Committee on Energy Resources and the Environment

There’s a Major Change Headed Our Way: Forecasting DERs for Planning Purposes

NARUC Summer Policy Summit

Forecasting DERs for Planning Purposes

Juliet Homer, P.E.

Pacific Northwest National Laboratory

NARUC Summer Policy Summit 2019
Committee on Energy Resources and the Environment
July 23, 2019

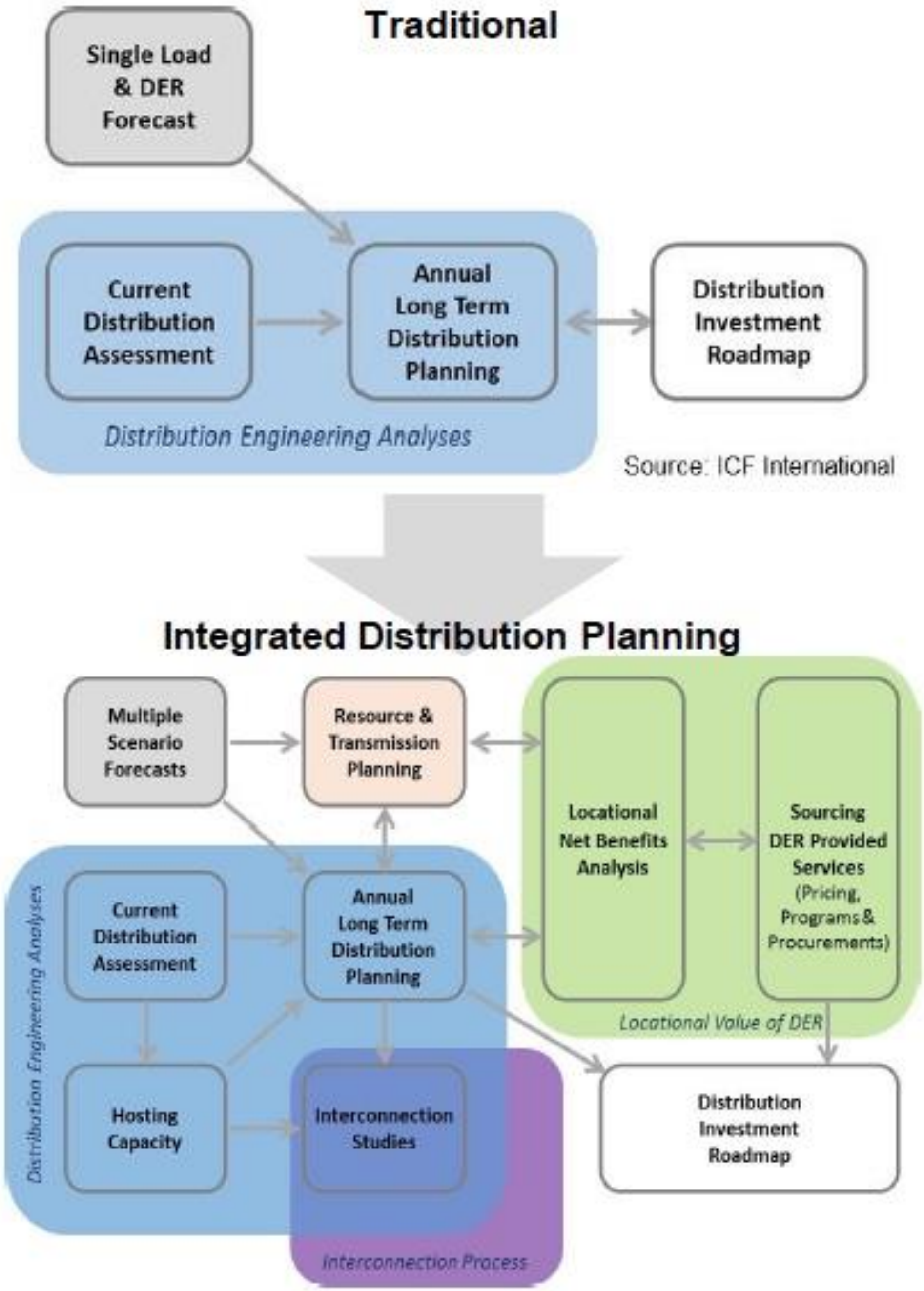
Historical context

- Utilities have been doing Integrated Resource Planning for years
  - Whole system electricity demand is projected over a planning horizon
  - Generation and demand side management options are evaluated for meeting whole system demand
- Utilities have always engaged in distribution system planning to assess needed physical and operational changes to local grids to maintain safe, reliable and affordable service
  - Typically short planning horizons and minimal involvement of regulators
- Some utilities have engaged in planning in more of a reactive way – e.g., creating plans for a new housing development
- Some distribution system planning has been done in piecemeal or siloed way – poles and wires needs and inventories separate from substation needs and inventories

Move Toward Advanced or Integrated Distribution Planning

- ➢ Develop multiple scenarios to address uncertainty in customer loads and DER growth and types
- ➢ Identify distribution hosting capacity
- ➢ Identify potential to use services from DER providers and the grid investments required to enable these services
- ➢ Evaluate alternatives to grid upgrades (e.g., for load relief)
- ➢ Engage stakeholders
- ➢ Coordinate distribution planning with other processes

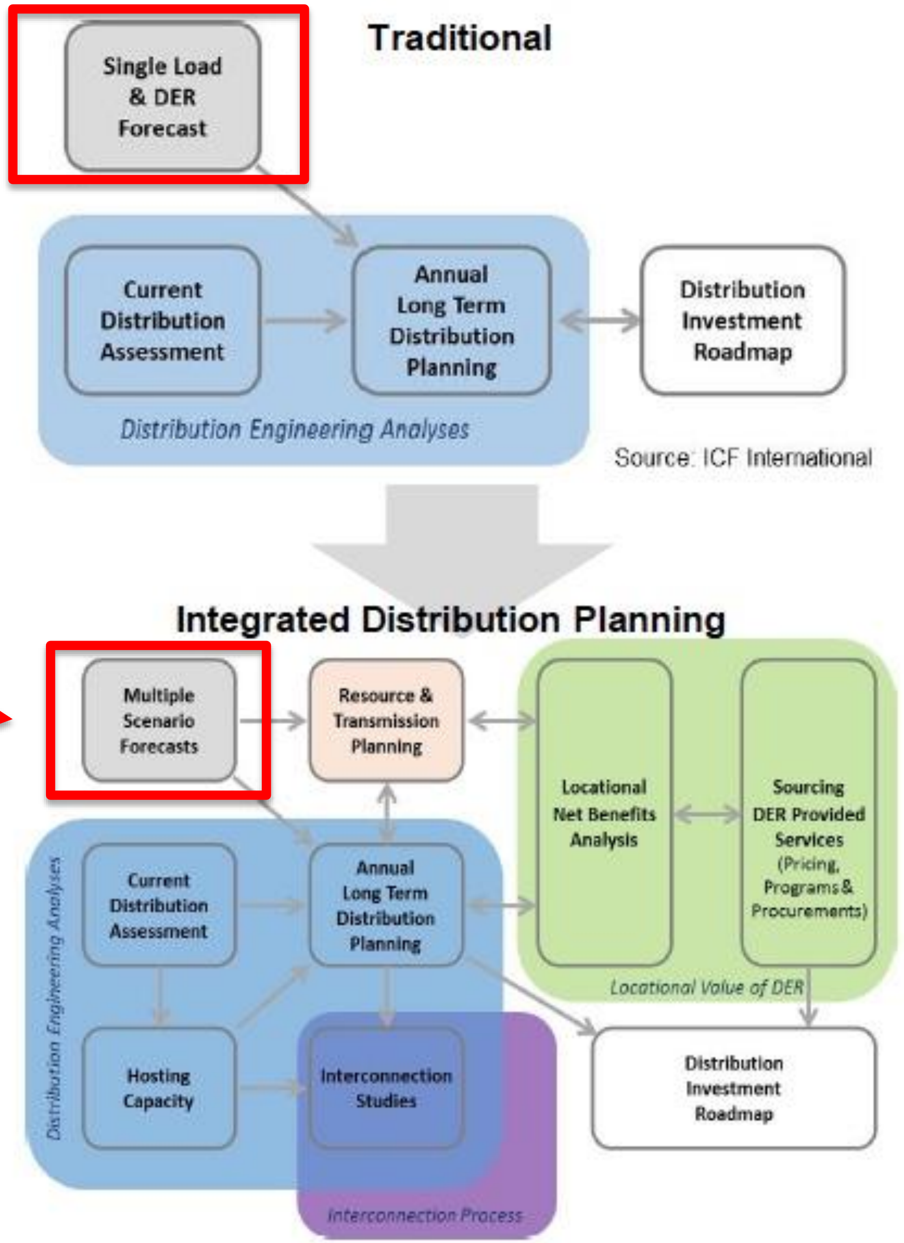
DOE's Modern Distribution Grid initiative
I. Customer and State Policy Driven Functionality
II. Advanced Technology Market Assessment
III. Decision Guide



