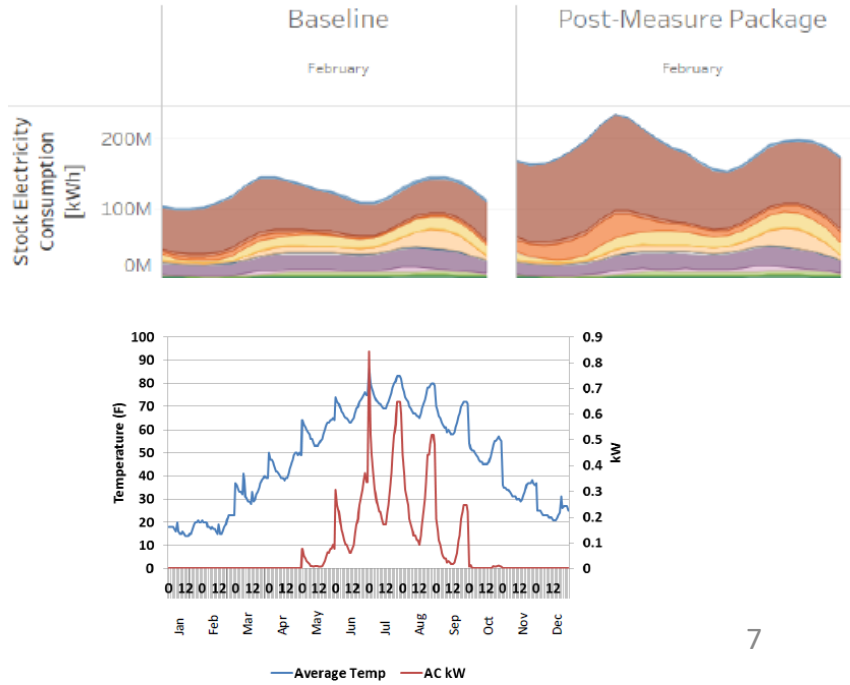
Sources:
Hawaiian Electric IGP Distribution Planning & Grid Services Working Group Documents:
https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20191204_dpwg_meeting_presentation_materials.pdf

End Use Profiles

- The overall load can be taken apart (disaggregated) to identify trends in individual end uses, such as understanding how air conditioning use (and therefore load) varies with respect to temperature.
- Disaggregation allows for assessment of the impact of energy efficiency, electrification, and climate change on load profiles.





