Resilient Distribution Systems Projects: Methodology for Value Estimation

MICHAEL SAMSA & MICHAEL KINTNER-MEYER

LAB VALUATION ANALYSIS TEAM

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RDS Projects: Year Two Update
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Overview

- Introduction: LVAT Project Leads
- Valuation Framework
  - Valuation Process Overview
  - Framework for Benefits Valuation
  - Resilience vs Reliability Benefits
  - Economic Assumptions
  - Treatment of Project Costs
- Important Challenges
  - Stacking of Benefits and Maximizing Benefits
  - Short RDS Field Test Periods
  - Likelihood and Consequence of Initiating Event
- General Schedule

RDS/LVAT Project Team Leads

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RDS Project	RDS Team Lead(s)	LVAT Team Lead
SLAC: Grid Resilience and Intelligence Platform (GRIP)	Ashley Pilipiszyn Malank Mayik	Patrick Balducci (PNNL) Jan Alam (PNNL)
INL: Resilient Alaskan Distribution System Improvements using Automation, Network Analysis, Controls, and Energy Storage (RADIANCE)	Rob Hovsapian (NREL) Mayank Panwar (INL)	Peter Larsen (LBNL) Vanessa Vargas (SNL)
PNNL: Increasing Distribution System Resilience using Flexible DER and Microgrid Assets enabled by Open Field Message Bus	Kevin Schneider	Caitlin Murphy (NREL)
ORNL: Integration of Responsive Residential Loads into DMS	Teja Kuruganti Michael Starke	Michael Kintner-Meyer (PNNL)
LLNL: CLeanStart Distributed Energy Resources and Management System	Emma Stewart	Michael Samsa (ANL)
SNL: Designing Resilient Communities: Standardizing Framework for Valuing Grid Resilience Investments	Bobby Jeffers Robert Broderick	Chuck Goldman (LBNL)

Valuation Framework Process
(GMLC 1.2.4)

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Phase A: Define Scope and Goal

- Step 1: Define the Valuation Context and Purpose
- Step 2: Identify Range of Alternatives
- Step 3: Plan and Initiate Stakeholder Engagement

Phase B: Frame Valuation Criteria

- Step 4: Identify Key Impact Metrics for Valuation
- Step 5: Determine Multi-Criteria Integration Approach

Phase C: Design Analysis

- Step 6: Approach to Address Uncertainties
- Step 7: Select Assessment Methods and Tools
- Step 8: Develop Assumptions and Input Data

Phase D: Determine and Present Results

- Step 9: Assess Impacts for Each Alternative
- Step 10: Calculate Integrated Values for Each Alternative
- Step 11: Compare Values, Document Analysis and Report Findings

Result: Report and Interpret Results

Framework of Benefit Valuation

- Benefits will depend on:
  - Technologies used in each field demonstration
  - Use cases in which a set of technologies is exercised
  - Reference case
- Value of benefits relate to services provided
  - Some services are monetized through wholesale or retail markets
  - Some are not monetized in the market
    - Value will be estimated using avoided cost techniques
- Perspectives
  - Focus is on societal perspective
    - Transfer payments, e.g. taxes, will not be counted
  - Acknowledge host utility and customer perspectives
  - Significant externalities will be discussed

Grid-Related Metric Categories

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Benefit Class	Quantifiable Benefits	Selected Metrics to Estimate Benefits
Resilience	• Improved safety • Maintain economic activity • Maintain healthy community • Provide shelter	Cumulative critical customer-hours of outage Loss of assets, impact on Gross Muni. Product No. of people exposed to cold/heat Reduce risk of loss of life
Distribution System Services	• Upgrade deferral • Outage mitigation • Volt-VAR control • Conservation voltage reduction	Cost of deferred investment Avoided economic loss due to outage Reduction of energy consumption Peak power reduction
Customer Services	• Energy charge reduction • Demand charge reduction • Improved reliability	Energy saved Reduction in customer bill Reduced cumulative customer-hour outages
Bulk Power services	• Capacity • Energy	Effective load carrying capacity Amount electricity produced or consumed
Ancillary Services	• Regulation • Load following • Frequency response • Reserves • Voltage support • Blackstart service	Various metrics to describe quality and quantity of service See appendix for more detail
Transmission Services	• Transmission congestion relieve • Transmission upgrade deferral	Location specific energy services capacity of transmission asset avoided or deferred

Resilience vs Reliability Benefits

PJM	Reliability is about designing, running and maintaining electricity supply to provide an adequate, safe and stable flow of electricity.	Resilience is the ability to prepare for, operate through and recover from significant disruptions … withstand prolonged events.

