Energy Research and Development Division
FINAL PROJECT REPORT

# POLICY RECOMMENDATIONS FOR THE INTERFACE BETWEEN CUSTOMER EQUIPMENT AND THE UTILITY ADVANCED METERING INFRASTRUCTURE TO FACILITATE DEMAND RESPONSE

Prepared for: California Energy Commission
Prepared by: L'Monte Information Services, Inc.


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# PREFACE

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*Policy Recommendations for the Interface Between Customer Equipment and the Utility Advanced Metering Infrastructure to Facilitate Demand Response* is the final report for the Requirements Engineering for the Advance Metering Infrastructure and the Home Automation Network (AMI-HAN) interface project (contract number 500-99-013, work authorization number 181-P-07 conducted by L'Monte Information Services). ]. The information from this project contributes to Energy Research and Development Division's Energy Systems Integration Program

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# ABSTRACT

The goal of this research project was to identify policy guidelines for the interface between California investor-owned utilities advanced metering infrastructure systems and California residential electricity customers and their equipment that promote the success of demand response--a critical component of California's Energy Action Plan II. A secondary goal was to evaluate how useful requirements engineering techniques are for defining policy guidelines.

The project team analyzed documents produced by the OpenHAN taskforce of the UtilityAMI, a utility industry group. These documents defined the utility advanced metering infrastructure interface to customer home automation network equipment. The analysis included modeling the OpenHAN taskforce configuration, referred to as the Utility Program Option, with context diagrams, Venn diagrams, and use case scenarios.

Using the same modeling techniques, the research team developed the Open Market and Utility Program Extended Options, which provide greater opportunities for customers to participate in demand response. Semantic models were developed to identify rights and obligations of customers, vendors and utilities in the utility advanced metering infrastructure and demand response rates and programs.

The final recommendations were two-fold. California investor-owned utilities' advanced metering infrastructure systems and demand response offerings should support the rights and obligations defined in this report, and should also incorporate the Open Market and Utility Program Extended options to extend customer opportunities for voluntary participation in demand response. It was also recommended that projects focused on implementing policy directives employ requirements engineering techniques to clarify policy goals in light of potential policy impacts.



**Keywords:** Advanced Metering Infrastructure, AMI, California, Demand Response, home automation network, HAN, IOU, obligations, OpenHAN, policy, requirements engineering, rights, use cases, utility, UtilityAMI

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# EXECUTIVE SUMMARY

## Introduction

As stated in the *State of California Energy Action Plan II: Implementation Roadmap for Energy Policies*, lowering consumer costs and increasing electricity system reliability are major goals of demand response, and advanced metering infrastructure (AMI) is an essential technology for enabling customer participation in demand response activities. AMI refers to a utility's AMI system including interval meters, communications, and back-office software.

California investor-owned utilities are investing significant resources to develop their AMI systems and define their demand response rates and incentive programs in response to AMI and demand response-related rulings and legislation. California investor-owned utilities have participated in the OpenHAN taskforce of the UtilityAMI Working Group, which has produced generic use cases and supporting documents to define the interface between the utility AMI and the customer's equipment. The UtilityAMI working group is operated under the auspices of the Utility Communications Architecture International Users Group. Their OpenHAN taskforce is focused on defining the interface between utilities' AMI systems and customer equipment. The OpenHAN taskforce use cases include home energy management devices such as programmable communicating thermostats, display devices, home automation systems and home area networks, which are clearly on the customer side of the interface. How the utility AMI system and the customer's equipment are integrated will play a significant role in determining to what degree the customer is provided with feasible and acceptable options for voluntarily participating in demand response and will impact whether the Energy Action Plan II goals are met.

## Project Purpose

The goal of this project was to develop policy guidelines that would foster the greatest customer participation in demand response by examining the customer choice implications of various AMI-customer equipment interface configurations. The main research objective was to develop policy guidelines for the interface between the utility AMI system and the customer's equipment including but not limited to energy management devices and home area networks. The project team was tasked with examining existing relevant documentation vetted by California investor-owned utilities and modeling various AMI system-customer equipment configuration scenarios to answer the following questions:

- What is needed in the AMI system customer equipment interface to promote widespread and effective voluntary customer participation in demand response?
- Do utility-proposed AMI system customer equipment solutions comply with current and upcoming demand response-related direction by California?
- Are there any responsibility and ownership issues in the AMI system-customer equipment interface that might threaten an open competitive home area network market or compromise customer choice?

The other research objective was to use a collaborative requirements engineering process and to evaluate how successful this approach was in identifying policy guidelines.

## Project Results

A team of California Energy Commission staff and consultants led by a requirements engineer at L'Monte Information Services developed requirements models to examine the implications of various AMI-customer configuration scenarios. This included analysis and modeling of UtiltyAMI's OpenHAN Taskforce use case documentation. The document *Joint IOU HAN Use Case Definitions / Assumptions / Actors* was analyzed to understand the foundational concepts defined in the use case and the underlying assumptions. The resulting models represented one configuration based on the OpenHAN documentation and two options developed by the project team:

- The Utility Program option was a two-way AMI communications configuration based on the OpenHAN documentation. It required customers to enroll in a utility program with equipment that used the utility AMI communication protocol in order to receive price and reliability signals.
- The Utility Program Extended option developed by the project team was based on the Utility Program option and expanded customer choice of demand response options with the addition of a translation device, and depending on interpretation, may or may not be supported by the OpenHAN documentation.
- The Open Market option developed by the project team allowed customers who do not wish to enroll in a utility program to receive price and reliability signals they could use to automate their voluntary demand response actions. In this configuration, one-way broadcast communications were used to provide a one-way signal that customers could use to facilitate their chosen demand response actions, such as Radio Data System, a proven technology with wide signal coverage to reach remote areas and strong building penetration capabilities.

The team identified policy guidelines from the models and options in the form of customer, vendor and utility rights and obligations that should be provided in utility AMI systems and demand response offerings.

The project team used a requirements engineering process of combining graphical modeling such as context and Venn diagrams with text-based techniques such as use case scenarios to evaluate configurations of the AMI customer equipment interface. Using different models gave the project team multiple vantage points for evaluation. For example, the rights and obligations generated with the graphical models were validated through the development of use case scenarios.

The project team recommended that utility AMI systems must support six main rights to realize the most effective demand response through pricing, rates, and programs. These rights were:

- R1. Customers have the right to receive price (periodic and real-time) signals and reliability signals via their enabled equipment without enrolling in utility programs and without registering their equipment with their utility.
- R2. Customers have the right to choose if and how they will program their programmable communicating devices to respond to price and reliability signals.
- R3. Customers have the right to purchase, rent or otherwise select from any vendor any and all devices and services used for energy management or other purposes in their premise.
- R4. Vendors have the right to compete in an open market to sell home area network-related systems, devices and services to all utility customers.
- R5. Utilities have the right to offer demand response and energy management services to customers that utilize the informational and communication capabilities of their advanced metering infrastructure system.
- R6. Customers have the right to participate in utility programs and at the same time use equipment not involved in the utility program that receives price and reliability signals.

The customer Utility Program option as defined in the *OpenHAN document* only promoted the utility right, R5, and limited or denied the customer and vendor rights, R1 – R4. The customer Utility Program Extended option was the Utility Program option with the addition of a translation device that provided support for customer right R3 and vendor right R4. The customer Open Market option developed by the project team supported all customer rights (R1 – R3) and vendor right R4. R6 was supported when customers were allowed to combine the Open Market option with one of the Utility Program options. Therefore the Open Market option and the Utility Program Extended option were both needed to provide support for all the rights defined in this report and to promote the widest participation in demand response.

The requirements engineering techniques used were effective in analyzing and evaluating the AMI-customer equipment interface researched in this project. The project team found that the process of developing multiple graphical and textual models and extracting and validating rights and obligations provided a consistent method for expressing policy guidelines.

As a result of these findings, it was recommended that the customer, vendor and utility rights and obligations defined in this report be used as a primary policy guideline for governing California investor-owned utility proposals for AMI systems and demand response rates and programs. It was also recommended that California investor-owned utilities should demonstrate that their AMI systems support the customer Open Market option and the Utility Program Extended Option to promote and protect all the customer, vendor and utility rights defined in this report.

In addition, it was recommended that projects focused on defining policy guidelines should consider utilizing a requirements engineering process of modeling the problem space and extracting rights and obligations from the models to form policy guidelines.

## Project Benefits

Demand response is a critical component of the California's Energy Action Plan II and has the potential to reduce customer costs, increase the reliability of the California's electric grid and avoid the expense of building new generation capacity to meet peak demand. The success of demand response depends to a large extent on how utilities implement their AMI systems. If the rights and obligations in the AMI-customer equipment interface recommended as policy guidelines in this report are adopted, they will help ensure that California investor-owned utilities include in their AMI configuration and demand response offerings more opportunities for customers to voluntarily participate in demand response. Increasing customer demand response opportunities should result in more effective demand response in California.

# CHAPTER 1:
# Introduction

The state of California has identified energy efficiency (EE) and demand response (DR) as top priorities for addressing increasing energy needs in California. The effectiveness of DR is closely linked to utility advanced metering infrastructure (AMI), an essential technology for customer participation in DR.

In response to AMI and DR-related rulings and legislation, California investor-owned utilities (IOUs) are investing significant resources to develop their AMI systems and define their DR rates and incentive programs. To this end the CA IOU's have participated in the UtiltyAMI's OpenHAN taskforce, a consortium of utilities and vendors who have developed generic use cases and supporting documents for defining the interface between the utility AMI and the customer's home automation network (HAN). The OpenHAN configuration includes control devices such as programmable communicating thermostats, display devices and HANs that are on the customer side of the interface. At the same time there has been rapid growth in the HAN market segment with vendors offering new products that are also on the customer side of the interface. Both utility AMI systems and vendor HAN products cover a range of different communication protocols. How the utility AMI system and the customer's equipment including HAN systems are integrated will play a significant role in customer participation in DR.

It is important to note here that this document makes a clear distinction between a communications signal that *controls* an end-use device and a communications signal to which an end-use device is programmed to respond. In the former, the signal originator takes over the device, imposing a new thermostat setting that the customer did not choose, for example; in the latter, the signal merely provides information that the device recognizes, that there is a system emergency, for example, to which the customer has programmed the device to respond. In this document, all one-way communications signals—both price and reliability—are defined as information to which the end-use device can be programmed *by the customer* to respond, or not.

The Public Interest Energy Research (PIER) Energy Systems Integration (ESI) program funded this research to evaluate the utility AMI customer equipment interface and derive recommendations and policy guidelines that would promote and expand DR by supporting a wider range of customer choices for voluntary DR participation.

A second key objective of this project was to evaluate the effectiveness of using a collaborative requirements engineering approach to perform this research. In particular, joint application development (JAD) workshops and requirements modeling including use cases were defined as part of the requirements engineering approach.

# CHAPTER 2:
# Project Approach

A project team of California Energy Commission staff and consultants in the DR field, led by a requirements engineer, was formed to develop requirements models including a project charter, context diagram and use case scenarios of the utility AMI-customer equipment interface. The modeling sessions were originally planned to be facilitated, joint application development (JAD) workshops. A JAD workshop is a facilitated collaborative session with specific deliverables. Usually there is a series of JAD workshops with the same group of participants who perform requirements exercises to produce the workshop deliverables.

The first JAD workshop was held to create a project charter. The resulting project charter, which can be found in Appendix A, identifies the project stakeholders, critical success factors and critical risks and issues. This document was used to guide the project through to the production of this final report.

The original plan was to develop all the requirements models using facilitated JAD workshops with a project team. However, due to constraints on team member availability and lack of time for requirements engineering training, the process adopted was for the requirements engineer to create draft models which were presented at review and editing sessions with the project team.

