Integrated Grid Planning

Forecast Assumptions Working Group

July 17, 2019

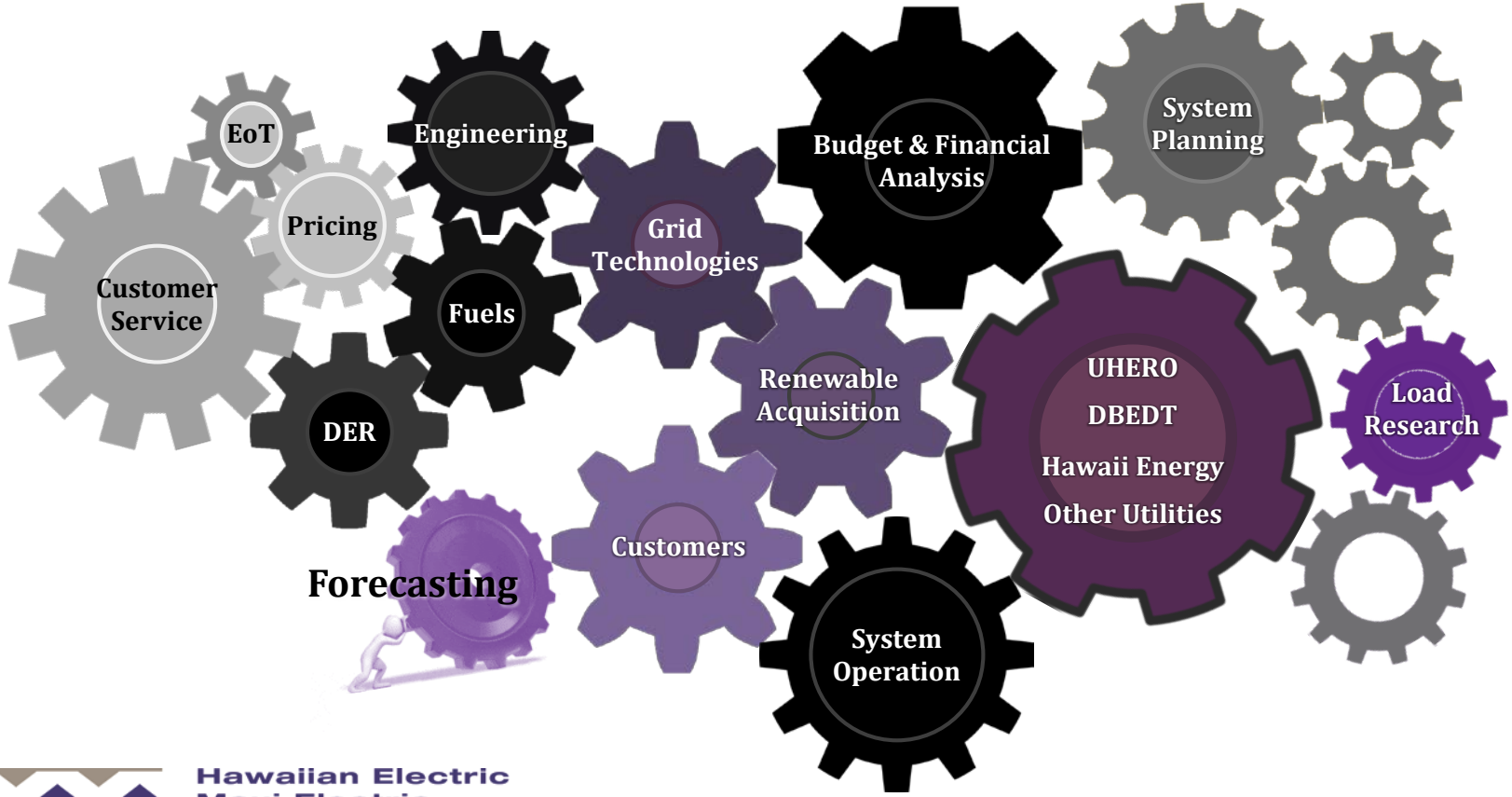
Hawaiian Electric
Maui Electric
Hawai'i Electric Light

IGP Forecast Assumptions Working Group

Forecast Methodologies

◆ Welcome and Overview	9:00 – 9:10
◆ Forecast Methods (Underlying & DER)	9:10 – 10:05
Break	10:05 – 10:20
◆ Forecast Methods (EE, EoT & Summary)	10:20 – 10:55
◆ Forecast Methods from Other Utilities	10:55 – 11:55
– ERCOT	
– NV Energy	
– Portland General	
– SMUD	
◆ Wrap-up	11:55 – 12:00

It takes a village to raise a forecast.



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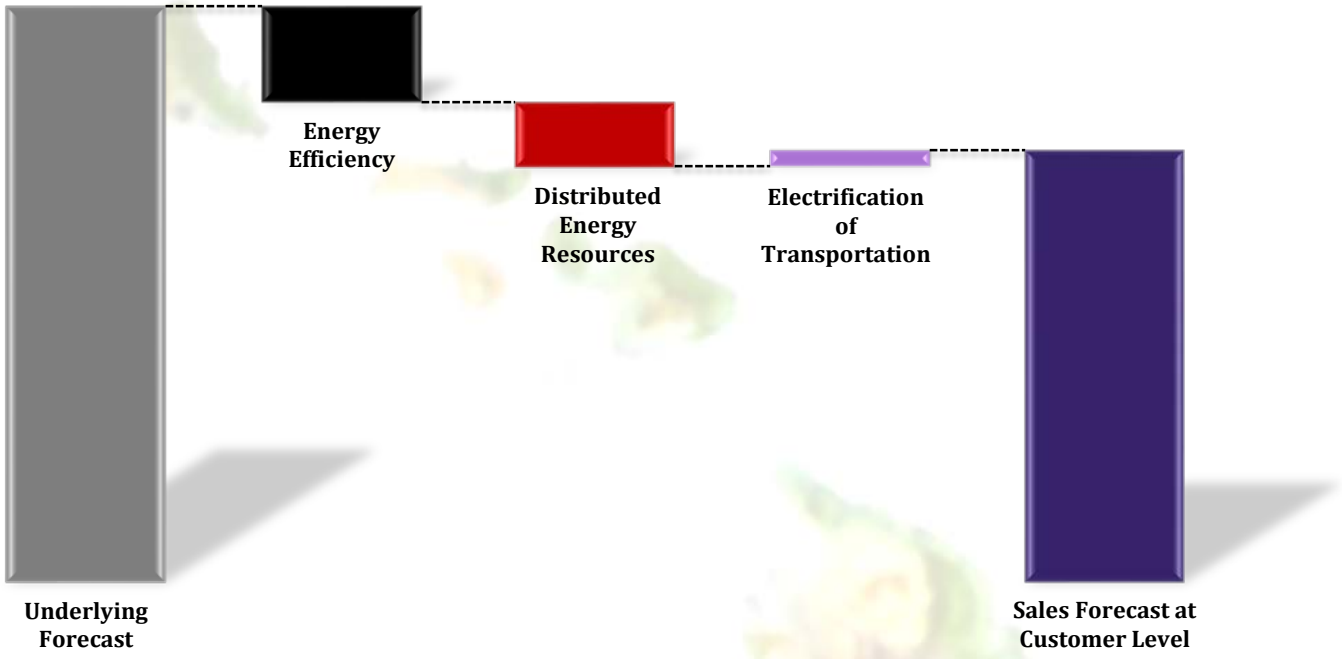
Our forecast is developed in layers.



Forecast will be further modified by demand response (DR) and controllable DER.

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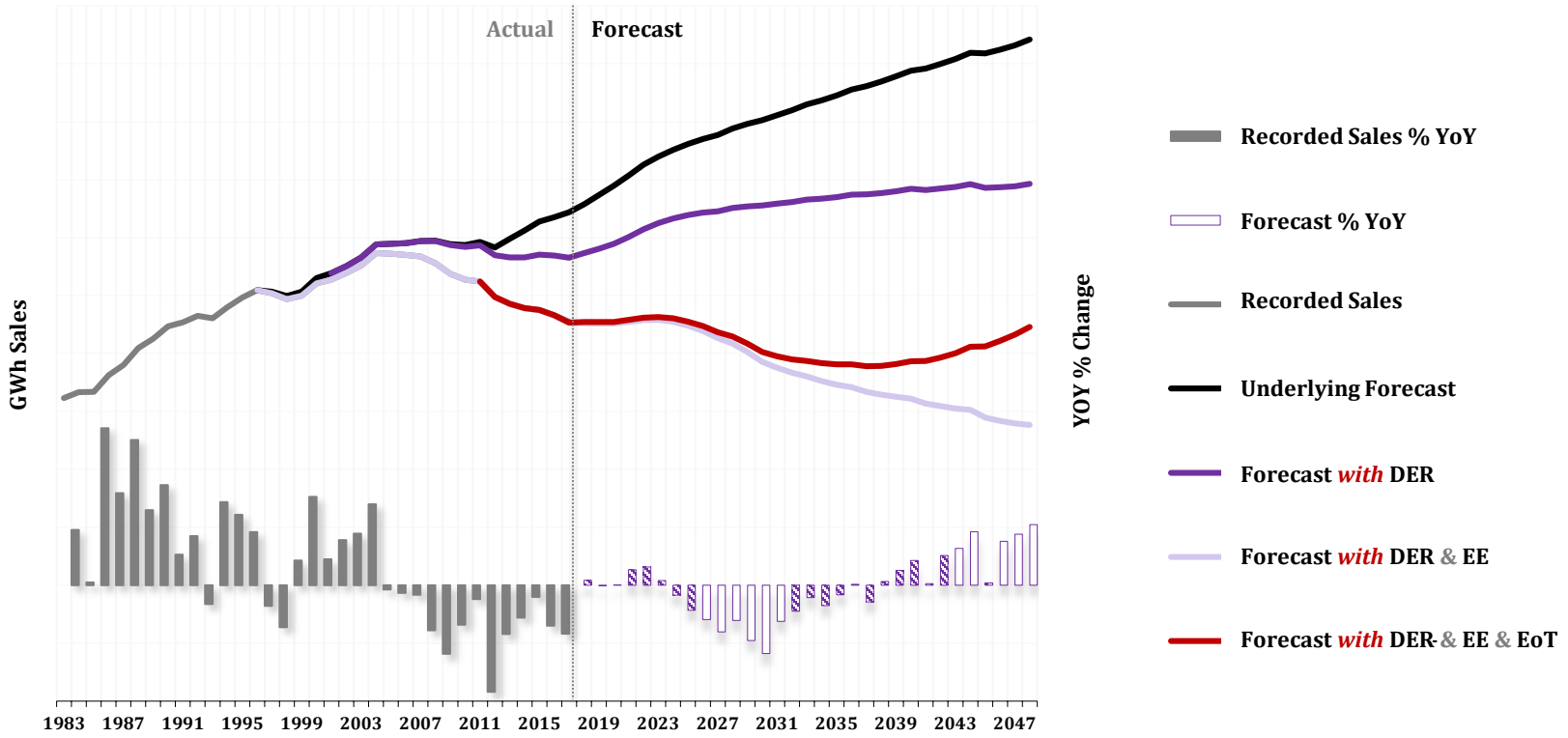
Illustrative Example

Sales Forecast with Layers



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Forecasting Methods

Underlying Forecast

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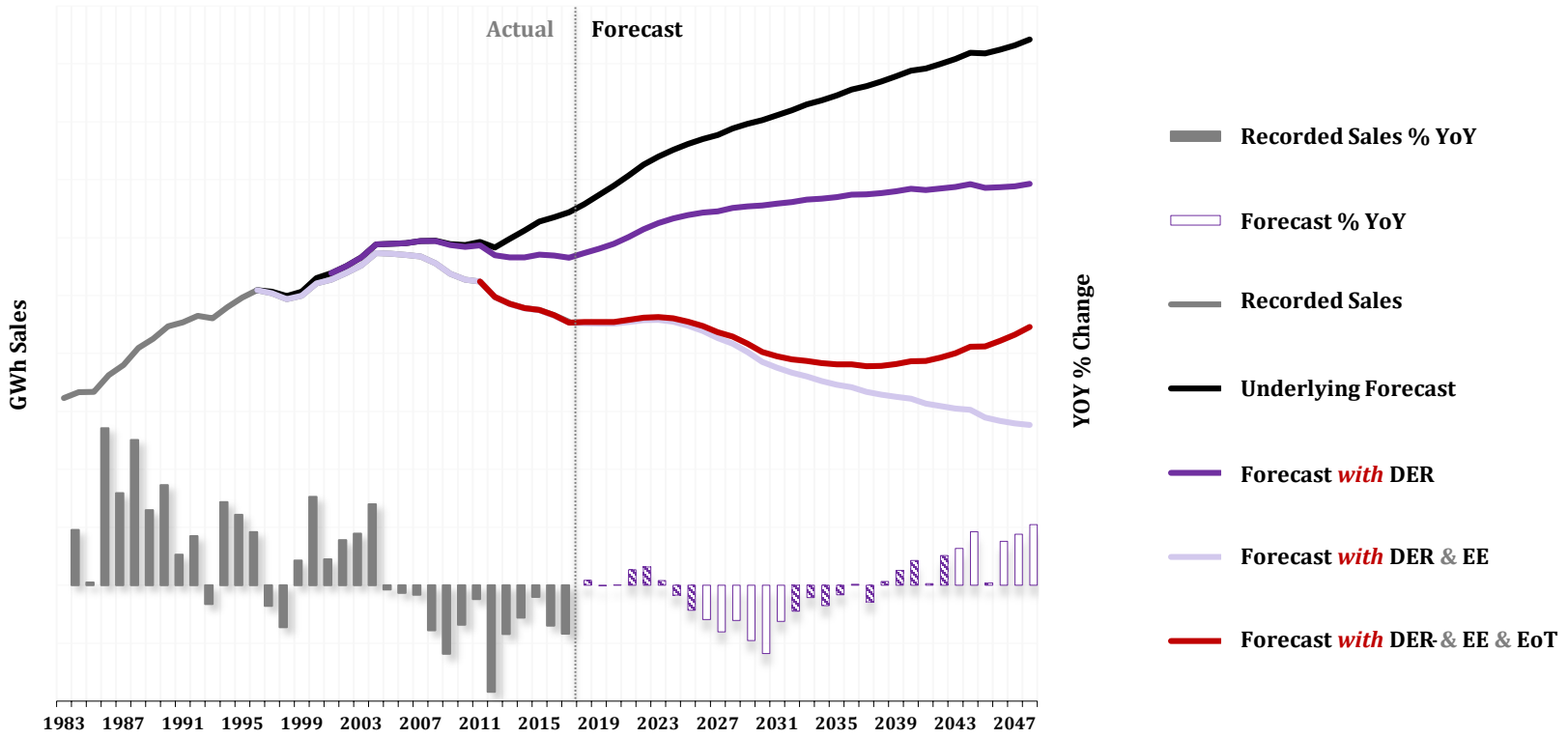
Sales Forecast with Layers



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Underlying Forecast – Energy Sales

- **Data**
  - Historical periods
    - Structural changes
    - Historical disruptions
  - Adjustments and reasons for adjustments
    - Large customer loads
    - Embedded layers
    - Estimated impacts

Forecast Inputs

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

Grid Technologies

Analytical Planning

Star Advertiser

DR

The Hawaiian Islands

Annual Business Forums

Pūlama Lānaʻi

EPRI Electric Power Research Institute

The Maui News

Fuels

Project Mgt

USA.gov Government Made Easy

Building Industry Magazine

eia

The Molokai Dispatch

HART

Customer Billing

University of Hawaiʻi Economic Research Organization

Renewable Acquisitions

Molokaʻi Community Service Council
kukui hele pō

Hawaii Energy

EEI Edison Electric Institute

DER

Customer Installation

EoT

Customer Solutions

Lānaʻi Today

IHS Markit

Corporate Energy Planning

Hawaii Tribune Herald

Customer Research

United States Census Bureau — American FactFinder

Molokaʻi Chamber of Commerce

Commercial Account Mgt / Key Account Mgt

Financial Analysis

MAUI

REALTORS® Association of Maui

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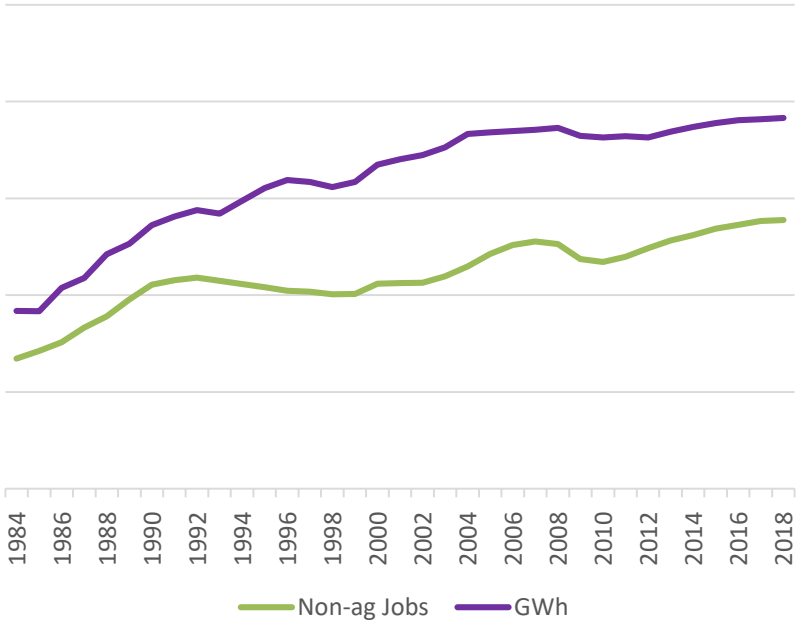
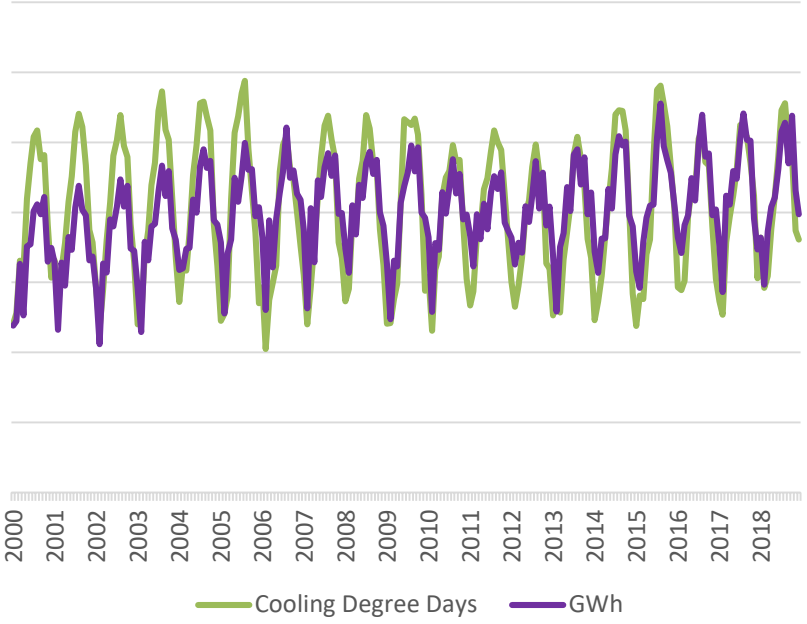
Underlying Forecast – Energy Sales

