IC-3 Non-dispatchable Distributed Energy Resources (DER) Changes ISO Forecast and Unit Commitment Decisions

ISO Smart Grid Use Case

Version 2.0

October 14, 2010

Approvals:
Signature indicates acceptance of the IC-3 Non-Dispatchable Distributed Energy Resources (DER) changes ISO forecast and unit commitment decisions for Smart Grid Roadmap Project as complete and sufficiently detailed to allow the project to be successfully executed.

Heather Sanders, Date

Revision History

Date	Version	Description	Author
6/17/2010	0.1	Create the document	Dave Hawkins
7/17/2010	0.2	Edits in Basic flow and alternative flow. Edits Business Rules. Misc edits	Khaled Abdul-Rahman
7/19/2010	0.3	Cleaned up document, edited Activity Diagram	Tarak Thaker
7/21/10	0.4	Made consistent with template. Added more context in section 1. Added actors that were included in the flows. Included PEV in consideration of load forecasting and unit commitment changes. Added requirements section	Heather Sanders
7/22/10	0.5	Misc Edits	Khaled Abdul-Rahman
7.22/10	0.6	Sync activity diagrams to flow of events	Tarak Thaker
7/22/10	0.7	Misc Edits	Khaled Abdul-Rahman
7/23/10	1.0	Made minor format/clean up changes and accepted all changes	Yinka Osoba
8/2/10	1.1	Changes proposed per EPRI / EnerNex feedback	Kevin Parker
8/3/10	1.2	Added description on forecasting components of system load Added description about ramping forecast Added assumption about freq response PEV Misc Edits	Khaled Abdul-Rahman
8/9/10	1.3	Reviewed and accepted all comments	Heather Sanders
8/10/2010	1.4	Added supplementary information about California statewide solar (PV) distributed generation in section 1 and accepted all changes. Also added glossary section (10).	Yinka Osoba
9/3/2010	1.5	Updated non functional requirements in section 8	Doug Walker/Yinka Osoba
10/14/10	2.0	Reviewed and accepted changes and prepared for publication	Heather Sanders

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1. Use-Case: Non-dispatchable Distributed Energy Resource changes ISO Forecast and Unit Commitment decisions.

The ISO forecasts system load and passes it to the market systems to economically commit units to meet this system load expectation in both day-head and real-time. As distributed energy resources (DER), particularly solar photovoltaic (PV) and plug-in electric vehicles (PEVs), become more prevalent in the distribution system, they will affect the expectations of system load as well as how unit commitment decisions are made. The increase in these DERs from a few hundred MWs to thousands of MWs will have a major impact on the ISO's forecasting programs. Although DERs will not be directly visible to the ISO, its energy production and load will have to be forecasted, and the market system load forecast modified based on the forecast calculation. The modified forecast will then be used by the market systems for generation scheduling and dispatching, unit commitment decisions, and ancillary services procurement decisions.

Table 1 shows the different solar programs and the amount of PV installed in California between 2007 & 2009.

Statewide Solar (PV) Distributed Generation

	Senate Bill 1 Megawatt (MW) Goals and Funding Life of Program			Yearly Progress - MW Installed										
Solar Program	MW Goal	Funding	Incentives Paid to Date	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total MW Installed 2007 - Present
California Solar Initiative (CSI) (Installations of solar systems on existing residential homes, commercial, industrial, agricultural, local governments and non-profit organizations in IOU territories)	1,940	$2,167,000,000	$629,382,780	19	131	134.6								284.6
Publicly Owned Utility (POU) - Subtotal* (Installations of solar systems on existing and new homes, affordable/low income, commercial, non-profit, local government, industrial, agricultural and mixed use in POU territories)	700	$784,000,000	$70,096,854	N/A	11.3	19.1								30.4
New Solar Homes Partnership Program (NSHP) (Installations of solar systems on new residential construction, affordable housing and custom homes in IOU territories)	360	$400,000,000	$18,700,000	0	1.3	3.9								5.2
Total	**3,000**	**$3,351,000,000**	**$718,179,634**	**19**	**143.6**	**157.6**								**320.2**
Self-Generation Incentive Program (SGIP)** (Includes information for solar photovoltaic installations only from 2001 - 2008)	N/A	N/A	$454,000,000	33 MW	21 MW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	136
Emerging Renewable Program (ERP) *** (Includes information for solar photovoltaic installations only from 1998 - present)	N/A	N/A	$343,914,695	29 MW	3 MW	73 kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	122

