Emerging distribution planning analyses

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Distribution Systems and Planning Training for Southeast Region
March 11-12, 2020

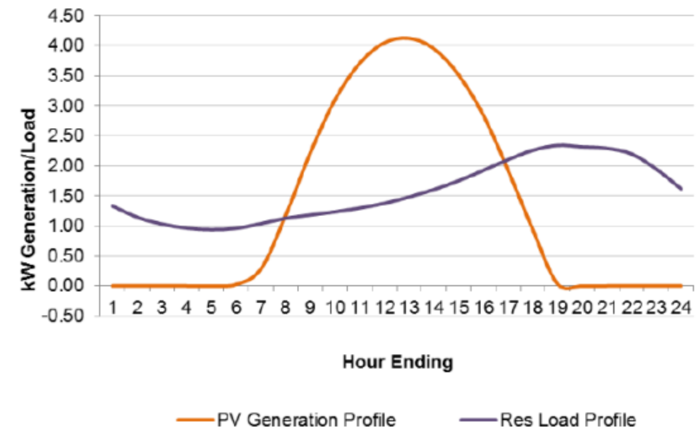
Outline

1) Introduction
2) Distributed Energy Resources (DER) growth and load forecasting
3) Hosting capacity
4) Locational net benefits analysis and distribution deferral opportunities

Introduction

DERs can impact system costs and reliability

- Impacts on the bulk power system
  - Variability
  - Generation not aligned with demand
  - May lead to oversupply
  - Provision of energy only – may not be providing capacity or ancillary services
  - Operational reliability – visibility, controls and communications
- Impacts on the distribution system
  - Depends on DER profile compared to feeder loading
  - Depends on location
  - Depends on DER capabilities and functionalities
- Deployment is optimized on customer economics. Customer economics and utility cost drivers often do not align.



Graphic: PG&E, Distribution Resources Plan Webinar, Aug. 3, 2015

Passive DER planning can be a mess

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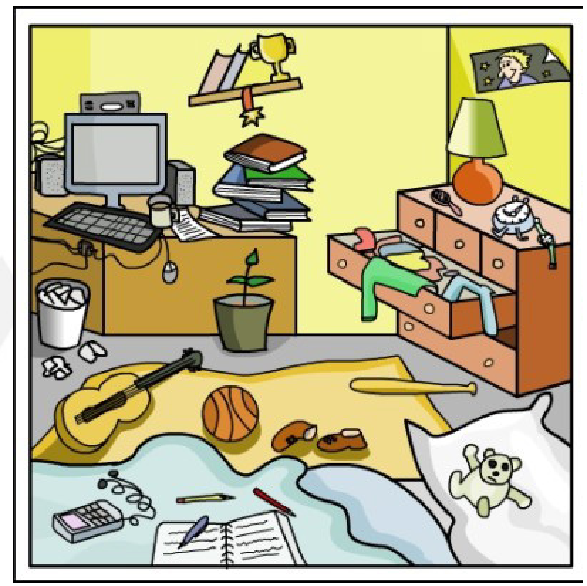
Autonomous DER deployment with little information/guidance

- Customer decides what DER to install, how big, where, and how to operate it
  - Utilities must manage integration
  - Unfavorable locations lead to expensive interconnection, with no one happy
- If the next DER requires upgrade or mitigation, that next customer is responsible, even though it might enable future DERs
- Utility compensates customer (e.g., net metering, fixed tariff)
  - Compensation may not reflect actual net value that DER brings
- Does utility need generation at that time and place? What is the value of demand flexibility at that time and place?



Proactive planning is more effective

Tell customers where the grid needs help. Tell customers what services the grid needs. Incentivize them.

- Load/DER forecasting helps resource planners avoid overbuilding and feeds into analysis of which feeders may be stressed by DER in the near-term.
- Hosting capacity shows how much more DER can be managed on a given feeder easily, or where interconnection costs will be low/high.
- Together, these can identify feeders that are likely to see DER growth and may need proactive upgrades.
- Locational net benefits analysis helps determine the benefits of specific services at a specific location to guide developers.

- Defer some traditional infrastructure investments through cost-effective non-wires alternatives that provide specific services at specific locations
- Leverage customer and third-party capital investments
- Inform rates and tariffs

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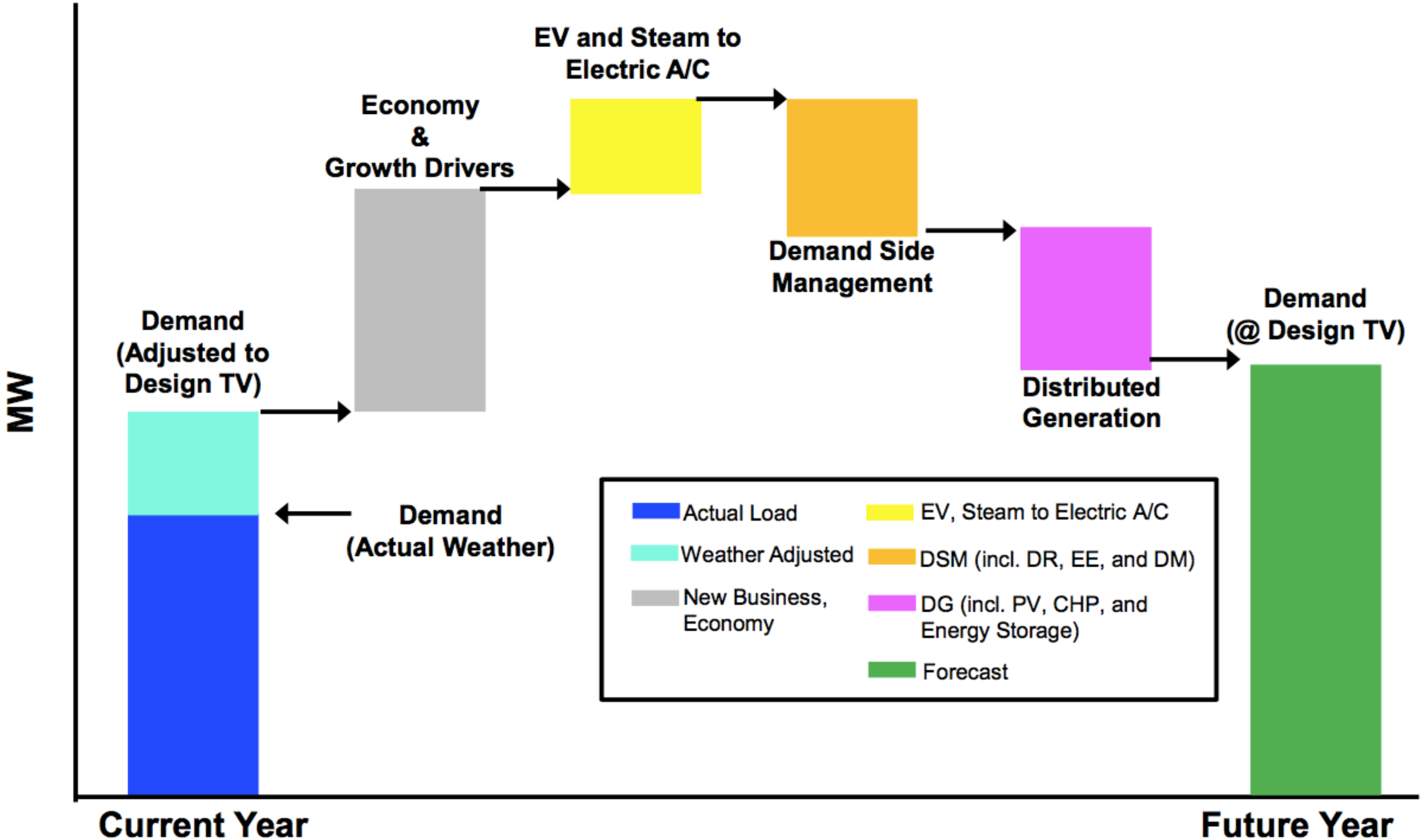
DER Growth and Load Forecasting

Feeding into the resource planning and distribution planning processes

Example of load forecasting with DER



Con Edison, *Distributed System Implementation Plan*, June 30, 2016

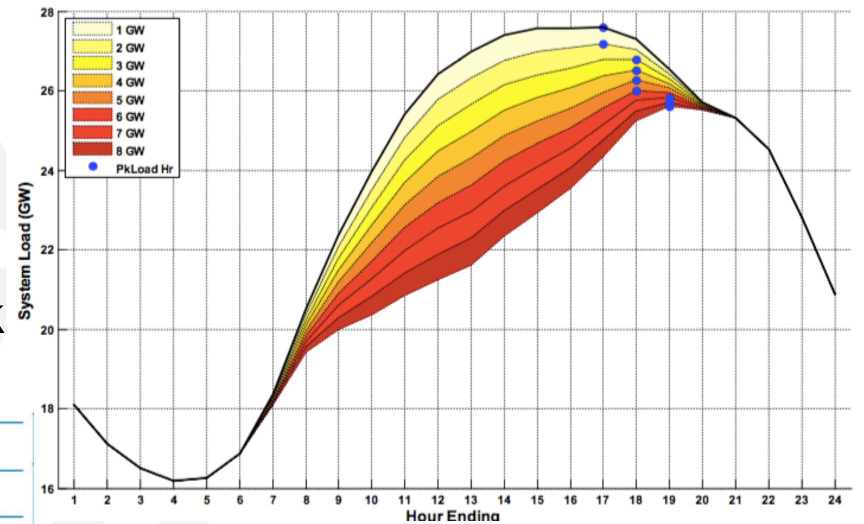
Where does the data come from?

Distributed Photovoltaics (PV) Data source	Source	Resolution
Demographic and socio-economic (customer characteristics)	US Census Bureau	Census tract/zip code
Demographic and socio-economic (customer characteristics)	Experian	Customer (res. only)
PV adoption history (historical PV adoption)	CA DGStats Database	zip code
IEPR forecast of solar PV (system level PV forecast)	CEC	System
GIS and parcel data (GIS info showing new development)	Integral Analytics	Zip code and/or parcel
PV adoption history and metered output where available	IOUs	Customer
Energy usage (historical energy usage)	IOUs	Customer
Service accounts and rate structure	IOUs	Customer
System topology (electrical topology showing customer, circuit, substation, IOU system)	IOUs	Electrical hierarchy
PV technical potential and profile (technical potential; typical solar shapes)	NREL	Zip code
Building stock growth forecast (Moody's forecast)	New Solar Homes Partnership	System

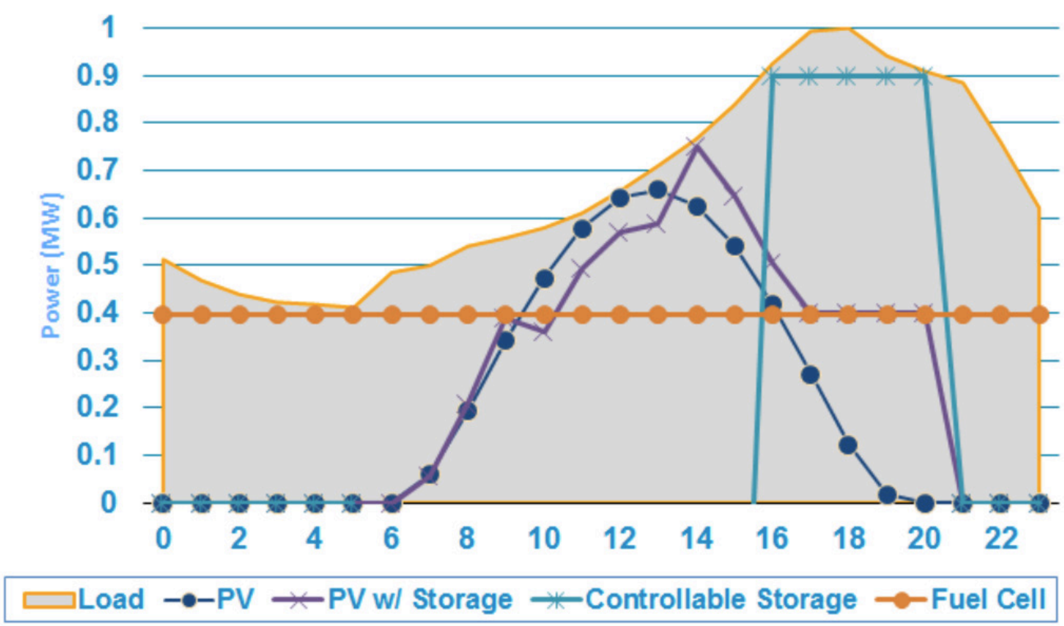
Itron, Distribution Forecasting Working Group Final report June 28, 2018

Load profiles/shapes are important

- “Peak” is moving because of a changing grid
- Resource adequacy now needs to be based on hourly data – can’t just look at peak hour/day
- System peak is different from circuit peak



Graphic: W. Henson, ISONE, 2016



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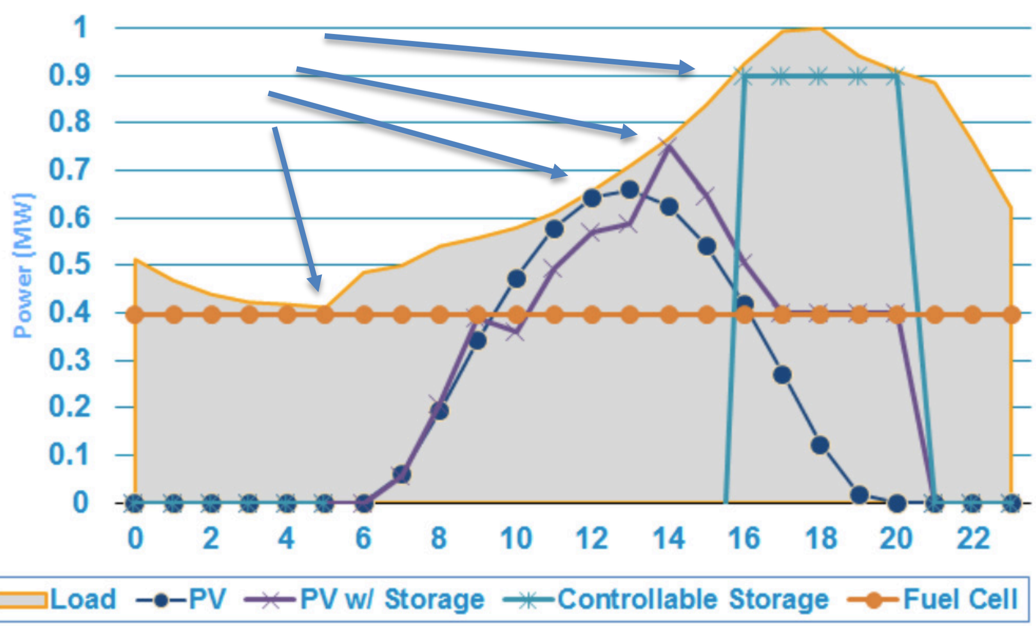
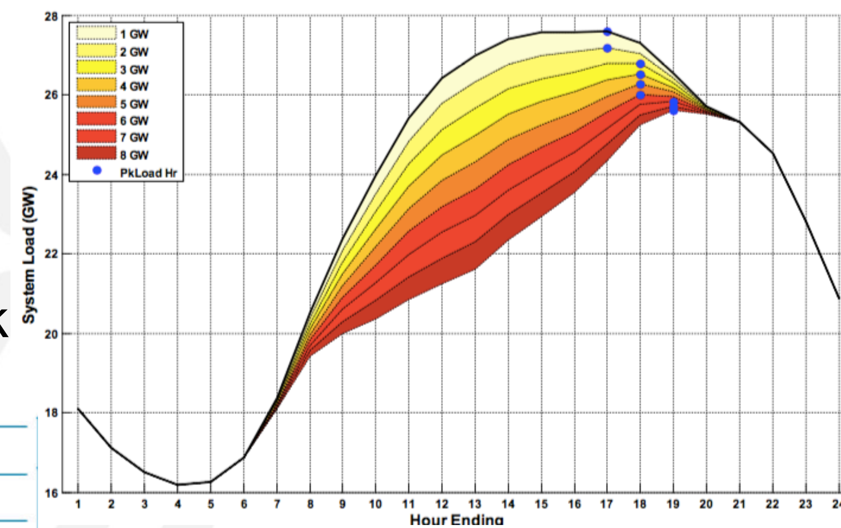


