AMI Use Case:

D1 - Distribution Operations curtails customer load for grid management

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Author: Robert Yinger

Document History

Revision History

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Approvals

This document requires following approvals.

Name	Title
Robert Yinger	*Mega-Team Lead*
Russ Neal	*Use Case Team Lead*
Kevin Wood	*System Architecture Team Chair*
Charles Vincent	*Engineering Team Chair*

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1. Use Case Description

1.1 Use Case Title

Distribution Operations curtails customer load for grid management

1.2 Use Case Summary

A customer is enrolled in a non-price responsive demand-side grid management program (possibly in exchange for reduced tariffs). This program allows the utility to request an automated load reduction at the customer site. The customer can override the request in exchange for a possible penalty charge. At least two levels of advanced warning are envisioned:

- Predicted energy shortages (long term – 24 hours, and short term - a few hours notice – these two cases do not develop any different requirements for the AMI system, but might cause the customer to respond in different ways)
- Emergency shortage (for example, a few minutes notice with no possibility of opting out)

The utility will measure (using data from the customer meter) the aggregate load reduction and possibly issue additional reduction requests. The actual load reduction could be fed back into a model used to determine the extent of future load reduction requests. The AMI system will provide a premise gateway component that may or may not be incorporated into the meter itself. The premise gateway will forward curtailment messages to customer equipment capable of receiving it. This equipment may be a sophisticated Energy Management System, a Programmable Communicating Thermostat, Load control devices directly attached to controllable equipment or a simple display at the customer premise. The premise gateway may or may not be used to return device status and logging information back to the utility on an individual or aggregate basis.

This use case leverages AMI components to improve the reliability of the distribution grid during periods when its ability to deliver power to customers is constrained by either supply or available paths. The use of AMI system components greatly enhances the utilities curtailment capabilities while at the same time reducing the impact of system constraints on customers. This curtailment capability can be used to allow delay of upgrades to power system components. The detailed data collected by the AMI system regarding customer compliance and actual load reduction allow the utility to better predict curtailment request responses and therefore limit the scope of customer asked to curtail. The ability of the system to allow customers to opt out is critical to enrollment in voluntary programs. At the other end of the spectrum, its ability to ensure curtailment through the service disconnect option provides the certainty required by operators to avoid more draconian measures required to avoid or minimize outage scope or duration. In periods of extreme system duress using curtailment instead of rolling blackouts, allows power to remain available to retail stores, hospitals, traffic lights etc which reduces liability and lost business for commercial and industrial customers. The load limiting capability of the service disconnect switch would likely also allow residential customers to maintain lighting loads enhancing safety and security, but would constrain the customer's ability to utilize unessential loads like pool pumps, electric stoves and HVAC systems.

Further, Granularity in load curtailment allows for continuation of revenue to the utility. In case of partial curtailment, revenue will still be generated from the customers whose load is not curtailed

1.3 Use Case Detailed Narrative

1) At the onset of a day where the weather is forecast to be extremely hot or cold or when it is known the possibility exists for a system emergency, the System Modeler runs models to determine where and when times of peak demand will occur. This modeling involves clearly defined parameters such as weather, tracked seasonal load, load availability factors, and customer load served by the transmission and/or distribution system. It is determined that due to maintenance issues or the location of some loads in relation to the infrastructure, the available amount of bulk power and or the transmission capacity is constrained. This results in the probability of a peak demand event that will require reduction of a certain amount of customer load.

(2) Under normal operating conditions, the utility provides from two to twenty four hours notice to the customer that load reduction is required and will occur. In a system emergency only a few minutes notice is provided. Typical emergencies considered would be the result of a generator tripping offline, lightning strikes on critical infrastructure components, or some other event causing the transmission and/or distribution infrastructure to be overloaded or unavailable, The utilities existing system will notify utility personnel and the AMI system. The AMI system will provide mechanisms to deliver the signal to the customer's equipment. The notification signal can then be used by customer user interface equipment (e.g. a light on a thermostat, the orb, etc.) capable of receiving and processing the signal

