NATIONAL RENEWABLE ENERGY LABORATORY

MI Power Grid Advanced Planning

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National Renewable Energy Laboratory

MI Power Grid Stakeholder Session
November 18, 2020

Interactions of grid planning processes

Why it may be helpful to align

Categories of Grid Planning

- Transmission Planning
- Generation Planning
- Distribution Planning
- Load Forecasting

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  - Upgrades to existing transmission infrastructure
  - New transmission corridors
  - Contracts and new connections for renewables
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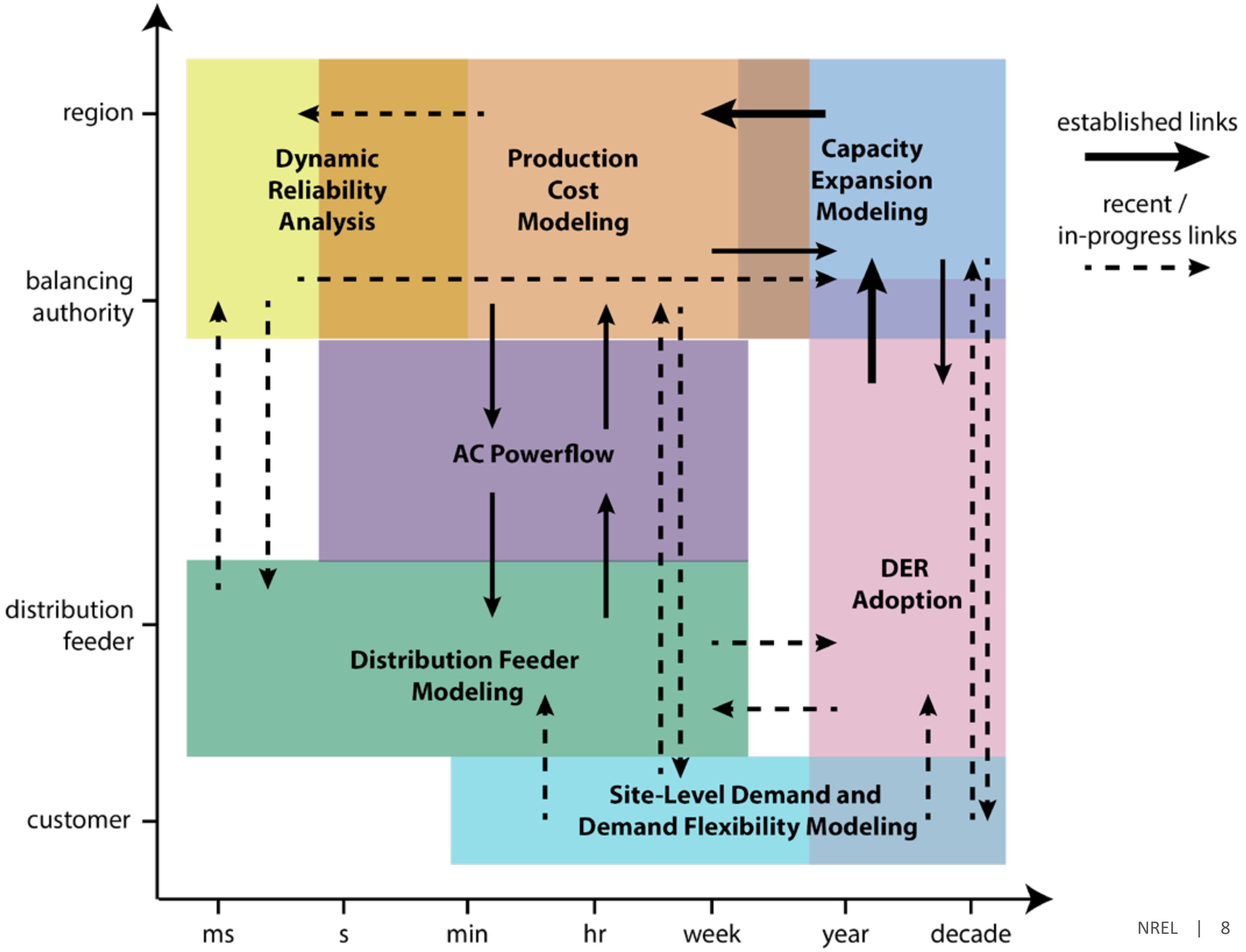
- Load Forecasting
  - How will load increase overall and how will load shapes change
  - Demand-side resource adoption

Interactions between modeling tools



Benefits of Integrated Planning

- Capture trade-offs between potentially more expensive generation types and building new transmission
- Better analysis of response to expected distributed energy resource adoption
- Solutions which may be approximately equivalent on the bulk power grid may have drastically different implications for the distribution grid

Planning Tools Used at NREL

- Capacity expansion models:
  - Regional Energy Deployment System--ReEDS (National/regional scale)
  - Resource Planning Model—RPM (regional/utility scale)
  - Renewable Energy Integration and Optimization—REOpt (building/campus/community/microgrid)
- Customer adoption of distributed generation and storage:
  - Distributed Generation and Market Demand Model—dGen
- Production cost models:
  - PLEXOS (commercial tool)
  - SIIP Powersimulations (NREL Developed, open source)
- Resource Adequacy:
  - Probabilistic Resource Adequacy Suite (PRAS)
- Distribution Feeder Modeling
  - Distribution grid Integration Solution COst—DISCO
- AC Powerflow:
  - PSLF/PSSE (commercial tools)

Planning Tools Discussed Today

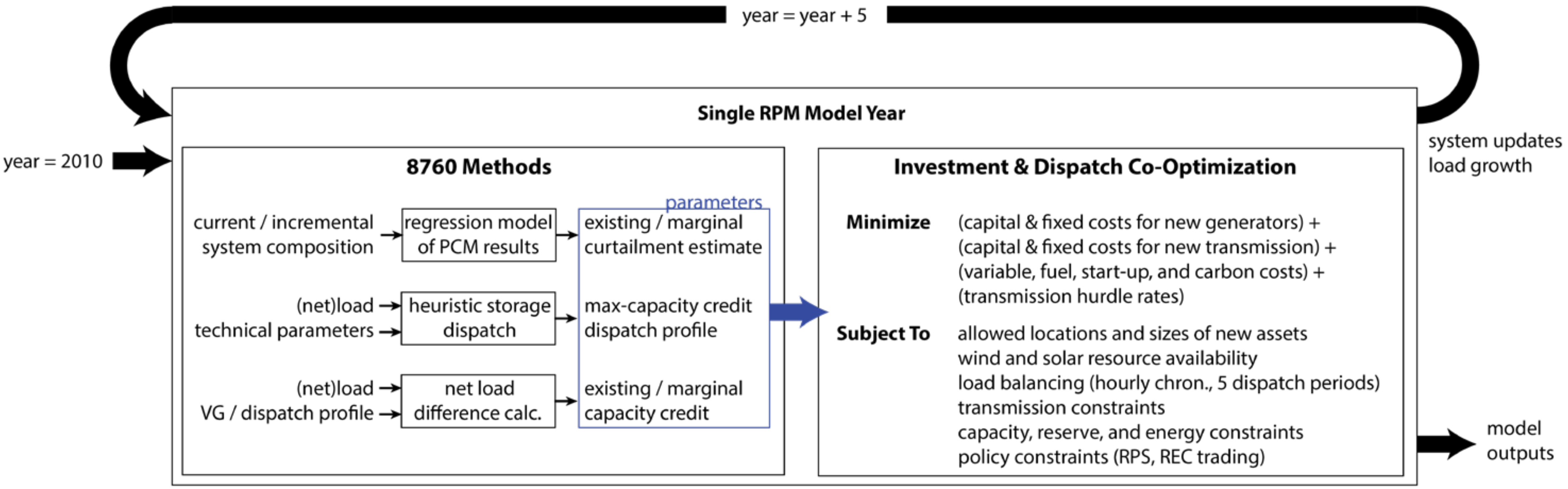
- Resource Planning Model (RPM)
  - Capacity Expansion Model
  - Incorporates transmission and generation
- dGen
  - Customer adoption model for distributed solar
  - Generation expansion on the demand side
- Distribution Modeling (DISCO)
  - Hosting capacity analysis