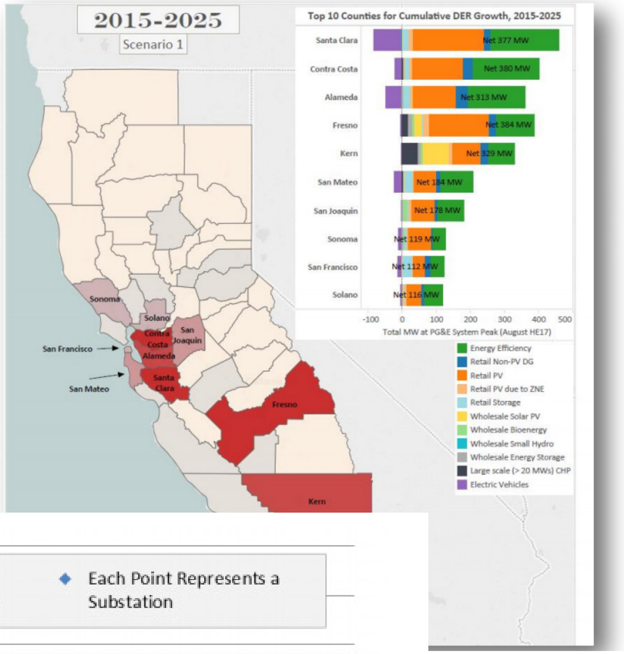
Source: PG&E, Distribution Resources Plan, 2015



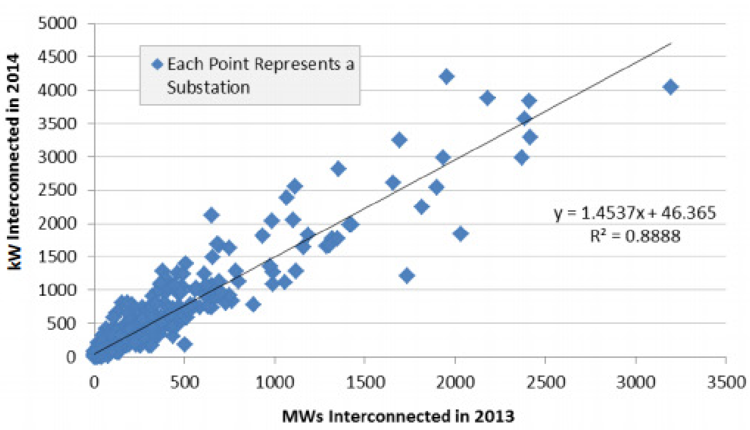
Graphic: W. Henson, ISONE, 2016

Findings from DER growth

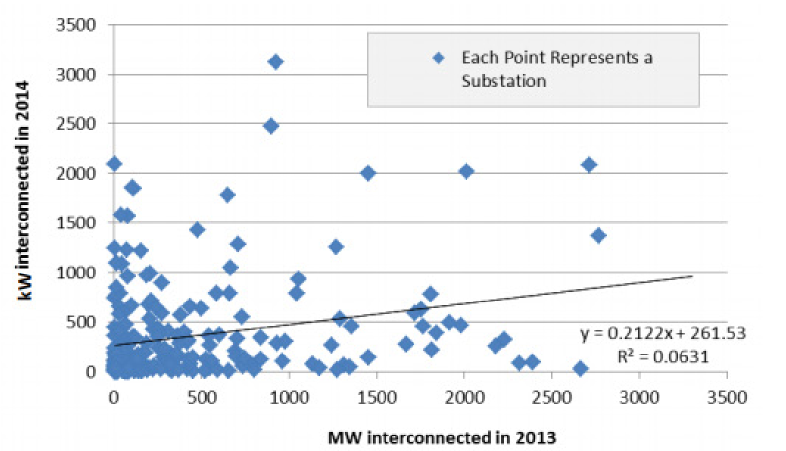
- ► DERs likely to cluster
- ► To estimate DERs, we need to understand load and adoption patterns
- ► Past behavior may not be indicative of future behavior



Residential



Non-Residential



PG&E, Distribution Resources Plan Webinar, Aug. 3, 2015

National Grid example: Impacts on load forecasting

- Reconstruct historical load by adding energy efficiency (EE), demand response (DR), PV, and storage back in and removing EVs
- Use hourly profiles because each of these has variability during the day/season
- Determine EE, PV, DR, storage, EV growth. Determine load growth. Construct net load forecasts for peak demand

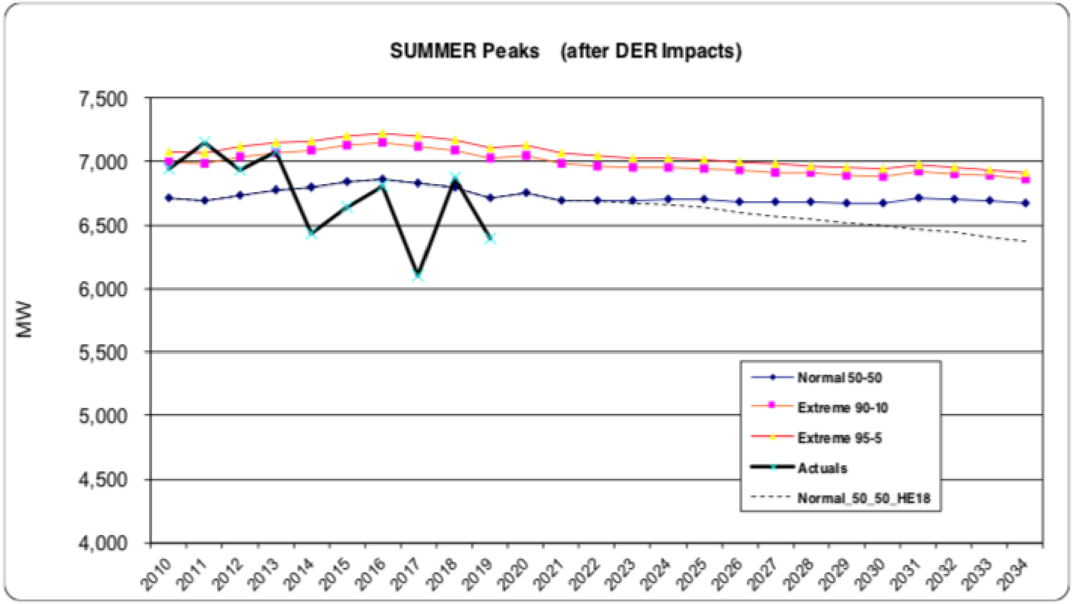


Figure 2: Historical (actual & weather-adjusted) and Projected Summer Peaks

Niagara Mohawk Power Company, *2020 Electric Peak (MW) Forecast 15-year Long-term,* Nov 2019

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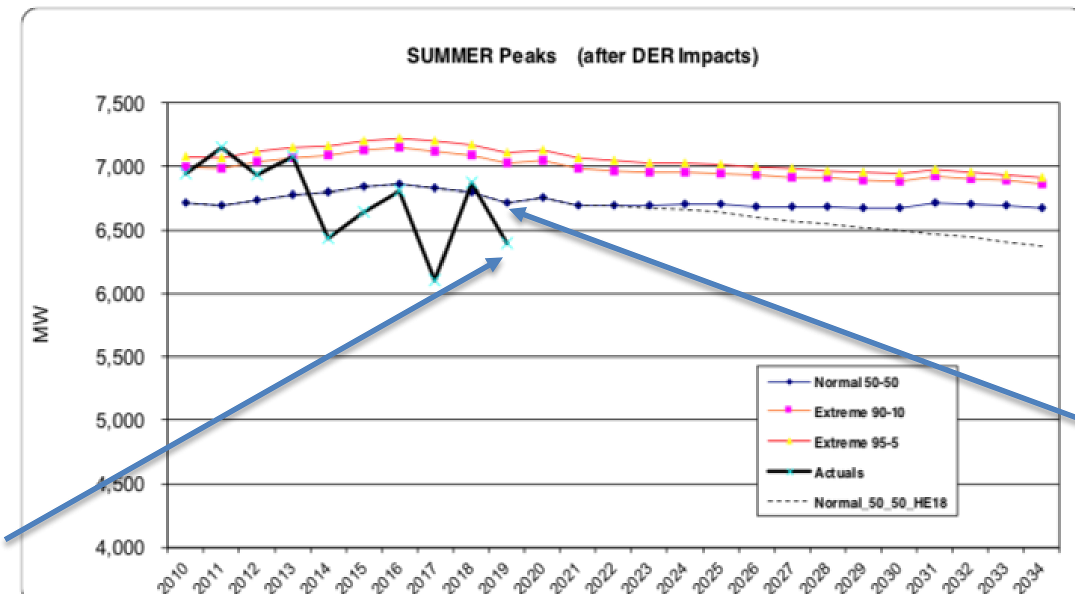

6396 MW

Adjusted 6708 MW

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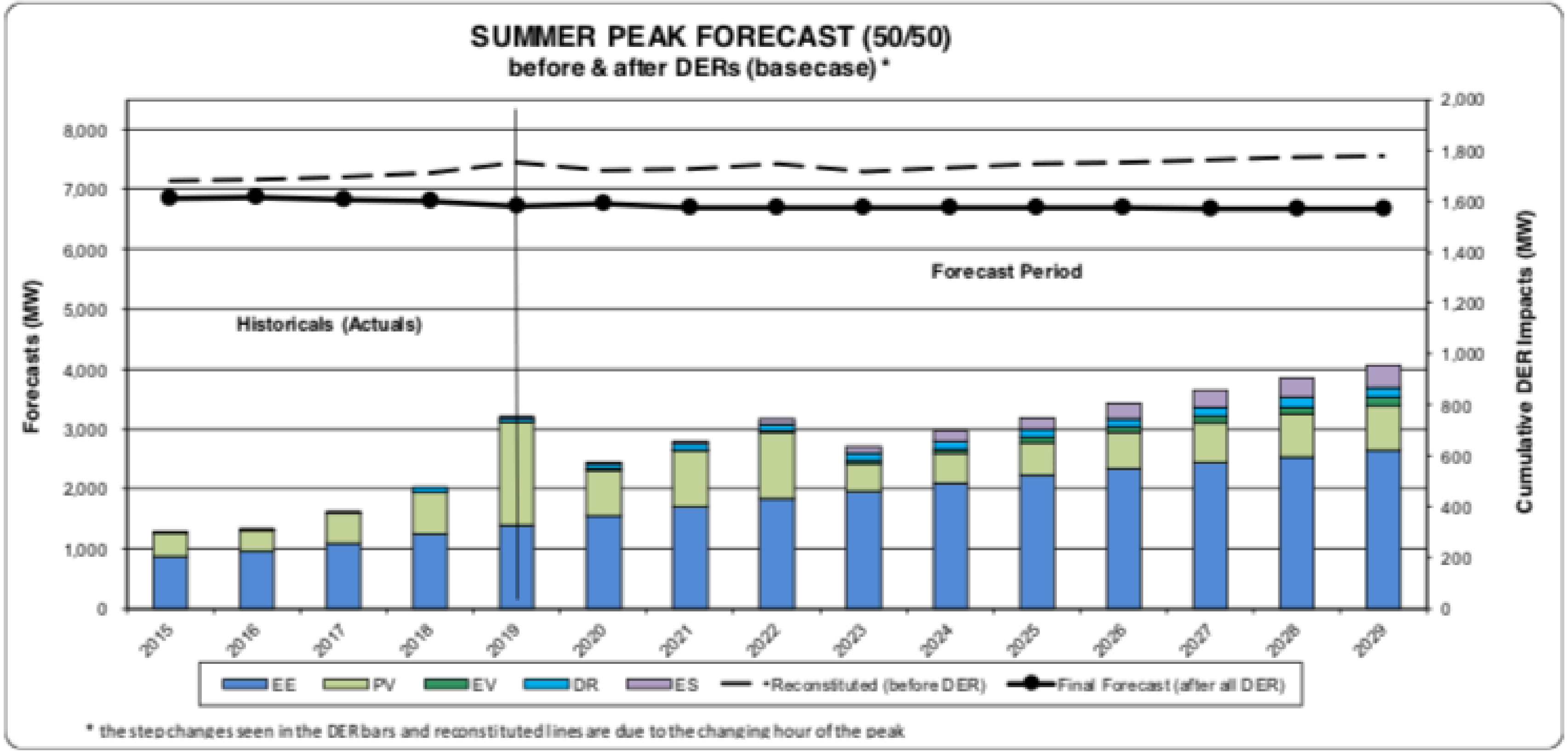
Niagara Mohawk Power Company, *2020 Electric Peak (MW) Forecast 15-year Long-term,* Nov 2019