*Refer to the *POU Life of Program and Yearly Statistics* spreadsheet for detailed information: http://www.energy.ca.gov/sb1/pou_reports/index.html

Per SB 1, POU's were to begin submitting data for 2008 on July 1, 2009. Subsequent years reporting data will be June 1st (for previous year data) - POU yearly reporting data located at: http://www.energy.ca.gov/sb1/pou_reports/index.html

** The SGIP paid incentives for the installation of solar photovoltaic systems from 2001 - 2008. As of January 1, 2008, only wind and fuel cell technologies remain eligible to receive incentives. Total numbers include life of program PV megawatts installed from 2001 - 2008.

*** The ERP was implemented in 1998 to provide incentives for the installation of solar photovoltaic, small wind turbine and fuel cell systems. Solar systems were removed from the program January 1, 2007, due to the passage of Senate Bill 1. Total numbers include life of program PV megawatts installed from 1998 - 2009.

Updated: July 2010

Table 1: Statewide Solar (PV) Distributed Generation (California Energy Commission, 2010)

DER typically includes distributed generation (DG) resources, such as diesel engines, micro turbines, fuel cells, solar photovoltaic (PV), small wind turbines, plug-in electric vehicles (PEV), etc. The major focus of this use case in on the impact of rooftop solar PV and other types of resources that are variable or change based on incentives. The current projection is that solar PV will increase from the current estimated level of less than 200 MW to as much as 3,000 MW by the year 2020.

The ISO's ability to accurately forecast its system load will become more complicated as the amount of DER increases on the system. Not only will there be more renewable distributed generation, there will also be loads that will respond to real-time prices, and new types of loads that will soon appear on the system such as PEV. One of the smart grid project goals is to provide real-time "prices to devices" in the form of a grid condition indicator so loads respond to unfavorable or favorable grid conditions. The challenge will be to keep the grid stable in the event the ISO has hundreds or even thousands of megawatts of load that suddenly turn off resulting from a reaction to grid conditions or changing weather conditions such as cloud coverage. It is estimated that new loads such as PEVs will start to appear on the system in the next 2-3 years and the goal will be to provide the optimum time/price incentives to move this load to off-peak periods.

Non-dispatchable distributed generation can be either passive system, such as rooftop PV, or it can be under the control of the local owner of the facility. DG can also be owned by the utility. Most, but not all, of PV generation will be behind the customer's meter and will essentially look like negative load to the system. The challenge will be to know how much PV is installed in an area and how big the impact will be on reduction of loads in an area. On a bright sunny day, the amount of reduction of loads in an area could be 50% or more. On a cloudy day, the PV output may be very low and/or very intermittent and the load will have to be completely covered by other system resources.

Another challenge is to predict the real-time volatility. The volatility of PV generation could be attributed to the changing weather conditions that were not known or factored in during the forecasting process.

The ISO is responsible for serving its system load. A key question that must be addressed is what information the Load Serving Entities (LSE) can provide to support this forecasting of net-load for each sub-area and the amount of load that is served by DER. It is expected that both the LSE and the ISO will do independent forecasts and then compare results. That potentially leads to the question of whose forecast is the most accurate. If the ISO creates a forecast for each area, then the ISO will need information from the LSE about the DER resources connected to each subarea. If the LSE does the forecast, then they will need the same information and information about the day ahead weather forecast (temperature, cloud coverage, humidity, time of day, day of week, season, etc…). for each area and forecasted energy prices.