- **Overview of Methods**
  - Market Analysis, Individual projects
  - Customer Service
  - Trending
  - Econometric
    - External variables, to be discussed in future meeting on assumptions
      - Weather
      - Economic forecast
      - Electricity prices
    - e.g. Sales = *f*(electricity price, jobs, weather)

Evaluating Relationship Between Sales and External Drivers





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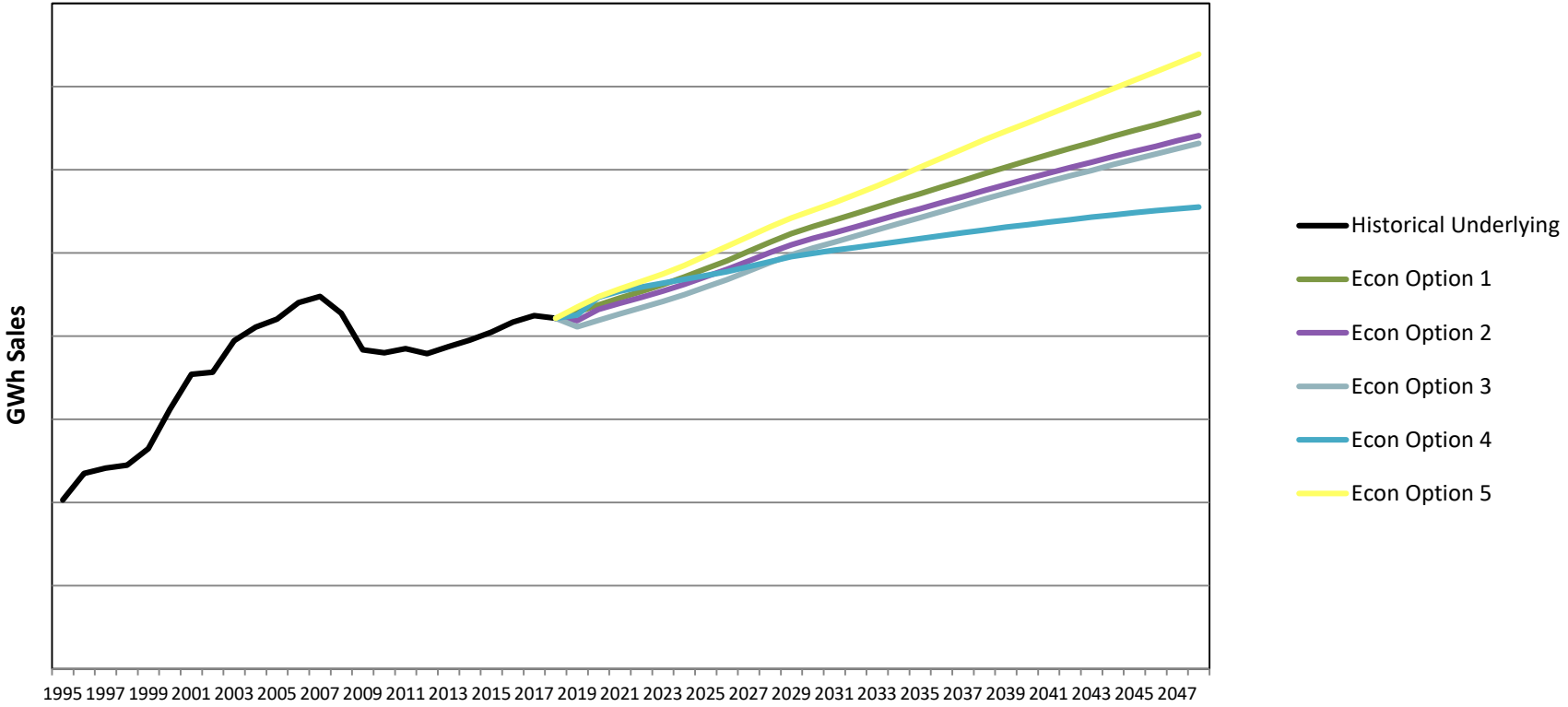
Multiple Underlying Sales Models



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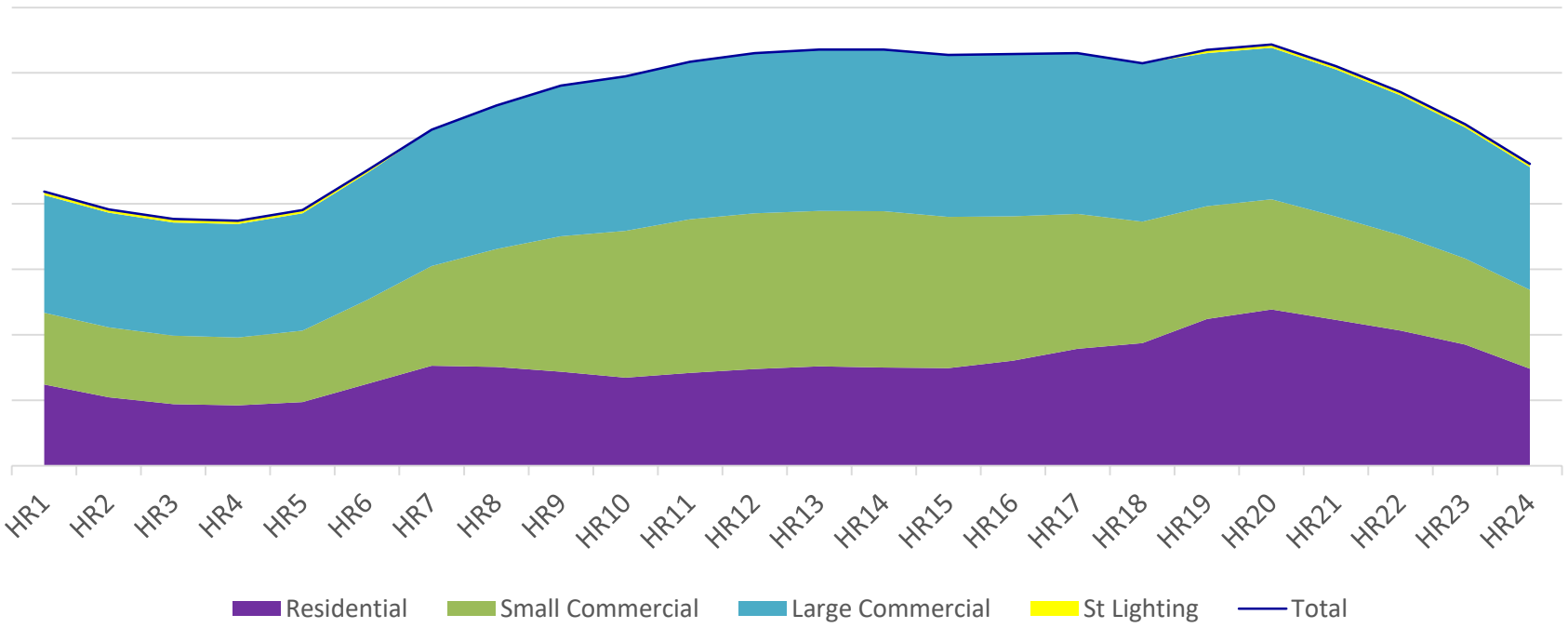
Underlying Forecast – Load Shapes

- **Hourly Load Shapes**
  - **Shapes**
    - Class Load Studies
    - Total System
  - **Method**
    - Hourly regression models
  - **Hourly Shape Drivers**
    - Seasonality / Calendar (Month)
    - Day of Week / Holiday
    - Weather

Hourly Profile By Class



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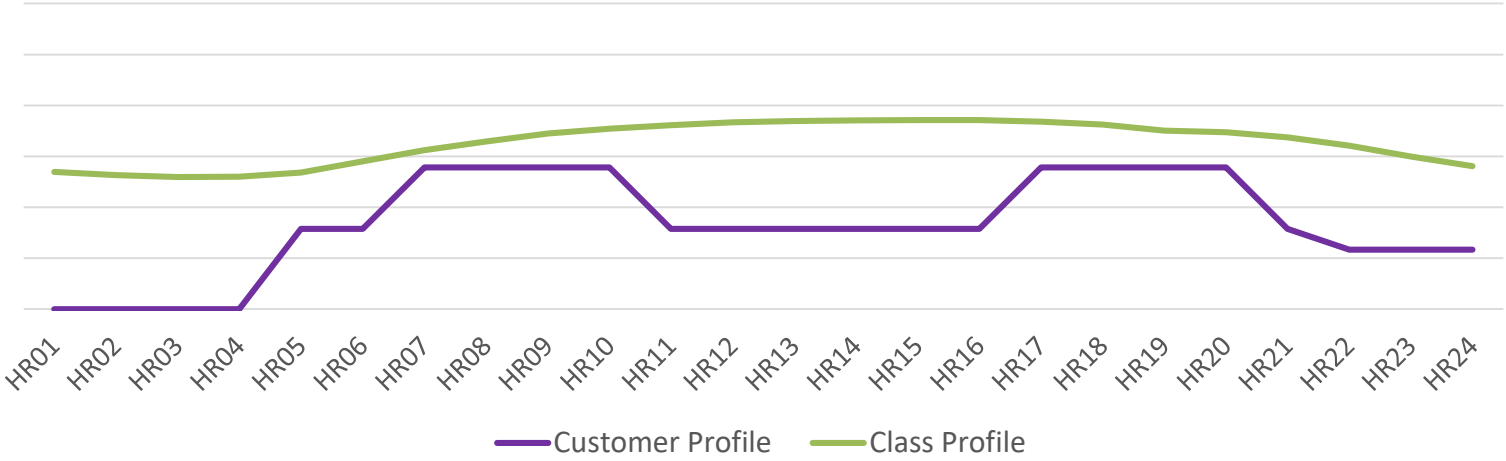
Underlying Forecast – Load Shapes

- **Hourly Load Shapes**
  - **Adjustments to underlying**
    - Individual large project profiles / energy
    - Layers



Distributed Energy Resources Forecast Methods

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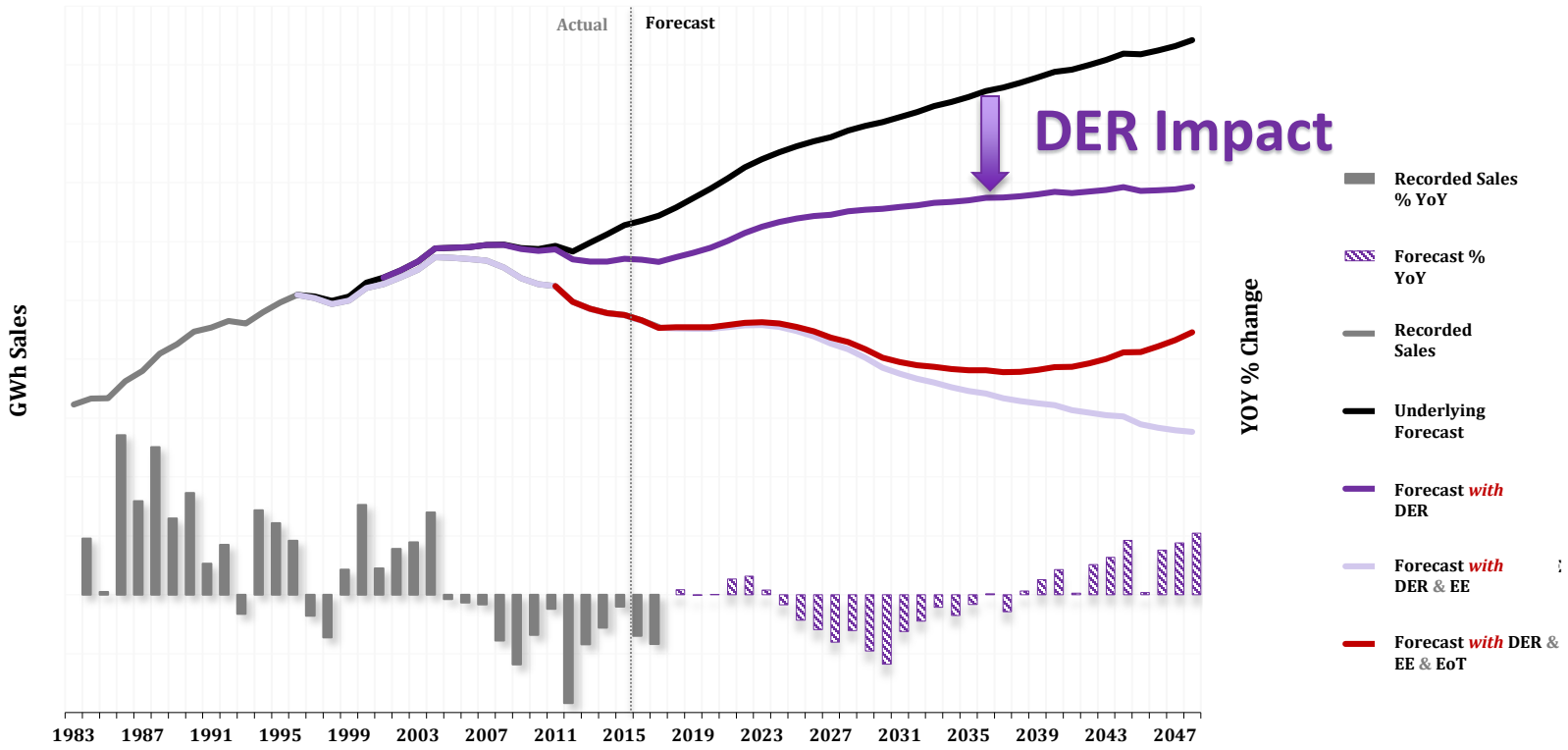
Sales Forecast with Layers



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DER Forecast

- Primary focus is behind the meter PV and battery storage
- Other technologies included on ad hoc basis for known projects
- New additions of capacity in each month by island, rate class and program
- Monthly sales impact
- Hourly load impact
- Future capacity on distribution circuits

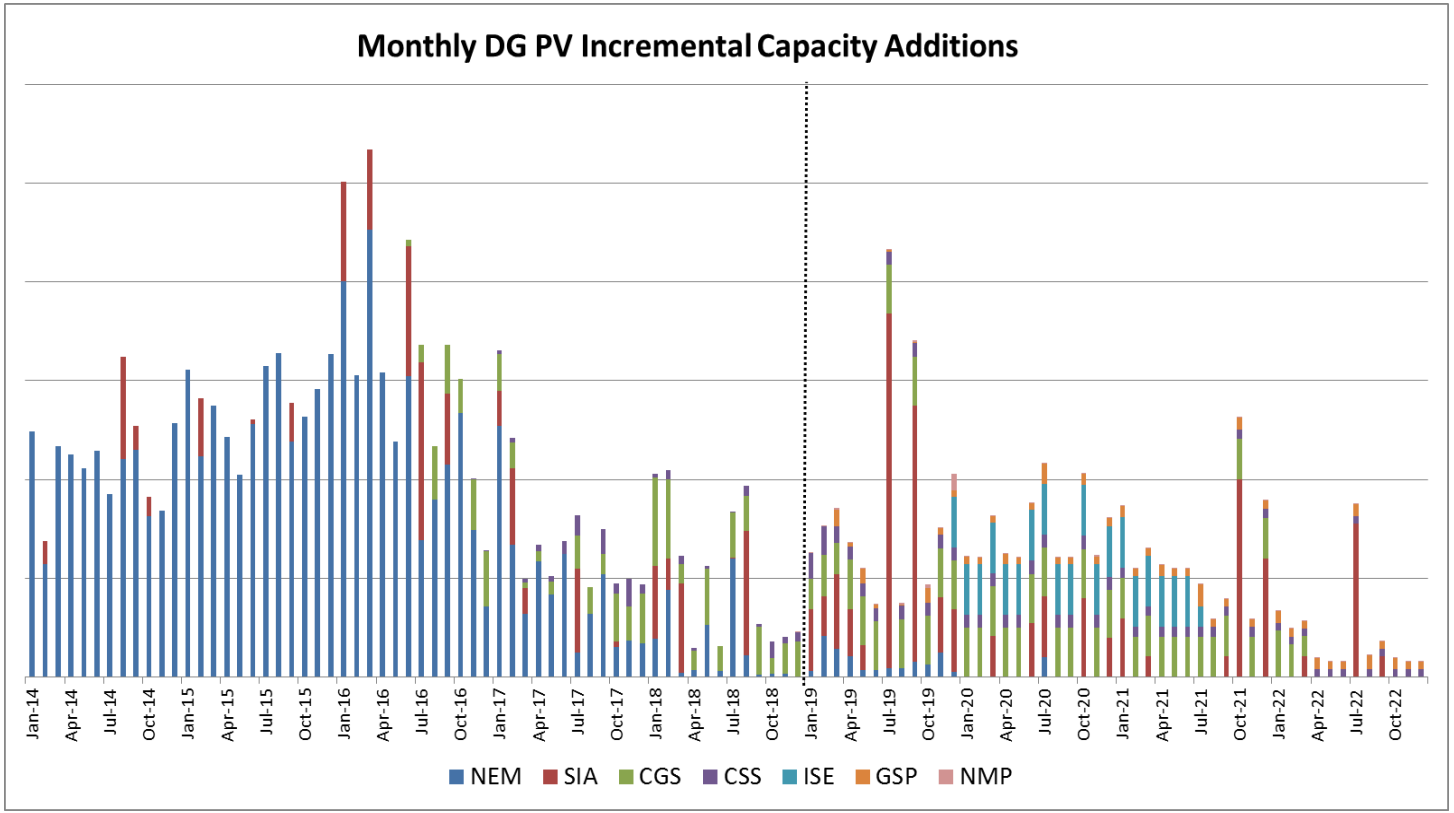
Different Methods Used by Utilities

- New Capacity Additions
  - Judgmental
  - Fixed program targets or mandates
  - Trending
  - Bass technology diffusion model
  - Econometric regression
  - Probabilistic regression
  - Economic choice
- Sales and Hourly Load Impact
  - Metered customer-sited PV data
  - NREL estimates
  - Historical bill reductions

