Distribution Planning with Local Resources: Integration and Valuation

Integrated Distribution System Planning 2.0: Planning for Load Growth and Local Resources

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Agenda

- Capabilities by Technology
- Value Streams and Benefit-Cost Analysis
- Hosting Capacity Analysis
- Costs and Benefits of Proactive Grid Investments and Cost Allocation Approaches
- Questions

Capabilities by Technology

Types of DERs

Solar Photovoltaic Systems

Wind Turbines

Energy Storage Systems

Combined Heat and Power

Electrical Vehicles

Managed or Price-Based Charging

Grid Interactive Buildings

Building equipped with smart appliances and energy management systems to contribute in EE and DR programs

Energy Efficiency

Microturbines

Localized generation using natural gas

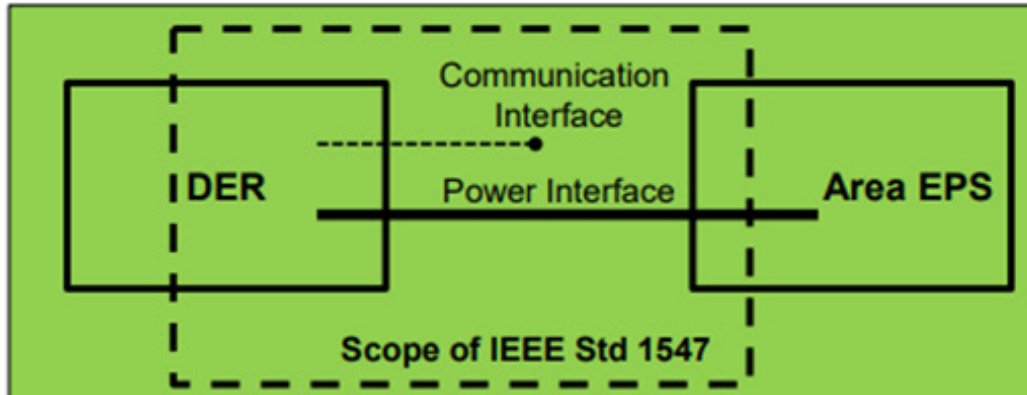
IEEE Standard 1547 - 2018

Overview

- IEEE 1547 governs definitions, **inverter requirements**, and **interoperability** of DERs and requires **smart inverter function** capabilities
- The standard also outlines roles for manufacturers, electric utilities, ISO/RTO, commissions, customers, and installers

Among the standards

- Hardware must be certified to UL 1741-SB
- Voltage and Frequency Ride-Through Requirements
- Voltage and Reactive Power Functions
- Communication protocols
  - Sunspec Modbus
  - IEEE 2030.5
  - DNP3



IEEE Std 1547-2018

- Focused on distribution and bulk system aspects.
- Specifications encompass the whole DER.
- Can be used for equipment listing as well as plant-level verification.
- Includes both electrical as well as interoperability/communications requirements.
- *Shall be capable of* ride-through and grid support

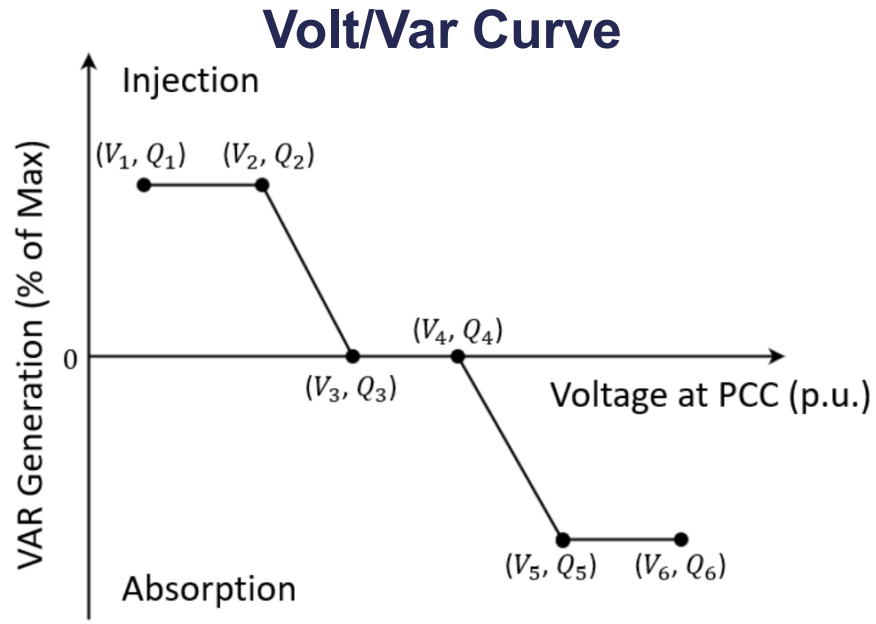
Source: 1547-2018 Standard Sections 1.4 and 10.7

Autonomous Voltage Response – Voltage Support

Volt/VAR Curve (VVC)

A VVC is a customizable curve that adjusts a DER inverter's **reactive power compensation** based on the **voltage measured** at the **inverter**.

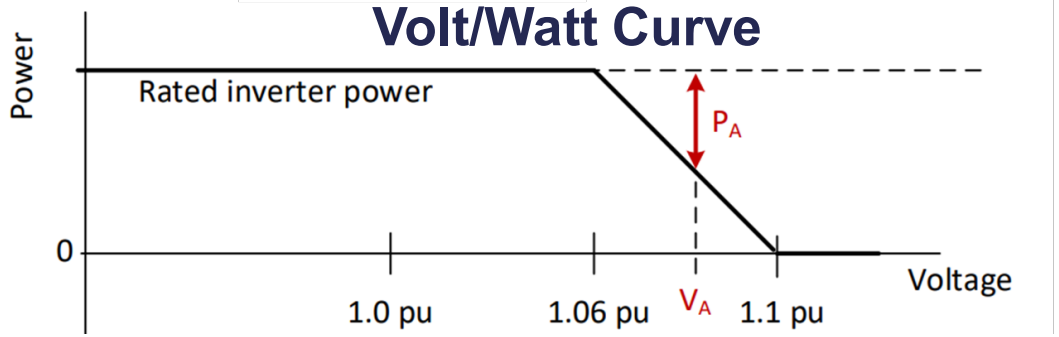
- If voltage is within the curve's deadband, no reactive power support is needed
- If voltage exceeds the curve's max deadband point, reactive power is absorbed
- If voltage exceeds the curve's min deadband point, reactive power is injected



Source: Typical Volt/VAR Curve for Smart Inverter

Volt/Watt Curve (VWC)

- A VWC is a customizable autonomous curve that will adjust a DER inverter's real power output based on the voltage measured at the inverter
- Can be used in addition to a VVC to address overvoltage