The ISO will continue to calculate the system load forecast including the impact of non-dispatchable DERs. It should be noted that the ISO will forecast the conforming part of the demand separate from the non-dispatchable DERs. Historically, the ISO forecasts the conforming load with very good accuracy. Trying to forecast the net system load as one quantity that includes both conforming and non-conforming quantities will increase the uncertainty level in the solution and decrease the accuracy of the forecast. Instead, the ISO will forecast the individual components of the system load (conforming load, non-dispatchable DER, non-dispatchable distributed PV, wind, concentrated solar, other renewable resources) separate from each other and net them to come up with the overall system forecast. This forecasting approach produces more accurate results due to the fact that each forecast can be better tuned and customized to suit the type of the forecasted variable.

For grid/price responsive DER, the ISO needs to understand their projected MW, location, and the associated threshold prices for each segment or type of price-sensitive DERs. The ISO system forecast will include these price responsive DERs as if the prices are below their threshold price (i.e. full expected load). The ISO expects to model the response of these grid/price responsive DERs, (their elasticity to the prices), in the optimization algorithm of the market systems without having them set the market price. This will allow the application to see the impact of these grid/price responsive DERs and dispatch other resources based on the expected behavior of these price-sensitive DERs.

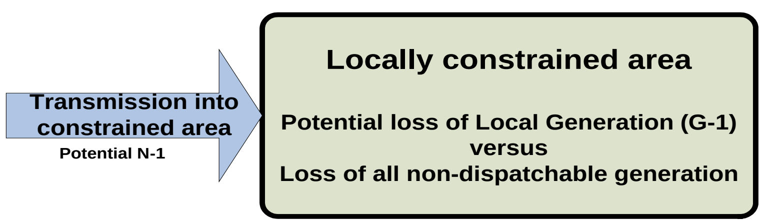
Another forecasting quantity that ISO will need to calculate and provide as an input to the market systems is the amount of on-line flexible ramping that the system needs for each time interval due to the variability of DERs and renewable resources in general. The flexible ramping requirement forecast is also useful to account for any forecast % errors associated with the process of forecasting the overall system load.

A second issue concerns the size of the areas that should be included for the aggregation of DER. The ISO needs to know the size of gross load in an area, the amount of DER that may serve a portion of that load, the corresponding net-load and the probability or risk that the DER will not show up to cover some of the load. Today the ISO does the forecast for ten subareas:

1. SDGE
2. PGE-BA
3. PGE-NBA
4. SCE-Coastal
5. SCE-Inland
6. NCPA
7. SVP
8. VERNON
9. RIVERSIDE
10. ANAHEIM

The question for the future is what areas will require specific forecasts and knowledge of DER. Possible subareas are the utility load aggregation areas. The answer on the optimum size areas will be a result of discussions with the utilities and learning more about expectations of DER and PEV in their systems.

As DER increases on the system, it is conceivable that it may become a dominant issue in some local areas and the loss of all PV due to clouds may be larger than the loss of a transmission line into the area (N-1) and the loss of a local Generator (G-1). While potentially difficult to believe at this point, this will be a factor to include in future Local area resource studies and the criteria for local Resource Adequacy capacity. The extreme case will be when DER in an area drives the net-load to zero.



2. Brief Description

The purpose of this use case is to describe how the ISO uses information about non-dispatchable Distributed Energy Resource (DER) to modify the ISO's system load forecast. This system load forecast is used by market systems to determine optimal unit commitment decisions to improve the operation of ISO markets and to provide essential information for real-time operations for supplemental energy dispatch and ancillary services requirements.

The goal of the use case is for the ISO unit commitment decision making to account for non-dispatchable distributed energy resources across a wide range of technologies.