Resource Planning Model

https://www.nrel.gov/analysis/models-rpm.html

Nodal Representation Captures Intra-Regional Transmission Expansion

Co-Optimize Generation and Transmission Assets



LA 100

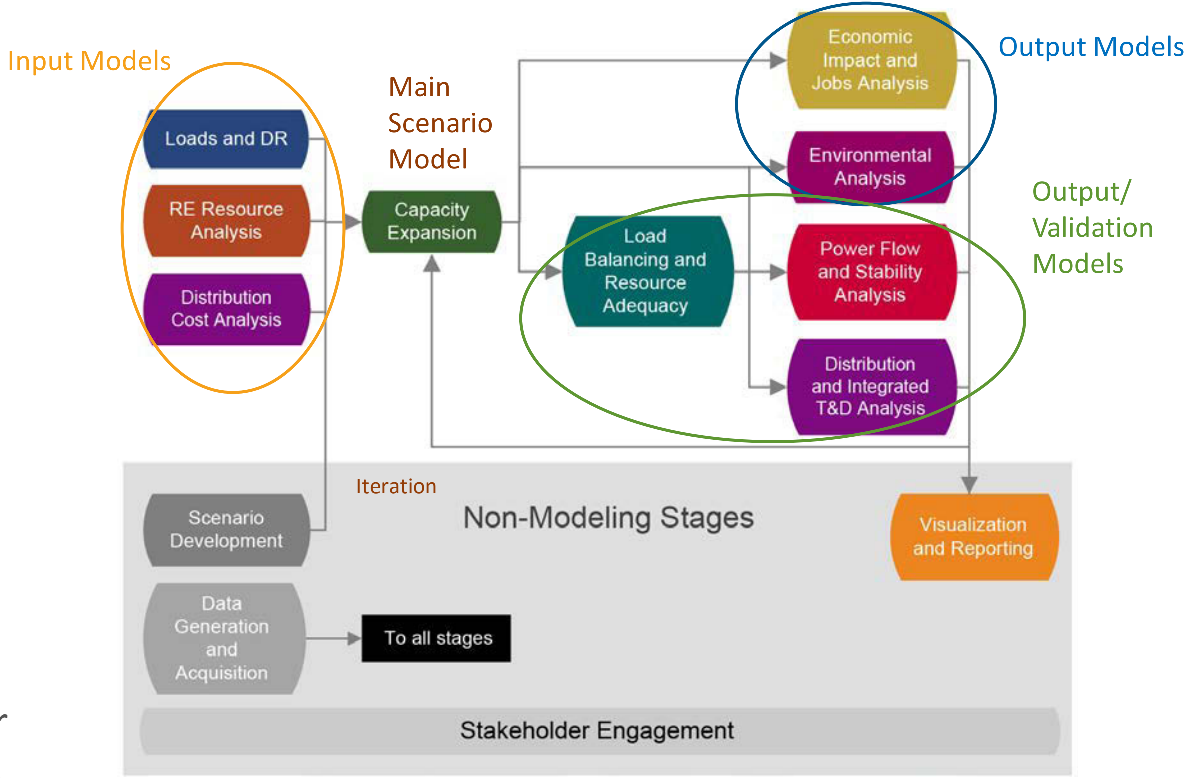
https://www.nrel.gov/analysis/los-angeles-100-percent-renewable-study.html

