1 Description of the Use Case

1.1 Name of Use Case: Microgrid- Optimization

Use Case Identification		
ID	***Domain(s)/ Zone(s)***	***Name of Use Case***
001	SGIP	Microgrid - Optimization

1.2 Version Management

Version Management				
Version No.	***Date***	***Name of Author(s)***	***Changes***	***Approval Status***
V001	2015-04-20	D.Bradley, S.Laval, D.Lawrence		draft
V002	2015-04-27	M. Joe Zhou		Draft review
V003	2015-05-29	J Waight		Revised draft with SGIP comments
V004	2015-06-17	J. Waight	Changes from review meeting on June 11 (references to EPRI Common Functions for Smart Inverters, consistent use of Microgrid SCADA	Final
V005	2015-09-28	S.Laval	Updates diagrams based on UML	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	Microgrid - Optimization
Objective(s)	Microgrid optimizer manages resources to follow optimization schedules that are generated either internally or from an external source such as utility DMS that controls the overall grid to which the micro grid is connected.
Related business case(s)	Microgrid - Islanded to Grid Connected Transition, Microgrid - Unintentional Islanding Transition

1.4 Narrative of Use Case

Narrative of Use Case
Short description
Microgrid optimization refers to creating optimal resource schedules, and updating and following these schedules when the micro grid is connect to a larger grid or when it is islanded. Note that the schedules for each state (connected or islanded) will be different. When the energy resources within the microgrid involve renewables such as wind and solar, a significant factor to drive the schedules will be the weather forecast. Other significant factors for microgrid schedules will be utility grid optimization requirements including that of demand response. While this use cases describes the interaction between Microgrid Optimizer and microgrid resources, the same architecture and processes can support more of a hierarchical control scheme, including a utility DMS.
Complete description
This use case deals with normal state daily operations of a microgrid, both grid connected and islanded. When grid connected, an initial set of interchange schedules is set up for the next operating day. When islanded, these interchange schedules are set to zero. Throughout the operating day, resource schedules are updated for the remainder of the operating day. When islanded, resource schedules, only, are considered as optimization variables. When the microgrid is connected to the main grid, flows to the external grid (interchange schedules) are considered to be fixed constraints in the next k intervals, and optimization variables in the following j intervals, with k, and j as selectable parameters. There are two parts to this use case: Day-Ahead and Intra-day. Within each part there are options. Day-Ahead Scheduling Several steps are followed: 1. Loads are forecasted for the day-ahead using load forecasting. 2. Renewable power resource (solar, wind) schedules for the day-ahed are forecasted, using renewable power forecasting. 3. Microgrid Optimizer optimizes the day-ahead plan and comes up with planned schedules for flows on

the connection to the grid, and microgrid resource operating schedules for each interval of the day-ahead.

4. Microgrid Optimizer sends the optimal interchange schedule to its higer level controller (utility control center / DMS) or alternatively, go to 4a

   4a Microgrid higher level controller (a utility DMS, for example) publishes its required day ahead interchange schedule (in the case of demand response events, for example) to Microgrid Optimizer

   3b Microgrid optimizer updates other resource schedules to follow interchange schedule received for day ahead

Intra-day Dispatching and Scheduling

1. Loads are forecasted for the remainder of the day using load forecasting
2. Renewable Power (solar, wind) schedules are forecasted for the remainder of the operating day, using renewable power forecasting
3. Microgrid Optimizer optimizes the remainder of the operating day and adjusts planned schedules for flows on the connection to the grid, and resource operating schedules for the remander of the operating day or alternatively go to 3a
4. Microgrid Optimizer sends schedules to its higer level controller (utility control center / DMS)

   3a. Microgrid higher level controller (a utility DMS, for example) publishes an updated required interchange schedule (in the case of demand response events, for example) to Microgrid Optimizer
   3b Throughout operating day, the microgrid optimizer updates the resource schedules for the remainder of the operating day to accommodate the updated interchange scheudle.

Microgrid Optimizer also has the following controls:
Selectable Constraints:
1) No power export
2) No power imported at Peak
3) Integrate weather forecasting
4) Net zero mode (over 1 day)
Modes:
1) Maximize renewable, green mode (produce all you can from DR)
2) Best economy TOU, understand least cost power
3) Blended objective function, e.g. 50 / 50
The SGIP demo will focus on the options within this use case, where the interchange schedule is determined by the Microgrid Optimizer.