National Grid example: DER impacts on peak



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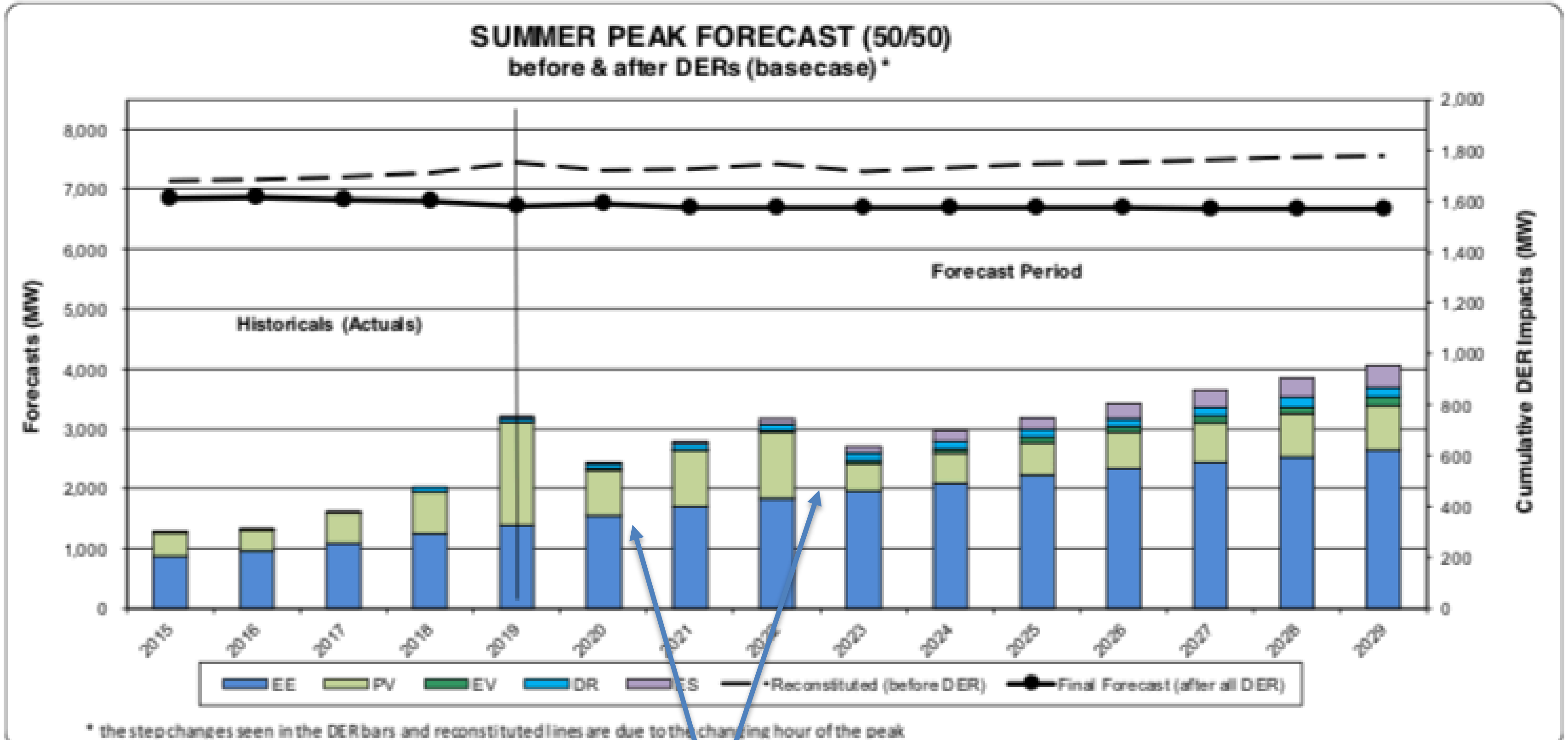
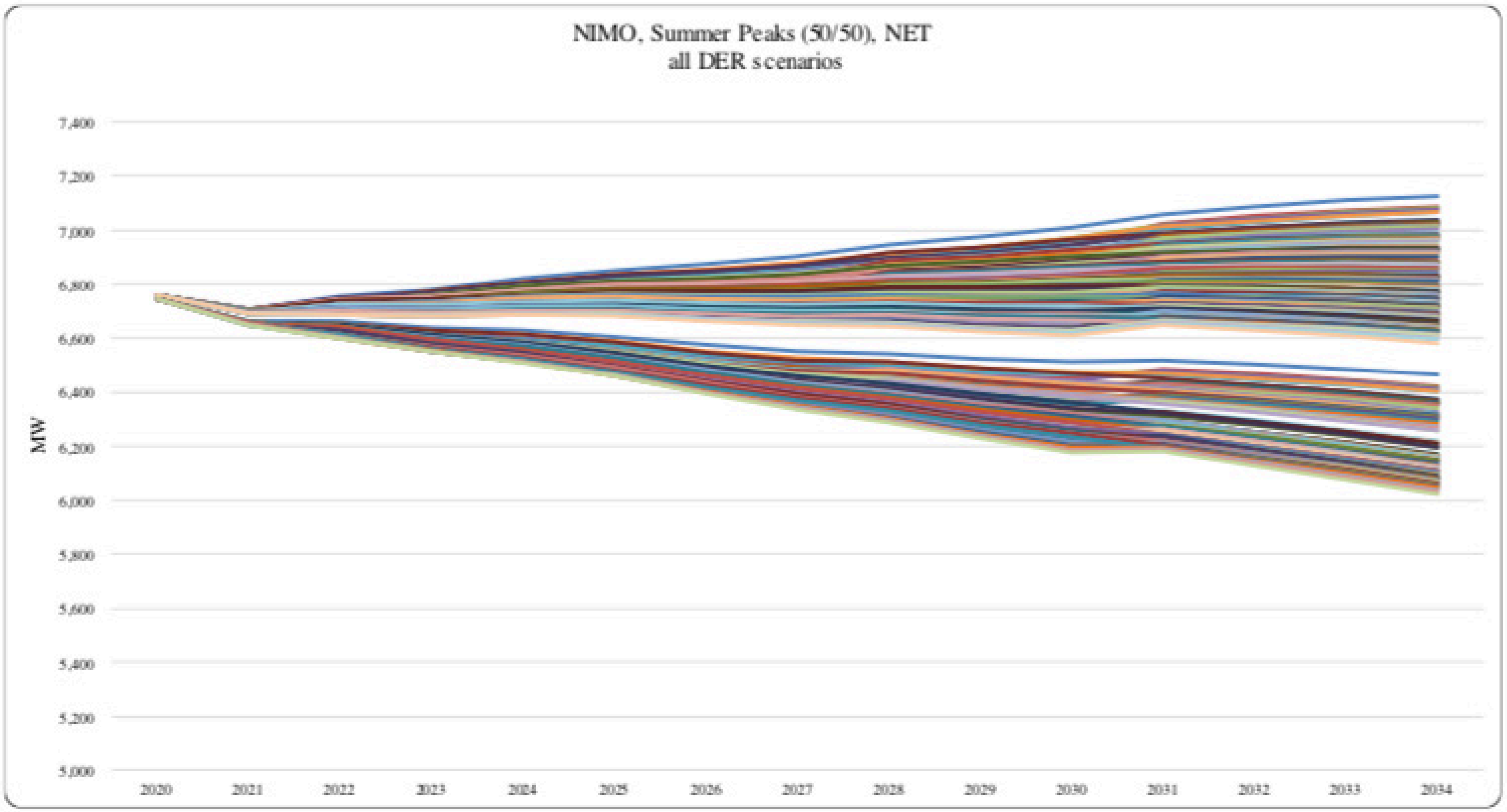


What's happening to the PV contribution? The peak hour shifts during those years to a later hour when PV provides less contribution

Niagara Mohawk Power Company, *2020 Electric Peak (MW) Forecast 15-year Long-term,* Nov 2019

National Grid example: Different DER scenarios show potential futures



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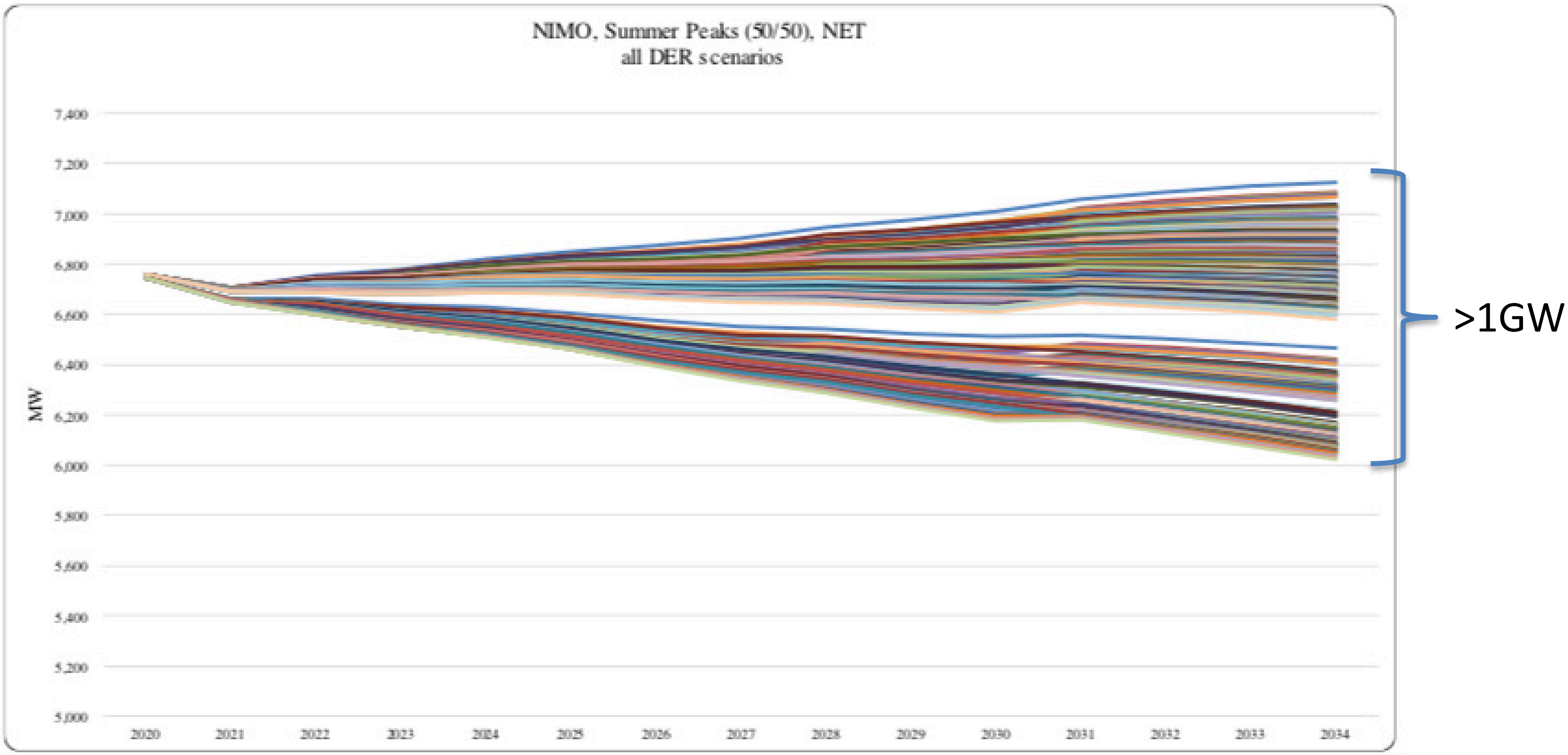
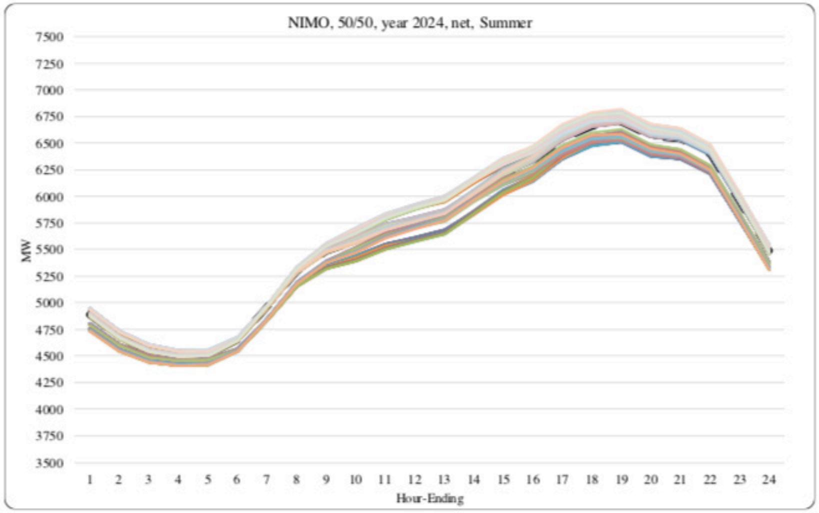
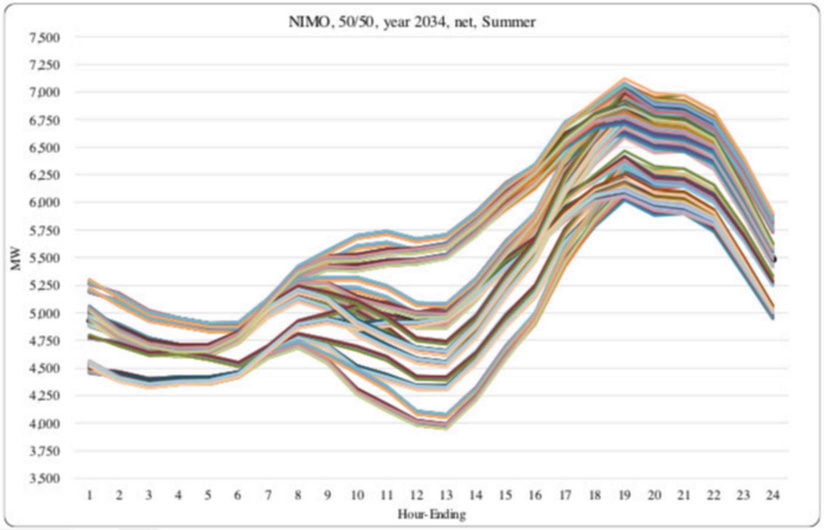


Niagara Mohawk Power Company, *2020 Electric Peak (MW) Forecast 15-year Long-term,* Nov 2019

National Grid example: Differences in scenarios greatest at midday





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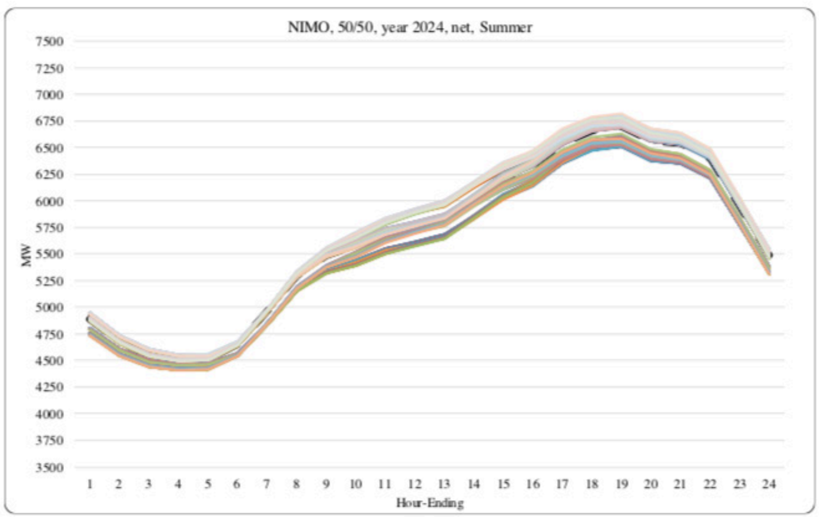
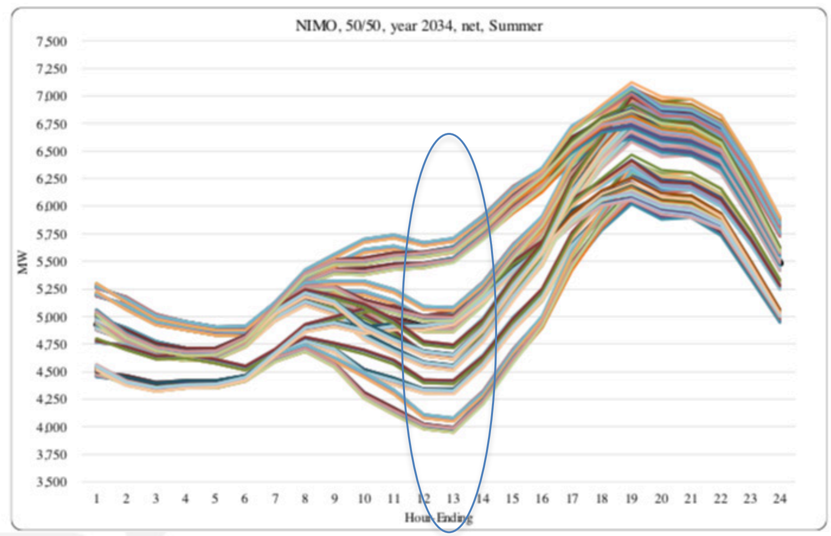
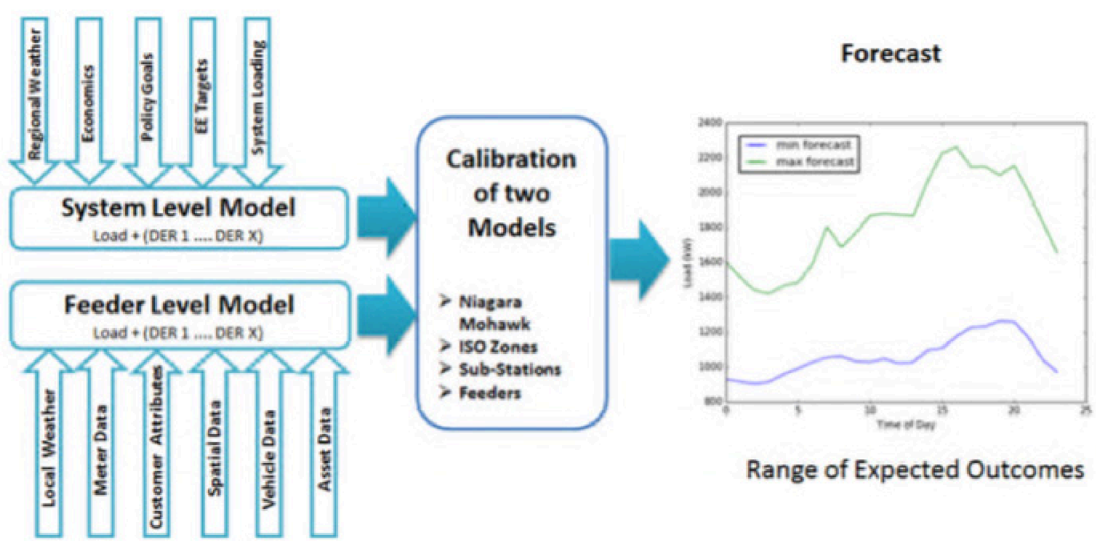




