NEDO Local Level Use Case #L4

Equipment Control within Smart House by HEMS

1 Descriptions of Function

All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work should be so noted.

1.1 Function Name

Name of Function

Equipment Control within Smart House by Home Energy Management System (HEMS)

1.2 Function ID

Identification number of the function

Local Level Use Case 4.

1.3 Brief Description

Describe briefly the scope, objectives, and rationale of the Function.

Efficient management of residential customer energy demand and usage can be achieved through load management and the control of installed energy resources. This use case describes the process to control the energy resources such as PV/ES (Photovoltaic/Energy Storage), HP (Heat Pump Hot water storage) and Smart Appliances, in a Smart House.

In the first scenario, HEMS schedules the operation of distributed energy resources based on the forecasts of PV power generation and the learning of historical power consumption pattern and data.

In the second scenario, HEMS has the capability to emulate the equipment operation in Smart House automatically based on pseudo load pattern. This emulation of customer operated equipment is very much needed to take care of situations when Smart House is unoccupied. This situation is the present case in the Smart House demonstration. HEMS emulates operation pattern as if customer operates the equipment.

In the third scenario, HEMS manages demand response and controls the customer premises equipment upon receiving a Demand Response signal from μEMS via Smart Meter. In this case also, the equipment is under emulated conditions as described in scenario 2.

1.4 Narrative

A complete narrative of the Function from a Domain Expert's point of view, describing what occurs when, why, how, and under what conditions. This will act as the basis for identifying the Steps in Section 2. All actors should be introduced in this narrative. All sequences to be described in section 2 should be introduced in prose here. Embedded graphics is supported in the narrative.

This document describes the HEMS functions that regulate the customer energy consumption in the event of Demand Response request from μEMS, while providing the home comfort in the Smart House equipped with PVs on a large scale.

In the first scenario, HEMS enables the optimal scheduling of distributed energy resources (PV/ES) and HP. This function utilizes both forecast information for PV power generation and internal learning system output which is based on the analysis of historical operation of the energy equipment and Smart Appliances usage pattern.

In the scenario 2, HEMS enables automatic control of Smart Appliances when customers are not at home. The Smart House is equipped with Smart Appliances and Distributed Energy Resources but unoccupied.

Smart Appliances are controlled by HEMS based on pseudo load pattern, which is defined for a family of four persons and is generated manually by pre-formulation.

The appliances in Smart House are configured by :

- Distributed Air Conditioner (some times referred as HVAC (Heating, Ventilating, and Air Conditioning)) equipment in each room
- Multiple LCD TVs

- Two Refrigerators (Assume the same power consumption as that of the combination of a freezer and a refrigerator)
- Multiple LED lighting systems
- Dummy load system to simulate the other appliances in a typical house

However, in this scenario 2, Air Conditioner (HVAC) equipment is representative of major energy consuming actors of Smart Appliances due to their power consumption and real time control to provide home comfort.

In the scenario 3, HEMS demonstrates its ability to manage demand response by reacting to demand response signals from µEMS via Smart Meter. In this case, HEMS controls the distributed energy resources, HP and Smart Appliances in order to minimize the power consumption and relieve the Grid from peak demand loads.