Future Capacity Forecast Methods

- Near to mid-term
  - Current pace of incoming applications and executed agreements
  - Existing program subscription level and caps
  - Feedback from program administrators and installers
  - Customer input
  - Short-term hurdles (e.g. circuit study, equipment upgrades)
- Mid to long-term blended method
  - Bass technology diffusion model
  - Customer economic choice model
  - Judgmental analysis
  - Assumption-driven high adoption

Example Near-Term Capacity Forecast



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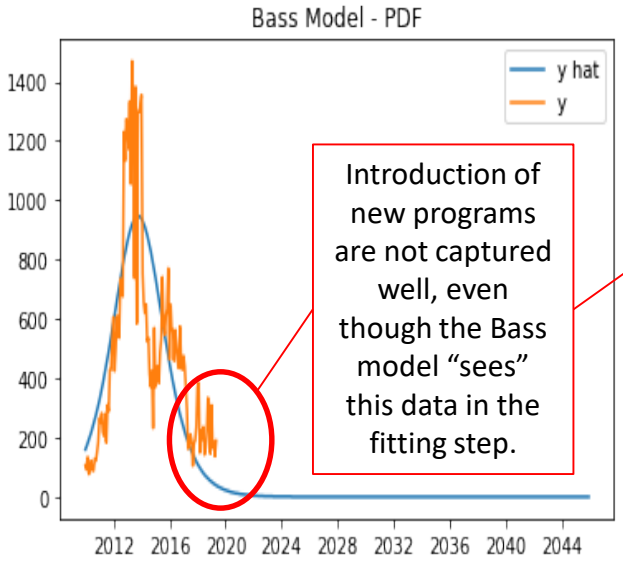
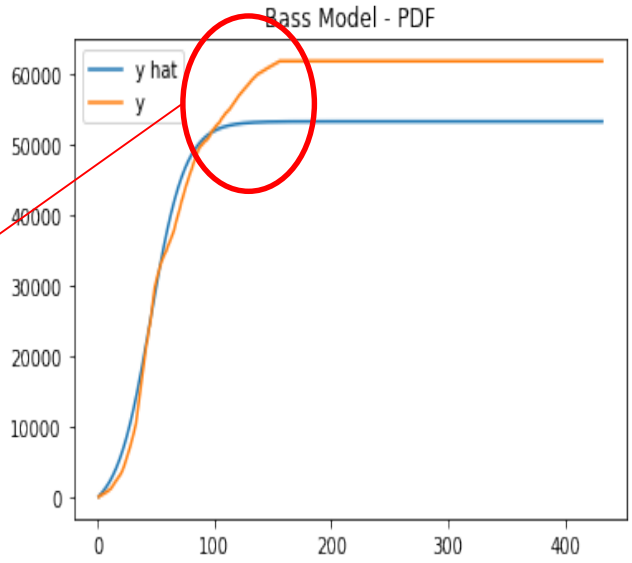
Bass Technology Diffusion Model

- Popular diffusion model to forecast uptake
- Usually used for new technology uptake
  - Historic data either not present or very little of it present
- Uses coefficients that relate to “market”
  - Adoption
  - Innovators & Imitators
  - Market size
- Several methods were explored
  - Diffusion models are limited given where we are with PV adoption
  - Perform poorly when trying to reflect impact of policy and economic changes
  - May be useful to inform allocation of forecast to more granular geographic areas

Bass Model Forecast Results

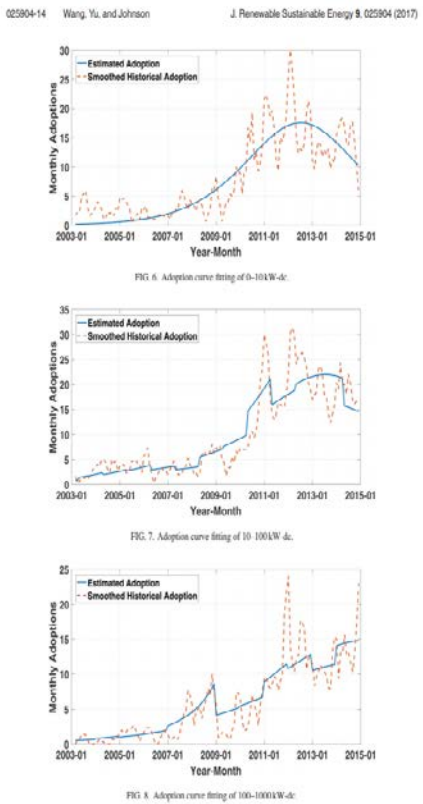


Introduction of new programs are not captured well, even though the Bass model "sees" this data in the fitting step.



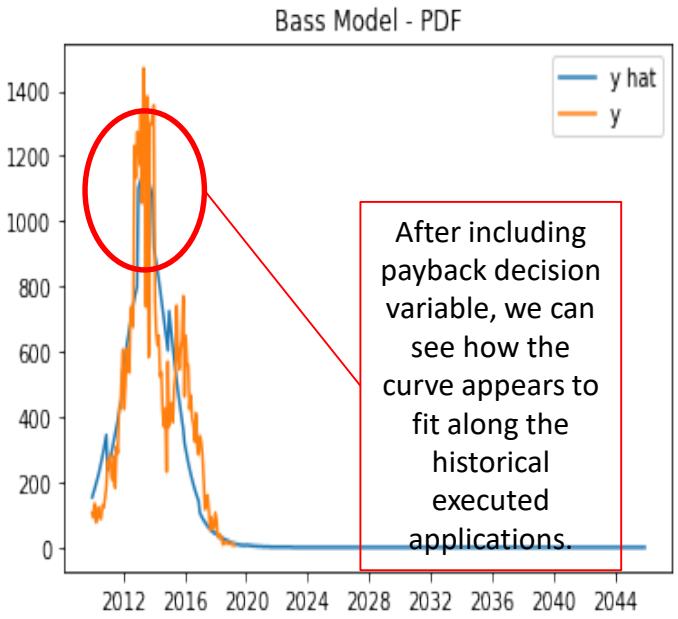
Generalized BASS Model (GBM)

- Wang, et al attempted to model the PV adoption using GBM.
- Bass function (PDF) transforms from the smoothed fitted curve to something that suggests responds to decision drivers.



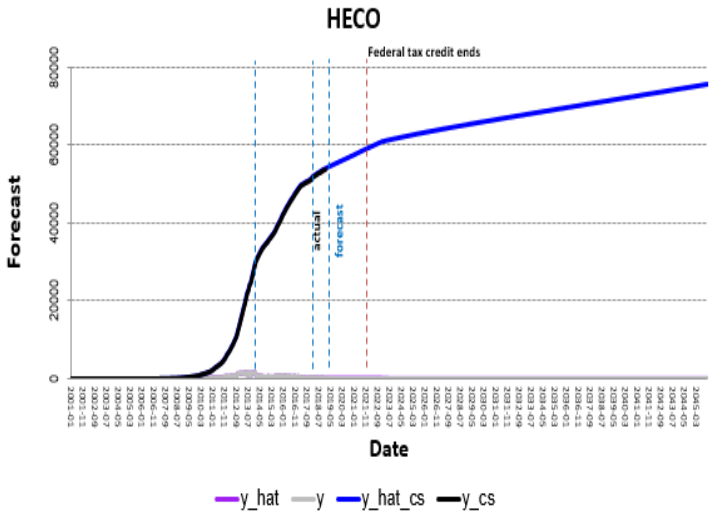
Generalized Bass Model - NEM

- GBM appeared to be "promising"
- Still resulted in similar forecasts as Bass.
  - Early historical adoption has surpassed the point of inflection



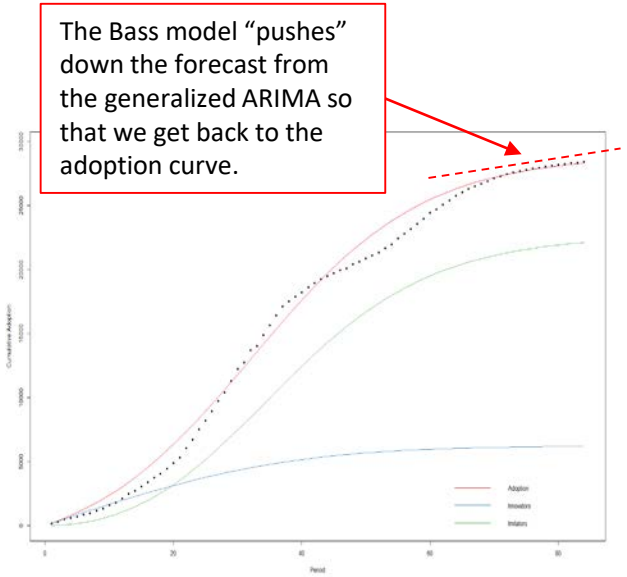
Blended ARIMA + Bass: ‘Take-off’

- Based on Christodolous et. Al.
- A ‘take-off’ is the forecast from the GLM + AR/MA and exogenous terms
  - ‘simple payback’
- Designed to lift curve after ITC ended as we did not think adoption would hover close to 0.



Blended ARIMA + Bass

- After ‘take-off’ period the model iterates through two-step process
  - Generalized Regression with ARIMA errors used to fit the model initially
  - The last two points are appended for the Bass model
  - The Bass is used to re-calibrate the forecast from ARIMA



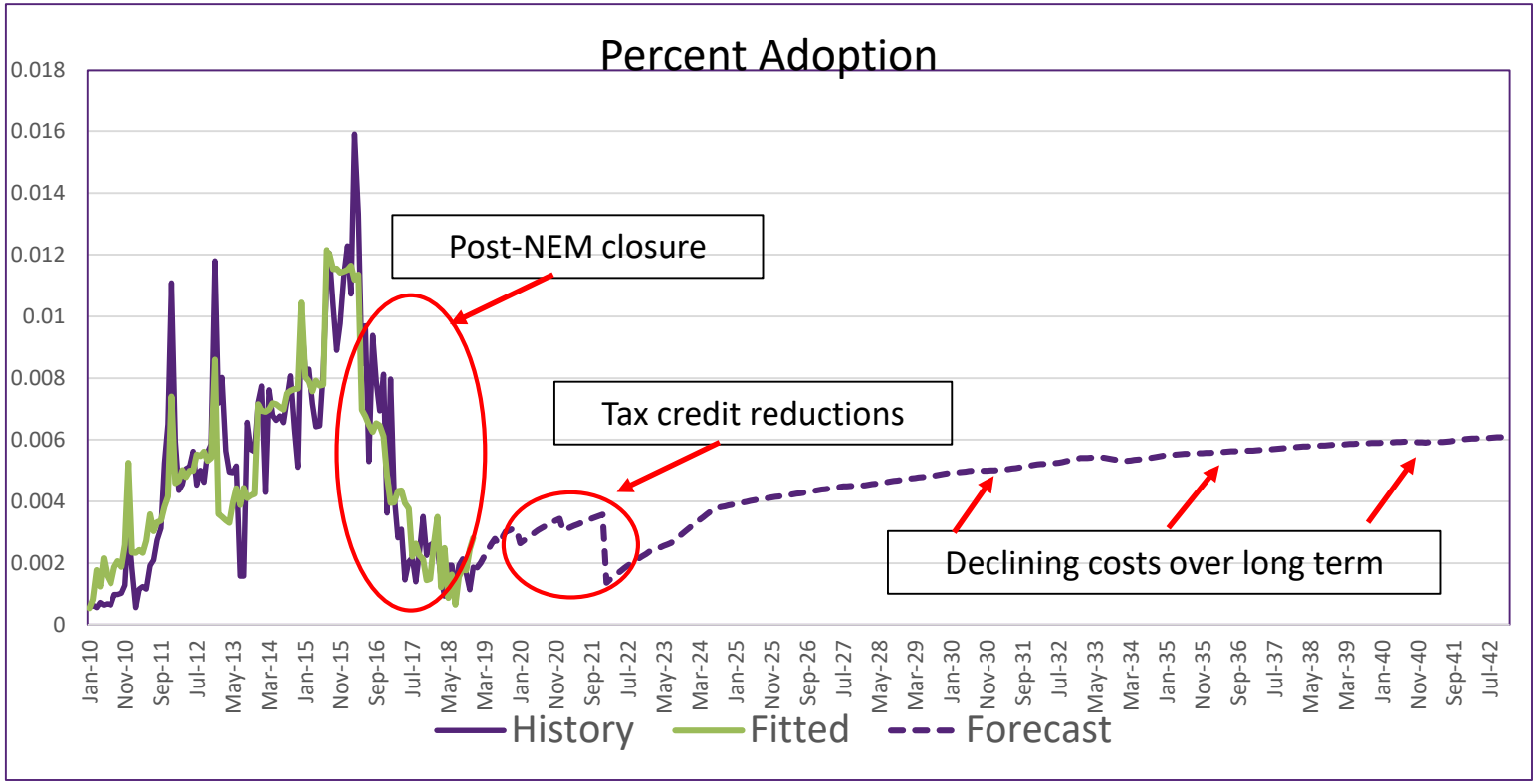
Output of Bass model during iterative fitting/forecasting

Economic choice model

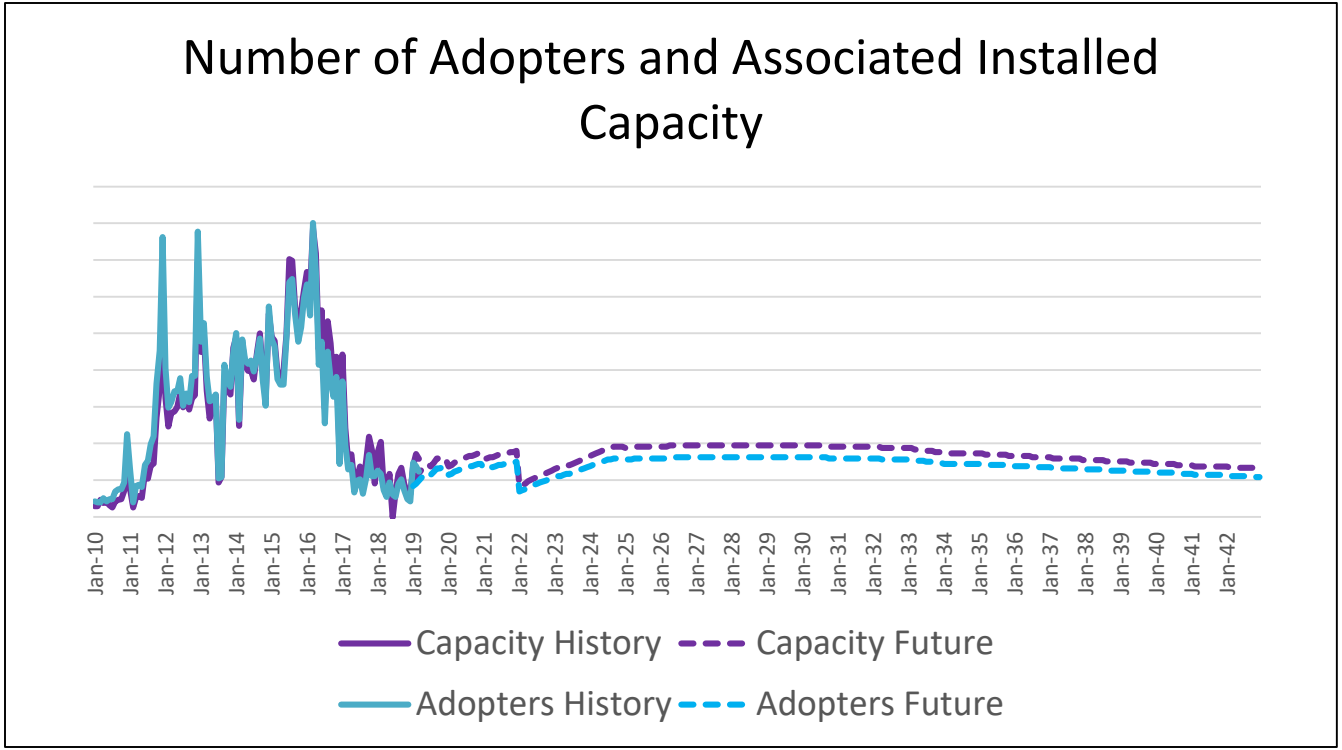
- Analyze historical relationship between adoption rate and economics
  - Dependent variable: Percent of potential PV customers that installed a system each month
  - Primarily driven by economics (savings, costs, payback time)
- Input future projections for economic drivers to get future percent adoption in each year
- New capacity additions derived by incorporating 2 additional key assumptions:

(% adoption) x (number of potential adopters) x (average system size)

Economic Choice Model



Economic Choice Model



Economic Choice Model

Benefits
Incorporates local historical economics and behavior
Future payback on investment and remaining pool of customers directly affect forecast
Responsive to varying assumptions for future economics
Accommodates PV paired with storage

Challenges
Defining proper segmentation and populations of potential participants
Incorporating demographics
Modeling multiple program choices
Predicting future disruptions (program closures or launches, technology breakthrough)

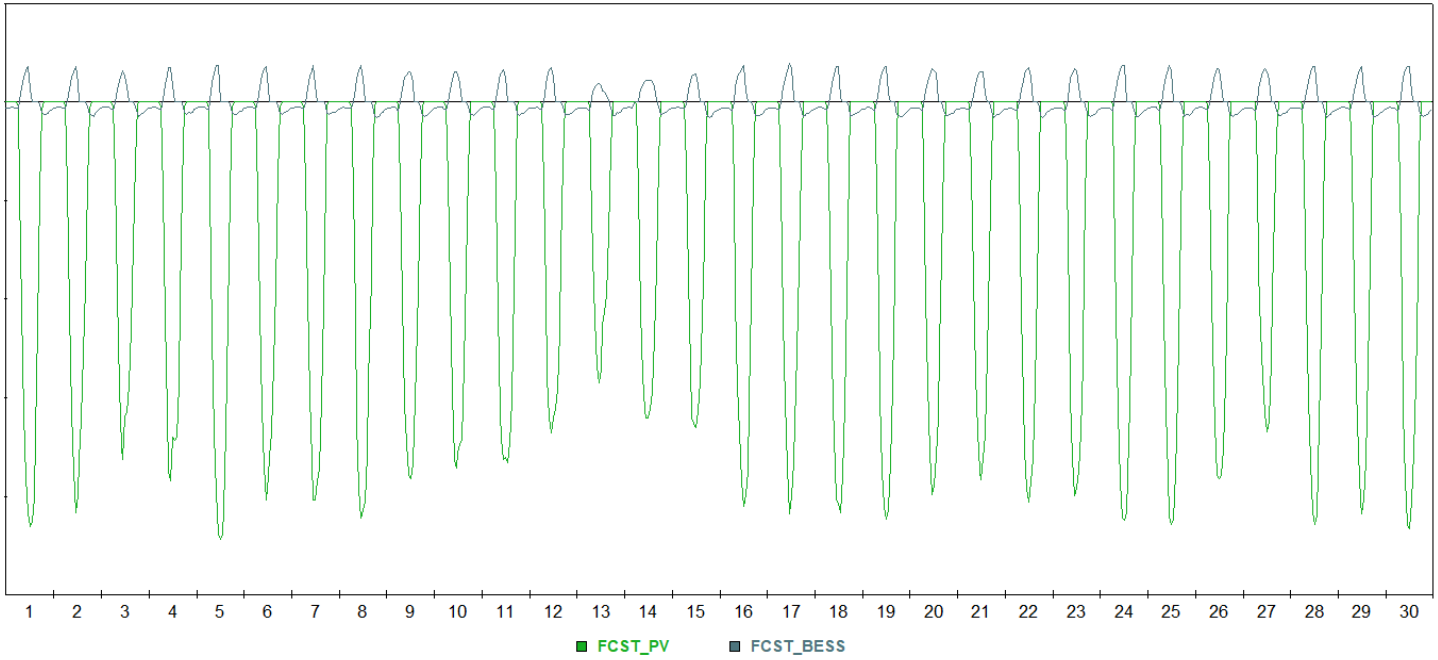
Fixed Endpoint Method

- Assume certain conditions at end of forecast horizon
- An example:
  - Single-family homes achieve net-zero
  - Participating commercial sectors mirror historical participation, but at a much higher penetration
  - Not driven or limited by cost-effectiveness of projects
  - Straight-line growth from the end of near-term forecast to end of forecast horizon

