CALIFORNIA ENERGY COMMISSION

Requirements Engineering for the Advance Metering Infrastructure and the Home Automation Network (AMI-HAN) interface

Staff Report

February 2008

Arnold Schwarzenegger, *Governor*

Abstract

The main goal of this research project was to identify policy guidelines for the interface between California investor-owned utilities (IOU's) Advanced Metering Infrastructure (AMI) and California residential electricity customers and their equipment, that will promote the success of demand response (DR), a critical component of California's Energy Action Plan II. A secondary goal was to perform the research using requirements engineering techniques and evaluate how useful the techniques are for defining policy guidelines.

A project team using requirements engineering techniques, analyzed documents produced by the OpenHAN taskforce of the UtilityAMI, a utility industry group. These documents include definitions, assumptions, actors and use cases that define the utility AMI interface to customers home automation network equipment. This analysis included modeling the configurations in these documents with context diagrams, Venn diagrams and use case scenarios. A second set of models representing an open market configuration was created for comparison. From this process rights and obligations of customers, vendor and utilities were identified and validated.

The final recommendation of this report is that the rights and obligations defined in this report be adopted as a primary requirement for governing California IOU's proposals for their AMI system and DR rates and programs. It is also recommended that the requirements engineering process used in this project, should be utilized in projects focused on developing policy.

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

Executive Summary

Introduction

As stated in the State of California Energy Action Plan II: Implementation Roadmap for Energy Policies (EAP II), lowering consumer costs and increasing electricity system reliability are major goals of demand response (DR), and the advanced metering infrastructure (AMI) is an essential technology for enabling customer participation in DR.

In response to subsequent AMI and DR related rulings and legislation, California investor-owned utilities (IOU's) are investing significant resources to develop their AMI systems and define their DR rates and incentive programs. To this end the California IOU's have participated in the OpenHAN taskforce of the UtilityAMI consortium of utilities and vendors, which has produced generic use cases and supporting documents to define the interface between the utility AMI and the customer's 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 (HAN) which are clearly on the customer side of this interface. How the utility AMI system and the customer's equipment are integrated will play a significant role in determining the success of the Energy Action Plan II and to what degree the customer is provided with feasible and acceptable options for voluntarily participating in DR.

Purpose

The goal of this project was to develop policy guidelines that would foster the greatest customer participation in DR by examining customer choice implications of various the AMI-customer equipment interface configurations.

Project Objectives

The main research objective of this project 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 HAN. To accomplish this, the project team was tasked with examining existing relevant documentation vetted by the California IOU's, and modeling various AMI-customer equipment configuration scenarios to answer the following 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?

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

Project Outcomes

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 documentation. The resulting models represent two configurations based on the OpenHAN documents and one option developed by the project team:

- Utility Program option, based on OpenHAN documentation
- Utility Program Extended option, which expands customer choice of DR options and depending on interpretation may or may not be supported by the OpenHAN documentation
- Open Market option, a configuration which separates the utility and customer domains and is not defined and controlled by enrollment in a utility program

From the models and options, the team identified policy guidelines in the form of customer, vendor and utility rights and obligations that should be provided for in the utility AMI systems and DR 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 vantages points for evaluation. For example, the rights and obligations generated with the graphical models were validated through the development of use case scenarios.

Conclusions

To support the most effective development of pricing, DR, and other energy programs, utility AMI systems must support the five main rights defined in this report.

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 the utility.

R2. Customers have the right to choose if and how they will 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 HAN systems, energy management systems, security and entertainment devices and services to all utility customers.

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.

The customer Utility Program option as defined in the OpenHAN document only promotes the utility right, R5 and limits or denies the customer and vendor rights, R1 – R4. The customer Utility Program Extended option is the Utility Program option with an additional feature which provides support for customer right R3 and vendor right R4. The customer Open Market option developed by the project team, supports all customer rights R1 – R3 and vendor right R4. The Open Market option and the Utility Program Extended option are both need to provide support for all the rights defined in this report and to promote the widest participation in DR.

