SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

Solar Critical Infrastructure Energization (SOLACE) System

Dr. Arindam Maitra
Senior Technical Executive

Dr. Brian Seal
Senior Program Manager

Electric Power Research Institute (EPRI)

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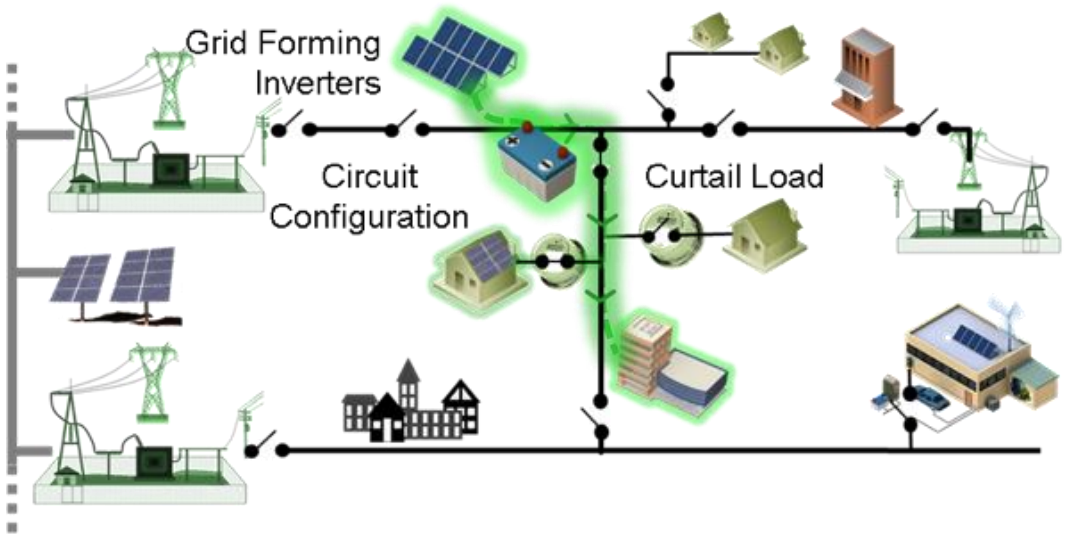
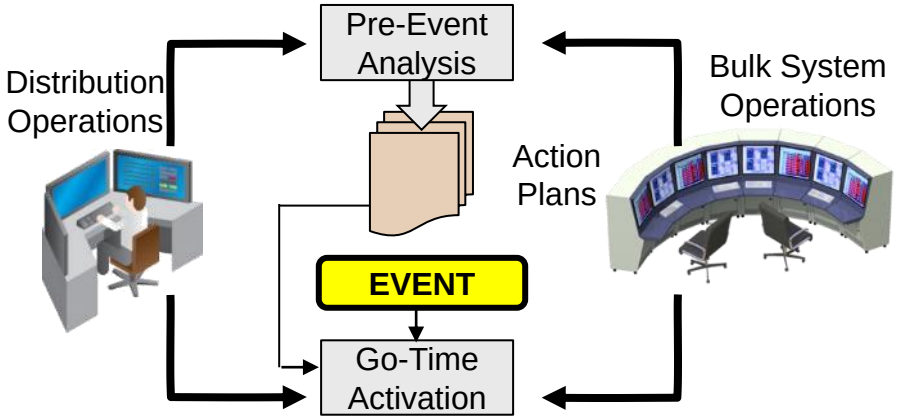
SOLAr Critical infras Energization System (SOLACE)

Viability planning methods + Advanced grid controls + Secure local communication = Resilient local power ?





