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Design and Development of a Sequence of Operation for Utility Microgrids

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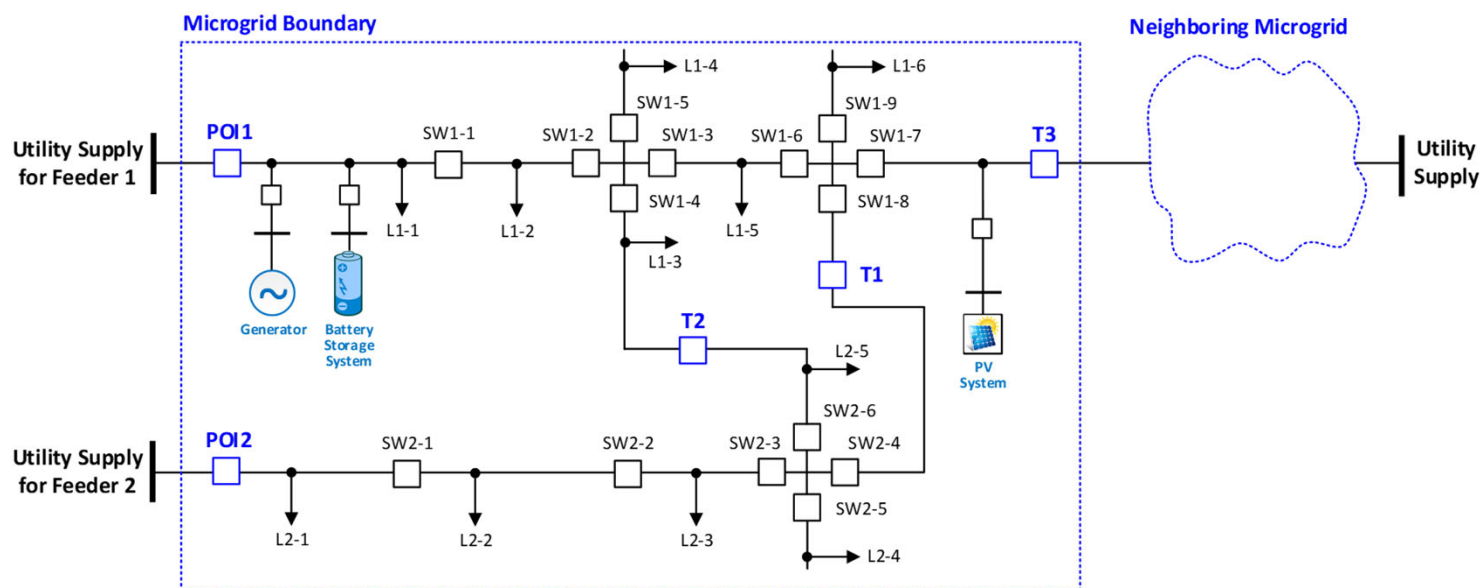
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N. Gurung, R. Sharma, H. Chen, H. Zheng, O. Alizadeh, "Design and Development of a Sequence of Operation for Utility Microgrids"

- Introduction: Microgrid Sequence of Operation (SOO)
- Methodology for Development of SOO
 - Determine Microgrid Modes
 - Develop high-Level Diagram of Operating Modes
 - Develop Process and Sub-process Flowchart
- Conclusion

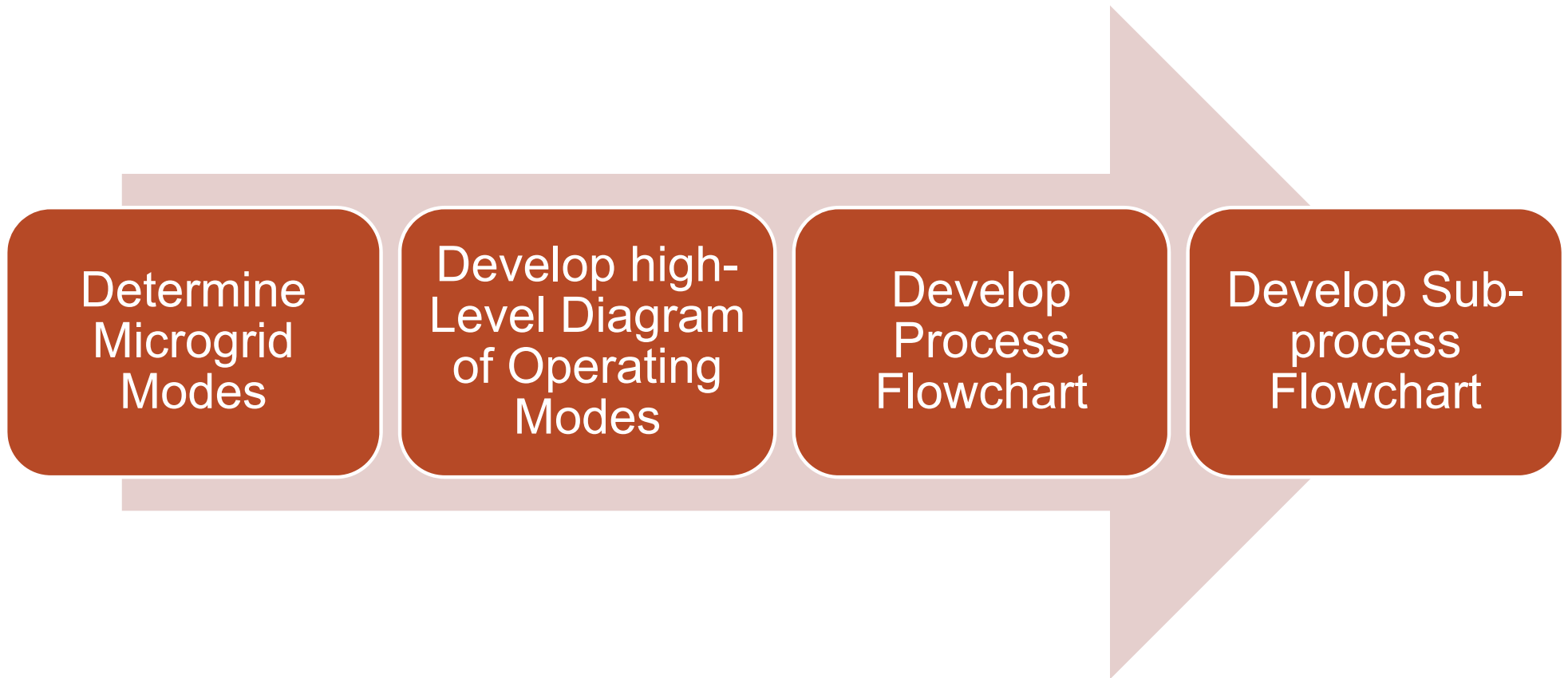
Introduction: Microgrid Sequence of Operation (SOO)