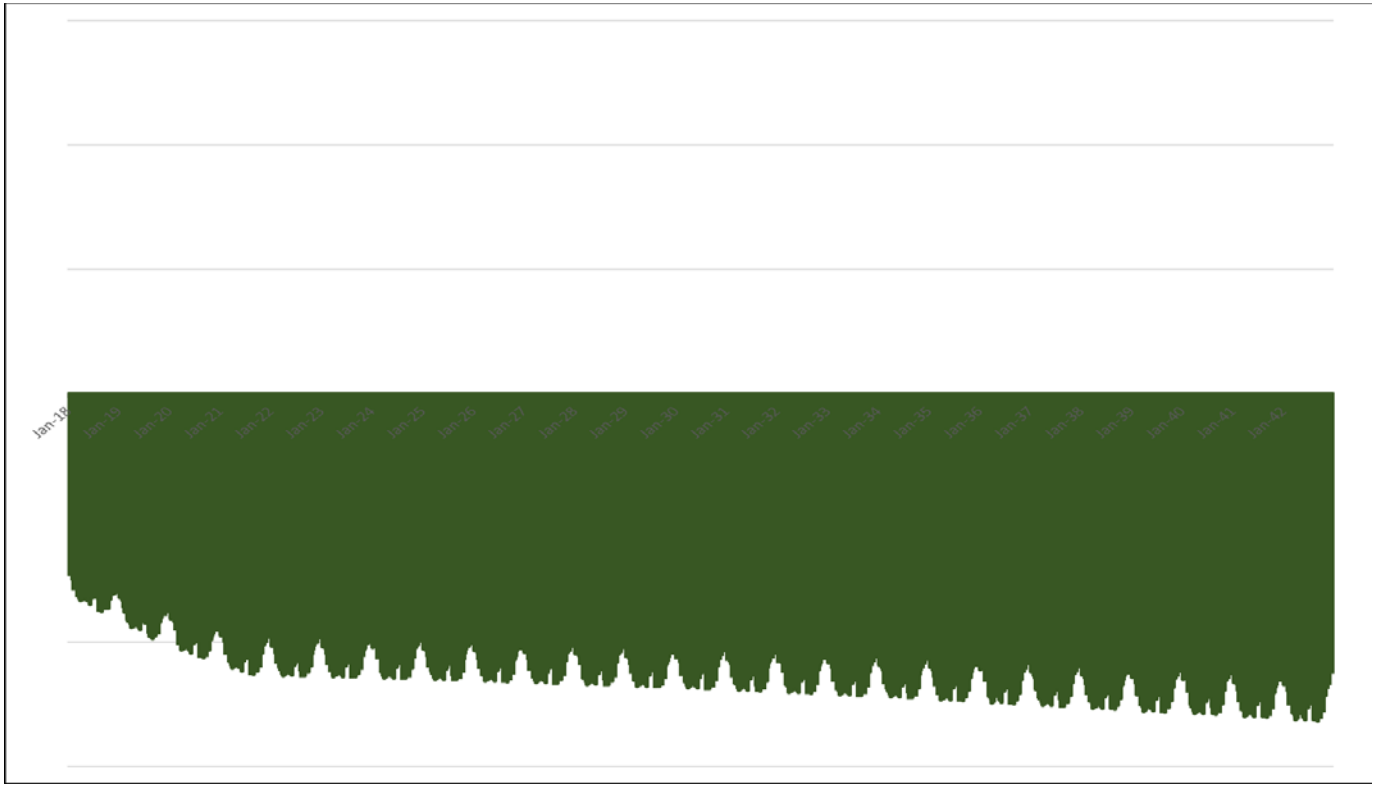
Sales Impact & Hourly Shape Method

- Method to estimate solar resource
- Historical island-wide satellite imagery provides gridded hourly irradiance
  - Weighted based on where PV is installed
  - Weighted hourly irradiance converted to unitized PV generation and monthly capacity factors
- Historical data used to create future capacity factors and hourly shapes
- Battery storage load shifting derived from hourly energy balancing of customer load, PV generation and storage

Hourly Shape for One Month



Full Forecast Period PV Shape




Time for a break

IGP Forecast Assumptions Working Group

Forecast Methodologies

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Forecast Methods
Energy Efficiency Forecast

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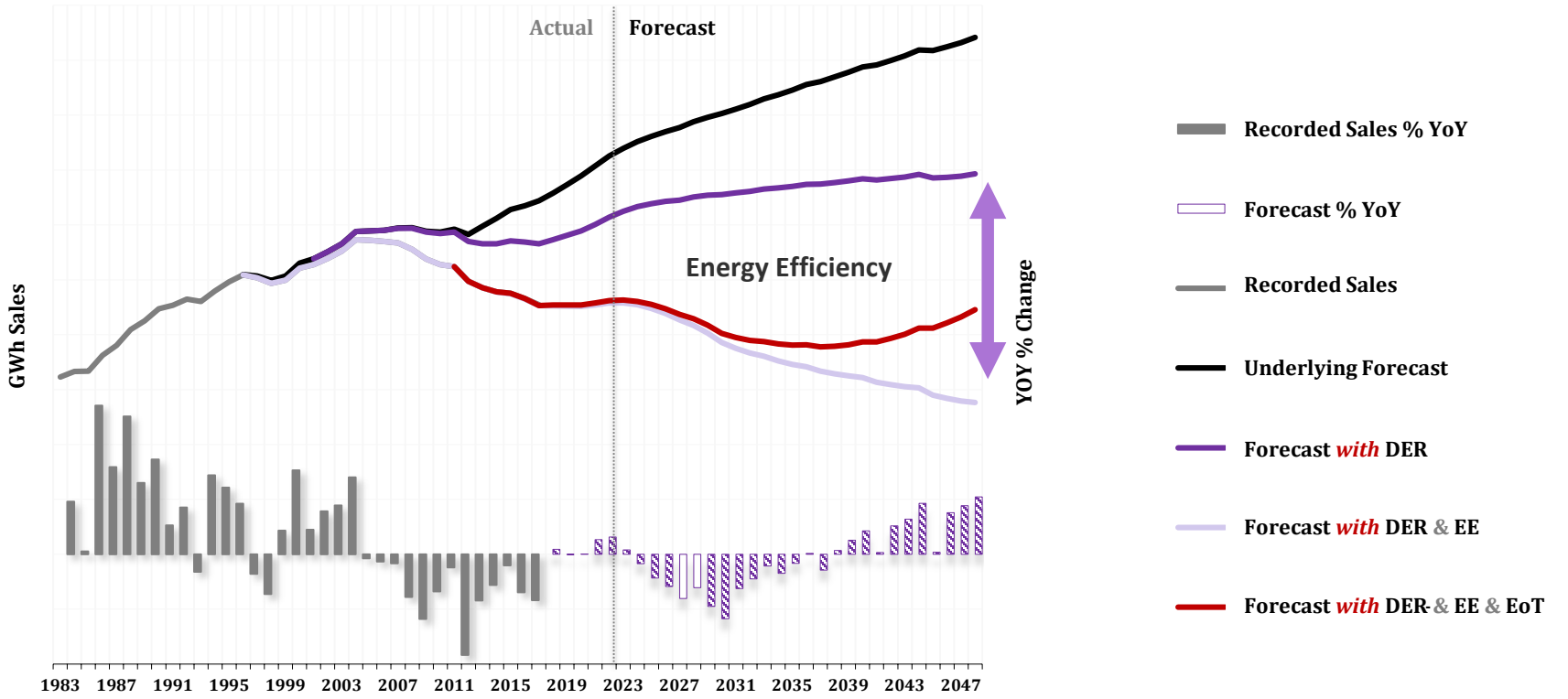
Sales Forecast with Layers



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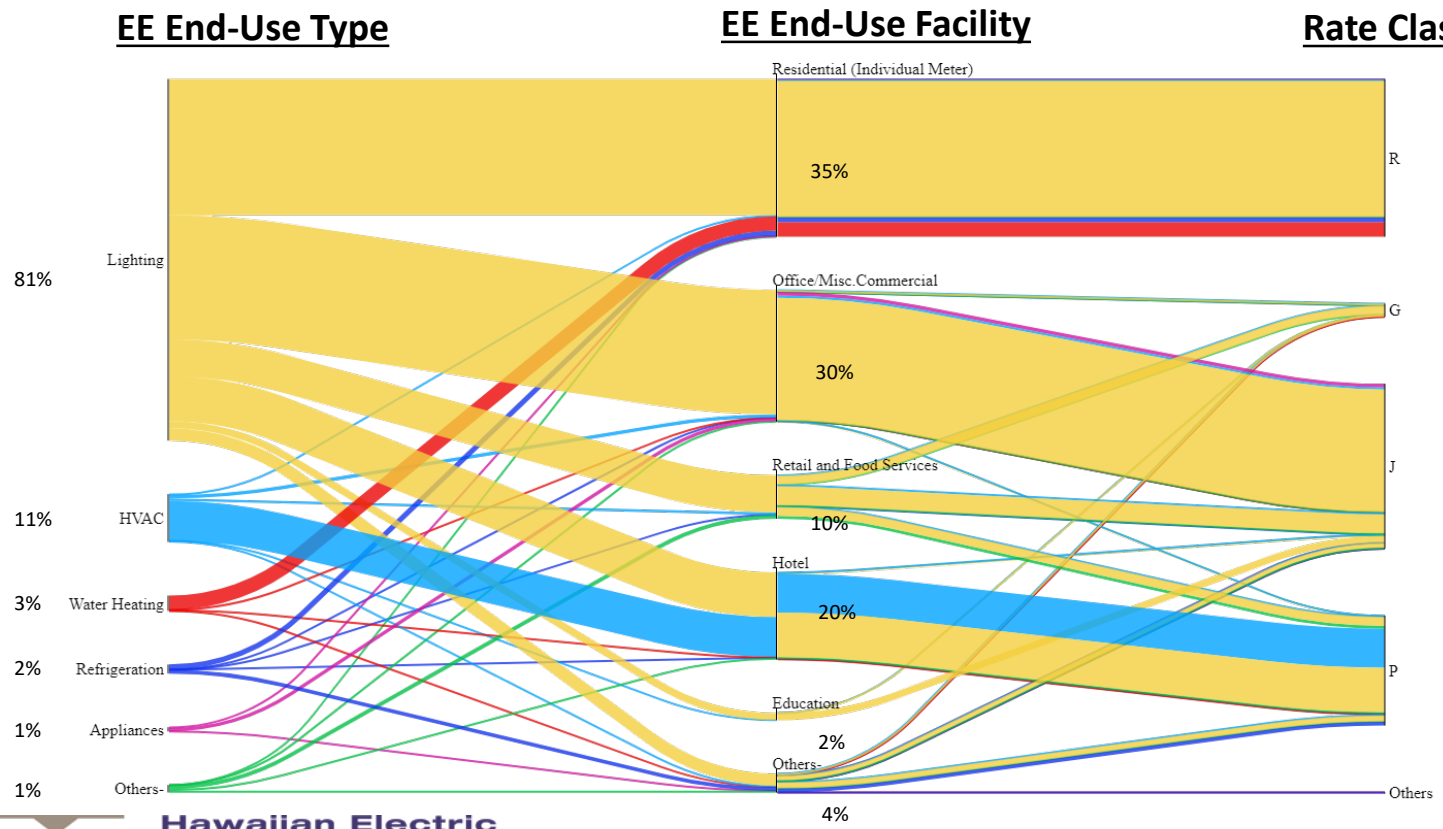
Energy Efficiency Forecast

- Hawaii Energy's plans for the near term forecast (1– 3 years)
- Longer term forecast will be based on Applied Energy Group's ("AEG") EEPS potential study and will consider:
  - Customer segmentation
  - Technologies and measures
  - Appliance standards and building codes
  - Hourly analysis
  - Study available in September
- Sensitivity analysis will be performed following discussions with the FAWG and AEG

Example of end-use mapped to facility type and rate



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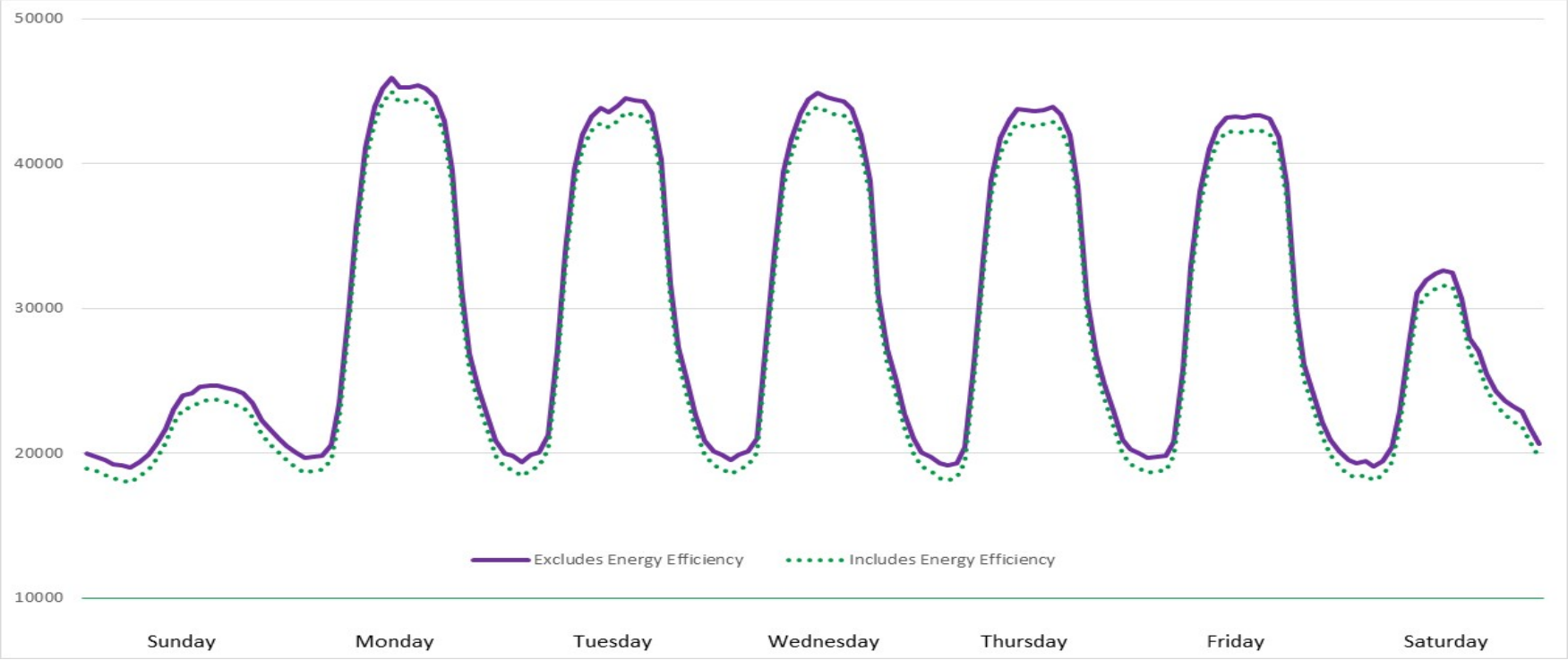
Load profiles for each facility type are used to identify operating hours

Typical energy efficiency load profile for large office buildings:



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Forecast Methods
Electric Vehicle Forecasting

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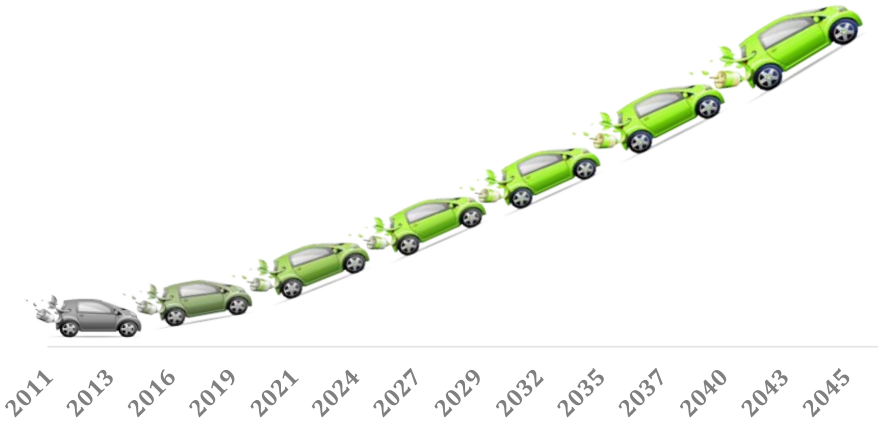
Forecasting light duty electric vehicles

