1 Description of the Use Case

1.1 Name of Use Case: DER Circuit Segment Management

Use Case Identification		
ID	***Domain(s)/ Zone(s)***	***Name of Use Case***
		Distributed Energy Resources (DER) Circuit Segment Management

1.2 Version Management

Version Management			
Version No.	***Date***	***Name of Author(s)***	***Changes***
1.0.0	20190430	UCA OpenFMB Users Group	Information Exchange section 5 moved to separate document
2.0.0	20210427	UCA OpenFMB Users Group	UML 2.0.0 model update

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	Management of a circuit segment with DER
Objective(s)	Manage DER impact on a layered circuit segment through local and interlayer layer coordination Harmonize DER operation with centralized systems
Related business case(s)	Solar Smoothing, Volt-VAr Management, Peak Demand, Anti-Islanding, Microgrid Unscheduled Islanding, Microgrid Reconnection, and Fault Location, Isolation, & Service Restoration (FLISR).

1.4 Narrative of Use Case

Narrative of Use Case

Short description

The business objective of this Distributed Energy Resources (DER) Circuit Segment Management use case is to actively coordinate circuit segment power system equipment to accommodate DER. The grid edge is moving from a hub-and-spoke control paradigm to devices with layered intelligence incrementally applied where it is most valuable. For a specific circuit segment, localized edge analytics combined with coordinated self-optimization, handle the increasing volume, velocity, and variety of information from an expanding number of heterogeneous devices. Local data exchange within layered circuit segments satisfies that segment's need for actionable decision in the field without a roundtrip to a central site. Multiple communications paths and observable interfaces enable interactions between devices and systems at all layer hierarchies. While complementing existing Supervisory Control and Data Acquisition (SCADA) systems, such as a Distribution Management System (DMS) or Energy Management System (EMS), this use case enables interoperability across all grid edge devices and systems to foster enhanced safety, reliability, resiliency, and security.

Building upon this foundational Open Field Message Bus (OpenFMB) use case, there are value-added use case extensions that include Solar Smoothing, Volt-VAr Management, Peak Demand, Anti-Islanding, Microgrid Unscheduled Islanding, Microgrid Reconnection, and Fault Location, Isolation, & Service Restoration (FLISR).

Complete description

Use Case Overview and OpenFMB Reference Implementation

The business objective of this foundational OpenFMB use case, DER Circuit Segment Management, is to quickly federate and actively coordinate power system equipment and DER within a layered circuit segment to maintain grid stability, while optimizing supply, demand, and resiliency. Figure 1 represents an example utility service provider's OpenFMB reference implementation that includes a circuit segment hierarchy with three layers. The Circuit Segment Service in each layer coordinates actors within its circuit segment and exchanges clearly defined message interface profiles to achieve business objective(s). Interconnection schedules are the coordination interfaces between upper and lower layers. Reserve profiles are also exchanged between upper and lower layers as well as neighboring layers.

In Figure 1, the circuit segment of primary interest is referenced as Feeder A (Layer 2). This circuit segment sits between an Upper Level circuit segment, referenced as a Substation (Layer 3), and a Lower Level circuit segment referenced as a Microgrid (Layer 1). Additionally, this circuit segment has a normally open tie point interconnection to a Neighboring circuit segment, referenced as Feeder B (also Layer 2).