- Microgrids can consist of a variety of components including critical and non-critical loads, distributed energy resources (DERs) such as solar photovoltaic (PV) and battery energy storage systems, and a wide range of controllable distribution assets.
- Microgrids may operate in different modes based on the system condition and needs
- Microgrid Sequence of Operation (SOO) defines the process for microgrid controller and microgrid resources to transition from one mode to another in a safe and secured manner



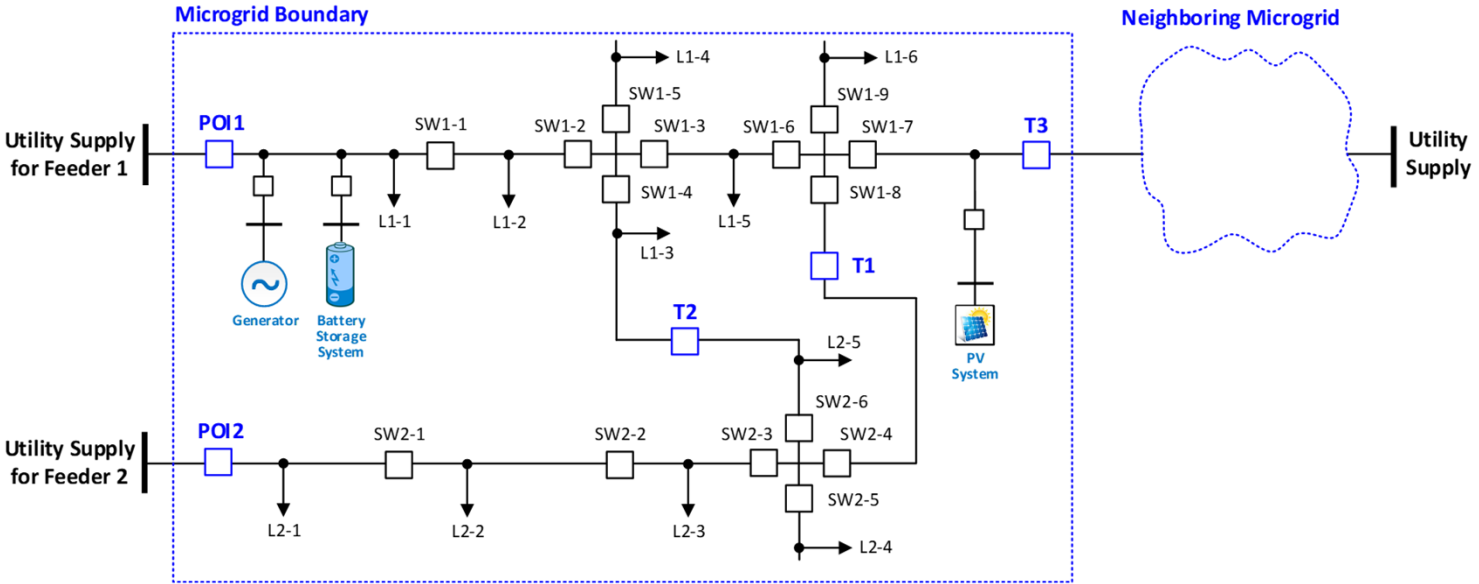
Representative Microgrid One-line Diagram