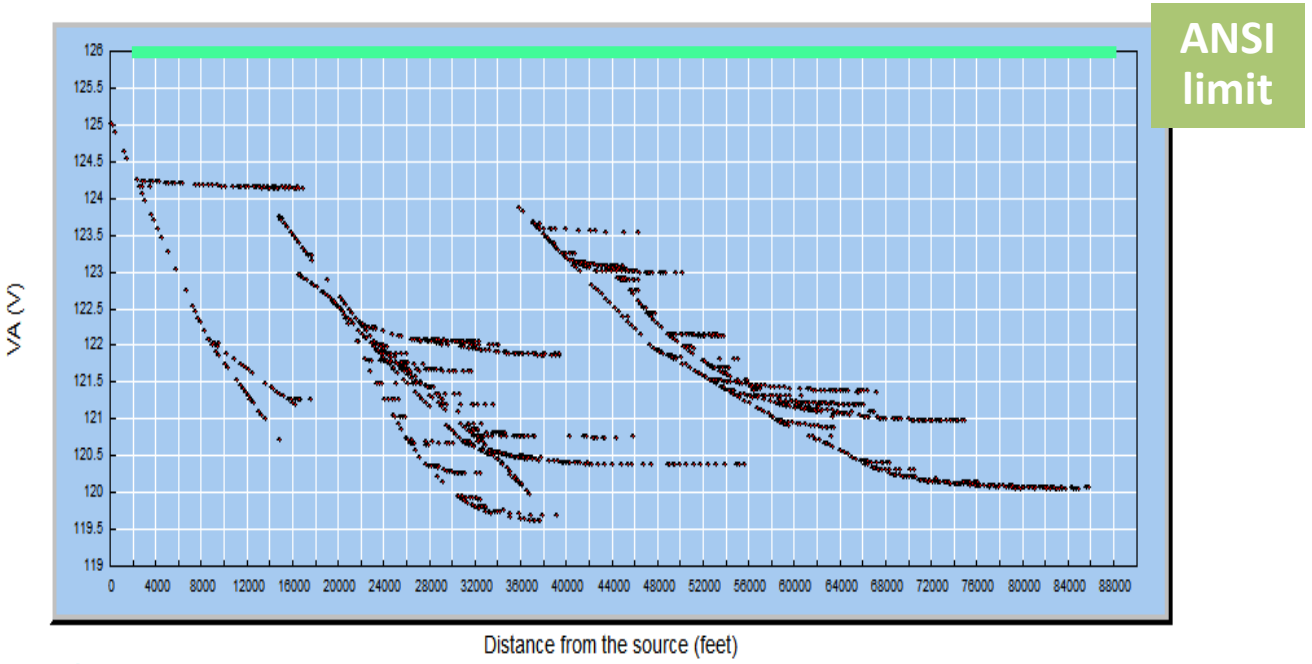


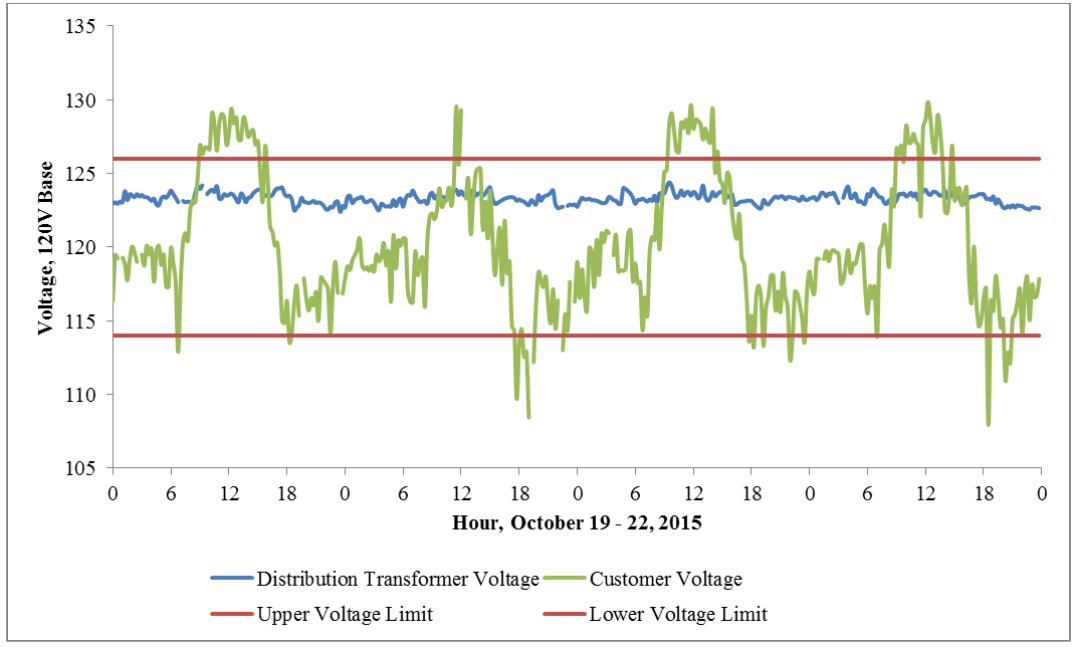
TELOS ENERGY

Sources:
2022 NREL End Use Profiles: https://www.nrel.gov/buildings/end-use-load-profiles.html
Minnesota TRM Load Profile Memo: https://mn.gov/commerce-stat/pdfs/mn-load-profile-memo.pdf

Location Also Matters

- To this point, the work has focused on identifying substation loading challenges, but additional challenges exist throughout the distribution system.
  - System conditions can vary along the length of a distribution line.
  - System conditions vary by time of day based on both load, PV and other DERs.
- Made more complicated by distributed generation that can make it difficult to "see" these conditions.