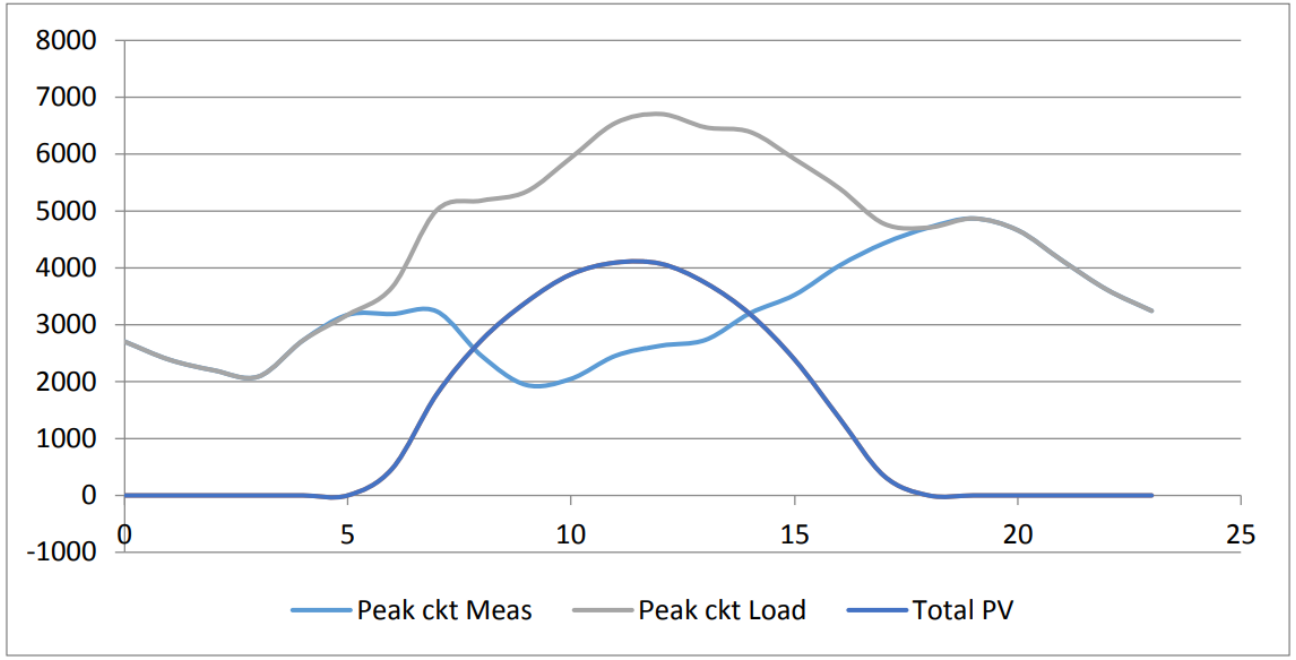
Source: Volt/Watt Curve Showing Max Possible Curtailment

Value Streams and Benefit-Cost Analysis

DER Capacity Impact and Value

- DERs can be utilized during peak loading to reduce the thermal load on system equipment
- Traditionally, utilities would need to upgrade overloaded equipment or construct a new circuit or substation
- Types of DERs to consider for reducing thermal load:
  - PVs – Generating time often aligns with summer peak hours
  - Energy storage systems – Energy can be stored and dispatched during peak load
  - Energy efficiency can broadly reduce load growth and improve capacity
  - Demand response (including grid-interactive buildings) can be dispatched for distribution capacity
  - Combined heat and power – Timing may depend on specific customer processes

Example Hourly Load Profile for Circuit's Peak Load Day



Source: NREL High-Penetration PV Integration Handbook for Distribution Engineers, Pg 5 (https://www.nrel.gov/docs/fy16osti/63114.pdf)

DER Reliability Impact

DER Reliability Impact

- DERs can provide an alternate source when there is a fault on the normal source
- Traditionally, utilities would build new ties or construct a redundant substation or circuit
- Traditionally, some customers used natural gas/diesel back-up generators
- Using DERs with grid-forming inverters, an intentional island can be created to restore service to unfaulted areas

Customer DER Improving Their Own Reliability

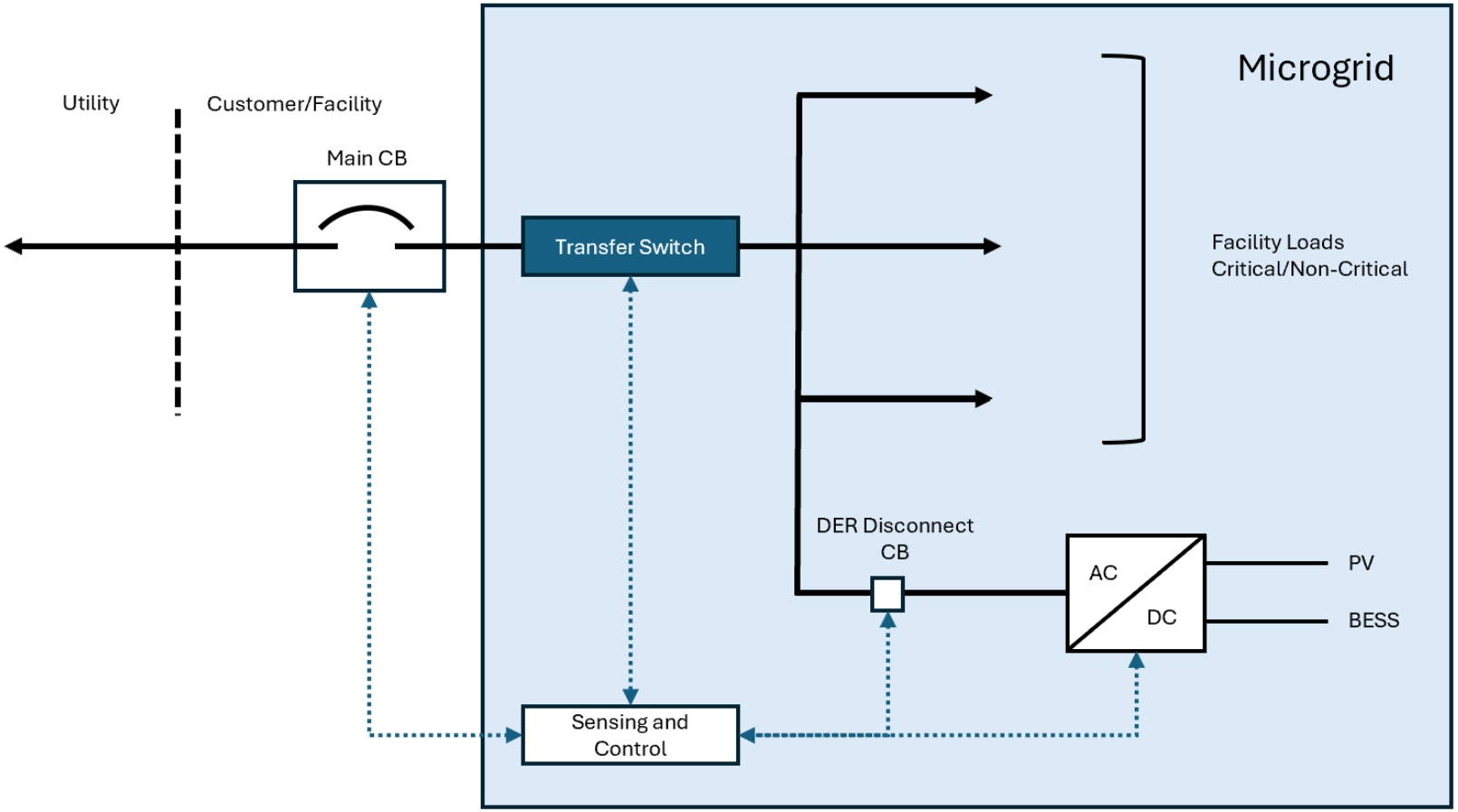
- Customers can disconnect themselves from the grid during an outage and utilize DER to power their own home/business