Source: Lisa Schwartz at LBNL PUC Distribution System Planning Practices, March 2019
Paul De Martini (ICF) for Minnesota Public Utilities Commission, *Integrated Distribution Planning*, 2016

Move Toward Advanced or Integrated Distribution Planning

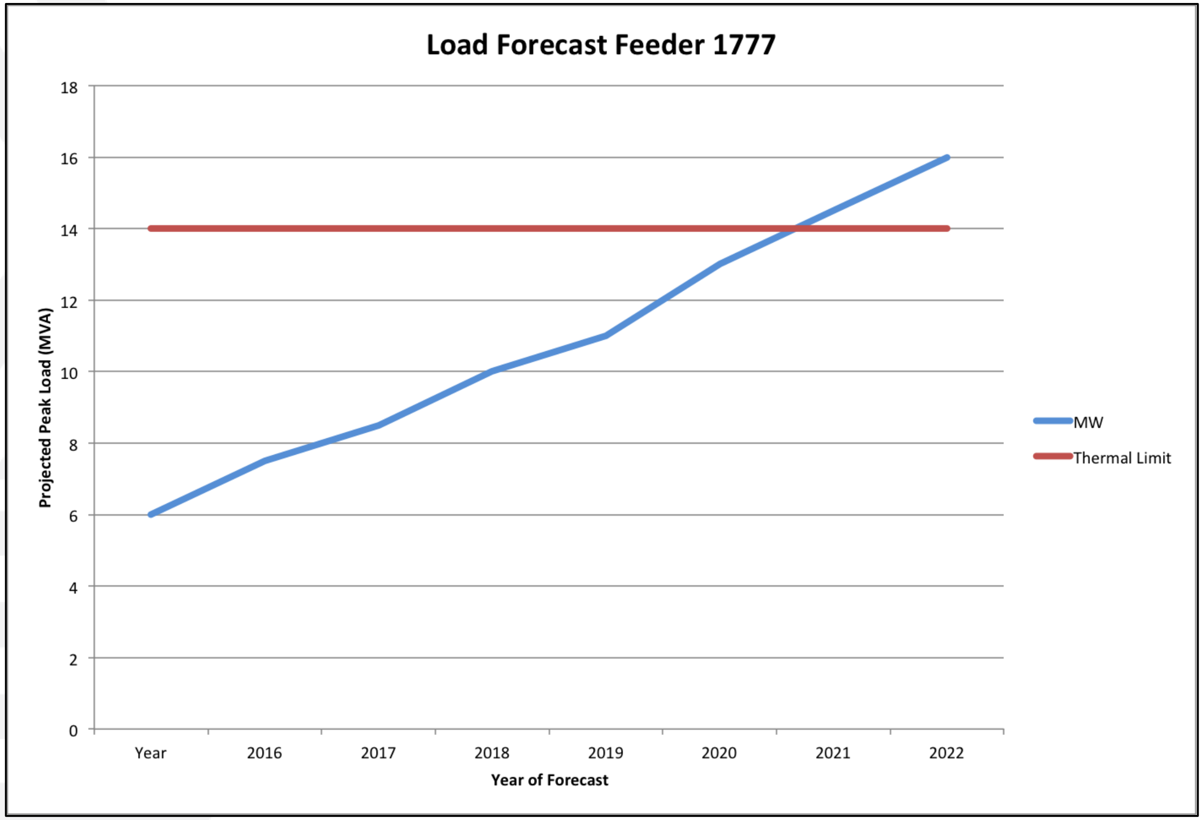
It all starts with load and DER forecasts



Source: Paul De Martini (ICF) for Minnesota Public Utilities Commission, *Integrated Distribution Planning*, 2016

Traditional Load Forecasting

- ► Track peak loads (using SCADA data)
- ► Evaluate each distribution feeder for annual growth and new loads
- ► Feeder load forecasts aggregated to show substation status, need for expansion
- ► Substations may require upgraded transformers, new transformer banks, transmission, distribution equipment
- ► Traditional load growth projections are commonly included in utility tools (e.g., Cyme, Synergi, Milsoft)



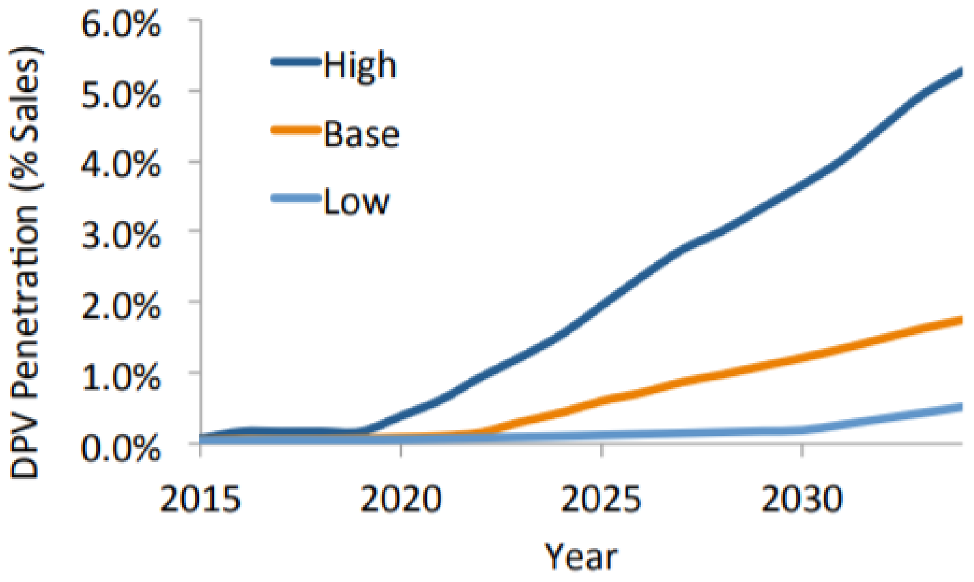
Source: Michael Coddington, Distribution System Planning 101 NREL, March 2019

Traditional DER Forecasting

- Traditional DER forecasting has been based on:
  - Historical trends
  - Specific targets set by policy or program goals
  - Regression-based approaches applied at the service area level
  - Planners judgement
- These rely on few or no quantifiable predictive factors and may not be sufficiently robust for planning purposes going forward.
- Forecasting load and DER often happens in a “top-down” way, separately forecasting load and quantity of DER at the system level, and then allocating that system forecast down to more granular levels.

More Advanced Load and DER Forecasting

- There is a move to more <u>granular</u> load forecasts in time and space, such as annual hourly load forecasts by feeder and/or by customer class.
- Multi-scenario forecasts of DER penetration and gross load can support understanding *potential* effects of DERs on a distribution system
- Scenarios may include:
  - a business-as-usual case
  - varying DER growth projections
    - (EE, DR, CHP, DG, EV and storage)
  - scenarios that reflect cost decreases for certain DERs
  - scenarios that reflect specific policies, including carbon/sustainability scenarios
  - scenarios that explore different energy service provider landscapes, such as a high community choice aggregation scenario.
- Market analysis reports, potential studies, procurement requirements, and internal company analysis can be used to develop different DER growth scenarios.



Source: Debbie Lew GE Consulting - Emerging distribution planning analyses, January 2018

More Advanced Load and DER Forecasting, cont.

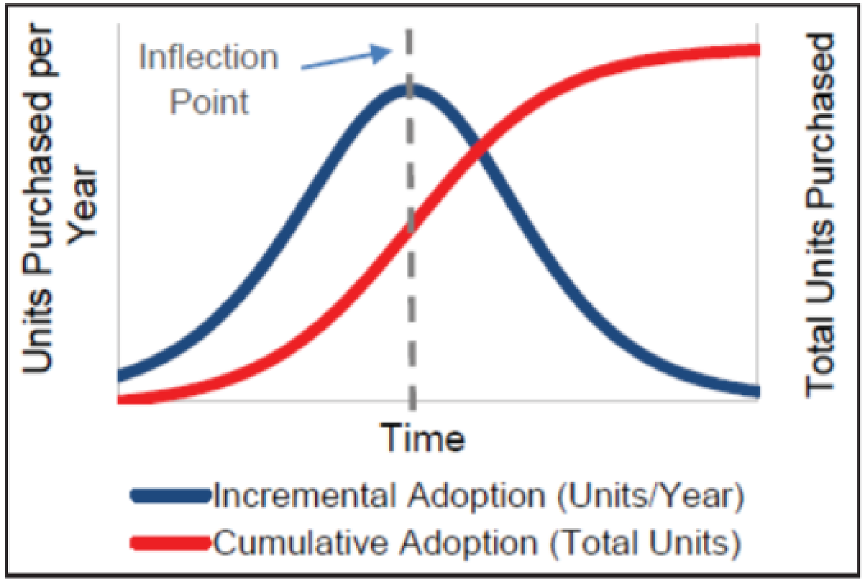
- Customer Adoption Modeling - To forecast DER adoption at the feeder level, steps can be taken to identify customers who are likely to have interest in different DERs and who are likely to have the economic potential to install different DERs.
- Some of the drivers to consider include:
  - potential savings,
  - clustering effect,
  - early adopter effect,
  - green customers,
  - customers interested in self-sufficiency, and
  - income levels.
- Data that can be particularly helpful include information on existing installations, information on the interconnection queue, and information from customer surveys and studies.