1. Forecasting Number of Electric LDV on the Road



2. Sales & Demand Impacts from EV Charging

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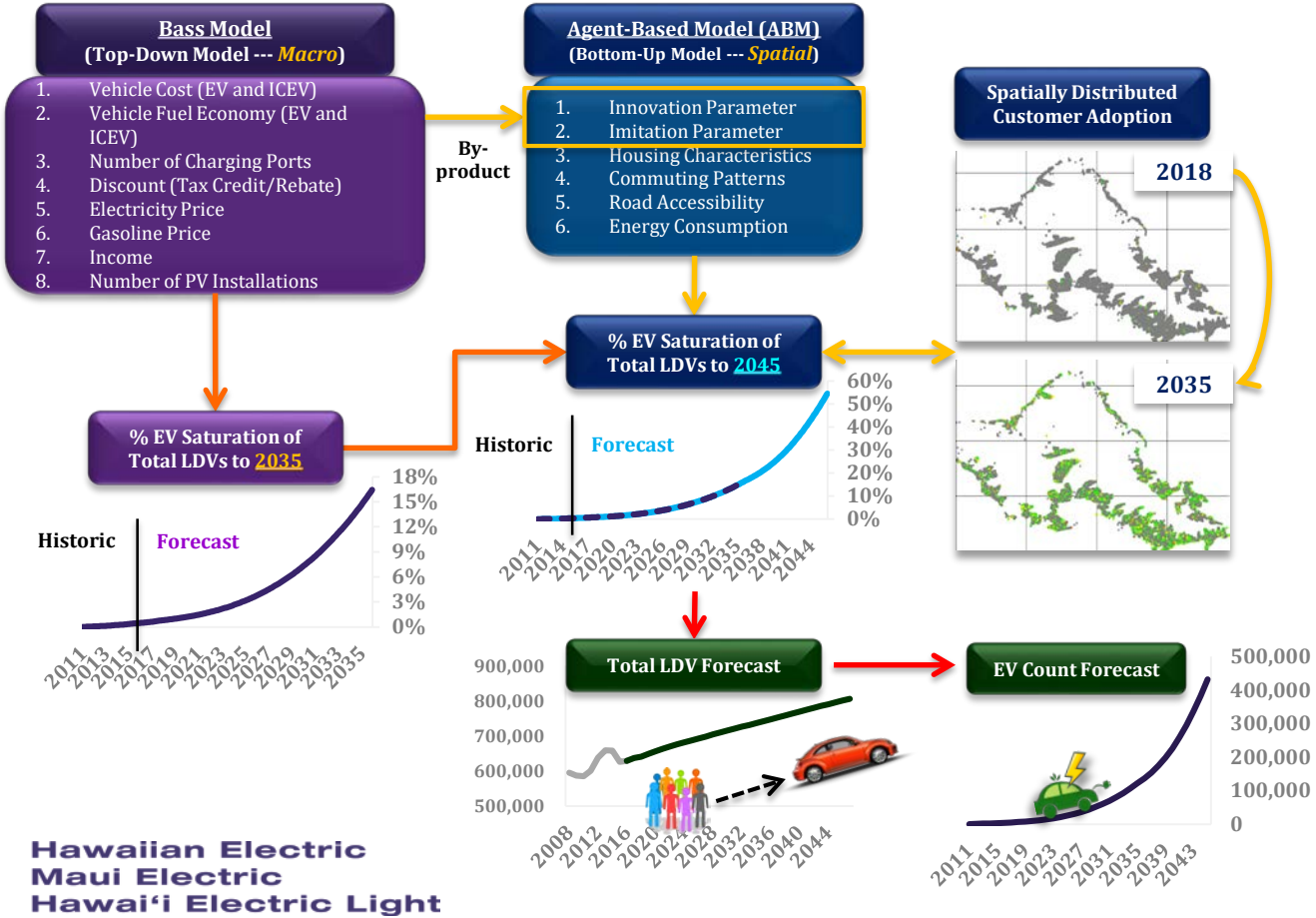
1. Electric Vehicle Forecast



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2. EV Charging Profiles

Who? When? Where? How? How Often?

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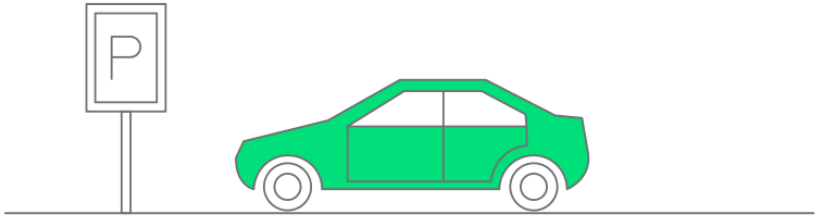
Inputs & Assumptions

I. Vehicle Miles Traveled ("VMT") & Energy Used per Vehicle

II. Charging Segmentation

III. Shapes of Charging Profiles



I. Vehicle Miles Traveled & Energy Used per Vehicle

VMT

Annual VMT By County (DBEDT)

Historical	= Annual VMT by County
Forecast	= Apply 1.01% CAGR from 2015-2035 and 0.71% from 2015-2045 **(FHWA)**

kWh/mile

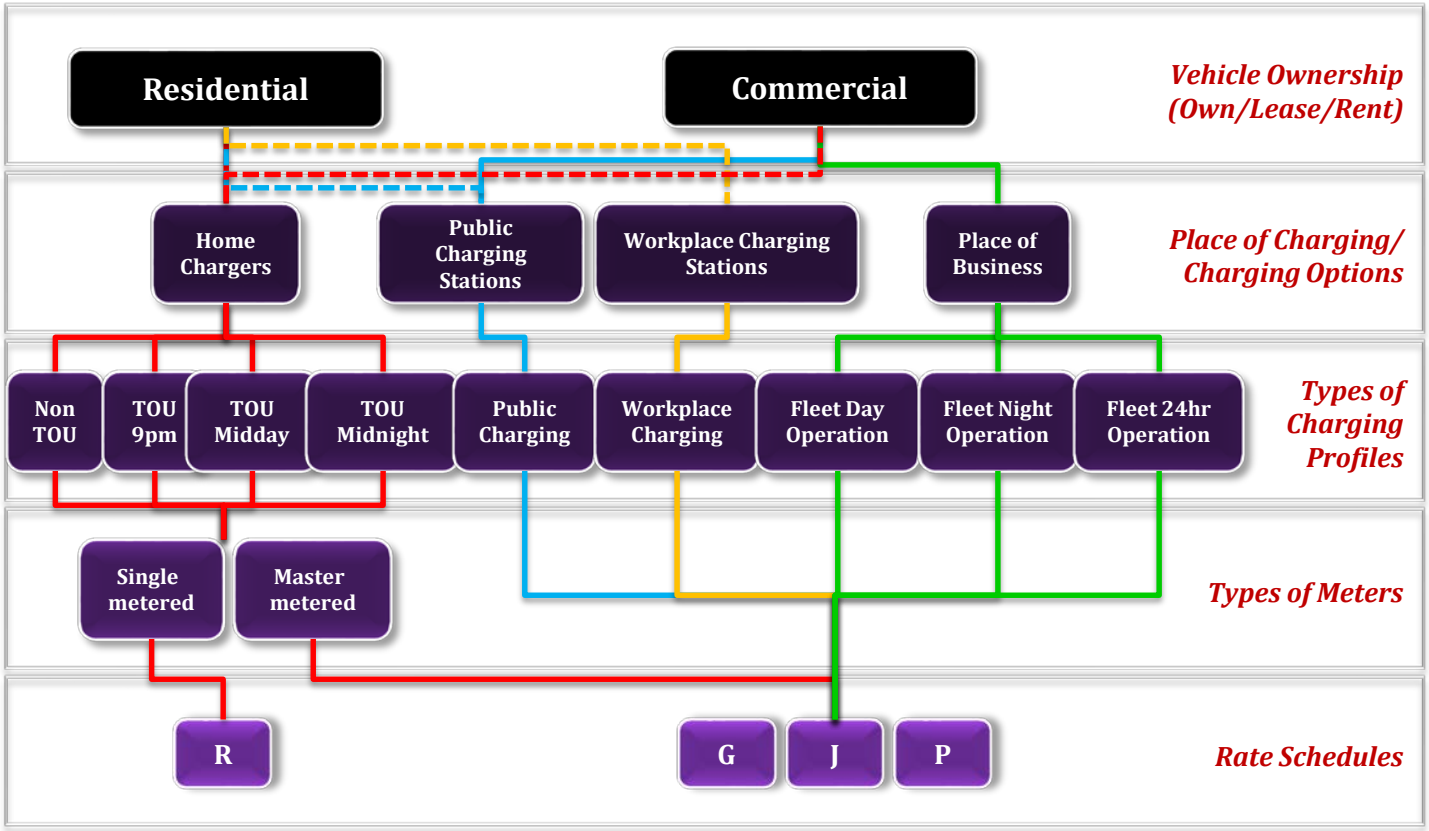
County's EV Sales by Vehicle Models **(Polk/EPRI)**

Fuel Economy **kWh/mile** **(Fueleconomy.gov)**

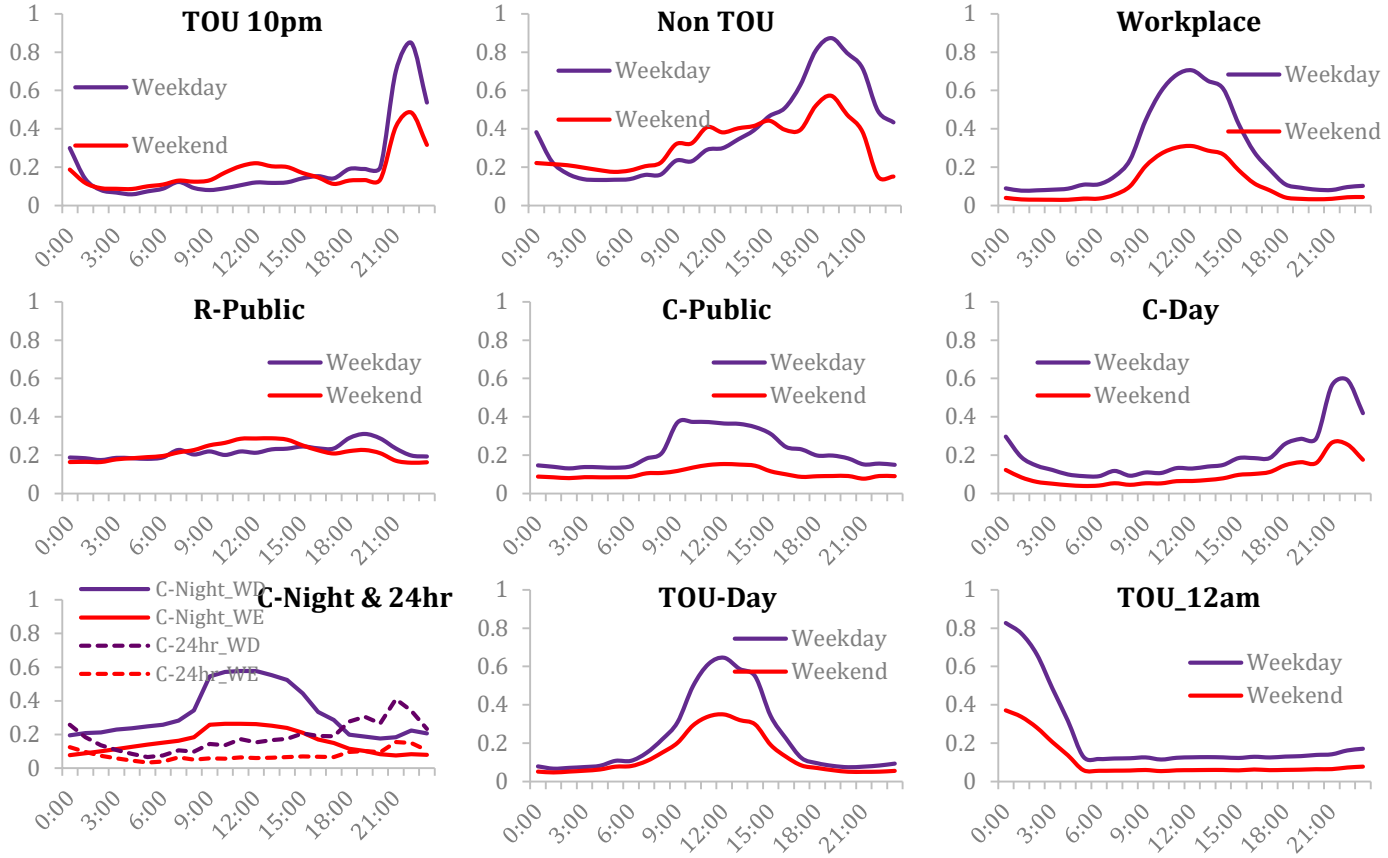
Historical	= Weighted average kWh/mile of most popular types of EVs
Forecast	= Apply growth rate from **EIA** reference case fuel economy forecast of 100 mile EV

$$\text{Annual kWh per Vehicle} = \frac{[\text{Annual VMT} * (\text{kWh/m})] * 10^6}{\text{Total Vehicle Forecast}}$$

II. Charging Segmentation



III. Average Charging Profiles



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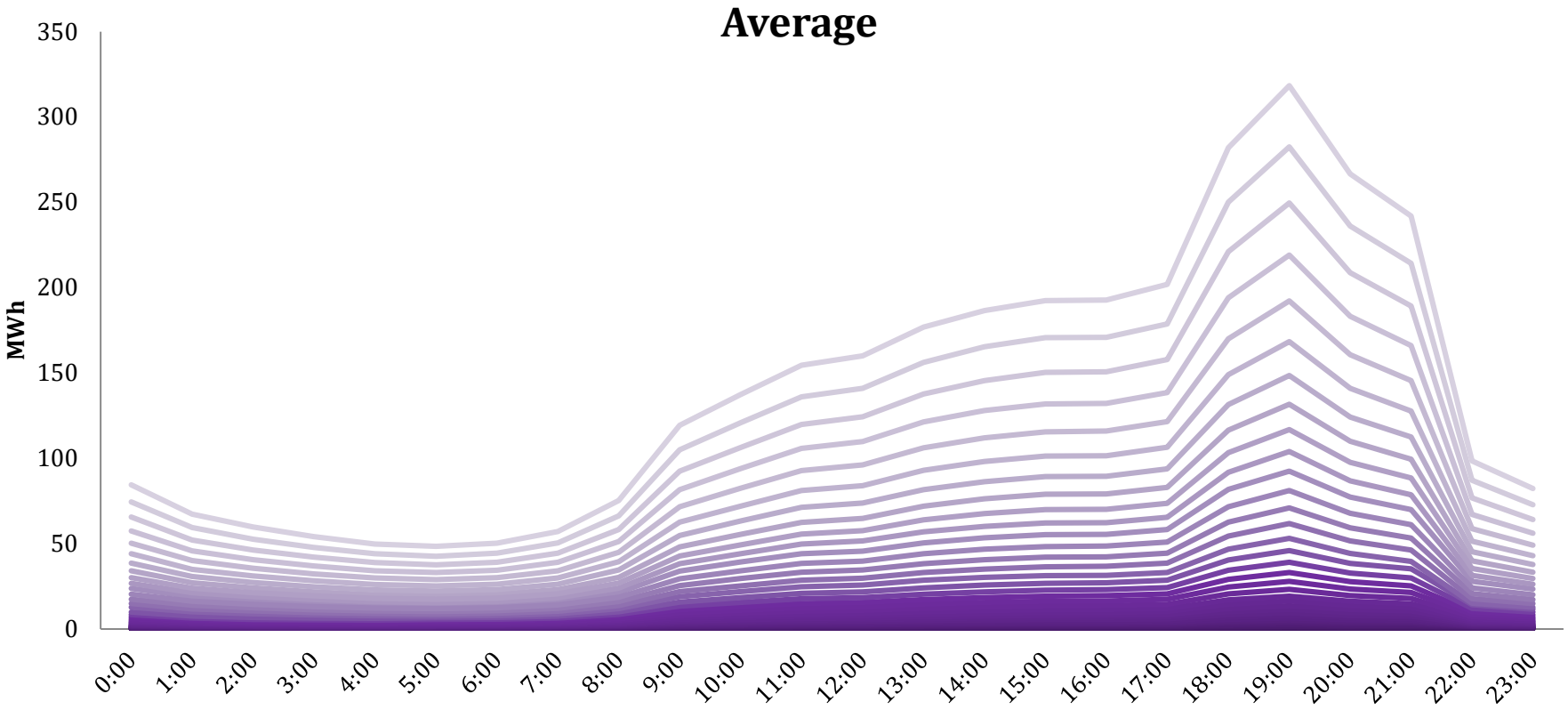
Aggregate Profiles



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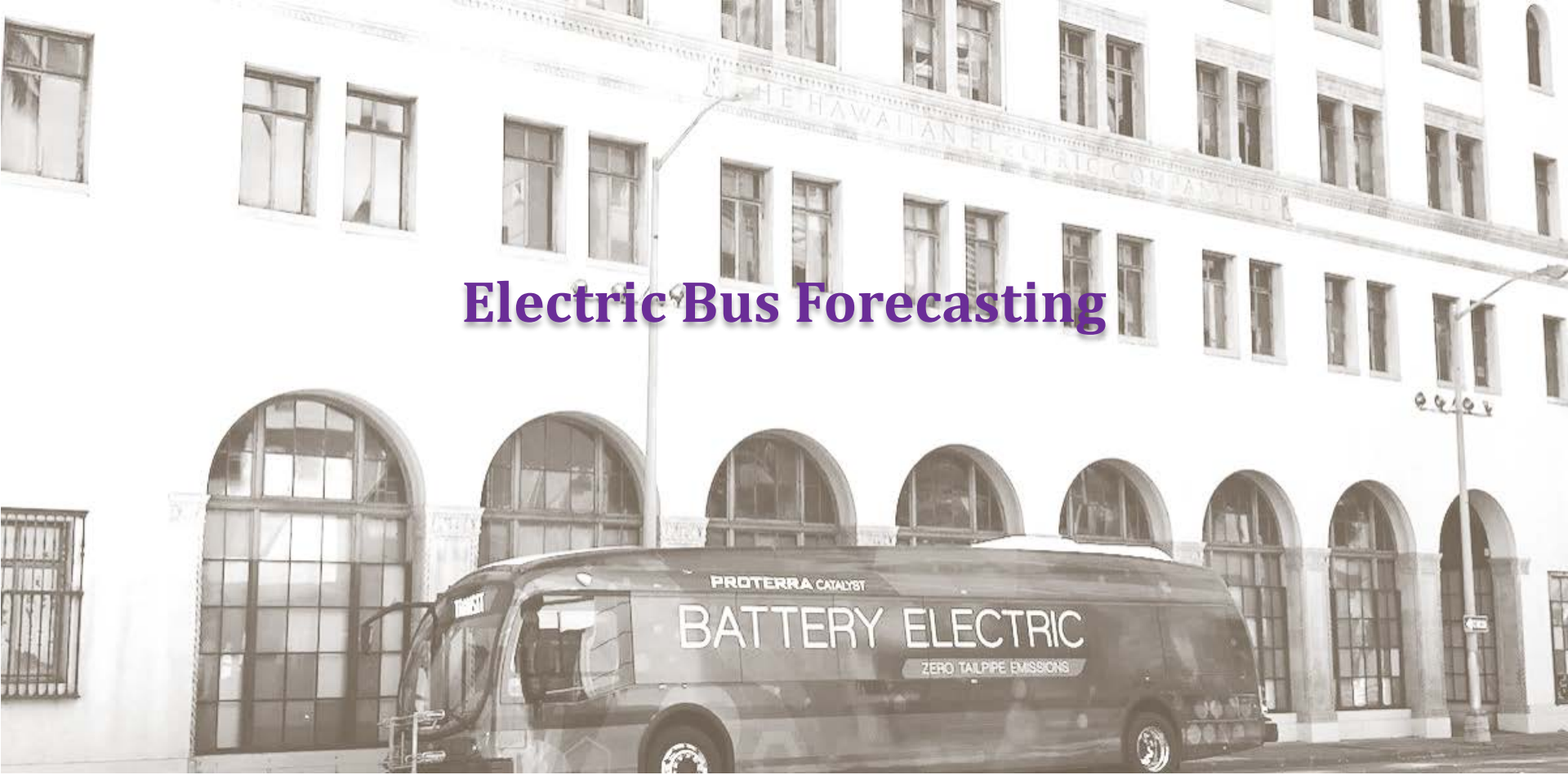
Electric Bus Forecasting



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Method

Collaborative discussions to gather preliminary assumptions on future state of EV Bus fleets.