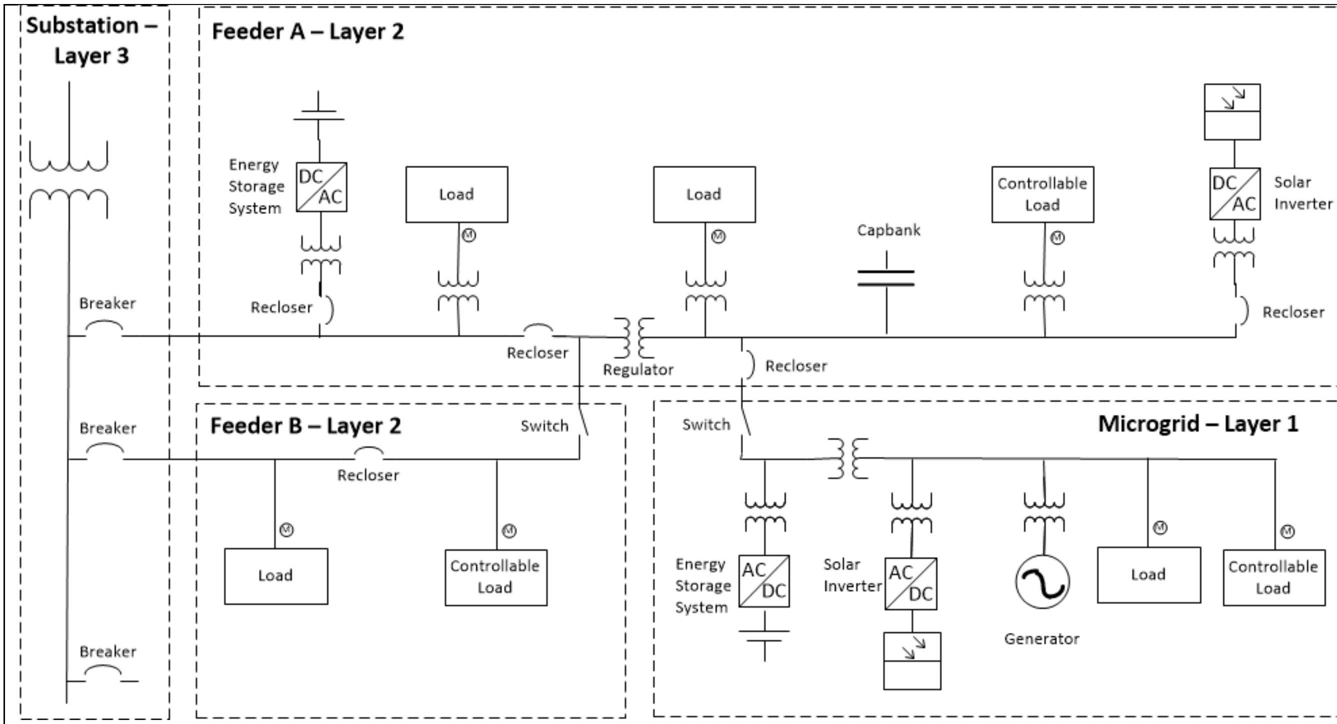


Figure 1: DER Circuit Segment Management Use Case Single Line Diagram

In Figure 1, the device actors in the circuit segment of primary interest, referenced as Feeder A (Layer 2), include a solar inverter, energy storage system (ESS), breaker, reclosers, regulator, cap bank, and loads. Complementing each device actor in that layer are OpenFMB nodes that interface to devices and communicate directly with other OpenFMB nodes within that layer as well as other OpenFMB nodes on adjacent layers. These OpenFMB nodes are responsible for exchanging peer-to-peer data and hosting the Circuit Segment Service actors that analyze and electrically manage each layer by developing four-quadrant real and reactive power schedules. Feeder A (Layer 2) coordinates with the adjacent Upper Level and Lower Level layers through the exchange of interconnection schedules. Additionally, Neighboring, Upper Level, and Lower Level layers share reserve request profiles (if applicable) and reserve availability profiles with Feeder A (Layer 2).

In Figure 1, the device actors in the Upper Level circuit segment, referenced as a Substation (Layer 3), include breakers and other bulk power system components. The substation operation may be directed by a SCADA system, such as a DMS or EMS. In such cases, an OpenFMB adapter, specific to the Upper Level Circuit Segment Service actor, is used to integrate and coordinate interconnection schedules, reserve request profiles (if applicable), and reserve availability profiles with those SCADA systems. Furthermore, the same substation in the Upper Level circuit segment also feeds the Neighboring circuit segment in Feeder B (Layer 2) which can act as reserve capacity for Feeder A (also Layer 2) and vice versa.

In Figure 1, the device actors in the Lower Level circuit segment, referenced as a Microgrid (Layer 1), include a switch, ESS, solar inverter, generator, and load(s). Complementing each device actor in that layer are OpenFMB nodes that interface to devices and communicate directly with other OpenFMB nodes within that layer as well as other OpenFMB nodes on adjacent layers. These OpenFMB nodes are responsible for exchanging peer-to-peer data and hosting the Circuit Segment Service actors that analyze and electrically manage and maintain each layer. The Microgrid (Layer 1) coordinates with the adjacent Upper Level Circuit Segment Service actor in Feeder A (Layer 2) through the exchange of interconnection schedules, reserve request profiles (if applicable), and reserve availability profiles. If the microgrid has a SCADA controller, then an OpenFMB adapter, specific to the Lower Level Circuit Segment Service actor, is used to integrate and coordinate interconnection schedules, reserve request profiles (if applicable), and reserve availability profiles with that microgrid controller.

