NEDO System Use Case #K1

Energy management by configuring a Virtual Microgrid using public communications where power is supplied to end-users while achieving simultaneous balancing of supply and demand

(NEDO KEEP Project)

Version 5.0

18 Nov, 2011

1 Descriptions of Function

1.1 Function Name

Energy management by configuring a Virtual Microgrid using public communications where power is supplied to end-users while achieving simultaneous balancing of supply and demand.

1.2 Function ID

System Level Use Case K1

1.3 Brief Description

This use case describes a "Virtual Microgrid (VMG)" that supplies power to end-users while achieving simultaneous balancing of supply and demand. "VMG" is a concept for specific distributed energy resources and power receiving facility to balance the total supply and demand in each time period (simultaneous balancing). Through construction of a VMG that includes renewable energy such as wind, PV and biomass, the use of these renewables can be maximized and the negative effects of output fluctuations on the commercial grid can be minimized.

In constructing a VMG, there may be cases where generation and loads are dispersed and located at great distances from each other. To achieve simultaneous balancing under such cases, it is desirable that the data entered into the system managing the simultaneous balancing (EMS) is time-stamped at the point of measurement. Also, it is possible to construct a cost-competitive VMG by employing existing public communications such as internet, thus avoiding building costly dedicated lines.

Technologies such as GPS can be used to generate measurement data with time stamps. Using public communications may present problems from the viewpoint of cyber security; however, these can be met by utilizing such technology as VPN (Virtual Private Network). In Japan, the concept of VMG was implemented by NEDO (New Energy and Technology Development Organization) in a demonstration project called "KEEP (Kyoto Eco Energy Project)" in Kyoto prefecture. The findings and knowledge obtained from this project form the basis for this use case. In KEEP, a Virtual Private Network ("VPN") was created by using public telecommunications (standard ADSL, ISDN connections to the public Internet).