Data analysis and forecasting to determine potential impact to sales and hourly load demands.

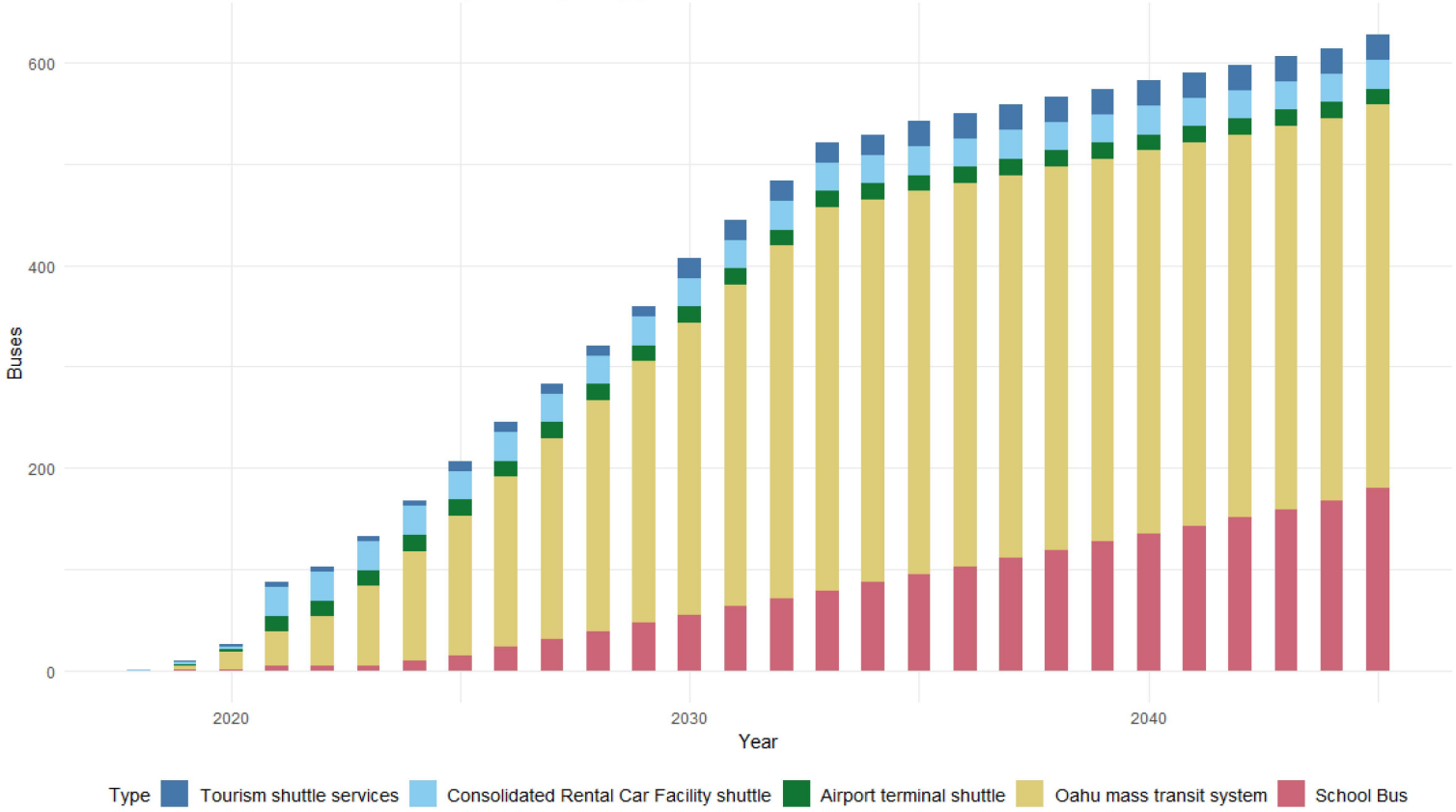
Generate ideas between partners to develop charging rates to align impact to customers' bills with grid needs.

Representative blend of major types of buses evaluated in Hawaii.

- Shuttle services; tourism market
- Oahu mass transit system
- Public school bus transportation
- Airport terminal and Consolidated Rental Car Facility (CONRAC) shuttle system

Electric Bus Forecast

Annual EV Bus counts by company, 2018-2045



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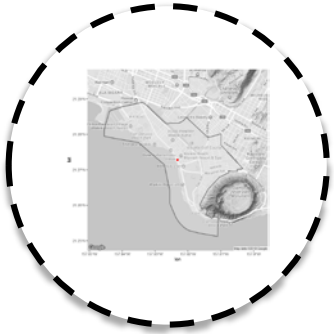
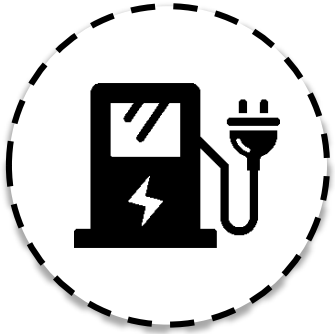
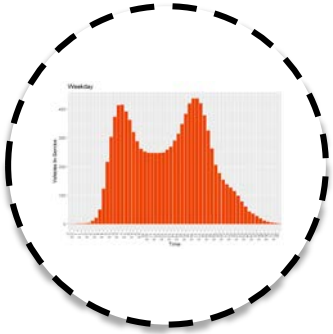
Assumptions were developed by considered multiple factors.



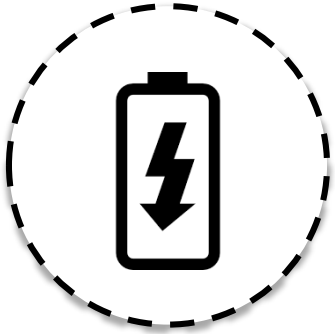
Route Information
Miles traveled



Location of chargers
(bulk/opportunity)



Operating Hours



Technical Specifications
(Battery size, charging rate, kWh/mi.)

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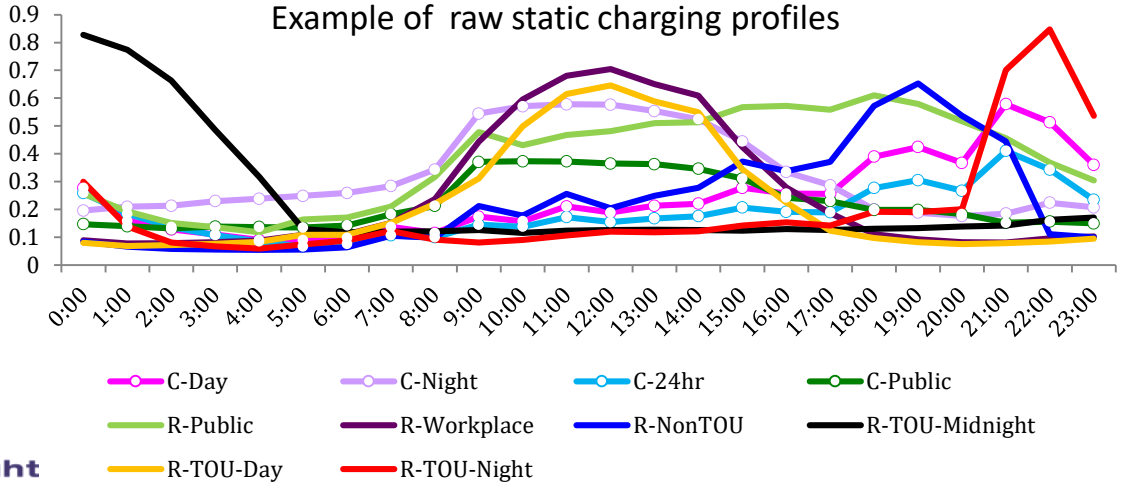
Charging shapes were then developed

- Utilizing unitized charging profiles from light duty vehicle forecast.
- Raw profiles blended to create a starting point for e-bus charging.
- Energy used for charging is placed under the charging curve.
- Long-term forecasts were developed by weekday, weekend and holidays for each bus operator to assess load and impact to peaks by circuit.



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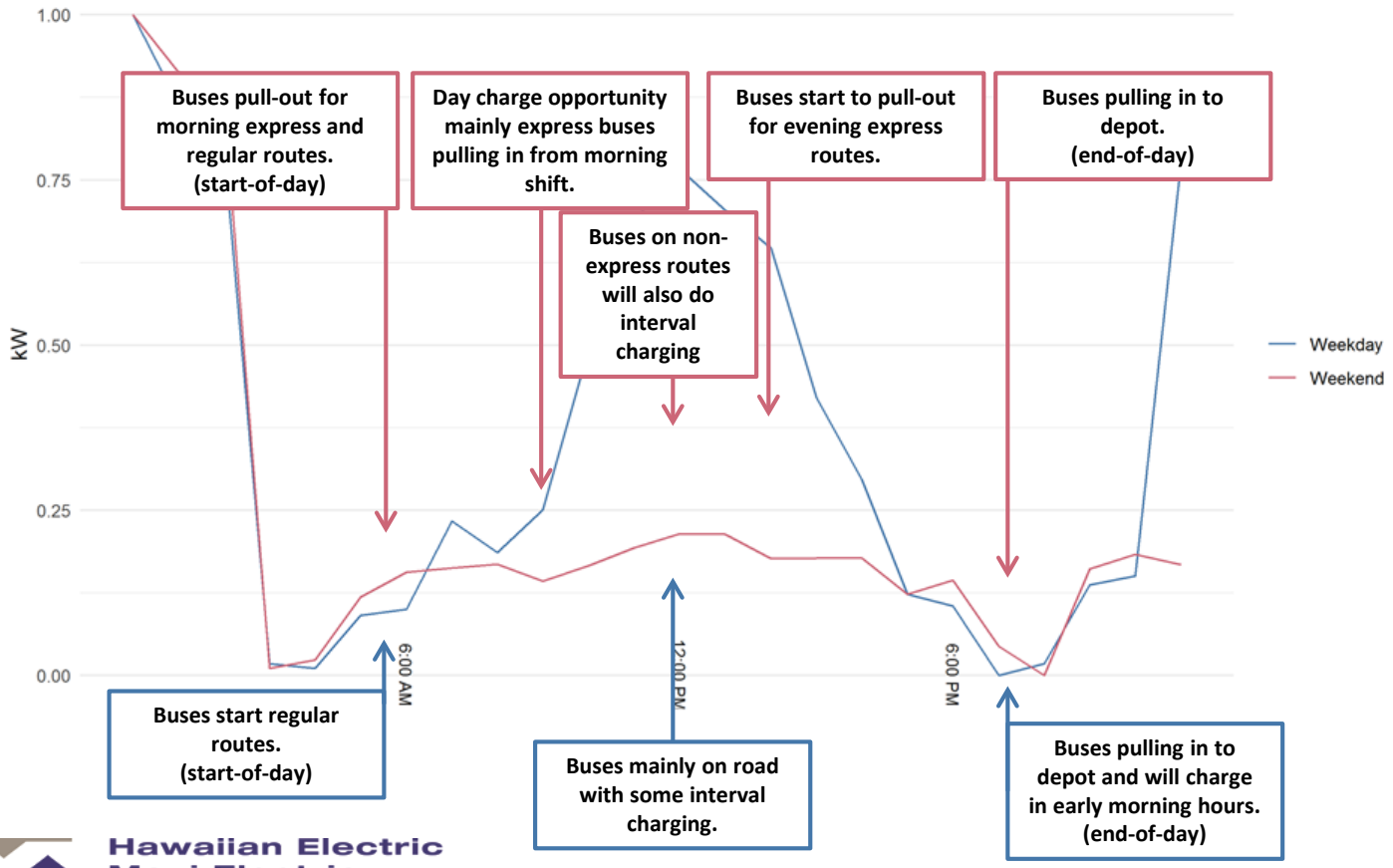
Electric Bus Charging Profile Example

24 hour EV charging profile; weekend vs. weekday



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Forecasting Methods
Hourly Forecast

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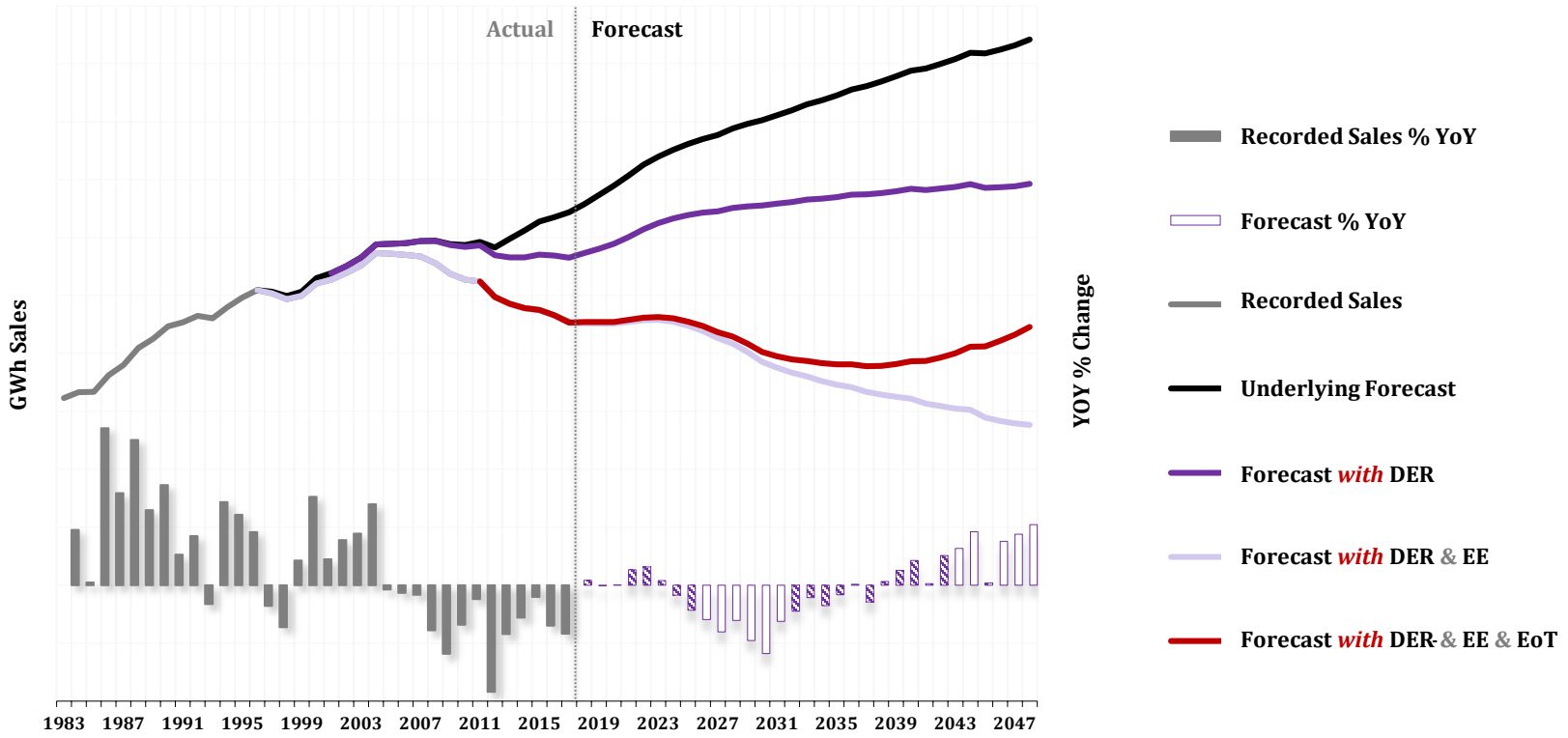
Sales Forecast with Layers



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Hourly Shape Method

Determine Class Shapes

- Class load study hourly shapes by rate class, no impact of PV
- Hourly regression models using independent variables: weather, month, day of the week, holidays
- Simulate future shapes for each rate class with independent variable assumptions