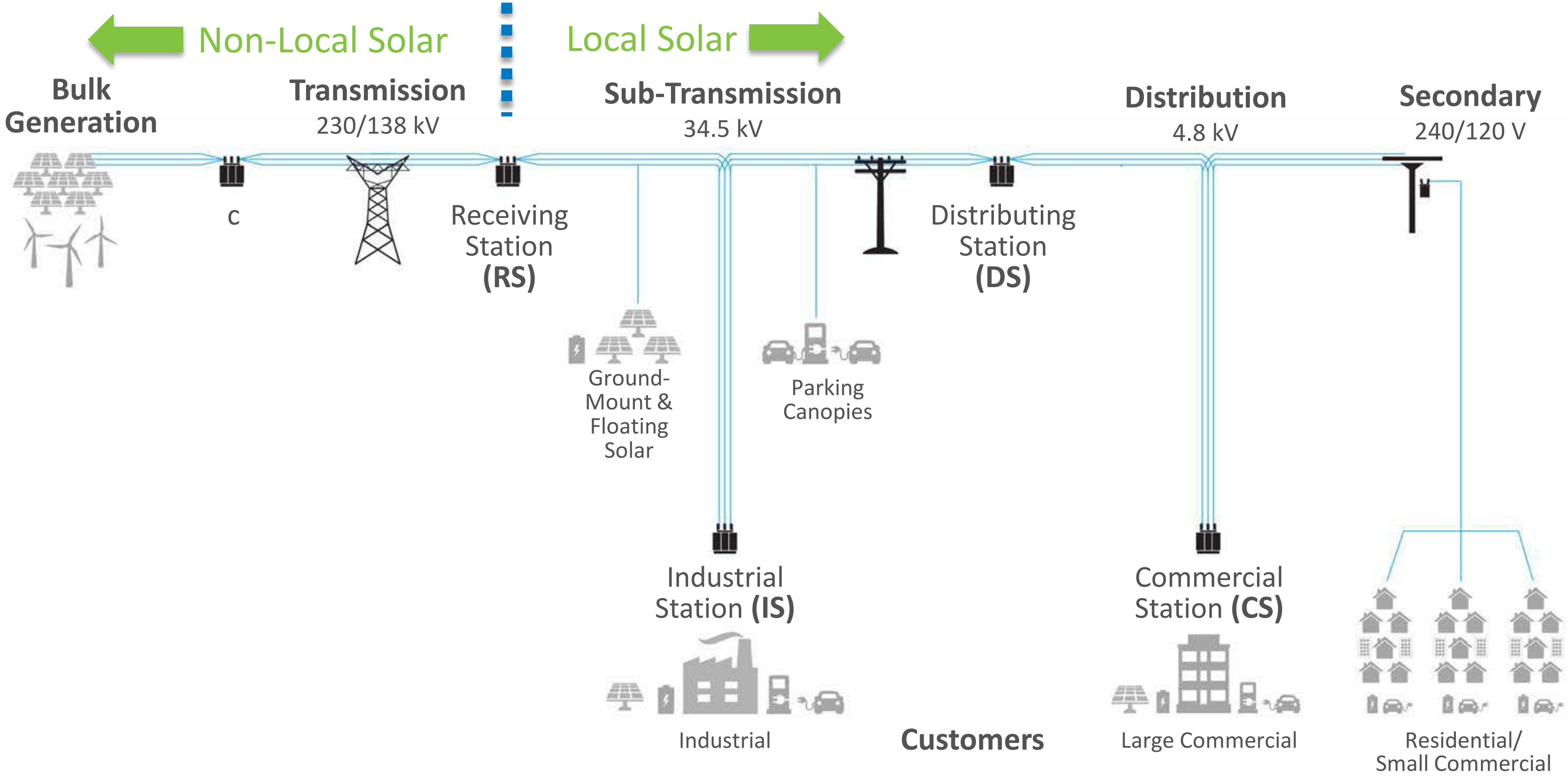
LA100 Integrated System Planning

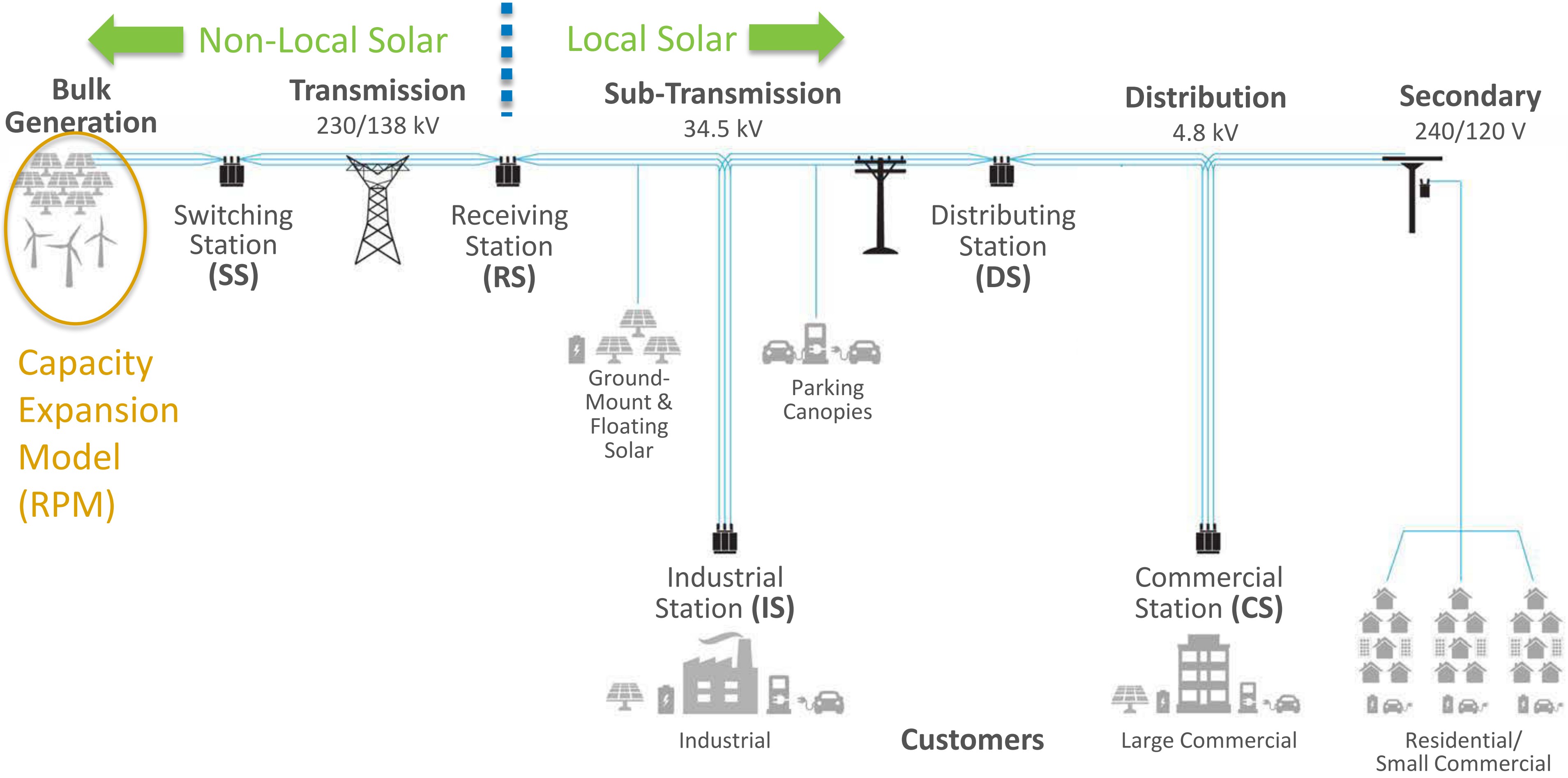
Objective

Evaluate pathways and costs to achieve 100% RE* while maintaining the current high degree of reliability