# CHAPTER 3:
# Project Outcomes

An analysis of the OpenHAN taskforce use case documentation which was approved by the California IOUs, was undertaken to evaluate its definition of the AMI-customer equipment interface. After reading the use cases available at the time, the document, *Joint IOU HAN Use Case Definitions / Assumptions / Actors*, hereafter referred to as the *OpenHAN document*, was selected for detailed analysis. The *OpenHAN document* was selected because it was referred to throughout the OpenHAN use cases, making it foundational to other OpenHAN documentation, and it appeared to be complete, unlike most of the use cases at the time. In a presentation toward the end of the project, a member of the UtilityAMI OpenHAN taskforce explained that this document did not represent all of the concepts later developed in some of the OpenHAN material. Therefore the project team recognizes that the *OpenHAN document* did not cover all of the configurations developed by the OpenHAN Task Force. However, the *OpenHAN document* provided the project team with a starting point for modeling the AMI-customer equipment interface with a scenario that has been the utility's main focus, customers enrolled in a utility DR program.

The definitions and actors and assumptions in the *OpenHAN document* define a configuration with two-way communications between the utility AMI system and the customer's equipment. This configuration requires that the customer enroll in a utility program and register their participating equipment with the utility. This configuration is called the customer Utility Program option. Due to some lack of clarity in the *OpenHAN document* which is discussed in section 3.1, the team developed a second option which extends the Utility Program option and is called the Utility Program Extended option.

The team also developed a separate configuration with one-way broadcast communications e.g., radio data system (RDS), that clearly separates the utility domain from the customer domain and allows for more customer choice and customer autonomy. This is called the customer Open Market option.

## 3.1 Analysis of the *OpenHAN document*

Analysis of the *OpenHAN document* resulted in the definition and modeling of the customer Utility Program option and Utility Program Extended option. The modeling process was difficult due to several problems encountered in the *OpenHAN document*. Specifically, the overloading of the term HAN, the use of self-referential definitions, and logical inconsistencies between assumptions, definitions and actors in the *OpenHAN document* resulted in interpretation issues. The following excerpts which exhibit these problems, present a conflicting picture of whether customer equipment not using the same networking communications as the utility AMI system will be allowed to participate and receive a signal.

> "Non-Interoperable HAN devices will not participate in Utility sponsored rates and programs"[1]
>
> "The HAN Device is utility compatible, meaning it is technology enabled to interoperate with the AMI system. "[2]
>
> "HAN Devices: Equipment owned by the Customer (or, in some cases, the Utility) and operating on the same HAN as the Utility HAN devices and providing energy management services to the AMI."[3]
>
> "Customers may, but do not have to, negotiate another communication method (such as cable, DSL, WiMax, city-wide WiFi, etc…) for price, consumption, load, event messages between their HAN devices and the AMI"[4]

The first quote which is one of the assumptions defined in the *OpenHAN document,* actually presents a logical impossibility by implying that the customer could have devices that use electricity but would not be on a rate. These concepts combine to depict a complicated and at times illogical configuration and raise the concern that it will be difficult to design, build, maintain and use. Given logical inconsistencies such as this, the project team created models using the most consistent and frequent representation based on all assumptions, definitions and actor definitions in the *OpenHAN document.* In this case an interpretation based on the first three excerpts is represented in the Utility Program option. Another model with a slight modification reflecting the last excerpt was developed into the Utility Program Extended option.

The following two assumptions are examples of statements that are supported by actor definitions and are not contradicted elsewhere in the *OpenHAN document*. Consequently they were used with higher confidence in the definition of both Utility Program options.

> "Customers must be enrolled in a demand response program to enable communications between the utility and the customer's control devices"[5]
>
> "All communications between the Utility AMI network and the HAN Devices are passed through the AMI Network Gateway"[6]

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1. UtilityAMI OpenHAN task force. *OpenHAN document*, page 1
2. UtilityAMI OpenHAN task force. *OpenHAN document*, page 2
3. UtilityAMI OpenHAN task force. *OpenHAN document*, page 4
4. UtilityAMI OpenHAN task force. *OpenHAN document*, page 2
5. UtilityAMI OpenHAN task force. OpenHAN document, page 2
6. UtilityAMI OpenHAN task force. *OpenHAN document*, page 1

## 3.2 Requirements Modeling: Open Market Option and Utility Program Options

To understand the differences and implications of the customer Open Market option and the two customer Utility Program options, the project team developed both graphical and textual models. In the diagrams representing the Utility Program options, names of actors from the *OpenHAN document* are underlined to identify when an actor definition is being represented. This is necessary because the actors are essential to understanding the basic configuration defined in the *OpenHAN document* and sometimes have different definitions than commonly used. A copy of the *OpenHAN document* actor table is reproduced in Appendix B.

Venn diagrams were developed to explore how responsibility and ownership differs between the two options. Context diagrams were developed to explore how the interfaces between all systems and actors including vendors are different in the two options. Graphical scenarios provided a more concrete representation of the three options. Use case scenarios were created to explore the interactions between the customer, their equipment and the utility AMI in order to understand and validate the rights and obligations which had been defined with previous models.

### 3.2.1 Venn Diagrams

Figure 1 depicts the customer Open Market option with broadcast price and reliability signals. There is a clear separation between the utility AMI, set A, and the Customer HAN, set B. The price and reliability one-way broadcast system is represented as subset A1 of the Utility AMI, to indicate that it is a responsibility of the utilities to provide this functionality to customers who don't wish to enroll in a utility program but do want to take advantage of the AMI meter and time varying rates. This follows the Utility Program option modeling convention which also includes the signaling system as a subset of the Utility AMI set. The broadcast signals are available to any devices in the customer premise that can receive the broadcast signal. In this Venn diagram the boundary between the customer's equipment and the utility AMI is very clear.

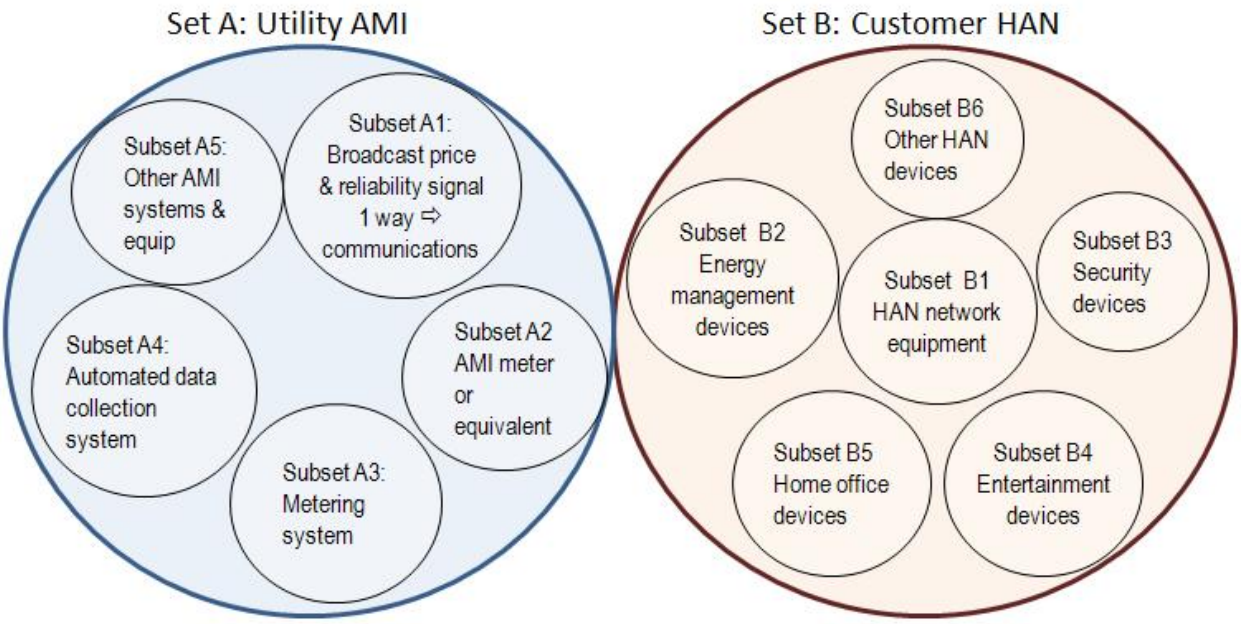


**Figure 1: Venn Diagram 1: Customer Open Market Option developed by the project team as a recommended customer option**

Source: L'Monte Information Services

Figure 2 depicts the more complex customer Utility Program option which introduces new sets and several overlapping sets. Set C is a new set which represents the Utility HAN actor in the *OpenHAN document*. Its only unique subset is C1, the Utility AMI Gateway actor through which all price and reliability signals are delivered and required responses from customer equipment are passed, making it a controlling agent for the customer's demand response activity. The Utility HAN actor is defined as also containing subsets from the other main sets, A' and B'. It contains subset A'2, the AMI meter, and subset B'2 the customer's energy management devices and load management interface devices such as an LCD display, PC or refrigerator magnet. It is unfortunate that the term HAN is so overloaded in the *OpenHAN document* actor names as it adds to the confusion over boundaries between the utility AMI and the customer premise. In particular, the actor called Customer HAN is misleading because it does not include everything in the customer's HAN. This actor, subset B'3, is defined in the *OpenHAN document* as containing all other customer devices "that are on the same HAN as the Utility HAN (such as security, child monitoring, home entertainment or other services)".[7] Consequently, subset B'3 is shown as also being in Set C, the Utility HAN. Having subsets of functionality and equipment belong to both a utility owned set and a customer owned set introduces ambiguity regarding ownership and responsibility.

Set D contains any customer HAN and/or devices that are 'non-interoperable' and do not use the AMI communication protocol.

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7. UtilityAMI OpenHAN task force. *OpenHAN document*, page 6