Niagara Mohawk Power Company, *2020 Electric Peak (MW) Forecast 15-year Long-term,* Nov 2019

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
- Put into GRIDLAB-D



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

Considerations for DER growth and load forecasting

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- Which DER are considered?
- Are hourly profiles considered? Does timing of system peak change?
- What data is used to determine growth rates for new DER and how does it vary by location?
- What scenarios are used to model potential futures and do they encompass a broad enough range for planning purposes?
- What range of uncertainty is used in examining inter-annual variability on feeders? On the bulk power system? For example, the average over the last 20 years? Planning for a 1 in 10 year event? A 1 in 20 year event?

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Integration Capacity Analysis/Hosting Capacity

Inform customers and distribution planning, streamline interconnection, improve real-time operations

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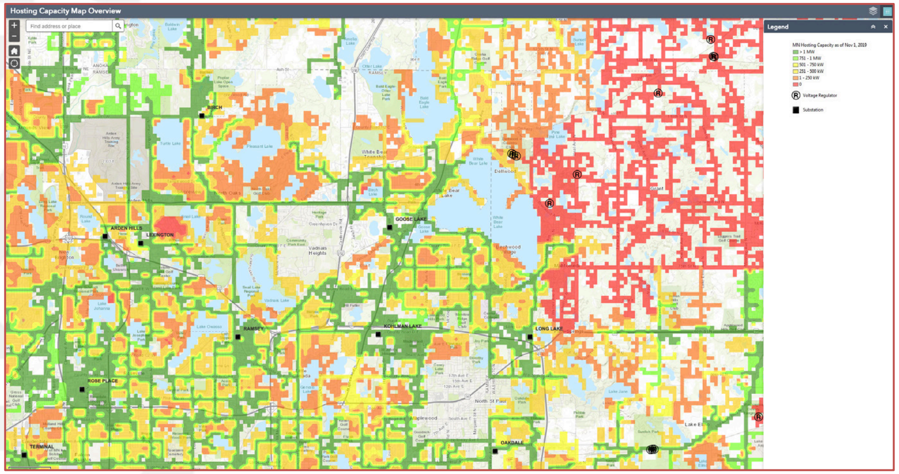
Why?

- Guide development: Which locations are easier or harder to interconnect?
- Technical screen: Streamline and potentially automate the interconnection process
- Inform distribution planning, such as where to proactively upgrade the grid to accommodate autonomous DER growth
- Dynamic hosting capacity: operational use; real-time impacts of DER



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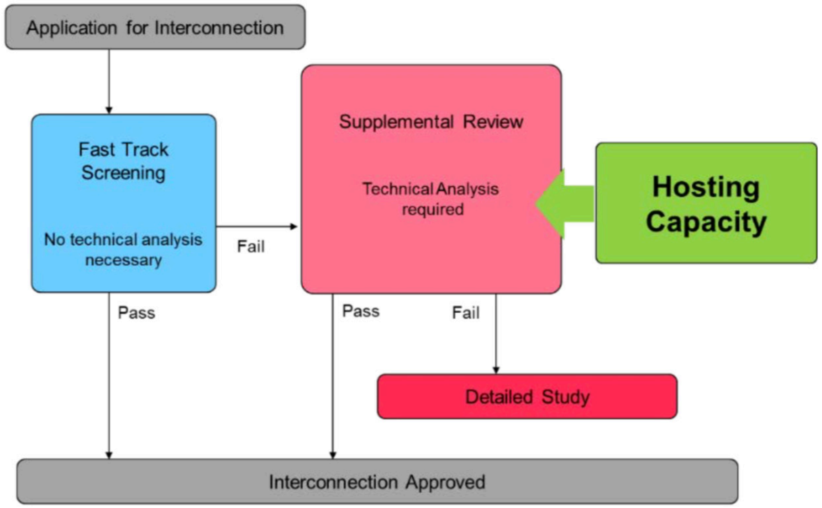

Graphic: EPRI. *Impact Factors, Methods, and Considerations for Calculating and Applying Hosting Capacity,* Feb 2018

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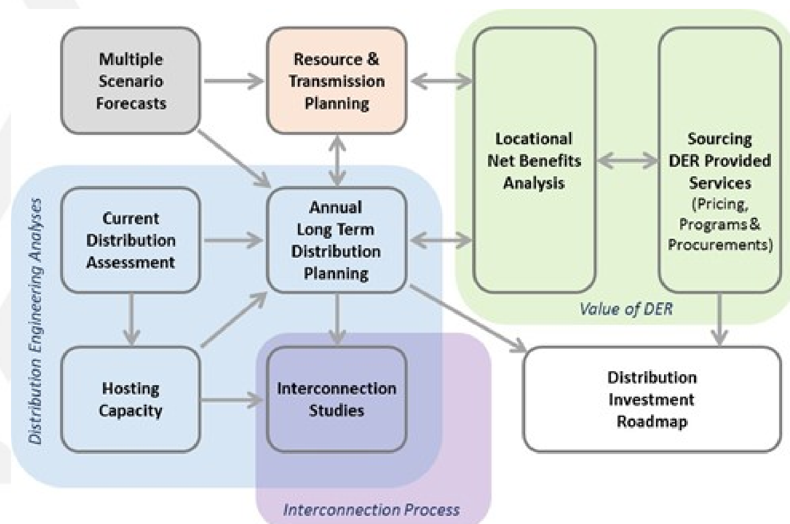

Graphic: ICF, *Integrated Distribution Planning*, August 2016

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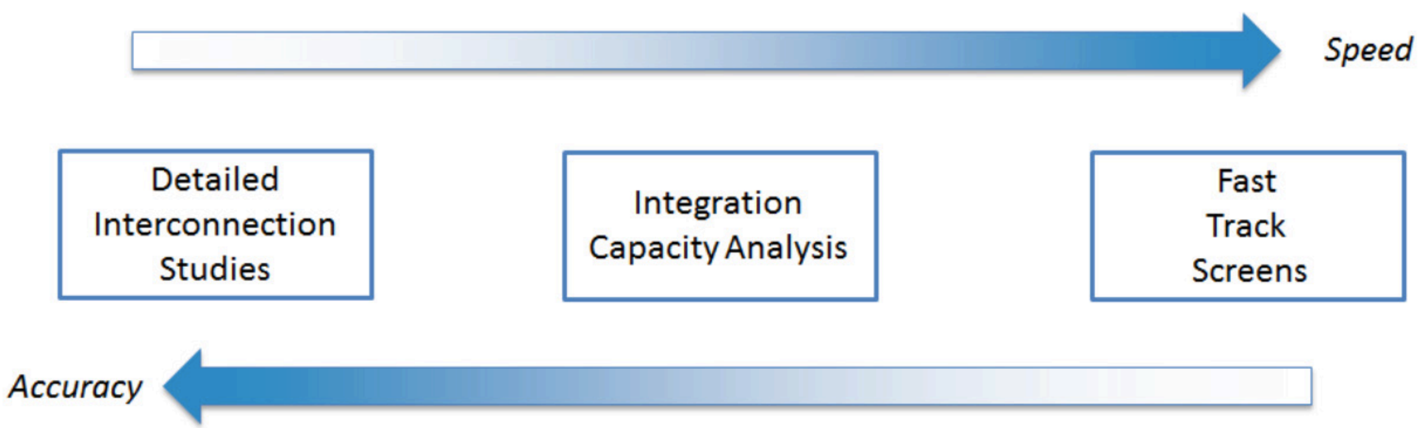

Graphic: PG&E, Distribution Resources Plan Webinar, Aug. 3, 2015

Data Inputs

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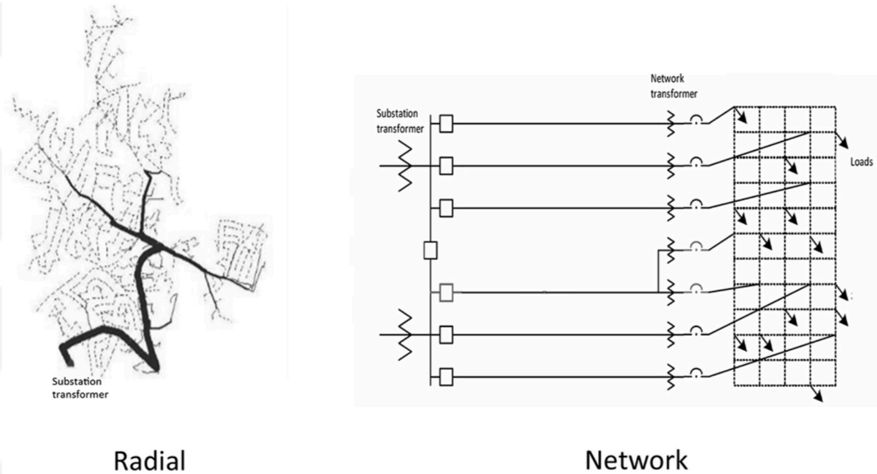
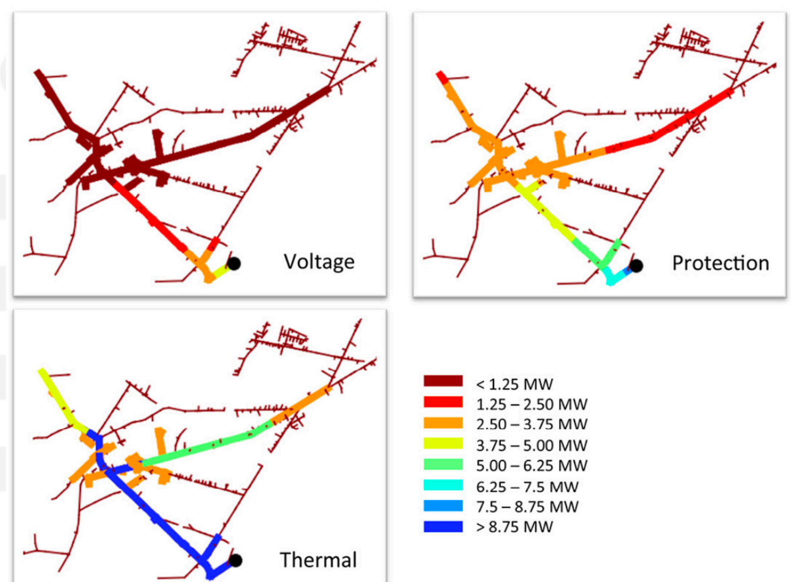
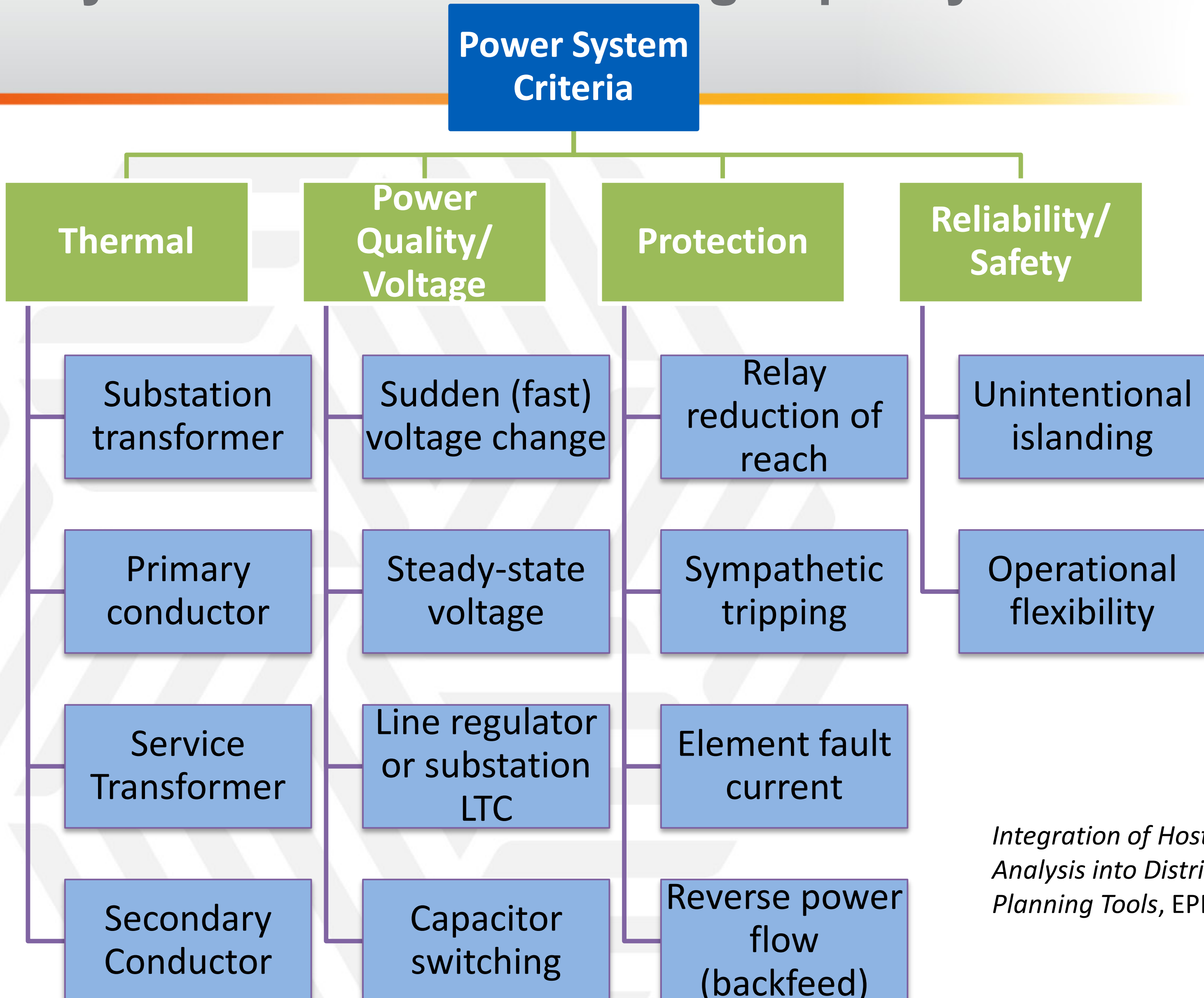
- Feeder models
- GIS data of distribution infrastructure
- SCADA data at substation - loading
- Current and future DER (or scenarios) – size, location, type, control, aggregation
- Voltage regulation – operational field settings
- Grid configuration – operational reliability