* Some scenarios include nuclear and/or natural gas offset by RECs




Non-Local Solar
Local Solar
Bulk Generation
Transmission
230/138 kV
Sub-Transmission
34.5 kV
Distribution
4.8 kV
Secondary
240/120 V
c
Receiving Station (RS)
Distributing Station (DS)
Ground-Mount & Floating Solar
Parking Canopies
Industrial Station (IS)
Commercial Station (CS)
Industrial
Customers
Large Commercial
Residential/ Small Commercial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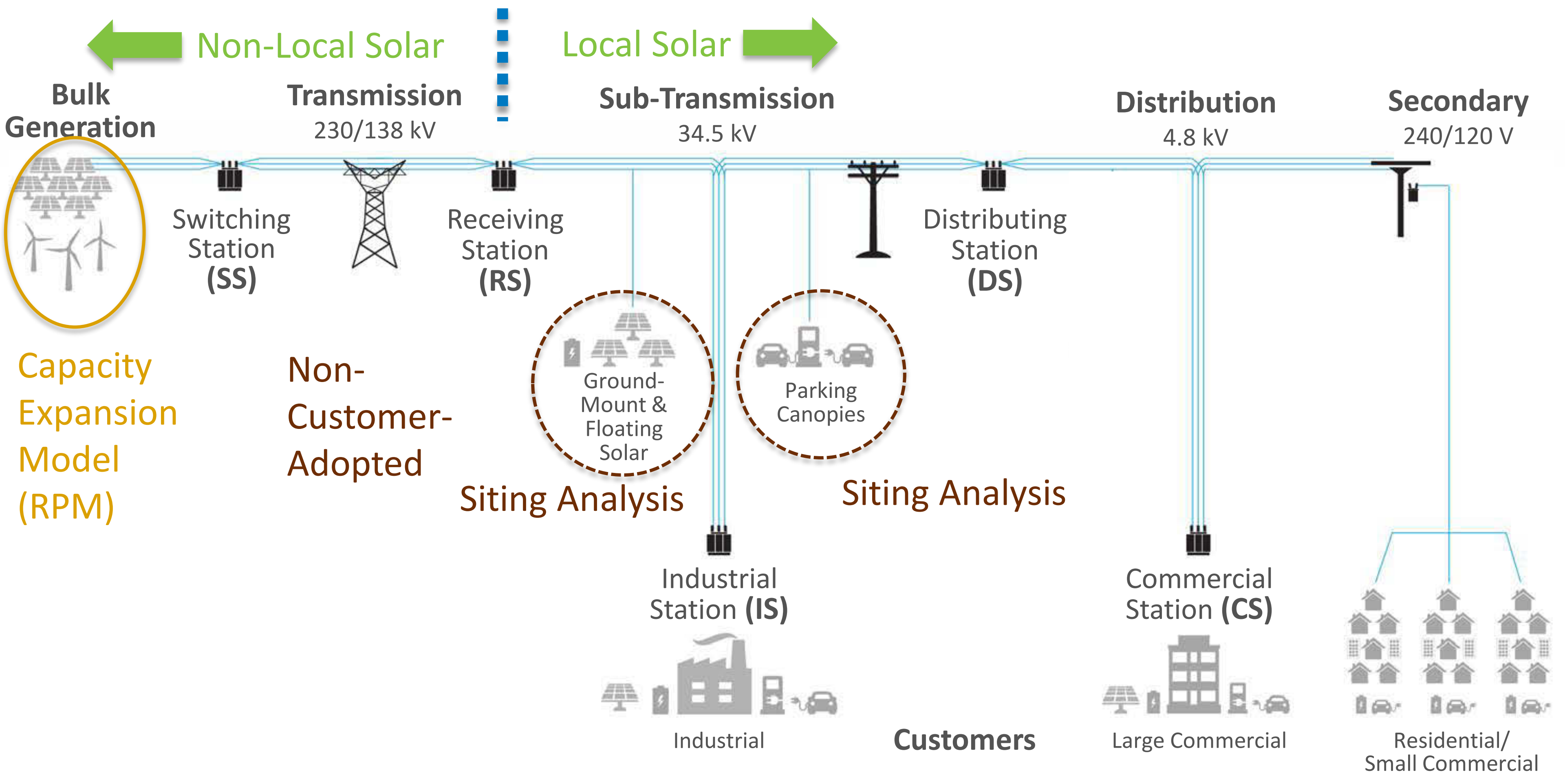

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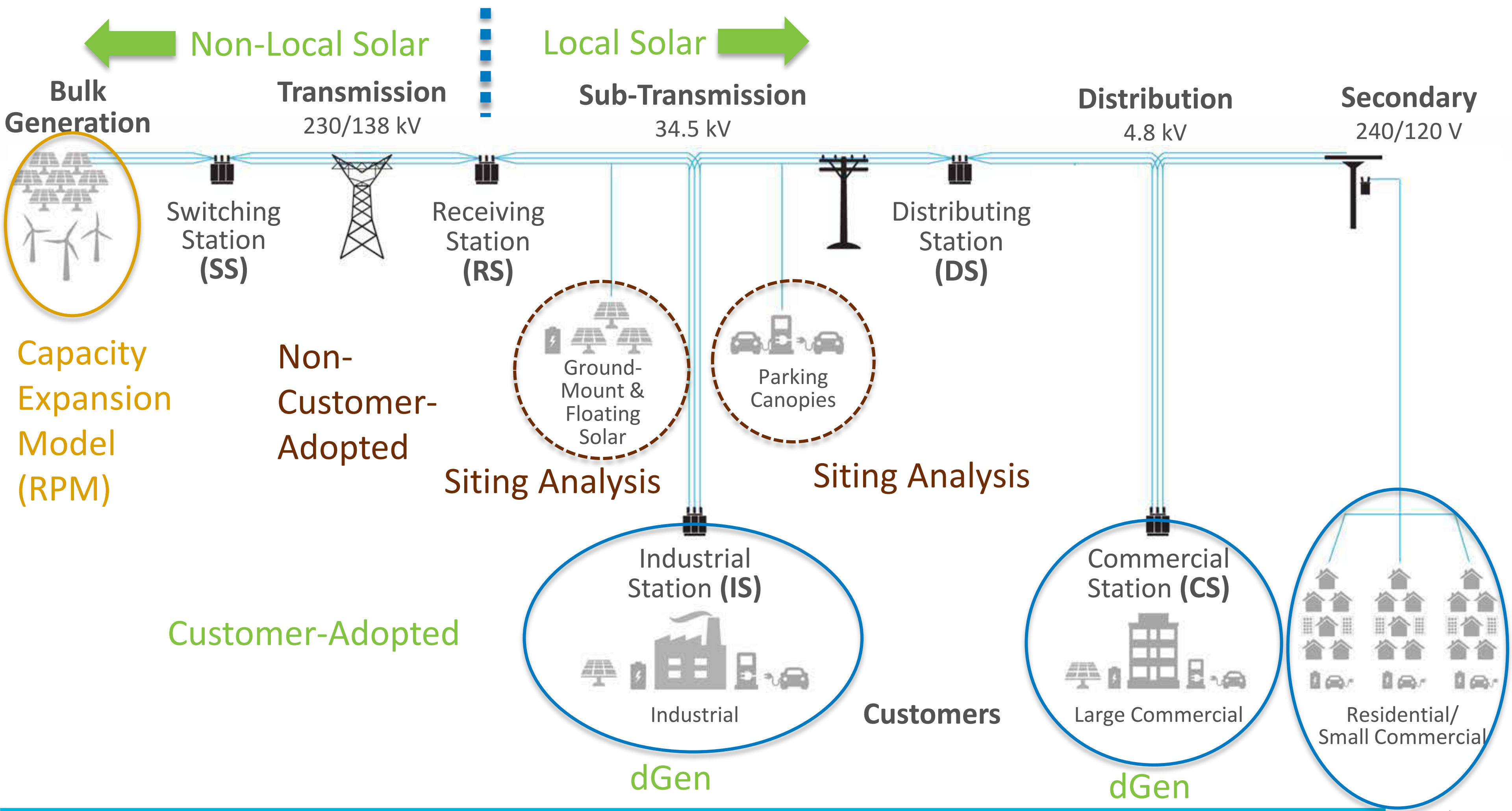
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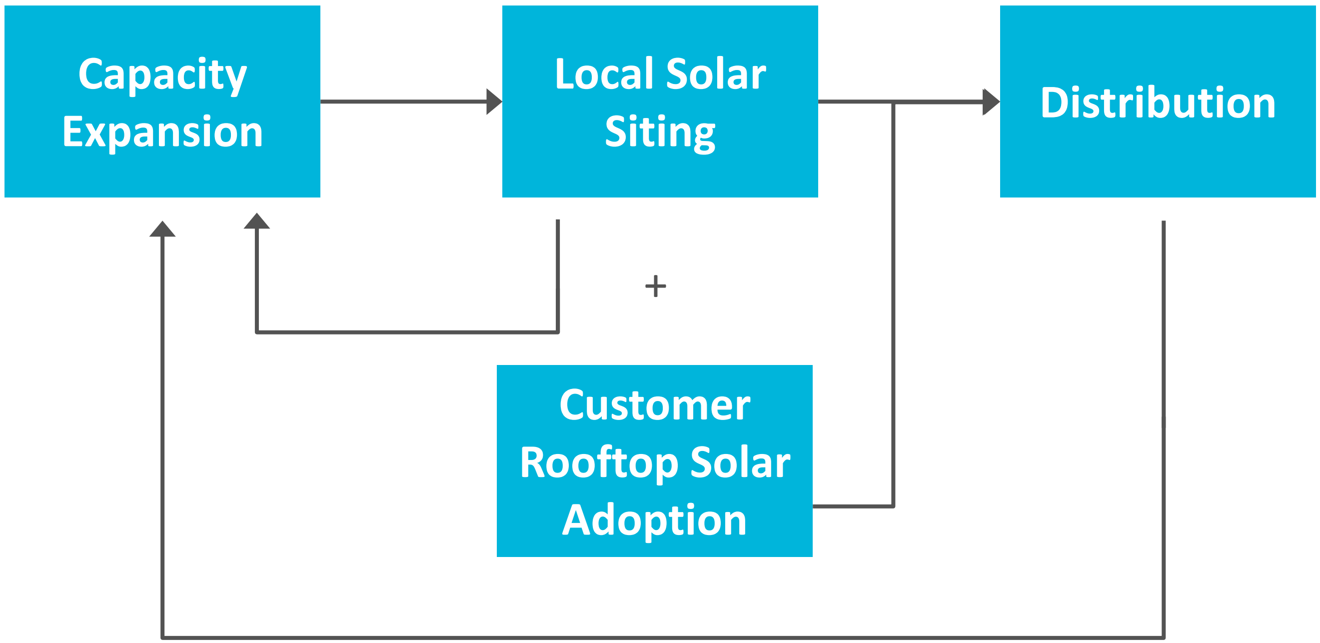
dGen