- ► Resilience Benefits
  - Interruptions lasting 24 hours or longer
    - Impact individual customers
    - Disrupt flow of goods and services
    - Affect health and safety of communities
  - Test using "mixed method" approach for one or two RDS projects (INL, PNNL)
    - (1) REAcct model
    - (2) Elicit direct costs of >24 hr. power interruption to representative mix of residential, commercial and industrial customers
- ► Reliability Benefits
  - Outages lasting up to 24 hours
  - Will use ICE Calculator to estimate reliability benefits of RDS project

Economic Assumptions

- Underlying assumptions that define the time horizon and accounting perspective of the project:
- Technology Lifetime
  - Asset with the longest economic life
  - Assume replacement of shorter lifetime components
  - Calculate annualized costs
- Discount Rate
  - 3% real (inflation-free)
  - Consistent with societal perspective

Options for Treatment of Costs

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- Estimating costs of new or emerging technologies challenging
- Will need to rely on RDS project teams as key information sources
- Options being considered:
  - Project Costs
    - Bill of material to build prototypes for field deployment
    - Labor for design and testing prior to deployment
    - Labor and other cost for deployment and monitoring
    - In-kind contributions ***(Note: Some RDS partners are sensitive to this.)***
  - First-of-a-Kind / Early-Stage Costs
    - At least one RDS team (ORNL) is planning to estimate first-of-a-kind technology and deployment costs at market introduction scale
    - Could also address other costs related to field preparation, commissioning, interconnection, warranty, O&M, and administrative cost
  - Determine Break-Even Cost
    - Cost at which the project would have positive net benefits

Important Challenges

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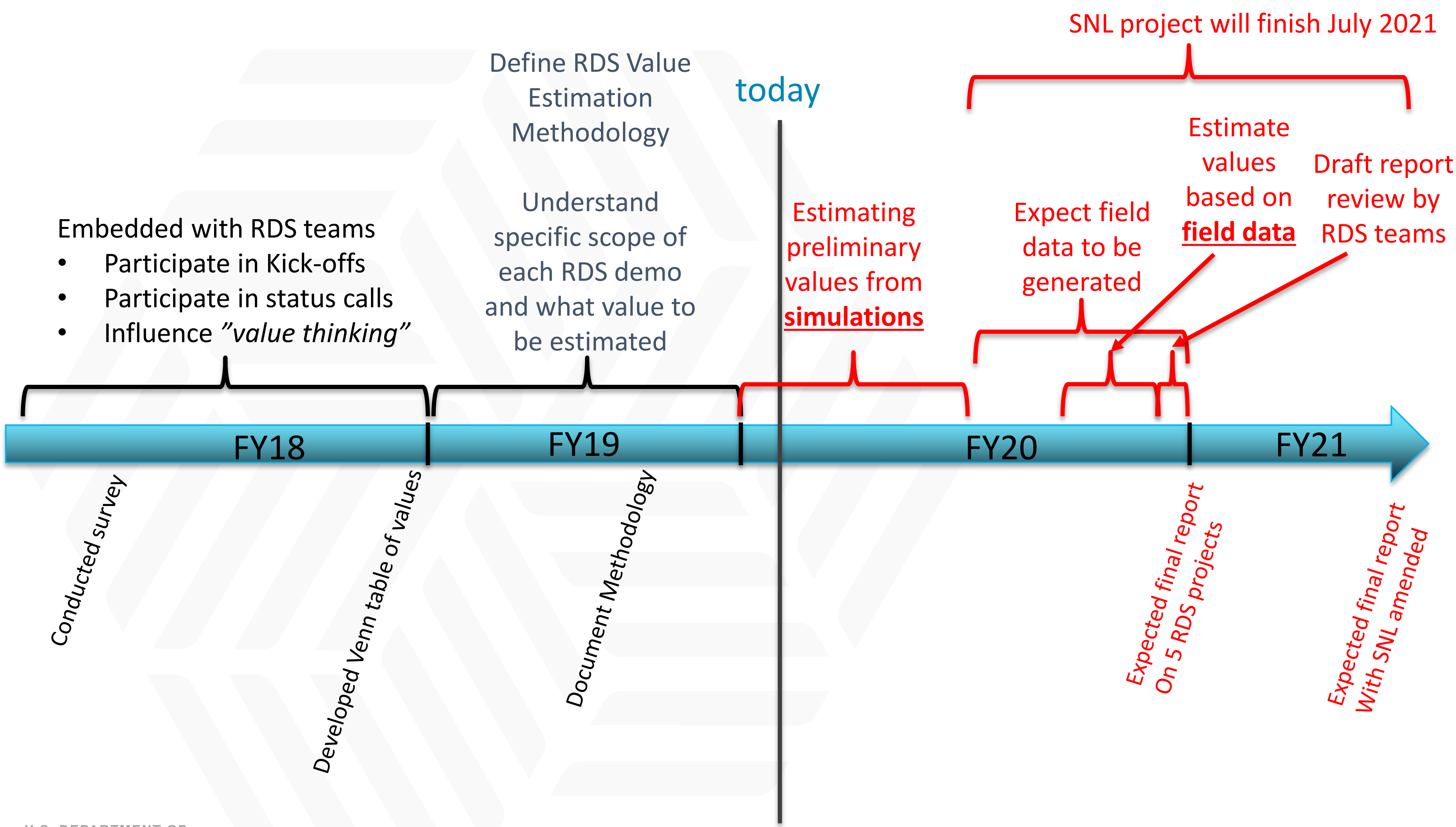
- RDS projects not designed to maximize value
  - Need to apply judgment to define schedule of use case applications for a representative year
  - Estimate annual societal benefit profile based on these estimated schedules of operation of RDS technologies
- Actual in-field demonstration may be relatively short (e.g., weeks rather than months)
  - Utilize simulation capabilities to estimate technical performance and value creation under a broader range of grid conditions
  - Parameterize the valuations on a range of plausible service assumptions
- Likelihood and consequence of adverse event may not be known
  - Postulate range of probabilities (e.g. 1 occurrence in 5,10, 20, 50 years) and perform resilience calculations for that range
  - May need to hypothesize the counter-factual cases representing the "without" technology outcome