Source: Debbie Lew GE Consulting - Emerging distribution planning analyses, January 2018

Tools for Advanced Load and DER Forecasts

- Spatial load forecasting tools, such as LoadSEER, produce different future load growth forecast scenarios based on economic, environmental, and societal factors.
- Advanced DER adoption models are often based on the Bass Diffusion Model
  - Used in many industries
  - Relies on sociological theory that adoption of a new technology is a function of early adopters influencing later adopters
  - Requires knowledge of relationship between market potential and payback period, determined through surveys; difficult to determine and keep current
  - Good for macro-level results but does not account for unique customer variables
- WattPlan® Grid is piloting advanced modeling and machine learning methods - Clean Power Research and SMUD

Figure 1: Generalized S-Curve Model



Source: Distribution Forecasting Working Group Progress Report, July 2019

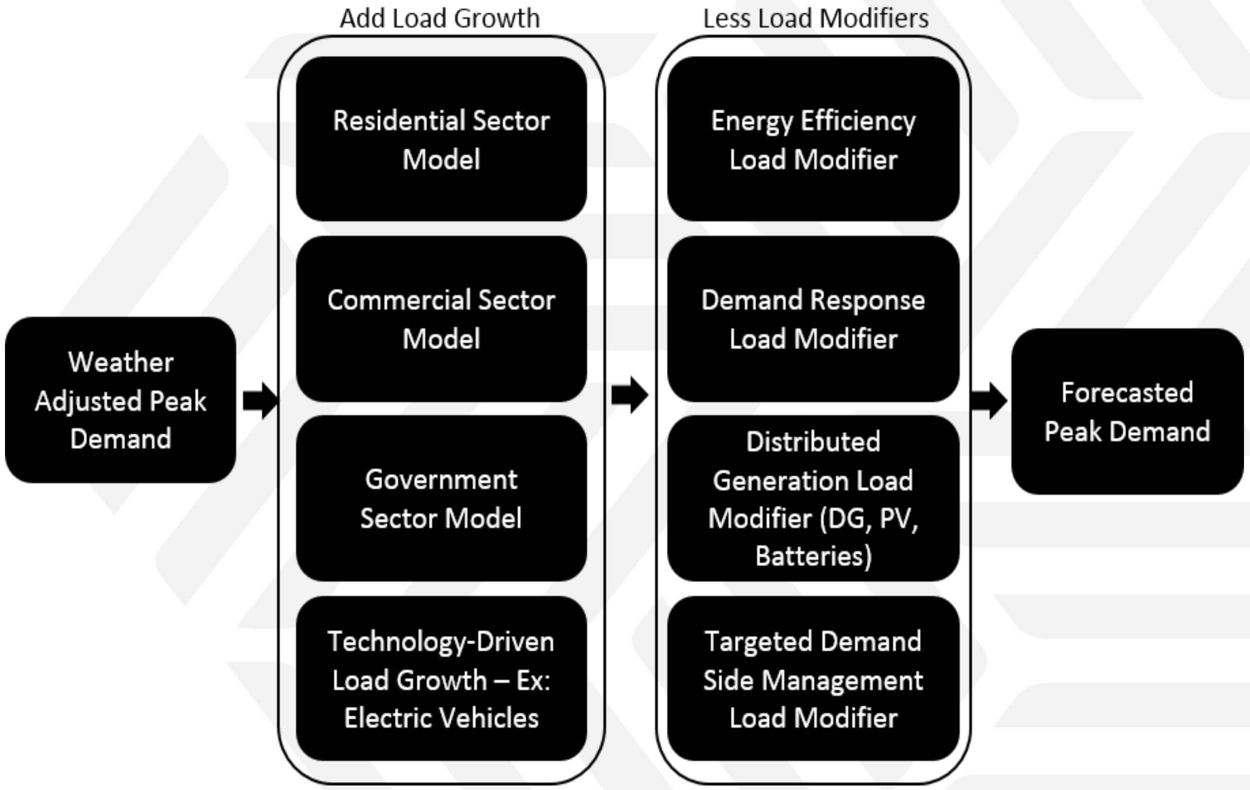
Example: Requirements for California Utilities

- 2015 Distribution Resource Plans required three 10-year DER growth scenarios:
  - Scenario 1: Trajectory - Adapts the California Energy Commission's Integrated Energy Policy Report (IEPR) "Trajectory" case for DER deployment for distribution planning at the feeder lever, down to each line section;
  - Scenario 2: High Growth - Adapts the IEPR "High Growth" case for DER adoption but also incorporates additional information from Load Serving Entities (LSEs), third party DER owners, and DER vendors; and
  - Scenario 3: Very High Growth - Based on very high potential growth in the use of DERs to meet transmission system needs, resource adequacy, distribution reliability, resiliency, and long-term greenhouse gas reductions.
- Pacific Gas & Electric and Southern California Edison
  - To project DER adoption - applied Bass-Diffusion model with post model adjustments to address new policies, such as the requirement for zero net energy goals.
  - Generation from behind-the-meter solar projected using modeled hourly generation by climate zone from NREL's PV Watts model for the residential and non-residential sectors and an assumed degradation rate of 0.5% per year.
  - To project the impact of DER on loads, granular level customer class load shapes (profiles) were used.

Source: Overview of Growth Scenario Forecasts – CPUC DER Scenarios Workshop, February 2017

Example: Con Edison

► Components of peak load forecast



2016 - Electric System Peak Demand Forecast (in Megawatts)

		2015	2016	2017	2018	2019	2020
1	**Updated System Forecast**	**13,600**	**13,781**	**13,942**	**14,048**	**14,124**	**14,164**
2	MW Growth:		181	161	106	76	40
3	% Growth:		1.30%	1.20%	0.80%	0.50%	0.30%
4	**Additional MW Growth (Incremental Rolling)**						
5	Electric Vehicles (EVs)		1	5	6	6	7
6	Steam A/C Conversion		11	22	33	43	54
7	**Load Modifiers (Incremental Rolling)**						
8	Photovoltaics/Solar (PVs)		-8	-29	-40	-51	-60
9	Distributed Generation (DG)		-22	-48	-85	-90	-91
10	Energy Storage		-2	-3	-3	-4	-4
11	**Coincident DSM (Incremental)**						
12	Con Edison EE		-22	-15	-19	-25	-25
13	NYSERDA EE		-5	-7	-8	-7	-7
14	NYPA		-7	-5	-5	-1	-1
15	BQDM		-6	-24	-6	13[27]	0
16	DMP		-36	-68	0	0	0
17	Demand Response		-32	-9	-8	-3	-3
18	Total Incremental DSM:		-109	-126	-46	-24	-36
19	Rolling Incremental DSM:		-109	-235	-281	-305	-341
20	**System Forecast less DSM, less DG, PVs and Batteries + EVs + Steam A/C**		**13,652**	**13,653**	**13,677**	**13,724**	**13,729**
21	MW Growth:		52	1	24	47	5
22	**Rounded System Forecast less DSM, less DR and PVs + EVs + Steam A/C**		**13,650**	**13,655**	**13,675**	**13,725**	**13,730**
23	MW Growth (Rounded):		50	5	20	50	5
24	% Growth:		*0.37%*	*0.04%*	*0.15%*	*0.37%*	*0.04%*

From Con Edison 2016 Distributed System Implementation Plan

Regulatory Approaches

- Minnesota Integrated Distribution Planning Requirements includes requirements for utility to provide:
  - Current DER deployment by type, size, geographic dispersion
  - Areas of existing or forecasted high DER penetration
  - Cases for low, medium, and high DER integration (define and develop)
  - Information on methodologies used to develop cases
  - Discussion of processes and tools that would be necessary to accommodate low, medium, and high levels of DER integration
  - Anticipated impacts from FERC Order 841(Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators)

Regulatory Approaches

- Oregon Distribution System Planning (Docket No. UM-2005) Utility Survey:
  - Granularity of load forecasting: To what level of granularity does the utility forecast? To what extent is the distribution system data collected by the utility reflected in load forecasts (e.g., does the utility employ an 8760-hour forecast at the substation level?)
  - Use of company-wide peak forecasts versus aggregation of substation or other circuit-level peaks: Does the utility use a top-down forecasting approach versus a bottom-up approach, or some combination of these approaches? Does the utility utilize peak-hour forecasts?
  - Comparison of actual asset loading against past forecasts: Does the utility employ back casting or ex post true-up to assess the accuracy of its forecasting process?
  - Impact on load forecasts of the projected availability of DER: What approaches and models does the utility use to forecast DERs?
    - How does the utility forecast the impact of DERs on distribution system needs?
    - How is utility forecasting impacted by utility assessments on adoption and penetration of DER?
    - Are multiple scenario forecasts developed, and if so, what are the basis of variations in scenarios?
  - Current status of distribution systems: What is the current and forecasted extent of DER deployment by type, size, and geographic dispersion?