Utility or Community DER Improving Local System Reliability

- Coordinate and/or deploy DER to improve reliability to many customers (e.g., feeder)
- Positively impacts circuit outage metrics (SAIFI/SAIDI)

Reliability Impact – Large Customer Example

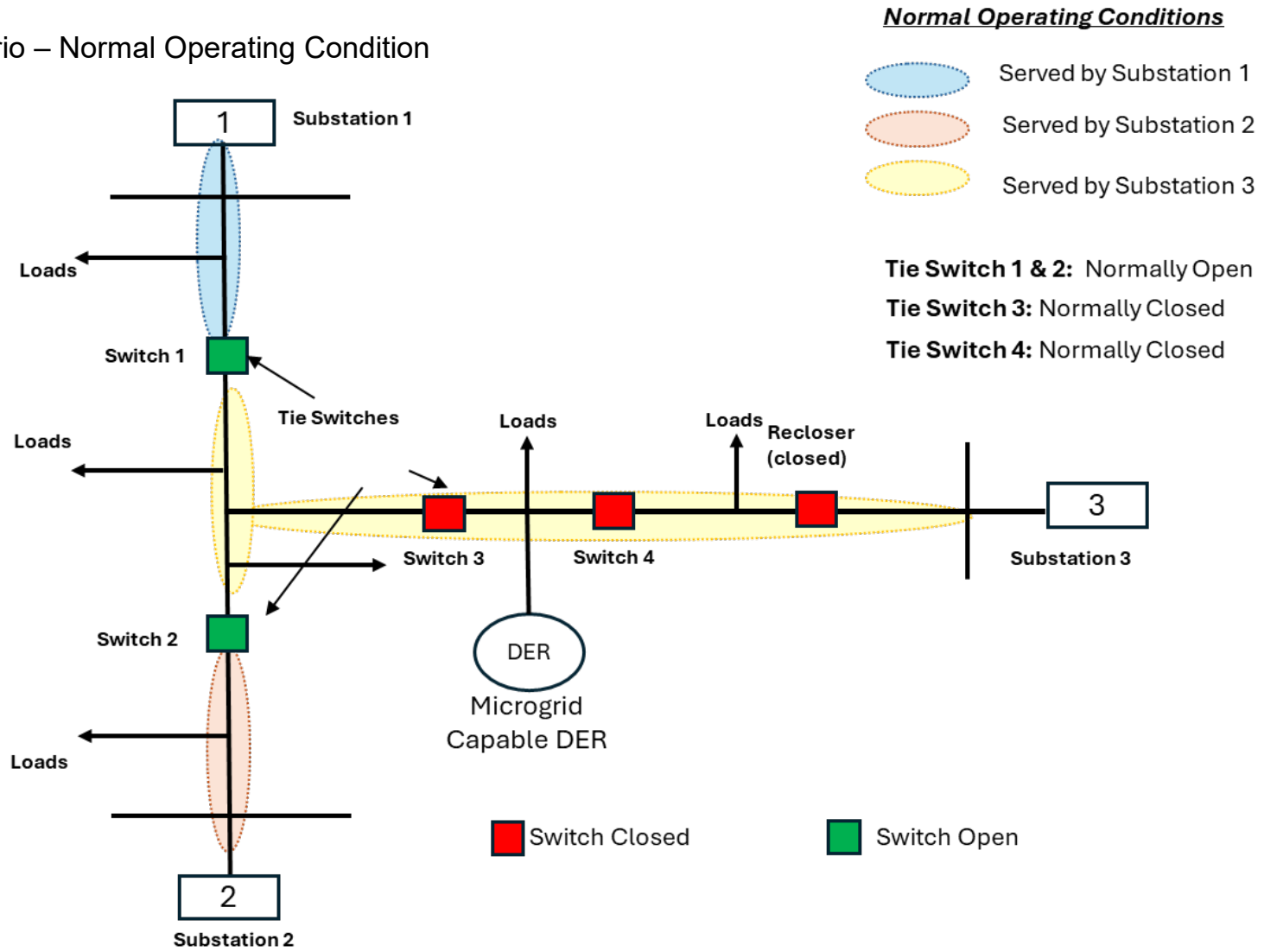
Example Customer Microgrid Equipment



Source: Ameren Illinois DER Value Workshop 3 Response Comments Appendix A

Reliability Impact – Utility Example

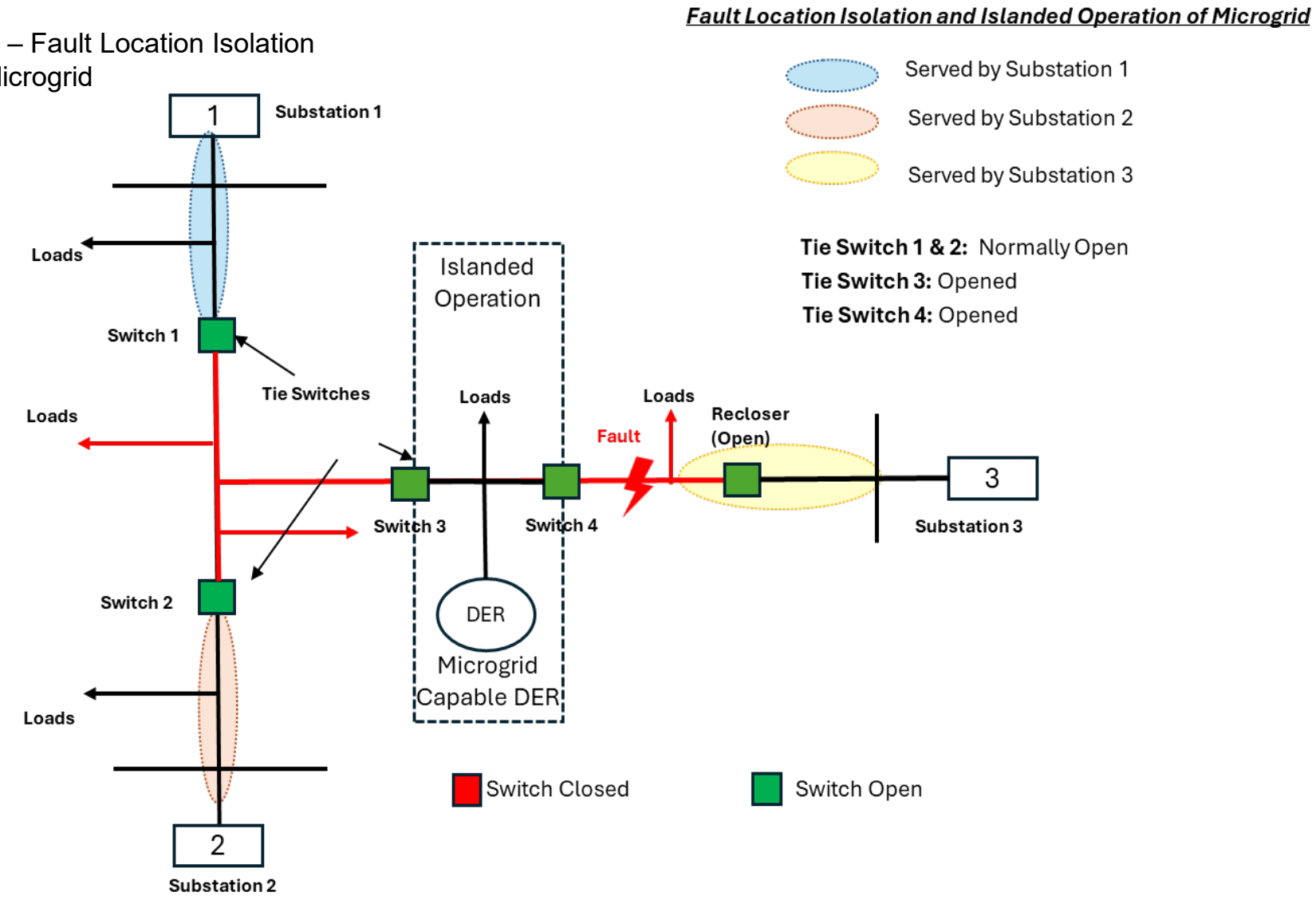
Example Microgrid Scenario – Normal Operating Condition