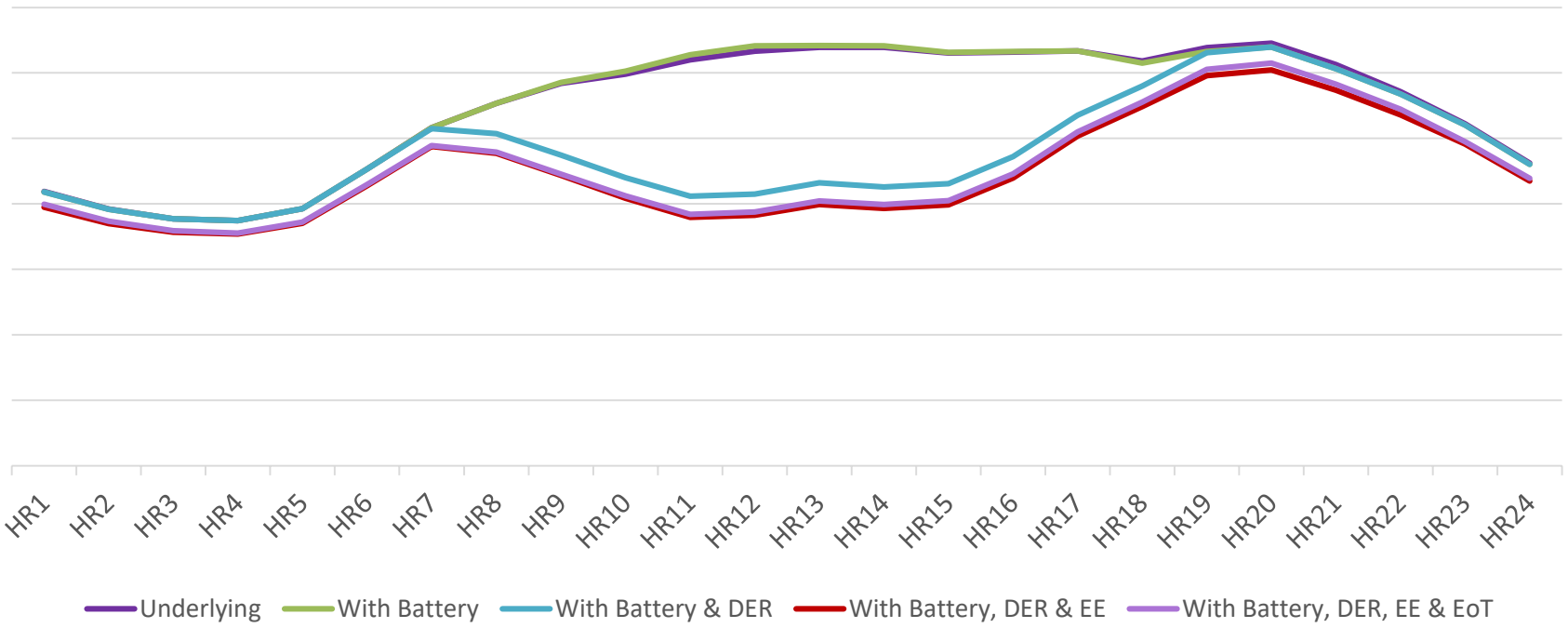
Layers

- Layer shapes: DER (PV), Battery load shift, EE, EoT, future layers?
- Possible to have multiple shapes by layer

Future Hourly System Load

- Input: monthly energy, future load shapes, loss factor
- Result: hourly net system load for entire forecast period

Hourly Profile By Layer



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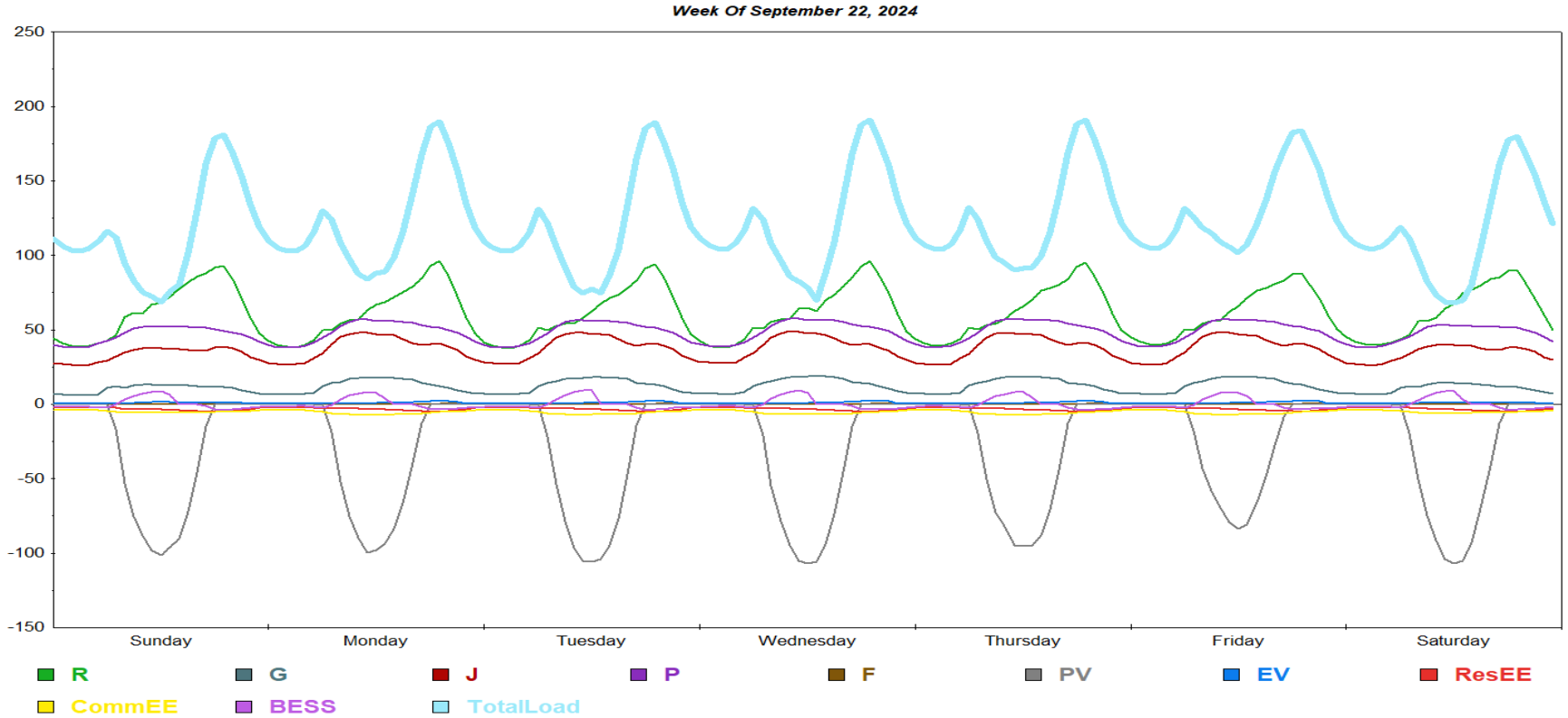
Hourly Profile By Layer



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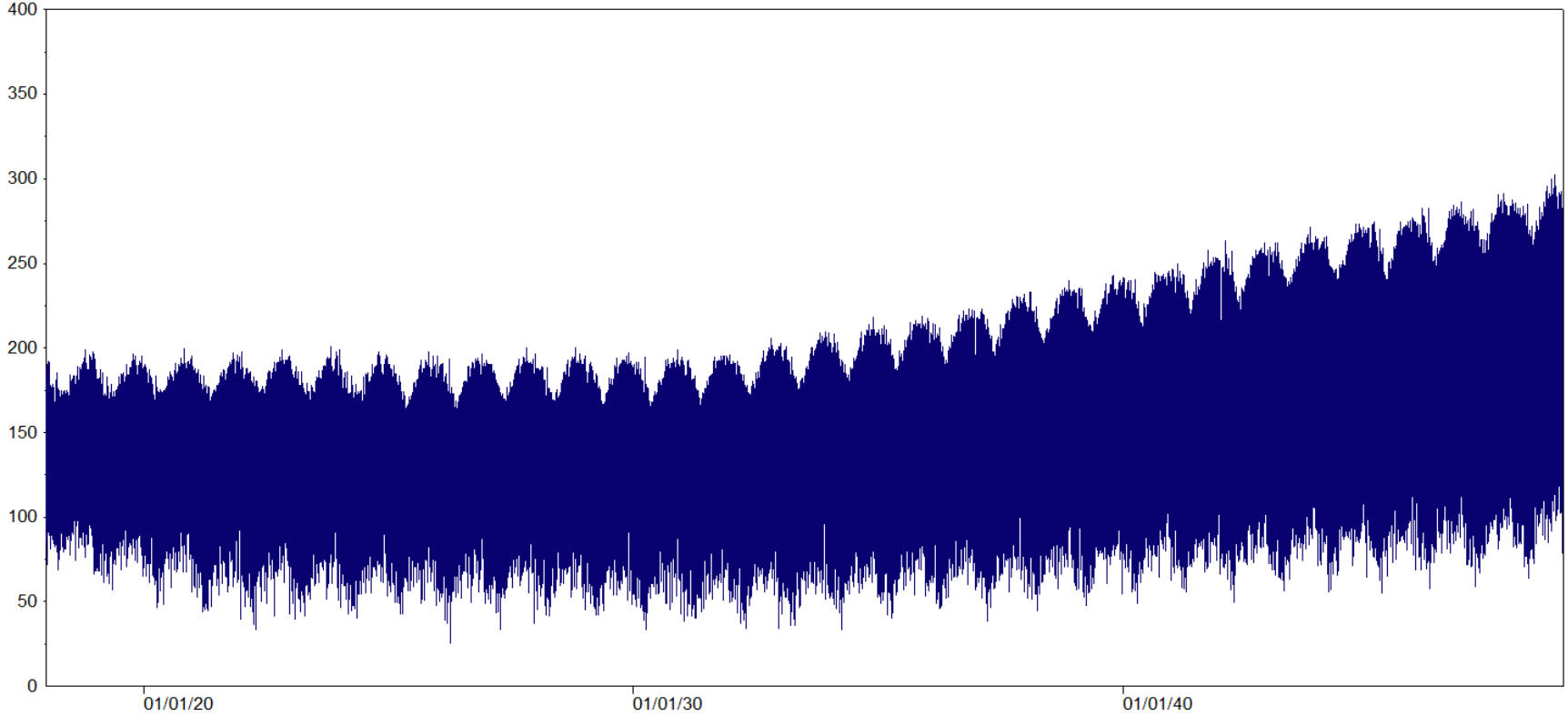
Hourly System Load Over Forecast Horizon



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IGP Forecast Assumptions Working Group

Forecast Methodologies

◆ Welcome and Overview	9:00 – 9:10
◆ Forecast Methods (Underlying & DER)	9:10 – 10:05
Break	10:05 – 10:20
◆ Forecast Methods (EE, EoT & Summary)	10:20 – 10:55
◆ Forecast Methods from Other Utilities	10:55 – 11:55
– ERCOT	
– NV Energy	
– Portland General	
– SMUD	
◆ Wrap-up	11:55 – 12:00

Next Steps

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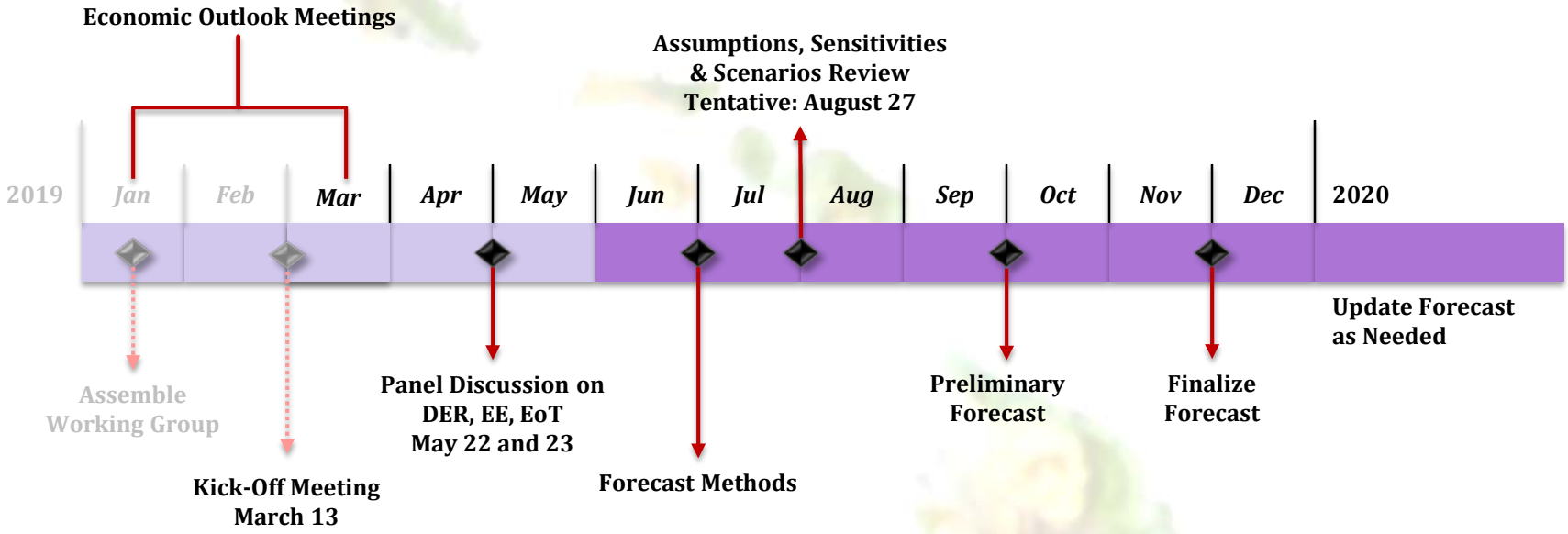
Next Steps


Economic Outlook Meetings
Assumptions, Sensitivities & Scenarios Review Tentative: August 27
2019
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2020
Update Forecast as Needed
Assemble Working Group
Kick-Off Meeting March 13
Panel Discussion on DER, EE, EoT May 22 and 23
Forecast Methods
Preliminary Forecast
Finalize Forecast


Mahalo!
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Hawai'i Electric Light

Scenario Based Long-Term Load Forecasting

Calvin Opheim

July 17, 2019
Forecasting Assumptions Working Group

Agenda

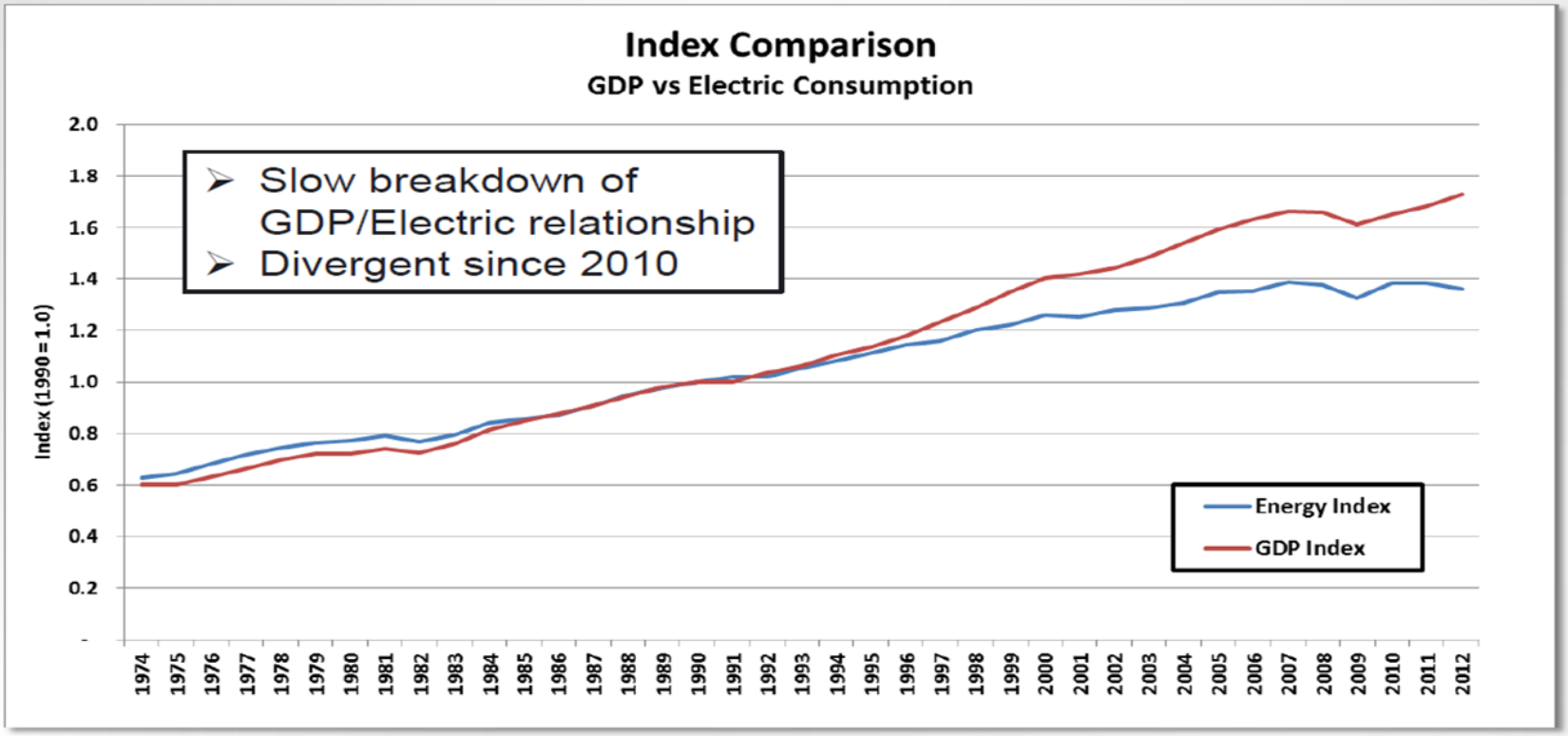
- History
- Scenario based forecasting
- 2018 Long-Term System Assessment (LTSA)
- Questions

Past

- Load forecasting was generally straight forward
- Could forecast pretty much with a linear regression

Past

GDP VS. ELECTRIC RELATIONSHIP



Itron

Past

- The breakdown or divergence between energy forecasts and economic variables was initially branded as the “job less” economic recovery

Today

- Other forces are impacting load forecasting
  - Roof top PV
  - Electric Vehicles
  - Batteries
  - Smart devices

- How do we account for all of these?

Scenario Based Forecasting

- A DOE project was funded for the ERCOT region in 2010
  - To improve its capability to conduct long-range transmission planning
  - Develop more rigorous long-term plans that reflect the diverse views of the stakeholder community

Scenario Based Forecasting

- ERCOT expanded the study period from 10 to 20 years
  - Because longer-term forecasts are more uncertain, ERCOT examined numerous scenarios to capture a broad range of possible futures
  - Develop more rigorous long-term plans that reflect the diverse views of the stakeholder community

Long-Term System Assessment (LTSA)

- Scenarios
  - Created in a collaborative manner through meetings with Market Participants
  - Include load impacts such as high growth industries and areas, rooftop PV, energy storage, electric vehicles, demand response, energy efficiency, extreme weather, recession, etc.
  - Fuel/technology prices, environmental regulations, capital costs, DC Tie additions, etc.

Long-Term System Assessment (LTSA)

- The results were not definitive statements of what ERCOT expected to happen but rather what might happen in the future

Long-Term System Assessment (LTSA)

- The Long-Term System Assessment (LTSA) is a planning study conducted by ERCOT System Planning per its obligation under PURA Section 39.904[1] and the ERCOT Planning Guide. The LTSA analyzes system conditions 10 to 15 years in the future and uses a scenario-based approach to transmission planning, in which ERCOT Planners study the economic and reliability needs of the system across a wide range of scenarios.

Long-Term System Assessment (LTSA)

- Planners may use the bases cases developed in this study to evaluate large transmission additions to the ERCOT System. Additionally, the study will help facilitate communication and understanding of long-term transmission needs among stakeholders.
- Primary focus is on the 345 kV system

Long-Term System Assessment (LTSA)

- Section 39.904(k) of the Public Utility Regulatory Act states that the commission and the independent organization certified for ERCOT shall study the need for increased transmission and generation capacity throughout this state and report to the legislature the results of the study and any recommendations for legislation. The report must be filed with the legislature not later than December 31 of each even-numbered year.