3. Actors

Actor Name	*Actor Type (person, device, system, etc.)*	*Actor Description*
Master File	System	Source system for all market related registered data.
Load Serving Entity (LSE)	Organization	Load Serving Entity that is responsible to delivering energy to the customers in their area.
Energy Services Provider (ESP)	Organization	The energy entity that provides services to retail or end-use customers in the service territory of a utility distribution company.
CEC/CPUC/Utilities/DMV	Organization	California Energy Commission, California Public Utilities Commission, Utilities, and the Department of Motor Vehicles are candidate actors to send estimates of the PEV per geographic area to the ISO.
Weather Bank	Service	Weather forecasting service provider
Cloud Forecaster	System	Device that observes, analyzes and reports cloud cover for a specific area
Day-time Forecast Analyst (DFA)	Person	Monitor weather forecasts for real-time, hour ahead, day-ahead, and 2 days ahead and potential energy production from renewable resources and DER
ISO Forecasting System	System	ISO forecasting application that uses weather data and other measurement data to perform load forecasting, renewable generation forecasting, ramping & cycling requirement forecasting. The forecasting system inherently includes a feedback loop through which continuous learning is achieved in subsequent forecast runs.
Day Ahead Ancillary Service Requirement Calculation Tool	System	Calculates the required regulation and operating reserve based on adjusted forecasts.
Day Ahead Market Operator (DAMO)	Person	Day ahead Market Operator publishes the 10 day, 7 day, and 2 day ahead forecast for the market participants The Day Ahead Operator updates the Day Ahead forecast, reviews outages for market impacts, and setups the market system with the most updated parameters
Day-Ahead Market System	System	Integrated forward LMP market system for the procurement of energy and ancillary services while observing transmission network constraints
Real-Time Market System	System	Real-time market system for procurement of supplemental energy and ancillary services for balancing the system in real-time.
Real-Time Market Operator (RTMO)	Person	Monitors the real-time forecasts, renewables energy production and supplemental energy available for balancing the system in real-time.
End Use Customer	Person	Individual(s) in possession of DER devices.

4. Assumptions

1. Agreement on the entities and organizations required to provide required DER and PEV estimates by load area or geographical areas.
2. The ISO has received and mapped the potential PV and DERs to each of the major interconnection substations where load is being served.
3. Negligible penetration of wind as DER
4. Storage (non PEV) is used for power quality at the distribution level or if dispatchable, is visible to the ISO
5. Use of PEV as a special distributed storage device to respond to frequency variations or provide ancillary services is excluded in this use case

5. Preconditions

1. The ISO footprint contains a substantive amount of DER installed and in use.
2. The ISO has systems and data integration in place to handle the DER requirements.
3. DER penetration levels, aggregated at some level (e.g., LSE) will be provided to the ISO.
4. The ISO has received and mapped the potential PV and DERs to each of the major interconnection substations where load is being served.

6. Post conditions

1. The primary output for this use case is the integration of DER penetration and forecasted response levels for use in ISO commitment and dispatch decision making.
2. Daily assessment of the forecast error after the real-time operating hour and determination of what data contributed to the forecast error:
   a. the impact on real-time prices volatility
   b. whether or not the ISO over committed the amount of dispatchable generation that was needed
   c. the statistical spread or deviation error in the net load and DER forecast and the corresponding risk of not being able to serve customer load in an area

7. Flow of Events

7.1 Basic Flow: ISO Adjusts Forecast for DER and PEV Projections

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	LSE/ESP	ISO receives DER PV density (MWs) from LSEs per load/geographic area.	The frequency of the data update is not finalized (May be monthly, quarterly, twice a year)
2	Weather Bank	Provides weather related data such as temperature forecast, humidity, wind speed, direction, cloud coverage, etc.	

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..*
3	Cloud Forecaster	Provides cloud cover forecast information	
4	Day-time Forecast Analyst (DFA)	Day-time Forecast Analyst reviews the weather forecasts and cloud coverage information for at least the next two days. The DFA aggregates temperature forecasts from 3 weather forecasting services and determines the temperature profiles for each of the forecast areas.	
5	ISO Forecasting System	The ISO forecasting system receives all weather forecast, solar PV density, and produces • forecasts taking into consideration the effect of solar PV, (whether price sensitive or not) as well as any other **non** price-sensitive distributed energy resources • Ramping requirement forecast due to variability or intermittent nature of renewable and distributed energy resources.	