1.5 General Remarks

General Remarks
Not Applicable

2 Diagrams of Use Case

Diagram(s) of Use Case

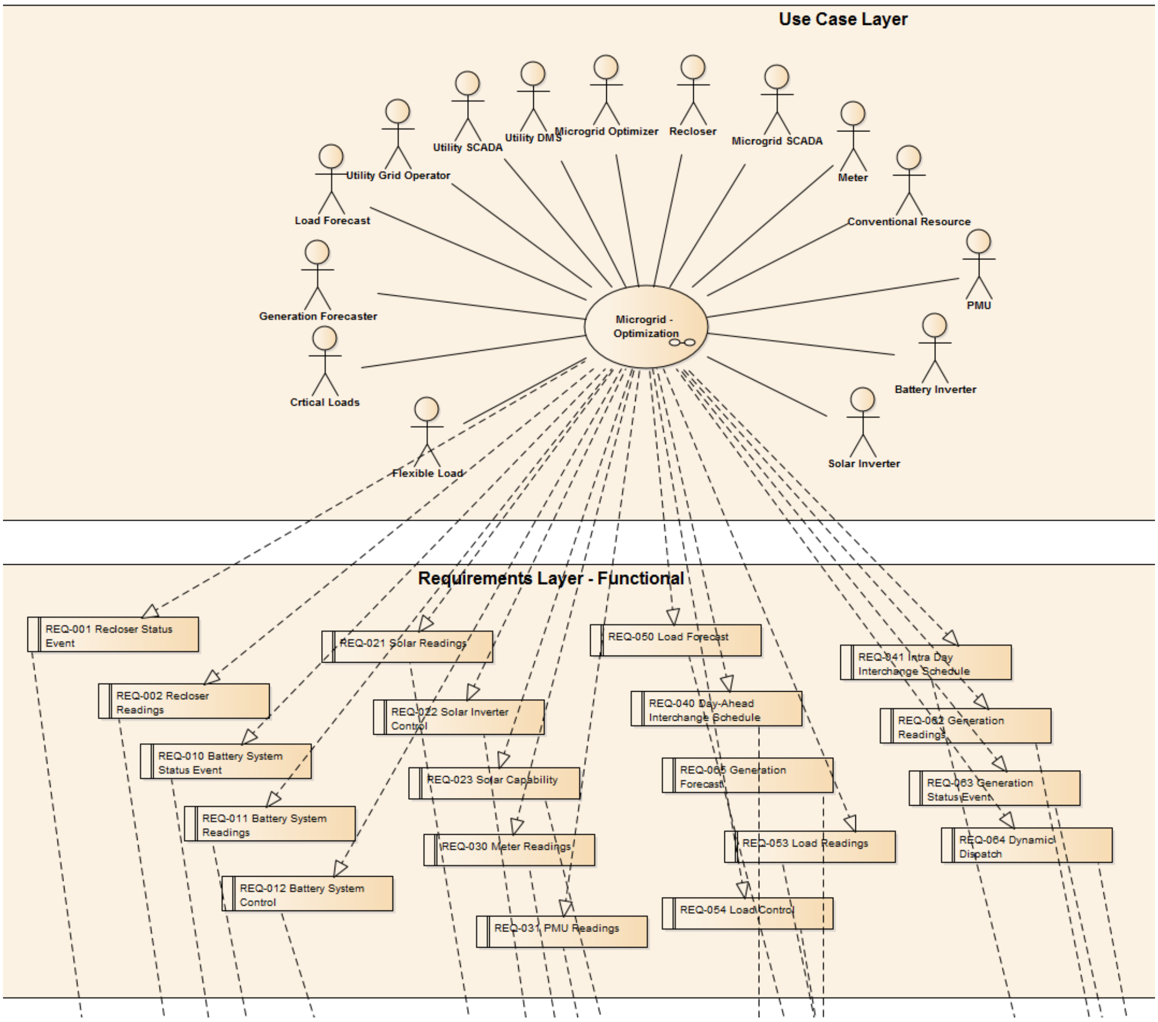

Figure 1 Use Case for Grid Connected or Islanded Operation

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***
Operator	person	Operator of the Microgrid. This actor is optional, as the system is autonomous and runs continuously.	
UtilitySCADA	System, application	SCADA applications including data acquisition, supervisory control, and user interface, and alarming.	
Utility DMS	System, application	System that manages and control the utility distribution grid that microgrids are connected to. Used by the utility distribution dispatcher or operator.	
Microgrid SCADA	System	Microgrid SCADA, gathers data from OFMB. Includes user interface, supervisory control, and alarming of resources within the Microgrid. Used by the operator of Microgrid	
Microgrid Optimizer	System, application	Application which optimizes the resources included in the microgrid. Optimization is done using a constrained dynamic dispatch.	
Recloser	device	This is the Point of Connection (common	

		coupling) to the grid. Indicates whether microgrid is in Normal or Islanded mode of operation.	
Meter	device	Measuring device for Microgrid electrical measurements.	
PMU	device	Highly accurate measuring device for Microgrid electrical measure, time tags, and frequency synchronization.	
Battery Inverter	device	Inverter that connects battery to the microgrid. Assumed to be capable of operation as a rectifier. Controllable up in range zero to current maximum capability of solar panel.	
Solar Inverter	device	Inverter that connects solar panel to the microgrid. Controllable up in range zero to current maximum capability of solar panel.	
Flexible Load	device	Controllable load to simulate Critical customer loads; both shedable and non-schedable components.	
Forecasting	System, Application	Microgrid forecasting includes load forecasting and forecasting of generation (available capability) from renewable resources. Uses forecast weather in short term: temperature, humidity, illumination as input data..	
Conventional Resource	device	Conventional resource in this context is usually a small diesel generation unit or microturbine. May not be present in every Microgrid.	
Crtical Loads	device	Loads that are classed as critical. These loads do not participate in the optimization, and hence may not be managed. The goal of the microgrid is to keep these loads supplied up to the service level agreement.	