2018 LTSA Scenarios

- Current Trends
- High Renewable and Distributed PV Growth
- High Economic Growth
- High Renewable Costs
- Emerging Technology

1. Scenario: Current Trends

Economic Growth
- 1.3% annual net of all factors affecting the system
- Industrial growth in Houston area
- Oil and gas and mid-stream development in west Texas area continues at moderate pace
- Average GDP growth in line with long-term average
- LNG growth based on permits existing
- Average weather assumptions used

Environmental Regulation
- Ozone, SO2 (NAAQs)- Implementing Current Regulations through 2025, SO2 non-attainment area
- Low emission cost on SO2, NOx, CO2
- 10$/ton Carbon throughout study horizon

Alternative Generation
- Renewable incentives expire as scheduled (2022)
- Increase in investment then slow to declining in rate of increase after 2022
- Limit capacity addition to 3000 MW wind and 1500 MW of solar annually
- Use Lazard assumptions for Storage

Technology
- No breakthroughs – steady modest cost improvements
- Only known potential DC tie (Southern Cross) added in the East

Government policy/mandate
- No reserve margin set for ERCOT
- Maintain energy-only market
- Economic retirements continues based on economics

End-Use
- Energy efficiency spending rises slowly to a rate of 0.25%/year
- Distributed generation increases to 2.5 GW by 2033
- Moderate increase in Demand Response

Natural Gas Price
- 2017 High Oil & Gas Production case from the 2017 EIA AEO

2. Scenario: High Renewable and Distributed PV Penetration

Economic Growth
- 1.3% annual net of all factors affecting the system
- Industrial growth in Houston area
- Oil and gas and mid-stream development in west Texas area continues at moderate pace
- Average GDP growth in line with long-term average
- LNG growth based on permits existing
- Average weather assumptions used

Environmental Regulation
- Ozone, SO2 (NAAQs)- Implementing Current Regulations through 2025, SO2 non-attainment area
- Low emission cost on SO2, NOx, CO2
- 20-40/ton Carbon throughout study horizon

Alternative Generation
- Renewable incentives continue through the study horizon
- Increase in investment then slow to declining in rate of increase after 2022
- Increase capacity addition to value greater than Current Trends

Technology
- No breakthroughs – steady modest cost improvements
- Only known potential DC tie (Southern Cross) added in the East

Government policy/mandate
- No reserve margin set for ERCOT
- Maintain energy-only market
- Economic retirements continues based on economics

End-Use
- Energy efficiency spending rises to a rate of 1%/year due to more aggressive building codes
- Distributed generation increases to 18 GW by 2033
- Moderate increase in Demand Response

Natural Gas Price
- 2017 High Oil Production case from the 2017 EIA AEO

3. Scenario: High Economic Growth

Economic Growth
- 1.8% annual net of all factors affecting the system
- Higher Industrial growth in Houston area (Gulf coast block load additions of 200 MW every 5 years)
- Oil and gas and mid-stream development in west Texas area picks up steam (at 1000 MW by 2018)
- Average GDP growth in line with long-term average
- LNG growth continues (4th train at Freeport, New terminal in Corpus Christi (500 MW) and Brownsville area (800 MW)

Environmental Regulation
- Ozone, SO2 (NAAQs)- Implementing Current Regulations through 2025, SO2 non-attainment area
- Low emission cost on SO2, NOx, CO2
- 10$/ton Carbon throughout study horizon

Alternative Generation
- Renewable incentives expire as scheduled (2022)
- Lower capital cost than Current Trends
- Limit capacity addition to lower than Current Trends
- Use Lazard assumptions for Storage

Technology
- No breakthroughs – steady modest cost improvements
- Only known potential DC tie (Southern Cross) added in the East

Government policy/mandate
- No reserve margin set for ERCOT
- Maintain energy-only market
- Economic retirements continues based on economics

End-Use
- Energy efficiency spending rises slowly to a rate of 0.25%/year
- Distributed generation increases to 3 GW by 2033 (slightly higher than Current Trends)
- Moderate increase in Demand Response

Natural Gas Price
- Higher than Current Trends
- Average of 2017 Ref and HOG case from the 2017 EIA AEO

4. Scenario: High Renewable Costs

Economic Growth
- 1.3% annual net of all factors affecting the system
- Industrial growth in Houston area
- Oil and gas and mid-stream development in west Texas area continues at moderate pace
- Average GDP growth in line with long-term average
- LNG growth based on permits existing
- Average weather assumptions used

Environmental Regulation
- Ozone, SO2 (NAAQs)- Implementing Current Regulations through 2025, SO2 non-attainment area
- Low emission cost on SO2, NOx, CO2
- 10$/ton Carbon throughout study horizon

Alternative Generation
- Renewable incentives expire sooner than Current Trends
- Capital costs higher than Current Trends; especially for Solar based on a potential import tariff
- Limit capacity addition to 3000 MW wind and 1500 MW of solar annually

Technology
- No breakthroughs – steady modest cost improvements
- Only known potential DC tie (Southern Cross) added in the East

Government policy/mandate
- No reserve margin set for ERCOT
- Maintain energy-only market
- Economic retirements continues based on economics

End-Use
- Energy efficiency spending rises slowly to a rate of 0.25%/year
- Distributed generation lower than Current Trends
- Moderate increase in Demand Response

Natural Gas Price
- 2017 High Oil Production case from the 2017 EIA AEO

5. Scenario: Emerging Technology

Economic Growth
- 1.3% annual net of all factors affecting the system
- Industrial growth in Houston area
- Oil and gas and mid-stream development in west Texas area continues at moderate pace
- Average GDP growth in line with long-term average
- LNG growth based on permits existing
- Average weather assumptions used

Environmental Regulation
- Ozone, SO2 (NAAQs)- Implementing Current Regulations through 2025, SO2 non-attainment area
- Low emission cost on SO2, NOx, CO2
- 10$/ton Carbon throughout study horizon

Alternative Generation
- Renewable incentives expire as scheduled (2022)
- Increase in storage, some co-located with renewable generation
- Increase in investment then slow to declining in rate of increase after 2022
- Limit capacity addition to 3000 MW wind and 1500 MW of solar annually
- Use Lazard assumptions for Storage

Technology
- EV penetration of 3 million vehicles on Texas roads by 2033. Some with vehicle to grid enabled
- Second-life EV batteries installed in residential locations
- Only known potential DC tie (Southern Cross) added in the East

Government policy/mandate
- No reserve margin set for ERCOT
- Maintain energy-only market
- Economic retirements continues based on economics

End-Use
- Energy efficiency spending rises slowly to a rate of 0.25%/year
- Distributed generation increases greater than Current Trends by 2033
- Moderate increase in Demand Response

Natural Gas Price
- 2017 High Oil Production case from the 2017 EIA AEO

2018 LTSA Scenario Summary

Category	Assumption	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
General	**Scenario Name**	**Current Trends**	**High Renewable and Distributed PV Penetration**	**High Economic Growth**	**High Renewable Costs**	**Emerging Technology**
Load	System Load Growth	Average	Same as Current Trends	High	Same as Current Trends	Same as Current Trends
	LNG export additions	Known	Same as Current Trends	High	Same as Current Trends	Same as Current Trends
Policy	Environmental Regs	Ozone, SO2 (NAAQs)	Same as Current Trends	Same as Current Trends	Same as Current Trends	Same as Current Trends
	Emission Cost	Low	Medium	Same as Current Trends	Same as Current Trends	Same as Current Trends
	Renewable incentives	Medium	High	Same as Current Trends	Low	Same as Current Trends
	DC Tie additions	Add known DC tie	Same as Current Trends	Same as Current Trends	Same as Current Trends	Same as Current Trends
End Use	Distributed PV	Low	High	Medium	Lower than Current Trends	High - EV with Storage
	EE Growth	Low	High	Same as Current Trends	Same as Current Trends	Same as Current Trends
	DR Growth	Medium	Same as Current Trends	Same as Current Trends	Low	Low
Renewables	Capital cost	Medium	Low	Low	High	Low cost storage
	Annual Cap. Limitation	Medium	High	Same as Current Trends	Low	Same as Current Trends
Fuel Prices	NG price forecast	2017 HOG	Same as Current Trends	Medium	Same as Current Trends	Same as Current Trends

Load Forecast Scenarios

	Summer Peak (MW)		
	Current Forecast	Higher Overall Growth	Industrial Growth
2017	72,934		
2018	74,149	74,514	74,349
2019	75,588	76,333	75,988
2020	76,510	77,645	76,910
2021	77,417	78,954	77,817
2022	78,377	80,328	78,777
2023	79,348	81,724	80,503
2024	80,315	83,129	81,470
2025	81,261	84,523	82,416
2026	82,286	86,012	83,441
Average Annual			
Growth Rate	1.3%	1.8%	1.5%

Current forecast methodology includes:

- 200 MW of Load Management
- 150 MW of Energy Efficiency
- 200 MW of behind the meter DG

Higher Overall Growth – increases current forecast growth rate by 0.5% per year.
Industrial Growth – increases current forecast for large industrial loads:

1) 200 MW in the Permian Basin in 2018 on
2) 200 MW in the Gulf Coast in 2019 on
3) 755 MW for LNG in 2023 on (500 in South, 255 in Coast)

2018 LTSA: The process

Scenario Development

- Review trends and forecasts
- Expert presentations with focus on key drivers for current LTSA
- Finalize scenario descriptions and assumptions for current LTSA

Load forecasting

- Develop 8760-hour load forecasts for each scenario with normal weather assumptions
- Develop 90th percentile summer peak forecast for each scenario

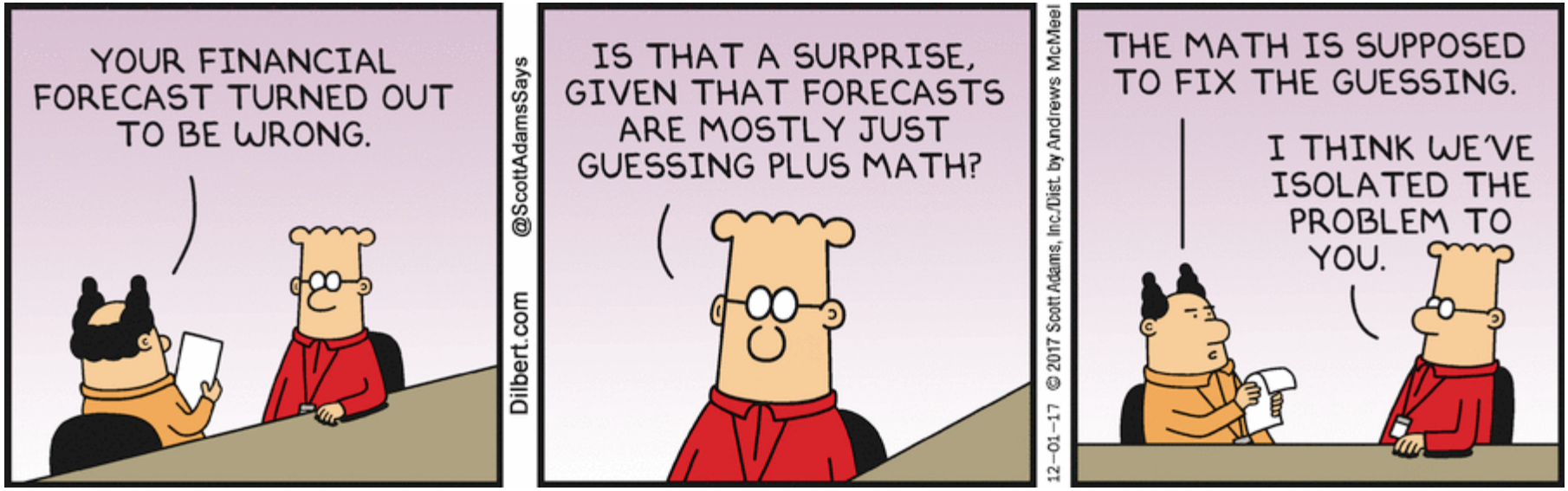
Generation Expansion

- Identify amount of generation added and retired by technology based on scenario description
- Identify potential sites for new generation

Transmission Analysis

- Build start cases based on the LTSA Scope and scenario descriptions
- Perform reliability analysis
- Perform economic analysis
- Identify transmission projects to address economic and reliability needs

Questions?


YOUR FINANCIAL FORECAST TURNED OUT TO BE WRONG.
IS THAT A SURPRISE, GIVEN THAT FORECASTS ARE MOSTLY JUST GUESSING PLUS MATH?
THE MATH IS SUPPOSED TO FIX THE GUESSING.
I THINK WE'VE ISOLATED THE PROBLEM TO YOU.
Dilbert.com @ScottAdamsSays
12-01-17 © 2017 Scott Adams, Inc./Dist. by Andrews McMeel

Portland General Electric Overview

Quick facts

- Vertically integrated electric company
- 887,000 customers in 51 Oregon incorporated cities
- 46 percent of Oregon's population lives within PGE service area
- 75 percent of Oregon's commercial and industrial activity occurs in PGE service area

Load Information

- 2018 peak demand of 3,816 MW
- Energy deliveries approximately 40% residential
- Installed customer sited rooftop PV capacity of approx. ~100 MW DC

Service territory

Energy Deliveries Forecast: Approach

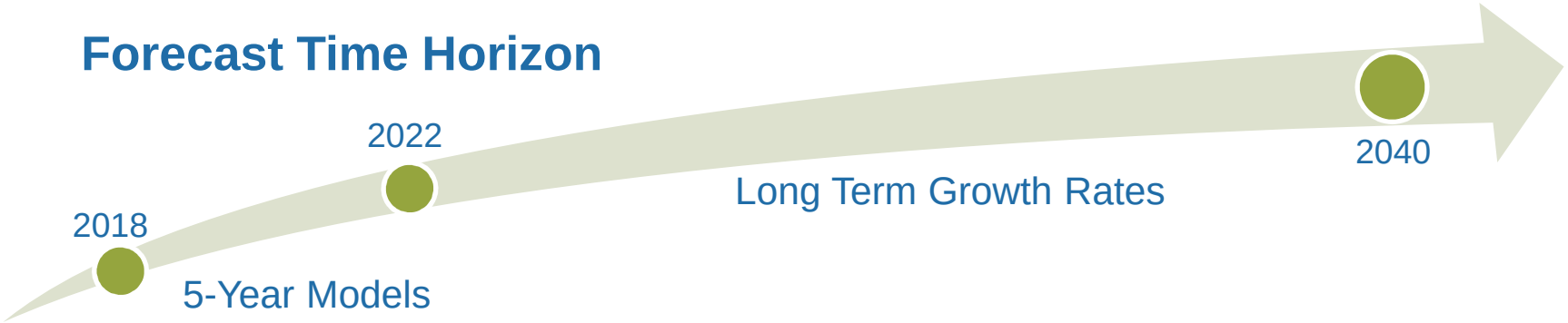
Near Term (1-5 Years)

- 25 regression-based monthly energy deliveries models
- Business cycle influences energy deliveries
- Adjusts for any known large customer changes and miscellaneous schedules
- Explicitly removes incremental energy efficiency
- Updated multiple times per year

Long Term (5+ Years)

- Convergence to long term growth rates, agnostic to business cycle and specific customer changes
- Three aggregated customer class models (by energy deliveries voltage, or revenue class) determine long term growth rates
- Assumes energy efficiency is embedded in growth rates
- Updated for IRP Cycle

Forecast Time Horizon



Energy Deliveries Forecast: Integration of DER's

Distributed Resource and Flexible Load Study

- Performed by Navigant
- Scope included Energy Efficiency*, Demand Response, Solar, Storage and Transportation Electrification

Integration into Load Forecast

- To combine this analysis with PGE's econometric forecast, PGE took the following approach
  - Assume EVs and passive DER embedded in the top-down forecasts as equal to the 2018 estimated values
  - Layer the incremental impacts from the Navigant analysis to PGE's forecast

* Navigant's study provided additional analysis on energy efficiency scenarios, PGE's base case EE forecast is provided by the Energy Trust of Oregon, a nonprofit organization that administers efficiency programs in Oregon.

Discussion Regarding SMUD DER Forecasting

Hawaii Utilities Integrated Grid Planning Forecast Assumptions Working Group

Patrick McCoy
Strategic Business Planner
July 17, 2019

Powering forward. Together.

SMUD

DER Forecasting Discussion

- Forecasting method
  - Data
  - Forecasting horizon
  - Customer treatment
  - Granularity
  - Constraints
- Forecast modeling
  - Techniques
  - Market potential
- Forecasting impacts
  - Tariffs, programs, incentives
  - Degradation, replacement
  - Other constraints

SMUD™

Forecasting Method

- Data
  - Metered hourly interval
  - PV production
  - LiDAR
  - Distribution grid
    - Feeder
    - Substation
    - Service Transformer
  - Customer billing
  - Customer identifier
    - Account
    - Meter number
    - Premise
    - Device location number (DLN)
  - PRIZM *(residential)*
- Business systems, processes and competencies

Forecasting Method

- Forecasting horizon
  - Customer programs and services – 3 years
  - Distribution planning – 5 years
  - Load forecasting and resource planning – 20 years
- Customer treatment
  - Residential: PRIZM segmentation, propensities
  - Commercial: currently economics (financial payback)
- Granularity
  - Currently feeder level, moving towards customer segments and aggregating up
- Forecast constraints

Forecasting Method – Modeling Technique

- Currently: linear multi-variate regression model
  - Bass technology diffusion model utilized for first adoption forecast
- Migrating to: logistic regression model
- Developing DER adoption forecasting tool with Clean Power Research

$$p_t^k = \beta^0 + \beta^1 x_t^{k,1} + \beta^2 x_t^{k,2} + \cdots + \beta^n x_t^{k,n}$$

Probability that remaining customer *k* will adopt in year *t*

Weighting factor

Predictive variable, evaluated for customer *k* in year *t*

Forecasting Method – Market Potential

- Technical potential
  - Capacity
  - PV energy production
- Economic potential
  - Financial assumptions
  - Payback analysis
- Market potential
  - Predictive analytics
  - Adoption curves

Forecasting Impacts

- Tariffs, programs and incentives
  - Net energy metering
  - Tariff rate structure
  - Fees and surcharges
- PV degradation and replacement
  - Degradation algorithm
  - Replacement? Expansion of existing system?
- Other
  - Technology cost curves
- Currently built into tool (scenario builder)

Thank You!

Patrick McCoy
Strategic Business Planner
Energy Strategy Research and Development
Grid Strategy and Operations

Patrick.McCoy@smud.org