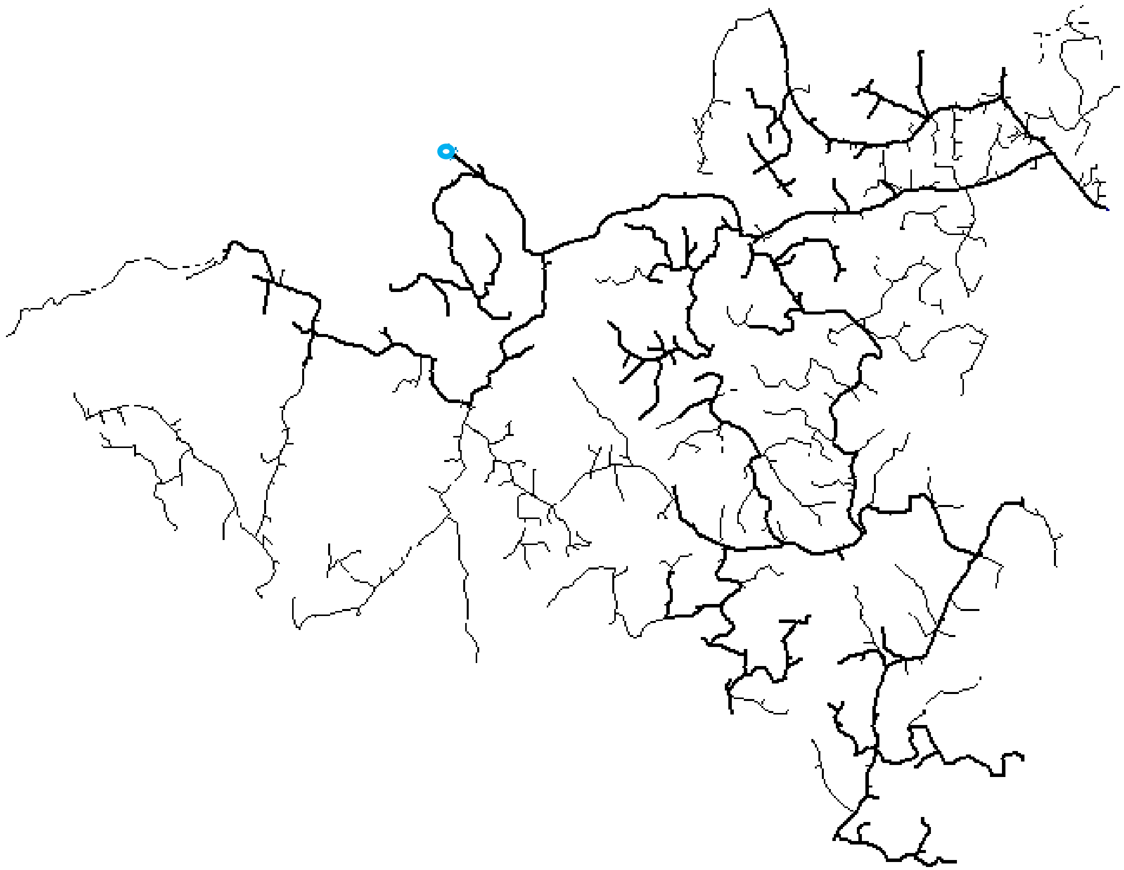
Graphics: EPRI, *Defining a Roadmap for Successful Implementation of a hosting Capacity Method for New York State*, June 2016

Power system criteria for hosting capacity



Integration of Hosting Capacity Analysis into Distribution Planning Tools, EPRI, 2015

We don't know where the PV will be interconnected



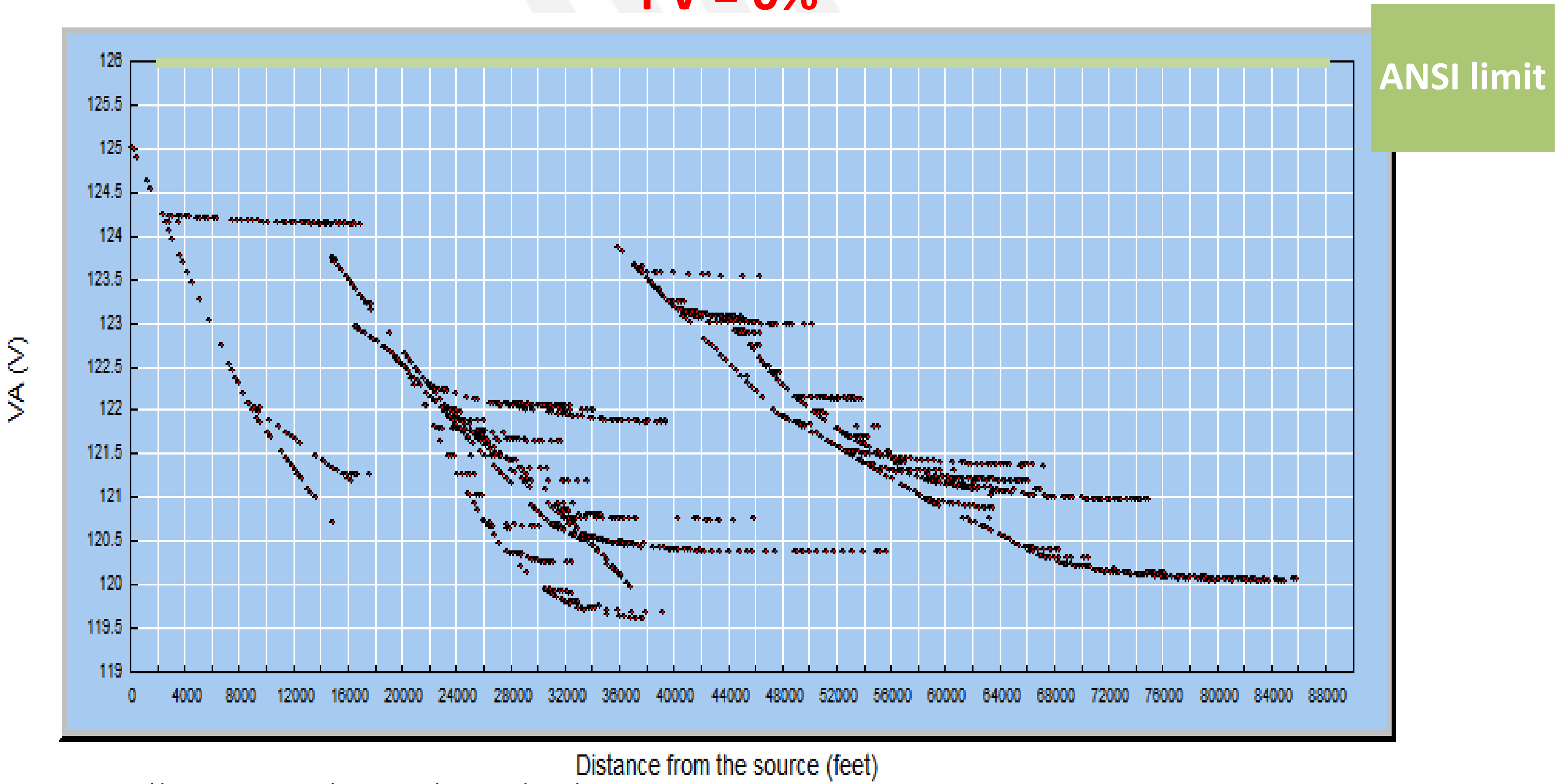
There are 4,000-5,000 nodes on this feeder where PV could be interconnected.

Graphic: S. Matic, GE Energy Consulting, 2017

PV location makes a huge difference

Feeder voltage profile

PV = 0%



DSTAR, http://www.dstar.org/research/project/103/P15-6-impact-and-practical-limits-of-pv-penetration-on-distribution-feeders

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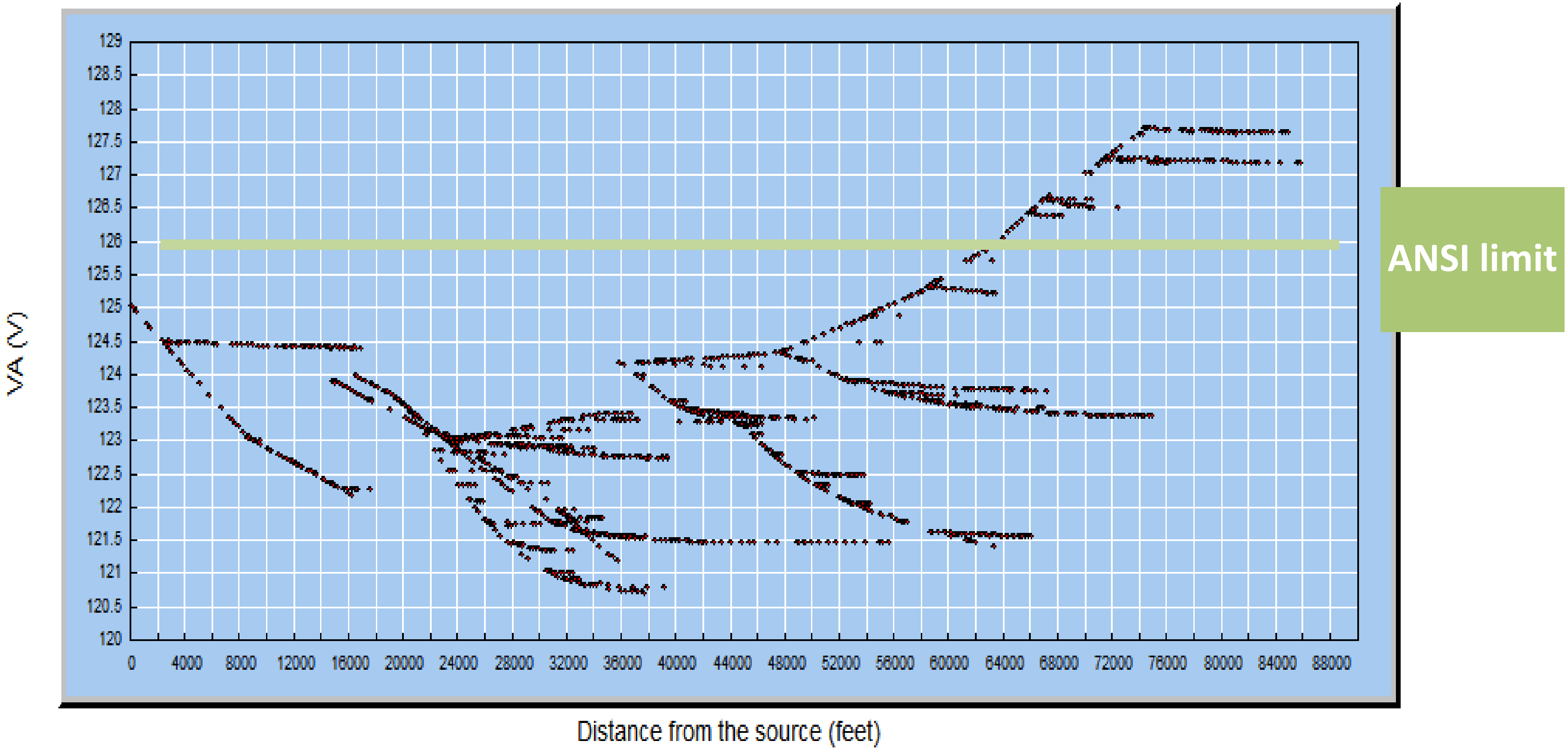
Feeder voltage profile

Single PV = 20%



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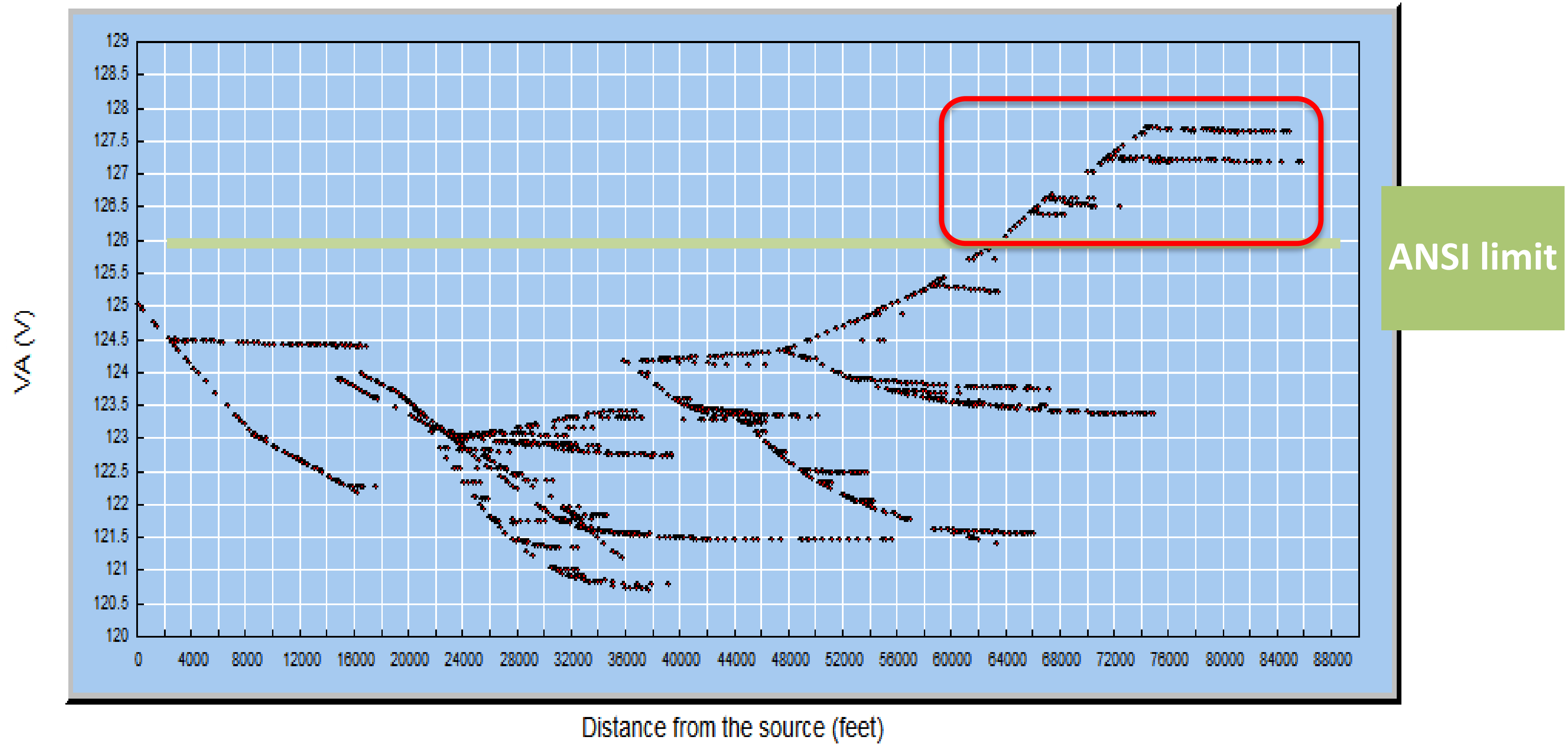

