SmartConnect Use Case:

D12 – Generation dispatch utilizes energy storage to balance renewable variability

April 15, 2009

Document History

Revision History

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Approvals

This document requires following approvals.

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Contents

1. Use Case Description

1.1 Use Case Title

Generation dispatch utilizes energy storage to balance renewable variability.

1.2 Use Case Summary

One of the obstacles to achieving higher penetration of large-scale renewable energy such as wind and solar power is the variable nature of these resources. Sudden weather changes can lead to corresponding variations in generation output across the service territory, potentially causing grid instability. This use case describes how monitoring the real-time status of renewable energy resources can increase the Independent System Operator's (ISO) and SCE's effectiveness in handling this variability. Possessing real-time status information about renewable resources allows the ISO to fill any energy shortfalls (or address any surpluses) to preserve grid stability.

A possible means of balancing this variability is to deploy energy storage devices as either participating variable generation or participating variable load resources. The use of energy storage devices introduces a need for real-time communications to monitor and control these resources. Examples of high capacity energy storage resources that can discharge energy instantaneously include pumped storage, batteries, flywheels, superconducting magnetic energy storage, ultra-capacitors, and aggregated plug-in electric vehicles. Another means is to use load control devices that can be dispatched to reduce consumption or, in times of excess low-cost renewable generation resources, to increase power consumption.

The benefits of these monitoring and control functions include improved system reliability, reduced greenhouse gas emissions, reduced costs, and other societal benefits.

1.3 Use Case Detailed Narrative

Given the constraints of today's electrical grid, there is a limit to the how deeply renewable energy resources can be introduced into the electrical system. The variable nature of these resources complicates their integration into the grid. Dynamic climatic conditions such as rising wind strength or cloud accumulations alter their generation output. High winds can cause sudden "cutouts", where wind turbines suddenly and completely cease generating electricity. Likewise, rapid cloud accumulation can substantially reduce the output of solar farms. This variability increases the complexity of scheduling and delivering energy to the grid, and ultimately increases grid instability. In this context, grid stability refers to the balancing of electricity supply and demand on a short term, minute-by-minute basis. Denmark, one of the largest users of wind energy, has observed instabilities at wind penetration levels above 32% (wind as a percentage of total electricity consumption). Other countries with high wind use have observed instabilities at wind penetration levels above 13%. The difference is that Denmark has a more sophisticated control scheme for its grid. Thus, increased use of renewable resources requires efforts to mitigate the effects of this generation output variability.

Options currently under discussion within the industry for addressing renewable variability include the following:

1. Balancing Energy Market: Obtain incremental (or decremental) power in the real-time energy balancing market.
2. Advanced Energy Storage Systems: Utilize energy storage devices to provide variable generation and/or variable load.
3. Demand Response: Incentivize customers (or groups of customers) to increase or decrease demand under pre-specified conditions.
4. Interconnection: Connect with other grid systems to supply surplus energy or purchase balancing energy.
5. Distributed Generation: Utilize distributed generation resources as a source of balancing energy.
6. Micro-Grids & Islanding: Utilize intelligent grid technologies to separate impacted areas to maintain grid stability.

These options are not mutually exclusive, as no single choice is likely to provide all the balancing energy required for grid stability. In the future, it is likely that these options will all participate in the real-time energy balancing market such that the least cost option(s) would provide the needed grid stability services. This use case considers the use of the real-time energy market and energy storage devices.

The use case scenario included within this document describes a hypothetical 100MW wind park that connects to the grid to supply energy in the scheduled forward market. Although the scenario describes a wind park, the steps would apply to any large-scale renewable resource. A prerequisite to connecting to the grid is that the resource must meet ISO telemetry standards, allowing the ISO to monitor the resource (e.g. generation output, availability, meteorological data, turbine availability and circuit breaker status).

Once the wind farm connects to the grid, the ISO and SCE immediately begin monitoring a set of the facility's operating parameters. The ISO receives operating data via SCADA systems in 4 second intervals. The ISO simultaneously transmits a portion of this data to SCE and to an external data modeling company. SCE uses this data to monitor the circuit. The modeling company uses the data to produce hourly schedules, forecasting how much energy the wind farm will generate. This is an hourly schedule produced in the hour-ahead market environment. A day-ahead schedule is also produced, but is not binding. Every hour a new hourly schedule is produced that includes the next 24 hours. The schedule that comes out 2 hours in advance of the beginning of the actual operating hour represents the binding hour schedule. SCE is required to schedule this energy in the ISO's hour-ahead market.