Finding the "optimal" amount of local solar



1. Estimate local solar needs by receiving station
2. Allocate local solar to individual sites
3. Simulate distribution impacts of local + rooftop solar
4. Iterate models

Aligning Interests

https://www.nrel.gov/docs/fy18osti/71042.pdf

Planning implications for distributed PV adoption

We used NREL's Resource Planning Model (RPM) and Distributed Generation Market Demand Model (dGen) along with the commercial tool PLEXOS to assess the **economic impacts** of errors in forecasting DPV adoption.

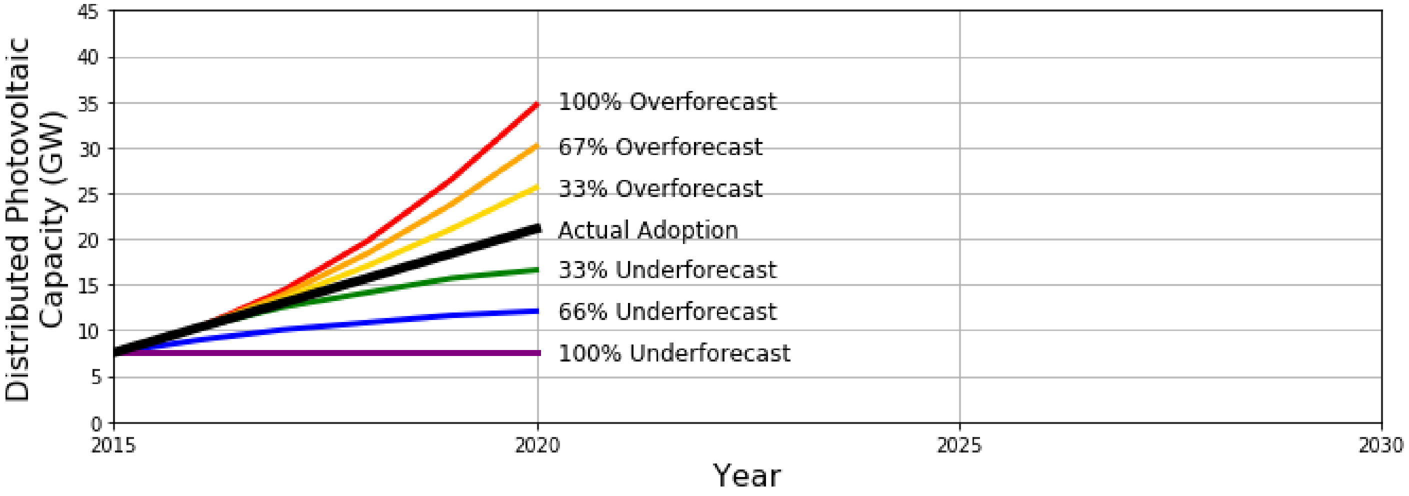


Figure from Gagnon et. al. 2018

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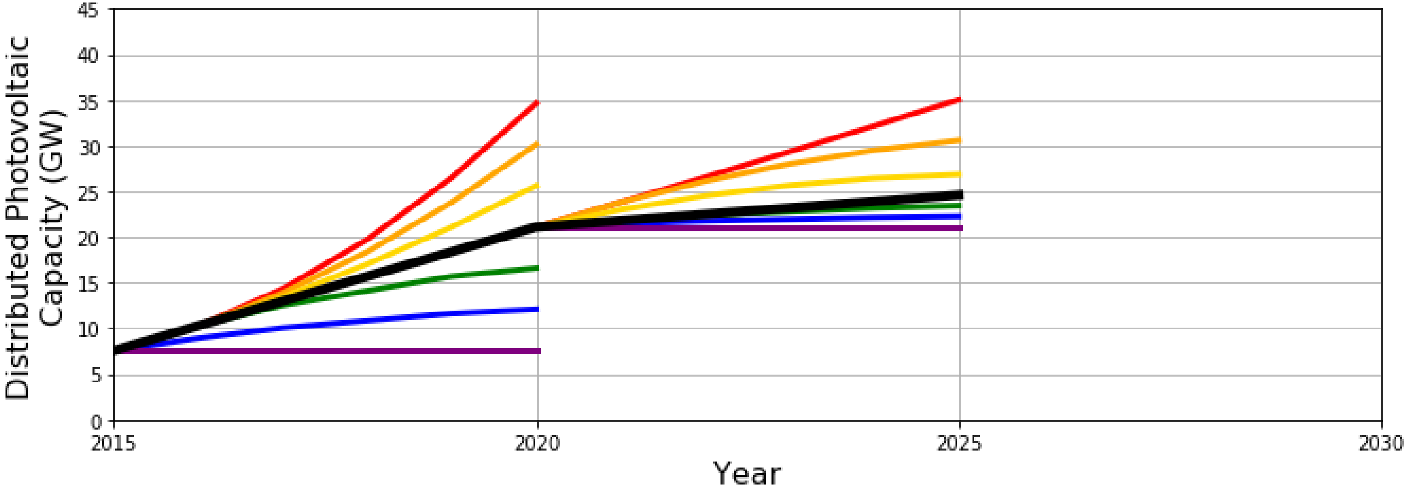