7.2 Alternative Flow A1: ISO Day-Ahead Market Utilizes the Adjusted Forecast by DER and PEV Projections

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 Forecasting System	The ISO forecasting system receives all weather forecast, PEV estimates, solar PV density, and produces • Day ahead forecasts taking into consideration the effect of solar PV, and PEV (whether price sensitive or not) as well as any other **non** price-sensitive distributed energy resources • Ramping requirement forecast due to variability or intermittent nature of renewable and distributed energy resources.	
2	DAMO / Day Ahead Ancillary Service Requirement	DAMO executes the day ahead ancillary service requirement calculation tool based on adjusted forecast to calculate the	

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..*
	Calculation Tool	required regulation and operating reserve.	
3	DAMO	DAMO reviews key input data for the day ahead market run (forecast, outages, inter-tie limits, nomograms, contingencies) and starts the execution of the DA market at 10:00am.	
4	DA Market System	DA Market application provides day ahead commitment decision, procurement of energy and ancillary services MW, day ahead LMP prices, ancillary service marginal prices, and shadow costs for binding inter-tie, network and nomogram constraints.	
5	DAMO	DAMO reviews the day ahead results and publish before 1:00pm	

Current work flow – 2010

ISO Operating Procedure M-401 describes the Day-Ahead Market procedure and how the forecast is used by the market system. A copy of the procedure is located on the ISO web site at: http://www.caiso.com/docs/2000/07/19/200007191535315040.pdf

7.3 Alternative Flow A2: ISO Real-Time Market Utilizes Adjusted Forecast by DER and PEV Projections and Impact of Price Sensitive PEV and DER on Real-time Operating Hour

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 Forecasting System	The ISO forecasting system receives all weather forecast, solar PV density, and produces • Real-time forecast taking into consideration the effect of solar PV, as well as any other **non** price-sensitive distributed energy resources • Ramping requirement forecast due to intermittent nature of renewable and distributed energy resources.	
2	Master File	Master file provides information about the price threshold setting for the price sensitive DERs to real-time market system.	This step assumes that such price thresholds are communicated to the ISO

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..*
			for those price/grid responsive DERs and PEVs that are capable of responding to ISO real-time pricing signals.
3	Real-Time Market System	Provides real-time commitment decisions, energy dispatch signals, additional real-time ancillary service procurement, real-time LMP prices, real-time marginal prices, and shadow costs for binding inter-tie, network and nomogram constraints.	The real-time market optimization will take into account the changes in the load due to the price/grid responsive DER and PEV
4	Real-Time Market Operator	Real time market operator reviews results before it get sent out automatically after review period completes.	The real time market operator must have the capability to prevent the results from published if necessary.

8. Requirements

#	Business Requirements	Associated Scenario #	Associated Step #
BRQ-001	ISO forecasting system shall calculate adjusted forecast to a certain granular level taking into account weather data, cloud coverage, and DER and PEV estimates.	7.1 7.2 7.3	6 1 1
BRQ-002	ISO forecasting system shall calculate forecasted ramping requirement due to intermittency of renewables and DER resources.	7.1 7.2 7.3	6 1 1
BRQ-003	Adjusted forecast taking into consideration DER shall be used in MPM and RUC runs of the day ahead market run. No forecast is used in IFM run.	7.2	4
BRQ-004	Adjusted forecast taking into consideration DER shall be used in all real time applications.	7.3	3
BRQ-005	Master file shall store market-only-resources to map to the price sensitive aggregate DER	7.3	2
BRQ-006	The real-time market optimization software shall consider the corresponding price threshold of price sensitive PEVs and DERs into the solution optimization to capture their impact on real time operation.	7.3	3
BRQ-007	The unit commitment optimization software shall consider dropping off/picking up price/grid responsive PEV and DERs based on the economics calculated based on the price threshold provided values in MF.	7.3	3
BRQ-008	The real time market software shall display the solution amount of price/grid responsive PEVs and DER for each time interval	7.3	3
BRQ-009	The price/grid responsive PEVs and DERs which are not bidding in the market shall not set the LMP at any of the intervals of the market run.	7.3	3
BRQ-010	The price/grid responsive PEV and DER will not be part of the ISO financially settlement process. No impact to settlement.	7.3	3