Source: Ameren Illinois DER Value Workshop 3 Response Comments Appendix A

Reliability Impact – Utility Example

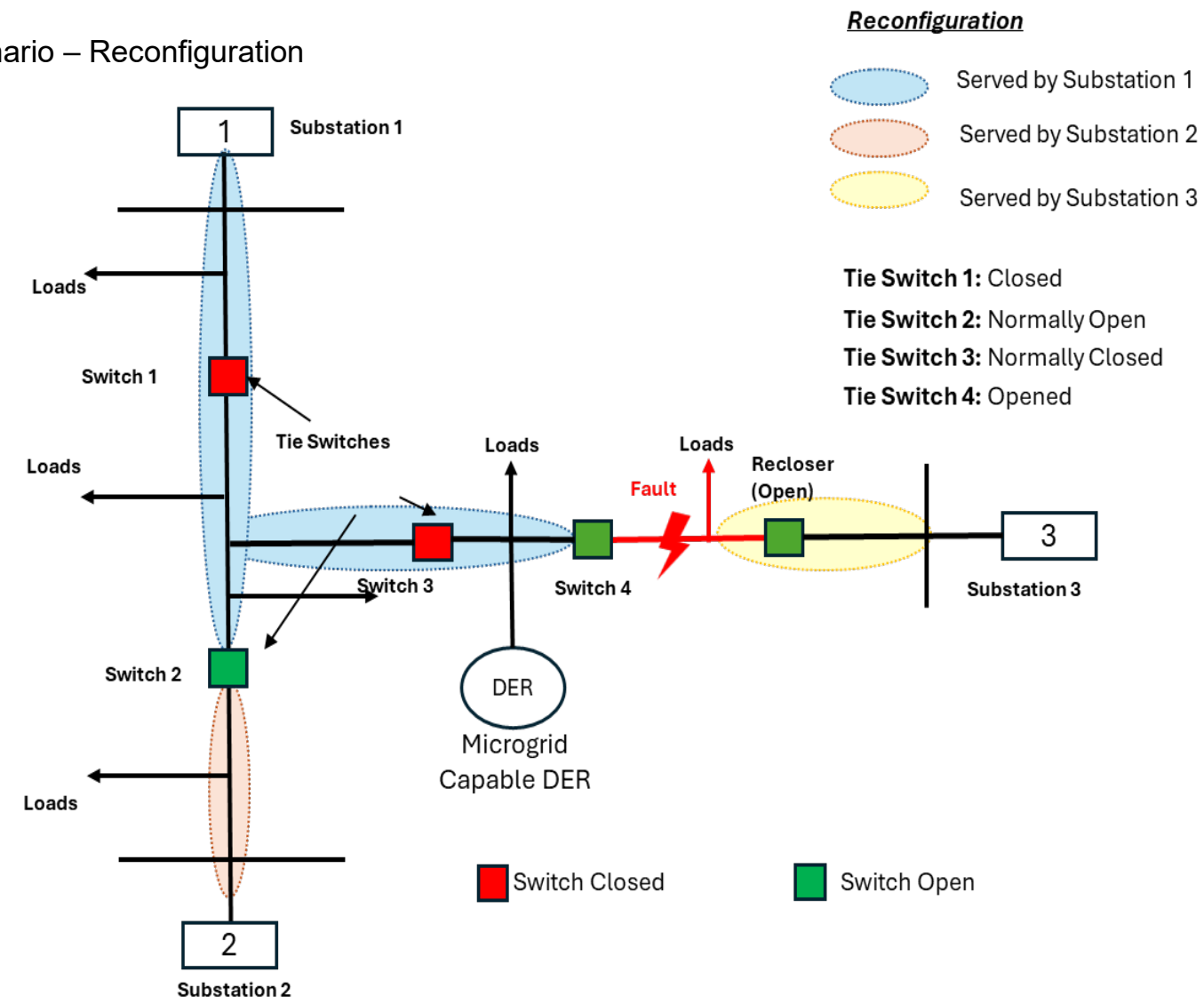
Example Microgrid Scenario – Fault Location Isolation and Islanded Operation of Microgrid



Source: Ameren Illinois DER Value Workshop 3 Response Comments Appendix A

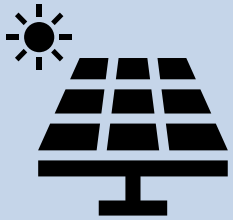
Reliability Impact – Utility Example

Example Microgrid Scenario – Reconfiguration



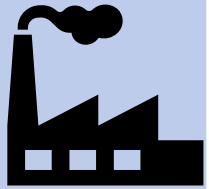
Source: Ameren Illinois DER Value Workshop 3 Response Comments Appendix A