Closing Thoughts

- Distribution planning at the core is about supporting investment decisions.
- Utilities base investments on identified need.
- Need changes as customers add DERs
  - DERs can decrease investment needs - less generating capacity to be procured
  - DERs can increase investment needs - proactive investments to increase hosting capacity or other required grid support investments
- Key challenge: Adoption of DER happens external to utility planning; utility planners don't decide how much, what kind and how to operate.
- Inaccurate DER estimates can lead to increased utility capital and operating costs.
  - Rate design can significantly affect adoption of distributed PV.
  - When forecasting DER adoption, scenarios are not independent of the decisions of the utility itself.
  - Regulators and utilities can use tariffs as a mechanism of influencing DER adoption and driving those scenarios.

Thanks!

Juliet Homer, P.E.
Pacific Northwest National Laboratory
Juliet.homer@pnnl.gov
509-375-2698

Committee on Energy Resources and the Environment

There's a Major Change Headed Our Way: Forecasting DERs for Planning Purposes

NARUC Summer Policy Summit

Forecasting DER for Planning (and everything else)

NARUC Summer Policy Summit

Integral Analytics
A Willdan company

Walk-Jog-Run: Where'd Everyone Go?

Rooftop Solar

EV Adoption

TOU Rates

Efficient Devices

Electrification

Why are any utilities still walking?

The Next 20 Years Happen Between Substation and Prosumer Device

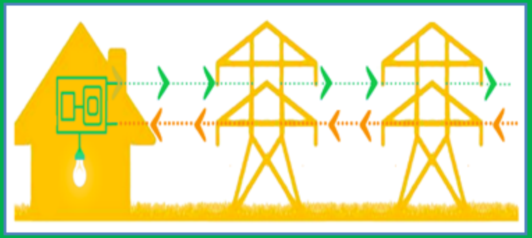
- Emergence of DER/TOU impact on load forecasting
- Solar duck curve/evening peaks become new “baseline”; EV loads are mobile
- Due to solar clustering, coincidence/covariance become risk factors at feeder level
- Nodal load magnitude changes via higher evening peaks due to EVs; lower “mins” from PV

This means more volatile load*shapes*....*planning must evolve:*

- Distribution Planning, Operations, DER Integration, IRP & Grid Mod **functions converge**
- **Locational and temporal value** of DER must be considered
- A circuit load forecast becomes a time-series of dynamically-refreshed, short-term forecasts with **scenario options** & risk tolerances
- Must include **multiple forecast methods** (econometric, geospatial, powerflow, behavioral)

Integral Analytics

Objective: DER-Ready Distribution Network



Modernize distribution system to accommodate expected DER growth through two-way power flow

Include granular DER scenarios into load planning and determine grid benefits or costs

Provide valuation metrics and DER-based cost effective capital alternatives

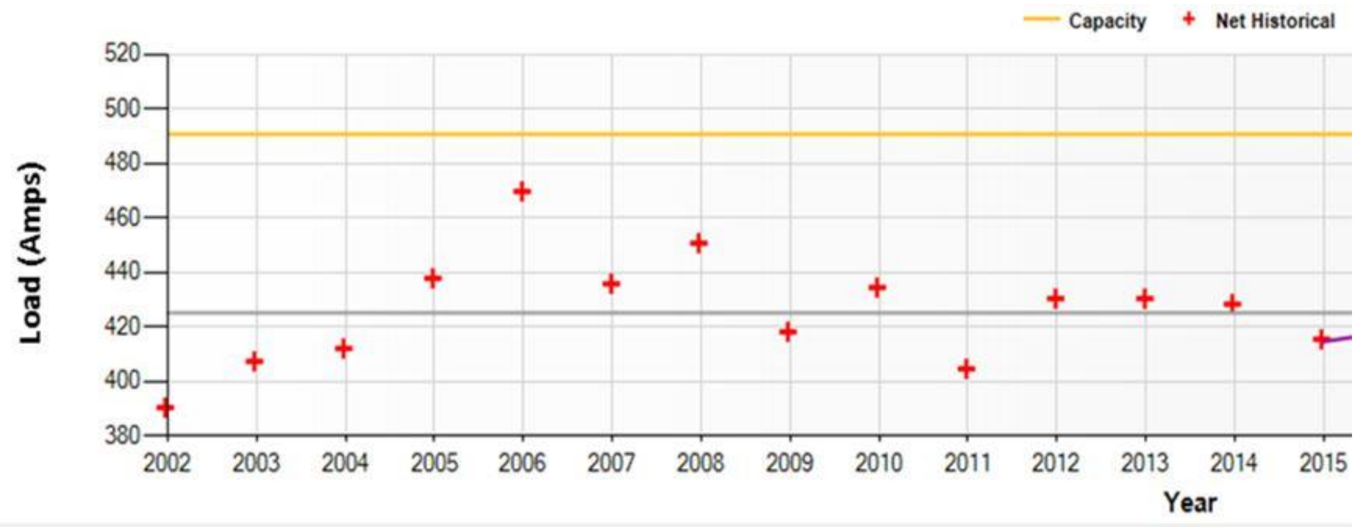
Identify Optimal Locations for deployment of DERs

Foundational Layer: Circuit-Level Load Forecasting

Integral Analytics

Pre-DER Planning: Annual Peaks

- Top-Down
- Corporate Forecasting/System-Level Assumptions
- Historical Regression
- Use of Annual Peak for Capacity
- Substation-Level
- Single IRP Value
- Focus: Capital Projects



Major Risk: Circuit and customer-level volatility from DER/EV and changing loadshapes renders traditional capital planning obsolete