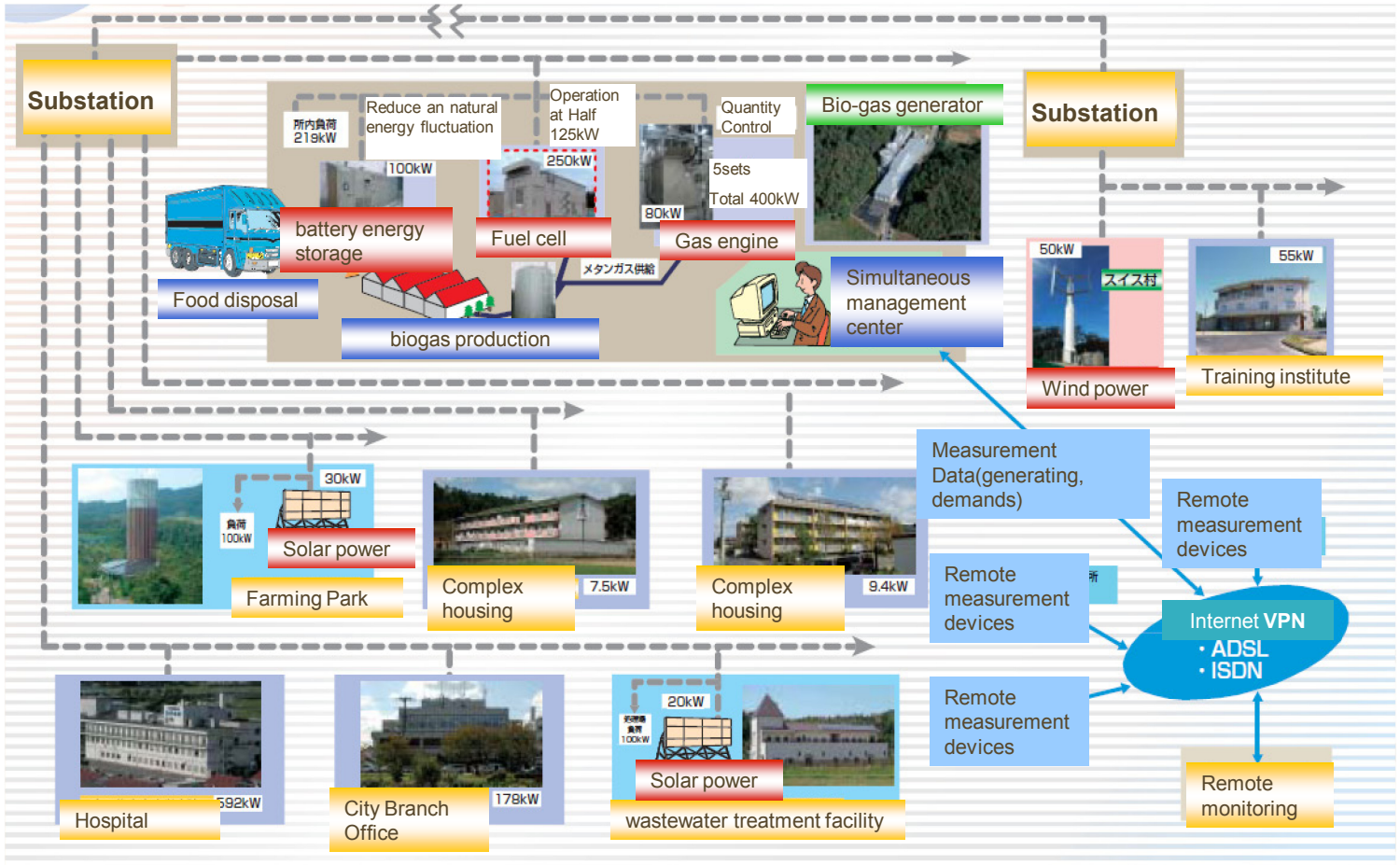

Fig.1. NEDO KEEP Project

1.4 Narrative

Because of intermittent output, generation from renewable energy sources (wind and photovoltaic) can have negative impacts on the operation of commercial grids. A VMG alone does not stabilize intermittent generation. But, in combination with other energy sources, it can provide a stable power supply to a specific area.

In order to achieve simultaneous power balancing between specific distributed generating equipment and power receiving equipment in a VMG, hourly time-stamped output data from each generating unit is collected at 10-sec. intervals via a VPN over public telecommunication lines and delivered to a communication server, where supply/demand imbalance is calculated. The resulting calculation is entered into the control system which implements simultaneous balancing (simultaneous balancing server and EMS) with minimum transmission delay (less than 10 sec.). At the EMS, on the other hand, the planned value for the operation of controllable generators is calculated. From this planned value and the calculation result at the communication server, the final output reference for the controllable generator (generation by biogas is assumed in this context) is calculated by the EMS, and the command is sent to the controllable generator. These functions of a VMG are described below in two stages.

◆**Stage 1: Development of generation and power purchase plan based on demand and generation forecasts**

Based on demand and generation forecasts, scheduling for controllable generators is developed by EMS. This stage is divided broadly into three steps, “long-term forecast,” “short-term forecast” and “scheduling.”

In the “long-term forecast” step, a rough forecast of load demand and generation for a week (48 times/day x 7 days) at 30-min. intervals is made based on the “weekly weather forecast” provided by a weather forecast service and historical demand data in the VMG.

In the “short-term forecast” step, a more accurate forecast than the long-term forecast is made for demand and intermittent generation output based on the “today and tomorrow’s weather forecast” provided by a weather forecast service and historical demand data in the VMG.

In the “scheduling” step, scheduling of controllable generators is conducted every half hour based on the results described above.