HEMS Controlled Smart House

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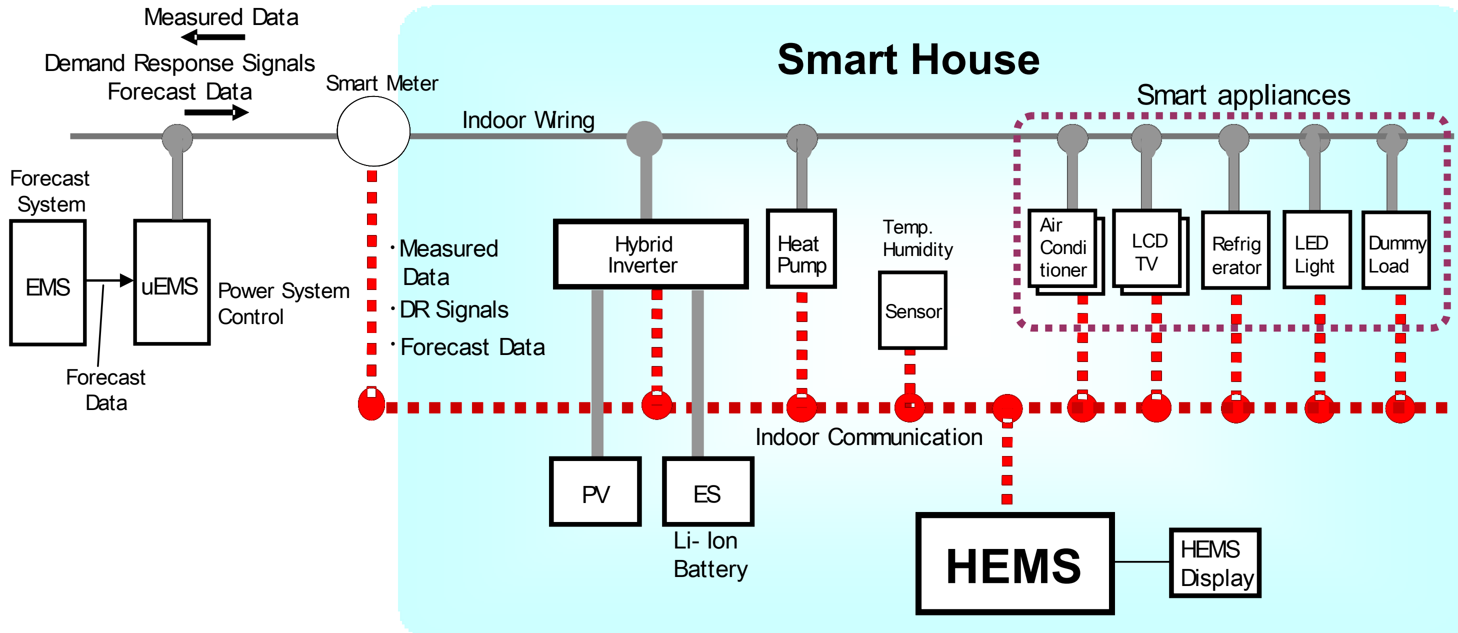

1.5 Actor (Stakeholder) Roles

Describe all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTO, RTU, IED, power system). Typically, these actors are logically grouped by organization or functional boundaries or just for collaboration purpose of this use case. We need to identify these groupings and their relevant roles and understand the constituency. The same actor could play different roles in different Functions, but only one role in one Function. If the same actor (e.g. the same person) does play multiple roles in one Function, list these different actor-roles as separate rows.

Grouping (Community) '		*Group Description*
Actors Functioning from Customer Premises		*Actors that perform their specific functions from the Customer premises*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
HEMS	Subsystem	Home Energy Management System has full set of control functions for energy resources (PV, ES) and HP as well as Smart Appliances. Also communication function is supported.
HEMS Display	Device	Display device displays the HEMS basic information / status such as consumption data, demand response condition to the HEMS operator.
PV	Device	Photovoltaic Panel for power generation from solar energy. (3.3kW)
ES	Subsystem	Energy Storage system consists of Li-Ion battery (24kWh). Charge/Discharge and ES power is controlled by Hybrid Controller (Controllable Inverter).
Hybrid Controller	Subsystem	Grid tied Controllable Inverter which handles PV generation and ES charge/discharge functions simultaneously. These functions are controlled by HEMS.
HP（Heat Pump Hot Water storage）	Subsystem	Hot water storage used to store the hot water operated by Heat Pump system.
Smart Appliances	Device	Home appliances such as Air Conditioners (HVAC), LCD TV, LED Lighting system, Refrigerator, Dummy load. All appliances are supported by communication capability of HEMS.

Replicate this table for each logic group.

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Grouping (Community) '		*Group Description*
The Utility Actors		*Actors that perform their specific functions as a part of the Utility*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
µEMS	System	Micro Energy Management System acts as a Utility electricity control center, is located at Utility facility. The µEMS is connected to each Smart Meter to send the demand control signals and receive the power usage information.
Forecast System	System	This subsystem predicts the weather conditions and PV power generation, and sends the forecast data to µEMS via internal network at the Utility facility.
Smart Meter	Subsystem	An electricity metering system capable of two-way communications between µEMS and HEMS.

1.6 Information exchanged

Describe any information exchanged in this template.