Sources:
DSTAR, http://www.dstar.org/research/project/103/P15-6-impact-and-practical-limits-of-pv-penetration-on-distribution-feeders
Hawaiian Electric Companies, Modernizing Hawai'i's Grid For Our Customers | August 2017

Use Locational and Probabilistic Analysis

- Recently, significant capabilities have been developed in the research community that provide locational and probabilistic forecasting for use in Integrated Distribution Planning.
- These analyses attempt to quantify:
  - What type of DER appear
  - Where DER will appear
  - When DER will come online
  - When (time of day / seasonality) DER can assist grid needs
- As granularity increases, so does uncertainty

FIGURE 3.3
MAP OF RESIDENTIAL AND COMMERCIAL DER ADOPTION FORECAST FOR SECTION OF SMUD TERRITORY, WITH EXAMPLE HOURLY DER PROFILES SHOWN

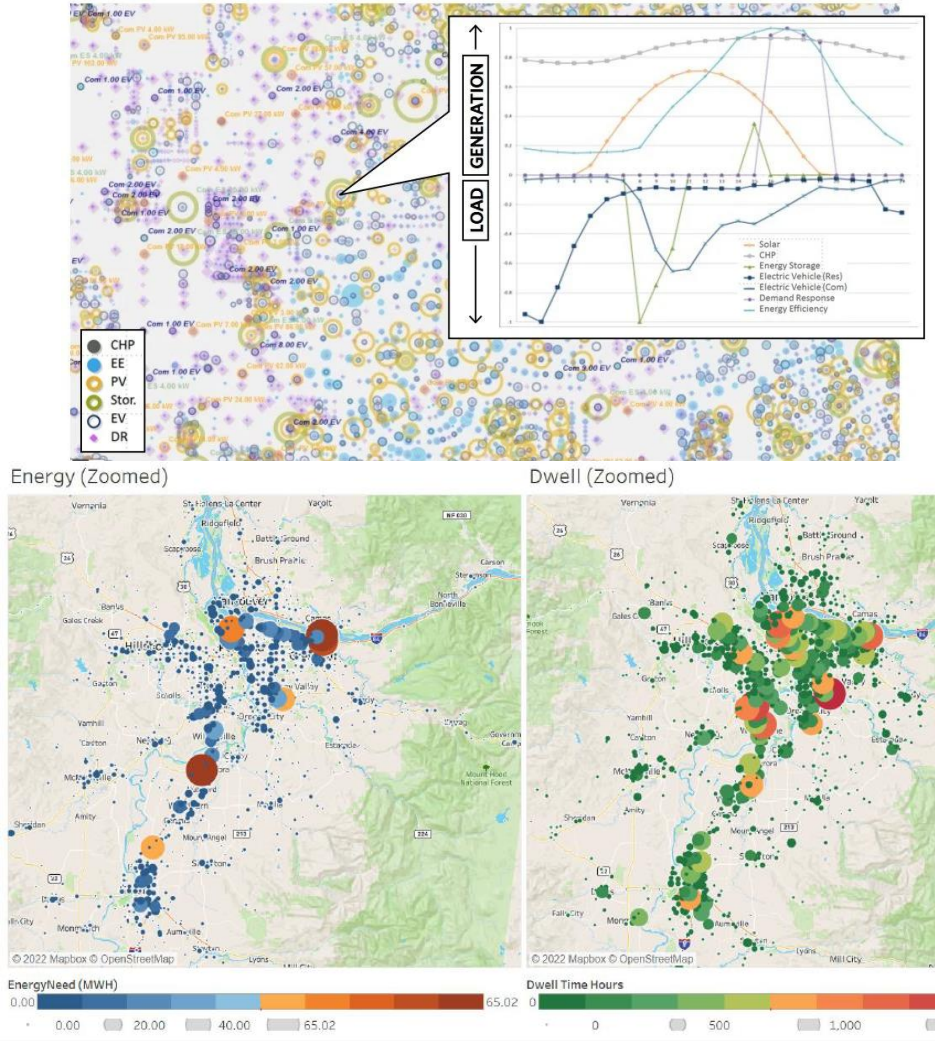


Image and analysis source: EPRI

Sources:
Beyond the Meter: Planning the Distributed Energy Future, Volume II
https://sepapower.org/resource/beyond-meter-planning-distributed-energy-future-volume-ii/
Advancing Locational Planning for TE (Portland General Electric / EPRI)

Forecasting in the Context of Scenarios

- DTE's 2021 Distribution Grid Plan was developed using U.S. Department of Energy's *DSPx grid modernization framework.*
  - "Multiple DER forecast scenarios reflecting potential changes in DER and loads…and use cases to assess current system capabilities needed may be employed to identify incremental infrastructure requirements and enable analysis of the locational value of DERs." (pg. 31)
- DTE used 3 future scenarios "to assess the potential changes that could impact the electric grid as well as their implications over the next 15 years."