DER Benefits Beyond the Distribution System



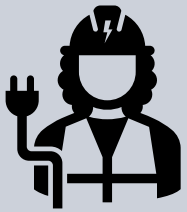
Customers may see lower energy bills

- Based on energy consumption habits post-DER adoption



Distributed renewable resources reduce the need for traditional generation

- Helps states meet relevant goals

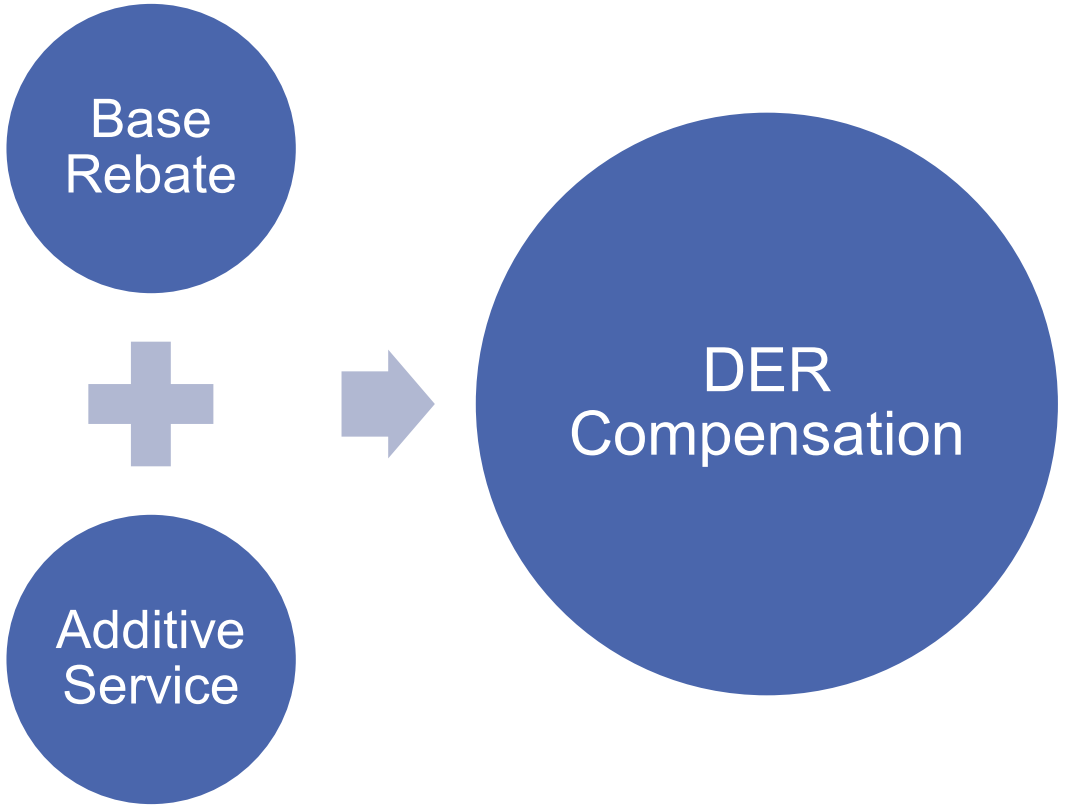


Local workforce may increase in some areas to install and maintain DERs

Providing access to DERs may meet other local and state goals

Valuing DERs – Example

- The Illinois Climate and Equitable Jobs Act (2021) prompted an Investigation Into The Value Of, And Compensation For, Distributed Energy Resources beginning in 2023
- Goal: Through a diverse set of stakeholders, create a value and compensation framework based on best practices that "prioritizes minimizing cost-shift from participants to non-participants"

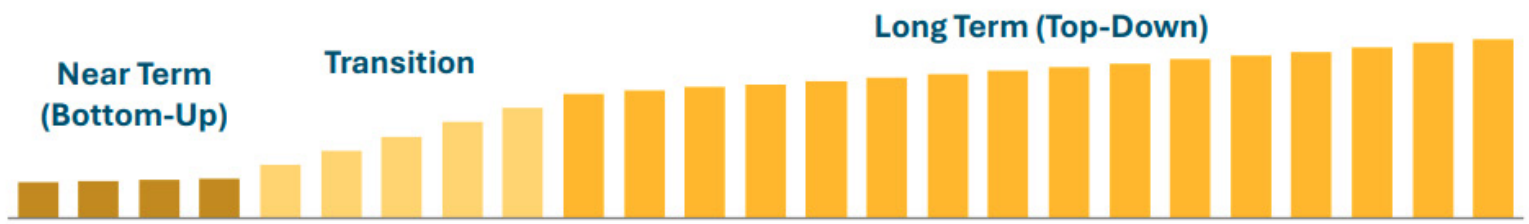


Framework for ICC Value of DER

Source: Illinois Commerce Commission (ICC)

Near-Term and Long-Term Capacity Value of DER Considerations

	Near Term Value	Long Term Value
Calculation Approach	**Bottom-Up** (Using filed Distribution Cost of Service Studies)	**Top-Down** (Using FERC Form 1 or grid plan data)
Data Needs	• Planned, specific distribution system investments, including costs and capacity need addressed	• Total distribution capacity upgrade cost • Total forecasted demand
Core Strengths	• Very good at isolating for marginal and potentially avoidable costs	• Able to capture longer-run costs • Requires less granular data
Limitations	• Limited to the specific planning period; may not be able to capture longer run costs • Limited transparency – requires nuanced assumptions with confidential utility data	• Likely to overestimate avoidable, capacity-related costs (can include embedded or non-DER deferrable costs) • Most reliable when there is a clear trend of increasing load + costs



Source: Investigation Into The Value Of, And Compensation For, Distributed Energy Resources, Series 2, Workshop 3 on 10/16/2024, Presentation Slide 12

Illinois' Most Recently Proposed Compensation Framework

- Uses the following benefit-cost analyses:
  - Participant Cost Test (PCT) – Do participants have enough incentive to adopt?
  - Ratepayer Cost Test (RIM) – Does the program increase or decrease rates?
  - Total Resource Cost Test (TRC) – Does the program provide net societal benefit?

Benefit-Cost Analysis Results Based on Technology

DER	Customer Type	Participant Cost Test (PCT)	Ratepayer Impact Measure (RIM)	Total Resource Cost Test (TRC)
Rooftop solar	All customers	Net benefit	Net cost	Net cost
Community solar	All customers	Net benefit	Net cost	Net cost
Standalone Storage	Residential	Net cost	N/A	Net cost
	Commercial	Net cost	Net cost	Net cost
Solar + Storage	All customers	Net benefit	Net cost	Net cost

Source: "Investigation Into The Value Of, And Compensation For, Distributed Energy Resources, Series 2, Workshop 3 on 10/16/2024, Presentation Slide 61

Illinois Value of DER – Facilitator Findings Thus Far

- Initial results of benefit-cost analyses showed that the base rebate was enough incentive, as evaluated DER technologies showed that the costs shifted to non-participants
- However, a DER could show value beyond the base rebate depending on its location
- Customers already recognize reliability and resiliency benefits and therefore are not recommended for additive services

[Source]: Investigation Into The Value Of, And Compensation For, Distributed Energy Resources, Series 2, Workshop 3 on 10/16/2024, Presentation Slide 62

Hosting Capacity Analysis: Solar and EV Charging

Hosting Capacity Overview

Hosting capacity refers to the amount of load or generation that can be added to the system before it causes a violation