Information Object Name	*Information Object Description*
Demand Response signals	Pricing index and demand control information are provided to the Smart House via µEMS. These signals are transferred and exchanged through IEEE802.15.4 Wireless Interface. The data formats are defined based on ZigBee Smart Energy Profile Ver1.0 with private extensions. Contents of the data include: (1) TOU (Time of Usage) Table Pricing index at 30 minutes interval per day (48 Elements). These index enable to lookup the pricing information index in Price Table (2) Price Table Price Table (6 Index for indicate price) (3) DR Signal

Information Object Name	*Information Object Description*
	Indicate DR requests to HEMS from µEMS. This signal includes operation mode request (Normal/Emergency) as well as information to achieve reduction in the power consumption.
PV forecast data	PV output forecasts signal in kW. (Forecast system → µEMS → Smart Meter → HEMS)
Pseudo load pattern	A daily power consumption pattern helps HEMS to operate the appliances automatically. This pattern is pre-formulated manually.
Smart Meter Demand response signals Request	A command signal which requests to send the Demand Response signals.
Smart Meter Demand response signals Response	A response signal which indicates the Demand Response signals.
Mode Control Command	A command signal which requests the specific operation from the HEMS to the hybrid controller. - Mode0 : Reverse Power flow mode - Mode1 : Grid Power mode - Mode2 : Islanding Operation mode These mode control commands includes the specific power information for PV, ES and Grid.
HC Status request	HEMS requests the status of the power condition of PV/ES/Grid.
HC Status response	The hybrid controller returns the status to HEMS which include the power availability of PV/ES/Grid including SOC(State Of Charge) of the ES.
Boiling Command	A command signal to turn ON/OFF the boiling of water for HP
Status request of remainder of hot water	A status request to query how much hot water is remaining.
Status response of remainder of hot water	A status response indicating how much hot water is remaining.

Information Object Name	*Information Object Description*
Appliances control command	A command signal for appliances ON/OFF, temperature setting These signals are issued via IEEE802.15.4 Wireless Interface. The data formats are defined based on ZigBee Home Automation Profile with private extensions. Content of the data : (1) Power Control ON/OFF (2) Air Conditioning Mode Cool/Heat/Dehumidifying (3) Set Temperature Temperature setting value (4) Set Humidity Humidity setting value (5) Etc….
Status Report	Smart Appliances (Air Conditioner) returns the current status
Display data	A data set for graphical HEMS display

1.7 Activities/Services

Describe or list the activities and services involved in this Function (in the context of this Function). An activity or service can be provided by a computer system, a set of applications, or manual procedures. These activities/services should be described at an appropriate level, with the understanding that sub-activities and services should be described if they are important for operational issues, automation needs, and implementation reasons. Other sub-activities/services could be left for later analysis.

Activity/Service Name	*Activities/Services Provided*
Demand Response signals	The HEMS receives updated Demand Response signals every 30 minutes.

1.8 Contracts/Regulations

Identify any overall (human-initiated) contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues that affect the design and requirements of the Function.

Contract/Regulation	*Impact of Contract/Regulation on Function*
Utility Regulations	TBD

Policy	*From Actor*	*May*	*Shall Not*	*Shall*	*Description (verb)*	*To Actor*
Provide Energy	ESP			X	Provide power on demand	Customer

Constraint	*Type*	*Description*	*Applies to*

1.9 Terms and Acronyms

Term	*Definition*
Demand Response	The control mechanism to manage customer power consumption of Smart House. The Demand Response is generated by µEMS while current power consumption is beyond the planed consumption.
Demand Response signals	The control signals to reduce the power consumption of Smart House. The Demand Response signals are issued from µEMS to HEMS via Smart Meter.
Smart Appliances	Home Appliances which have capability to control to/from HEMS.
Hybrid Controller	Grid tied Controllable Inverter for PV and ES.
Smart Meter	An electricity metering system

Acronyms	*Definition*
HEMS	Home Energy Management System

Acronyms	*Definition*
PV	Photovoltaic
ES	Energy Storage
HP	Heat Pump Hot water storage
HVAC	Heating, Ventilating and Air Conditioning
μEMS	Micro Energy Management System
TOU	Time of Use
DR	Demand Response
HC	Hybrid Controller
SOC	State of Charge

2 Step by Step Analysis of Function

Describe steps that implement the function. If there is more than one set of steps that are relevant, make a copy of the following section grouping (Steps to implement function, Preconditions and Assumptions, Steps normal sequence, Post-conditions) and provide each copy with its own sequence name.

2.1 Steps to implement function – Scenario 1

Name of this sequence.