The primary goal of each layer's Circuit Segment Service is to manage and maintain:

- Voltage and Power Factor constraints
- Frequency and Interconnection Schedules
- Current and Thermal limits

Operating Environment

The OpenFMB interoperability framework enables utility service providers to employ Distributed Intelligence capabilities for securely accessing and quickly federating grid edge field data between devices and systems. Since each utility service provider may have its own unique operating environment, the prevalence and capabilities of their existing devices along a given circuit segment can vary per deployment scenario. As a result, additional intelligent devices could be installed to enhance the operational performance and potential stacked benefits of OpenFMB use cases. A suggested security best practice is to isolate actor communications within a circuit segment and to only allow bridging of neighboring or adjacent circuit segment networks for exchanging interconnection schedules and reserve profiles.

Some considerations that influence the role that the Circuit Segment Service can play in a brownfield environment include whether:

- SCADA Systems (e.g. DMS, EMS, or microgrid controller) can be integrated and coordinated with an OpenFMB adapter
- Utility DER sites can be controlled and/or monitored by OpenFMB
- Customer DER sites can be controlled and/or monitored by OpenFMB
- Distribution Automation (DA) devices can be controlled and/or monitored by OpenFMB
- Controllable Loads and/or Meters can be controlled and/or monitored by OpenFMB
- Neighboring Circuit Segments can be integrated and coordinated with OpenFMB

General Information Flow

For a specific circuit segment layer, such as those shown in Figure 1, the general iterative flow of information is:

1. Actors on the circuit publish messages
    a. All Device(s) publish events, readings, and status
    b. Upper level Circuit Segment Service publishes requested interconnection schedule, reserve request (if applicable), and reserve availability
    c. Lower level Circuit Segment Service(s) publish planned interconnection schedules, reserve request (if applicable), and reserve availability.
    d. Neighboring Circuit Segment Service(s) publish to each other reserve request (if applicable) and reserve availability.
    e. Services (e.g. weather forecast, load forecast, markets, electrical state, electrical connectivity) publish status
2. The Circuit Segment Service subscribes to messages from relevant actors
    a. Device(s) events, readings, and status
    b. Upper level Circuit Segment Service requested interconnection schedule, reserve request (if applicable), and reserve availability
    c. Lower level Circuit Segment Service(s) planned interconnection schedules, reserve request (if applicable), and reserve availability.
    d. Neighboring Circuit Segment Service(s) reserve request (if applicable) and reserve availability.
    e. Services (e.g. weather forecast, load forecast, markets, electrical state, electrical connectivity) status
3. The Circuit Segment Service develops four-quadrant real and reactive power schedules for devices on its circuit segment and for adjacent Lower Level Circuit Segments. The Circuit Segment Service also calculates the aggregated reserve profiles for the Neighboring, Upper Level, and Lower Level Circuit Segment(s) reserve request (if applicable) and reserve availability.
4. If there are significant schedule changes, the Circuit Segment Service publishes updated messages
    a. Relevant Device(s) schedules
    b. Upper level Circuit Segment Service planned interconnection schedule, reserve request (if applicable), and reserve availability
    c. Lower level Circuit Segments Service(s) requested interconnection schedule(s), reserve request (if applicable), and reserve availability
    d. Neighboring Circuit Segment Service(s) reserve request (if applicable) and reserve availability.
5. Actors on the circuit subscribe to messages from the Circuit Segment Service
    a. Relevant Device(s) subscribe to and execute schedules
    b. Upper level Circuit Segment Service subscribes to planned interconnection schedule and incorporates it in its four-quadrant real and reactive power schedules. It also subscribes to and processes reserve request (if applicable) and reserve availability
    c. Lower level Circuit Segments Service(s) subscribe to requested interconnection schedules and incorporate them in their four-quadrant real and reactive power schedules. They also subscribe to and processes reserve request (if applicable) and reserve availability
    d. Neighboring Circuit Segment Services(s) subscribe to and processes reserve request (if applicable) and reserve availability