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

Recommendations

As a result of these findings, it is recommended that the customer, vendor and utility rights and obligations defined in this report be used as a primary policy guideline for governing all California IOU proposals for their AMI system and DR rates and programs. It is also recommended that the California IOU's should demonstrate that their AMI systems support the customer Open Market option and the Utility Program Extended Option which combined, promote and protect all the customer, vendor and utility rights defined in this report.

It is recommended that projects focused on defining policy guidelines should consider utilizing a requirements engineering process of modeling the information and extracting rights and obligations from the models to form policy guidelines.

Benefits to California

Demand Response, a critical component of the California's Energy Action Plan II, has the potential to reduce customer costs, 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 depends to a large extent on how the utilities implement their AMI systems. The rights and obligations in the AMI-customer equipment interface recommended as policy guidelines in this report, if adopted will ensure that California IOU's include in their AMI configuration and DR offerings more opportunities for customers to voluntarily participate in

DR. It is envisioned that increasing customer DR o pportunities will result in more effective DR in California.

1.0 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 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 (IOU's) 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 Open HAN configuration includes control devices such as programmable communicating thermostats, display devices and HAN's which 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 these two systems, the utility AMI system and the customer's equipment including HAN systems, are integrated will play a significant role in customer participation in DR.

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.

2.0 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 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 indentified 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.

3.0 Project Outcomes

An analysis of the OpenHAN taskforce use case documentation which was approved by the California IOU's, 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. This document was selected because it was referred to throughout the OpenHAN use cases, was foundational to other OpenHAN documentation, and 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. Therefore 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, a second option was developed which is slightly different than the Utility Program option and called the Utility Program Extended option.

The team developed a separate configuration depicting a 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 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]

Given interpretation problems such as this, the models were created 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]

1

2

3

4

5

6

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 customer Utility Program options, the project team developed both graphical and textual models. In the diagrams representing the Utility Program options, the names of actors from the OpenHAN document are underlined to identify them and facilitate looking them up in the copy of the OpenHAN document actor table which is reproduced in Appendix B.

Venn diagrams were developed to explore how responsibility and ownership differs in 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 & 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.