Methodology for Development of SOO

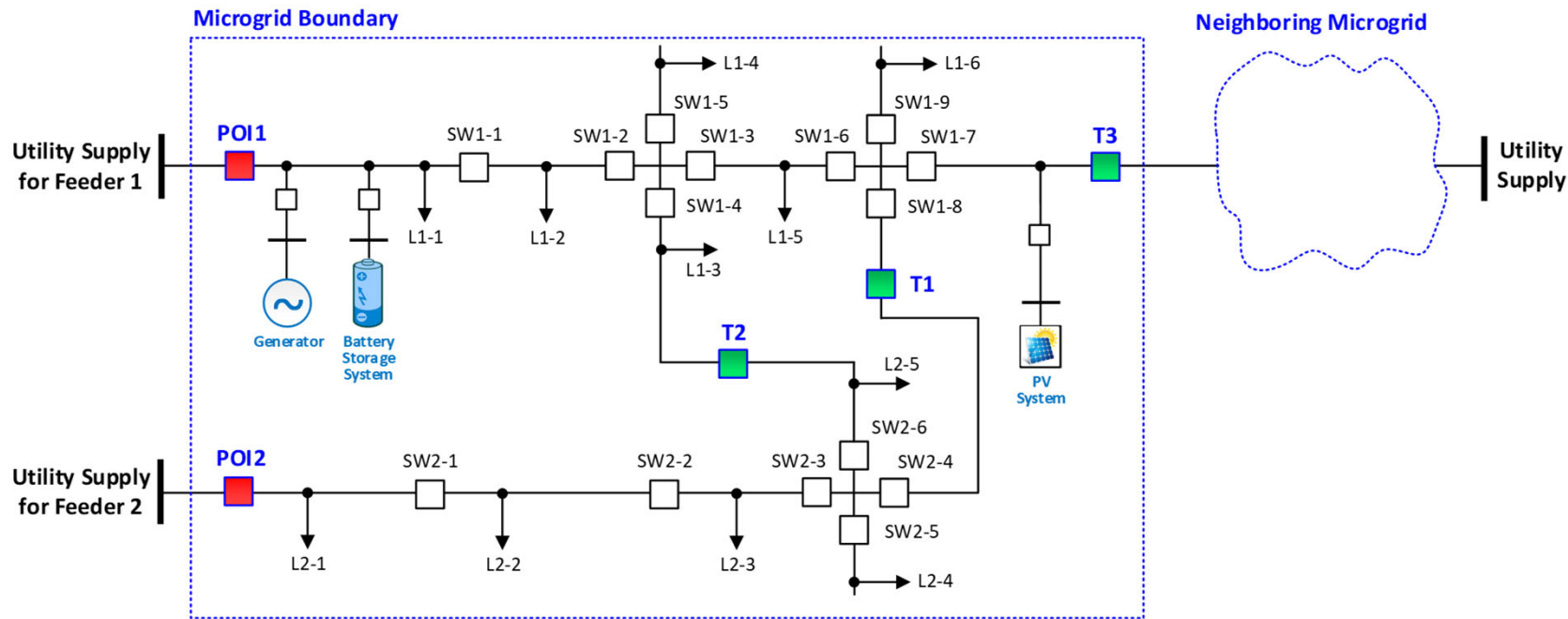


Determine Microgrid Modes

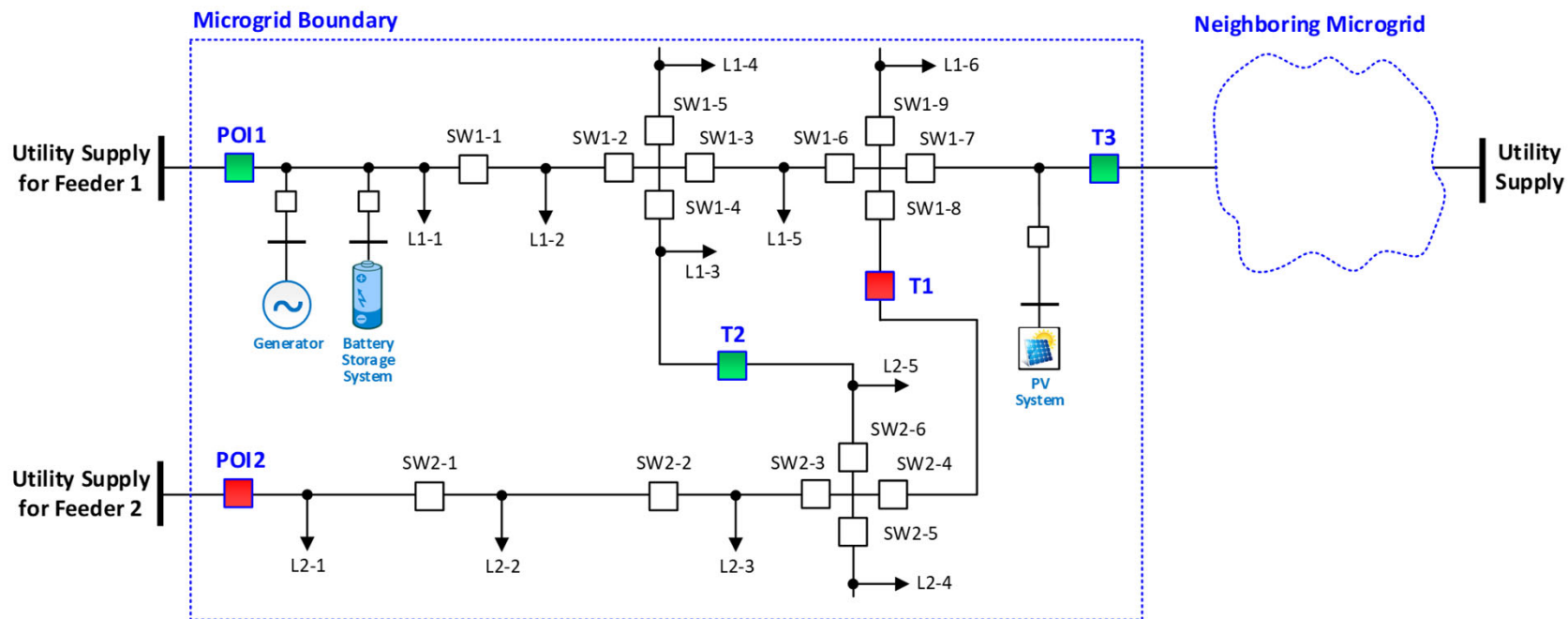
Operating Mode	Status of Switches				Remarks
	POI1	POI2	T1 (or T2)	T3	
Normal	C	C	O	O	
Load Transfer 1	O	C	C	O	Load on feeder 1 is transferred to feeder 2 using tie switch T1 (or alternatively, by using tie switch T2)
Load Transfer 2	C	O	C	O	Load on feeder 2 is transferred to feeder 1 using tie switch T1 (or alternatively, by using tie switch T2)
Partial Island	O	C	O	O	Isolation of feeder 1 from the grid using the grid-forming generator connected to the feeder
Full Island	O	O	C	O	Full isolation of both feeders from the grid using tie switch T1 (or alternatively, by using tie switch T2) and using the grid-forming generator connected to feeder 1
Partial Cluster	O	C	O	C	Cluster of the partial island (i.e., isolated feeder 1) with the neighboring microgrid using the tie switch T3
Full Cluster	O	O	C	C	Cluster of the full island with the neighboring microgrid using the tie switch T3