(3) When the peak demand period is about to begin or when the system emergency occurs, the utility control center sends a command via utility's communications infrastructure (internal, leased, or public) that is received by intermediate utility equipment or directly by customer load control equipment. The system operator can target individual regions or specific customers to address the amount of load reduction required and the operational situation of the utility system. If intermediate utility equipment is used (such as a smart meter acting as a communications gateway), the commands are relayed to the load control device. Commands such as "Thermostat Setback," "Turn Off A/C Unit," and "Check Transponder Health" are representative of the commands to be sent out. The intermediate equipment and/or load control equipment has auditing capability to determine whether the signals were received and if the load control action was successful. The utility can download data from the smart meter, home gateway and other audit information sources to determine system health and to validate the models used to predict system operation, peak demand, and needed load reduction.

(4)The load control equipment interfaces with thermostats, water heaters, swimming pool pumps, and other load equipment. The customer equipment is located at both residential and commercial locations and was selected for its predicted load patterns and ease of remote control. This use case assumes the applicable tariff will allow customers to choose to override the signal, but they will pay a penalty if they do so.

(5)The utility verifies customer participation via acknowledgement of a successful "Turn Off" command. After each instance of load reduction, the utility conducts an assessment of how many MW of load was reduced and uses this information, along with a review of the command logs and receipt of successful "Turn On" and Turn Off" commands to refine the model used to ascertain when the load control programs need to be activated, how it needs to be implemented across the service territory, and operating condition of the communications and control equipment.

1.4 Business Rules and Assumptions

- Customer in the sense of this use case is a customer with grid connection less than 200 KW
- Demand side management program exists.
- Infrastructure has been put in place to implement automated load control.
- This scenario takes place during normal and emergency power system operations where some customers have contracted to receive and respond to load control signals
- These customers have electric appliances that can be remotely controlled and shut off. For example, space cooling and/or heating and/or electric water heaters and/or pool pumps .
- Tariffs and associated programs will need to be developed to define appropriate use of the disconnect switch for grid management.
- This use case assumes that the customer can override a non emergency curtailment request, but that they cannot override an emergency curtailment request. It is our belief based on industry studies that customers will more readily sign up for demand management programs they offer an override capability whether the customer ever actually exercises it or not.
- An emergency curtailment is one resulting from an event that current practice would dictate responding with a rolling blackout.

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
California Independent System Operator (CAISO)	Agency	Controls the California transmission grid
Grid control center (GCC)	System	GCC operates the SCE transmission grid and measures the load at the customer site
Energy Management System (EMS)	System	System that controls customer equipment. It has the ability to measure load of various pieces of equipment and control their operation.
Load reduction model system	System	A system that supports the development, maintenance and analysis of models to predict load reduction available based on the past load data and customer behavior.
Distributed Resource Availability and Control System (DRAACS)	System	A system that collects detailed information about customer loads and customer response patterns. It also maintains information regarding the number of times a customer has complied in a given time period vs the compliance requirements of the tariff applicable to that customer. This information is brought together for the user so that the user can see what probable load is available to be curtailed in total and at various points in the network. The system will also receive and process requests for curtailment and will balance the requests across subscribers based on load, and how recently they have been curtailed.
Customer Equipment	System	Equipment directly connected to load devices capable of receiving curtailment signals and carrying out the requests or otherwise responding to them. Would also include an Energy Management system described above.
Meter	System	Device for collecting and recording energy usage
Premise Gateway	System	Device for receiving signals from utility systems over utility owned equipment (or equipment operated on behalf of the utility) and forwarding that information to Customer equipment over a customer network or common carrier.

Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
Edge Data Center Aggregator	System	Handles collection of information from all field and premise equipment via the Neighborhood Aggregator
Neighborhood Aggregator	System	Handles collection of information from all associated field and premise equipment.
Customer	Person	Is responsible for load reduction at the home/ business
System Management Console	System	Monitors the AMI remote provisioning functions, control and diagnostics

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: Load limit for grid management

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)*
Electrical system is overloaded or there is a lack of available generation resources	*Customer*	*Customers have signed up for load curtailment for grid management*	*All customer load is restored*

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..*

Step #	*Actor*	*Description of the Step*	*Additional Notes*
1	Grid Control Center	Grid Control Center issues signal to limit load to customer contract amount via DRAACS. The signal may require an immediate curtailment, or be scheduled.	
2	Premise Gateway	Premise Gateway receives signal. from DRAACS and forwards it to customer's equipment	
3	Customer's Equipment	Customer equipment gets notification of the scheduled curtailment	
4	Premise Gateway	Premise Gateway resends signal at scheduled start of event to meter and Customer's equipment	
5	Customer's Equipment	Customer equipment is informed of the compliance status	
6	Customer's Equipment	Customer equipment reduces demand to bring down the load within the grace period	
7	Meter	After the grace period, the meter checks the load at the customer site against the curtailment threshold as per the subscription	
8	Meter	If actual load > subscribed threshold, load curtailment takes place via the meter disconnect	
9	Customer	Customer reduces potential load	Assume that automated handling is not an option since power is out, For example, EMS system would probably be unpowered.
10	Customer	Customer requests power back	
11	Meter	Disconnect closes	
12		Go to step # 5 (Main Scenario)	
13	Grid Control Center	Curtailment period ends	
14	Customer's Equipment	Customer's equipment restores load with minimal impact to the network	

3.2 Alternate Primary Scenario: Emergency Curtailment (in lieu of Rolling Blackout)

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)*
Electrical system is overloaded or there is a lack of available generation resources that would normally trigger a rolling blackout	*Customer*		*All customer load is restored*

3.2.1 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	Grid Control Center	Grid Control Center issues signal to limit load to customer contract amount via DRAACS. The signal may require an immediate curtailment, or be scheduled.	

Step #	*Actor*	*Description of the Step*	*Additional Notes*
2	Premise Gateway	Premise Gateway receives signal. from DRAACS and forwards it to customer's equipment	
3	Customer's Equipment	Customer equipment gets notification of the scheduled curtailment	*There is no option for customer to override curtailment or opt out.*
4	Meter	The meter checks the load at the customer site against the curtailment threshold as per the request.	
5	Customer's Equipment	Customer equipment is informed of the compliance status	
6	Customer's Equipment	Customer equipment reduces demand to bring down the load within the grace period	
7	Meter	After the grace period, the meter checks the load at the customer site against the curtailment threshold as per the subscription	
8	Meter	If actual load > subscribed threshold, load curtailment takes place via the meter disconnect	
9	Customer	Customer takes steps to configure their load so that its stable draw is less than the threshold.	Assume that automated handling is not an option since power is out, For example, EMS system would probably be unpowered.
10	Customer	Customer requests power back	
11	Meter	Disconnect closes	
12	Grid Control Center	Curtailment period ends	
13	Customer's Equipment	Customer's equipment restores load with minimal impact to the network	

3.3 Alternate Scenario: Customer opts out of curtailment for Grid Management.

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)*
Customer decided not to curtail load as requested	*Customer*	*Customer has been asked to reduce load for grid management* *This is not an emergency curtailment.* *Scenario 1 steps 1 through 4 have taken place.*	*Customer load remains energized*

3.3.1 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..*
3.3.1	Customer Equipment	Customer opts out of curtailment by sending a non curtailment message to the meter.	
3.3.2	Premise Gateway	Premise Gateway logs the customer override to be reported with standard read schedule	
3.3.3	Premise Gateway	Premise Gateway forwards logs to System Management Console on scheduled basis	
3.3.4		No curtailment at customer site.	

3.4 Alternate Scenario: Load at the customer site is already below threshold

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)*
Customer load is already below curtailment threshold	*Customer*	*Customer has been asked to reduce load for grid management* *This scenario applies to both normal curtailments and emergency curtailments* *Scenario 1, steps 1 through 4 have taken place.*	*No change in customer load curtailment*

3.4.1 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..*
4.1.1	Meter	Load at the customer site is already below threshold.	
4.1.2		No curtailment at customer site.	