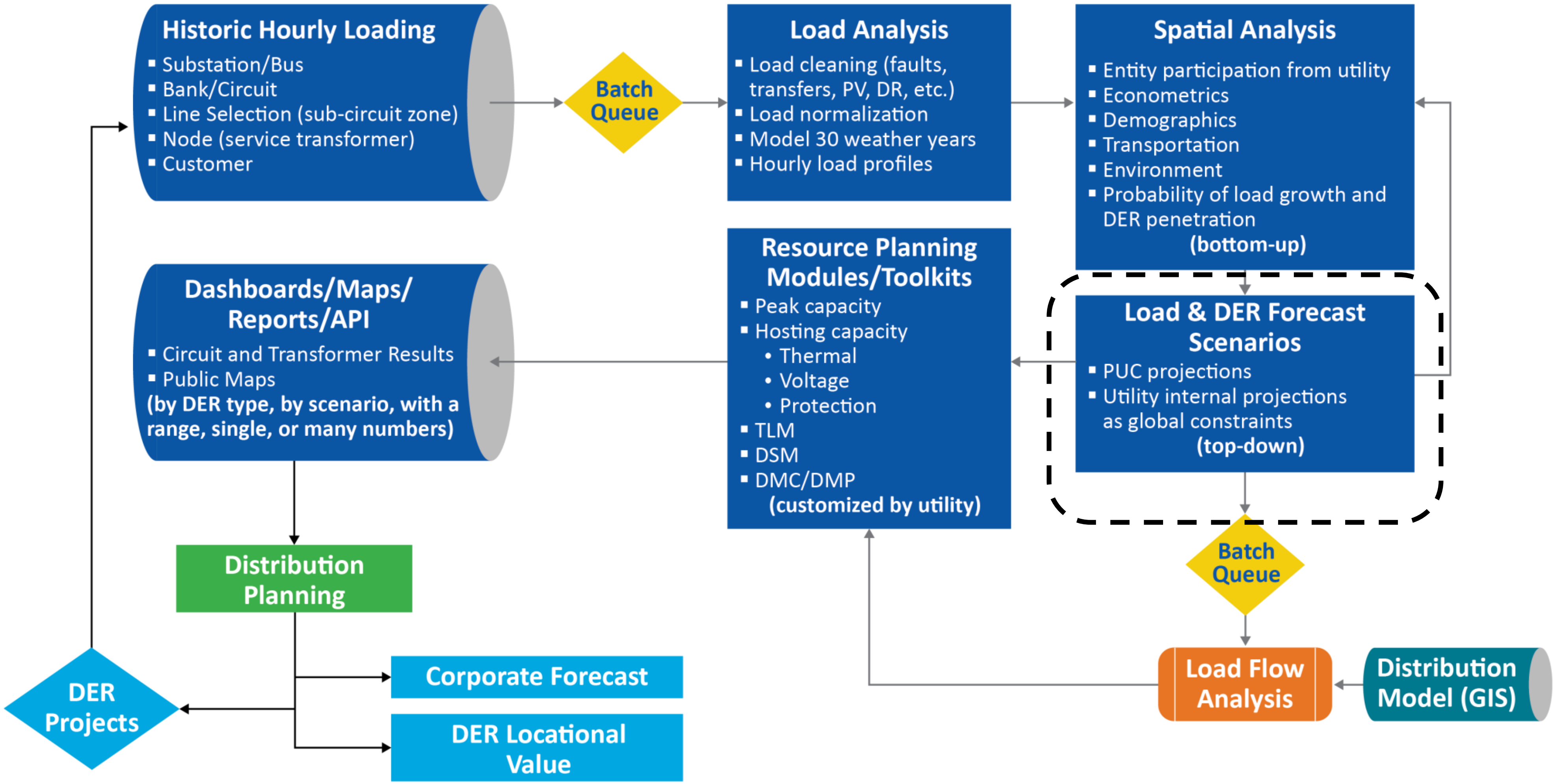
Integral Analytics

DER-Integrated Grid Planning: It's Here

Capability	Conventional Wisdom	Reality	Where?
Nodal, 8760 Load Forecasting with Powerflow	Data availability and quality prohibitive	Commercially available	PG&E, Entergy, SDG&E, Seattle City Light, others
Full System Hosting Capacity	Too computationally-intensive	Commercially available	PG&E, SDG&E, SCE
Embedded DER Penetration Impact	Hard to reconcile corporate fcst to circuit level	Commercially available	PG&E, SCE, SRP, Hawaiian Electric
DER/Non-Wires Value/Optimization	Locational value measurement	Commercially available	Hawaiian Electric, PG&E, Seattle, CPS
Dynamic Data and Circuit Impact "Refresh"	System Integration and Data Management Challenge	Commercially available	Entergy, PG&E, FortisBC, Hawaiian Electric

Integral Analytics

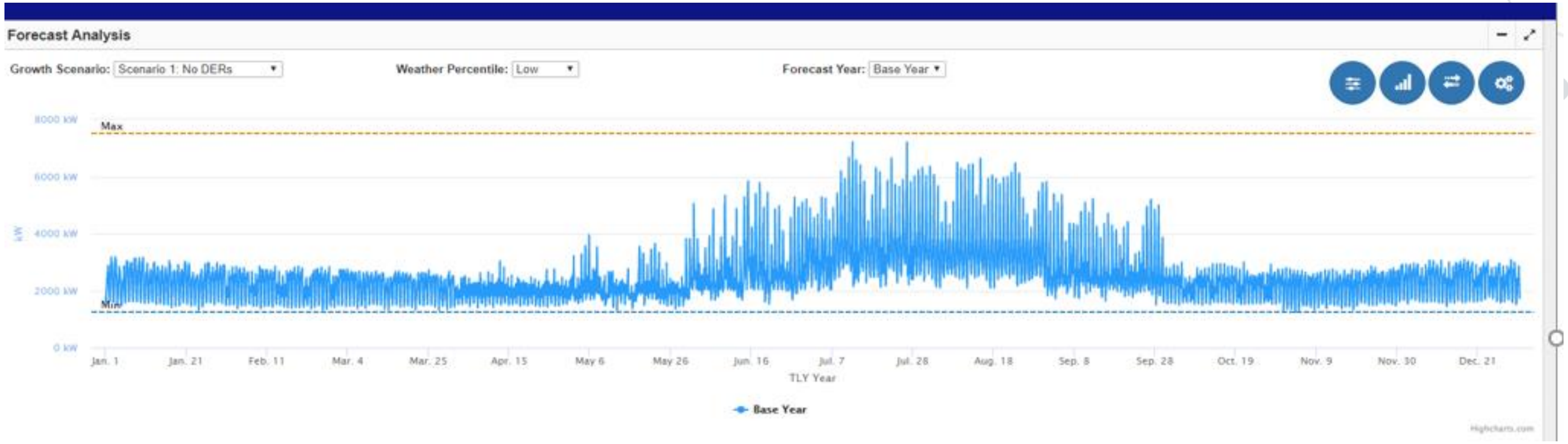
DER Forecast Scenarios Critical to Circuit Risk Management

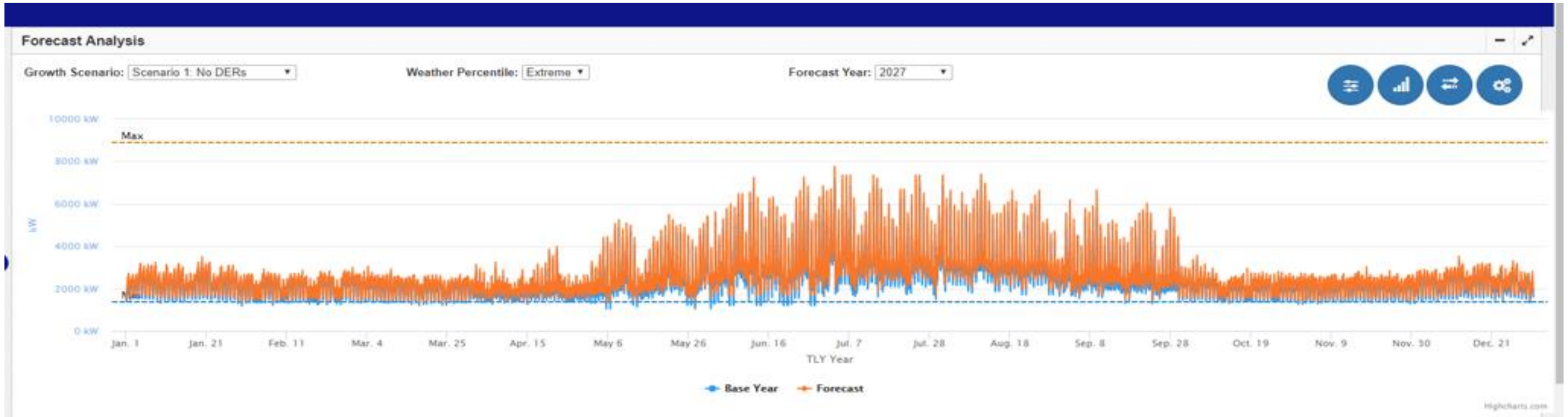


Integral Analytics

“Shocking the Baseline”: 8760 as a Standard

- Computational efficiency allows for system-level, 8760 forecasting
- Application of DER adoption projections at circuit level, rather than system-wide
- Hourly load resolution prescribes surgical investment