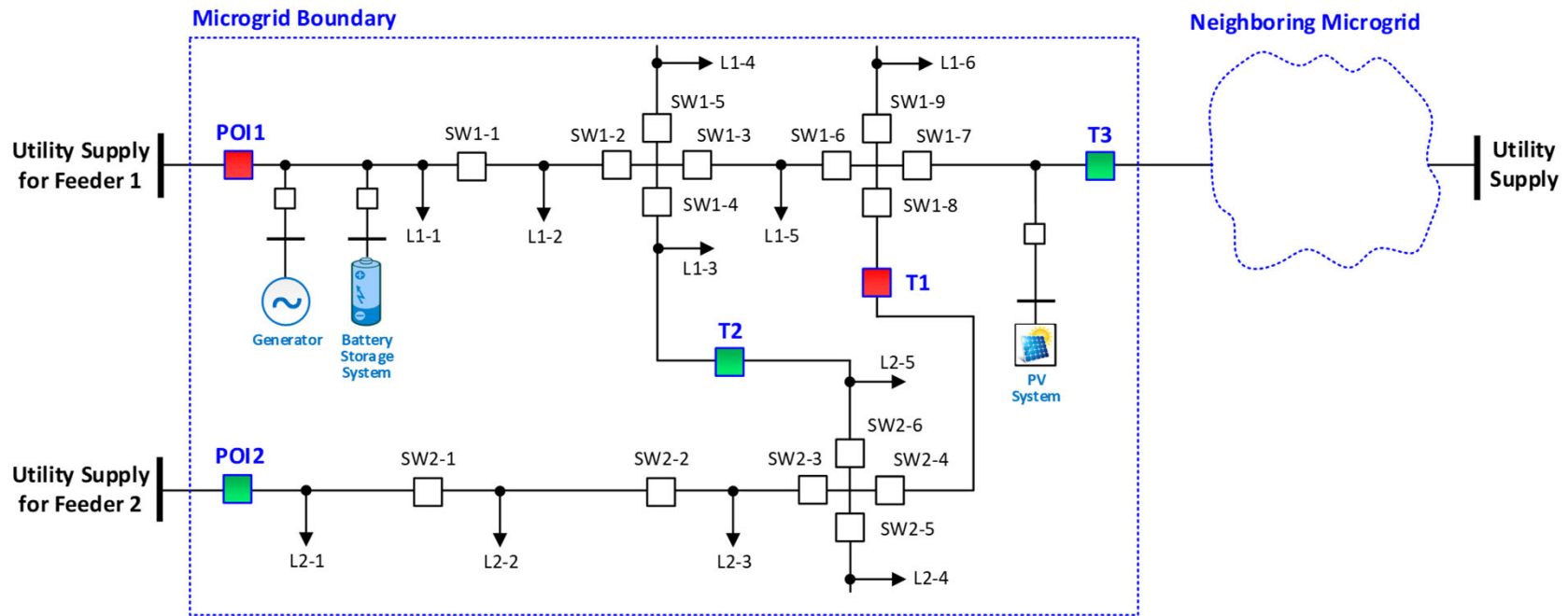
Normal/Grid Connected Mode



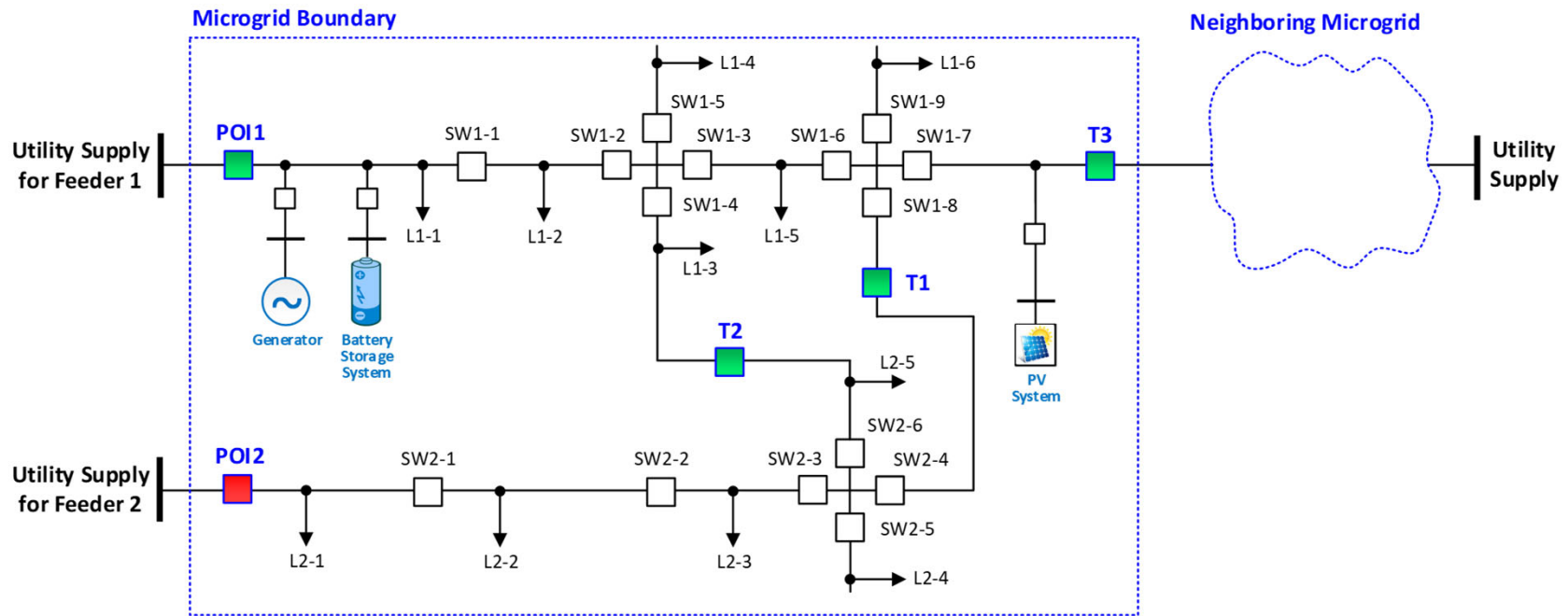