LVAT Project timeline



Backup / Detailed Content Slides

Summary of RDS Projects

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Lead Lab	Project Title	Test Sites	Simulations	Innovation	Demonstrations
SLAC	Grid Resilience and Intelligence Platform (GRIP)	Vermont, SCE, City of Riverside	IEEE test feeder,	Develop and demonstrate how to (1) anticipate potential grid threats, (2) absorb grid stress, and (3) recover from grid events.	To be defined in later phases of project
INL	RADIANCE	City of Cordova system	None	Resilience by design using DER and controls technologies	Field demonstration of DERs and controls to test mitigation strategies against extreme events.
PNNL	Increasing Distribution System Resilience Using Flexible DER and Microgrid Assets Enabled by OpenFMB	4 circuits with 20 MW of connected load centered around the Anderson Civic Center in Anderson, SC	Simulation of customer behavior with hardware in the loop	Next-generation fault location, isolation, and system response using distributed technologies	Self-healing strategies by segment-based sectionalizing hardware in 4-circuit distribution system with microgrid; 3 use cases that reflect increasing outages
ORNL	Integration of responsive residential loads into distribution management systems	Petersburg, FL (Duke Energy), Chattanooga, TN (EPB: distribution and TVA: transmission), and Atlanta, GA (Jackson EMC)	GridLab-D of feeders and load response	Low-cost open protocol communication to HEMSs and integration with DMS	Field demos of most of 12 use cases
LLNL	CleanStart DERMS	1. PG&E's HIL test facilities; and, 2. RPU Operations Center site	Simulation of system behavior prior to field tests	Predictive analytics for DER controls for blackstart and restoration	Three use cases including blackstart microgrid restoration, synchronization of two microgrids, and reconciliation of an islanded grid due to a grid-forming DER being dropped because of a cyberattack
SNL	Designing Resilient Communities: Standardizing a Framework for Valuing Grid Resilience Investments	San Antonio, Buffalo, Puerto Rico	simulations to optimize cost-effective resilience investment	Resilience nodes as a concept of islanded microgrid with RE resources	Field demonstrations of cost-effective resilience strategies. Yet to be determined what will be included.