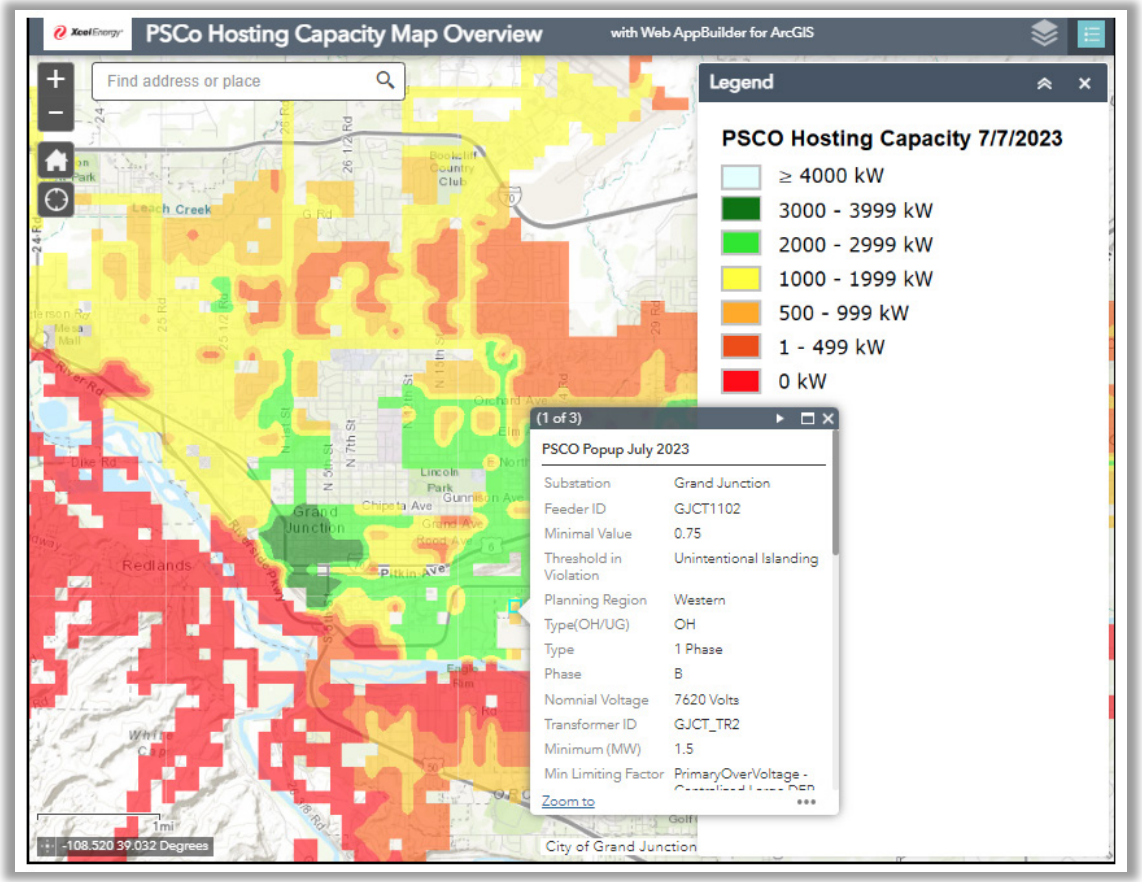
- Same concepts and methods for both load and generation
- Load maps relatively less common and are more useful for loads with locational flexibility
  - e.g., EV Fast Charging Hubs

Utilities perform hosting capacity to:

- Aid developers in decision-making for new projects
- Reduce application screening time and improve success rate of applications
- Aid in distribution planning

Hosting capacity studies typically consider:

- Thermal limits
- Overvoltage
- Reverse flow limitations
- Protection considerations



Hosting Capacity Map Example

Source: Xcel Energy (Colorado)

Hosting Capacity Maps

- Goal
  - Lower application volume and increase application success rate by:
    - Directing applicants to **locations with capacity** and where system modifications are more likely to be cost-effective
    - Providing enough information for applicants to make decisions

- Map Use Cases for Developers
  - Understand potential upgrade costs at varying DER sizes for various locations
  - Understand interconnection timeline based on DER queue size
  - Determine site feasibility based on hosting capacity, land, zoning, etc.

Hosting Capacity (HCA) Map Elements	Benefits to DER Developer
Substation location and HCA data	• Determine substation level constraints (e.g., size and voltage of transformer) • Identify equipment that may impact hosting capacity (e.g., load tap changer or regulator) • Determine approximate distance from circuit to substation
Feeder location and HCA data	• Determine feeder HCA constraints for DER load and generation • Assess if costly system upgrades are likely at a location given constraints • Identify equipment that may impact HCA (e.g., voltage supervisory reclosing)
HCA criteria violations	• Determine which violation criteria (e.g., thermal, voltage) is causing the limit, identify appropriate technical solutions to overcome constraint(s), and estimate associated costs (e.g., for system upgrade)
Substation/feeder load profiles	• Screening tool for locating DER load interconnections (e.g., storage, EV chargers) • Assess if costly system upgrades are likely at a location given constraints
DER connected and in queue	• Determine if hosting capacity is likely available to new projects

Synapse Report on Hosting Capacity Map Benefits to Developers

Source: Synapse Energy Economics, Inc. in Comments to Minnesota PUC

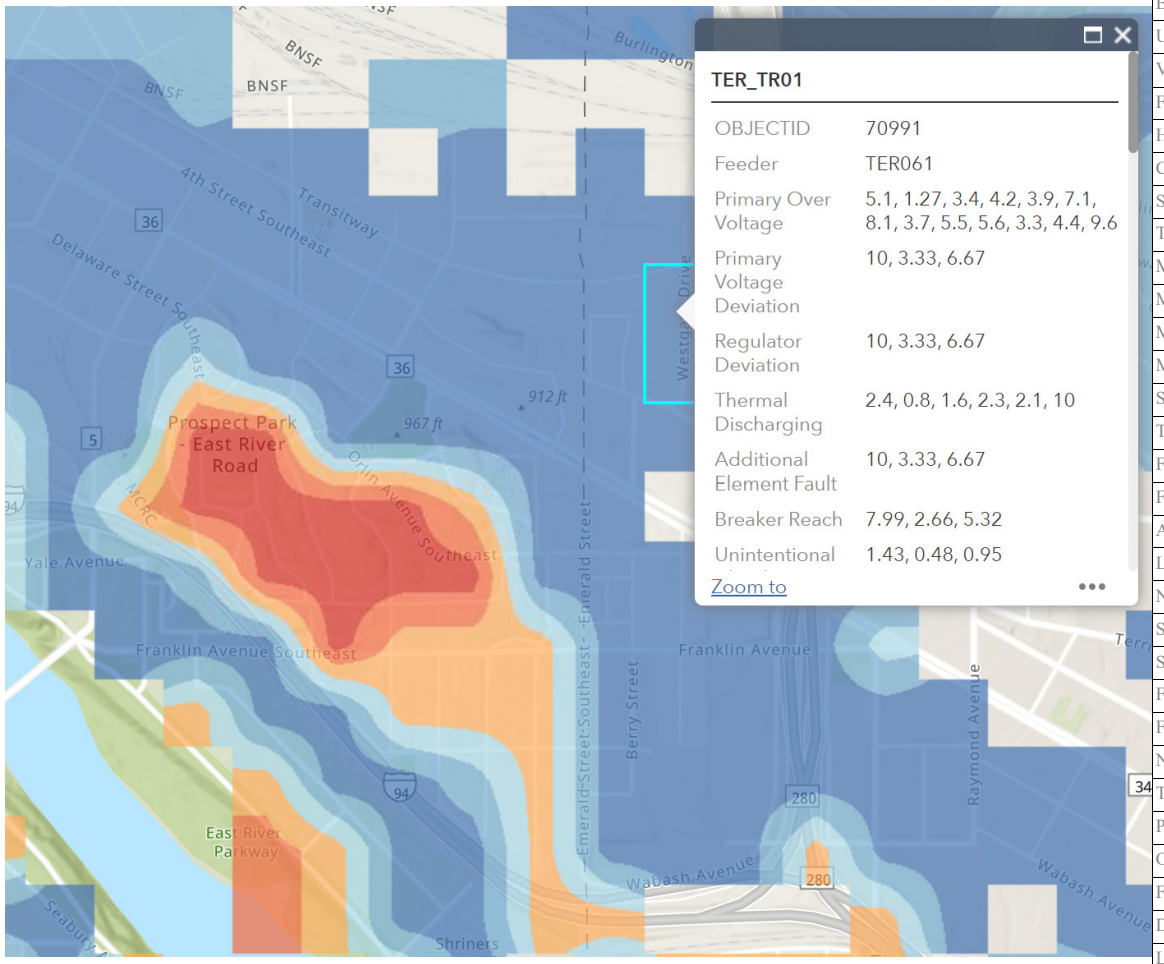
Hosting Capacity Map Effectiveness

- Assessing effectiveness
  - Is the information provided **locationally specific** enough to be useful?
  - Is the information **up to date** enough to be trusted?
  - Is **enough information provided** to empower developers to site and size DER applications effectively?