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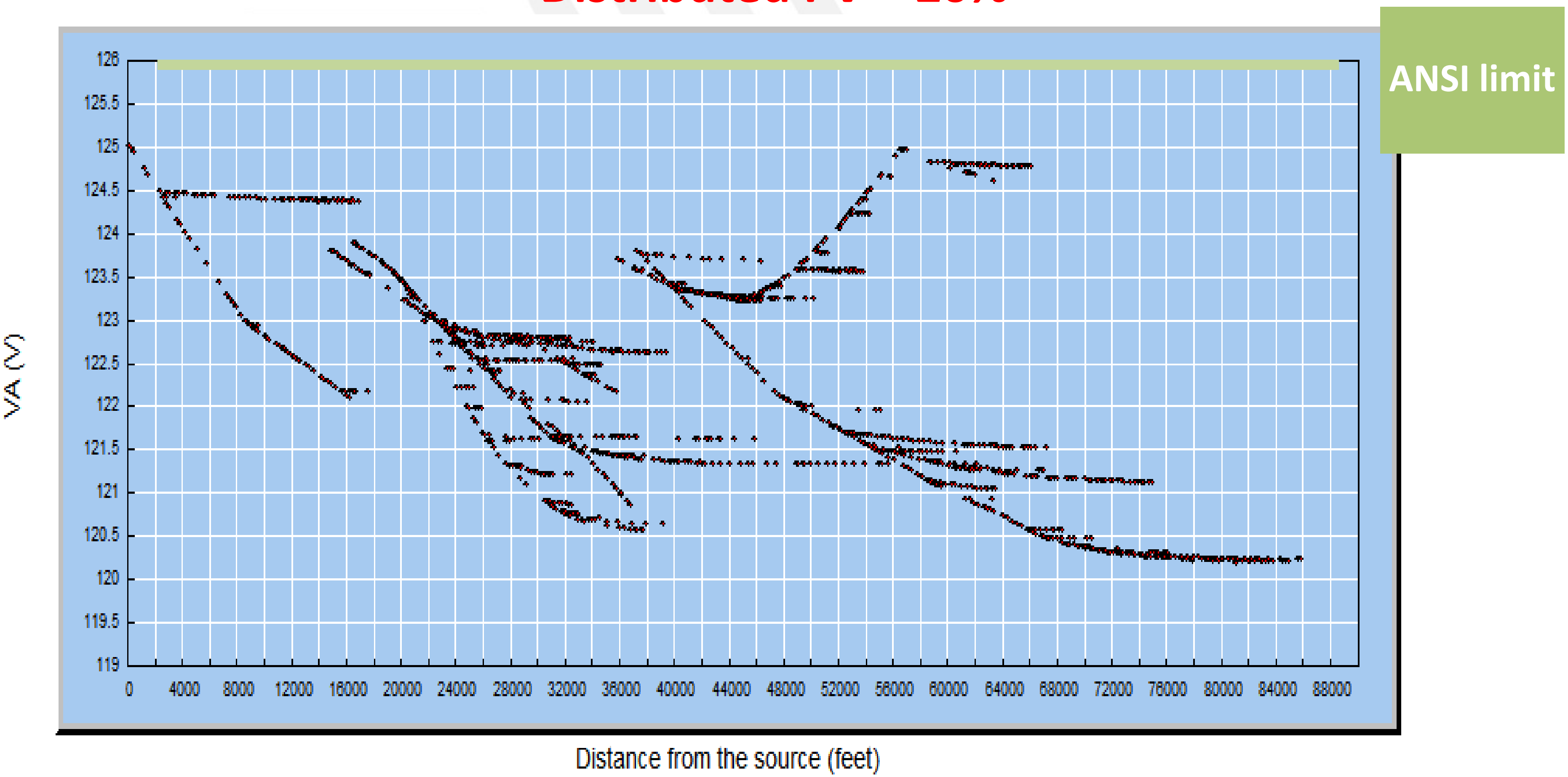
Feeder voltage profile

Distributed PV = 20%



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Summary of Hosting Capacity Methodologies

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Type	Load levels	Scenarios	Run time	Data intensive	Application	Example users
Stochastic	Varies	Thousands	Hours	Yes	Planning, information	Pepco, ComEd
Streamlined	576	Many	Minutes	Yes	Planning, information	PG&E originally
Iterative	576	One DER location at a time	Hour(s)	Yes	Planning, information, interconnection study	SCE, SDG&E, PG&E
Hybrid/ DRIVE	2	Centralized, distributed, rooftop PV	Minutes		Planning, information, interconnection study	Xcel, NY, National Grid, TVA

This is a generalized summary. Specific approaches may vary.

Xcel Energy example: Hosting Capacity Analysis (HCA)

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- November 2019 study
  - 1,050 feeders were analyzed using EPRI's DRIVE tool
  - Examined distributed generation (not batteries, not EVs)
  - Examined peak and minimum load
  - Compared results to actual interconnection studies
  - Outreach and stakeholder engagement for desired data outputs
  - Cost of analysis, license, mitigation, etc. - $630k
- Results in heat maps and tables
  - 129 feeders have zero HC – most of these have significant DER already
- Case study sensitivity analysis on one feeder
  - Big impacts from feeder loading, DER location
- Mitigation options analysis on 95 feeders with zero HC from 2018 study
  - Over a third of these could increase HC (by about 2MW on average) for <$5k

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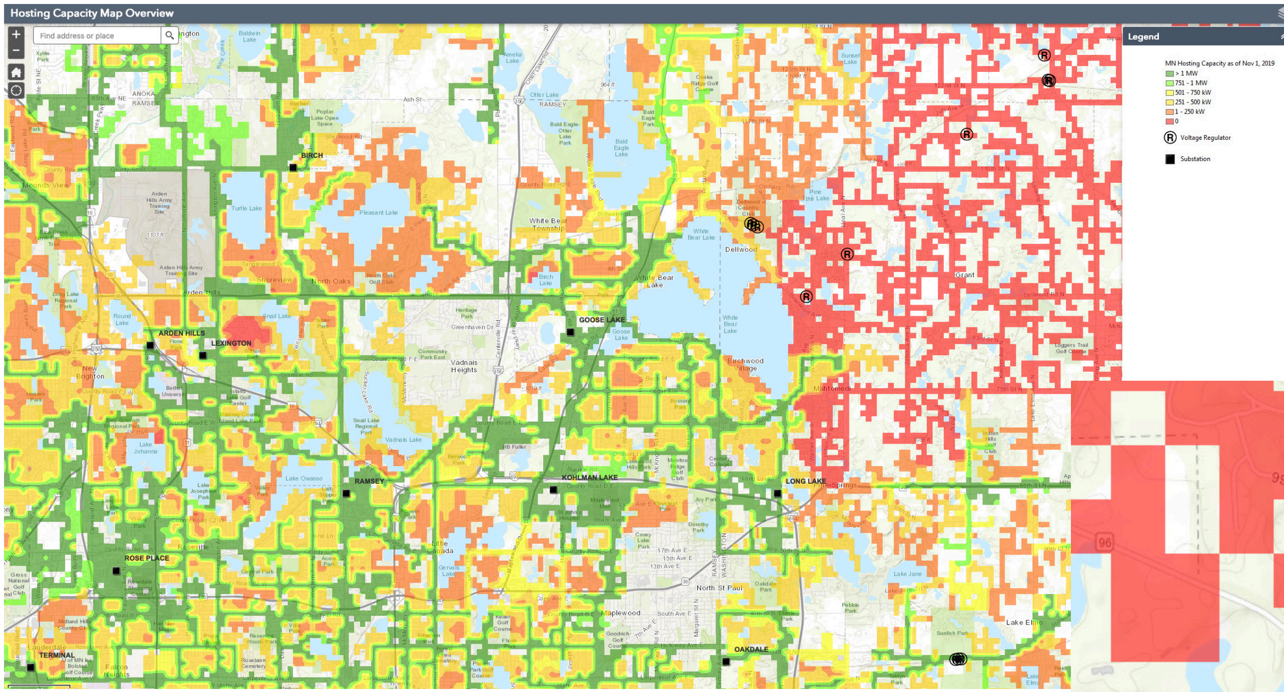
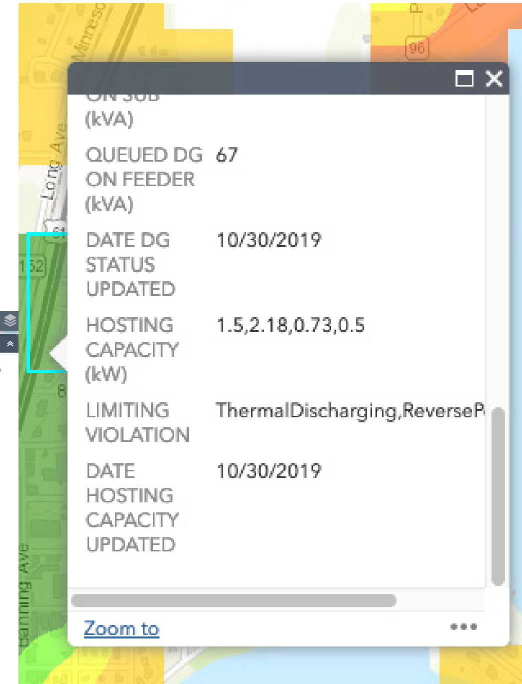
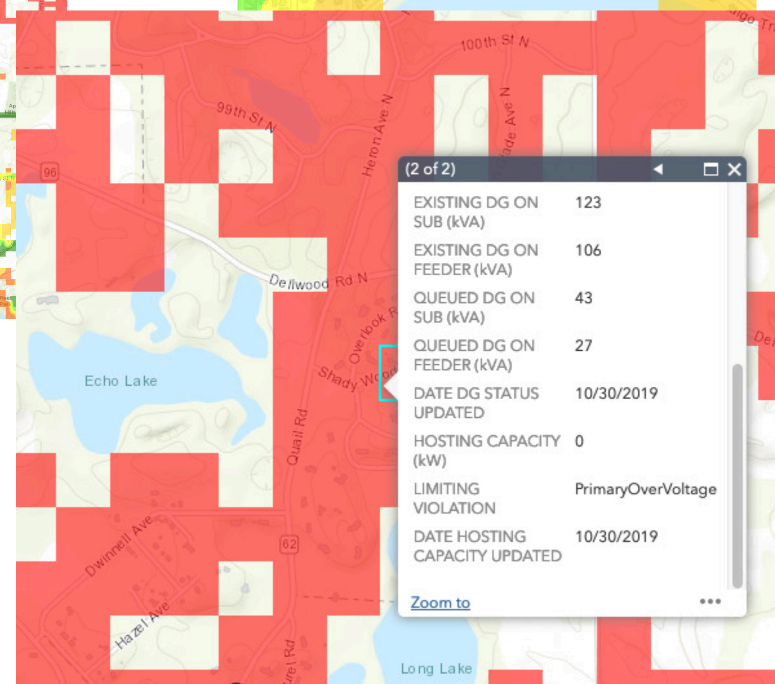
Xcel Energy example:
Heat map results for HCA







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Xcel Energy example: Mitigation

$0

$250k/mile

Category	Impacts	Mitigation
Voltage	Overvoltage	Adjust DER power factor setting, reconductor
	Voltage Deviation	Adjust DER power factor setting, reconductor
	Equipment Voltage Deviation	Adjust DER power factor setting, adjust voltage regulation equipment settings (if applicable), or reconductor
Loading	Thermal Limits	Reconductor, replace equipment
Protection	Additional Element Fault Current	Adjust relay settings, replace relays, replace protective equipment
	Breaker Relay Reduction of Reach	Adjust relay settings, replace relays, move or replace protective equipment
	Sympathetic Breaker Relay Tripping	Adjust relay settings, replace relays, move or replace protective equipment
	Unintentional Islanding	Installation of Voltage Supervisory Reclosing

Are these the only mitigation options? No. Does Xcel use all of these options today? No. But this strikes a balance between a semi-automated process and cost-effective capabilities that we are on the cusp of using in the near future.

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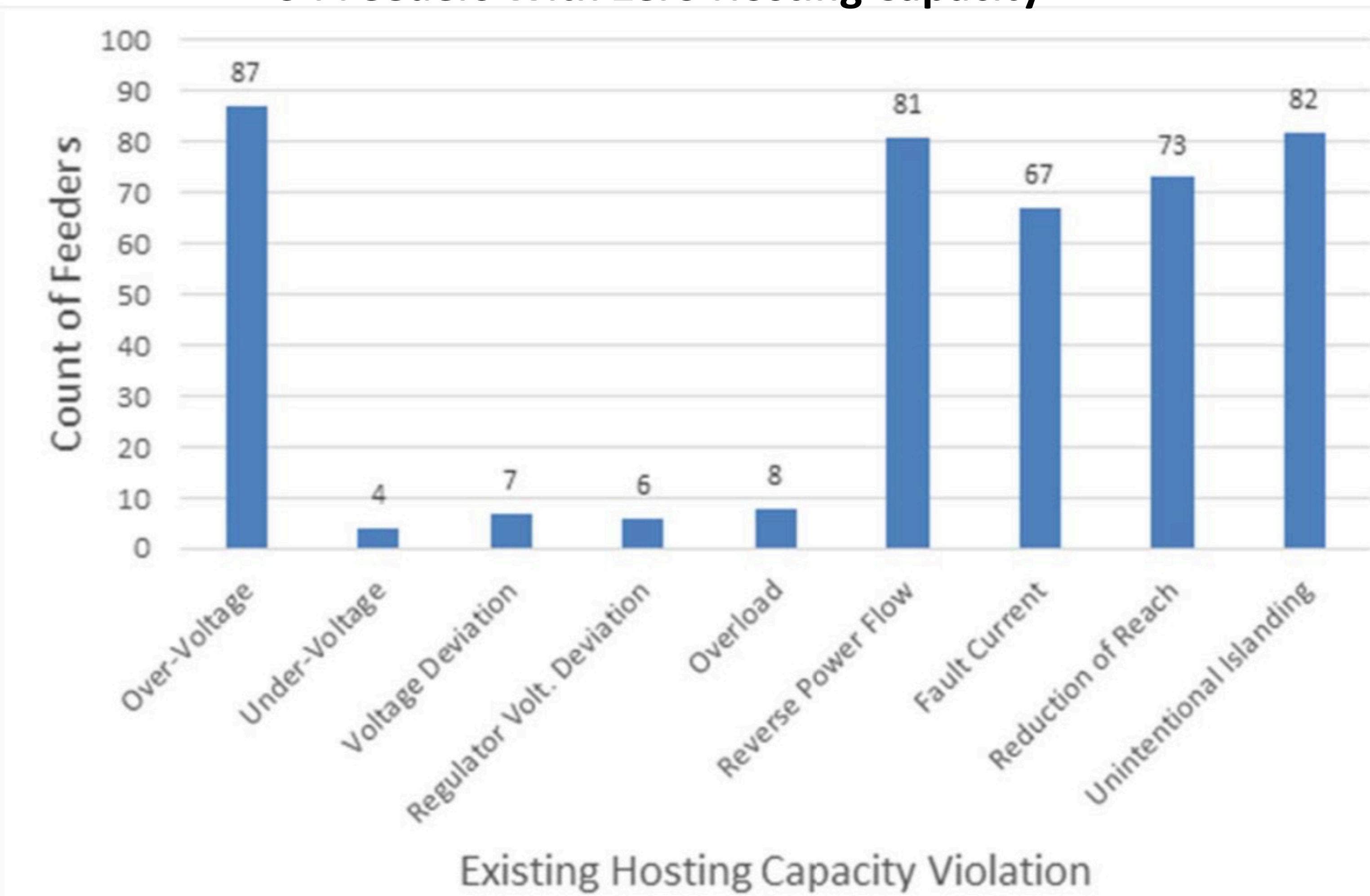
Xcel Energy example: Hosting Capacity violations