Taxonomy of Grid-Related Benefits and Metrics (1 of 7)

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Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Resilience	Improved safety	Maintain street lights at night. Avoid abandonment of neighborhood, power emergency services, and emergency response staging areas.	• Loss of economic value of critical services without power • Average number (or %) of critical loads that experience an outage • Cumulative critical customer-hours of outages • Critical customer energy demand not served
	Maintain economic activity	Avoid business losses that could arise due to a prolonged power outage, including those associated with sectoral interdependencies (e.g., impacts on communications infrastructure).	• Loss of assets and perishables • Business interruptions • Time to electric service recovery • Time to communications systems recovery • Impact on GMP and GRP (gross municipal/regional product) consistent with geographic definition of project influence
	Maintain healthy community	Avoid exposure to extreme weather conditions. Reduce acute air-quality and air emission issues. Reduce risk of spreading diseases.	• Exposure to cold • Exposure to heat • Reduced hours or avoidance of clean air violations
	Provide shelter	Avoid exposure to high-risk conditions.	• Reduced injuries • Reduced risk of loss of life

Taxonomy of Grid-Related Benefits and Metrics (2 of 7)

Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Distribution System Services	Distribution Upgrade Deferral	Reducing loading on a specific portion of the distribution system, thus delaying the need to upgrade the distribution system to accommodate load growth or regulate voltage	• Location-specific energy services • Change in present value cost of the deferred distribution-level investment
	Outage mitigation	The use of technology to reduce or eliminate the costs associated with power outages to utilities	• Use the Interruption Cost Estimation Calculator to estimate value of avoided/reduced outage for durations ≤24 hours • Avoided loss of utility revenue • Avoided cost of grid damages (e.g., repair or replace lines, transformers) • Avoided cost of recovery • Reduced penalties to utilities associated performance metrics
	Volt-VAR Control	Volt-ampere reactive (VAR) is a unit used to measure reactive power in an alternating current electric power system. VAR control manages the reactive power, usually attempting to get a power factor near unity (1).	• Customer bill reduction (per customer per year) • Demand reduction • Reduction in energy consumption • Reduced wear and tear of tap changes. Proxy: extended life or avoided life-reductions of tap changers. • Release of upstream capacity associated with generators that can provide more real power
	Conservation Voltage Reduction (CVR)	Using voltage control in distribution system to maintain voltage at the lower voltage ranges Benefits can be reduction of energy consumption of 0.3 to 1%. Effectiveness depends on end-use devices.	• Energy saved • Peak power reduced when used during peak periods

Taxonomy of Grid-Related Benefits and Metrics (3 of 7)

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Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Customer services	Energy charge reduction	Reducing customer charges for electric energy	• Energy saved • Energy rate
	Time-of-Use Charge Reduction	Reducing customer charges through time-shifting of energy consumption	• Reductions in customer bill
	Demand charge reduction	Reduces the maximum power draw by electric load in order for customers to avoid peak demand charges. Commonly applicable to C/I customers.	• Avoided peak demand • Demand charge savings
	Improved reliability	Power reliability reduces or eliminates power outages to customers.	• Cumulative customer-hours of outage • Cumulative customer energy demand not served • Average number (or %) of customers experiencing outage during a specified time period • Avoided/reduced outage cost (see Outage Mitigation above)

Taxonomy of Grid-Related Benefits and Metrics (4 of 7)

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Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Bulk power system services	Capacity	Capacity quantity that reflects the ability to deliver energy during periods of tight system conditions; contributes to supply adequacy. (Milligan 2006)	• Effective Load Carrying Capacity (ELCC) • Cost of capacity
	Arbitrage	Purchasing energy during low-price periods and selling it in an energy market during high-price periods	• Market revenue
	Energy	Electric energy amount generated or consumed	• Amount of electric energy produced or consumed Cost of energy at wholesale determined by market mechanisms in organized wholesale markets or determined by production cost modeling

Taxonomy of Grid-Related Benefits and Metrics (5 of 7)