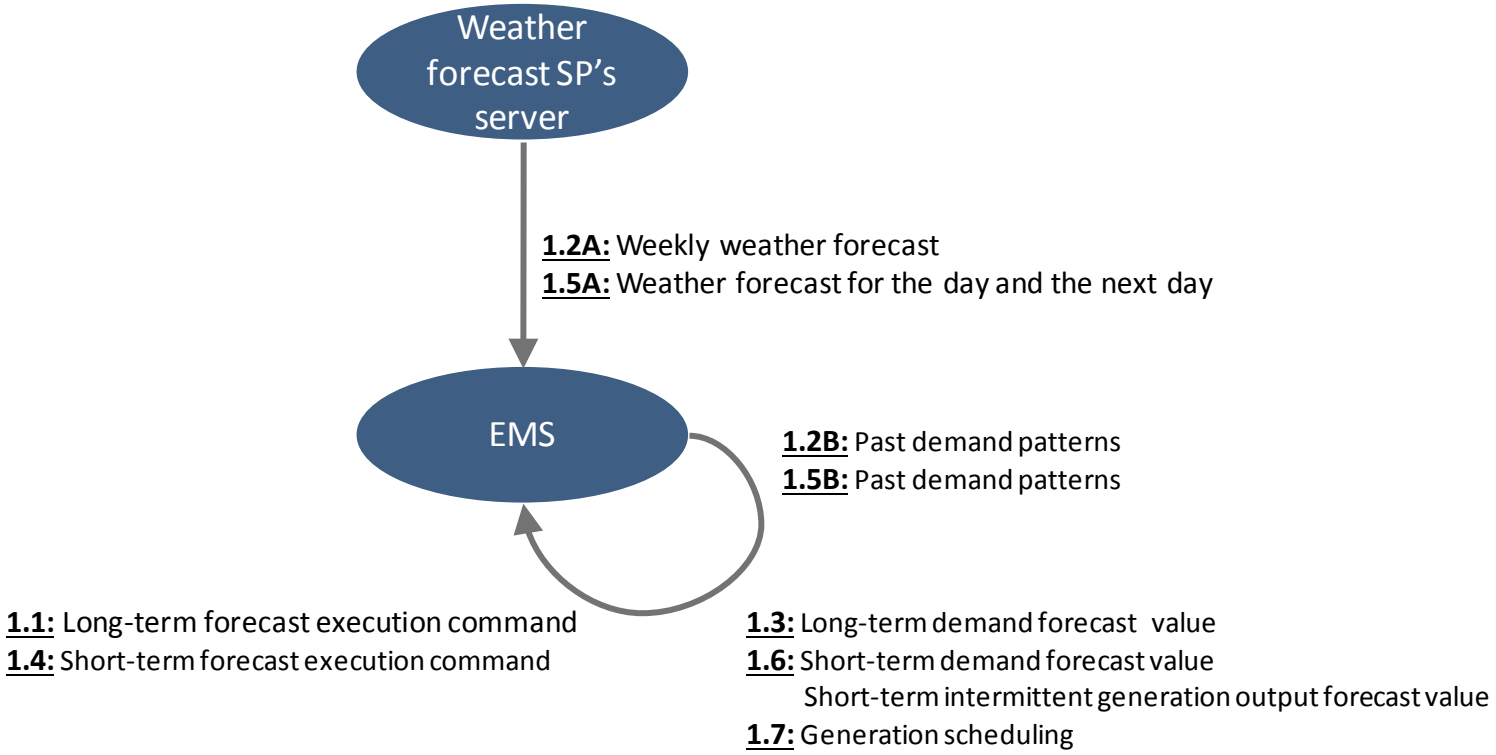

Fig.2. Diagram of Stage 1

◆Stage 2: Supply/demand control to achieve simultaneous balancing

The EMS controls supply of controllable generators to achieve simultaneous balancing based on the generation scheduling developed in Stage 1 and the real time measurement data obtained at the communication server. This stage is classified broadly into two steps, "real time measurement" and "real time reference value."

- Real time measurement: The communication server collects actual result data at 10-sec. intervals that are obtained from RTUs installed in end-customers' and/or generation facilities. These measurements are the data with time stamp of the sampling time. After sorting the obtained measurement data by time, the communication server calculates the imbalance between demand and supply within the VMG for each time.

- Generation of real time reference value: The EMS generates reference value for the operation of controllable generators based on generation scheduling developed in Stage 1 and the result of real time measurement, and transmits the command value to the controllable generator.