Load Transfer 1



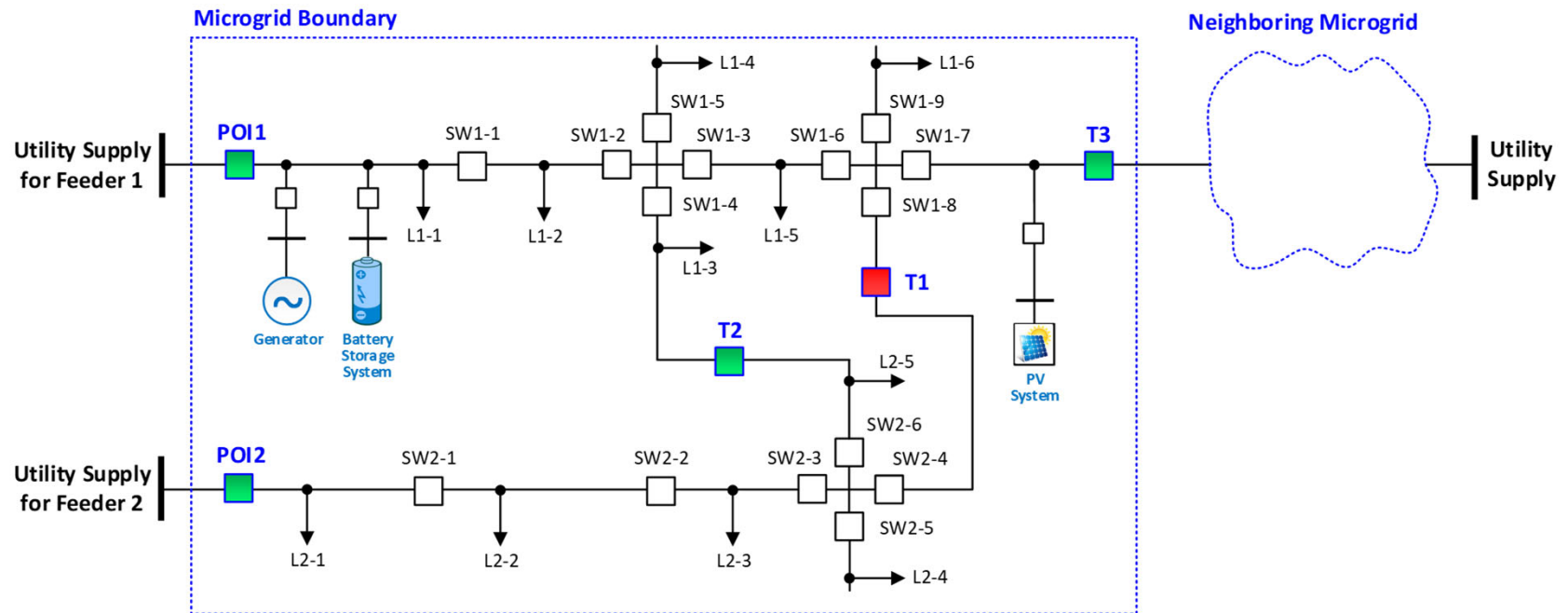
Load Transfer 2