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Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Ancillary Services	Regulation	Service to respond to an area control error in order to provide a corrective response to all or a segment portion of a control area.	• Prices ($/MW) obtained using customary values from market products (e.g., organized wholesale market) or avoided costs in vertically integrated systems (e.g., capital cost deferred) or opportunity cost of units otherwise used • Capacity in the market • Duration of service
	Load following	Similar to regulation with direct control by AGC. Ramping within a prescribed area in response to changes in system frequency, tie line loading, so as to maintain the scheduled system frequency and/or established interchange with other areas.	• Price sometimes available in real-time markets, otherwise estimate avoided cost • Usually denominated in unit power (MW) or ramping (MW/min)
	Frequency response	Service that requires close-loop control on generation units without requiring communication to grid operator. Service can be executed autonomously by sensing the AC system frequency. Used to maintain frequency stability, thereby keeping generation and load balanced within the system.	• Generally, market prices are not available for frequency response • See NERC interconnection guidance/rule Capacity under frequency control. Perhaps responsiveness measured in MWs ramping capabilities
	Spin/non-spin reserves	Capacity that is online and capable of synchronizing to the grid within 10 minutes. Non-spin reserve is offline generation capable of being brought onto the grid and synchronized within 30 minutes.	• Spin and non-spin prices • Capacity in service

Taxonomy of Grid-Related Benefits and Metrics (6 of 7)

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Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Ancillary Services	Voltage support	Voltage support consists of providing reactive power onto the grid to maintain a desired voltage level.	• kVar of resources available. • Avoided cost
	Flexible ramping	Ramping capability provided in real-time, financially binding in five-minute intervals in CAISO, to meet the forecasted net load to cover upward and downward forecast error uncertainty.	• Capacity • Price of service information is available in some wholesale markets. • Otherwise estimate avoided cost
	Blackstart service	Blackstart service is the ability of a generating unit to start without an outside electrical supply and is necessary to help ensure the reliable restoration of the grid following a blackout.	• Cost of service: units are identified for blackstart and their documented costs are then funded and rolled into a tariff for cost recovery. • Or, the cost of service is computed as a flat rate payment issued to the generator.

Taxonomy of Grid-Related Benefits and Metrics (7 of 7)

Benefit Class	Quantifiable Benefit	Example of Service Definition	Metrics to Measure and Estimate Benefits
Transmission Services	Transmission congestion relief	Energy service during time of transmission system congestion to provide relief during hours of high congestion	• Location-specific energy services • Priced at congestion price through decomposition of locational marginal prices
	Transmission upgrade deferral	Benefit is accrued by reducing loading on a specific portion of the transmission system, thus delaying the need to upgrade the transmission system to accommodate load growth or regulate voltage.	• Location-specific energy services • Prices at deferred cost over period of deferment

Key Challenges: Stacking of Benefits

- RDS project teams are not necessarily designing projects that maximize value; focus on developing use cases and demonstrating scenarios that are of most interest to partner utilities
- Ideally, optimization techniques would be required to determine optimal mix of functionalities and services performed by technologies being demonstrated (i.e. stacking of benefits).
- LVAT will not optimize scheduling of use cases in order to maximize benefits of RDS technologies
  - LVAT/RDS teams need to apply reasonable economic/engineering judgment to define schedule of use case applications of a representative (full year) period.
  - LVAT will then estimate annual societal benefit profile based on these estimated schedules of operation of RDS technologies

Key Challenges: Short RDS Technology Periods

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- For some RDS projects, actual in-field demonstration may be relatively short (e.g., weeks rather than months).
- Estimating and reporting value streams over this brief period may not expose "good" grid conditions that would generate high revenue streams for performing a certain service.
  - Example: If DR services are to be tested in a use case, what happens if utility system conditions (or prices) are not stressed during the test period
- Possible approaches
  - Utilize simulation capabilities to estimate technical performance and value creation under a broader range of grid conditions
  - Parameterize the valuations on a range of key service assumptions that are believed to be plausible based on the RDS installation

Key Challenges:
Estimating Value of Resilience

- To estimate value of a resilient system, need to:

  (1) assess probability of occurrence of a black sky condition

  (2) determine consequences of such black-sky condition with and without technology deployment

- Initial conversations with RDS teams indicate that they are unlikely to assess probability of occurrence of black-sky conditions

- Proposed approach

Postulate range of probabilities of black sky conditions (e.g. 1 occurrence in 5,10, 20, 50 years) and perform resilience calculations for that range

May need to hypothesize the counter-factual cases representing the "without" technology outcome