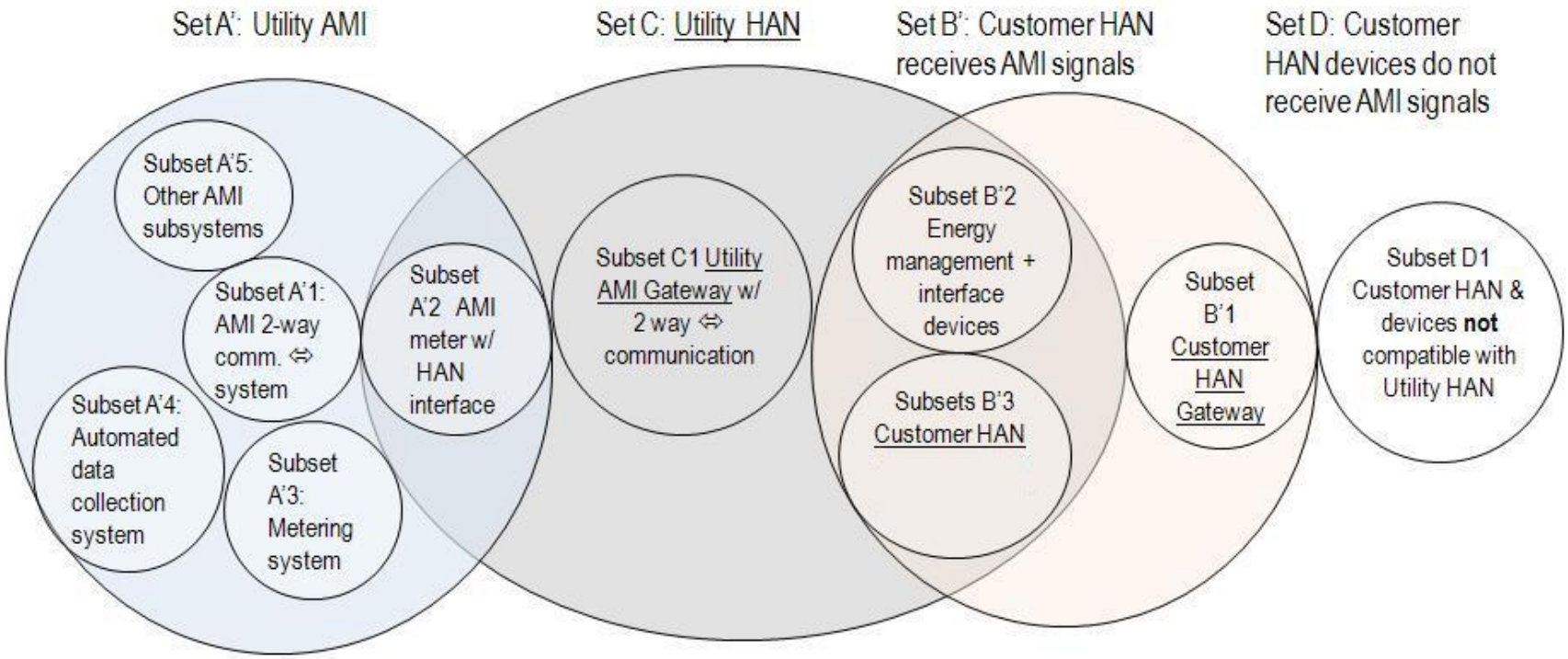


**Figure 2: Venn Diagram 2: Customer Utility Program Option based on the *OpenHAN Document***

Source: L'Monte Information Services

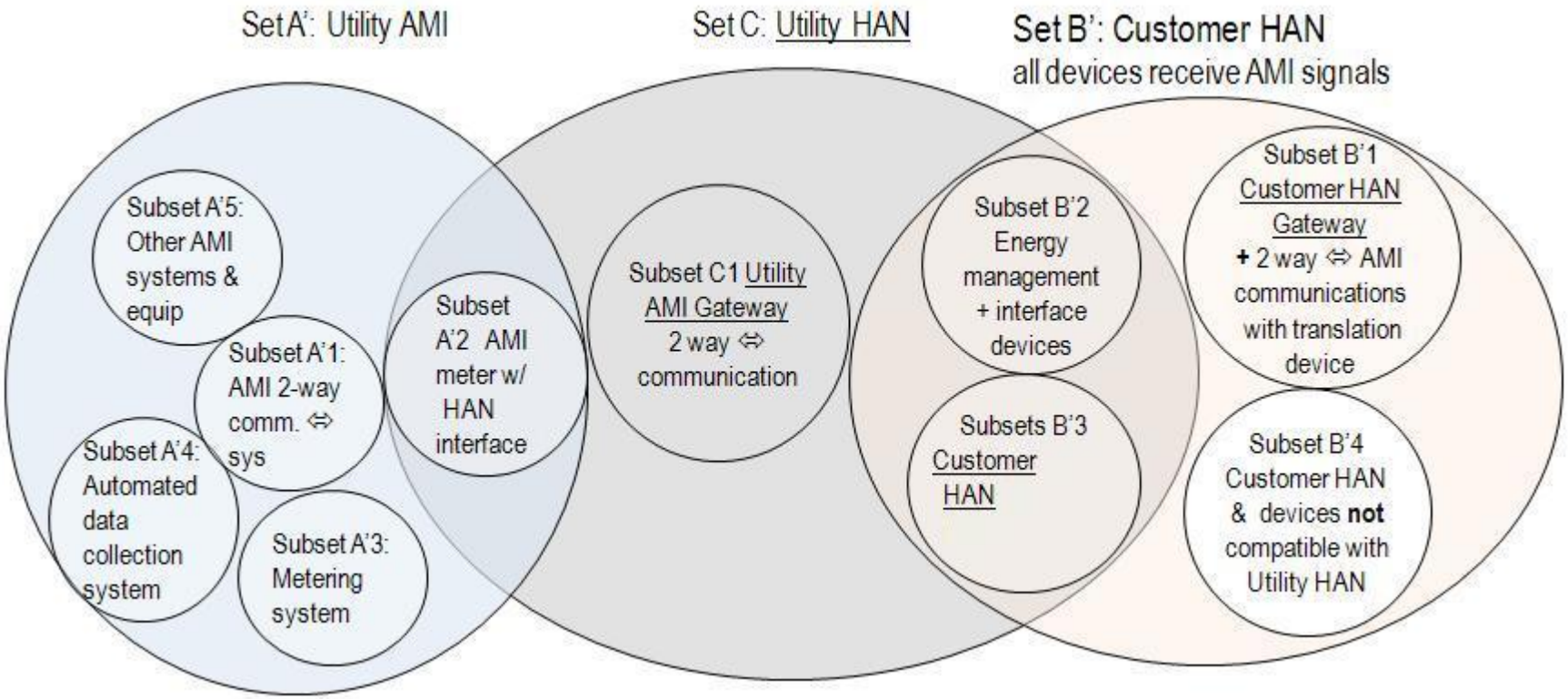


**Figure 3: Venn Diagram 3: Customer Utility Program Extended Option, developed by project team as a recommended extension to the Utility Program Option**

Source: L'Monte Information Services

Figure 3 depicts the customer Utility Program Extended option which makes only one modification. Adding a translation device to the Customer HAN Gateway allows the equipment using a different communications protocol (Set D in Figure 2) to join the rest of the customer's HAN devices in Set B' as subset B'4. This device would translate the AMI price and reliability signal into a form usable by devices in subset B'4 and expand customer options for participating in DR. This modification also clarifies ownership and responsibility by leaving all customer HAN's and devices in Set B'. It improves support for customer right R3 and vendor right R4 by allowing the customer to use devices in a utility program that do not use the AMI communication protocol.

### 3.2.2 Context Diagrams

Modeling the customer options with context diagrams provided a view into how each option supports or limits customer choice and an open market.

The context diagram in Figure 4 depicts the customer Open Market option. There is a simple interface between the Utility AMI and the customer equipment with a one-way broadcast price and reliability signaling system. Vendors of energy management equipment and other HAN devices have a direct interface with customer and the equipment and services the customer has selected from them. The broadcast price and reliability signals can be picked up by any device that has the ability to receive the broadcast signals.[8] The Open Market option gives customers the choice of participating in demand response without being enrolled in a utility program and without registering their equipment with the utility. It also allows vendors to provide devices and services in a market that is not limited to the utility prescribed communications protocol. The Open Market option would use an open (non-proprietary), one-way communication system. One example of a communication system is RDS, a proven, effective communications technology which is also being considered for statewide emergency communications, and could be adopted by smaller utilities who cannot afford the more complex two-way AMI systems.

8. Each device would have to be activated to "listen" for the correct utility signal—analogous to tuning a radio to a particular station; however, the activation would be the responsibility of the customer and the settings could be adjusted by the customer at any time.

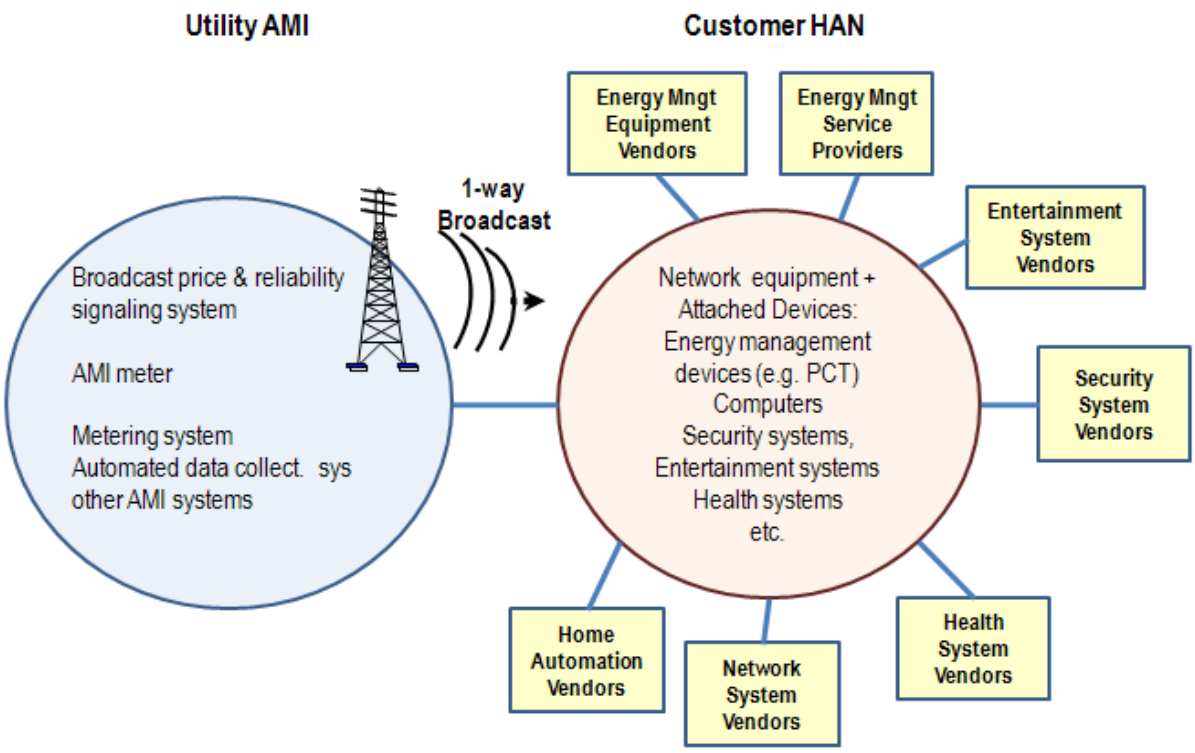


**Figure 4: Context Diagram 1: Open Market Option with 1-way Broadcast Price & Reliability Signals, developed by the project team as a recommended customer option**

Source: L'Monte Information Services

The context diagram in Figure 5 depicts one configuration of the customer Utility Program option defined in the *OpenHAN document*. The single interface is replaced with a new system made up of the Utility HAN and Customer HAN actors. This diagram represents the customer who has limited their choice of networks and equipment to vendors including utilities, who have offerings that use the AMI communications protocol.

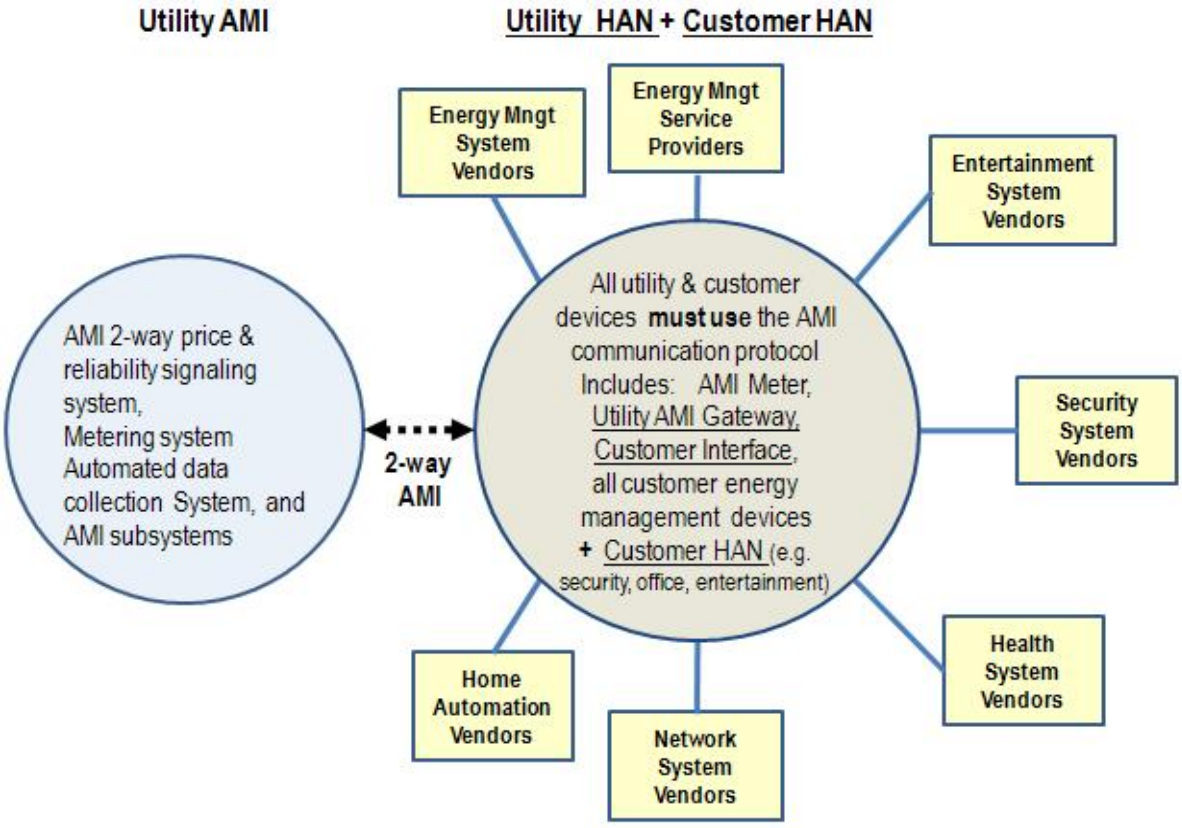


**Figure 5: Context Diagram 2: Utility Program Option with all equipment using AMI communications protocol, based on the *OpenHAN Document***

Source: L'Monte Information Services

The context diagram in Figure 6 depicts the customer Utility Program option for the customer who already has a HAN and devices that do not use the AMI communications protocol. Based on the definition of the Utility HAN actor, in order to participate, the customer would have to replace their existing energy management equipment with equipment using the AMI defined communications protocol.