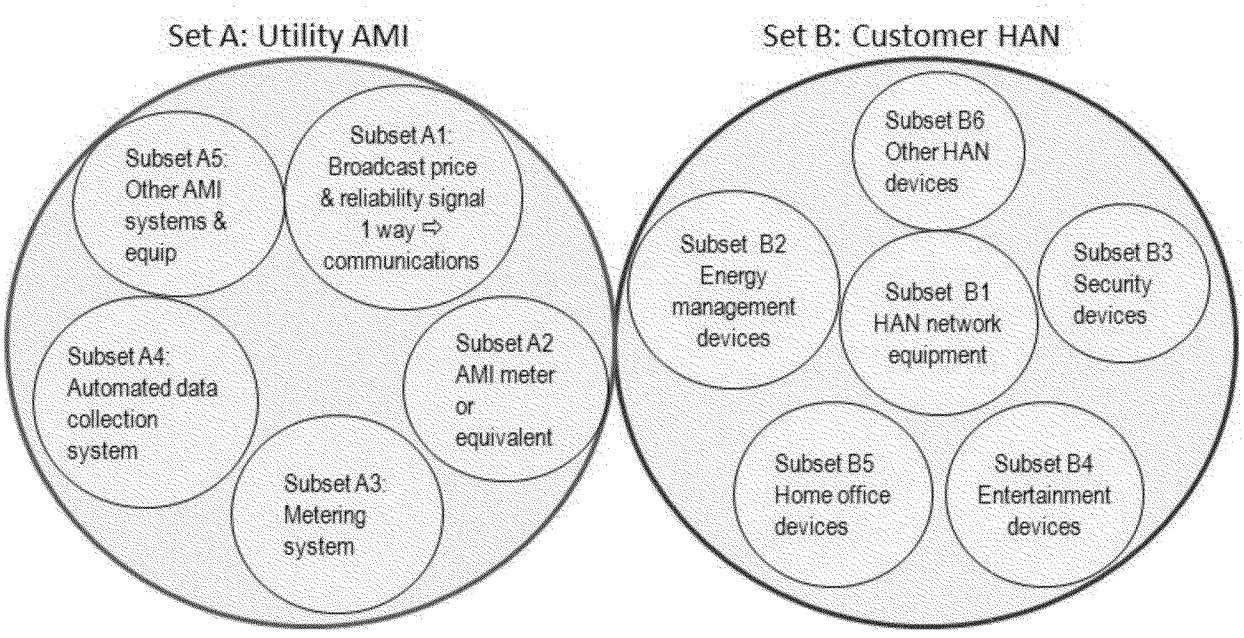

Figure 1. Venn Diagram 1: Customer Open Market Opt ion

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 fridge 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)". 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.