Circuit Segment Service

DER Circuit Segment Management is the foundational use case that ensures use case extensions like Solar Smoothing, Volt-VAr Management, and FLISR (among others) operate effectively. The Circuit Segment Service can be composed of sub-algorithms that orchestrate use case extensions, based on multiple objectives, devices, and priority. The Circuit Segment Service manages Voltage and Power Factor constraints, Frequency and Interconnection Schedules, and Current and Thermal limits for a given circuit segment for the coordination and control of actors like Distribution Automation (DA) devices and DER. The Circuit Segment Service also calculates the aggregated reserve profiles and handles circuit reconfiguration(s) during unplanned outages. The following other services enable and support the DER Circuit Segment Management use case:

Electrical State Service

The electrical state service mirrors and models the state of the electrical system, which is defined as the combined values of voltage magnitude, and phase angle. The electrical state service can either be a separate service actor or integrated within the Circuit Segment Service.

Electrical Connectivity Service

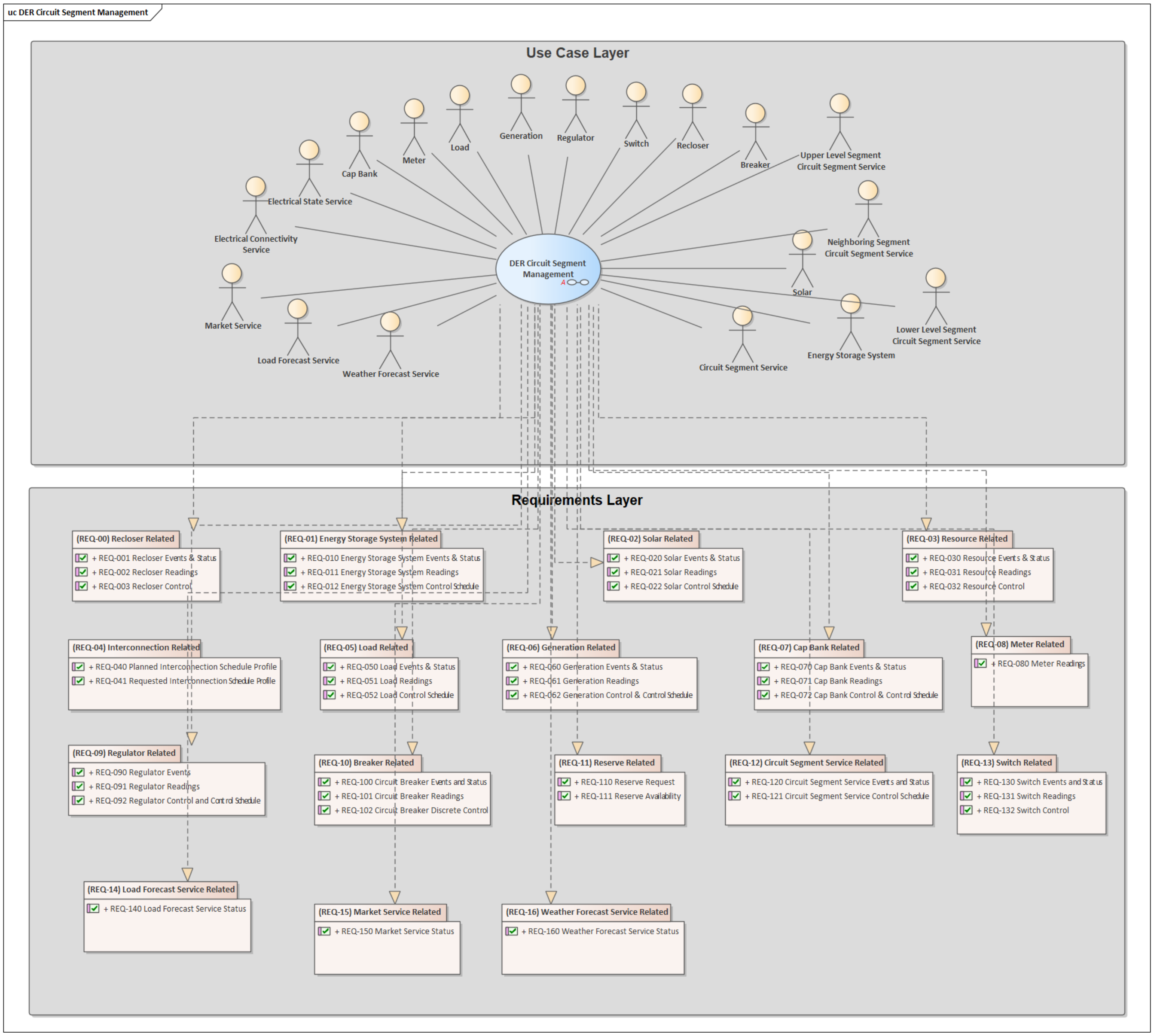
The Electrical Connectivity Service provides a grid connectivity model used by the utility service provider’s distribution operations often drawn from a static as-built Geospatial Information System (GIS) model. Additionally, it can be dynamically discovered at the grid edge via OpenFMB nodes determining near-real-time as-operated connectivity with their neighbors. The electrical connectivity service can either be a separate service actor or integrated within the Circuit Segment Service.