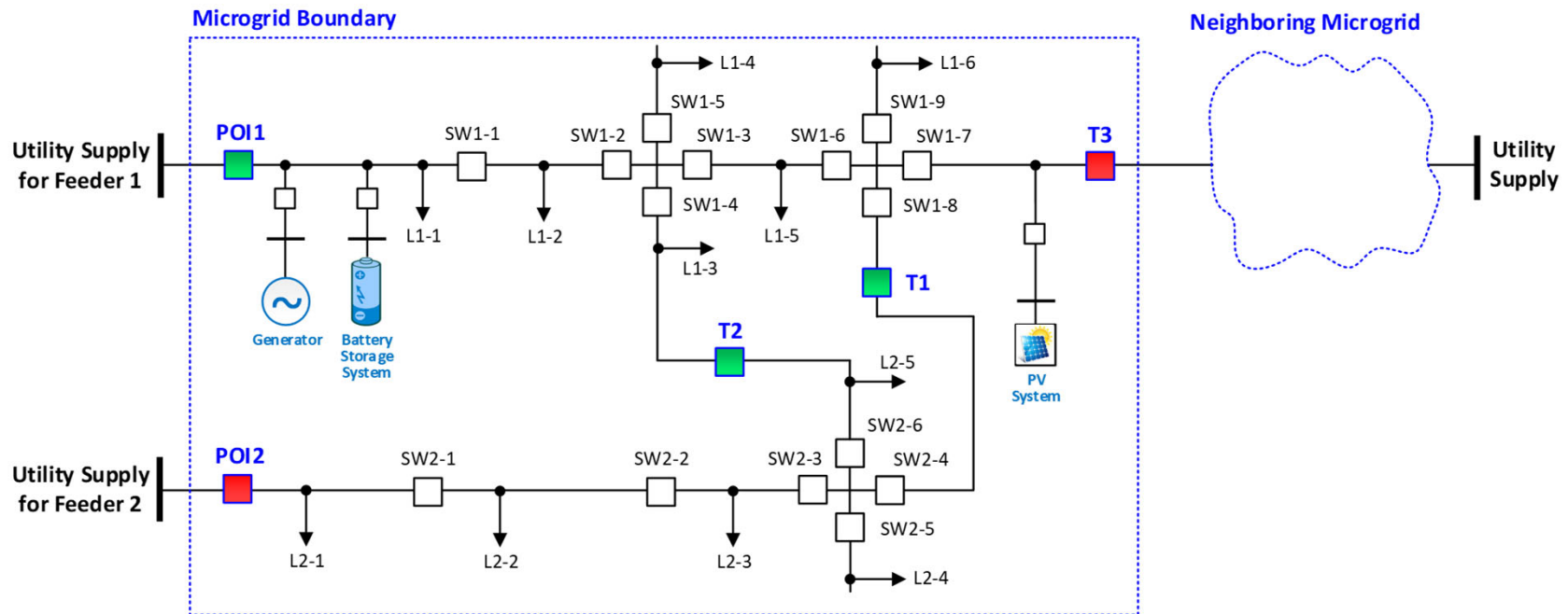
Partial Island



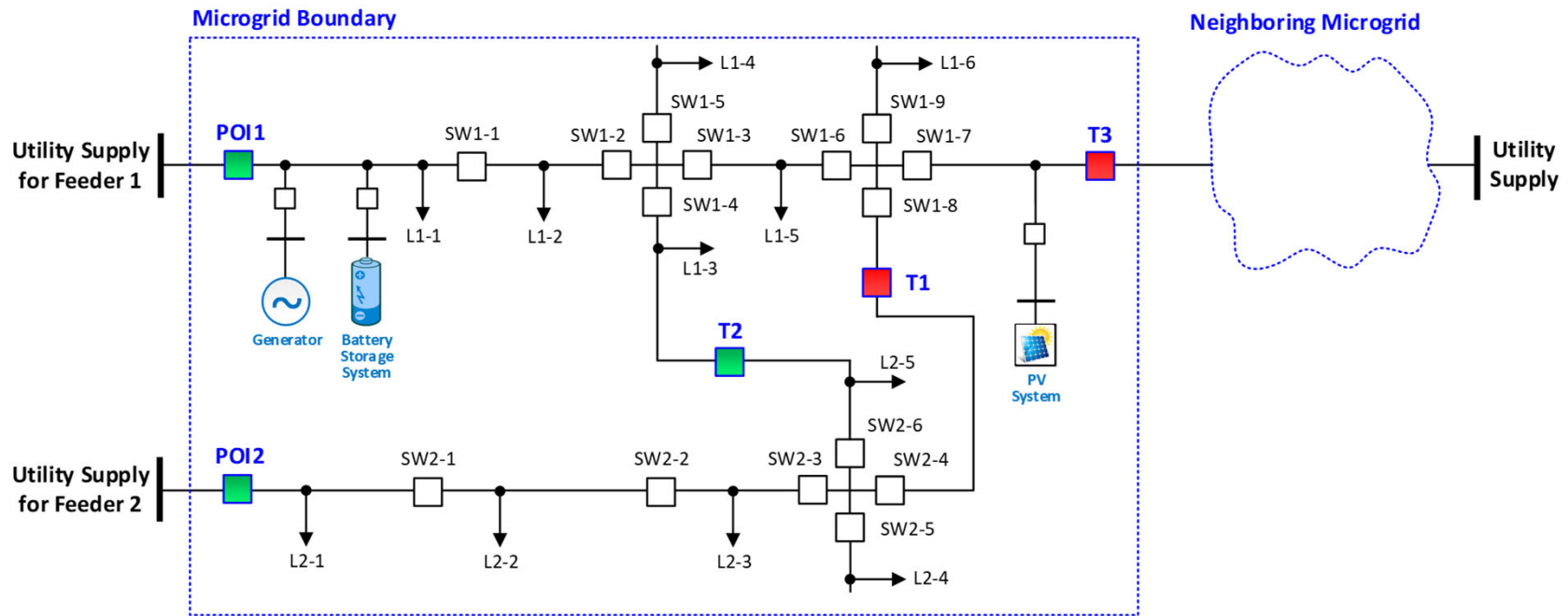
Full Island