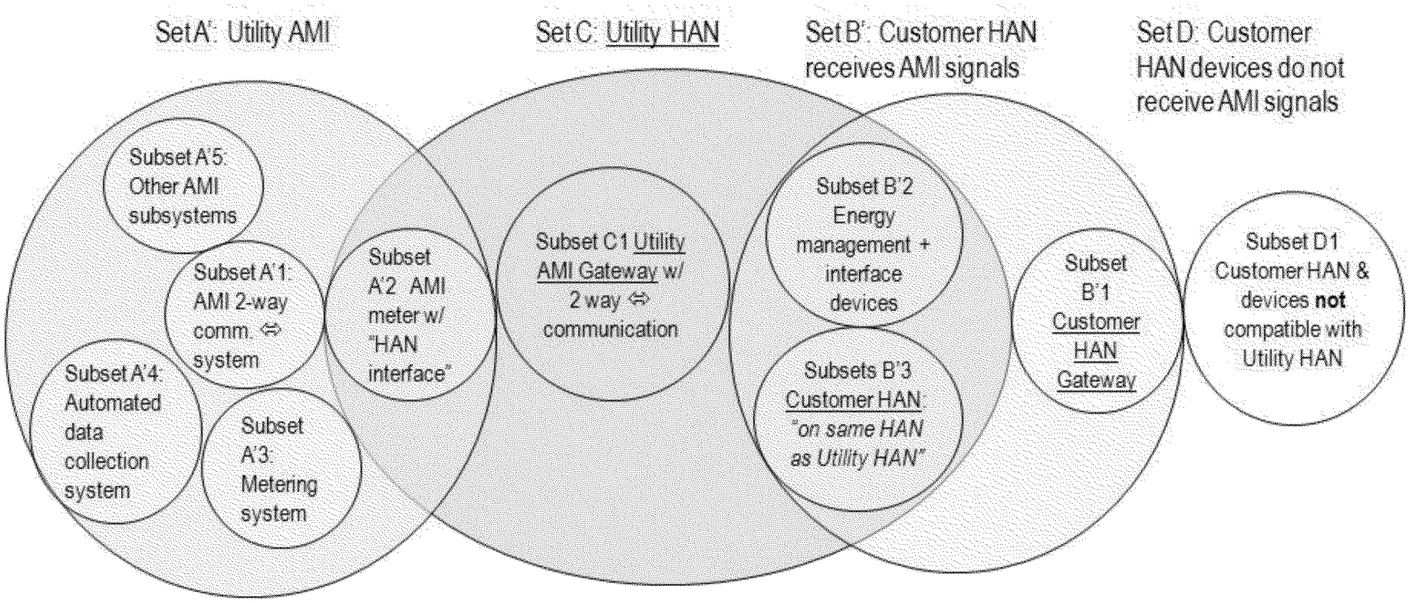

Figure 2. Venn Diagram 2: Customer Utility Program Option

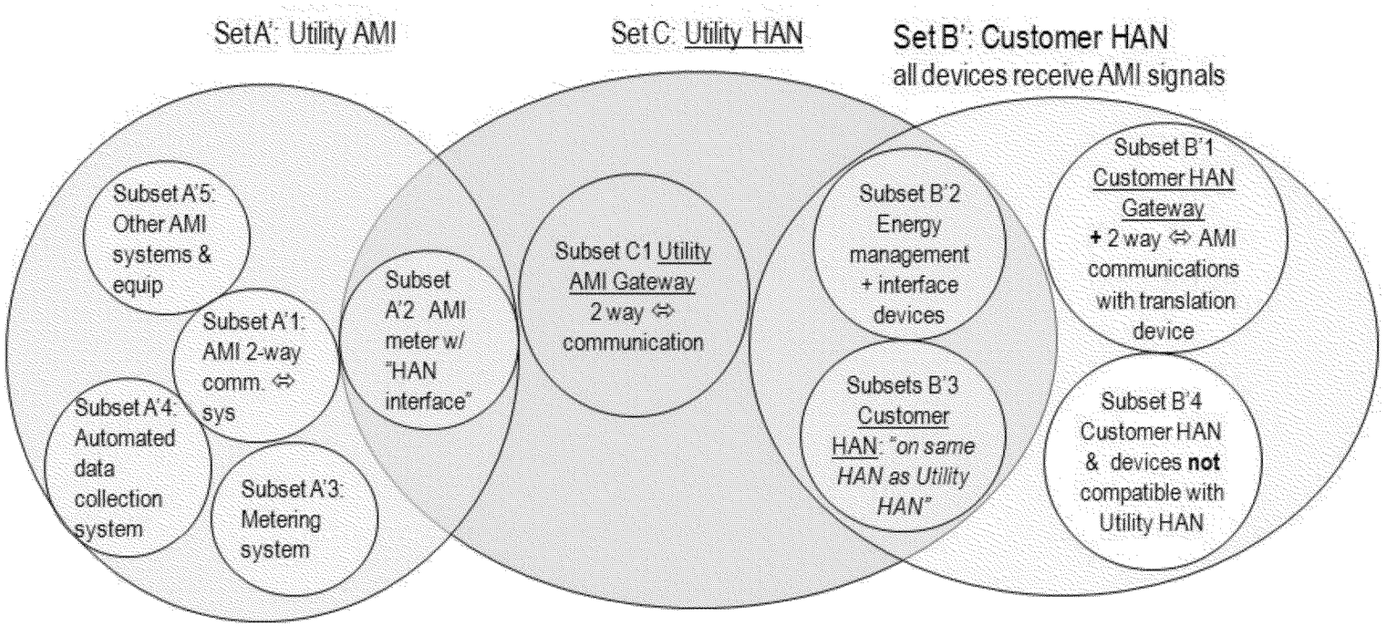

Figure 3. Venn Diagram 3: Customer Utility Program Extended Option

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 relability 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. The vendors have a direct interface with customer and the equipment and services the customer has selected from them. The broadcast price & reliability signals can be picked up by any device that has the ability to receive the broadcast signals. 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.