In the operating hour, the wind farm initially generates 100MW, consistent with the schedule. However, output begins trending downward and falls beneath 100MW. Electricity supply and demand must balance to maintain grid stability, so the ISO must immediately fill the shortfall between the 100MW of scheduled output and actual output. The ISO's first step is to utilize Automatic Grid Control (AGC). AGC represents the ability of the ISO to automatically control the power output of participating generation units that are connected to the ISO's Energy Management System (EMS) via a Remote Intelligent Gateway (RIG). These generating units are available to provide limited amounts of balancing energy, known as "regulating power", which is sold as an ancillary service. For 10 minutes, every 4 seconds the ISO will communicate with these generating units, sending them instructions to either increase or decrease output. This allows the ISO to maintain grid frequency stability at 60 cycles per second. However, if a balancing issue persists, eventually the ISO runs out of regulating power since they only procure a set amount of it, and only a small number of units can provide it reliably.

The ISO next replaces AGC by dispatching energy from the 5 minute market (Balancing Energy Ex-Post Pricing or BEEP stack). The BEEP stack represents the real-time energy balancing market. This market is run as an auction in which participants enter bids based on 10 minute intervals, to increase or decrease power output. Every 5 minutes the ISO selects the least expensive bids in the BEEP stack and sends Automated Dispatch System (ADS) instructions to the operators of the generating units. The operators then adjust their power output accordingly. The BEEP stack includes ancillary services (e.g. spinning reserves, non-spinning reserves, and replacement reserves) and supplemental energy bids. This could include any resource that meets ISO requirements for participating generators or participating load (including energy storage resources).

Energy storage resources participating in the 5-minute balancing energy market must have telemetry capabilities that enable resource monitoring, and control of charging and discharging. These requirements would be consistent for all dispatchable participating generation and participating load resources. “Pumped Storage” is an example of participating generation and load in which hydroelectric plants use off-peak generation capacity to pump water from a lower elevation to a higher elevation reservoir. The water is stored in a reservoir until electricity demand increases, at which time the water is released through turbines to generate electricity. In the future there is an expectation that thousands (or perhaps millions) of aggregated home energy storage devices, plug-in electric vehicles (PEV), air conditioning units or other independent devices could perform a similar role as participating load resources, and in some cases, participating generation resources.

For the purpose of this use case, these small-scale energy storage resources would actually provide negative load. In other words, on a short term basis they would be net providers of electricity (generation) rather than net consumers of electricity (load). Energy storage devices and PEVs would supply small amounts of stored electricity from their batteries. Whereas large pumped storage facilities are monitored and controlled by the ISO on a direct and individual basis, these smaller resources would be aggregated, and then monitored on a sample basis. For example, the ISO would communicate with a statistically significant sample of all energy storage devices and calculate the aggregate load available (or total negative load available) at that moment. This resource would then participate in the balancing energy market, supplying incremental or decremental energy in the same manner as other traditional participating load and participating generation resources.

Business Value

The benefits of monitoring the status of renewable resources to better inform decisions about responding to their variability include the following:

1. **Reduced Costs**:
    a. Economic Generation Dispatch:
        i. **Economic Dispatch of Renewable Resources**: Increasing the participation of variable generation and load resources in the real-time energy market could potentially reduce the cost of these renewable resources.
        ii. **Avoid Interconnection Fees**: To the extent there is a reduction in imported electricity, there would be an associated reduction in interconnection fees.
    b. Liquidity of Carbon Trading Market: Prospective carbon cap and trade schemes would provide a mechanism to monetize the carbon dioxide emission reductions associated with renewable energy resources. Increased penetration of renewable resources would increase the liquidity of the carbon credit market, reducing transaction costs.
2. **Reduced Greenhouse Gas Emissions**:

a. Renewable Resource Integration: Increased integration of renewable resources is expected to result in less use of fossil fuels for electricity generation, and corresponding reduction in green house gases.