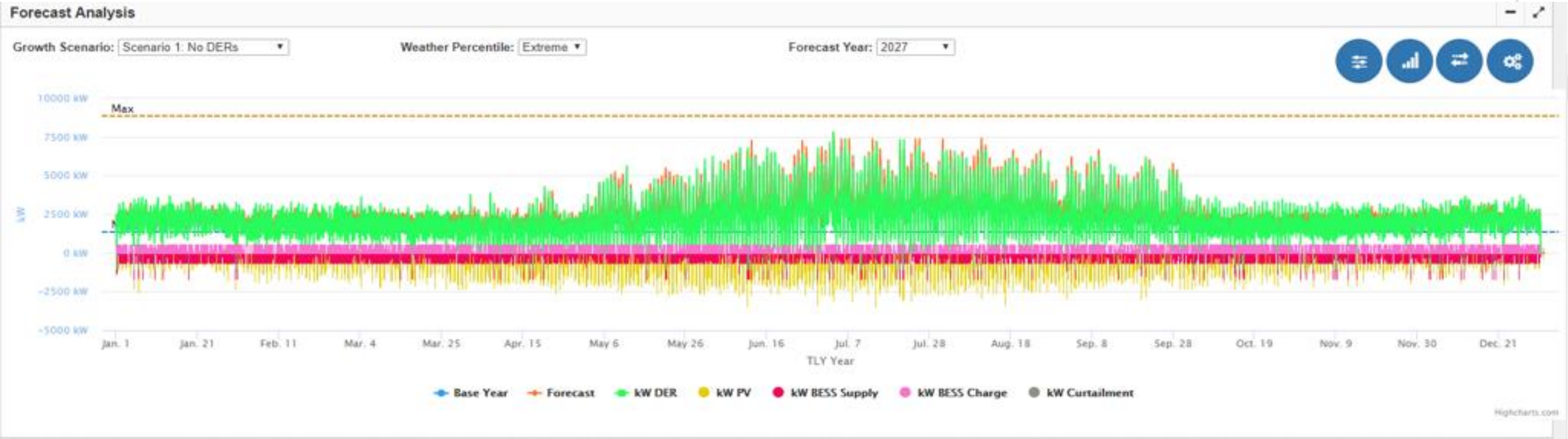


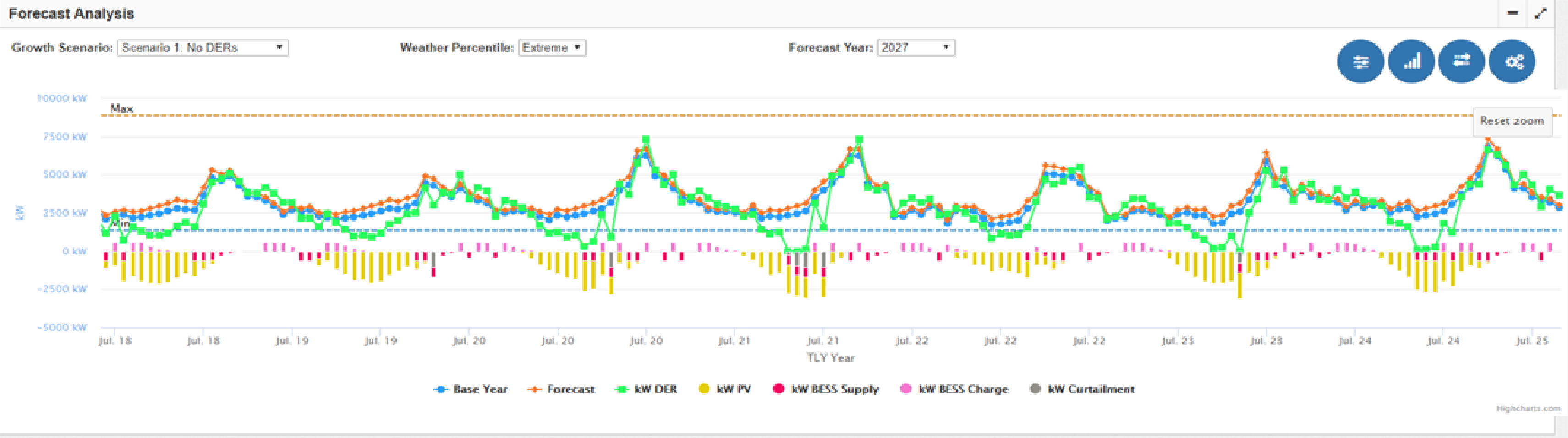


INTEGRAL ANALYTICS

What’s Going on at the Load*shape* Level?

- “Portfolio solving” at least cost: planning answer to an operational question
- Management of covariance reduces volatility
- “Micro-IRPs” provide confident hedging upstream of the substation





Least-Cost Circuit DER Choreography Drives Planning

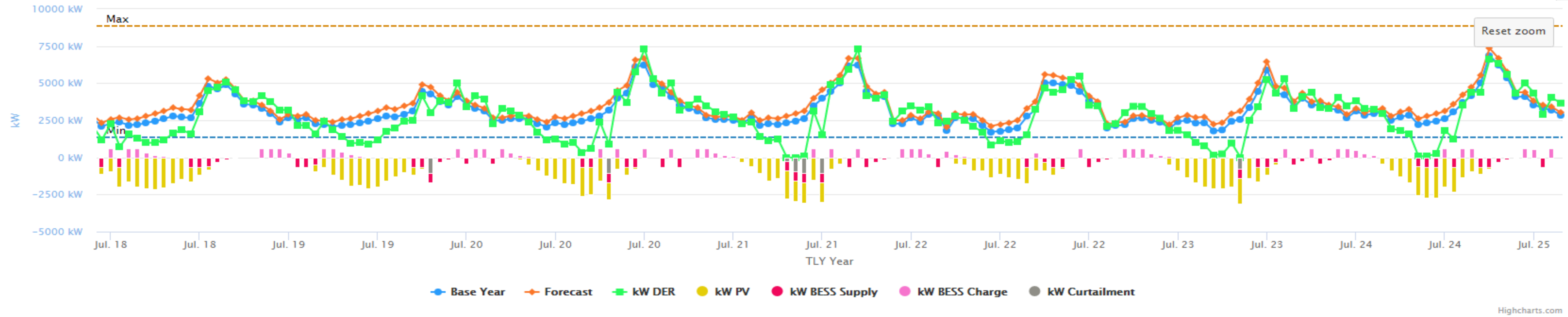
LoadSEERNext - Integral

loadseernextdemo.integralanalytics.com/lsn/node/workbench/0b612652-0d3f-4b2d-8fe6-601e17cce68f

- Dashboard
- Map
- Explorer
- Library
- Data Manager
- Administration

Forecast Analysis

Growth Scenario: Scenario 1: No DERs   Weather Percentile: Extreme   Forecast Year: 2027



Optimization Settings

- General Settings
- PV Settings
- Storage Settings

Include Storage ☑

Installed Capital Cost: $2,000.00 /kW

System Incentive (% off): 0% 10% 100%

Charge Rate (% Cap. / Hr): 0% 25% 100%

Summary

Type	Capacity	Cost
BESS	2,512 kW	$251,230.00
PV	2,173 kW	$108,667.00
DR	1,076 kW	$102,219.00
EE	0 kW	$0.00
EV	0 kW	$0.00
Total	**5,761 kW**	**$462,116.00**

Month	Pre-DER	Post-DER	Savings
January	$105,158.84	$70,505.51	$34,653.34
February	$42,200.57	$33,485.87	$8,714.70
March	$77,158.43	$47,538.59	$29,619.84

Integrated Grid Planning: Capturing Volatility Upstream

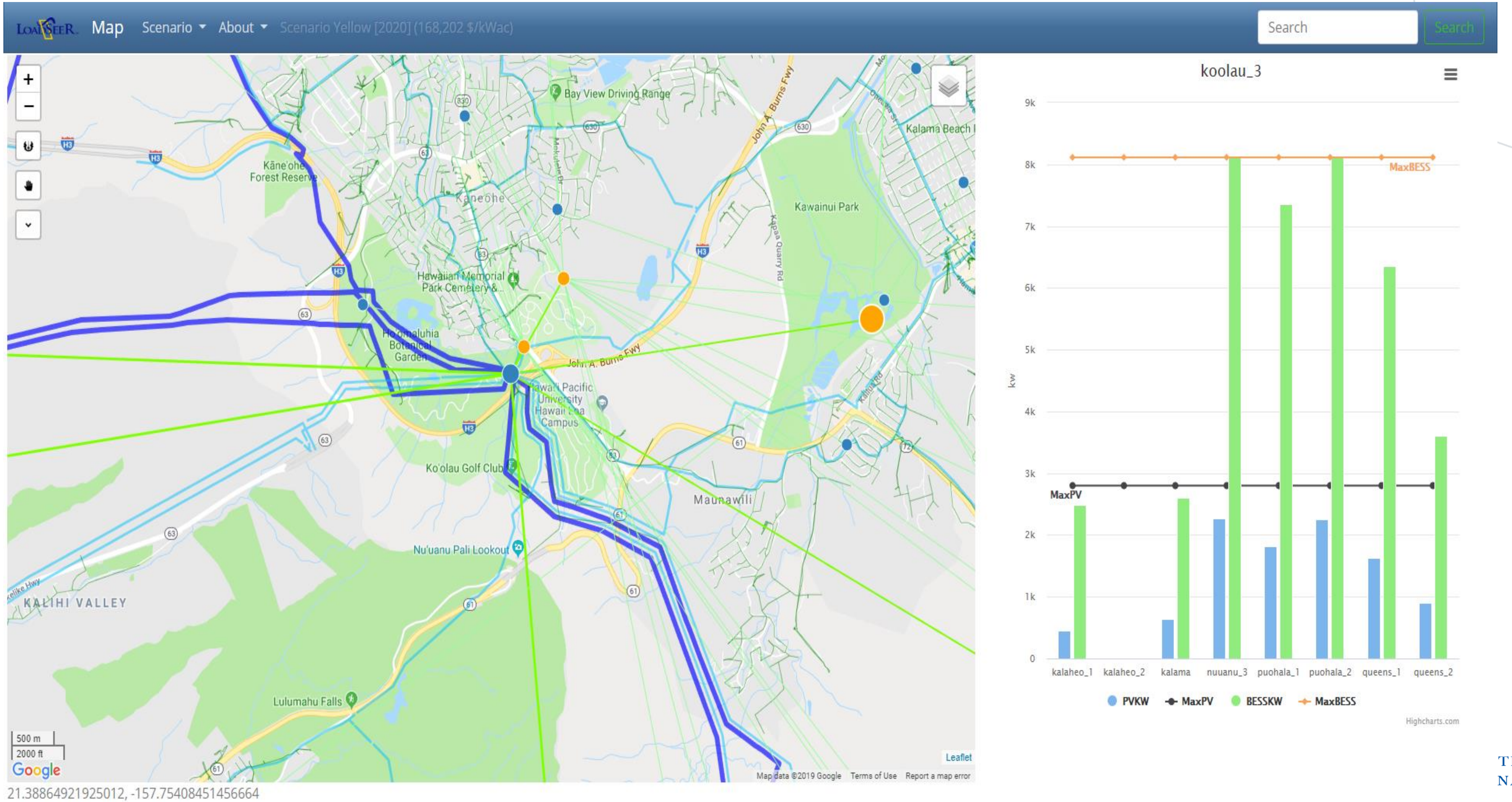
Circuit loadshape changes matter for transmission planning

