Microgrid Protection

Version 1.2

March 11, 2014

1   Descriptions of Function

1.1   Function Name

Microgrid Blackstart

1.2   Function ID

Microgrid Functional Use Case #F-9

1.3   Brief Description

This is the function where a microgrid restores islanded operation after a complete shutdown.

MICROGRID FUNCTIONAL USE CASES

This is one of ten (10) use cases related to control and operations between the area Electric Power System (AEPS) and Advanced Microgrids in connected, transition and islanded modes. Microgrid operations and control is described in terms of functions.

The Functional Use Cases for Control and Operations of Advanced Microgrids are

1. Frequency control

2. Voltage control (grid-connected & islanding)

3. Grid-connected to islanding transition - Intentional

4. Grid-connected to islanding transition – Unintentional

5. Islanding to grid-connected transition

6. Energy management (grid-connected & islanding)

7. Protection

8. Ancillary services (Grid-connected)

9. Black start

10. User interface and data management

1.4 Narrative

During a blackstart procedure, a microgrid is restored to islanded operation mode after a complete shutdown. The restoration process involves the microgrid central controller (microgrid EMS and microgrid SCADA), multiple resources, loads, and switchgear. Based on the system topology, capacities and sizes of the resources and loads, and the controllability of the devices, the blackstart procedure can be pre-determined and implemented in the microgrid central controller and other devices. The execution of the blackstart can be automatic with minimal operator involvement.

First a primary source will be restored with loads matching generation capacity. The primary source is able to control voltage and frequency and form an islanded microgrid. Other resources and loads are added on following a pre-determined order with specified real and reactive power generation/consumption. After the whole microgrid is completely restored, it will be operated in the normal islanded mode. At this point it can be determined whether the microgrid will resynchronize and reconnect to the main grid or remain in islanded operational mode.

Microgrid SCADA executes the pre-implemented blackstart procedure by first checking if the microgrid switch is open or not to ensure that the microgrid is completely disconnected from the main grid. If not, a command will be sent to the microgrid switch controller to open the switch. The next step is to open switchgear to isolate the primary source and match loads from the rest of the microgrid. The primary source starts operation by feeding loads and controlling frequency and voltage in specified ranges. When an islanded microgrid is formed, other resources and loads will be brought to the microgrid following the pre-determined order and the devices operating procedures.

1.5 Actor (Stakeholder) Roles

Grouping (Community) '		Group Description

Actor Name Actor* - This use case.	Actor Type (person, organization, device, system, or subsystem)	Actor Description
Area Electric Power System (AEPS) *	System	The electrical power system that normally supplies the microgrid through their point of common coupling.
Area Natural Gas Supply (ANGS)	System	The natural gas pipeline system that supplies natural gas to the microgrid.
Asset Switches (ASw)	Device	The ASw has the capability to disconnect assets within the microgrid (e.g. NCL) from the microgrid for control purposes. The ASw can receive control signals from the MC and can inform the MC of its status.
Centralized Protection Controller (CPC)	System	This is a central control that is able to communicate with protective devices. It can operate to update settings, or coordinate the operation of protection in real time. This can be a standalone function, or it could be a part of the MCC.
Critical Load (CL) *	Device	Loads within the microgrid having the highest priority of service. These loads will be served at the expense of all other loads in the microgrid and at the expense of any other service the microgrid could provide. The priority of loads within the critical loads is not distinguished.
Market Operator (MO)	System	The MO accepts bids from assets, such as a MG, in its AEPS and dispatches these assets to provide energy and ancillary services to ensure reliability for the AEPS. The MO may be part of the AEPS or may be a separate entity.
Microgrid controller (MC)	System	A control system that is able to dispatch the microgrid assets, e.g. opening/closing switches, changing control reference points, changing generation/consumption levels, etc. Other than the microgrid functions specifically referenced below, this Use Case does not specify the objective of any of the microgrid controller functions. This Use Case does not specify how the control signals are transferred or implemented in the microgrid assets.