Scenario	Description	Implications
Electrification Scenario	High electrification of transportation, buildings, and industrial processes	Distribution overloads begin to occur at 2% adoption on quite a few substations
Increasing CAT Storm Scenario	Increased catastrophic (CAT) storm frequency and intensity threat to aging grid reliability	Current system loading and designs flexibility will be further challenged
DG/DS Scenario	High adoption of distributed generation (DG) solar PV and distributed storage (DS) behind the meter (BTM)	Distribution voltage, thermal and protection issues will increasingly arise at relatively low adoption levels DTEE Needs a DER operational & control strategy for DER, Including MISO coordination

Sources:
DOE DSPx: https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx
DTE Distribution Grid Plan Final Report ; MSPC Case No U-20147

Review

- How to Forecast?
  - Incorporate a lot of granular data
  - Incorporate macro-economic trends
  - Incorporate policy impacts

- Scenario Planning
  - Helps stretch the thinking beyond the values of the variables
  - Identifies key drivers for change

The Impact of Increased DER Penetration on Forecasting Electricity Loads for Rate Cases & Distributed System Plans

Caitlyn Edmundson, Principal Economist,
New York State Department of Public Service

NARUC PUC Peer-Sharing Webinars on Integrated Distribution System Planning
March 20, 2023

Disclaimer

The following slides reflect the views of the author and do not represent the views of the New York State Public Service Commission or the Department of Public Service Staff.