- **Pre-Event Planning methods**: Enable utilities to assess their T&D system to determine if and where *existing DER and grid* can be utilized for resilient local operation during time of crisis.
- **Controls & Operations:** Utilize centralized DMS functions to isolate and operate the local grids.
- **Technology Advancement:** Grid forming DER development, advanced load management, cyber-secure systems

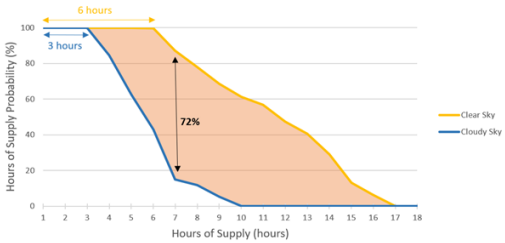
Work with the existing grid, not replace it. Utilize existing DER to provide resilience service to critical customers. Changes lie in where the control and monitoring layers are

Resilience Planning Methodology – PERPA

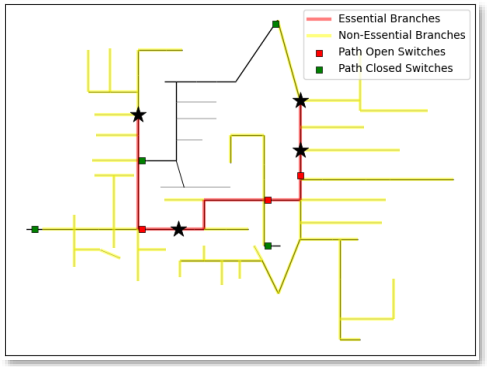
Step 0 - Determine Operational and Planning Criteria

- High-Level Operational Limits and Criteria for Different Analyses

Criteria for Normal Operation	Reference Standards	Recommended Criteria for use in PERPA
Voltage Imbalance < 3%	ANSI C84.1	Might utilize range B (Service Voltage – 8.3% to4 +5.8%)
Harmonics	IEEE Std 519-1992	Can be relaxed within reason
Grounding	IEEE/ANSI C62.92	Can be relaxed up to the Dx arrested TOV assuming that...
…	…	…

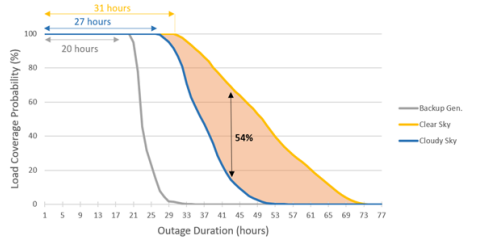


Analysis to Identify Pathways



Step 1 - Critical Facility and DER Ident. and Characterization

- Identification and Characterization of Crit. Facilities and DER
- Combinations and filtering of Crit. Facilities and DERs
- Preliminary Power and Energy Adequacy Assessment
- Estimation of extra resources needed (if necessary)



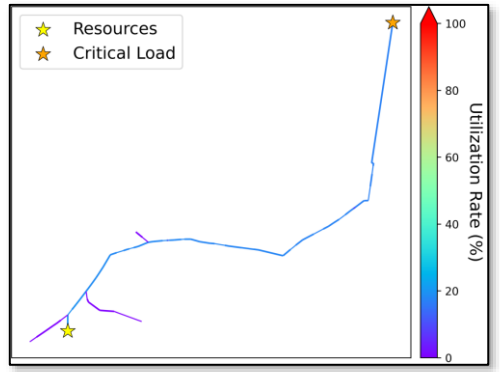
Step 2 - Potential Pathways Identification

- Identification of potential paths
- Initial characterization of potential paths

Analysis of Each Identified Pathways

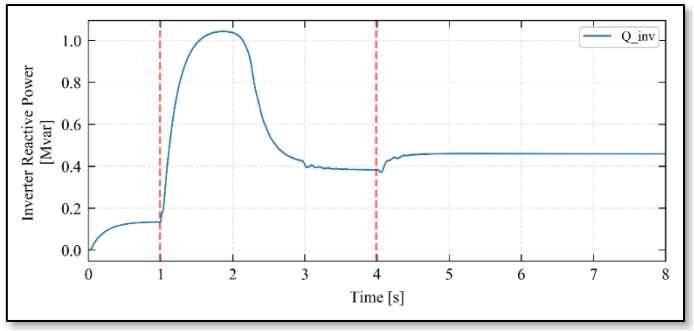
Step 3 - Pathway Steady-State Analysis

- Power-Flow
- Thermal
- Reactive Power Supply
- Voltage and Load Balance
- Etc



Step 4 - Pathway Dynamics Analysis (EMT)