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Grouping (Community) '		Group Description

Actor Name Actor* - This use case.	Actor Type (person, organization, device, system, or subsystem)	Actor Description
Microgrid EMS	System	Energy management system for a microgrid. It is the interface to participate in energy market and interact with market operator. It manages the sources and loads in the microgrid, dispatches optimized operational commands to meet economic objectives while the system stability constraints are met.
Microgrid SCADA *	System	The communication and data acquisition of the microgrid controller. It collects real-time data from each individual microgrid actor, passes the data to the microgrid EMS for the calculation of economic dispatch, receives the economic dispatch commands from the microgrid EMS, and distributes them to the microgrid actors. It also controls and coordinates the sources and loads to maintain system stability.
Microgrid Switch (MS)*	Device	A switch at the point of common coupling of the microgrid and the AEPS. The switch has the capability to detect the loss of power from the AEPS and disturbances in the AEPS. The MS can open and close automatically and on command from the MC and can inform the MC of its status.
Non-Critical Load (NCL)*	Device	Loads within the microgrid having the lowest priority of service. These loads may be left unserved in favor of Critical Loads. The priority of loads within the critical loads is not distinguished.
Other Resource (OR)*	Device	All energy resources in the microgrid except for the primary resources. OR could be a generator, energy storage system, or a load.
Point of Common Coupling (PCC)		The electrical interface between the AEPS and the microgrid.
Primary Resource (PR)*	Device	The energy resources responsible for frequency and voltage regulation. PRs could be a generator, an energy storage system, or controllable load.

Grouping (Community) '		Group Description
Actor Name Actor* - This use case.	Actor Type (person, organization, device, system, or subsystem)	Actor Description
Protection device (PD, w-com) (with communications)	Device	This is a relay type device that is able to interrupt fault current and communicates with other devices or the MCC. An example would be a protective relay that has communication with the MCC.
Protection device (PD, w/o-com) (without communications)	Device	This is a relay type device that is able to interrupt fault current and operates in isolation. Examples include relays without the ability to communication, and fuses.
Protection relay (PR)	Device	The device to detect and clear a fault.
Switching device (SD, w-com) (with communications)	Device	This is a switching device that communicates with other devices or the MCC/CPC.
Switching device (SD, w/o-com) (without communications)	Device	This is a switching device that does not communicate with other devices or the MCC/CPC.

1.6   Information exchanged

Information Object Name	Information Object Description
APS status	Microgrid switch detects that area power system is in normal operation and sends a signal to microgrid SCADA indicating the status.
Microgrid status	Information sent by microgrid SCADA to area power system indicating the operation status of the microgrid.

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Information Object Name	Information Object Description
Microgrid switch open command	A signal sent by microgrid SCADA to microgrid switch to open the microgrid switch before the blackstart starts. It ensures that the microgrid is disconnected from any other external circuit.
Microgrid switch status	A signal sent by microgrid switch indicating the status of the microgrid switch.
Blackstart request	A signal sent from microgrid SCADA to area power system requesting permission for blackstart.
Response to blackstart request	The response of area power system to the blackstart request. It can be yes (allow blackstart) or no (not allow).
Blackstart initialization commands	Commands sent by microgrid SCADA to all microgrid actors to set up the system for blackstart, including proper system configuration to ensure power capacity matching between sources and loads at each step.
Confirmation of blackstart initialization	A signal sent by microgrid actors to microgrid SCADA indicating that the initialization is completed.
Start primary source command	A signal sent by microgrid SCADA to primary source to start energizing the microgrid by starting the primary source with proper load levels.
Confirmation of primary source start	A signal sent by primary source to microgrid SCADA indicating that the primary source is started and a microgrid is formed.
Start other sources and loads commands	Following pre-determined procedures, microgrid SCADA send operation signals to other sources and loads to restore the operation of the entire microgrid.
Confirmation of the start of other sources and loads	A signal sent by each source or load to microgrid SCADA indicating the start of the actor.
Islanded operation dispatch	Dispatch commands sent by microgrid EMS to microgrid SCADA for economic dispatch in islanded mode.