3. **Improved System Reliability**:

   a. Energy Storage Integration: Integration of energy storage and other participating generation and participating load resources will help maintain reliability as generation provided by less reliable renewable resources increases.

   b. Cell Structure Distributed Generation: This involves increasing the autonomous nature of grid operations to small and local areas at the substation or circuit level in a cell or islanding structure that self-corrects for energy imbalances utilizing renewable resources.

4. **Increased Customer Benefits**:

   a. Sustainable Cities: Provide cities the ability to tailor electricity supplies to suit their power needs, including costs, environmental impacts and levels of reliability and power quality. This could include increased levels of distributed generation, perhaps as a means of combating renewable resource variability.

5. **Other Benefits**:

   a. Reduce Energy Import Dependence: As renewable energy resources achieve increased penetration, there is a reduced need for the United States to import energy resources from other nations.

   b. Achieve Public Policy Goals: Increased integration of renewable resources and energy storage resources will assist SCE in meeting public policy goals at lowest cost, while not sacrificing reliability.

1.4 Business Rules and Assumptions

- Scenario considers large-scale energy resources (e.g. 100MW wind park).
- Wholesale market prices for energy will be a factor in dispatch of large renewables (greater than 10MW). In other words, the resource is market-participating and is not a “must take” for the utility.
- Additional market value streams will be taken into account when considering the dispatch of large renewables (e.g. monetizing potential renewable contract penalties, cap and trade requirements, or Renewables Portfolio Standard (RPS) requirements and penalties for non-compliance).
- Power Quality requirements and standards for the production of energy by renewable resources will be enforced.
- Renewable energy resource must be dispatchable and controllable.
- The resource used to address the variability of the renewable resource must also be dispatchable and controllable. This includes energy storage devices.

2. Actors

Describe the primary and secondary actors involved in the use case. This might include all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, customer, end users, service personnel, executives, meter, real-time database, ISO, power system). Actors listed for this use case should be copied from the global actors list to ensure consistency across all use cases.

Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
Energy Management System (EMS)	System	The Energy Management System (EMS) is a system of tools used by system operators to monitor, control, and optimize the performance of the transmission system. The monitor and control functions are performed through the SCADA network. Optimization is performed through various EMS applications.
Energy Storage Unit	Device	Energy storage units include small-scale storage devices such as home energy storage units and plug-in electric vehicles (PEVs). Large-scale energy storage units include pumped storage, batteries, flywheels, superconducting magnetic energy storage, ultra-capacitors, and aggregated PEVs.
Energy Supply & Management Operator (ES&M Operator)	Person	The ES&M Operator is responsible for scheduling generation resources in the forward energy market. This operator is also responsible for scheduling available energy storage resources (participating generation) and demand response resources (participating load) into the Balancing Energy Ex-Post Pricing market (i.e. the BEEP stack).
Generation Management System (GMS)	System	The Generation Management System (GMS) maintains the system resource stack of available supply and demand resources and their price parameters. Energy traders use the GMS to select resources to bid to the ISO. The stack of resources, generally considered supply resources, is listed from cheapest to most expensive allowing the traders to balance supply with forecasted system load. In this use case, the amount of demand response available for any given market window is considered a resource in the stack.

Actor Name	Actor Type (person, device, system etc.)	Actor Description
Independent System Operator (ISO)	Organization	The Independent System Operator (ISO or Regional Transmission Organization) is responsible for the economic and reliable operation of the transmission grid. The ISO creates a functioning market for Energy, Capacity, and Ancillary Services. The ISO is responsible for compliance with federal and state rules and regulations. The Independent System Operator, or California Independent System Operator, is the regional transmission system operator. The regional transmission system, regional grid, is operated independently of the suppliers and load aggregators by the ISO. The ISO is sort of like the "traffic cop" charged with balancing the electricity and the flow on the grid.
Participating Generation Resource	Device	Participating generation resources are those resources that have elected to participate in the real-time energy market in which the utility (as directed by the ISO), has the ability to exert control over the resource to supply energy during peak load periods. These resources must be fitted with a control device for the utility to exert this control. Examples of participating generation resources include pumped storage facilities, flywheels, batteries, and aggregated small-scale resources such as plug-in electric vehicles and home energy storage units. Small-scale resources such as PEVs and home energy storage units would likely be dispatched at an aggregated level.
Participating Load Resource	Device	Participating load resources are those resources that have elected to participate in load control programs in which the utility has the ability to exert control over the resources to reduce load during peak periods. These resources must be fitted with load control devices for the utility to exert this control. Examples of participating load resources include air conditioning (controlled through Programmable Communicating Thermostats), pool pumps, pumped storage facilities, crop irrigation pumps, batteries, plug-in electric vehicles (PEVs), and other smart appliances. Small scale resources such as PEVs, home energy storage and smart appliances would likely be dispatched at an aggregated level.
Transmission & Distribution Business Unit (TDBU)	Organization	The business unit that manages the installation, operations and maintenance of the utility's transmission and distribution assets.
Wind Park	Generation Resource	This is used as an example in this use case. It represents a hypothetical 100MW generation facility.