Shorter- vs. Longer-Term Forecasting

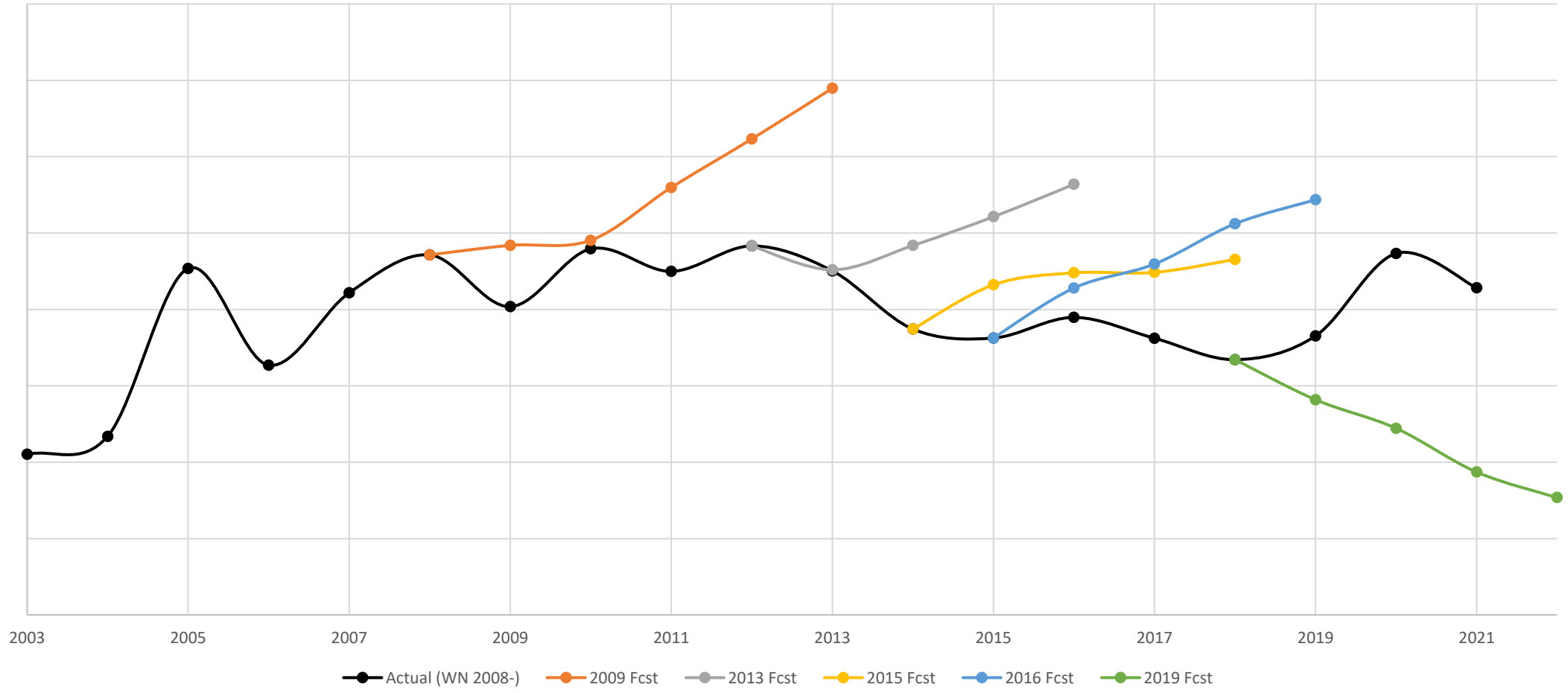
- Shorter-Term Forecasting
  - Rate Cases: 1- to 3-year horizon
    - Both utilities and DPS Staff produce their own sales (kWh) forecasts, which are then reconciled during the litigation/settlement phases of rate cases
- Longer-Term Forecasting
  - Distributed System Implementation Plans (DSIP): 5-year horizon
    - Includes peak demand (kW) and energy load (kWh) forecasts developed by the utilities and filed with the Commission for stakeholder use
    - Updated every two years

Sales Forecasts vs. DSIP Load Forecasting

- Sales forecasts
  - Determine revenue requirements
    - With Revenue Decoupling Mechanisms (RDM), the primary purpose of the sales forecast is to set rates at a level where there will not be large swings/changes in retail rates
    - Forecasting errors have recently increased due to difficulties in forecasting DER penetration[1]
- DSIP load forecasting
  - Ensure reliable grid operation by ensuring generating and grid capacity are sufficient to satisfy potential maximum demand

[1]Isakower, Sean, Caitlyn Edmundson, Anping Liu, & Richard E. Schuler, Jr. *Impact of Increased Distributed Energy Resources on Electric Sales Forecasting Methodologies*. Rutgers Advanced Workshop in Regulation and Competition: 36th Annual Eastern Conference. 2017. (Available upon request.)