Partial Cluster (Cluster 1)

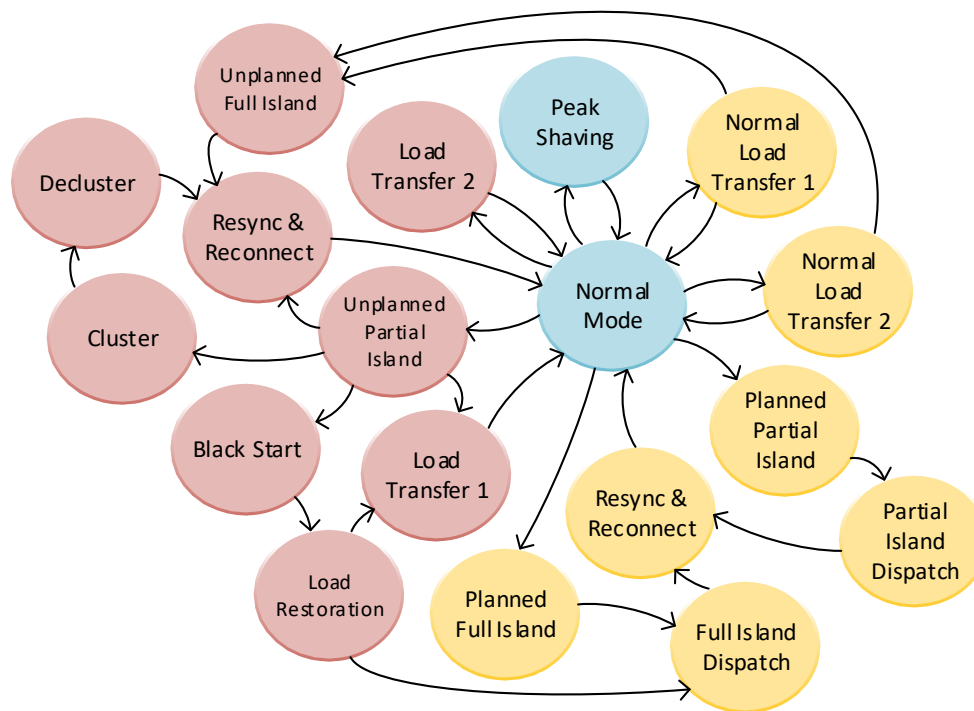


Full Cluster (Cluster 2)