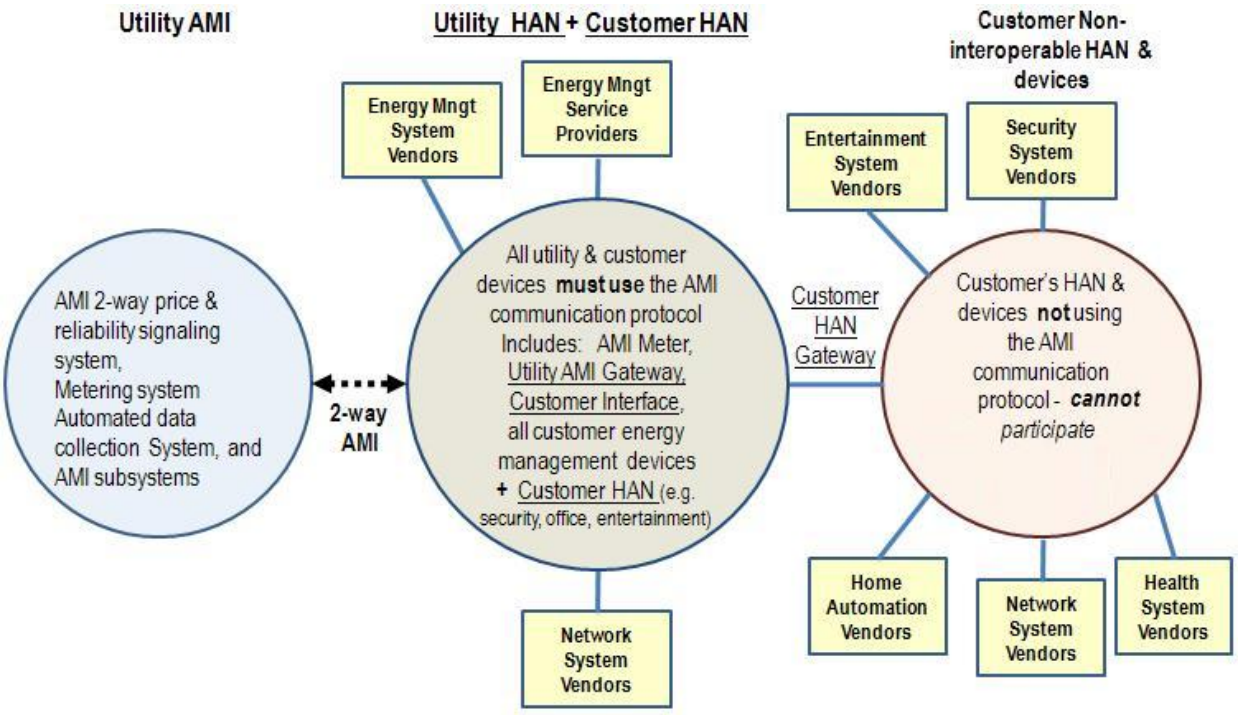


**Figure 6: Context Diagram 2a: Utility Program Option, with some equipment not using AMI communication protocol, based on the *OpenHAN Document***

Source: L'Monte Information Services

Figure 7 shows the customer Utility Program Extended option with the translation device added the Customer HAN Gateway which supports for customer right R3 and vendor right R4.

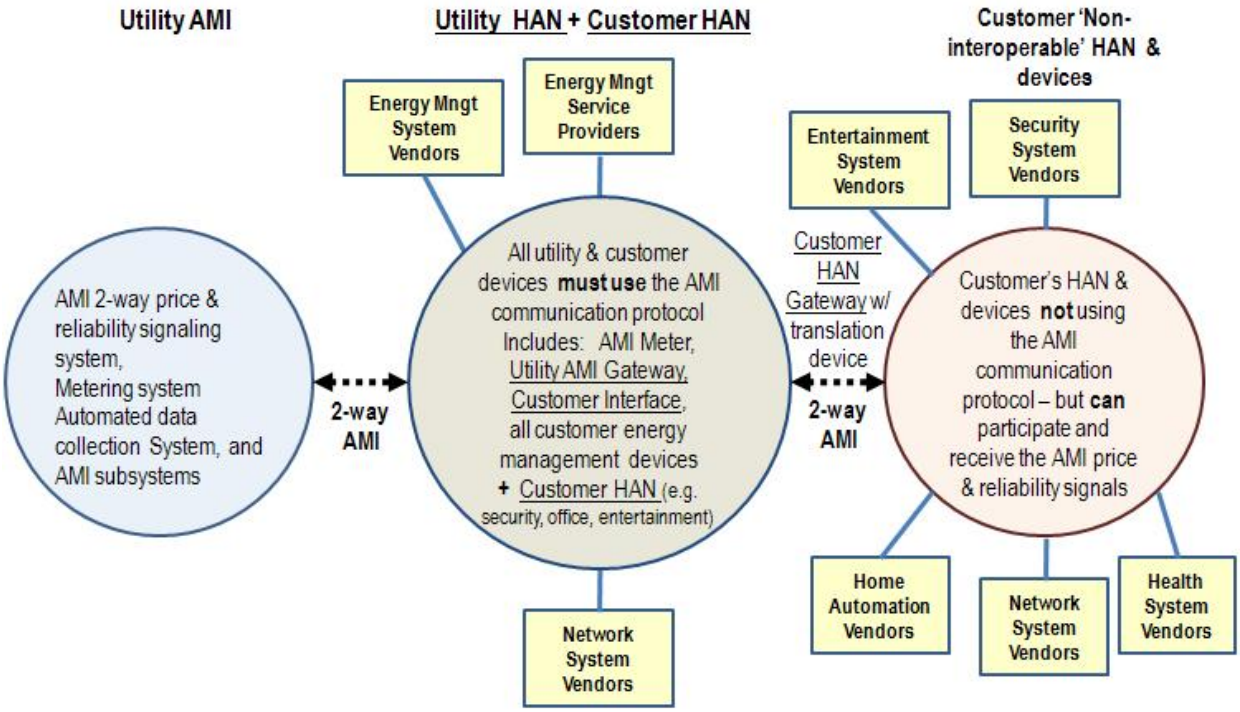


**Figure 7: Context Diagram 3: Utility Program Extended Option with translation device, developed by project team as a recommended extension to the Utility Program Option**

Source: L'Monte Information Services

### 3.2.3 Graphical Scenarios

Graphical scenarios are line drawing representation of the physical arrangements. They provide a more concrete view of the two options and were used to corroborate the more abstract context diagrams and Venn diagrams.

Figure 8 depicts the customer Open Market option for a customer who has one or more individual devices that can receive broadcast price and reliability signals and be voluntarily programmed to respond. The customer is not required to register the devices with the utility or be enrolled in a program in order to receive the broadcast signal.

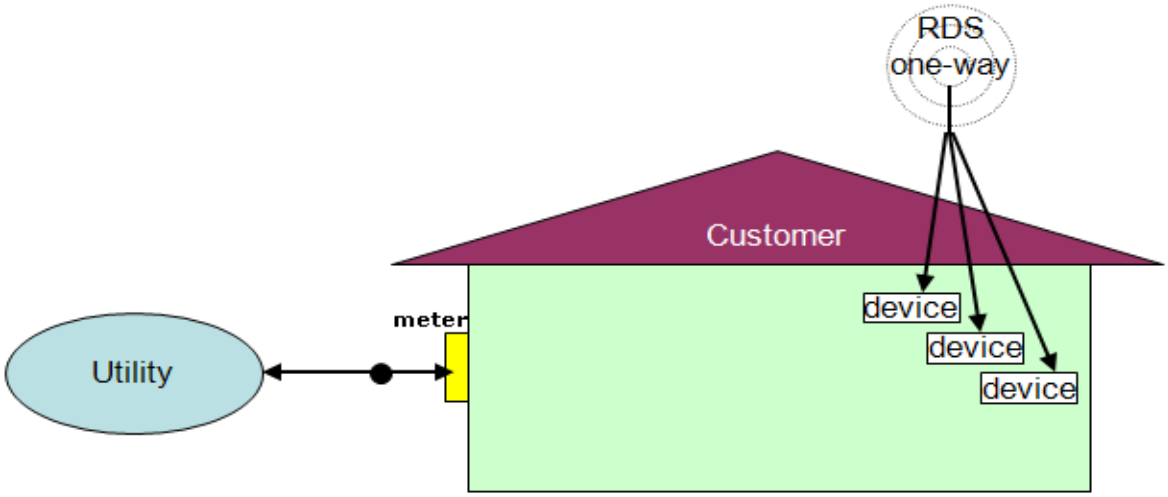


**Figure 8: Graphical Scenario 1: Open Market Option with individual devices, developed by the project team using RDS as an example of a one-way broadcast communication system. This is a recommended customer option.**

Source: L'Monte Information Services

Figure 9 depicts the Open Market option for a customer with devices attached to a PCT or HAN. The broadcast signal is received by the PCT or HAN and then passed on to the attached devices. Again no registration or communication to the utility AMI system is required; however, the customer would have to activate each device by programming it to receive the correct signal and choosing response setting, which he or she could then change at any time.