Forecasts generally track actuals reasonably well until recently when DER penetration has become more significant



Rate Case Forecasting Methodology

- For each utility service class, an econometric model is estimated relating electric sales (kWh) to independent variables including real price of electricity, income, employment, GDP, weather, billing cycle days, etc.
- Values of the independent variables for the forecasting period are obtained from third-party sources
- Weather is assumed to be normal (10-year average) during the forecast period
  - 10-year average better reflects the trend in weather than a 30-year average
- DER (i.e., EE, PV, EV, heat pumps, other beneficial electrification, etc.) is accounted for through out-of-model (OOM) adjustments

Forecasting Methodologies to Account for DER

- NYS rate case sales forecasts (kWh) have typically included manual OOM adjustments based on historical DER data, particularly since significant DER penetration has been a fairly recent phenomenon
  - DER forecasts based on historical program evaluations and reports, as well as past installations and application queues
    - kWh output based on standard formula estimated from installed capacity
- As DER penetration continues to increase over time, other methodologies should be considered

Forecasting Methodologies to Account for DER[2]

- Add Back Method
  - Estimate reconstituted load, or the load that would have occurred without DER
  - Final sales forecast is produced by adjusting the forecasted reconstituted load by expected cumulative and incremental DER (this is an OOM adjustment)
  - This method appears to work well in situations with a short history of minor DER investments and the impact of DER programs can be accurately estimated and used to reconstitute load
  - Inaccurate estimates of DER impact and inconsistent estimation methodologies in different time periods and for different DERs may result in large forecast errors
  - Estimating the counterfactual load is more difficult over a longer period of time

[2]McMenamin, Stuart and Mark Quan. *Incorporating DSM into the Load Forecast*. Itron White Paper. 2010.

Forecasting Methodologies to Account for DER[3]

- Independent Variable Method
  - DER variable(s) is included as an independent variable in the forecasting model
  - Final sales forecast is produced by using a forecast of the cumulative impact of past and future DER
  - This method requires that historical programs have had a major impact on historical sales and that there is enough independent variation in the impact history to generate statistically significant parameters
  - This method could potentially be more useful down the road as compliance with New York's Climate Leadership & Community Protection Act (CLCPA) ramps up DER penetration and more accurate and consistent data become available
  - The challenge with using this method is deciding what DER variable to use. Ideally this would be the investment dollars spent on DER programs. It is often difficult to interpret the coefficient on the variable.

[3]McMenamin, Stuart and Mark Quan. *Incorporating DSM into the Load Forecast*. Itron White Paper. 2010.

Forecasting Methodologies to Account for DER[4]

- Trend Method
  - This method assumes current levels and trends of DER penetration are already baked into the historical load and will continue into the future
  - Historical load is not reconstituted and no DER variables are included in the model
  - Final sales forecast is produced by adjusting the forecast by expected incremental DER penetration that deviated from established historical trends (this is an OOM adjustment)
  - Works well in situations where there has been a longstanding and relatively stable DER penetration history and where there is expected to be a significant future change in program activity
    - This describes the climate in NYS right now
      - Data goes back 10-20 years for EE and PV
      - CLCPA is expected to significantly ramp up DER penetration
    - This is the method favored by NYS DPS Staff during the most recent rate cases

[4]McMenamin, Stuart and Mark Quan. *Incorporating DSM into the Load Forecast*. Itron White Paper. 2010.

DSIP Forecasting

- The DSIP guidance documents[5] require:
  - Forecasts detailed enough to support both short-term and long-term planning
  - Forecasts to aid in predicting the hosting capacity available at existing and potential DER locations
  - Annual peak demand, peak day load shape, and energy (kWh) load forecasts for each of the next five years at the company-wide level
  - Granular 8,760 hour forecasts at the substation level
  - Separately provided forecasts for key areas including but not limited to PV, energy storage, EVs, and EE

[5]Case 16-M-0411 – In the Matter of Distributed System Implementation Plans

Forecasting Moving Forward

- Improve overall accuracy of forecasts for demand and energy reductions that derive from EE programs and increased penetration of DER
- Synchronize top-down and bottom-up forecasts to improve accuracy
- Probabilistic forecasting
  - Aids in probabilistic planning and optionality
  - Reflects the difficulty in forecasting inter-related effects of different types of DER on load growth
  - Reflects the uncertainty associated with different weather/climate change scenarios
- Longer-horizon forecasts that reflect the impact of building and transportation electrification