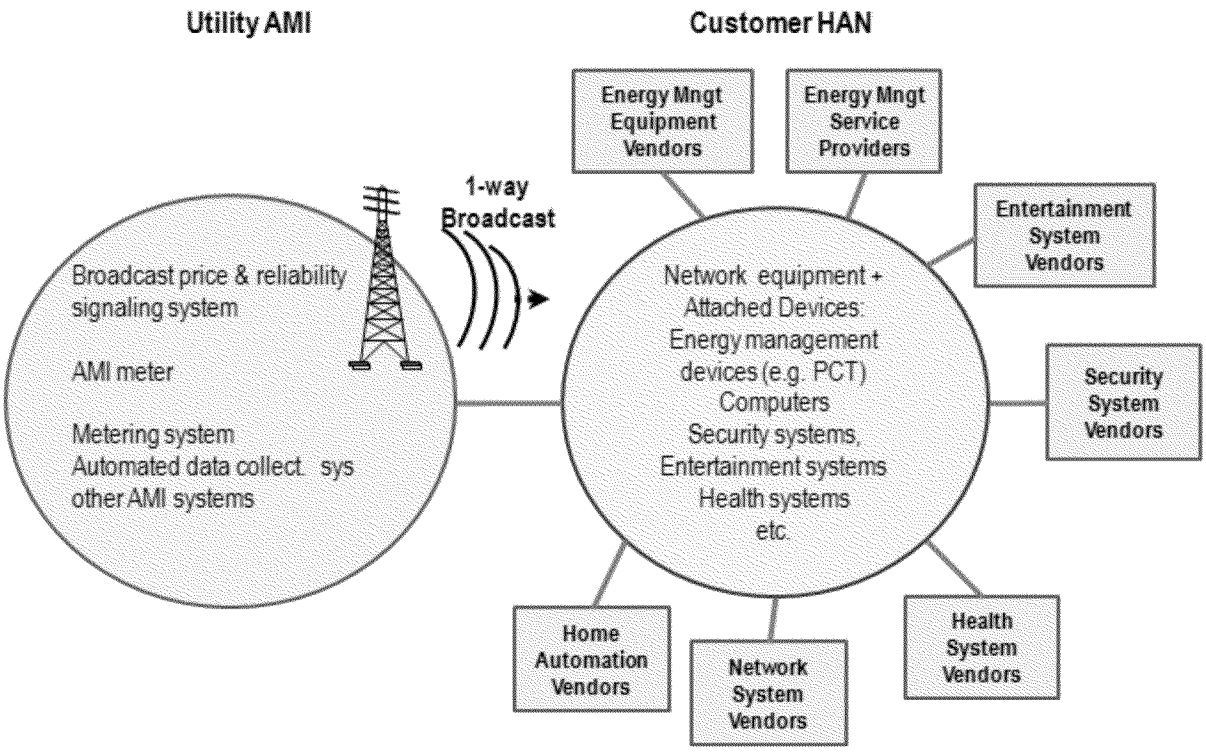

Figure 4. Context Diagram 1: Open Market Option wi th 1-way Broadcast Price & Reliability Signals

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.