94 Feeders With Zero Hosting Capacity



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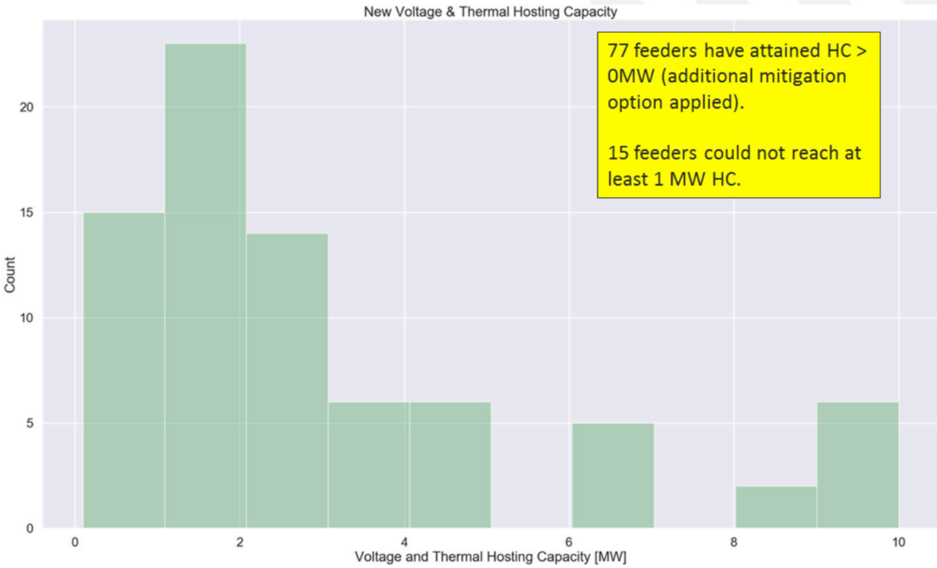
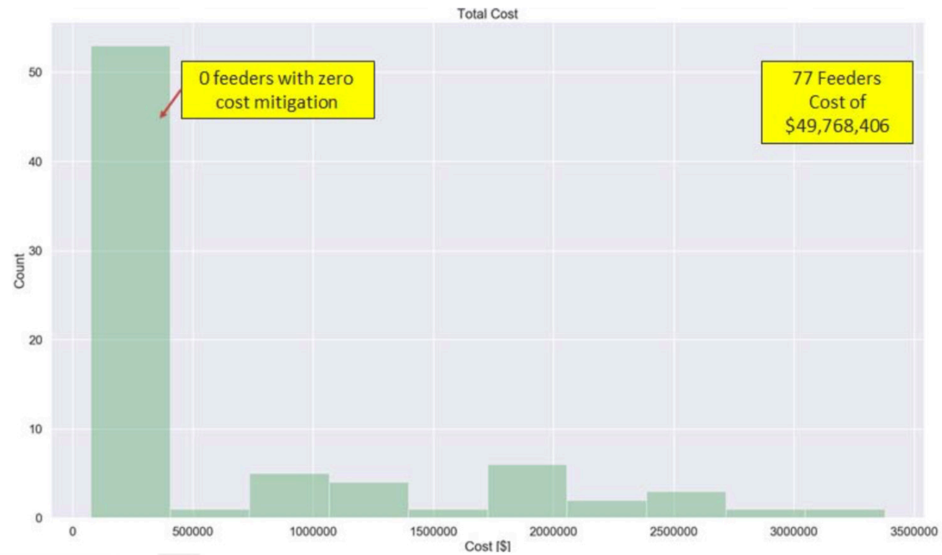
Xcel Energy example: Hosting Capacity gain and cost





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Considerations for hosting capacity analysis

- What is the goal or use case for your utility?
- Does HC provide value in this use case?
- Does the utility have appropriate data so that results are meaningful and accurate?
- How can privacy be protected as data is used or as HC results are publicized?
- Is the HC method appropriate for the use case and the available data?
- How will results be communicated to developers and other stakeholders?
- What is the cost of doing this analysis in terms of engineering labor and money? Are the costs outweighed by the benefits?

POLL

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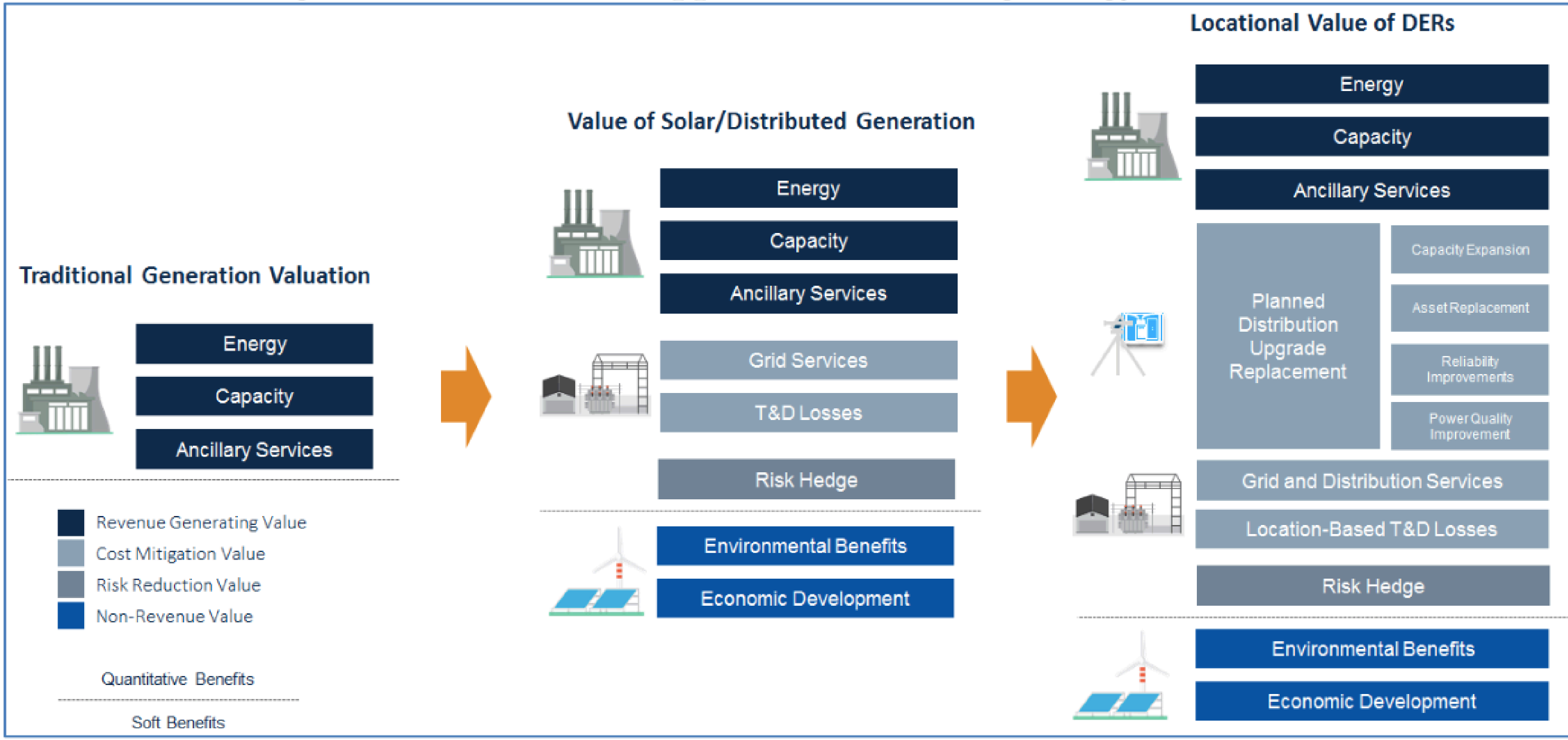
Locational Net Benefits Analysis

Preparing for Non-Wires Alternatives

Why LNBA?

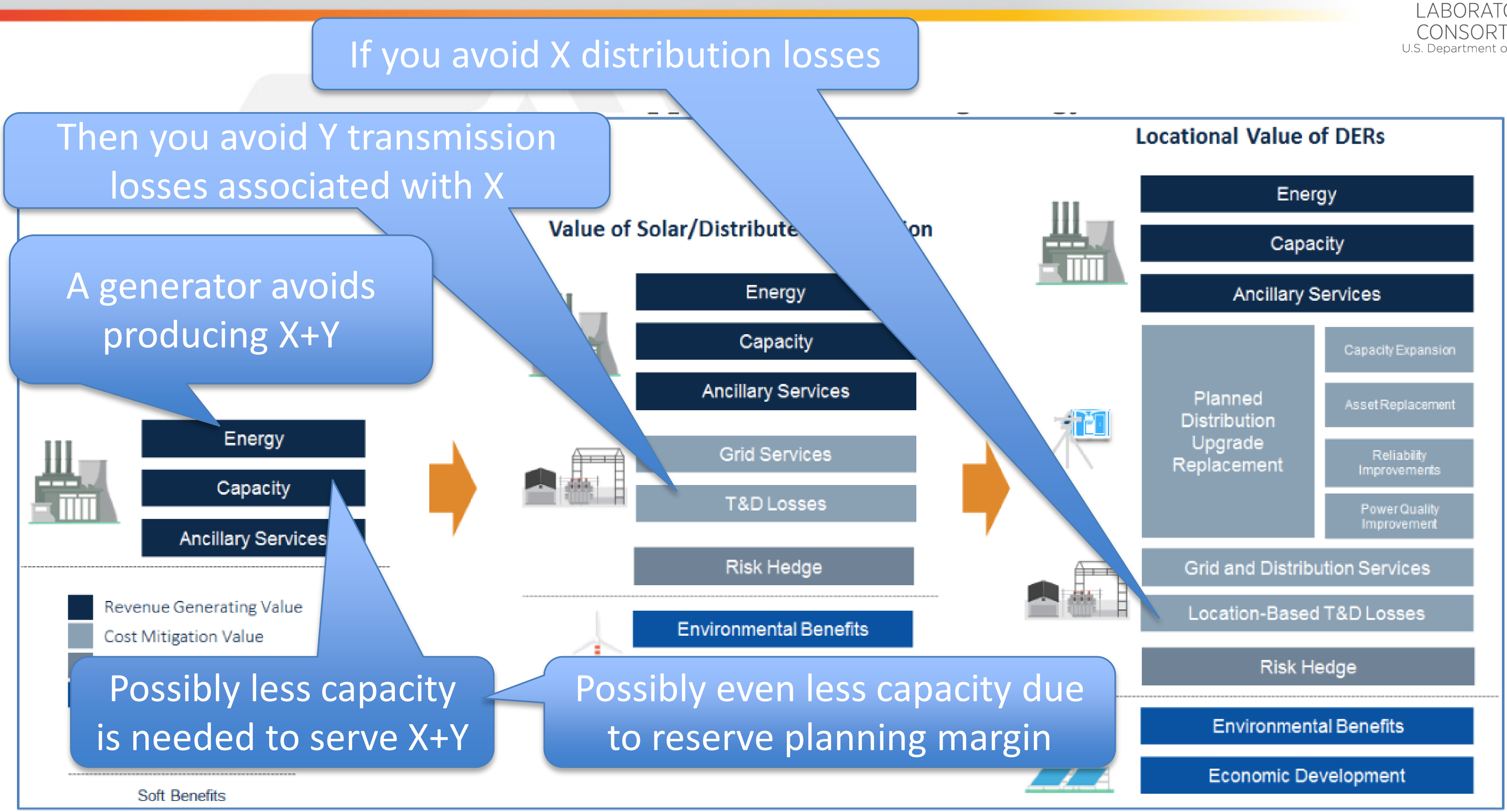
- What is the value of providing this service at this time at this location?
- Compensation for DER
  - Inform compensation such as value of solar tariff or net metering; programs and incentives; and rate design
- Non-wires alternatives (NWA)
  - What are the costs of the traditional upgrades that the utility would otherwise undertake?
  - What is the suitability of NWAs to distribution system needs?
  - Public tool and heat map
  - Prioritization of candidate distribution deferral opportunities
  - Determine cost-effectiveness, compare projects

Benefits of DERs



Ben Kellison, "Unlocking the Locational Value of DER 2016: Technology Strategies, Opportunities, and Markets," January 2016,

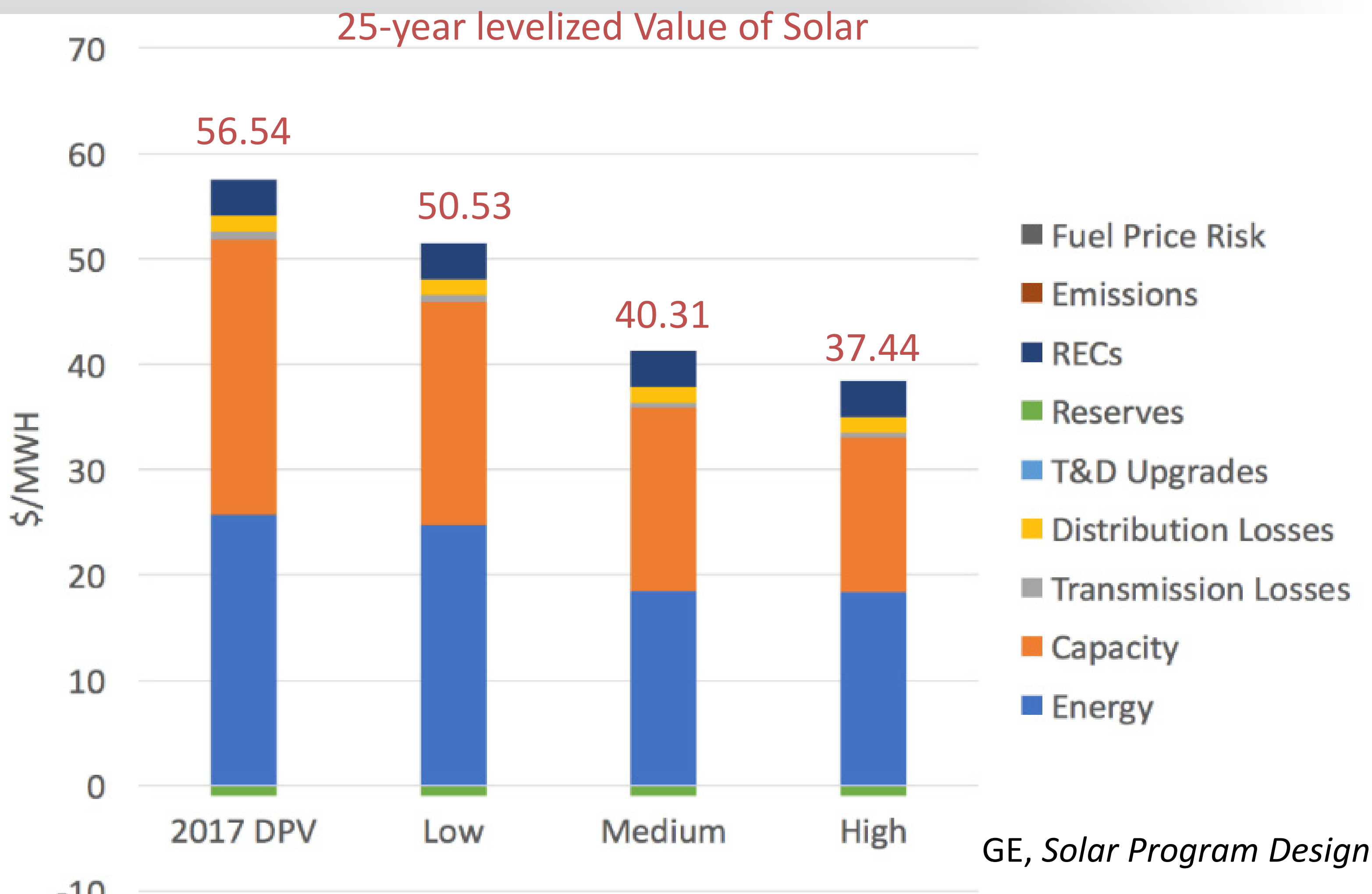
These value streams have ripple effects



Ben Kellison, "Unlocking the Locational Value of DER 2016: Technology Strategies, Opportunities, and Markets," January 2016,