HEMS schedules the operation of the energy equipment

2.1.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	*Preconditions or Assumptions*
Forecast System	Forecasts PV generation
µEMS	Demand Response signals are generated by µEMS
Learning System	The energy usage pattern data collection and analysis is done by HEMS internal process

2.1.2 Steps – Name of Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot '.'. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
1.2A.1 - In parallel to activity 2 B do step 1
```

```
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 - Do step 2
```

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
#	*Triggering event? Identify the name of the event.*[1]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
1.1	µEMS sends demand response signals and PV forecast data to Smart Meter	µEMS	Demand response signals and PV forecast data to Smart Meter	µEMS sends demand response signals to Smart Meter which includes TOU/Price table based on µEMS demand forecasting. µEMS also sends the PV forecast data	µEMS	Smart Meter	Demand response signals and PV forecast data		

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

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
1.2.1	HEMS requests demand the response signals and PV forecast data to Smart Meter	HEMS	Requesting the demand response signals and PV forecast data	HEMS requests the demand response signals and PV forecast data to Smart Meter	HEMS	Smart Meter	Smart Meter Demand response signals Request and PV forecast data		
1.2.2	Smart Meter sends the demand response signals and PV forecast data to HEMS	Smart Meter	Smart Meter sends the demand response signals and PV forecast data	The demand response signals and PV forecast data are transferred to HEMS	Smart Meter	HEMS	Smart Meter Demand response signals Response and PV forecast data	HEMS checks TOU/Price table and PV forecast data. And store it into internal memory	
1.3.1	HEMS checks the SOC of the ES	HEMS	HEMS collect the energy remaining condition	HEMS checks the latest condition of ES SOC	HEMS	Hybrid Controller	HC status request		
1.3.2	Hybrid Controller response	Hybrid Controller	HEMS collects the energy remaining condition	Hybrid Controller sends the status to HEMS	Hybrid Controller	HEMS	HC Status response		

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
1.4.1	HEMS checks the level/volume of remaining hot water	HEMS	HEMS collects the energy remaining condition	HEMS sends Status request to enquire remaining hot water	HEMS	HP	Status request to enquire remaining hot water		
1.4.2	HP response	HP	HEMS collects the energy remaining condition	HP sends Status response on remaining hot water	HP	HEMS	Status response on remaining hot water		
1.5	Scheduling	HEMS	HEMS generates the schedule	Scheduling the energy resources (PV, ES) and HP usage	HEMS	HEMS	Schedule data		

2.1.3 Post-conditions and Significant Results

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

Describe any significant results from the Function

Actor/Activity	***Post-conditions Description and Results***
HEMS	HEMS stores the scheduled data internally for energy resources operation

2.2 Steps to implement function – Scenario 2

Name of this sequence.

HEMS operates Smart Appliances automatically.

2.2.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	*Preconditions or Assumptions*
Pseudo load pattern	Pseudo load pattern is pre-formulated manually in HEMS

2.2.2 Steps – Name of Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot '.'. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
```

```
1.2A.1 - In parallel to activity 2 B do step 1
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 - Do step 2
```

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
#	*Triggering event? Identify the name of the event.*[2]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
2.1	Timer (Every hour on the hour)	HEMS	Loading Pseudo load pattern from internal memory	HEMS loads the pseudo load pattern from its internal memory to control Smart Appliances	HEMS operator	HEMS	Pseudo load pattern		

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

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
2.2	HEMS sends Appliances control command to Smart Appliances	HEMS	HEMS sends the control command to Smart Appliances	HEMS controls Smart Appliances operation as if these are manually controlled.	HEMS	Smart Appliances	Appliances control command		

2.2.3 Post-conditions and Significant Results

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

Describe any significant results from the Function

Actor/Activity	*Post-conditions Description and Results*
Smart Appliances	Appliances are operating as a base load for demand response control

2.3 Steps to implement function – Scenario 3

Name of this sequence.

Appliances Control

2.3.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	***Preconditions or Assumptions***
Demand response signals	µEMS generated demand response signals to reduce the grid power consumption
Scheduling data	HEMS generated the operation schedule for energy resource (PV, ES) and HP
Learning data	HEMS updated historical energy consumption data and pattern of Smart Appliances
Smart Appliances	Smart Appliances are operating automatically by pseudo load pattern