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

Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
Meter shall support communication with DRAACS for the purpose of receiving curtailment requests	1	2,3,4
Meter shall support two way communications with in home display / load control system in order to communicate with the customer about the curtailment request related events	1 2	3 1
Meter or some other device shall be the gateway for communication to the customer load control equipment.	1	2, 4
Customer shall be notified via pager, cell phone, standard telephone, or customer in-home display if he is being asked for load control .	1	3,4
Meter shall support the remote upgrade of curtailment and load restoration algorithms for the purpose of correcting defects and apply improvements to algorithm behavior. The curtailment and load restoration logic function may also be located at some central point.	1	
If the meter receives no message for load restoration before the curtailment time specified in the curtailment initiation message, the curtailment will be allowed to expire.	1	12
Meter shall record the demand in KWh – see NFR1	1	6
In case of a hardware failure, meter shall allow the curtailed loads to go back to their default status (Fail safe)	1	12
Meter shall be individually addressable.	1	2
Meter shall be able to communicate load control messages to a load control switch.	1	5

Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
Load data from meter shall be provided on demand.	1	6
Meter shall provide information to the GCC through DRAACS on how much load is available for load control.	1	1
Meter shall support a curtailment override option at the customer site for non-emergency events. This override function can be implemented through the use of a button/ data link to the meter directly or indirectly through communications with the neighborhood aggregator or edge data center aggregator	2	1
Meter shall support multiple subscription programs.	1	7
Meter shall be coupled with the customer account for individual addressability.	1	2
Grid control center operator shall know how much controllable load is available on a feeder. This information shall be made available through the DRAACS.	1	1
Grid Control Center shall differentiate between subscribed and non subscribed customers. This information shall be made available through the DRAACS.	1	1
Deleted this functional requirement since it duplicative of FR #4. ~~Meter shall provide pre-event notification of the curtailment to the customer through pager, cell phone, standard telephone, or customer in-home display.~~	1	3,4
Meter shall support two types of messages for, • Load control that can be overridden. • Load control that cannot be overridden.	1	3,4
If the customer load is above the agreed level (demand limit), the meter shall open the disconnect switch.	1	4,7
Meter needs to log receipt of the curtailment request from DRAACS Log : - time of day (from the meter's clock) - message received	1	2

Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
Meter shall log its attempt and success/failures of the delivery of the curtailment request to the load control devices. Log : - time of the day (from the meter's clock) - success - failures - Message content or code number - ID of device being addressed **(assumption : meter = gateway)**	1	7
Meter shall log customer override request. Log : - time of day (from the meter's clock) - override command - Message content of code number	2	1
Meter shall log non-compliance with curtailment request after grace period (load > threshold). Log : - time of day (from the meter's clock) - load level above threshold - Message content of code number	1	7
Meter shall monitor compliance with the curtailment request as long as the load control event is in progress	1	11
Meter shall be capable of receiving and storing at least two different curtailment requests (See NFR 4, FR 19)	1	3
Meter shall support an on demand read by DRAACS of curtailment events	1	2
The local display device (either meter display or in-home device) shall be updated with the compliance status (load vs. curtailment threshold) periodically and with the time the customer has to comply (expiration of grace period) (assumption – local display device exists**)**	1	4
The customer shall only be able to override curtailment requests related to predicted energy shortages	2	1

Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
The notification of the curtailment request on the meter or in-home display device shall differentiate between predicted (override available) and emergency (no override) energy shortage curtailment requests	1	3
Meter shall provide a mechanism to initiate a reconnect after an "involuntary" curtailment has taken place via the disconnect switch	1	9
The meter shall be capable of limiting the number of reconnect requests by the customer after an involuntary curtailment.	1	9
The curtailment request shall include - time of the day - expected duration of curtailment - level which load is to be curtailed to (from contract) - time at which curtailment is to start	1	2, 3
A curtailment end message may be received so that the curtailment can be ended earlier than specified in the original request. In this case, the curtailment ends when the message is received. Customer load is then restored through the load control devices.	1	12