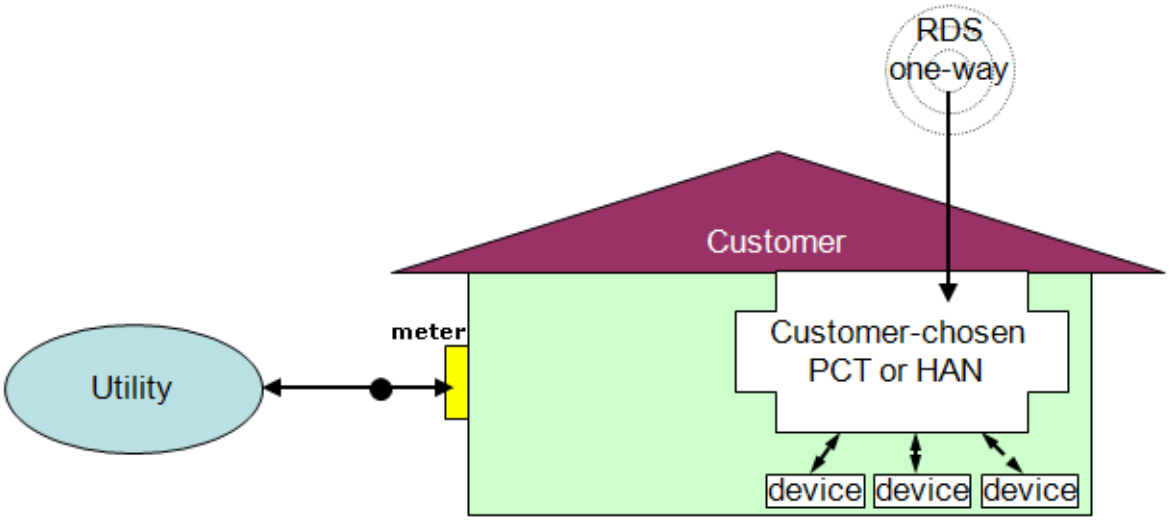


**Figure 9: Graphical Scenario 2: Open Market Option with a PCT or HAN with attached devices, developed by the project team using RDS as an example of a one-way broadcast communication system. This is a recommended customer option**

Source: L'Monte Information Services

The customer Utility Program option depicted in Figure 10 provides two-way communication for customer devices that are interoperable with the utility AMI. Using the two-way communications through the Utility AMI gateway, the devices register with the AMI system, receive utility price and reliability signals and return information required by the utility AMI system. This sketch shows one device that does not receive the signal because it does not use the utility defined communications protocol and is considered non-interoperable.

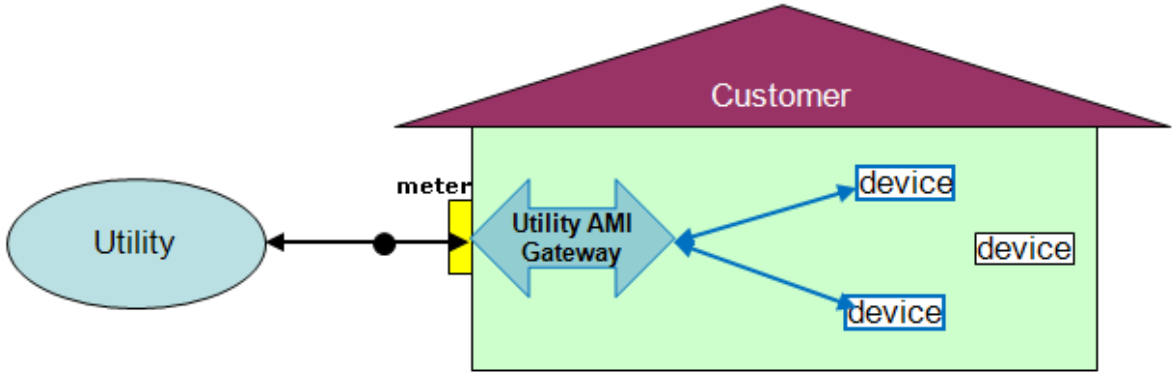


**Figure 10: Graphical Scenario 3: Utility Program Option with individual devices, based on the *OpenHAN* Document**

Source: L'Monte Information Services

The graphical scenario in Figure 11 depicts the Utility Program option for a customer who has devices attached to a controlling device such as a PCT or to a HAN. As with Figure 10, two-way communication through the utility AMI gateway allows the HAN or PCT to register itself with the AMI system, receive utility price and reliability signals and return information required by the utility AMI system. This sketch also shows one device that does not receive the signal because it does not use the utility defined communications protocol.

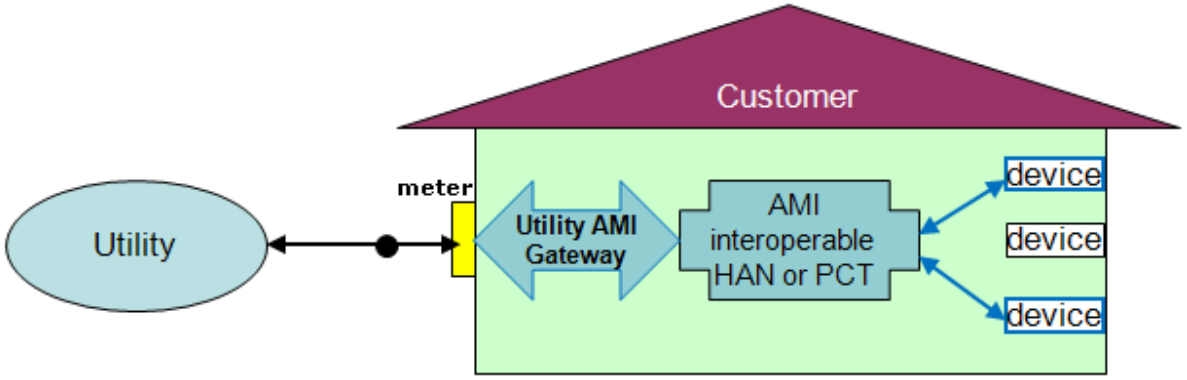


**Figure 11: Graphical Scenario 4: Utility Program Option with a PCT or HAN with attached devices, based on the *OpenHAN Document***

Source: L'Monte Information Services

The customer Utility Program Extended option depicted in Figure 12 shows the addition of a translation device to graphical scenario 3 for the customer who wants all their devices to receive the AMI price and reliability signals, including those that use a different communication

protocol. Graphical Scenario 4 could also be changed to the Utility Program Extended with the addition of a translation device.

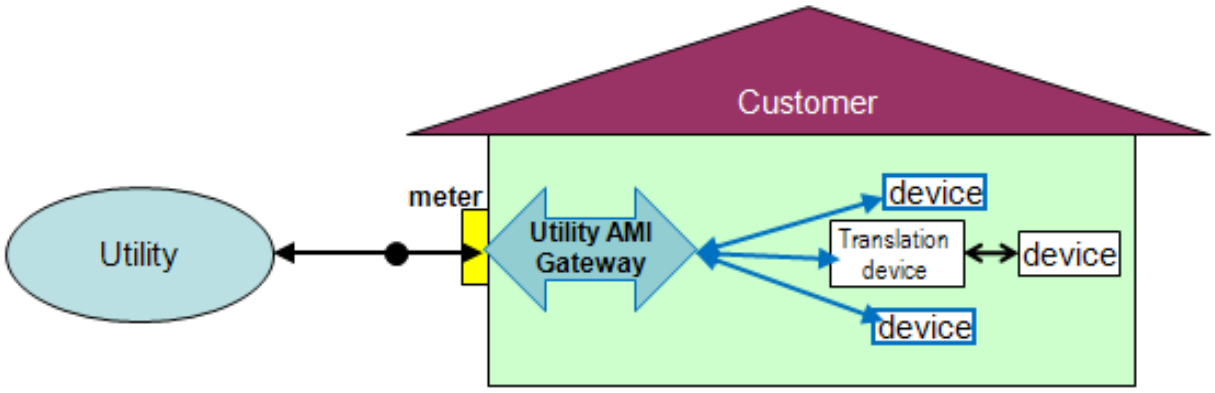


**Figure 12: Graphical Scenario 5: Utility Program Extended Option with additional translation device, developed by project team as a recommended extension to the Utility Program Option**

Source: L'Monte Information Services

The graphical scenario in Figure 13 depicts a customer who has signed up for a utility program and has two devices receiving AMI price and reliability signals through the utility AMI gateway. The customer also has a device that does not use the AMI protocol and has RDS communications capability. The customer has programmed this device to receive and respond to the one-way RDS signal. This graphical scenario provides support for the customer right, R6 (discussed in detail in Section 5), to participate in a utility program and also have devices not involved in that program that can receive one-way price and reliability signals.

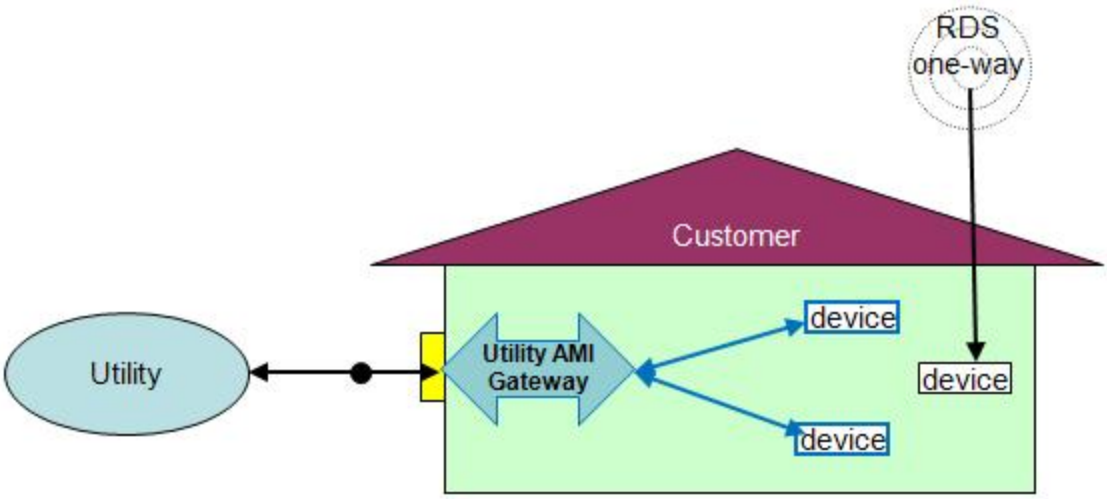


**Figure 13: Graphical Scenario 6: Utility Program Option + Open Market Option, showing customer participation in both options at the same time using RDS as an example of a one-way broadcast communication system.**

Source: L'Monte Information Services

# CHAPTER 4:
# Use Case Scenarios

Use case scenarios describe the interactions between a system and an actor to satisfy the actor's goal. Alistair Cockburn in his book *Writing Effective Use Cases* explains that a use case captures a contract between the stakeholders of a system and its behavior. As such, use case scenarios are useful for exploring the validity of system and actor rights and obligations identified using other requirements models.

In the use case scenarios developed for this project, the system is the California investor-owned utility and their advanced metering infrastructure (AMI) systems, and the primary actor is a California residential electricity customer. Two sets of use case scenarios were developed, one set for the customer Open Market option and one set for the customer Utility Program options. The objective was to explore the validity of customer and utility rights and obligations already defined, and reveal any new rights and obligations in the interaction. In this exercise of envisioning an interaction that does not yet exist, functionality was described not for the purpose of defining specific requirements but to explore ways in which the rights and obligations could be supported and determine whether they are reasonable and feasible.

## 4.1 Open Market Option Use Case Scenarios

The customer Open Market option use case scenarios focus on two areas. The first summary use case, 1.1 and its scenarios explores possible ways the customer could prepare a technology-enabled device to recognize the correct one-way price and reliability signals without being enrolled in a utility program. It also examines ways to do it without registering the device with the utility.

The next summary use case, 1.2, and its scenarios examine the interaction between the customer, the utility and its one-way broadcast system, and a technology-enabled device in the customer premise for receiving and responding to real-time price and emergency signals. Table 1 lists the Open Market option use case scenarios developed.

In the Open Market option use cases, the RDS one-way communications system is used as a specific example.