- Dramatic change in loadshapes creates pockets of unseen needs at specific transmission nodes, or substations
- Over a 10 to 20-year planning horizon, there are many scenarios where knowing the specific hourly shapes at specific substations (especially in urban zones) can significantly mitigate capital and operational risk

Loadshape changes significantly impact traditional IRP plans

- Historically, IRPs focused at zonal or large regions, or even entire states
- Bottoms-up scenario planning becomes portfolio planning when aggregated
- Full interoperability between distribution and transmission planning models is critical

Integrated Grid Planning: Circuit-Level DER Adoption Impacts Tx

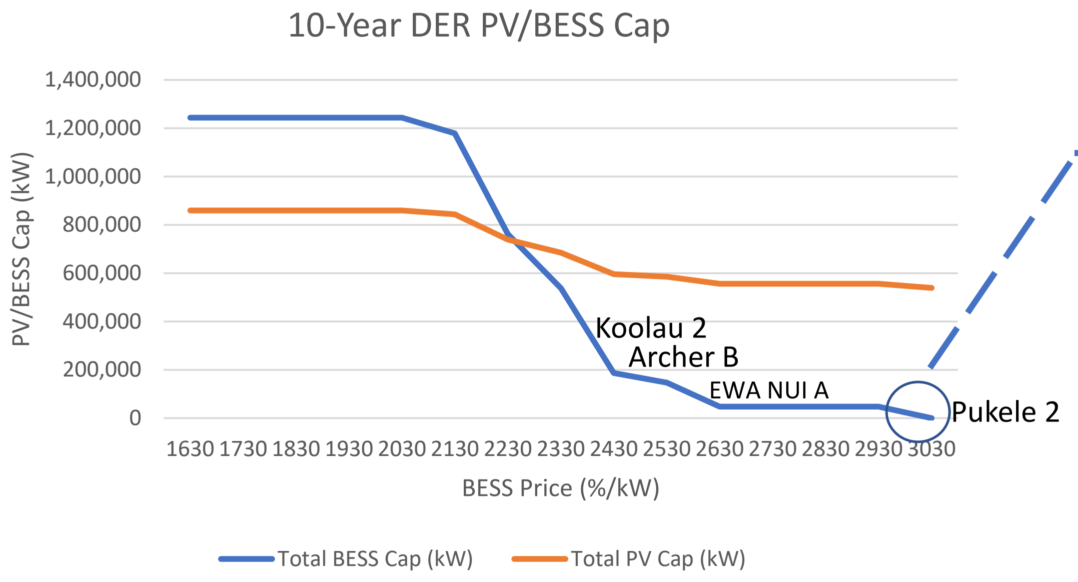


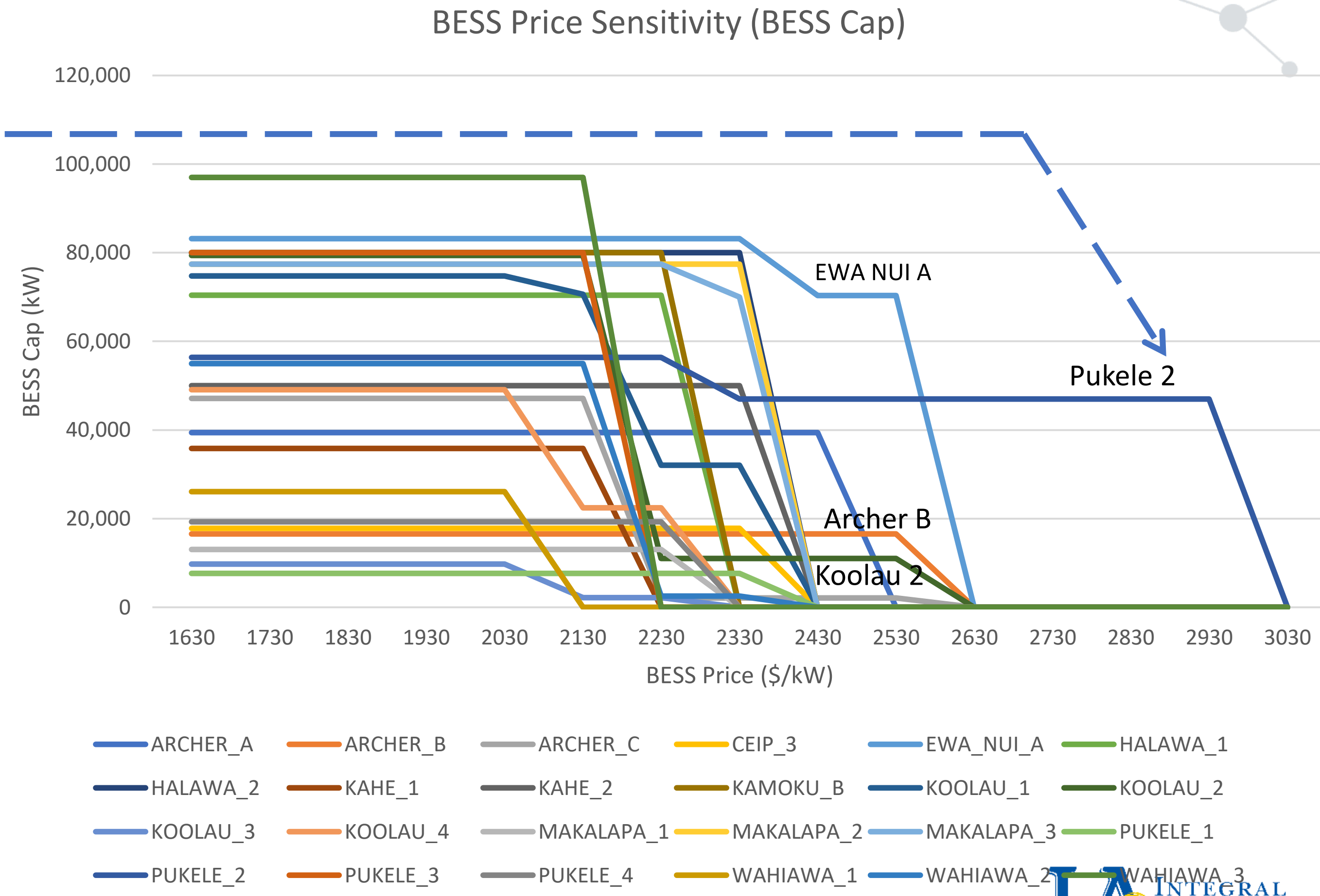
TEGRAL
NALYTICS

Drilling Down: System Optimal to Circuit Optimal

Least cost PV amounts rise from 550 MW to 850 MW as Storage prices drop from $3000 to $2000 per KW.

At planning zones (n=25, Oahu), the first adopters of early Storage include Pukele 2, EWA NUI A, Archer B and Koolau 2.





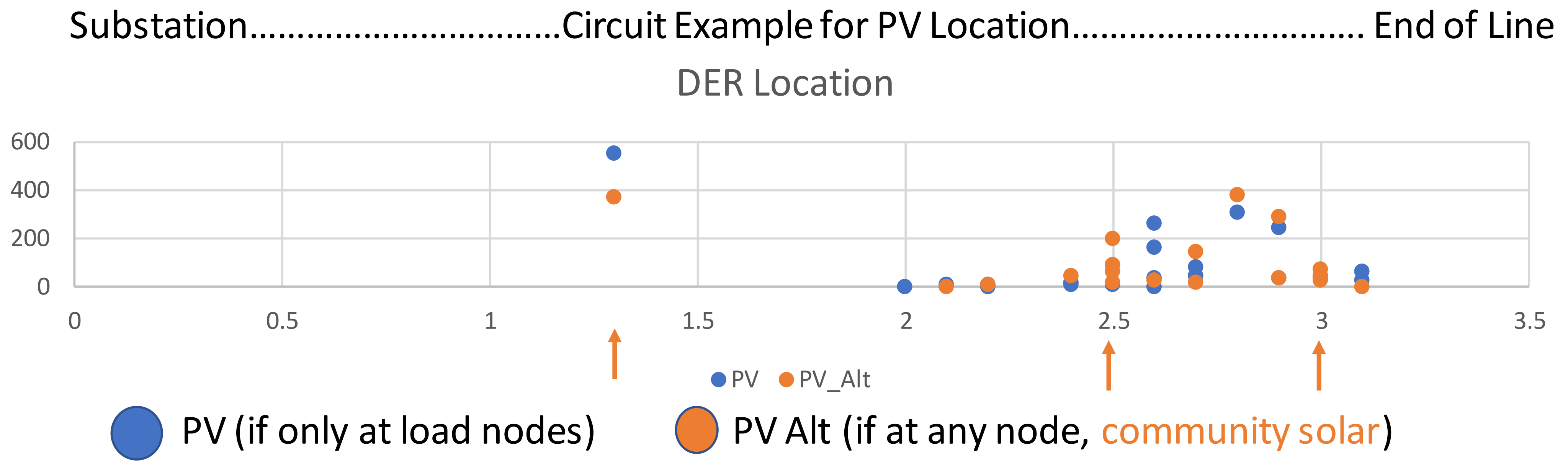
Uses production cost modeling (SCUC) on 8760 shapes and 25 Oahu zones. Some PV is cost effective now, and more is added with cheaper BESS.