- Protection Analyses
- Black-Start and Motor Start
- Generation, Large Load and Capacitor Switching

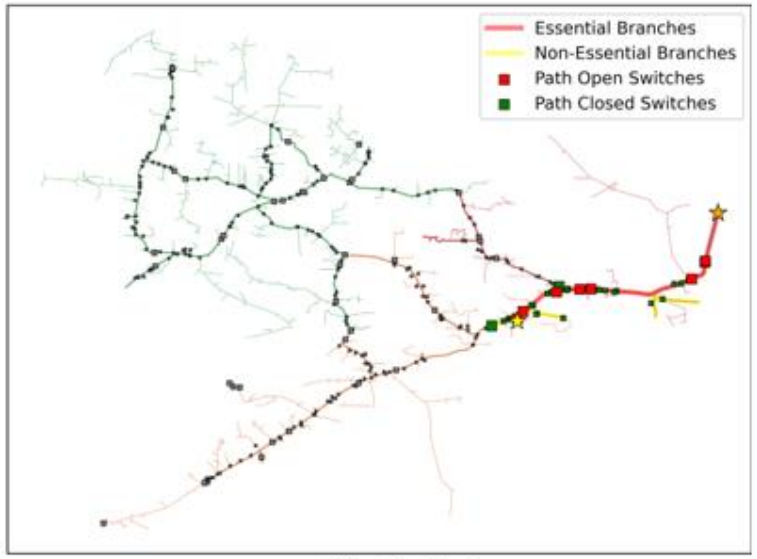


Step 5 - Final Viable Plan Creation

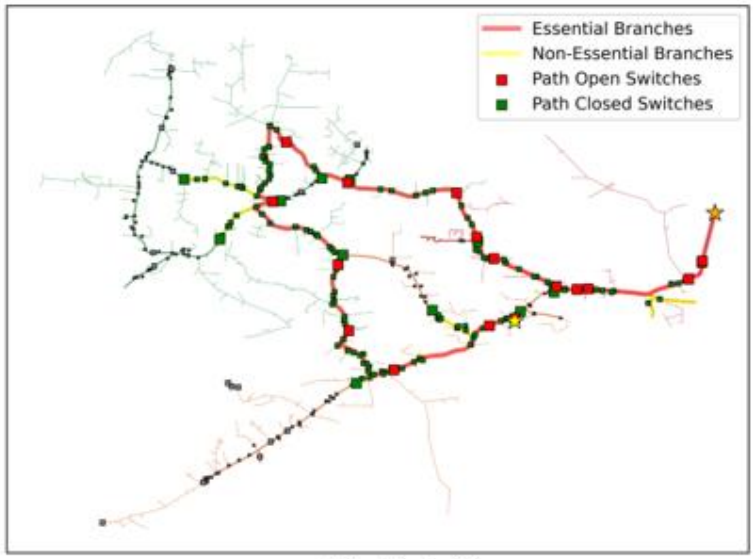
- Creation of Pathways Ranking Matrix
- Solution Paths Characterization for Go-Time Activation

Path Name	Load Coverage Probability	Total Length	Total Sequence Impedance	# of Devices to be Adjust.	Cost ($)	Path Ranking Position
1						
2						
3						