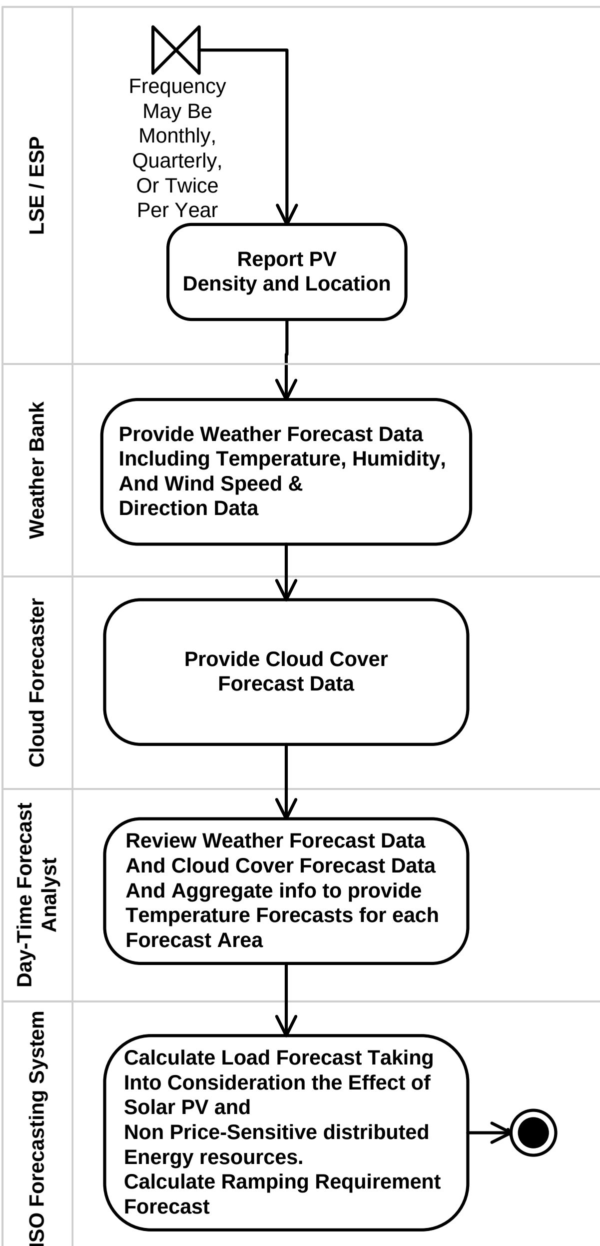
#	Non- Functional Requirements	Associated Scenario #	Associate Step #
NFR-001	The ISO market system shall be available 24X7X365 with an overall service availability of 99.9%	7.2 7.3	4 3
NFR-002	Forecasting data from third parties (such as the weather bank) shall be available 99.995% of the time utilizing appropriate transports, infrastructure and interfaces	7.1	3,4
NFR-003	Weather forecasts (including cloud cover forecasts) shall be provided to the ISO with a minimal degree of latency (specifics are TBD)	7.1	3,4
NFR-004	The ISO's market system shall record access, data creation/modification as well data receipt/publication by identity for audit purposes	7.2 7.3	4 3
NFR-005	The ISO's forecast system shall record access, data creation/modification as well as data receipt/publication by identity for audit purposes	7.1 7.2 7.3	6 1 1

#	Non- Functional Requirements	Associated Scenario #	Associate Step #
NFR-006	The ISO's forecast system shall be available 24X7X365 with an overall service availability of 99.995%	7.1 7.2 7.3	6 1 1
NFR-007	Audit data shall be available electronically to the ISO in predetermined formats within predetermined timeframes	7.1 7.2 7.3	6 1,4 1,3
NFR-008	Data exchanged between the ISO's systems and third party systems shall maintain its authenticity and integrity between the established source and destination	7.1	1,2,3,4