LoadSEER Batch Tool runs multiple DER price points, multiple weather years, varied solar scenarios, EV and DER scenarios, for sensitivity assessment.

300 Oahu banks are limited to their (25) zonal total amount of PV, BESS.

Integral Analytics

Along the Circuit: The Right DER at the Right Spot



- ***Solving for least-cost DER portfolios on each circuit merges financial and grid reliability stewardship; the basis for customer programs, non-wires options and upgrades***

Integral Analytics

Speed To Intelligence: The Time is Now

1. DER proliferation is underway; customers and new market entrants aren't waiting
2. Frequency and granularity of Planning processes must match the pace of change
3. Many states have mandated or created the environment to support DRP/IGP
    - CA, HI, MN, NV, NY, WA, AZ, ME, MA, CT
4. Billions already spent on data acquisition; must translate to intelligent capital investment
5. Proven DER planning applications are commercially available and computationally robust
6. Unmanaged circuit risk will only increase over time

Set the Standard: Require ***annual circuit-level risk analysis*** to be filed to approve distribution CAPEX

- Must include DER adoption and loadshape scenarios
- Must highlight potential capacity, voltage or hosting constraints
- Should govern all distribution capital investment

Committee on Energy Resources and the Environment

There’s a Major Change Headed Our Way: Forecasting DERs for Planning Purposes

NARUC Summer Policy Summit

NARUC 2019 Summer Policy Summit: Forecasting DER Adoption for Planning Purposes

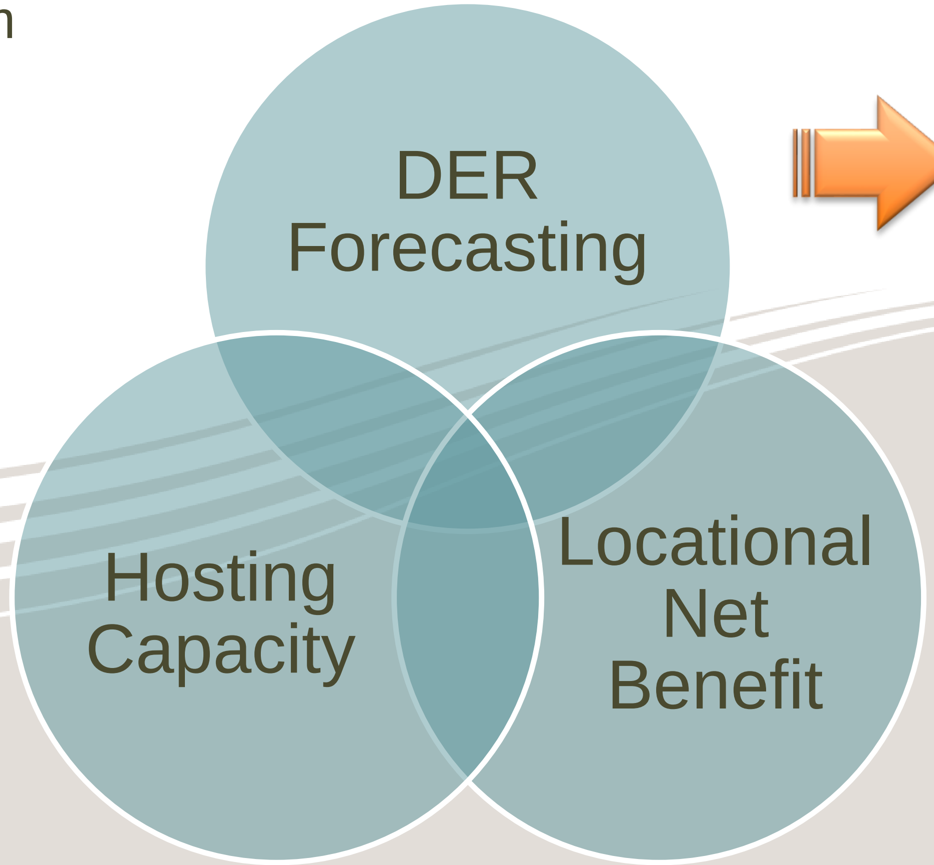
Patrick McCoy
Energy Strategy R&D
Grid Strategy and Operations
July 23, 2019

Discussion

- Why Is This Important?
- Spectrum of Scenarios
- Scenario Analysis Example
- Data, Analysis and Reports
- How To Get Started

Why Is This Important?

- How will the growth of DERs impact my system and feeder load profiles?
- How do I need to think about this from the distribution grid perspective?
- How will my revenues be impacted?
- What will I have to spend to integrate increasing amounts of DERs?
- What's my strategic objective(s)?



- Load Forecasting
- Resource Planning

- Distribution Planning
- Distribution Operations
- Grid Modernization

- Capex
- Programs
- Revenues

Spectrum of Scenarios

From the Perspective of:	*Range of Possible Scenarios*				*Key Scenario Impact*
Net Energy Metering	Full Retail Credit	Avoided Cost of Generation	Value of Solar	Fixed Cost Recovery	PV Adoption
Rate Design	Tiered	Demand Charge	TOU	Hybrid	Revenues
Grid Planning and Ops	Hosting Capacity	Locational Net Benefits	Non-Wires Alternatives	Transactive Grid	Flexible Load

"Easy" ⟷ *"Hard"*

SMUD™

Scenario Analysis Example

- Case Study: Net Energy Metering (NEM)
  - Scenario: Fixed Cost Recovery
  - Objective: Recover fixed costs that are being avoided by NEM customers (most all solar PV)
  - Options:
    - Continue full retail credit *(rate design implications)*
    - Non-bypassable charges ($/kWh)
    - Demand charge ($/kW)
    - Grid access charge ($/kW)
  - Question: What is the impact to customer adoption of solar PV?
- Utilized DER adoption forecast tool *(Clean Power Research's Wattplan Grid)*
- Discovery: Proposed NEM rate dramatically decreased residential solar PV adoption
- Outcome: staff directed by the SMUD Board to submit revised NEM proposal

SMUD™

Data, Reports and Analysis

- What data is required to prepare a DER adoption forecast?

Customer Specific	Grid Specific	Market Specific	Technology Specific	Other

- Assess gaps in data
  - Data in hand vs need-to-have data vs nice-to-have data
  - Determine how to acquire need-to-have data
  - Evaluate nice-to-have data (*cost to acquire, contribution to forecast*)

SMUD™

Data, Reports and Analysis

- What reports are important to obtain?

Resource planning	Market intelligence
Distribution planning	Economic studies
DER studies and research	Cost trajectories

- Analysis
  - Load flow calculations (*Synergi*)
  - Production cost models (*Plexos*)
  - Marginal cost studies
  - DER hosting capacity
  - Customer research

SMUD™

How To Get Started

- Confirm purpose and rationale
  - Policy mandates
  - Regulatory directives
  - Concerns about business and operational impacts
  - Timeframe
- Establish strategic objectives
- Gain a clear understanding of the DER landscape:

Policy direction and trajectory	Market intelligence
Technology trajectory	Evolving business models
Customer sentiment	Cost trajectories

- Conduct customer research
- Select forecast approach and/or methodology
- Evaluate tools in your toolkit for analysis

Additional Thoughts

- Rate design
  - Inhibit or accelerate DER adoption
  - Fixed cost recovery
  - Lever to achieve strategic objectives
- Value of DERs
  - Resource planning
  - Grid planning
  - Customer perspective/demand
- Moving target
  - Continuous evaluation and assessment
  - Manage adoption trajectories?

SMUD™

Thank You!

Patrick McCoy

Strategic Business Planner

Energy Strategy Research and Development

Grid Strategy and Operations

Patrick.McCoy@smud.org

SMUD™

Committee on Energy Resources and the Environment

There’s a Major Change Headed Our Way: Forecasting DERs for Planning Purposes

NARUC Summer Policy Summit