**Table 1: Open Market Option Use Case Scenarios**

| Use Case # | Primary Actor: Customer<br>Use Case Name – the primary actor's goal with the system | Scope Level |
|---|---|---|
| 1.1 | Prepare RDS-enabled device to recognize correct RDS signals | Summary |
| 1.1.1 | Program RDS-enabled device to recognize correct RDS price signals | Scenario |
| 1.1.2 | Register RDS-enabled device to recognize correct RDS signals | Scenario |

| Use Case # | Primary Actor: Customer<br>Use Case Name – the primary actor's goal with the system | Scope Level |
|---|---|---|
| 1.2 | Receive signals through one-way RDS system | Summary |
| 1.2.1 | Receive real time price signals through one-way RDS system | Scenario |
| 1.2.2 | Receive emergency signals through one-way RDS system | Scenario |

## 4.2 Utility Program Option Use Case Scenarios

The customer Utility Program option use case scenarios focus on the same type of functionality for the customer who enrolls in a utility program. The summary use case, 2.1, and its scenarios cover the process of enrolling in a utility program to explore customer and utility rights and obligations in different scenarios. The second summary use case, 2.2, and its scenarios examine the interaction between the customer, the utility and its AMI system, and equipment in the customer premise for receiving and responding real-time price and emergency signals. Table 2 lists the Utility Program option use case scenarios developed in this project.

**Table 2: Utility Program Option Use Case Scenarios**

| Use Case # | Use Case Name – The Primary Actor's Goal | Scope Level |
|---|---|---|
| 2.1 | Enroll in utility DR program or change enrollment | Summary |
| 2.1.1 | Enroll in utility DR program without any energy management devices | Scenario |
| 2.1.2 | Enroll in utility DR program with existing HAN using a different communication protocol than utility AMI system | Scenario |
| 2.1.3 | Change connection to AMI by signing up with a 3rd party load aggregator | Scenario |
| 2.2 | Receive signals through the AMI system | Summary |
| 2.2.1 | Receive real-time price signals through the AMI system | Scenario |
| 2.2.2 | Receive emergency signals through the AMI system | Scenario |

## 4.3 Open Market Option Use Case Records with Scenarios

Use Case ID: 1.1.1a

Use Case Name: Program RDS-enabled device to recognize correct RDS signals

Primary Actor: California residential electricity customer; referred to as Customer

Secondary Actor: Programmable communicating device (e.g., PCT) with RDS communications capability; referred to as Device

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: Utility's AMI system including the one-way price and reliability RDS signaling is operational.

Utility's RDS system only carries the default dynamic price rate.

Customer is on the default dynamic price rate.

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends Customer current bill which contains the utility-location identifier for programming an RDS-enabled device to recognize the correct RDS signals |
| 2 | Customer | Enters the utility-location code into the RDS-enabled device and if required, activates the RDS capability in the Device |
| 3 | Customer | Programs how the device should respond to the signal.<br>NOTE: This step is optional and voluntary. If the customer does not program the device, it will use factory defaults. |
| 4 | Utility | Sends default dynamic price RDS signal |
| 5 | Device | Receives signal and performs check to see if the signal contains the utility-location code entered by the customer. If it does, it responds as programmed by the customer. |

Alternate Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends Customer current bill which contains the utility-location identifier for programming an RDS-enabled device to recognize the correct RDS signals |
| 2a | Customer | Does nothing because Customer does not want the Device to receive and respond to RDS price or emergency signals. |
| 3 | Customer | Does not program the Device |
| 4 | Utility | Sends default dynamic price RDS signal |
| 5 | Device | Does nothing |

| | |
|---|---|
| Use Case ID: | 1.1.1b |
| Use Case Name: | Program RDS-enabled device to recognize correct RDS signals |
| Primary Actor: | California residential electricity customer; referred to as Customer |
| Secondary Actor: | Programmable communicating device with RDS communications capability; referred to as Device |
| System: | California investor-owned utility and their systems, referred to as Utility |
| Preconditions: | Utility's AMI system including the one-way price and reliability RDS signaling is operational.<br>Utility's RDS system carries several dynamic price rates.<br>Customer is on the default dynamic price rate and eligible for others. |

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends Customer current bill which contains information for programming a RDS-enabled device to recognize the correct RDS signals. This includes utility-location code and rate codes for which the Customer is eligible |
| 2 | Customer | Enters the utility-location code and rate codes into the RDS-enabled device and if required, activates the RDS capability in the Device |
| 3 | Customer | Programs how the device should respond to the signal.<br>NOTE: This step is optional and voluntary. If the customer does not program the device, it will use factory defaults. |
| 4 | Utility | Sends a price RDS signal |
| 5 | Device | Receives signal and performs check to see if the signal contains the utility-location code and rate codes entered by the customer. If it does, it responds as programmed by the customer |

| | |
|---|---|
| Use Case ID: | 1.1.2 |
| Use Case Name: | Register RDS-enabled device to recognize correct RDS signals |
| Primary Actor: | California residential electricity customer; referred to as Customer |
| Secondary Actor: | Programmable communicating device with RDS communications capability; referred to as Device |
| System: | California investor-owned utility and their systems, referred to as Utility |
| Preconditions: | Utility's AMI system including the one-way price and reliability RDS signaling is operational.<br>RDS-enabled device has a factory set unique ID that can be displayed.<br>Utility includes registered RDS-enabled device unique IDs in the RDS signals. |

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends Customer RDS-enabled device registration instructions which include number to call |
| 2 | Customer | Gets unique ID from RDS-enabled device |
| 3 | Customer | Calls the Utility's registration number |
| 4 | Utility | Asks for Customer account number and RDS-enabled device unique ID |
| 5 | Customer | Gives their account number and the RDS-enabled device unique ID |
| 6 | Utility | Arranges to include the Customer's RDS-enabled device unique ID in RDS signals carrying price rates the Customer is eligible for |
| 7 | Customer | If required, activates the RDS capability in the Device |
| 8 | Customer | Programs how the device should respond to the signal.<br>NOTE: This step is optional and voluntary. If the customer does not program the device, it will use factory defaults. |
| 9 | Utility | Sends RDS signal |
| 10 | Device | Receives signal and performs check to see if the signal contains its unique ID and the programmed utility-location code and if it does, it responds as programmed by the customer |

| | |
|---|---|
| Use Case ID: | 1.2.1 |
| Use Case Name: | Receive real-time price signals through one-way RDS system |
| Primary Actor: | California residential electricity customer, referred to as Customer |
| Secondary Actor: | Programmable communicating device with RDS communications capability; referred to as Device |
| System: | California investor-owned utility and their systems, referred to as Utility |
| Preconditions: | Utility's AMI system including the one-way price and reliability RDS signaling is operational.<br>Customer voluntarily programmed the Device and it is ready to receive and respond to RDS signals.<br>Customer is on the utility real-time price tariff. |

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends real-time price RDS signal with a price that is very high |
| 2 | Device | Receives signal and performs check which shows that it should respond to the signal |
| 3 | Device | Responds as customer programmed it by curtailing loads and displays the new price indicating that it is very high |
| 4 | Customer | Turns off other loads in response to very high price indication because they want to save money. NOTE: This step is optional and voluntary. |
| 5 | Utility | Sends real-time price RDS signal with a lower price |
| 6 | Device | Receives signal and performs check which shows that it should respond to the signal |
| 7 | Device | Responds as programmed, displays the new lower price |
| 8 | Customer | Turns loads back to normal after noticing price decrease.<br>NOTE: This step is optional and voluntary. |
| 9 | Utility | Measures electricity use for billing |
| Alternate Scenario 1 | | |
| 2a | Device | Performs check which shows that it should **not** respond to the signal |
| 9 | Utility | Measures electricity use for billing |

Use Case ID: 1.2.2

Use Case Name: Receive emergency signals through one-way RDS system

Primary Actor: California residential electricity customer, referred to as Customer

Secondary Actor: Programmable communicating device with RDS communications capability; referred to as Device

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: An emergency event has occurred.

Utility's AMI system including the one-way price and reliability RDS signaling is operational

Customer voluntarily programmed the Device and it is ready to receive and respond to RDS signals.

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends emergency start signal through the RDS system |
| 2 | Device | Receives emergency start RDS signal |
| 3 | Device | Performs check which shows that it should respond to the signal |
| 4 | Device | Responds as customer programmed it to curtail load, and displays emergency signal alarms |
| 5 | Customer | Turns off other loads in response to emergency indications<br>NOTE: This step is optional and voluntary. |
| 6 | Utility | Sends emergency stop RDS signal |
| 7 | Device | Receives emergency stop RDS signal |
| 8 | Device | Performs check which shows that it should respond to the signal |
| 9 | Device | Returns to normal load profile and indicates emergency is over |
| 10 | Customer | Turns loads back to normal after noticing emergency is over<br>NOTE: This step is optional and voluntary. |
| 11 | Utility | Measures electricity use for billing |
| Alternate Scenario 1 | | |
| 3a | Device | Performs check which shows that it should **not** respond to the signal |
| 11 | … | |

## 4.4 Utility Program Options Use Case Scenarios

Use Case ID: 2.1.1

Use Case Name: Enroll in utility DR program without any programmable communicating devices

Primary Actor: California residential electricity customer; referred to as Customer

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: Customer does not have a programmable communicating device; referred to as Device

Utility's AMI system is operational

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends Customer information about DR program offerings |
| 2 | Customer | Enrolls in a DR program |
| 3 | Customer | Purchases a Device w/ AMI communication module from Utility |
| 4 | Utility | Tests and registers the Device with the AMI communication system |
| 5 | Customer | Programs Device with personal settings if different from defaults |
| Alternate Scenario 1 | | |
| 3a | Utility | Provides the Customer with a Device with AMI communication module inserted, tested and registered with their AMI system, as part of the program |
| 5… | | |
| Alternate Scenario 2 | | |
| 3a | Customer | Purchases a Device with built-in RDS communication system from retail store |
| 3b | Utility | Provides Customer with AMI communication module |
| 3c | Customer | Installs AMI communication module in their Device |
| 4… | | |

Note: Utilities are not obligated to provide customers with programmable communicating devices if the customers enroll in a program and do not have one. However, utilities can include programmable communicating devices in their programs if customers do not have a means of receiving the signal.

Use Case ID: 2.1.2

Use Case Name: Enroll in utility DR program with existing HAN that does not use the utility's AMI communication protocol

Primary Actor: California residential electricity customer; referred to as Customer

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: Customer has an existing HAN with a programmable communicating device such as a PCT; referred to as Device

Utility's AMI system is operational

The HAN uses a different communication protocol than the utility AMI system.

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends Customer information about DR program offerings |
| 2 | Customer | Enrolls in the Utility's DR program, with their existing HAN |
| 3 | Utility | Finds that HAN does not use the AMI communication protocol and tells Customer that they must provide a translation device for communication between the HAN and the utility AMI system |
| 4 | Customer | Purchases and installs translation device to connect AMI to HAN |
| 5 | Utility | Tests communication between AMI meter and HAN and tests and registers the Device |
| Alternate Scenario 1 | | |
| 3a | Customer | Decides to enroll with just the Device and disconnects it from the HAN |
| 4a | Utility or Customer | Gets and inserts an AMI communication module into Device |
| 5a | Utility | Tests and registers Device with their AMI system |

Use Case ID: 2.1.3

Use Case Name: Change connection to AMI by signing up with a third-party load aggregator who will provide price and reliability signaling

Primary Actor: California residential electricity customer; referred to as Customer

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: Customer already enrolled in utility DR program that works with their programmable communicating device.

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Customer | Notifies Utility that they are discontinuing their enrollment in the DR program after this billing month. |
| 2 | Utility | Responds with information on the date when the Customer will be dropped from the DR program. |
| 3 | Customer | Completes contract and all installment procedures to test 3rd party load aggregator's price / reliability signal and response functionality |
| 4 | Utility | Drops Customer from DR program and disables the AMI meter price and reliability signaling capability |
| Alternate Scenario 1 | | |
| 1a | Customer | Notifies Utility that they are signing up with a 3rd party aggregator but want to continue participating in the Utility DR program. |
| 2a | Utility | Allows the Customer to stay in the DR program if there is no overlap between their DR program and the 3rd party aggregator's program. |

Use Case ID: 2.2.1

Use Case Name: Receive real-time price signals through the AMI system

Primary Actor: California residential electricity customer, referred to as Customer

Secondary Actor: Programmable communicating device enabled to receive the utility AMI communications, referred to as Device

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: Utility's AMI system is operational.