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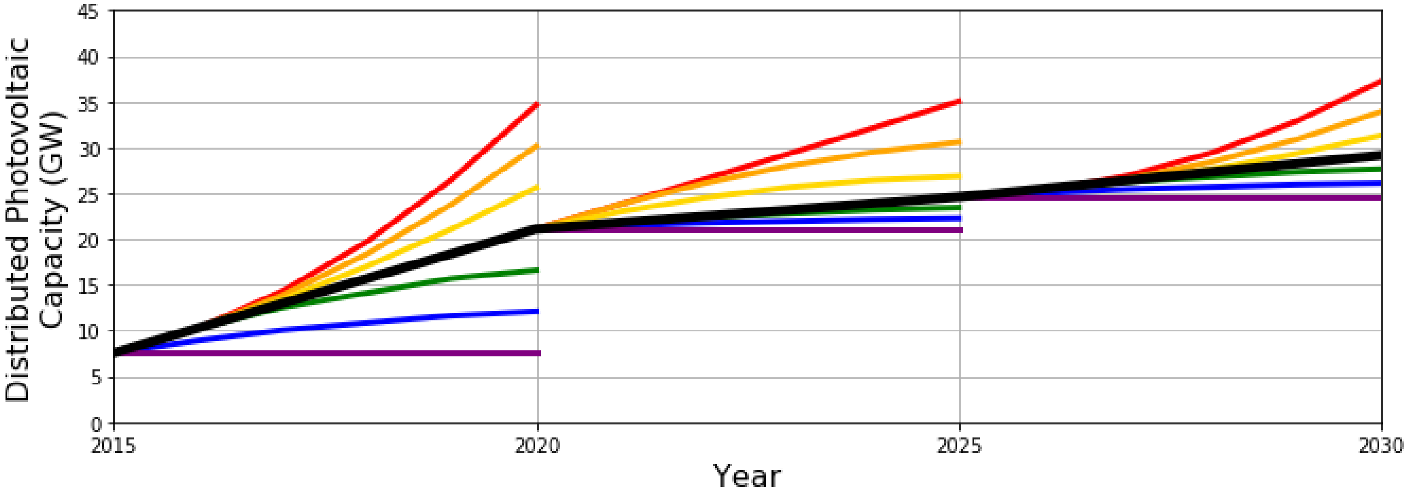


Figure from Gagnon et. al. 2018

Forecasting errors have opposite impacts on Capital and Operating Costs

Over-estimating DPV adoption leads to building less bulk power capacity, however it leads to a system that is more costly to operate

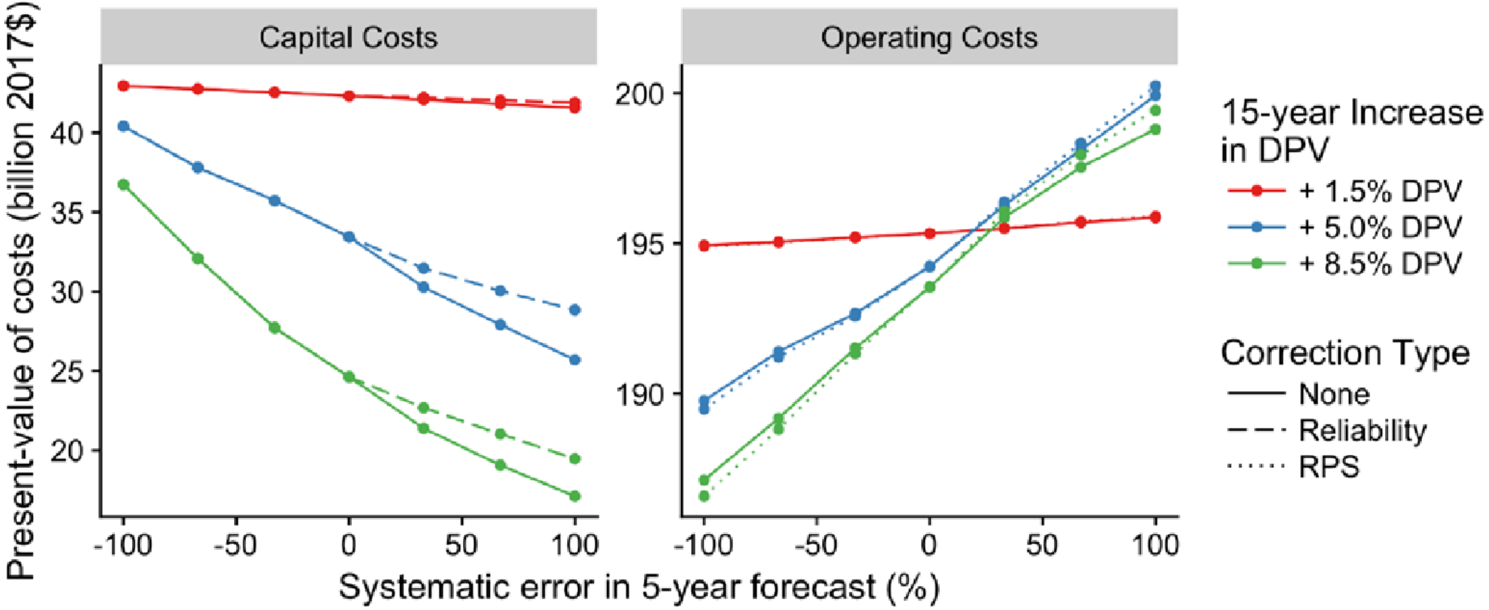
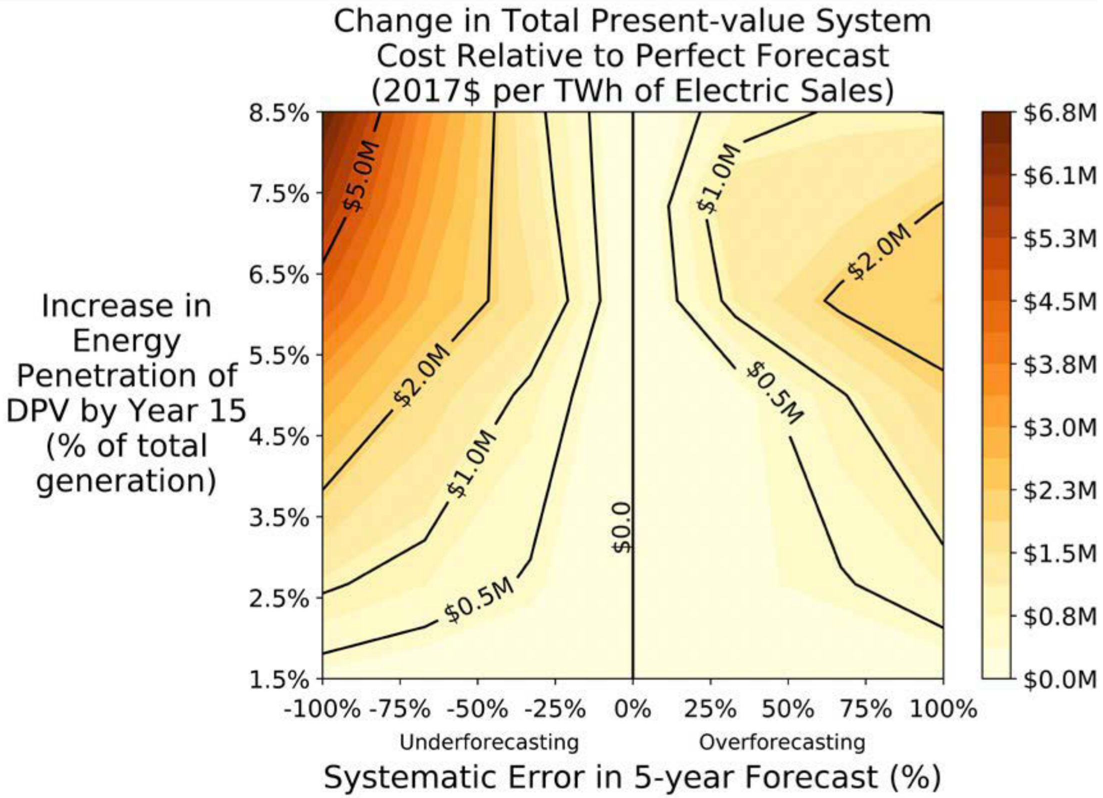