2.3.2 Steps – Name of Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot '.'. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
1.2A.1 - In parallel to activity 2 B do step 1
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 - Do step 2
```

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
#	*Triggering event? Identify the name of the event.*[3]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
3.1	µEMS sends demand response signals to Smart Meter	µEMS	Generate demand response signals	µEMS decides to reduce the power consumption of demand side, and then sends demand response signals to Smart Meter	µEMS	Smart Meter	Demand Response signals		

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

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#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
3.2.1	HEMS request demand response signals to Smart Meter	HEMS	Requesting the demand response signals	HEMS sends the request for the demand response signals to Smart Meter	HEMS	Smart Meter	Smart Meter Demand response signals Request		
3.2.2	Smart Meter sends the demand response signals to HEMS	Smart Meter	Smart Meter sends the demand response signals	The demand response signals are transferred to HEMS	Smart Meter	HEMS	Smart Meter Demand response signals Response	HEMS checks the DR mode in the Demand Response signals whether µEMS request to reduce the power consumption	
3.3.1	HEMS checks the SOC of the ES	HEMS	HEMS collect the energy remaining condition	HEMS checks the latest condition of ES SOC	HEMS	Hybrid Controller	HC status request		
3.3.2	Hybrid Controller response	Hybrid Controller	HEMS collects the energy remaining condition	Hybrid Controller sends the status to HEMS	Hybrid Controller	HEMS	HC Status response		

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
3.4.1	HEMS checks the remaining hot water	HEMS	HEMS collects the energy remaining condition	HEMS sends Status request on remaining hot water	HEMS	HP	Status request on remaining hot water		
3.4.2	HP response	HP	HEMS collects the energy remaining condition	HP sends Status response on remaining hot water	HP	HEMS	Status response on remaining hot water		
3.5.1	HEMS sends Mode Control Command to Hybrid Controller	HEMS	HEMS switch Hybrid Controller operation mode	HEMS sets the operation mode to 0 to enable reverse power flow from PV or ES	HEMS	Hybrid Controller	Mode Control Command		
3.5.2	HEMS sends status request to Hybrid Controller	HEMS	Check the status of Hybrid Controller	HEMS checks the status of Hybrid Controller condition	HEMS	Hybrid Controller	HC Status request		
3.5.3	Hybrid Controller returns the status	Hybrid Controller	Check the status of Hybrid Controller	HEMS checks the status of Hybrid Controller condition	Hybrid Controller	HEMS	HC Status response		
3.6	HEMS sends Boiling Command to HP	HEMS	HEMS sends Boiling command to stop boiling	HEMS sends Boiling command to stop boiling if HP is operated	HEMS	HP	Boiling Command (Off)		

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environment
3.7	HEMS updates HEMS display	HEMS	Display the demand response operation	HEMS displays the process of demand response on the HEMS display	HEMS	HEMS Display	Display data		
3.8.1	HEMS updates Smart Appliances consumption	HEMS	HEMS sends Appliances control command to Smart Appliances	In order to reduce the consumption, HEMS controls Smart Appliances	HEMS	Smart Appliances	Appliances control command		
3.8.2	Smart Appliances response	Smart Appliances	Smart Appliances send Status Report to HEMS	Smart Appliances send Status Report to HEMS to reflect current condition	Smart Appliances	HEMS	Status Report	Reduce power consumption of Smart Appliances	

2.3.3 Post-conditions and Significant Results

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

Describe any significant results from the Function

Actor/Activity	*Post-conditions Description and Results*
Energy equipment	Stop charging and Reverse power flow if possible
Smart Appliances	Operating with Reduced power consumption

2.4 Architectural Issues in Interactions

Elaborate on all architectural issues in each of the steps outlined in each of the sequences above. Reference the Step by number. Double click on the embedded excel file – record the changes and save the excel file (this updates the embedded attachment).

FUTURE USE

2.5 Diagram

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the Steps where possible.

FUTURE USE

3 Auxiliary Issues

3.1 References and contacts

Documents and individuals or organizations used as background to the function described; other functions referenced by this function, or acting as "sub" functions; or other documentation that clarifies the requirements or activities described. All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work must be so noted.

FUTURE USE

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

3.2 Action Item List

As the function is developed, identify issues that still need clarification, resolution, or other notice taken of them. This can act as an Action Item list.

FUTURE USE

ID	Description	Status
[1]		
[2]		

3.3 Revision History

For reference and tracking purposes, indicate who worked on describing this function, and what aspect they undertook.

FUTURE USE

No	Date	Author	Description
1	12-15-2010	K. Kiuchi	Initial draft
2	1-20-2011	K. Kiuchi	Revise descriptions by 1st Review In Scenario 1, add additional steps for monitoring the status of each equipment. Add interface specification in "information exchanged" section for intercompany communications (Smart Meter to HEMS, HEMS to Smart Appliances) Change signaling path via Smart Meter for PV forecasting data Corrections and cleanup for Actors, Information Exchanged and Steps
3	5-16-2011	K. Kiuchi	Corrections and cleanup