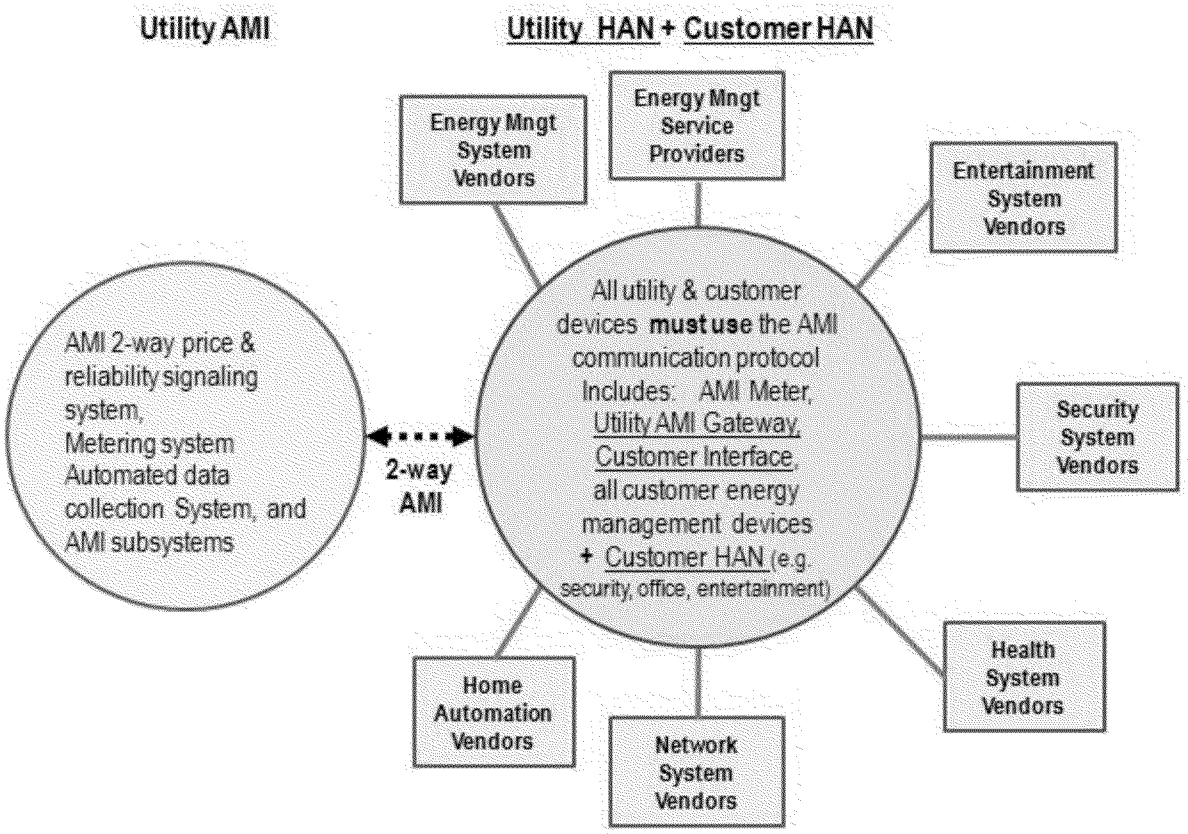

Figure 5. Context Diagram 2: Utility Program Opti on, all equipment using AMI comm. Protocol

The context diagram in Figure 6 depicts the customer Utility Program option for the customer who already has a HAN and/or 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. All other devices on the customer's original HAN using a different communication protocol, are represented as a separate system and cannot receive the AMI price and reliability signals. The Customer HAN Gateway actor manages network traffic between the customer's operable HAN and devices, and the customer's 'non-operable' networks and devices, but as defined in the OpenHAN document, this actor does not include a translation device.

Figure 7 shows the customer Utility Program Extended option with the translation device added the Customer HAN Gateway which provides support for customer right R3 and vendor right R4 by allowing the customer's HAN's and equipment that uses a different communication protocol to receive the AMI price and reliability signals.