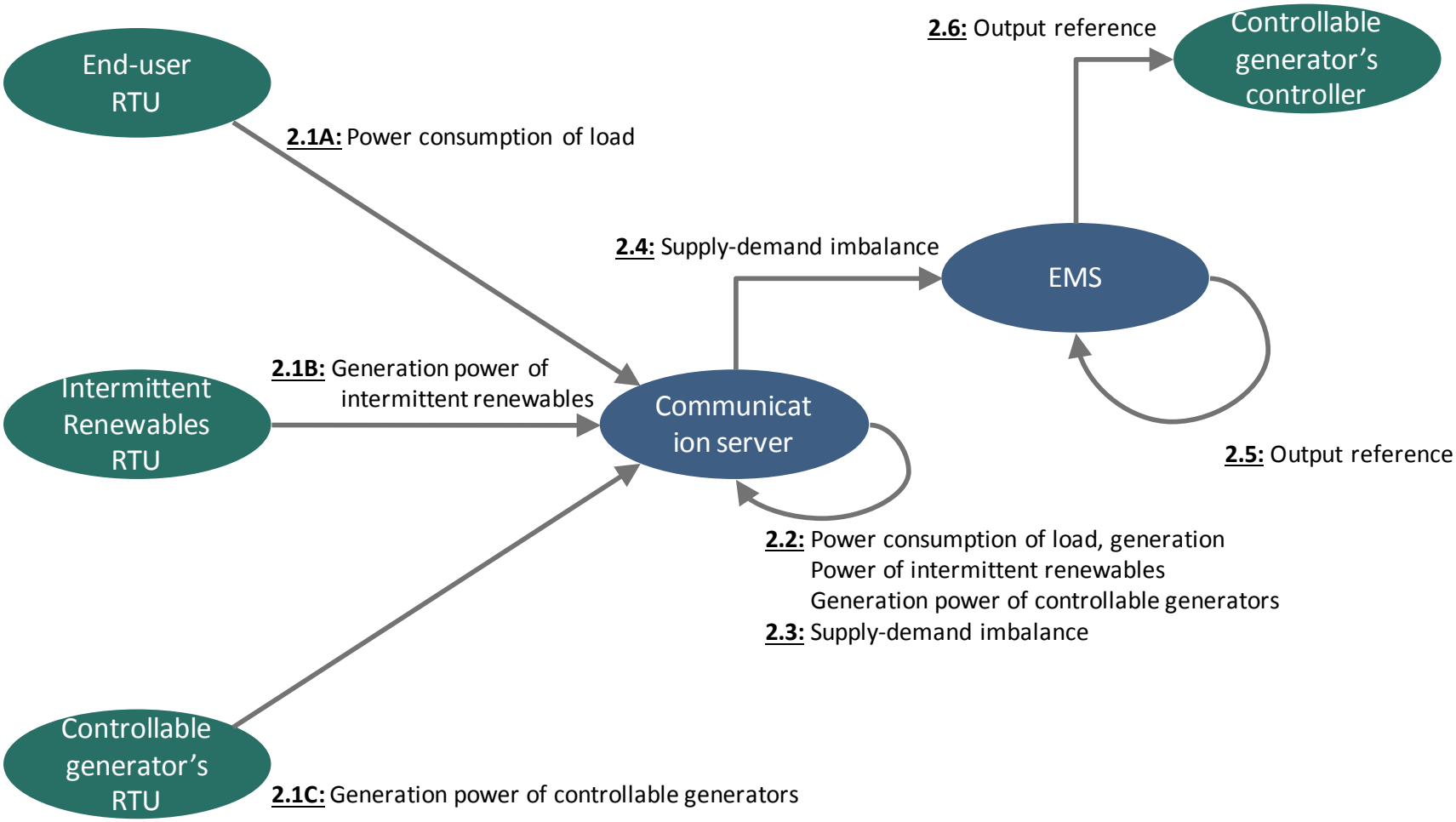

Fig.3. Diagram of Stage 2

1.5 Actor (Stakeholder) Roles

Grouping (Community)		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EMS (simultaneous balancing)	System	EMS, as the "heart" of the VMG, provides controllable generator's output reference to develop generation scheduling and achieve balance of supply and demand in the VMG.
Communication server	System	Communication server collects various measurement data from customer's power receiving facilities and organizes the data for each hour to calculate imbalances of supply and demand within the VMG. The calculated supply and demand imbalance is sent to the EMS.
End-user RTU	Device	End-user's RTU measures real time consumption data of customer's power receiving facilities. The RTU's clock is synchronized with other RTUs' clocks by GPS.
Controllable generator RTU	Device	This is the RTU that measures real time generation output of controllable generators. The RTU's clock is synchronized with other RTUs' clocks by GPS.
Controller for controllable generator	System	This controller for controllable generator receives output reference from EMS to control controllable generators.
Intermittent Renewables (PV, WT, etc.) RTU	Device	This is the RTU that measures real time generation output of renewables whose output cannot be adjusted (wind, PV, etc.).
Weather forecast SP server	System	Weather forecast information, which is indispensable for developing generation scheduling, is provided by a weather forecast service provider.