3. Step by Step analysis of each Scenario

Describe steps that implement the scenario. The first scenario should be classified as either a "Primary" Scenario or an "Alternate" Scenario by starting the title of the scenario with either the work "Primary" or "Alternate". A scenario that successfully completes without exception or relying heavily on steps from another scenario should be classified as Primary; all other scenarios should be classified as "Alternate". If there is more than one scenario (set of steps) that is relevant, make a copy of the following section (all of 3.1, including 3.1.1 and tables) and fill out the additional scenarios.

3.1 Primary Scenario: Renewable generation status is monitored to inform decisions for adjusting use of energy storage or conventional generation to manage renewable variability

This scenario describes how a hypothetical 100MW wind farm connects to the grid and supplies electricity in the scheduled forward market without causing grid instability in the operating hour. Real-time monitoring of this variable resource allows the ISO to respond to unexpected changes in generation output caused by climatic variability. In this scenario, during the operating hour the wind farm experiences a decrease in generation output, below their scheduled output. The ISO responds by filling the gap between scheduled output and actual output with Automatic Generation Control (AGC) energy and energy from the real-time energy balancing market. One of the ways in which the ISO might balance energy supply and demand is through the deployment of energy storage resources.

Triggering Event	***Primary Actor***	***Pre-Condition***	***Post-Condition***
(Identify the name of the event that start the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to consider the scenario complete)*
100MW wind park connects to the grid		The Independent System Operator (ISO) must be able to monitor the following: 1. Generation output (MW, MVar, Voltage) 2. Availability (on line or not) 3. Meteorological data 4. Turbine availability data 5. Circuit breaker status	Renewable resource connects to the grid and, despite the variability of the renewable resource, grid stability is maintained.

3.1.1 Steps for this scenario

Describe the normal sequence of events that is required to complete the scenario.

Step #	Actor	Description of the Step	Additional Notes
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or value of the step to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1	ISO	The ISO begins monitoring a set of operating parameters from the grid-connected wind park.	SCADA data is sent in 4 second intervals from the wind park to the ISO.
2	Generation Management System (GMS)	The ISO sends a portion of data from Step 1 to SCE's GMS.	Data is transmitted from the ISO to SCE via the Energy Control Network (ECN).
3	Energy Management System (EMS)	SCE's Transmission & Distribution Business Unit (TDBU) begins monitoring the operating data at the wind park interconnection via EMS for reliability purposes.	TDBU monitors for power quality, power failure, security, voltage, and VAR support to ensure the system is operating within the allowable reliability parameters. This is monitored through EMS, and is not from the same data path as steps 1 and 2. TDBU might also monitor this data on a historical basis for system planning purposes.
4	Generation Management System (GMS)	GMS monitors a set of operating parameters for participating load and generation resources (e.g. energy storage resources).	For example, GMS monitors large energy storage units and aggregated small storage resources. GMS monitors the current state and loading of participating load