Information Object Name	Information Object Description
Islanded operation status	Information on microgrid islanded operation sent by microgrid SCADA to area power system.

1.7   Activities/Services

Activity/Service Name	Activities/Services Provided
Critical Load Service	The microgrid will provide electrical power service to all critical loads.

1.8   Contracts/Regulations

Contract/Regulation	Impact of Contract/Regulation on Function
IEEE Std. 1547 Series	Standard for Interconnection to the area EPS at the PCC
Interconnection Agreement	Typical Provisions include: Construction, Interconnection, Operations, Safety & Maintenance, Access, Exterior AC Disconnect Switch / Isolation Device, Conflicts in Agreements, Disconnection, Customer Generator Billing & Payment, Insurance, Customer-Generator Indemnification, Limitation of Liability, Termination, Permanent Disconnection, Survival Rights, Assignment/Transfer of Ownership of the Customer-Generator Facility

Contract/Regulation	Impact of Contract/Regulation on Function
Public Utility Net Metering Regulations	As applicable, where the microgrid exports to area EPS
ISO Market Rules	As applicable, where the microgrid participates in markets

Policy	From Actor	May	Shall Not	Shall	Description (verb)	To Actor
Obligation to serve	Area Electric Power System (AEPS)			X	Provide power on demand at PCC	Microgrid Operator

Constraint	Type	Description	Applies to

2   Step by Step Analysis of Function

2.1 Steps to implement function – Name of Sequence

2.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	Preconditions or Assumptions

2.1.2 Steps – Name of Sequence

NOTE:

The step-by-step table and bubble diagram also show the operations before and after the intentional islanding transition.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
#	*Triggering event? Identify the name of the event.[1]*	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*
0.0	Check microgrid switch status and send open command	Microgrid SCADA			Microgrid SCADA	Microgrid switch	Microgrid switch open command	

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[1] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

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#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
0.1	Confirm microgrid status	Microgrid switch			Microgrid switch	Microgrid SCADA	Microgrid switch status	
0.2	Send blackstart request	Microgrid SCADA			Microgrid SCADA	Area power system	Blackstart request	
0.3	Respond to blackstart request	Area power system			Area power system	Microgrid SCADA	Response to blackstart request	
1.0	Start blackstart procedure	Microgrid SCADA						
1.1	Send blackstart initialization commands	Microgrid SCADA			Microgrid SCADA	Primary sources, other sources, and loads	Blackstart initialization commands	
1.2	Execute blackstart initialization commands	Primary sources, other sources, and loads						
1.3	Confirm initialization execution	Primary sources, other sources, and loads			Primary sources, other sources, and loads	Microgrid SCADA	Confirmation of blackstart initialization	

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#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1.4	Start primary source and matching load 1	Microgrid SCADA			Microgrid SCADA	Primary source, load 1	Start primary source command	
1.5	Execute primary source start	Primary source						
1.6	Confirm the start of primary source	Primary source			Primary source	Microgrid SCADA	Confirmation of primary source start	
1.7	Start other sources and loads according to the order in the pre-determined procedure	Microgrid SCADA			Microgrid SCADA	Other sources and loads	Start other sources and loads commands	
1.8	Execute the start of other sources and loads	Other sources and loads						
1.9	Confirm the start of other sources and loads	Other sources and loads			Other sources and loads	Microgrid SCADA	Confirmation of the start of other sources and loads	
2.0	Start islanded operation	Microgrid SCADA			Microgrid SCADA	Microgrid EMS	Start islanded operation	

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#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
2.1	Islanded operation dispatch	Microgrid EMS			Microgrid EMS	Microgrid SCADA	Islanded operation dispatch	
2.2	Send islanded operation status	Microgrid SCADA			Microgrid SCADA	Area power system	Islanded operation status	

2.1.3 Post-conditions and Significant Results

Describe conditions that must exist at the conclusion of the Function. Identify significant items similar to that in the preconditions section.