1.6 Information exchanged

Information Object Name	*Information Object Description*
Long-term forecast execution command	Long-term forecast of the day begins at 23:00 the previous day, following an issuance of the long-term forecast execution command at 23:00.
Short-term forecast execution command	Short-term forecast of the day begins at 23:30 the previous day, following an issuance of the short-term forecast execution command at 23:30.
Weekly weather forecast	Highest and lowest temperatures for each day of the week ahead.
Weather forecast for the day and the next day	Forecast temperature for each period of time (e.g. 30 min.) for 24 hours.
Past demand pattern	Database of past demand data.
Long-term demand forecast value	Long-term demand forecast value is a rough demand forecast for a week, prepared based on weekly weather forecast data and past demand pattern.
Short-term demand forecast value	Short-term demand forecast value, which is based on weather forecast for the day and the next day, is designed to be more detailed than the long-term demand forecast.
Short-term intermittent generation forecast value	Forecast of intermittent generation power output based on weather forecast for the day and the next day.
Generation scheduling	Generation scheduling for controllable generators which is calculated based on the long- and short-term demand forecasts.
Power consumption of load	Real time power consumption of load with time stamp.
Intermittent renewables generation power	Real time generation power of intermittent renewable such as wind power or PV, whose output is uncontrollable. Power data are attached with time stamps.
Controllable generators power	Real time generation power of controllable generators. Power data are attached with time stamps.

Information Object Name	*Information Object Description*
Supply-demand imbalance	Balance between supply and demand within the VMG that varies over time. Controllable generators must be controlled so as to eliminate the supply-demand imbalance.
Output reference	Output reference generated by EMS for controllable generators.

1.7 Activities/Services

Activity/Service Name	*Activities/Services Provided*
Long-term forecast	Conduct rough forecast of demand and intermittent generation output for each 30-min. period for the week ahead.
Short-term forecast	Conduct detailed forecast of demand and intermittent generation output for each 30-min. period for the next 24 hours based on the weather forecast data which are more accurate than the long-term forecast.
Generation scheduling	Prepare generation scheduling for controllable generator based on long- and short-term forecast, etc.
Real time measurement	Collect time-synchronized data for demand in the VMG, generation facilities, etc. and calculate hourly supply-demand imbalance within the VMG.
Real time generation of reference value	Generate real time reference value for controllable generator based on generation scheduling for controllable generators and supply-demand imbalance within the VMG.

1.8 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
Interconnection Agreement with local Distribution Utility	Contract is capacity-based.
Purchase Agreement with local Distribution Utility	Contract is capacity-based.

Contract/Regulation	*Impact of Contract/Regulation on Function*
	Logic in microcontroller must be customized when contract with utility changes.

2 Step by Step Analysis of Function

2.1 Steps to implement Stage 1 – Development of generation and power purchase plan based on demand and generation forecasts

2.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Weather forecast service provider	Weather forecast service provider provides "Weekly Weather Forecast" forecasting highest and lowest temperature for each day of the week ahead and "Weather Forecast for the Day and the Next Day" forecasting temperatures for each period of time of the day and the next day.
EMS	EMS stores past demand results as "Past Demand Patterns" in database.
Fuel tank system of controllable generator	Fuel tank of controllable generator contains sufficient amount of fuel.

2.1.2 Steps – Development of generation and power purchase plan based on demand and generation forecasts

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1.1	23:00 1-Day ahead	EMS	Command for long-term forecast	EMS starts the long-term forecast.	EMS	EMS	Long-term forecast execution command	To be executed daily at 23:00. (Once a day)