3.2 Triggering Event, Preconditions, Assumptions

Use Case Conditions			
Actor/System/Information/Contract	***Triggering Event***	***Pre-conditions***	***Assumption***
Load	Load is always on. Load changes are random events, but generally follow a statistical model.		All load is metered. Resource attributes are prepopulated in Mircrogrid Optimizer. Flexible load may be reduced or shed by Mircrogrid Optimizer. Parameters or steps are configured in Mircrogrid Optimizer.
Operator	Optional human operator. May observe operations of microgrid and over-ride as needed. Operator inputs are random	Operator trained in use MGMS system	
Utility DMS	There is a higher level controller for the grid to the microgrid is connected, such as DMS to manage and control the overall distribution grid. Inputs from the utility DMS will be random.	Utility distribution planning has approved the connection of microgrid	Interaction with a utility DMS will not be included in the SGIP demo in 2015.
Microgrid Optimizer	Dispatching is done on a periodic basis that is set during system configuration. Some defined event can trigger an exceptional run of the optimization.	Mircrogrid Optimizer dispatching is always on.	Resource attributes are prepopulated in Mircrogrid Optimizer.
Microgrid SCADA	Microgrid SCADA systems receives data on a periodic basis	SCADA is always on.	Resource attributes are prepopulated in Mircrogrid Optimizer.
Forecasting	Forecasting runs on a periodic basis.	Forecasting is always on.	Assumption is that the weather service is an

	Publishes updated forecasts on a periodic basis.		external 3rd party supplier to the utlity
Recloser	Power system disturbance is detected by relaying protection scheme that operates system. Opening of the recloser is a random event. Manual closing the recloser is done as part of a procedure to reconnect the microgrid to the utility grid.	Separation of the microgrid from the main grid is the objective of protection scheme. Protection scheme may also performs initial balancing through load shedding, when needed.	Separation and reconnection of microgrid were part of design of microgird protection scheme.
Solar PV Array	The solar PV array may experience sudden changes in power production due to moving cloud cover. This can trigger an exceptional dispatch of the optimizer. Other renewable resources also may experience rapid changes in output (eg wind turbine trips on overspeed protection)		