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			resources, and the current state and generation levels of participating generation resources.
5	Energy Supply & Management Operator (ES&M Operator)	ES&M Operator uses GMS to schedule the expected wind park output in the hour-ahead market for 100MW.	The ISO provides Participating Intermittent Resource Program (PIRP) data to a modeling company which takes the data (generation output, availability, meteorological data, etc.) and produces an hourly model. This sets the expectation for how much energy the resource will be able to generate. SCE is required to schedule to this model in the ISO market. This is an hourly schedule produced in the hour-ahead market environment. A day-ahead schedule is also produced, but it is not binding. Every hour a new hourly schedule is produced that includes the next 24 hours. The schedule that comes out 2 hours in advance of the beginning of the actual operating hour represents the binding hour schedule.
6	ES&M Operator	ES&M Operator bids available energy storage resources (participating generation) or demand response resources (participating load) into the Balancing Energy Ex-Post Pricing market (i.e. BEEP stack).	This includes both large scale resources and aggregated small scale resources.
7	Wind park	The wind park receives schedule information and operates at 100MW in the operating hour (according to the schedule).	The ISO scheduling system expects the wind park to generate 100MW.
8	Wind park	The wind park's actual output trends downward and falls beneath 100MW.	For example, the wind starts to calm and generation output falls.
9	ISO	ISO Automatic Generation Control (AGC) responds to fill the gap between scheduled resources and actual generation output.	AGC represents the ability of the ISO to automatically control the power output of generation units connected

Step #	Actor	Description of the Step	Additional Notes
			to the ISO's Energy Management System (EMS) via a Remote Intelligent Gateway (RIG). These units are available to provide limited amounts of balancing energy, known as "regulating power", which is sold as an ancillary service. For 10 minutes, every 4 seconds the ISO will communicate with these generating units and send messages instructing them to increase or decrease output. This allows the ISO to maintain grid frequency stability at 60 cycles per second. However, eventually the ISO runs out of regulating power, since they only procure a set amount of it, and there are a small number of units that can provide it reliably.
10	ISO	ISO awards incremental imbalance energy to participating generation resource (e.g. energy storage resource) out of bid stack (BEEP stack) to replace the AGC.	The ISO replaces AGC by dispatching energy out of the 5 minute market (BEEP stack). The BEEP stack represents the real-time energy balancing market. This market is run as an auction in which participants enter sets of bids, based on 10 minute intervals, to increase or decrease their power output. Every 5 minutes the ISO selects the least expensive bids and sends Automated Dispatch System (ADS) instructions to the operators of the generation units. The operators then adjust their power output accordingly. The BEEP stack includes ancillary services (e.g. spinning reserves, non-spinning

Step #	Actor	Description of the Step	Additional Notes
			reserves, and replacement reserves) and supplemental energy bids. This could include any resource that meets ISO requirements for participating generators or participating load (including energy storage resources). Energy storage resources must have the right telemetry capabilities to enable monitoring and control of charging and discharging.
11	ES&M Operator	The ES&M Operator uses GMS to dispatch energy storage resource.	This action is taken based on instructions from the ISO through ADS.
12	Energy Storage Unit	The energy storage unit responds to the ADS instructions automatically by providing generation to the grid by discharging (participating generation), or by providing load to the grid by charging (participating load).	Whether the energy storage unit provides energy by discharging or provides load by charging depends on the resource needed. This use case scenario involves energy storage acting as participating generation through discharging. However, there could be a situation in which energy storage in needed to act as participating load. For example, if wind generation increases during the night when load is low, and the wind generation output increases above the scheduled amount, energy storage could be dispatched to begin charging to absorb this incremental wind farm output.
13	ISO / TDBU	The ISO and SCE monitor resources for future necessary balancing energy adjustments.	

4. Requirements

Detail the Functional, Non-functional and Business Requirements generated from the workshop in the tables below. If applicable list the associated use case scenario and step.

4.1 Functional Requirements

Req. ID	*Functional Requirements*	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
1	The renewable resource shall be able to provide MW output status to the Independent System Operator (ISO).	1	1,7,8,13
2	The renewable resource shall be able to provide its MVar output status to the ISO.	1	1,7,8,13
3	The renewable resource shall be able to provide its voltage output status to the ISO.	1	1,7,8,13
4	The renewable resource shall be able to provide its availability status to the ISO.	1	1,7,8,13
5	The renewable resource shall be able to provide its meteorological status to the ISO.	1	1,7,8,13
6	The renewable resource shall be able to provide its circuit breaker status to the ISO.	1	1,7,8, 13
7	SCE's Generation Management System (GMS) shall be able to receive SCADA data for large-scale renewables from the ISO via the Energy Control Network (ECN).	1	2
8	GMS shall be able to monitor the current state of participating load resources.	1	4
9	GMS shall be able to monitor the current loading of participating load resources.	1	4
10	GMS shall be able to monitor the current state of participating generation resources.	1	4
11	GMS shall be able to monitor the generation output of participating generation resources.	1	4
12	The renewable resource shall meet the ISO's tariff requirements for participating generators. (This is a requirement for all generation resources participating in the Balancing Energy Ex-Post Pricing (BEEP) market.)	1	5,9,10
13	SCE's GMS shall be able to receive Participating Intermittent Resource Program (PIRP)	1	5