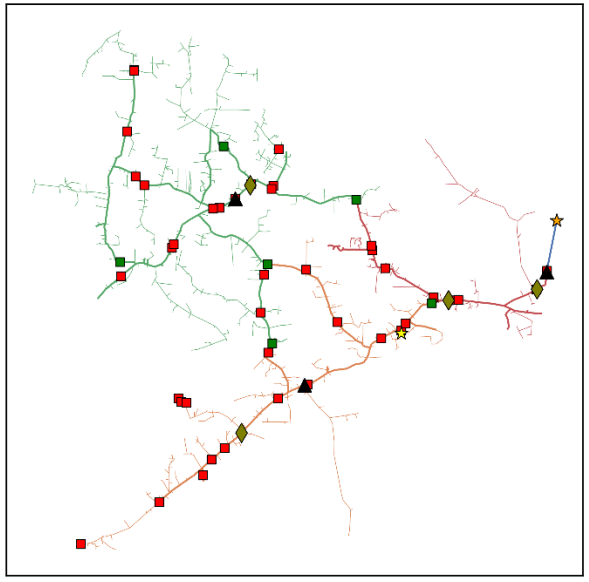
Potential Pathways Connecting Critical Load to Resources

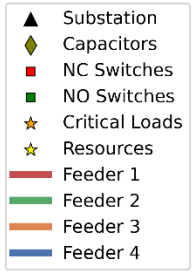


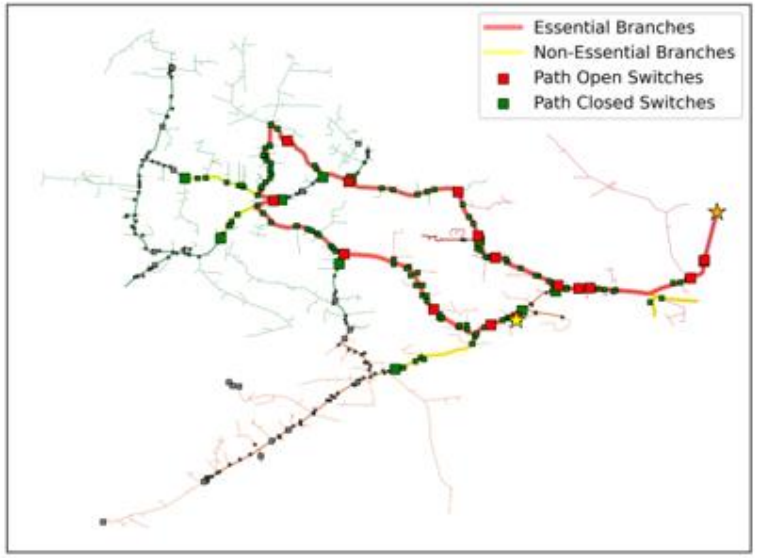
(a) Path 1



(b) Path 2

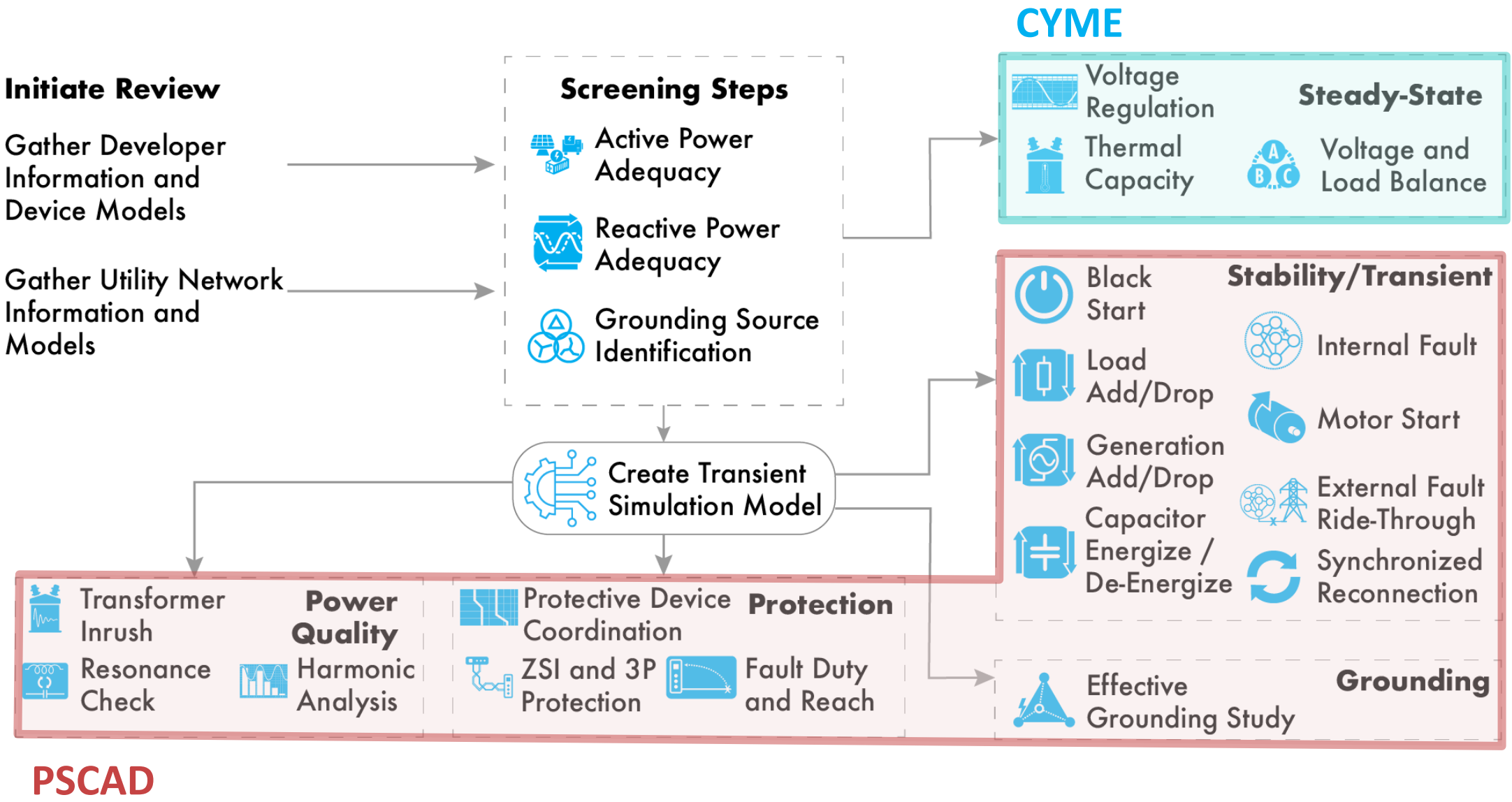




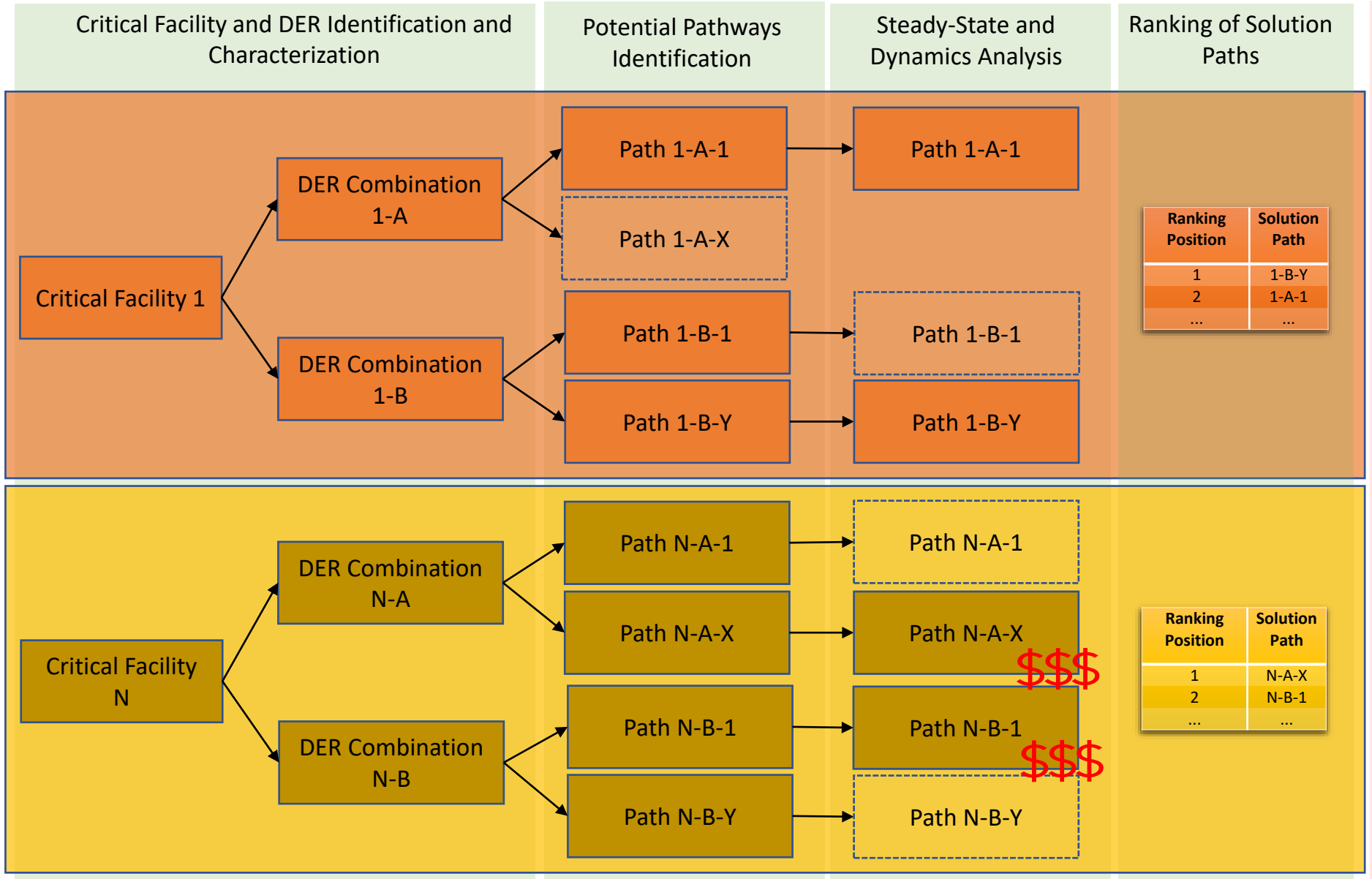


(c) Path 3

Microgrid Interconnection Analysis Process



Resiliency Planning Methodology – PERPA



Go-Time Activation

Critical Facility Priorit. Position	Critical Facility	Solution Path Ranking Position	Solution Path
1	2	1	N-A-X
		2	N-B-1
2	1	1	1-B-Y
		2	1-A-1

- PERPA:
  - Critical facilities selected and ranked by third-party (e.g., Gov.)
  - Solution paths ranked by planning engineer
- Go-Time: operations engineer identifies a valid solution path to activate following the ranking matrix

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GFM Inverter Control and Hardware Development

Grid Following Inverter (GFL)

- Current source (Current control)
- PLL is required to estimate grid phase angle and voltage magnitude
- No black start capability (anti islanding protection)
- Without frequency support
- Fast response to the intermittent irradiation levels (no buffer)