Device is registered, programmed, and ready to receive AMI signals.

Customer is enrolled in a utility DR program.

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends AMI two-way real-time price signal with a price that is very high |
| 2 | Device | Receives AMI two-way real-time price signal and sends acknowledgement |
| 4 | Device | Responds as customer programmed it by curtailing loads and displays the new price indicating that it is very high |
| 5 | Device | Sends information to AMI system on actions taken |
| 6 | Customer | Turns off other loads in response to very high price indication<br>NOTE: This is optional and voluntary |
| 7 | Utility | Sends AMI two-way real-time price signal with a lower price |
| 8 | Device | Receives AMI two-way real-time price signal and sends acknowledgement |
| 10 | Device | Responds as programmed, displays the new lower price |
| 11 | Device | Sends information to AMI system on actions taken |
| 12 | Customer | Turns loads back to normal after noticing price decrease<br>NOTE: This is optional and voluntary |
| 13 | Utility | Measures electricity use for billing |

Use Case ID: 2.2.2

Use Case Name: Receive emergency signals through the AMI system

Primary Actor: California residential electricity customer, referred to as Customer

Secondary Actor: Programmable communicating device enabled to receive the utility AMI communications, referred to as Device

System: California investor-owned utility and their systems, referred to as Utility

Preconditions: An emergency event has occurred.

Utility's AMI system is operational.

Customer is enrolled in a utility DR program.

Device is registered, programmed, and ready to receive AMI signals.

Scenario:

| Step # | Performed by | Action performed |
|---|---|---|
| 1 | Utility | Sends AMI two-way emergency start signal |
| 2 | Device | Receives AMI two-way emergency start signal and returns acknowledgment |
| 3 | Device | Responds as customer programmed it to curtail load and displays emergency signal alarms |
| 4 | Device | Sends information to AMI system on actions taken |
| 5 | Customer | Turns off other loads in response to emergency indications<br>NOTE: This is optional and voluntary |
| 6 | Utility | Sends AMI two-way emergency stop signal |
| 7 | Device | Receives AMI two-way emergency stop signal and returns acknowledgment |
| 8 | Device | Returns to normal load profile and indicates emergency is over |
| 9 | Device | Sends information to AMI system on actions taken |
| 10 | Customer | Turns loads back to normal after noticing emergency is over<br>NOTE: This is optional and voluntary |
| 11 | Utility | Measures electricity use for billing |

Alternate Flow

| | | |
|---|---|---|
| 1 | Utility | Sends emergency start AMI signal |
| 2 | Device | Receives emergency start AMI signal and returns acknowledgment |
| 3 | Device | Responds as customer programmed it to curtail load and displays emergency signal alarms |
| 4 | Device | Sends information to AMI system on actions taken |
| 5 | Customer | Over-rides Device emergency programming because of a special condition e.g., sick family member |

# CHAPTER 5:
# Rights and Obligations

Customer, utility, and vendor rights and obligations were identified and evaluated throughout the development of the different models. The method of defining policy guidelines by identifying rights and obligations of all parties involved in a process is based on the work of T.D.Breaux and A.I.Anton at North Carolina State University. Their approach involves analyzing existing regulations, developing semantic models, and then extracting and balancing rights and obligations in order to clarify ambiguities in the regulations. The authors discuss future work where the development of rights and obligations would begin the process and play a direct role in the authorship of policy guidelines[9] which is the approach taken in this project.

Semantic activity models of balanced right-obligation pairs were created to identify implicit rights and obligations for each explicit right and obligation. This process also improved the logical expression of the rights and obligations. After a final evaluation and reworking, the following rights and obligations with their associated activity models (shown in Table 3 through Table 8 below) were identified as essential to the Open Market option and the Utility Program Extended option.

R1. Customers have the right to receive price (periodic and real-time) signals and reliability signals without enrolling in utility programs and without registering their equipment with their utility.

O1. Utilities are obligated to provide their customers with broadcast price and reliability signals which can be received by customer equipment that is neither registered with the utility nor used in a utility program.

**Table 3: Activity Model for R1-O1 Balanced Right-Obligation pair**

| Activity Model 1 | Right 1 | Obligation 1 |
|---|---|---|
| **Actor** | Customers | Utilities |
| **Action** | Receive | Provide |
| **Object** | Real-time price and emergency signals | Real-time price and emergency signals |
| **Purpose (optional)** | Save money, avoid outages | Manage loads and avoid outages |
| **Target (optional)** | Customer equipment with enabling technologies (e.g., PCT) | Customer equipment with enabling technologies (e.g., PCT) |
| **Method (optional)** | Without enrolling or registering equipment | Using 1-way RDS system |

9. T.D. Breaux, A.I. Antón, *Analyzing Goal Semantics for Rights, Permissions, and Obligations*. p185.

R2. Customers have the right to choose if and how they will program their programmable communicating devices to respond to price and reliability signals.

O2. Vendors of programmable communicating devices are obligated to provide a means of setting the device to not respond to signals, and a means of overriding programming.

**Table 4: Activity Model for R2-O2 Balanced Right-Obligation pair**

| Activity Model 2 | Right 2 | Obligation 2 |
|---|---|---|
| **Actor** | Customers | Vendors |
| **Action** | Chose | Provide |
| **Object** | Response to signals | No response and overriding capability |
| **Purpose (optional)** | Customer choice | Customer choice |
| **Target (optional)** | Customer equipment with enabling technologies (e.g., PCT) | Customer equipment with enabling technologies (e.g., PCT) |
| **Method (optional)** | Programming or doing nothing | Programming or default settings |

R3. Customers have the right to purchase, rent or otherwise select from any vendor any and all devices and services used for energy management or other purposes in their premise.

O3. Utilities are obligated to provide an AMI communication system that uses an open communication protocol to support customer choice of equipment or services for performing DR.

**Table 5: Activity Model for R3-O3 Balanced Right-Obligation pair**

| Activity Model 3 | Right 3 | Obligation 3 |
|---|---|---|
| **Actor** | Customers | Utilities |
| **Action** | Purchase, rent, select | Provide |
| **Object** | Devices and services | AMI communications |
| **Purpose (optional)** | Customer choice | Customer choice, open market |
| **Target (optional)** | Energy management, other purposes | Customer devices |
| **Method (optional)** | From any vendor | Using open communications protocol |

R4. Vendors have the right to compete in an open market to sell HAN related systems, devices and services to all utility customers.

O4. Utilities are obligated to allow customers enrolled in utility programs to use equipment that has a communications protocol different than the AMI communication protocol.

**Table 6: Activity Model for R4-O4 Balanced Right-Obligation pair**

| Activity Model 4 | Right 4 | Obligation 4 |
|---|---|---|
| **Actor** | Vendors | Utilities |

| | | |
|---|---|---|
| **Action** | Sell | Allow |
| **Object** | HAN systems, devices, services | Customers enrolled in programs |
| **Purpose** | Open market | Open market |
| **Target** | Utility customers | Use vendor HAN systems, devices, services |
| **Method (optional)** | Open market | With communication protocol different than AMI comm. protocol |

R5: Utilities have the right to offer DR and energy management services to customers which utilize the informational and communication capabilities of their AMI system.

O5. Customers are obligated to maintain their equipment used in utility programs, in good working order, and to provide any communications translation device if needed.

**Table 7: Activity Model for R5-O5 Balanced Right-Obligation pair**

| Activity Model 5 | Right 5 | Obligation 5 |
|---|---|---|
| **Actor** | Utilities | Customers |
| **Action** | Offer | participate |
| **Object** | DR, energy management services | Utility DR programs |
| **Purpose** | Effective, economical utility DR programs | Effective participation |
| **Target** | Utility customers | Customer equipment |
| **Method (optional)** | Using AMI information and communication abilities | By maintaining, providing needed translation device |

R6. Customers have the right to participate in utility programs and at the same time, use equipment, not involved in the utility program, that receives price and reliability signals.

O6. Utilities have an obligation to provide price and reliability signals through their AMI two-way signal system and through a one-way broadcast signal system.

**Table 8: Activity Model for R5-O5 Balanced Right-Obligation pair**

| Activity Model 6 | Right 6 | Obligation 6 |
|---|---|---|
| **Actor** | Customer | Utility |
| **Action** | Receive | sends |
| **Object** | Price and reliability signals | Price and reliability signals |
| **Purpose** | Increase customer DR opportunities | Increase customer DR opportunities |
| **Target** | Customer devices | Customer equipment |
| **Method (optional)** | Participate in utility DR program and have other devices that receive one-way signals | Provide two signaling systems: utility AMI two-way signal system and one-way signal system |

# CHAPTER 6:
# Conclusions and Recommendations

## 6.1 Conclusions

The requirements engineering process of developing graphical models such as Venn diagrams and context diagrams, and text models such as use cases and rights-obligation activity models, was very effective in analyzing the Automated Metering Infrastructure (AMI)-customer equipment interface and producing verified customer, utility and vendor rights and obligations that need to be supported by California investor-owned utilities' (IOU's) AMI systems.

A starting point in the process was analysis of the existing use case material produced by the Utility AMI OpenHAN taskforce, which was vetted by the three California IOUs. Despite problems with completeness and some logical inconsistencies, analysis of the *OpenHAN document* was useful in defining the Utility Program option and the Utility Program Extended option and developing the Open Market option. Modeling the three options helped provide answers to the project's key research questions:

- What is needed in the AMI customer equipment interface to promote wide-spread and effective voluntary customer participation in DR?
- Do utility proposed AMI customer equipment solutions comply with current and upcoming DR-related direction by the state of California?
- Are there any responsibility and ownership issues in the AMI customer equipment interface that might threaten an open competitive HAN market or compromise customer choice?

Developing the context diagrams helped the project team address all the research questions. In the context diagrams representing the Utility Program option, it's clear that customers are not allowed to receive the utility price and reliability signals and participate in DR unless they are enrolled in a utility program. The Open Market option context diagram fills this need by showing a one-way broadcast signaling system that can be received by customer equipment without utility program enrollment. The Utility Program option also does not allow equipment using communications protocols different from the AMI communications protocol to receive a signal. This restricts customers and vendors by prescribing the utility AMI communications protocol for customers enrolled in a utility program. The context diagram for the Utility Program Extended option with the additional translation device, allows customers enrolled in utility programs to get the AMI price and reliability signal to equipment that uses a different communication protocol. To promote wide-spread and effective voluntary customer participation in DR and comply with current and upcoming DR-related direction by the state of California, the Open Market option and the Utility Program Extended option need to be supported in California IOU's AMI systems and DR offerings.

The Venn diagrams addressed the question of responsibility and ownership differences between the three customer options. The Venn diagram of the Utility Program option based on

the *OpenHAN document* reflects an ambiguity regarding utility and customer ownership and responsibility. In this option the customer has to submit to a high level of utility control over their DR activities. The Venn diagram for the Open Market option and the Utility Program Extended option show alternate arrangements that provide more autonomy for the customer and a clearer separation of utility and customer responsibility and ownership.

From the graphical models, use cases were developed which explored the validity and feasibility of the different rights identified in the three customer options. Then the rights were examined using right-activity models. Through this process six fundamental right-obligation pairs were identified in the AMI customer equipment interface.

## 6.2 Recommendations

### 6.2.1 Recommended Customer Options

As a result of the report findings, it is recommended that the customer Open Market option and the Utility Program Extended Option are requirements of CA IOU's AMI systems and DR offerings.

### 6.2.2 Recommended Customer, Vendor and Utility Rights and Obligations

It is recommended that the following customer, utility, and vendor rights and obligations identified through this research project should be used as policy guidelines to govern all California IOU proposals involving utility DR offerings or the interface between their AMI system and the California residential electricity customer and their equipment.