Figure from Gagnon et. al. 2018

The Results: Impacts on Present Value System Cost



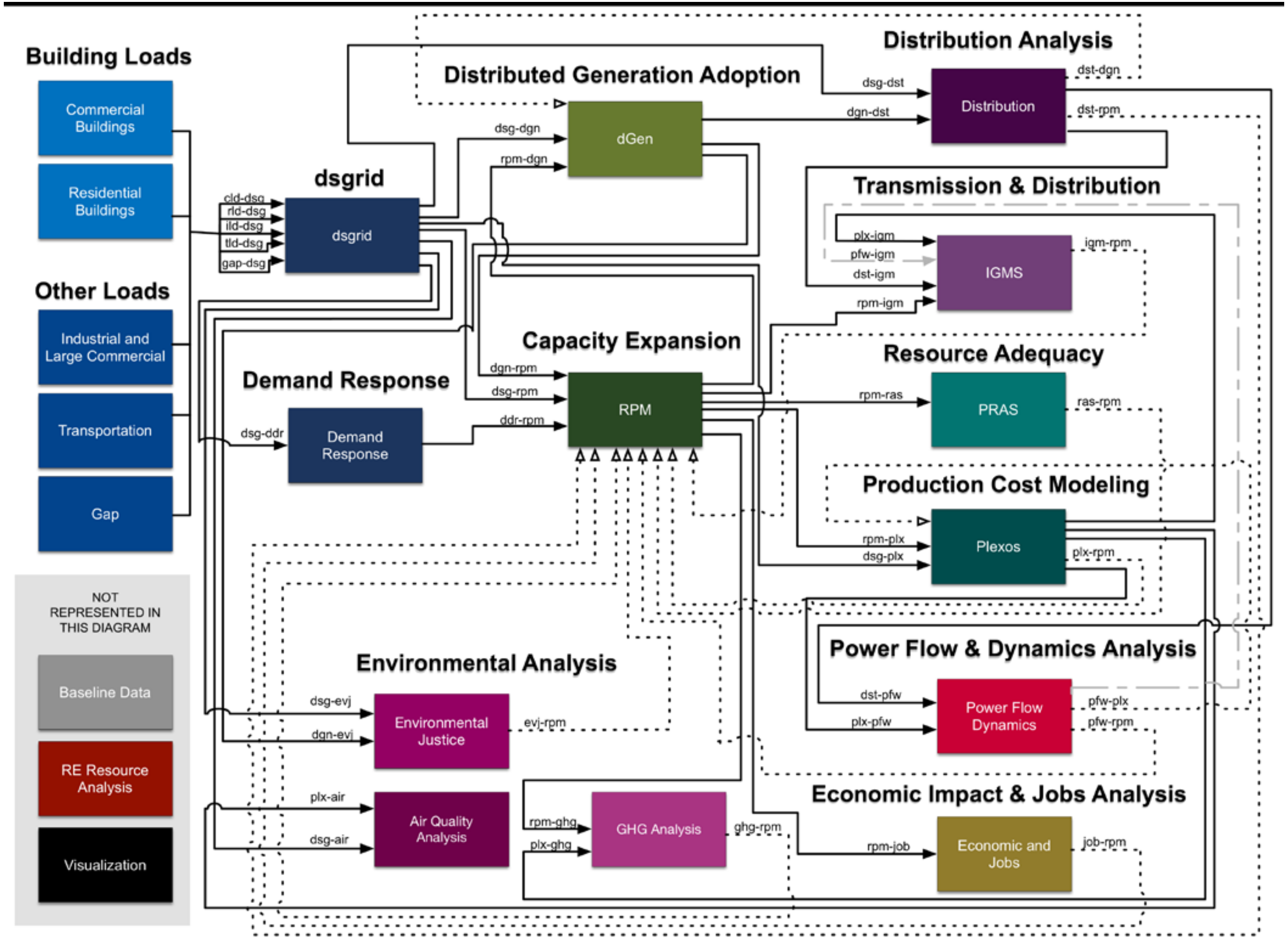
Errors in forecasting DPV has the **greatest impact** on present value system costs when either **DPV penetrations are high**, or **DPV adoption trends are severely incorrectly forecasted**

Figure from Gagnon et. al. 2018

Aligning Planning Processes

Steps to move towards alignment

Detailed Modeling Framework Of LA100 Data Handoffs Between Models



Questions for alignment

- How do models incorporate different types of data?
- How would data be transferred between models?
- What key information is missing in any particular model?
- How would that information be provided by another model?

Types of alignment

- Direct simulation
  - Expand models to incorporate more types of planning processes
  - RPM for generation and transmission
  - Inclusion of dGen results directly in RPM
- Iteration
  - Pass prices between models
  - Pass capacities between models
  - Incorporation of distribution costs in RPM based on RPM capacities built in prior run

Scenario Analysis

Dealing with uncertainty

What is scenario analysis?

Utilization of multiple potential categorizations of the future to analyze relevant pathways that may define future grid needs or development

These may include a range of cost trajectories, potential policy decisions, technology improvements, load projections, and other potential influential and unknown future impacts

What we can learn from scenario analysis?