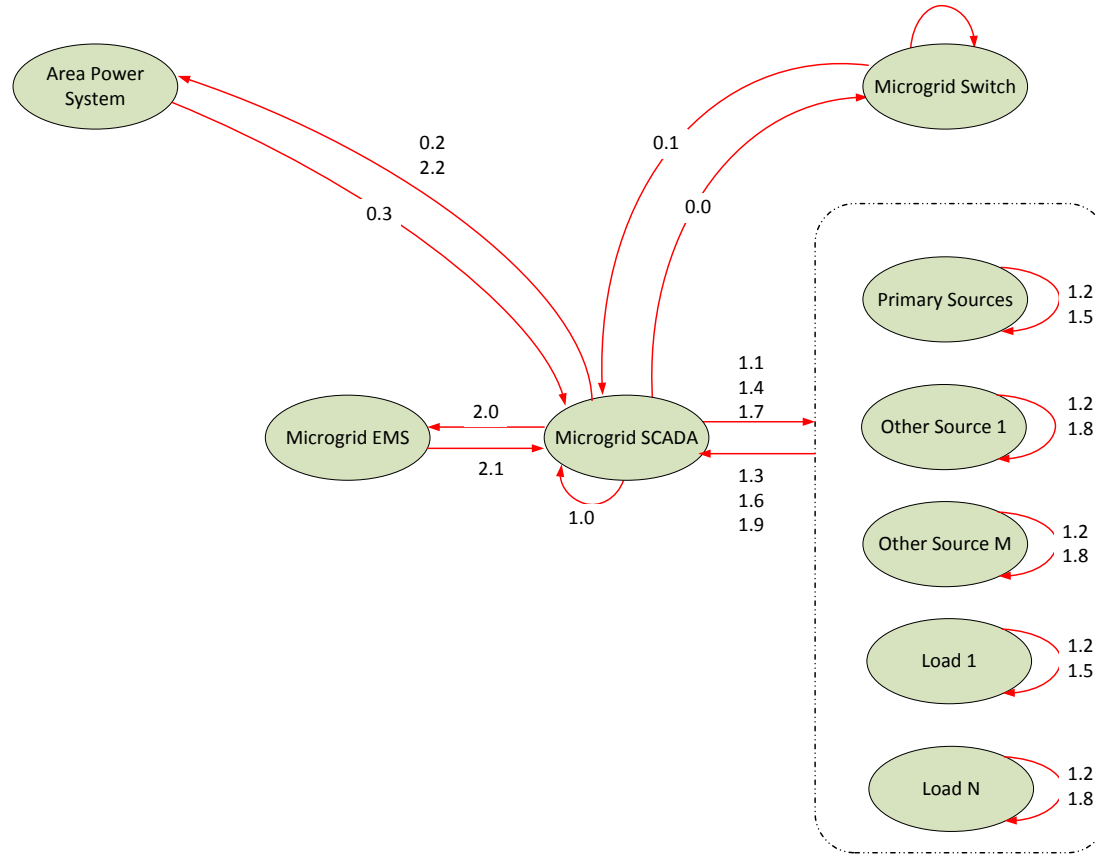| Actor/Activity	Post-conditions Description and Results

2.2 Architectural Issues in Interactions

FUTURE USE

2.3   *Diagram*

3   Auxiliary Issues

3.1   References and contacts

ID	Title or contact	Reference or contact information
[1]		
[2]		

3.2   Action Item List

ID	Description	Status
[1]		
[2]		

3.3   Revision History

No	Date	Author	Description
1.0	27 Feb14	Y. Xu	Initial use case
1.1	10 Mar 14	J. Reilly	1.3 (insert), 1.7, 1.8
1.2	11 Mar 14	Y. Xu	1.6 Information Exchanged