3.3 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on Use Case***	***Originator / Organisation***	***Link***
1	EPRI Smart Grid Resource Center	Use Case Repository		Similar to current usecase	Electric Power Research Institute	`http//smartgrid.epri.com/repository/repository.aspx`
2	New Energy and Industrial Technology Development	Microgrid use cases		Similar to current usecase	New Energy and Technology Development Organization, Japan	Available through EPRI Smart Grid Resource Center:
3	International Electrotechnical Commission TC 8	IEC 62559-2		Template used for current usecase		Available through IEC webstore
4	ORNL	Microgrid use cases		Similar to current usecase	Oakridge National Laboratory, Tennesse	
5	EPRI	Common Functions for Smart Inverters, Ver 3		Describes functions seen in smart inverters	EPRI	EPRI public document 3002002233, available on EPRI website

3.4 Further Information to the Use Case for Classification / Mapping

Classification Information
Relation to Other Use Cases
There are other use cases related to separation of the microgrid from the main grid, and reconnection.
Level of Depth
Mid level
Prioritisation
High
Generic, Regional or National Relation
Will be applied in a generic test at Duke, CPS Energy, NREL ESIF, and SCE test beds.
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
1	Day-Ahead Scheduling	Microgrid Optimizer Dispatching	Triggered periodically at a configurable time	Microgrid Optimizer set up, tested.	Day-ahead schedules established
2	Intra-Day Dispatching and Scheduling	Microgrid Optimizer Dispatching	Triggered periodically at a configurable time	Microgrid Optimizer set up, tested	