Markets Service The Market Service provides market pricing information, such as Locational Marginal Prices (LMPs). *Load Forecast Service* The Load Forecast Service provides a forecast of anticipated load, for both controllable and uncontrollable loads (as available), on a specific circuit segment. *Weather Forecast Service* The Weather Forecast Service provides short-term (minutes) and mid-term (hours to one-day) weather forecasts for temperature, pressure, air speed, and fire risk. Certain use case extensions may require specific weather forecast services for day-ahead or alternative term forecasts. The Weather Forecast Service also interfaces directly with auxiliary devices, such as weather sensors or sky cameras.

1.5 General Remarks

General Remarks
Not Applicable

2 Diagrams of Use Case

Diagram(s) of Use Case
 Figure 2: DER Circuit Segment Management Use Case

3 Technical Details

3.1 Actors

Actors			
Grouping *(e.g. domains, zones)*		***Group Description***	
Actor Name *see Actor List*	***Actor Type*** *see Actor List*	***Actor Description*** *see Actor List*	***Further info***
Devices			
Cap Bank	Device	Group of several capacitors interconnected in parallel or in series to improve power factor on electric distribution circuits by reactive power compensation. This will lower the losses on electric feeders.	
Breaker	Device	Automatic switch, also known as a circuit breaker, on a distribution system to stop overloads or shorts on a circuit.	
Energy Storage System (ESS)	Device	Group of devices that operate together to manage charging and discharging of energy storage. Commonly includes power control system inverter / rectifier, battery management system, and a plant controller.	
Generation	Device	Device producing electrical power.	
Load	Device	Electrical components whose power consumption may or may not be under the control of the entity of concern.	
Meter	Device	Electrical measuring device.	
Recloser	Device	A switch which can automatically disconnect and reconnect a portion of a circuit.	
Solar Inverter	Device	Group of devices that manage AC power conversion from photovoltaic panels. Commonly includes power control system inverter and may also include a plant controller.	
Switch	Device	A switch which can be operated.	
Regulator	Device	Device with adjustable voltage output also known as a voltage regulator.	
Services			
Circuit Segment Service	Service	A service electrically balancing a circuit segment. for circuit segment management. This service may have adjacent instances, such as Upper Level and Lower Level, as well as Neighboring instances.	
Electrical Connectivity Service	Service	A service providing as built and dynamic connectivity models.	
Electrical State Service	Service	A service providing voltage magnitude and phase angle at circuit segment locations.	
Load Forecast Service	Service	A service providing load forecasts drawing upon historical load information and forecast conditions.	
Market Service	Service	A service providing market prices such as Local Marginal Price (LMP)	
Weather Forecast Service	Service	A service providing short and medium term weather forecast that may draw upon information from local sensors or a sky camera.	

3.2 Triggering Event, Preconditions, Assumptions

Use Case Conditions			
Actor/System/Information/Contract	***Triggering Event***	***Pre-conditions***	***Assumption***
Circuit Segment Service		Circuit Segment Service operating	
Devices	Devices publish readings, status, events	Devices operating	
Upper Level Circuit Segment Service		Upper Level Circuit Segment Service operating	
Lower Level Circuit Segment Service		Lower Level Circuit Segment Service operating	

3.3 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on Use Case**	**Originator / Organisation**	**Link**
1	IEC	62559-2		Utilized use case narrative template	Omnetric, Jim Waight	
2	ORNL	ORNL microgrid use cases		Similar to current use case	Oakridge National Laboratory, Tennessee	
3	PNNL	Modern Distribution Grid Volume I starting with the discussion at the bottom of page 28 regarding Figure 5		Laminar Architecture	Jeffrey D. Taft Pacific Northwest National Laboratory, Washington	https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-I_v1_1.pdf