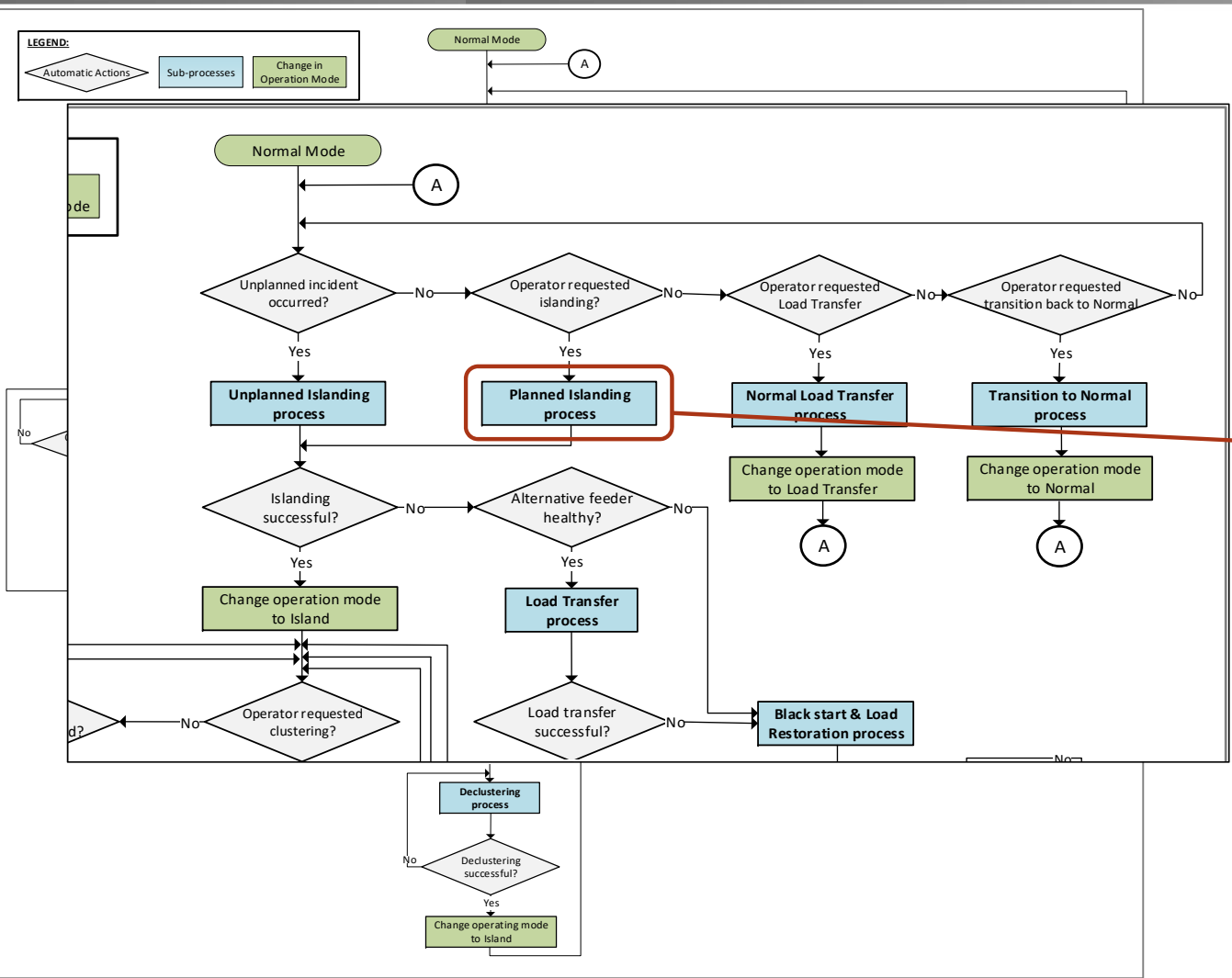


High-Level Diagram of Operating Modes

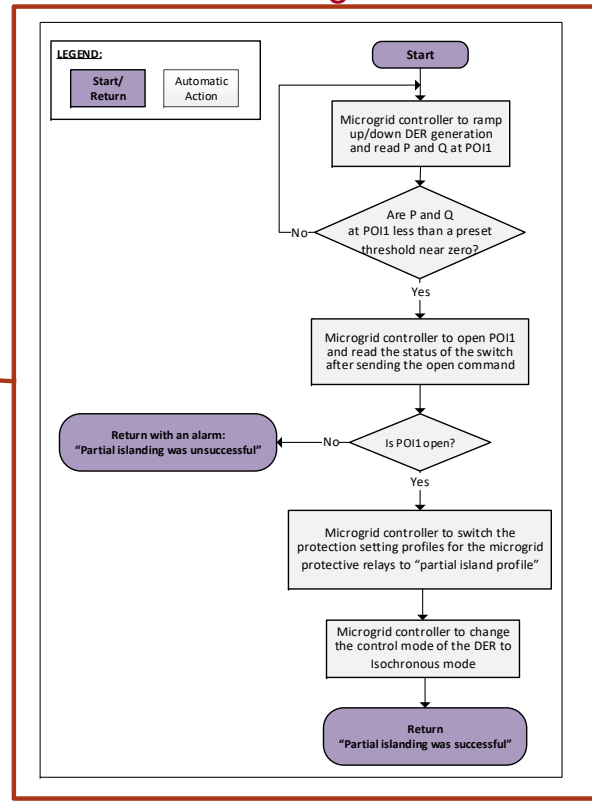
- Normal
- Load Transfer 1
- Load Transfer 2
- Partial Island
- Full Island
- Partial Cluster
- Full Cluster
- Blackstart and Restoration



Develop Process and Sub-process Flowchart



Planned Islanding Procedure



Conclusion

- Step by Step Methodology to develop SOO for utility-operated microgrids
- Determining Modes of operation feasible and planning for transition between different modes of operation
- Demonstrated how different modes are determined for a representative microgrid
- Presented the overall process flowchart and subprocess to show how microgrid controller will be designed and coordinated with microgrid assets such as DERs and DA devices



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