Calculate the localized impacts first

Stacking the value stream for rooftop PV

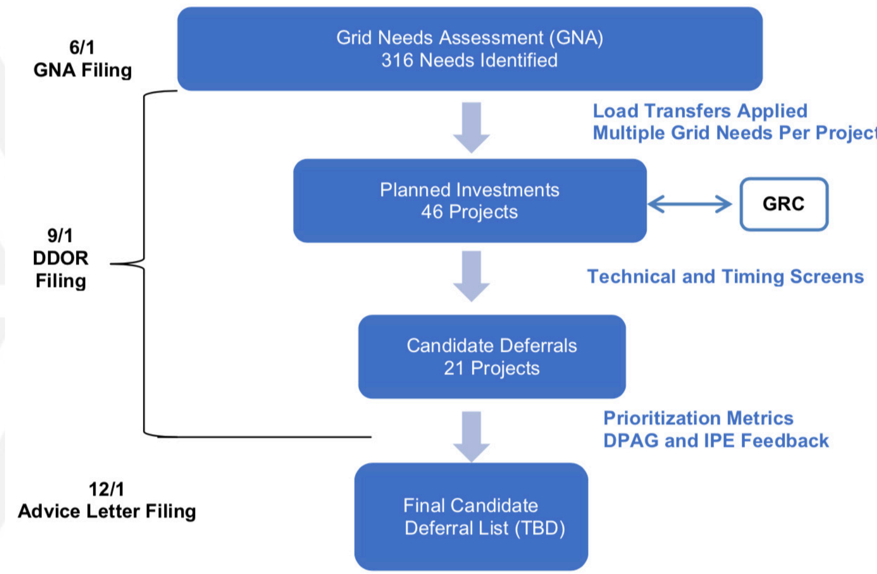


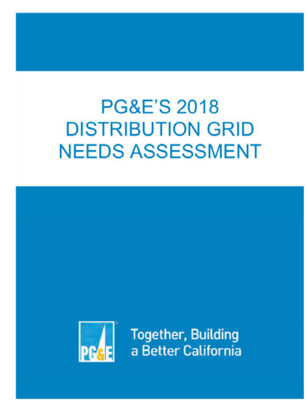
GE, *Solar Program Design Study*, 2017

DPV	7.1MW	20MW	50MW	100MW
UPV	19MW	89MW	89MW	89MW

PG&E example: Distribution Investment Deferral Framework (DIDF)

- Transparent process to create candidate deferral shortlist, grid mod investments, & proactive hosting capacity upgrades to accommodate forecasted DER growth
- 5 year planning horizon
- Grid Needs Assessment (GNA)
- Investment projects
- Technical and timing screens
  - Capacity, reactive power, voltage, reliability (backtie), resiliency (microgrid)
  - Can DER provide required service?
  - Operating date
- Prioritization metrics
  - Cost-effectiveness
  - Forecast certainty
  - Market assessment

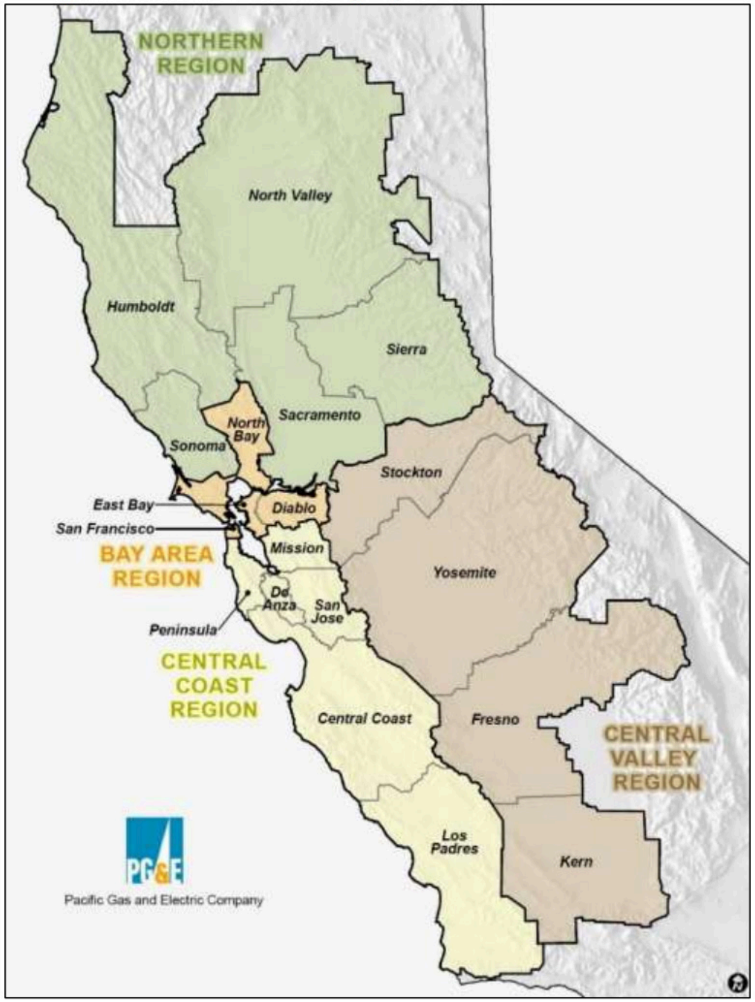




Source: PG&E's 2018 Distribution Deferral Opportunity Report, Sep. 4, 2018

PG&E example: Grid Needs Assessment (GNA)

- GNA Report and Spreadsheet
  - 6994 separate grid needs
  - Location
  - Distribution service required
  - Primary driver of grid need
  - Date needed
  - Equipment/Facility rating
  - Forecasted deficiency over 5 years
  - What mitigation options are possible? Can they be mitigated through distribution switching and load transfers?



Graphic showing four Distribution Planning Regions: PG&E

PG&E example: Grid Needs Assessment

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Project Type	Distribution Capacity	Voltage Support	Reliability (Back-tie)	Resiliency (microgrid)	Total
Substation/Bank	59	0	10	0	**69**
Feeder	107	0	23	0	**130**
Distribution Line	631	6153	11	0	**6795**
Totals	**797**	**6153**	**44**	**0**	**6994**

PG&E's 2019 Grid Needs Assessment/Distribution Deferral Opportunity Report, 2019

PG&E Example
Qualitative Prioritization Methodology

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- Cost-effectiveness – Projects with higher costs or higher LNBA are ranked higher. DER can potentially provide a high value by avoiding expensive solutions.
  - Unit costs
  - LNBA $/kW-yr
  - LNBA $/MWh-yr
- Forecast certainty – How certain is the grid need? Near-term needs and locations with SCADA are ranked higher.
  - Forecasted need
  - SCADA available
  - # customers on asset
- Market assessment – How likely can DER successfully meet the requirements? Projects that are day-ahead, have fewer grid needs, fewer days/year and lower overcapacity are ranked higher
  - Real-time or day-ahead notification
  - Days/year
  - Number of grid needs
  - Hours per call
  - Overcapacity

Engineering judgment and experience play into *all* three metrics

PG&E example: Performance and operational requirements

Candidate Deferral	Grid Need Location	Real Time (RT) or Day Ahead (DA)	Offer Size (MW)	Delivery Months	Calls/Year	Delivery Hours	Hours Duration
Alpaugh New Feeder	Corcoran 1112	DA	4.4	Jun-Sep	113	3:00PM-10:00PM	7
Calflax Bank 2	Calflax Bank 1	DA	4.8	May-Aug	92	4:00PM-8:00AM	16
Santa Nella	Canal Bank 1	DA	1.2	Jun-Aug	75	5:00PM-8:00PM	3
	Canal 1103	DA	4	Jun-Sep	122	3:00PM-10:00PM	7
	Ortiga 1106	DA	3.8	Jun-Sep	122	4:00PM-10:00PM	6
FMC 1102	FMC 1101	RT	0.8	Jun-Sep	4	12:00AM-12:00AM	12

PG&E's 2019 Grid Needs Assessment/Distribution Deferral Opportunity Report, 2019

PG&E example: Candidate projects

- PG&E identified 18 candidate deferral opportunities totaling 83 MW
  - Tier 1: four projects totaling 19.3 MW that are more likely to be deferrable with DER
  - Tier 2: two projects totaling 2.1 MW that have some red flags; monitor status
  - Tier 3: 12 projects totaling 62 MW with multiple, major red flags; unlikely that DER can be successfully sourced

Candidate DER Distribution Deferral Prioritization Metrics (Public)

Tier	Candidate Deferral	In-Service Date	Deficiency (MW)	Prioritization Metrics		
				Cost Effectiveness	Forecast Certainty	Market Assessment
1	Alpaugh New Feeder	2022	4.4			
	Calflax Bank 2	2023	CC[1]			
	Santa Nella New Bank & Feeder	2022	9.3			
	FMC 1102	2023	0.8			
2	Camp Evers 2107	2022	0.9			
	Brentwood 2105	2022	1.2			
3	Estrella Substation	2024	19.4			
	Pueblo Bank 3	2022	23.2			
	Oceano 1106	2022	1.2			
	Rosedale 2102	2022	1.8			
	Rob Roy 2105	2022	3.0			
	Peabody 2106	2022	CC			
	Madison 2101	2022	CC			
	Martin SF H 1108	2022	1.0			
	Martin SF H 1107	2022	1.8			
	Avenal 2101	2022	CC			
	Edenvale 2108	2022	1.5			
	Dairyland 1110 New Feeder	2022	4.5			

PG&E's 2019 Grid Needs Assessment/Distribution Deferral Opportunity Report, 2019

PG&E example: Candidate projects

Tier	Candidate Deferral	Cost Effectiveness			Forecast Certainty			Market Assessment				
		Unit Cost ($k)	LNBA ($/kW-yr)	LNBA ($/MWh/yr)	In-Service Date	SCADA Avail. (Y/N)	Cust-omers	Real Time (RT) or Day Ahead (DA)	Days/ Year	# of Grid Needs	Hours/ Call	Over-capacity (%)
1	Alpaugh New Feeder	$3,600	$89	$88	2022	Y	2650	DA	113	1	9	38%
1	Calflax Bank 2	$6,070	$88	$60	2023	Y	228	DA	CC	1	CC	CC
1	Santa Nella New Bank & Feeder	$7,256	$55	$78	2022	Y	973	DA	122	4	7	36%
2	Camp Evers 2107	$1,720	$202	$2,100	2022	Y	6370	RT+Islanding	8	1	12	3%
2	FMC 1102	$1,700	$232	$4,830	2023	Y	3422	RT	4	1	12	4%
2	Brentwood 2105	$640	$59	$612	2022	Y	2841	RT+Islanding	8	1	12	6%
2	Estrella Substation (hypothetical)	$18,500	$209	$293	2024	Y	2738	DA	122	3	9	21%
3	Pueblo Bank 3	$6,936	$21	$110	2022	Y	9952	RT	8	1	24	52%
3	Oceano 1106	$425	$18	$64	2022	Y	6811	RT+Islanding	12	1	24	8%
3	Rosedale 2102	$400	$24	$84	2022	Y	1378	RT	12	1	24	9%
3	Rob Roy 2105	$500	$18	$63	2022	Y	8056	RT+Islanding	12	1	24	13%
3	Peabody 2106	$390	$8	$28	2022	Y	2845	RT+Islanding	CC	1	CC	CC
3	Madison 2101	$105	$13	$45	2022	Y	2068	RT+Islanding	CC	1	CC	CC
3	Martin SF H 1108	$180	$9	$33	2022	Y	6716	RT+Islanding	12	1	24	8%
3	Martin SF H 1107	$150	$4	$15	2022	Y	7090	RT+Islanding	12	1	24	18%
3	Avenal 2101	$65	$6	$21	2022	Y	1948	RT+Islanding	CC	1	CC	CC
3	Edenvale 2108	$95	$7	$24	2022	Y	6630	RT+Islanding	12	1	24	7%
3	Dairyland 1110 New Feeder	$3,887	$96	$24	2022	Y	518	DA	168	1	24	34%

PG&E's 2019 Grid Needs Assessment/Distribution Deferral Opportunity Report, 2019

Considerations for LNBA

- What is your use case for LNBA and is the calculation methodology appropriate for that use case?
- How are needs screened? Are these screens so restrictive that they eliminate projects that seem viable?
- What criteria do you use to prioritize candidate projects? To what extent did engineering (or other) judgment change prioritization of projects and why?
- Is there data or infrastructure that could give more certainty to the overall process?

Resources

- California DRPs: http://www.cpuc.ca.gov/General.aspx?id=5071
- New York REV DSIPs: http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=14-m-0101&submit=Search+by+Case+Number
- NREL on DPV benefits and costs: https://www.nrel.gov/docs/fy14osti/62447.pdf
- DSTAR on hosting capacity: http://www.dstar.org/research/project/103/P15-6-impact-and-practical-limits-of-pv-penetration-on-distribution-feeders
- EPRI on hosting capacity: https://www.epri.com/#/pages/product/1026640/
- Niagara Mohawk Power Company, *2020 Electric Peak (MW) Forecast 15-year Long-term*, Nov 2019; *National Grid 2018 DSIP Update*
- Xcel Energy Integrated Distribution Plan: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={F08D276E-0000-CC16-9736-712CDB337895}&documentTitle=201911-157103-01
- PG&E Distributed Resources Plan, 2015: http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5141
- PG&E Maps: https://www.pge.com/en_US/for-our-business-partners/distribution-resource-planning/distribution-resource-planning-data-portal.page
- PG&E's 2019 Grid Needs Assessment/Distribution Deferral Opportunity Report

Any Questions?

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New York Benefit-Cost Handbook

Table 3.3.1. New York Assumptions for Version 2.0 of BCA Handbook

New York Assumptions	Source
Energy and Demand Forecast	NYISO Load & Capacity Data Report ("Gold Book")[261]
Avoided Generation Capacity Cost ("AGCC")	DPS Staff ICAP Spreadsheet Model[262]
Locational Based Marginal Prices ("LBMP")	NYISO Congestion Assessment and Resource Integration Study Phase 2 (CARIS Phase 2)[263]
Historical Ancillary Service Costs	NYISO Markets & Operations Reports[264]
Wholesale Energy Market Price Impacts	DPS Staff: To be provided[265]
Allowance Prices (SO_2 and NO_X)	NYISO: CARIS Phase 2[266]
Renewable Energy Certificate ("REC") Contract Price	Most recent NYSERDA solicitation results[267]