3.4 Further Information to the Use Case for Classification / Mapping

Classification Information
Relation to Other Use Cases
Use case extensions include Solar Smoothing, Volt-VAr Management, Peak Demand, Anti-Islanding, Microgrid Unscheduled Islanding, Microgrid Reconnection, and Fault Location, Isolation, & Service Restoration (FLISR).
Level of Depth
Mid level
Prioritization
High
Generic, Regional or National Relation
Will be applied in a generic test at Duke test bed.
Viewpoint
Technical
Further Keywords for Classification

4 Step by Step Analysis of Use Case

4.1 Steps – Scenario Name

Scenario Conditions					
No.	**Scenario Name**	**Primary Actor**	**Triggering Event**	**Pre-Condition**	**Post-Condition**
Primary					
1	DER Circuit Segment Management	Circuit Segment Service	Devices publish readings, status, and events	Circuit Segment Service and devices operating	Devices executing respective schedules

4.2 Steps – Scenarios

4.2.1 Steps – DER Circuit Segment Management

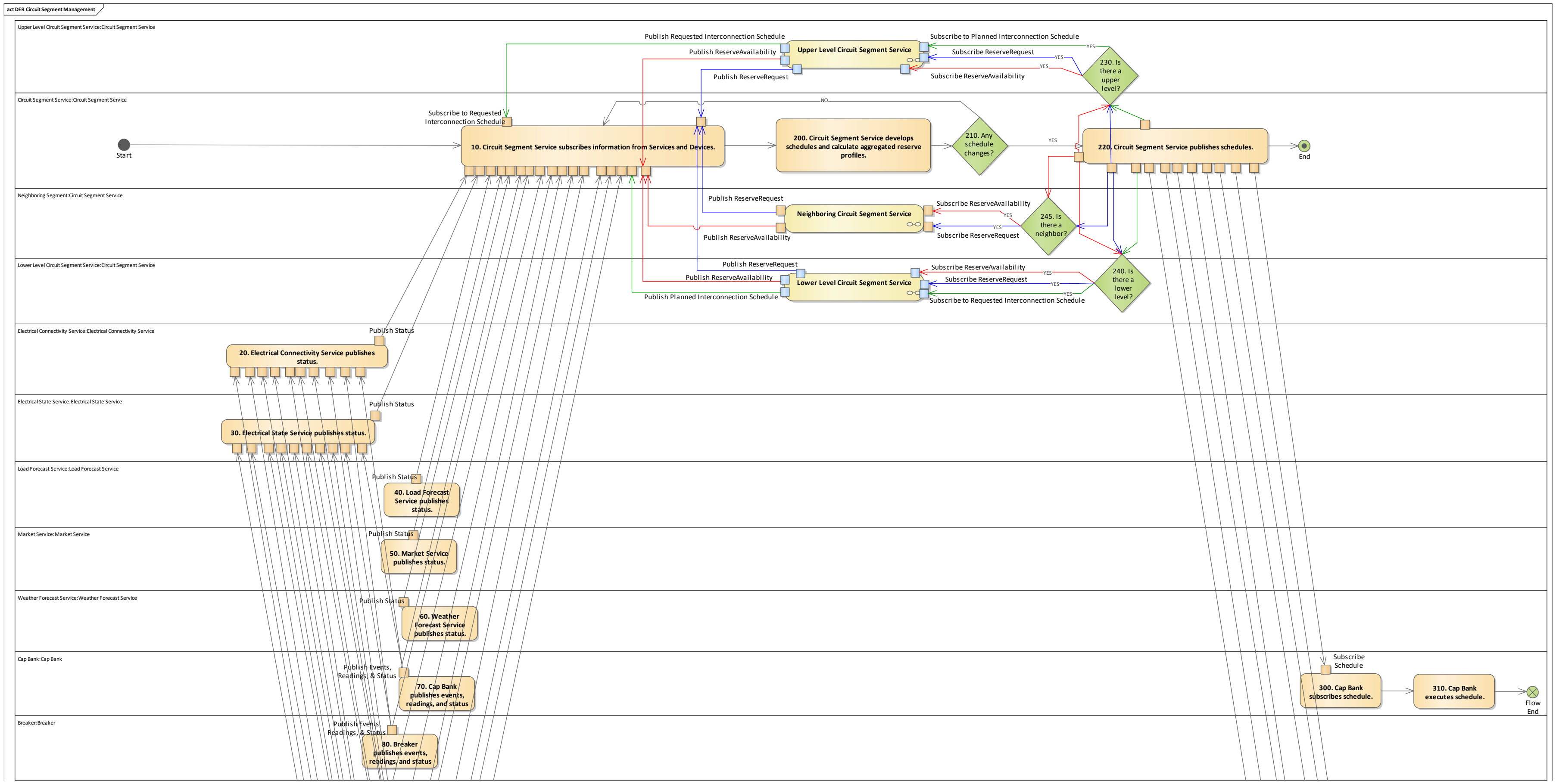


Figure 3: DER Circuit Segment Management Activity Diagram (Part 1)

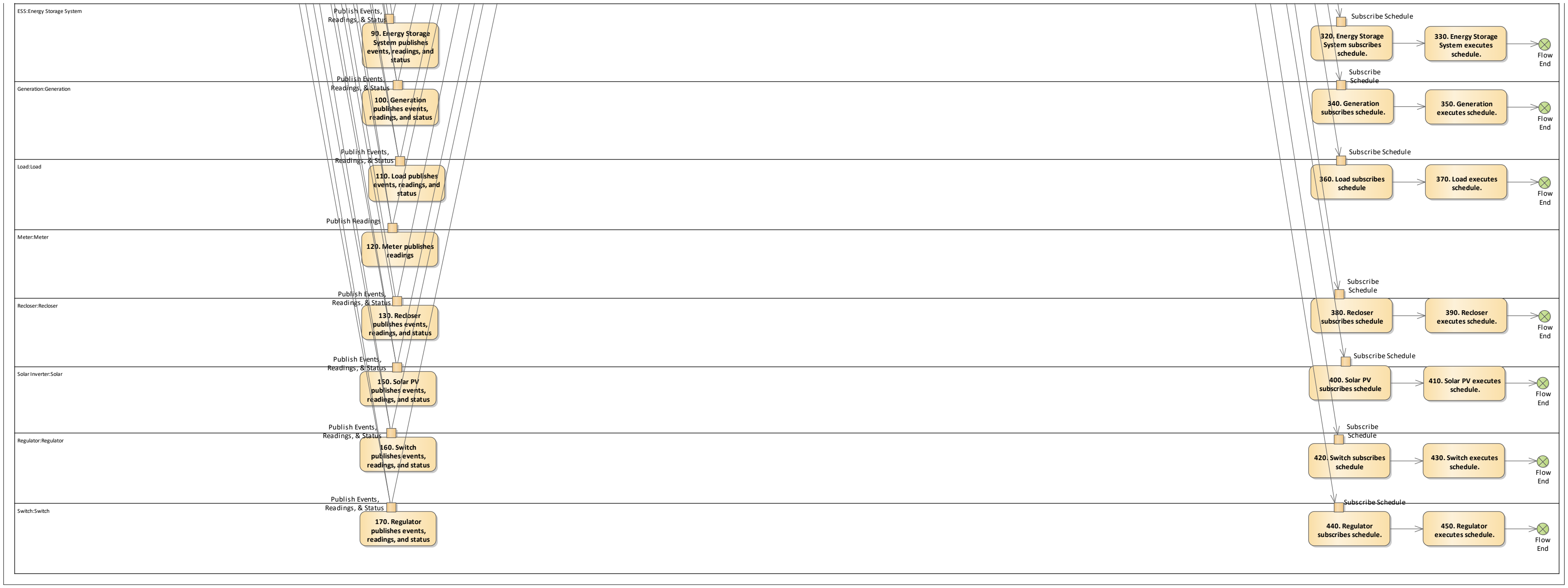


Figure 4: DER Circuit Segment Management Activity Diagram (Part 2)

5 Information Exchanged

See OpenFMB Information Exchanged supplementary document.

6 Requirements (optional)

Requirements (optional)	
Categories for Requirements	**Category Description**
NA	
Requirement ID	**Requirement Description**
NA	

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
NA	

8 Custom Information (optional)

Custom Information (optional)		
Key	***Value***	***Refers to Section***
NA		