Req. ID	***Functional Requirements***	***Associated Scenario #*** ***(if applicable)***	***Associated Step #*** ***(if applicable)***
	data from external data modeling companies.		
14	SCE's GMS shall be able to schedule PIRP resources based on models received from external modeling companies.	1	5
15	Storage resources can also be scheduled "price takers" per forecast prices.	1	6,9,10
16	Large-scale participating generation and participating load resources shall be able to directly communicate their status to the ISO and SCE (same requirements that exist for pumped storage facilities).	1	6
17	Small-scale participating generation and participating load resources (plug-in electric vehicles, air-conditioning units, etc.) shall communicate their status to the ISO and SCE on a sample basis (same requirements that exist for pumped storage facilities). This data could also be provided directly to an external data modeling company.	1	6
18	The ISO and SCE, either directly or through an external data modeling company, shall model the collective sample output of the small-scale resources (from functional requirement 18).	1	6
19	SCE's GMS shall be able to receive small-scale resource model data from external data modeling companies.	1	6
20	ISO shall send Automated Dispatch System (ADS) instructions to the energy storage unit operator.	1	10
21	SCE shall be able to receive ISO generation / load dispatch instructions from ADS.	1	10
22	Energy storage resources shall be able to take high speed dispatch controls from SCE (e.g. to charge, discharge, or to change rate of charging or discharging). This applies equally to large-scale and small-scale resources. See use case P4 for a discussion of the Distributed Resources Availability and Control System (DRAACS), a system which could be used to dispatch these small scale resources.	1	12

4.2 Non-functional Requirements

Req. ID	*Non-Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
1	The renewable resource shall be able to provide its MW output status to the Independent System Operator (ISO) every 4 seconds.	1	1,7,8,13
2	The renewable resource shall be able to provide its MVar output status to the ISO every 4 seconds.	1	1,7,8,13
3	The renewable resource shall be able to provide its voltage output status to the ISO every 4 seconds.	1	1,7,8,13
4	The renewable resource shall be able to provide its availability status to the ISO every 4 seconds.	1	1,7,8,13
5	The renewable resource shall be able to provide its meteorological status to the ISO every 4 seconds.	1	1,7,8,13
6	The renewable resource shall be able to provide its circuit breaker status to the ISO every 4 seconds.	1	1,7,8,13
7	The ISO shall provide renewable resource operating data (SCADA subset) to SCE via the Energy Control Network (ECN) every 4 seconds.	1	2
8	Dispatchable participating load and participating generation resources (e.g. PEVs) shall be able to provide monitoring data to the ISO and SCE every one minute or upon status change. These communications will likely be initiated by a distributed resource controller device that aggregates information from multiple smaller resource devices (e.g. PEVs) and transmits the data to the ISO and SCE.	1	4
9	SCE shall monitor dispatchable participating load and participating generation resources greater than 1MW.	1	4
10	The ISO shall be able to respond to changes in renewable resource generation output within 1 minute. Different renewable resources have different rates at which they ramp up and down. Thus the ISO needs to be able to respond to the fastest rate at which resources change output. The fastest is likely to be wind turbine cutouts.	1	9 & 10

Req. ID	***Non-Functional Requirements***	***Associated Scenario #*** ***(if applicable)***	***Associated Step #*** ***(if applicable)***
11	SCE shall be able to perform 15 minute-interval metering of participating load and participating generation resources. This function is necessary for settlement purposes.	1	9 & 10
12	Dispatchable participating load and participating generation resources shall be able to respond to ISO requests for AGC or real-time energy balancing services within 1 minute.	1	12

5. Use Case Models (optional)

This section is used by the architecture team to detail information exchange, actor interactions and sequence diagrams

5.1 Information Exchange

For each scenario detail the information exchanged in each step

5.2 Diagrams

6. Use Case Issues

Capture any issues with the use case. Specifically, these are issues that are not resolved and help the use case reader understand the constraints or unresolved factors that have an impact of the use case scenarios and their realization.