R1. Customers have the right to receive price (periodic and real-time) signals and reliability signals without enrolling in utility programs and without registering their equipment with their utility.

O1. Utilities are obligated to provide their customer with broadcast price and reliability signals which can be received by customer equipment that is neither registered with the utility nor used in a utility program.

R2. Customers have the right to choose if and how they will program their programmable communicating devices to respond to price and reliability signals.

O2. Vendors of programmable communicating devices are obligated to provide a means of setting the device to not respond to signals, and a means of overriding programming.

R3. Customers have the right to purchase, rent or otherwise select from any vendor any and all devices and services used for energy management or other purposes in their premise.

O3. Utilities are obligated to provide an AMI communication system that uses an open communication protocol to support customer choice of equipment or services for performing DR.

R4. Vendors have the right to compete in an open market to sell HAN related systems, devices and services to all utility customers.

O4. Utilities are obligated to allow customers enrolled in utility programs to use equipment that has a communications protocol different than the AMI communication protocol.

R5: Utilities have the right to offer DR and energy management services to customers which utilize the informational and communication capabilities of their AMI system.

O5. Customers are obligated to maintain their equipment used in utility programs, in good working order, and to provide any communications translation device if needed.

R6. Customers have the right to participate in utility programs and at the same time, use equipment, not involved in the utility program, that receives price and reliability signals.

O6. Utilities have an obligation to provide price and reliability signals through their AMI two-way signal system and through a one-way broadcast signal system.

## 6.3 Benefits to California

### 6.3.1 Customer Benefits

By providing customers with the recommended Open Market and Utility Program Extended options for easy voluntary participation in DR, the customer has the opportunity to control their energy consumption and reduce their electricity costs. The recommended rights ensure that the customer has a greater choice of energy management solutions to pick from, including the choice to do nothing.

### 6.3.2 Vendor Benefits

The rights and obligations recommended in this report, if adopted will ensure that vendors in the related industries will not be restricted in their offerings by utility required communications protocol.

### 6.3.3 Utility Benefits

Development of California IOU's AMI systems has already required significant effort and resources. The analysis of the UtilityAMI OpenHAN taskforce documents has shown that the *OpenHAN document* does not support a number of the recommended customer and vendor

rights. It is hoped that the analysis and recommendations of this report will help utilities avoid unnecessary expense of developing AMI systems that are limited to the Utility Program option and later having to revise them to provide functionality defined in the Utility Program Extended option and the Open Market option.

### 6.3.4 State Energy Management Benefits

Demand Response has been identified as a critical component of the California's Energy Action Plan II because it has the potential to increase reliability of the California's electric grid and avoid the expense of building new generation capacity to meet peak demand. The success of Demand Response (DR) depends to a large extent on how easy it is for customers to participate, if they choose. The implementation of utility Advance Metering Infrastructure systems and DR programs will have a major impact on how easy it is for customers to perform DR. By providing customers with the Open Market option and the Utility Program Extended option which support all of the customer, vendor, and utility rights recommended in this report, the utilities will significantly expand the range of customer DR options. Increasing customer opportunities to participate in DR will likely lead to much more widespread participation in demand response than the utility program options, which will lead to greater levels of demand response and have a positive effect on electric grid reliability and California's ability to manage peak demand without incurring the significant expense of building new generation capacity.

# GLOSSARY

The following are definitions for terms, phrases, acronyms and abbreviations used in this report

| | |
|---|---|
| AMI | advanced metering infrastructure including interval meters, communications, back-office software, implemented by the utility |
| customer | residential customer |
| customer equipment | equipment in the customer premise including thermostats, pool pumps, appliances, gateways, routers, TV monitors, health monitors, computers |
| DR | demand response |
| EAP II | Energy Action Plan II defines goals and actions to ensure adequate, reliable, and reasonably-priced electrical power and natural gas supplies through policies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers. The EAP II is a joint effort of the three key energy agencies in California – the California Energy Commission (CEC), the California Power Authority (CPA), and the California Public Utilities Commission (CPUC) |
| HAN | home area network or home automation network of customer equipment |
| OpenHAN | a task force of the UtilityAMI working group addressing issues related to the utility/consumer interface. |
| OpenHAN document | *Joint IOU HAN Use Case Definitions / Assumptions / Actors*, produced by the UtilityAMI OpenHAN task force as a foundational document for their use cases. The Utility Program option was developed from analysis of this document. |
| Open Market option | a customer equipment – AMI interface option developed by the project team that provides the customer with access to utility price and reliability signals via communication channels available to the open market which must include one-way RDS broadcast, and may also include broadband communication e.g. internet. This option does not require the customer to enroll in a program or register their equipment in order to get the signal. |
| PCT | programmable communicating thermostat, a thermostat with a communications module for receiving electric price or system reliability signals, and programming capability to automatically change thermostat setpoint adjustments in response to the signals. |
| RDS | Radio Data System, a standard for sending small amounts of digital |

| | |
|---|---|
| | information using conventional FM radio broadcasts. It can reach remote areas, has strong building penetration and minimal message latency. |
| regulator | regulatory bodies in California involved in energy regulation, specifically California Energy Commission and California Public Utility Commission |
| utility | California investor-owned utilities |
| UtilityAMI | a forum for defining serviceability, security and interoperability guidelines for advanced metering infrastructure (AMI) and demand responsive infrastructure from a utility / energy service provider perspective |
| Utility Program option | utility AMI – customer equipment interface that provides access to utility price and reliability signals via utility controlled two-way communication channels and requires customer to enroll in a utility program order to get the signal. |
| Utility Program Extended option | the Utility Program option extended to explicitly include a translation device to allow customers to use equipment in the utility program that has a different communication protocol than the AMI communications system |
| vendors | vendors and service providers of HAN or DR related products and services used in the customer premise |

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# Appendix A:
# Project Charter

Mission Statement

Provide guidance and clear policy direction to encourage customer-driven demand response (DR) and energy efficiency (EE) by developing a system that provides pricing, reliability, and load information available to all

Objectives

Create regulatory use cases based on these premises:

Price and reliability signals should be available to all

Utility advanced metering infrastructure (AMI) requirements should not unduly control the home area network (HAN) market

From the use cases, extract applicable rights and obligations of customers, vendors and utilities, and develop guiding principles for regulating utilities AMI communications with customers

Assess whether the proposed AMI-HAN configuration defined in the OpenHAN use case material satisfies these rights and obligations of customers, vendors and utilities

Critical Success Factors

This project will be a success if:

CSF 1: Guiding principles are provided to and used by utilities and the CPUC.

CSF 2: The CPUC agrees with CEC vision expressed in the guiding principles and uses them to encourage utilities to modify their AMI communication system design.

CSF 3: Utilities change their AMI specifications to include the broadcasting of price and reliability signals to any HAN network.

CSF 4: Customers receive signals that facilitate an automatic response to price without actively participating in a program.

CSF 5: Application of guiding principles results in enhanced DR and efficiency from customers.

Critical Risks and Issues

Project success is jeopardized by:

CRI 1: The very small window of opportunity (3 weeks) to produce enough of project deliverables be considered by CPUC and utilities in the AMI design decisions.

CRI 2: Utilities ambiguous usage of HAN throughout their use cases makes it difficult in this project to identify and communicate a clear, decisive, unambiguous "bright line" between the AMI and HAN domains

CRI 3: the possibility that CPUC will not understand or agree to the guiding principles developed in this project

Stakeholders

End Users of project results

Energy Commission: staff and policymakers

California Public Utilities Commission: staff and policymakers

California utilities

Creators of use cases and project materials

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Sponsor of project:

Public Interest Energy Research, Energy Systems Integration

Appendix B Actor Table from *Joint IOU HAN Use Case Definitions / Assumptions / Actors*, produced by the UtilityAMI OpenHAN task force

| **Actor Name** | **Actor Type** | **Actor Description** |
|---|---|---|
| Customer | Person | Receives pricing and event information from the AMI. Pre-programs responses to events into their load controller(s). Needs to reduce their load throughout the event to reduce energy costs or receive financial benefit. |
| HAN Devices | Devices | Equipment owned by the Customer (or, in some cases, the Utility) and operating on the same HAN as the Utility HAN devices and providing energy management services to the AMI. |
| Customer Interface | Device(s) and/or System | Any user interface available to the customer to display information related to load management and/or Utility HAN behavior, including but not limited to a PCT, In-home LCD display, Personal Computer, Fridge Magnet, and EMS etc… Connects to, commissions and configures HAN devices in the customer premises. Configures appropriate demand response information such as price, consumption, load or event responses. May store data for customer audit and analysis. May be an Energy Management System such as HomeSeer." |
| AMI | System | The AMI system is made up of systems that are required to enable remote two-way communications with meters and data storage (e.g., MDMS and MS). |
| Metering System (MS) | System | System that can communicate with AMI meters remotely (e.g., program meters, test meters, retrieve data). This system is a component of the AMI. |

| Actor Name | Actor Type | Actor Description |
|---|---|---|
| Utility AMI Gateway | Device | The logical network interface between the AMI and the HAN regardless of how that interface is embodied – e.g., meter, substation, aggregator, set-top box, DSL router, WiMAX box, etc |
| Customer Service System (CSS) | System | System that provides utility employees ability to view customer specific information regarding billing, tariffs, programs, metering, interval usage, etc. (e.g. system used by the call center) |
| AMI and/or HAN Trust Center | System | Logical software entity that provides appropriate security interactions to establish proper credentials for AMI to HAN interaction(s). |
| Automated Data Collection System (ADCS) | System | System that can communicate with AMI remotely (e.g., program meters, test meters, retrieve data). This system is a component of the AMI. |
| Utility HAN | Devices | Equipment directly connected to load devices capable of receiving curtailment, pricing, load, and event messages and carrying out the requests or otherwise responding to them. Would also include Customer Interface devices or systems described below. The Utility HAN is a combination of three things: 1) AMI meter (with HAN interface) and 2) the customer selected or utility-supplied set of HAN-Connected Control Equipment and 3) Customer Interface. All devices on the Utility HAN, working in concert, switch loads on or off or reduce load in response to events or messages communicated by the AMI system (AMI Meter). At least one device needs to follow the pre-programmed rules (e.g., PCT). The rest may be pre-programmed to respond to messages or events, or may be programmed by the Customer Interface. |
| Customer HAN Gateway | Device | Customer device that coordinates the HAN commissioning and behavior. Customer device |

| Actor Name | Actor Type | Actor Description |
|---|---|---|
| | | that interfaces to, and routes network traffic between, the HAN, external, non-HAN networks (such as premises WiFi, cable, DSL, satellite, etc… networks) and the Customer HAN Interface. May or may not be the Premises Gateway. |
| Customer HAN | Devices | Equipment owned by the Customer and operating on the same HAN as the Utility HAN devices and providing non-utility use case services (such as security, child monitoring, home entertainment or other services). Prior to installation/provisioning a subset of Customer HAN Equipment could be attached to (or part of) load bearing equipment and be capable of participation in AMI programs. |
| Pool Pump Controller | Devices | The controller is a separate device and resides between the timer and the pool pump. The controller has minimal intelligence and sends and receives signals through the HAN. |
| Customer Representative | Person or System | Intelligent system that consumer interacts to work with a business (e.g., utility). |
| HAN Device Registration Application | Application | Computer logic that automates certain registration activities on behalf of a device or consumer. |
| In Home Display (IHD) | Device | A standalone device and simply receives data and displays information. It has minimal intelligence and storage capacity and receives data from the AMI system through the Utility AMI gateway. |
| Energy Management System (EMS) | Application | Computer program used primarily for controlling energy-controllable devices (e.g., pool pump, PCT, light ballasts). Program may reside within a PCT, computer, cable set top box, "smart" IHD, or other computing device with ability to display parameters and accept user input. |