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1.2 A		EMS	Acquisition of weekly weather forecast information	EMS acquires weekly weather forecast information.	Weather forecast SP's server	EMS	Weekly weather forecast	
1.2 B		EMS	Reading of past demand patterns	EMS reads past demand patterns.	EMS	EMS	Past demand patterns	
1.3		EMS	Development of long-term forecast	EMS conducts long-term forecast based on weekly weather forecast and past demand patterns.	EMS	EMS	Long-term demand forecast value	
1.4	23:30 1 Day-ahead	EMS	Command for short-term forecast	EMS starts the short-term forecast.	EMS	EMS	Short-term forecast execution command	To be updated every 30 minutes.
1.5 A		EMS	Acquisition of weather forecast for the day and the next day	EMS acquires weather forecast for the day and the next day.	Weather forecast SP's server	EMS	Weather forecast for the day and the next day	
1.5 B		EMS	Reading of past demand patterns	EMS reads past demand patterns.	EMS	EMS	Past demand patterns	

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1.6		EMS	Development of short-term forecast	EMS conducts short-term forecast based on the weather forecast for the day and the next day and past demand patterns.	EMS	EMS	Short-term demand forecast value Short-term intermittent generation output forecast value	
1.7		EMS	Development of generation scheduling	EMS develops generation scheduling.	EMS	EMS	Generation scheduling	

2.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
EMS	EMS possesses generation scheduling of controllable generators.

2.2 Steps to implement Stage 2 – Supply/demand control to achieve simultaneous balancing

2.2.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
EMS	EMS possesses generation scheduling.
Communication server All RTUs	All RTUs involved in the VMG have a time synchronization function. Each RTU is in an environment where they can communicate with communication server to upload the information to the communication server.

2.2.2 Steps – Supply/demand control to achieve simultaneous balancing

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
2.1 A	On-going Monitoring Data by Communication server	Communication server	Acquisition of power consumption of load	Communication server acquires power consumption of load.	End-user RTU.	Communication server	Power consumption of load	
2.1 B	On-going Monitoring Data by Communication server	Communication server	Acquisition of generation power of intermittent renewables	Communication server acquires generation power of intermittent renewables.	Intermittent Renewables RTU	Communication server	Generation power of intermittent renewables.	
2.1 C	On-going Monitoring Data by Communication server	Communication server	Acquisition of generation power of controllable generators.	Communication server acquires generation power of controllable generators.	Controllable generator's RTU	Communication server	Generation power of controllable generators	
2.2		Communication server	Alignment of RTU data	Communication server organizes the data obtained from RTUs in chronological order.	Communication server	Communication server	Power consumption of load, generation power of intermittent renewables, generation power of controllable generators	
2.3		Communication server	Calculation of supply-demand imbalance	Communication server calculates supply-demand imbalance.	Communication server	Communication server	Supply-demand imbalance	

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
2.4		Communication server	Transmission of supply-demand imbalance to EMS	Communication server transmits supply-demand imbalance to EMS.	Communication server	EMS	Supply-demand imbalance	
2.5		EMS	Generation of Output reference of controllable generators	EMS generates output reference of controllable generators based on supply-demand imbalance and generation scheduling.	EMS	EMS	Output reference	
2.6		EMS	Output command	EMS transmits output command to the controller of controllable generator.	EMS	Controllable generator's controller	Output reference	

2.2.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
Controllable generator	Output is controlled so that controllable generator can achieve simultaneous balancing for a short amount of time, e.g. up to 10 minutes.
Entire VMG System	Simultaneous balancing of supply and demand for a short amount of time, e.g. up to 10 minutes, is achieved across the entire VMG system.

3 Auxiliary Issues

3.1 References and contacts

ID	Title or contact	Reference or contact information
[1]	The technologies supporting distributed energy system (in Japanese)	Fuji Electric Co., Ltd. http://www.fujielectric.co.jp/company/jihou_archives/pdf/78-06/FEJ-78-06-423-2005.pdf
[2]		

3.2 Action Item List

ID	Description	Status
[1]		
[2]		

3.3 Revision History

No	Date	Author	Description
0.0	8-26-2011	H. Irie H. Maejima	Draft for Review 1
1.0	9-18-2011	H. Irie H. Maejima	Draft for Review 2
2.0	9-20-2011	J. Reilly	Modified Draft

No	Date	Author	Description
3.0	9-30-2011	S. Nii T. Ohta	Review in terms of detailed description
4.0	10-17-2011	H. Irie H. Maejima	Update Draft
5.0	11-18-2011	J. Reilly H. Irie	Final Version