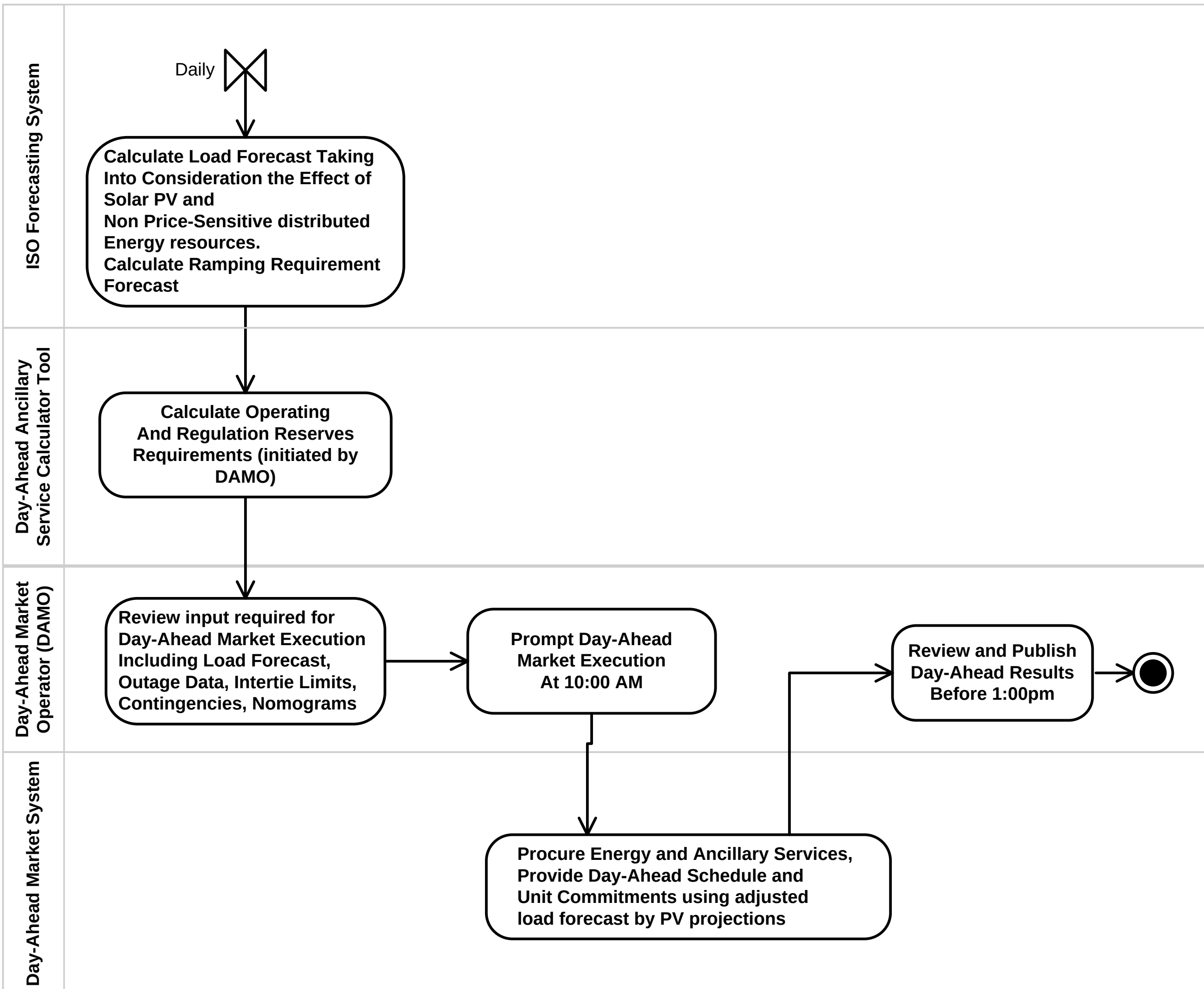
#	Business Rules	Associated Scenario #	Associate Step #
BRL-001	Grid/price responsive PEV and DER has no financial obligation to the ISO, since they are not part of the ISO markets.	7.3	3
BRL-002	The impact of grid/price responsive PEV and DER is considered in the market run for system reliability purposes therefore they don't set the LMP price.	7.3	3
BRL-003	Price threshold are a single price associated with the estimated value of PEV or DER.	7.3	2,3
BRL-004	Price threshold for the grid/price responsive DER and PEV are stored in Master File and can be updated based on existing update cycle of MF in production.	7.3	2