- Map qualities
  - Maps with **large geographic area blocks and little information, and that are updated infrequently,** are *less effective*.
  - Maps with **small geographic area blocks, most/all relevant information, and current/recent information** are *most* effective.

Effective Map Example

- Xcel Energy (Minnesota)
  - Geographic area blocks are small.
  - The map provides enough information to:
    - Enable project sizing
    - Understand project timeline
    - Understand likely system upgrades
    - Understand likely line extension
  - Still, there are improvement opportunities (e.g., the map is 6 months old)



Source: Xcel Energy MN Hosting Capacity Map

OBJECTID	72875
Feeder	MPK075
Primary Over Voltage	8.1
Primary Voltage Deviation	10
Regulator Deviation	10
Thermal Discharging	4.9
Additional Element Fault	10
Breaker Reach	10
Unintentional Islanding	1.2
VSR Equipped	No
Feeder Technical Planning Standard	Compliant
Hosting Capacity	1.2
Constraining Metric	Unintentional Islanding
Substation	Merriam Park
Transformer Name	MPK_TR02
Minimum Available Hositng Capacity (MW)	0.9
Min Constraining Metric	Thermal Discharging
Maximum Available Hosting Capacity (MW)	1.2
Max Constraining Metric	Unintentional Islanding
Substation Transformer Minimum Load (kVA)	3587
Transformer Absolute Min (kVA)	2750
Feeder Daytime Minimum Load (kVA)	1700
Feeder Absolute Min (kVA)	1700
Actual Daytime Min Load	Yes
LTC or Regulator	LTC
Network or Radial	Radial
Substation Transformer Installed DG (kW)	10647
Substation Transformer Queued DG (kW)	147
Feeder Installed DG (kW)	487
Feeder Queued DG (kW)	0
Notes	
Type	3 Phase
Phase	ABC
OH/UG	UG
Feeder Voltage	13800 Volts
Data Cutoff	1/30/2024, 6:00 PM
Latest Quarterly Update	4/30/2024, 7:00 PM
Shape__Area	0.000002283913090650458
Shape__Length	0.0061357020010746055

Using Map Data Effectively – Practical Example

Enable Project Sizing and Likely System Upgrades

Primary Over Voltage	8.1
Primary Voltage Deviation	10
Regulator Deviation	10
Thermal Discharging	4.9
Additional Element Fault	10
Breaker Reach	10
Unintentional Islanding	1.2
VSR Equipped	No
Feeder Technical Planning Standard	Compliant
Hosting Capacity	1.2
Constraining Metric	Unintentional Islanding

Key Takeaways

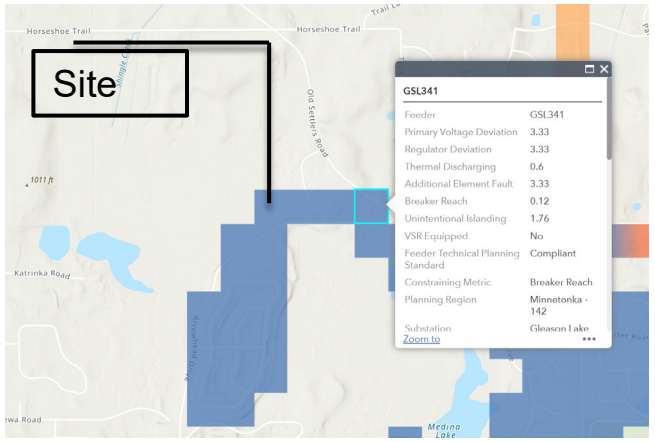
- Expect cost to add Voltage Supervisory Recloser (VSR) at 1.2 MW of DER (to address unintentional islanding)
  - Cost estimate: $200k-$400k (source)
- Next constraint: Thermal Overload at 4.9 MW
  - Line overload cost calculable using distance to substation or first map node where thermal hosting capacity limit changes
- Recommendation: 4.8 MW DER, expect $200k-$400k Upgrade

Understand Project Timeline

Substation Transformer Installed DG (kW)	10647
Substation Transformer Queued DG (kW)	147
Feeder Installed DG (kW)	487
Feeder Queued DG (kW)	0

Minimal Queued Generation = Fast Study Timeline

Understand Likely Line Extension

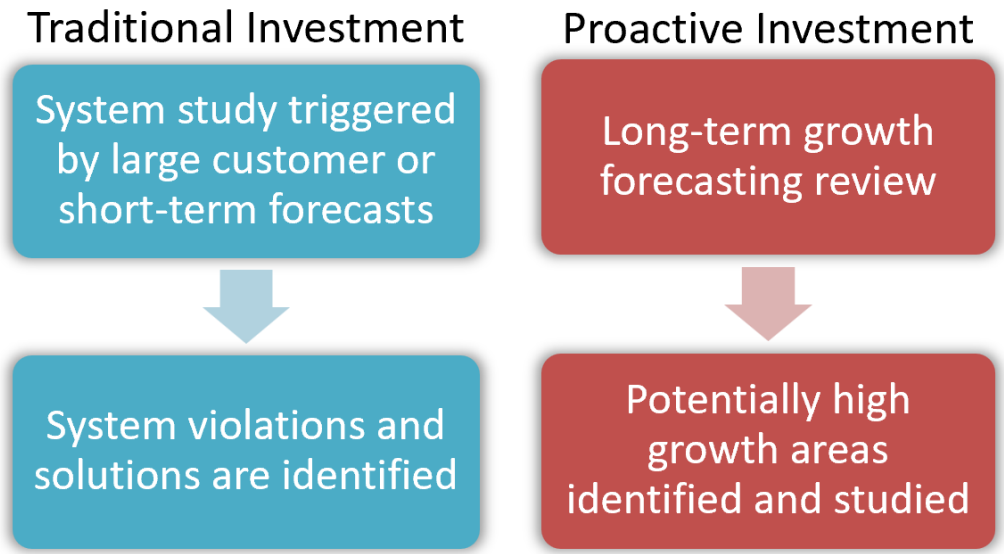


Estimate line extension distance and easement needs

Costs and Benefits of Proactive Grid Investments and Cost Allocation Approaches

Proactive vs Reactive Planning – Overview

- Traditional utility capacity planning is reactive
  - System changes are relatively slow
  - Acting on high-confidence information
    - Known load additions
    - Known DER interconnections
    - Short-term load growth forecast (1–3 years)
- Traditional approach can limit speed of load/DER growth if system changes are faster than utility can respond to
  - 2–5 year lead times for major upgrades
- Proactive planning builds load/DER capacity based on longer-term expected growth



Proactive vs Reactive Planning – Differences

Reactive Planning

- **Goals**
  - Minimize risk of unutilized investment
  - Allocate costs to cost causer
    - Rate-base for baseline growth
    - Contribution in Aid of Construction for large spot load additions
    - DER interconnection costs paid by developer/customer
- **Risks**
  - Construction timelines (1–2+ years)
    - Load construction timelines generally long (new buildings)