- Understand the impact of uncertain forecasts on model predictions
- Identify range of likely results
- Identify potential common pathways amongst all scenarios
- Manage uncertainty in future forecasts

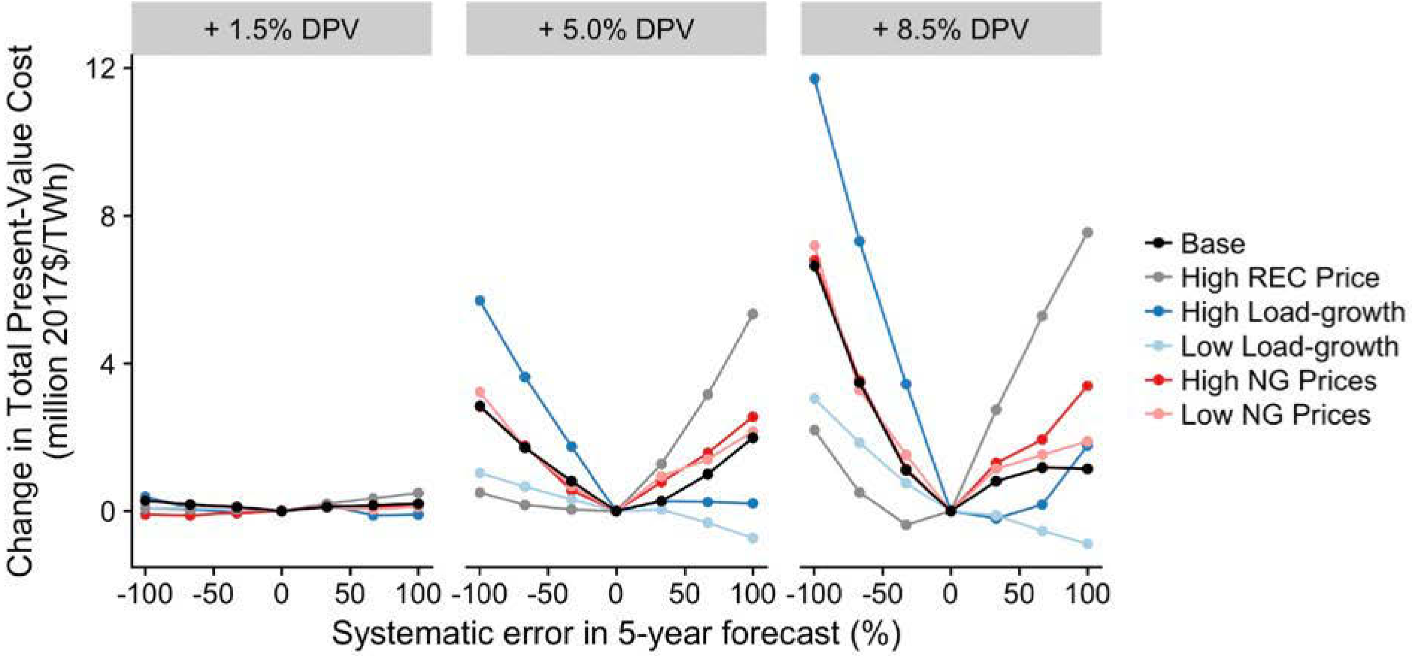
LA 100 Scenarios

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load Stress
		SB100	LA-Leads, Emissions Free (No Biofuels)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biofuels)	Transmission Renaissance	High Distributed Energy Future	SB100
	RE Target in 2030 with RECs	60%	100%	100%	100%	60%	100%	100%	100%	60%
	Compliance Year for 100% RE	2045	2035	2045	2045	2045	2035	2045	2045	2045
Technologies that <u>do not</u> vary in eligibility across scenarios	Solid Biomass	N	N	N	N	N	N	N	N	N
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	RE-derived Hydrogen Combustion	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geothermal	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technologies that <u>do</u> vary	Biofuel Combustion	Y	No	Y	Y	Y	No	Y	Y	Y
	Natural Gas	Y	No	No	No	Y	No	No	No	Y
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

The reference case is the 2017 IRP "Recommended Case," which allows comparison of cost and reliability to business as usual.

Sensitivities on Present Value Cost Impacts

Many other factors also influence the net impacts of DPV forecasting errors, including load growth, natural gas prices, and availability of RECs



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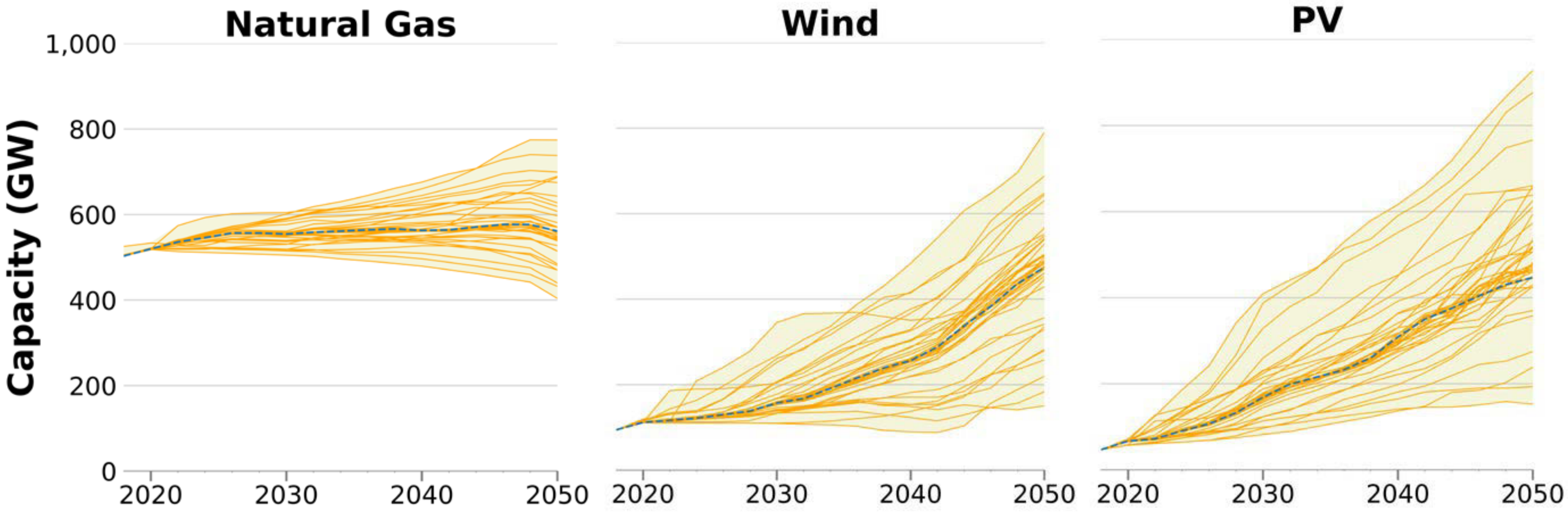
ReEDS Standard Scenarios



Captures range of technology cost, fuel cost, technology advancement, policy decisions, and demand growth assumptions as well as model parameters settings

2019 **Standard Scenarios** Report: A U.S. Electricity Sector Outlook, Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-74110.

Thank you

www.nrel.gov

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