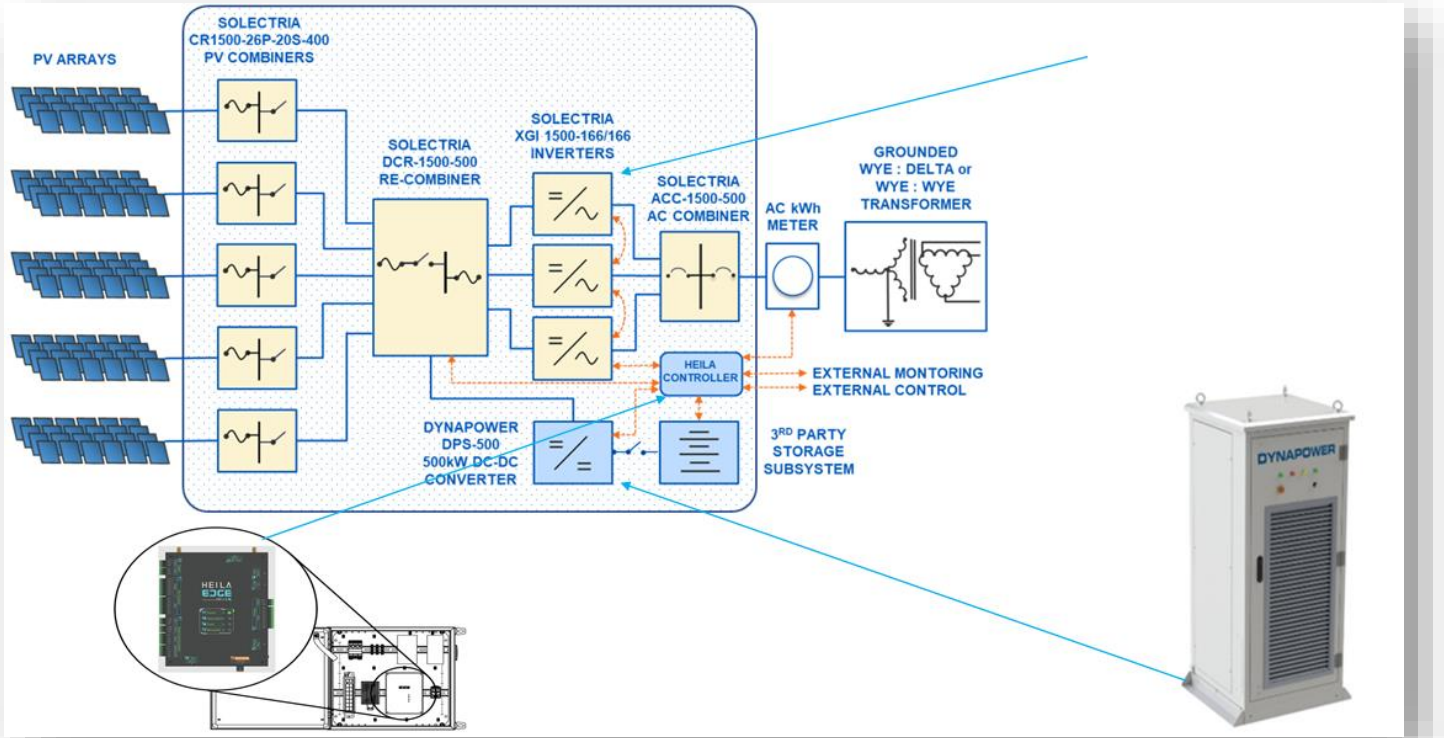
Grid Forming Inverter (GFM)

- Voltage source (can serve as PV bus or PQ bus)
- Operates like a synchronous generator
- Has its own voltage & frequency (Swing bus)
- No PLL required
- Black start capability
- Inertia support and primary frequency response

Proposed GFM Architecture: DC Coupled PV Synchronous Generator (PVSG)

- Connect an energy buffer at the DC side (hardware change)
- Change the PV inverter controller for GFM
- System acts like a synchronous generator

- **Based on UT Austin PVSG Design**
- **Based on Solectria XGI-1500**
- **Upgraded control from GFL to GFM**



Thank You