Proactive Planning

- **Goals**
  - Don't block load / DER growth
    - EV and PV/BESS construction timelines much shorter
- **Risks**
  - **Risk of under-utilized investment**
  - High reliance on accuracy of long-term forecasts
    - Geospatial – Where is adoption?
    - Temporal – When will they interconnect?
  - Cost allocation
    - Process issues for large loads and DERs

Cost Allocation Under Proactive Planning – Challenges

Large Load Customer Interconnection

- Customers adding large loads generally pay a portion of system upgrade costs
  - Based on expected revenue that will offset the costs
  - Contribution in Aid of Construction
  - If a large load interconnects in an area impacted by a proactive upgrade, it is **hard to determine and recover its contribution**

DER Interconnection

- DERs often bear all costs for hosting capacity upgrades to accommodate interconnection
- There are cost allocation **challenges to rate-basing any hosting capacity upgrades**
- If a large DER interconnects in an area impacted by a proactive upgrade, it is **hard to recover its contribution**

Flexible Interconnection Considerations

- Flexible interconnection attempts to **maximize** utilization of **existing infrastructure**
- Proactive capacity build-out can create **disincentives** for customers **to pursue or utilize Flexible Interconnection**

Cost Allocation Methods – Potential Solutions

Large Load Customer Interconnection

- Track large load interconnections in areas impacted by proactive investment
- Apply traditional cost allocation mechanisms to the cost of the completed upgrade
  - Contribution in Aid of Construction: Interconnection cost based on upgrade and line extension cost, expected bill contribution, and relative utilization of upgrade

DER Interconnection

- Incorporate within existing or potential DER cost-sharing frameworks
  - Determine if reasonable to socialize to prevent "closed" feeders that can't accommodate new small solar interconnections
- Track large DER interconnections in areas impacted by proactive investments
  - Recover avoided DER interconnection cost

Flexible Interconnection Considerations

- Customers who elect to use flexible interconnection options could be exempted from avoided interconnection cost recovery

Source: ESIG – A Proactive Approach for Accommodating High Penetrations of Distributed Generation Resources (link)

Targeting Proactive Investment – Strategies to Minimize Risk

- Utilize only where needed to achieve specific goals
  - Improved investment efficiency / reduced lifecycle cost
  - Prevent system from blocking expected growth
  - Spread out investment/construction over time
- Focus on areas of high confidence in the forecast
  - Residential / small commercial
- Focus on projects with multiple benefit streams

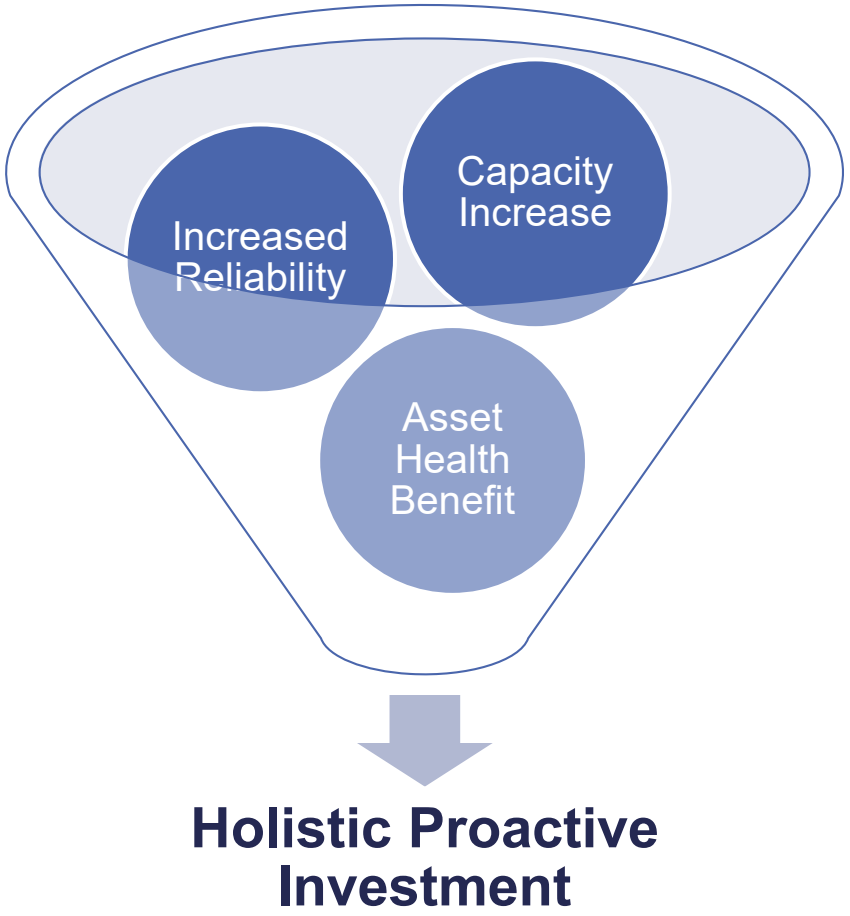
Targeting Proactive Investments – Small Customer Growth

- Upgrades to provide load and DER hosting capacity for residential and small commercial customers can be prioritized for proactive investments
  - Investments for small customer load growth are rate-based under current practices
  - Cost-sharing mechanisms for small customer DER interconnection can be considered
  - Forecasting growth for large numbers of customers is typically more reliable than forecasting the magnitude, location, and timing of large customers
  - It also is more feasible to develop feeder-specific forecasts for growth of small customer loads with sufficient accuracy to justify the proactive investment
- If large customers are allowed to use capacity from proactive investments, utilities can propose, and regulators can determine, large customers' cost contribution

Targeting Proactive Investments – Diverse Benefit Streams

Lower risk by diversifying benefit streams

- Most utility investments have multiple positive impacts
  - Capacity
  - Reliability improvement
  - Asset health improvement
- Evaluate other benefits of proactive investment options to minimize risk of stranded assets



Closing

Actions States Can Take

State Regulators

- Investigate current mechanisms for DER services and compensation
- Direct utilities to study the value of DER services for various DER types
- Review hosting capacity map requirements, information, and capabilities for potential improvements
- Review justification and cost allocation methods for utility investments
- Initiate working groups or other forums for developing effective mechanisms for proactive hosting capacity

State Energy Offices

- Provide input on the value of DER with respect to alignment with state policy goals
- Participate in hosting capacity analysis efforts to support state goals and reduce barriers to DER adoption
- Provide guidance on state priorities and program information relevant to proactive investment opportunities

Utility Consumer Advocates

- Participate in value of DER efforts by reviewing scope, objectives, inputs, assumptions, and results
- Provide feedback on hosting capacity information, costs, data sharing, privacy, and enhancements
- Review proactive investment frameworks and proposals for reasonableness and cost-effectiveness

Questions States Can Ask

- How are DERs compensated today for their value to the utility's electricity system?
- What compensation mechanisms and value streams may be suitable for DERs?
- How effective is the hosting capacity information provided by utilities?
- What enhancements could be made to improve effectiveness of hosting capacity maps?
- What types of costs and other barriers exist to making those enhancements?
- How do utilities plan and prioritize distribution system capacity investments today?
- Are any proactive investments anticipated to be needed?
- How would existing cost allocation frameworks impact proactive investments?

ENERGY MARKETS & POLICY

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