4.2 Non-functional Requirements

Non-Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
Meter shall record data periodically in the range of 5 min to 60 min.	1	6
Load available for load control shall be based on the statistical models fed by historical data from meter. This calculation shall be done by DRAACS.	1	1
Pre – event notification shall range from one minute in an emergency up to 24 hours for normal load reduction requests.	1	3

Non-Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
The grace period allowing the customer to reduce load after reception of a curtailment request shall be 1 hr for predicted energy shortages and 1 min for emergency shortages	1	6
A curtailment request from GCC through DRAACS shall be delivered to the meter in less than 1 min at the highest priority	1	2
The load level at the customer meter shall be calculated using an averaging interval that prevents hunting around the threshold, expected to be around 1 min (See FR 24)	1	7
The log of the reception of the curtailment request from DRAACS at the meter shall be reported to DRAACS in : - less than a week for system auditing - 24 hrs for compliance evaluation (See FR21)	1	2
The on demand read of curtailment events by DRAACS shall be returned to DRAACS in less than 5 min (See FR27)	1	2
The meter shall compare compliance of load versus curtailment threshold at least at a rate equivalent to the averaging interval for measured kW (See FR24, FR25)	1	7,11
Update of the meter or in-home display with the compliance status shall be at interval of less than 5 sec (See FR28)	1	5
Meter shall support a minimum of 5 power back requests by the customer for any curtailment event (See FR31)	1	9
The minimum time between the opening of the disconnect switch because of a curtailment request and the close of the switch after a power back request shall be in the range of 1 to 2 minutes (See FR31)	1	10
The meter shall support from 10 to 100 curtailment requests during 1 year. This would be the equivalent of 150 to 1500 curtailment requests during its life cycle	1	1
The meter shall support upgrade of algorithms for curtailment or load restoration at least 30 times over the life of the meter / premise gateway. (See FR5)	1	2
Upgrades of algorithm for curtailment or load restoration shall be possible within 5 days after the last upgrade.	1	2
Load control time ranges from 30 min to 360 min/day	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

Scenario #	*Step #, Step Name*	*Information Producer*	*Information Receiver*	*Name of information exchanged*
#	*Name of the step for this scenario.*	*What actors are primarily responsible for Producing the information?*	*What actors are primarily responsible for Receiving the information?*	*Describe the information being exchanged*
1		DRAACS	Premise Gateway	Curtailment Request
		Premise Gateway	In Home Display	Curtailment Request
		Premise Gateway	Customer Equipment	Curtailment Request
		Meter	DRAACS	Compliance Status
		System Management Console	Meter, Premise Gateway	Program Updates
		Meter	DRAACS	Load
		Customer Equipment	Premise Gateway	Override Request
		DRAACS	Customer Phone, Pager	Curtailment Request
1	1	GCC	DRAACS	Curtailment Goal
1	2	DRAACS	Premise Gateway	Curtailment Request

Scenario #	*Step #, Step Name*	*Information Producer*	*Information Receiver*	*Name of information exchanged*
1	4	Premise Gateway	Customer Equipment	Curtailment Request
1	10	Customer	Premise Gateway	Service Restoration Request
2	1	GCC	DRAACS	Curtailment Goal
2	2	DRAACS	Premise Gateway	Curtailment Request
2	5	Premise Gateway	Customer Equipment	Curtailment Request Affirmation
2	10	Customer	Premise Gateway	Service Restoration Request
3	3	Premise Gateway	Edge Data Center Aggregator	Curtailment Logs

5.2 Diagrams

The architecture team shall use this section to develop an interaction diagram that graphically describes the step-by-step actor-system interactions for all scenarios. The diagrams shall use standard UML notation. Additionally, sequence diagrams may be developed to help describe complex event flows.

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.

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**

8. References

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

Intelligrid Use Cases 51. and 5.1.2 "RTP-Demand Response Load Control Non-Price Responsive" and "Demand Response - Utility Commanded Load Control"

OpenAMI Use Case 4 "Distribution Operator Curtails Customer Load"

9. Bibliography (optional)

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

Advanced Meters and Dynamic Pricing In California, Implementing a Vision for The Future, William J Keese.