9. Activity Diagrams

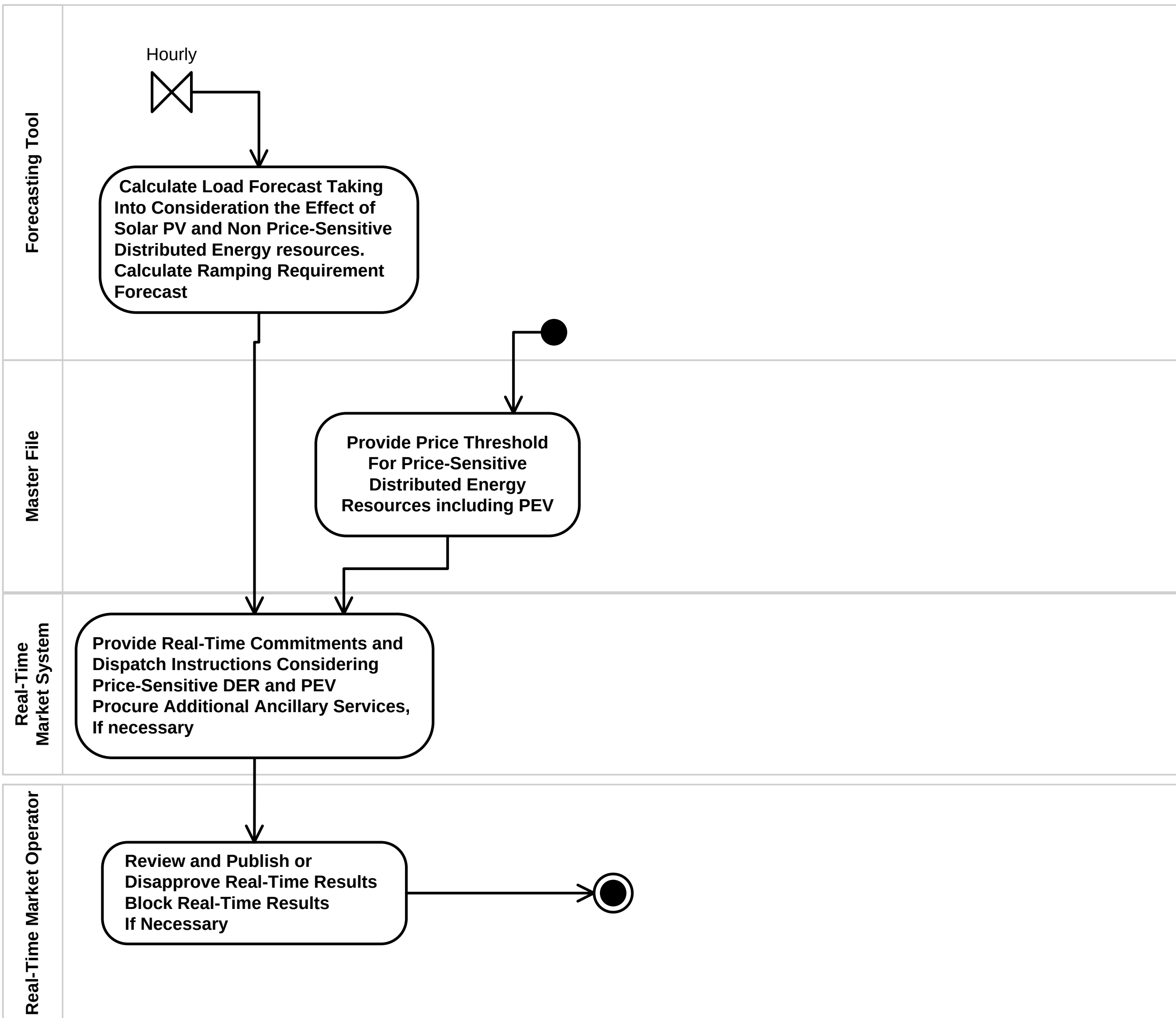
9.1 ISO Adjusts Forecast for DER and PEV Projections



9.2 ISO Day-Ahead Market Utilizes the Adjusted Forecast by DER Projections



9.3 ISO Real-Time Market Utilizes Adjusted Forecast by DER Projections and Impact of Price Sensitive PEV and DER on Real-time Operating Hour



10. Glossary

See [California ISO BPM for Acronyms and Definitions]