4.2 Steps – Scenarios

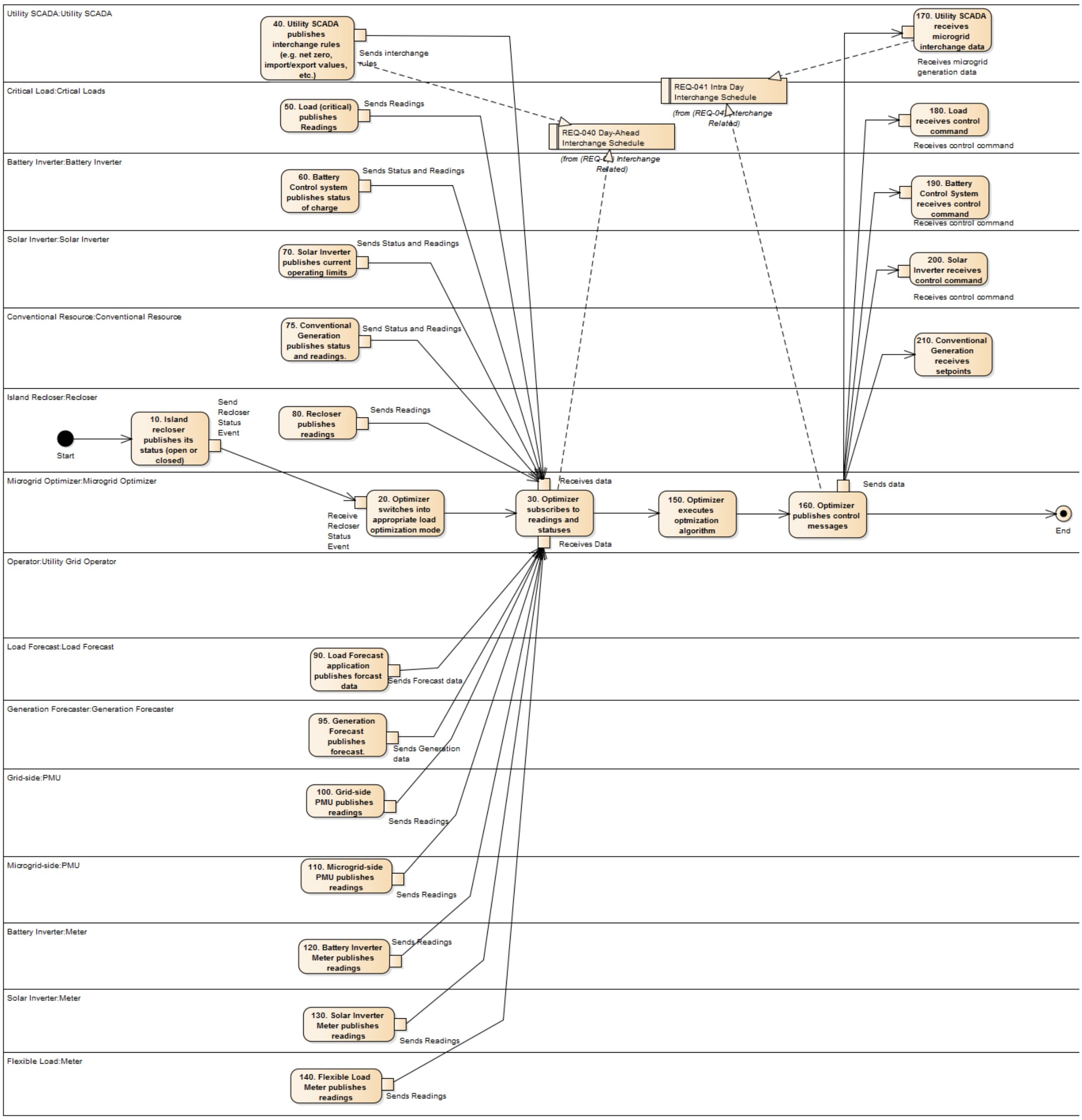

Figure 2: Activity Diagram - Use Case for Grid Connected or Islanded Operation

5 Information Exchanged

Information Exchanged		
Name of Information (ID)	***Description of Information Exchanged***	***Requirements to information data***
Recloser Status	Switch mRID Discrete Value Date/time	ok
Flexible Load Current Values	Load mRID Current MW Current MVAR Current power factor Current Voltage Current Operating Limits Quality Codes Date/time	ok
Solar Panel Inverter Solar Panel Current Capability	Resource mRID, Analog mRIDs MW High Limit MW Low Limit Voltage Quality Code Date/time	ok
Forecasting:	Weather Forecast Data, schedules	Assume that these are obtained from a weather service, and will not be transported by the OFMB.
Solar Panel Inverter: Current Solar Values	Resource mRID Analog mRIDs Current MW Current MVAR Current power factor Current Voltage Quality Code Date/time	ok
Battery Inverter: Battery State of Charge	Resource mRID Current MWH Percent of charge Quality Code Date/Time	ok
Battery Inverter Current Battery Values	Resource mRID Analog mRIDs Current MW Current MVAR Current power factor Current Voltage Quality Code Date/time	ok
Critical Load: current values	Load mRID Analog mRID Current MW Current MVAR Current power factor Current Voltage Quality Code Date/time	ok
Microgrid SCADA, Resource Current Values	Analog mrIDs Analog Value Quality Code Date/time	ok
Forecasting: Solar Power Forecast	Shedules with: MW value Time Interval Version Version Date/Time	ok
Forecasting: Load	Shedules with:	ok

Forecast	MW value Time Interval Version Date/Time	
Optimizer: Dispatching, Dynamic Dispatch	Resource mRID Analog mRID Analog Value Discrete Value Date/Time	Goes to Battery Inverter, solar Inverter, flexible loads, and conventional resources
Microgrid interchange Schedules	Schedules for Microgrid interchange MW value Time interval Schedule version Version Date/Time Author	
Conventional Generation: current values	Generator mRID Current MW Current MVAR Current power factor Current Voltage Current Operating Limits Quality Codes Date/time	ok
PMU:	PMU mRID Current MW Current MVAR Current Voltage Current Voltage Angle Quality Codes Date/ precise time	

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**
Normal	The microgrid is operating in a normal state when all the equipment in the microgrid is within safe long term operating limits, and when any of a list of credible first contingencies can be sustained without blacking out the grid.
schedule	A time series made up of a sequence of point pairs (kW, time) that correspond to the past or future kW production or demand of a resource in the Microgrid.
Interchange schedule	In this context, an interchange schedule is schedule of the planned inflow or outflow of the microgrid to the utility to which it is connected through the point of common coupling.
SCADA	Supervisory Control and Data Acquisition. System that allows remote monitoring and control of entities in the field. Includes a User Interface, Limit checking and alarming functions.
Utility SCADA	SCADA system used by utility operator or dispatcher
Microgrid SCADA	SCADA system used by utility operator or dispatcher

8 Custom Information (optional)

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