Issue
Describe the issue as well as any potential impacts to the use case.
1. Different renewable resources have different ramp up and ramp down rates. These need to be better understood for purposes of developing requirements related to communications and control response speeds.
2. Regulatory policy limits the ability of renewable resources to be considered for economic dispatch.
3. Micro forecasting for distributed renewable energy resources that are variable in nature is required to more accurately schedule those resources for delivery in the forward market.

7. Glossary

Insert the terms and definitions relevant to this use case. Please ensure that any glossary item added to this list should be included in the global glossary to ensure consistency between use cases.

Glossary	
Term	**Definition**
Ancillary Service (AS)	Ancillary Services represent balancing energy services provided to maintain grid stability. The two largest AS are frequency regulation (also referred to as regulation energy) and spinning reserves. Other AS include non-spinning reserves and replacement reserves.
Automatic Generation Control (AGC)	Generation equipment that automatically responds to signals from the ISO's EMS control in real-time to control the power output of electric generators within a prescribed area in response to a change in system frequency, timeline loading, or the relation of these to each other, so as to maintain the target system frequency and/or the established interchange with other areas within the predetermined limits. This is the mechanism that keeps the grid in balance at a 60Hz frequency. (definition from Cal ISO website)
Balancing Energy Ex-Post Pricing (BEEP)	This represents the real-time energy balancing market. This market is run as an auction in which participants enter bids (incremental and decremental) to supply energy (or to not supply scheduled energy) in the hour-ahead market. Bids are submitted once per hour. Each of these hourly bids contains 6 10-minute intervals.
Distributed Generation (DG)	Distributed Generation refers to the energy supplied by multiple small electricity producers.
Energy Control Network (ECN)	Energy Control Network (ECN) is a real-time communications network that provides access to information exchange between generation, transmission, distribution, and grid control system resources. ECN supports 4 sec update rates among resources that allow for efficient and reliable grid operations.
Participating Intermittent Resource Program (PIRP)	The Participating Intermittent Resource Program allows intermittent resources, such as wind-powered generators and other resources with an uncontrollable fuel source, to schedule energy in the ISO forward market without incurring imbalance charges when the delivered energy differs from the scheduled amount.
Plug-In Electric Vehicle (PEV)	Plug-in Electric Vehicles plug into an electrical outlet at a premise to be charged. These vehicles are capable of two-way communications with the utility through an Energy Services Communications Interface.
Power Quality	Power Quality is a set of guidelines which, if met, allow electrical systems to function such that electrical equipment operates correctly, reliably, and without damage or stress.
Pumped Storage	Pumped storage represents a form of load balancing in which hydroelectric plants use excess generation capacity to pump water from a lower elevation to a higher elevation reservoir. The water is stored in a reservoir until electricity demand increases, at which time the water is released through turbines, generating electricity.
Renewables Portfolio	RPS is California's set of renewable energy standards, established in 2002 under Senate Bill 1078 and

Standard (RPS)	accelerated in 2006 under Senate Bill 107. The RPS program requires electric corporations to increase procurement from eligible renewable energy resources by at least 1% of their retail sales annually, until they reach 20% by 2010.
Remote Intelligent Gateway (RIG)	A device functionally defined by the ISO and used to directly telemeter secure operational data from a generation resource to the ISO EMS and to provide direct control of the generating resource by the ISO. Installation of a RIG is a prerequisite for participation in the ISO AGC/Regulation market.
SCADA (Supervisory Control and Data Acquisition)	SCADA refers a group of centralized systems that monitor and control the assets within SCE's transmission and distribution system. SCADA data is relayed in 4 second intervals.

8. References

Reference any prior work (intellectual property of companies or individuals) used in the preparation of this use case

9. Bibliography (optional)

Provide a list of related reading, standards, etc. that the use case reader may find helpful.

Timur Gul and Till Stenzel, International Energy Agency, “Variability of Wind Power and other Renewables: Management Options and Strategies”