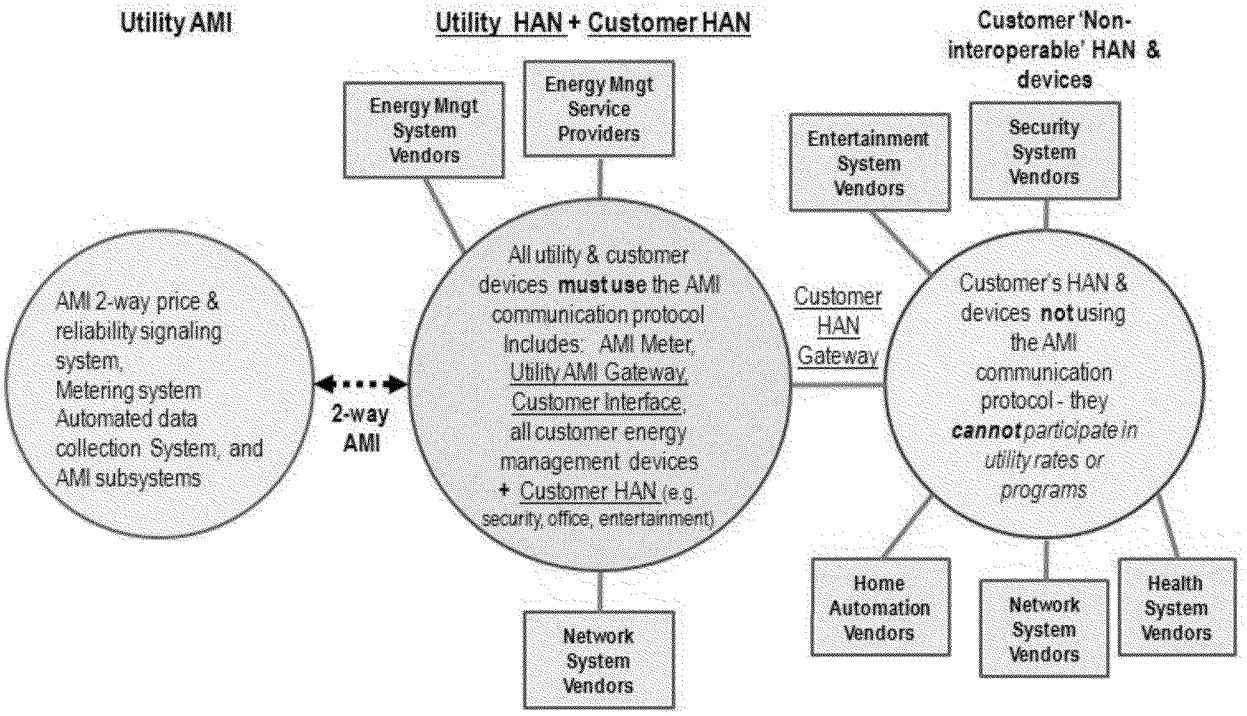

Figure 6. Context Diagram 2a: Utility Programs Opt ion, with some equipment not using AMI comm. protocol

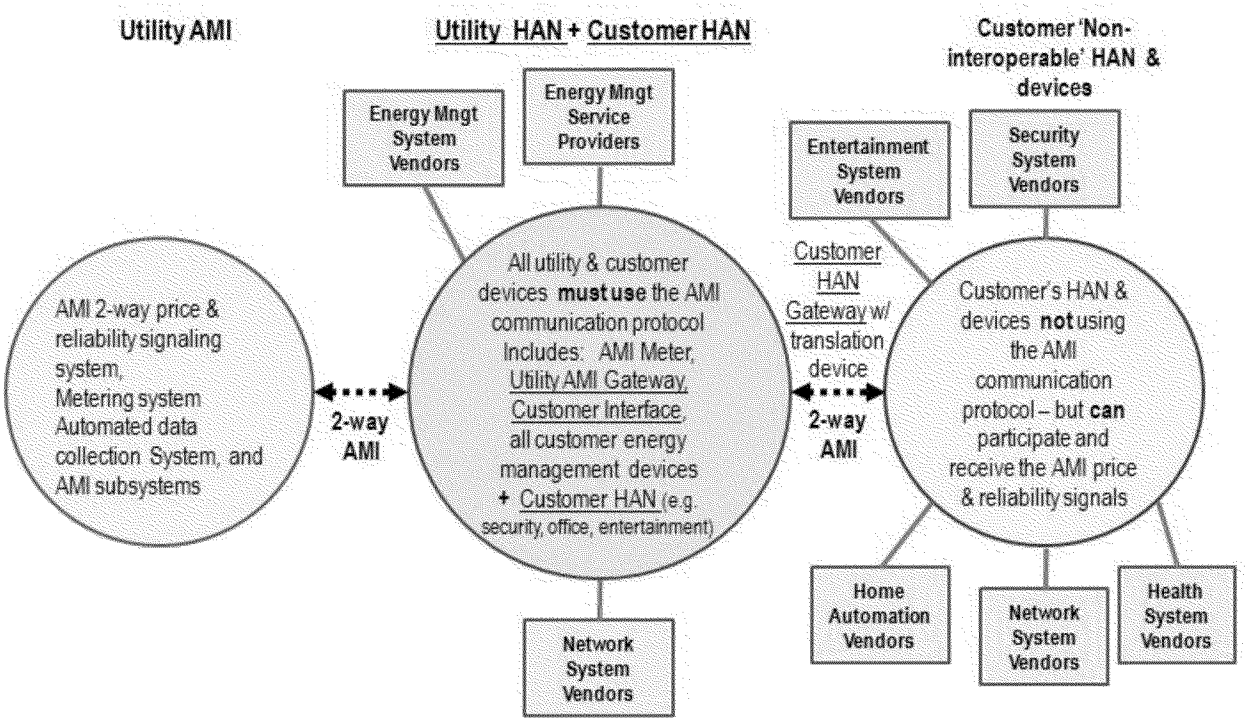

Figure 7. Context Diagram 3: Utility Programs Exte nded Option, with translation device

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 & 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.

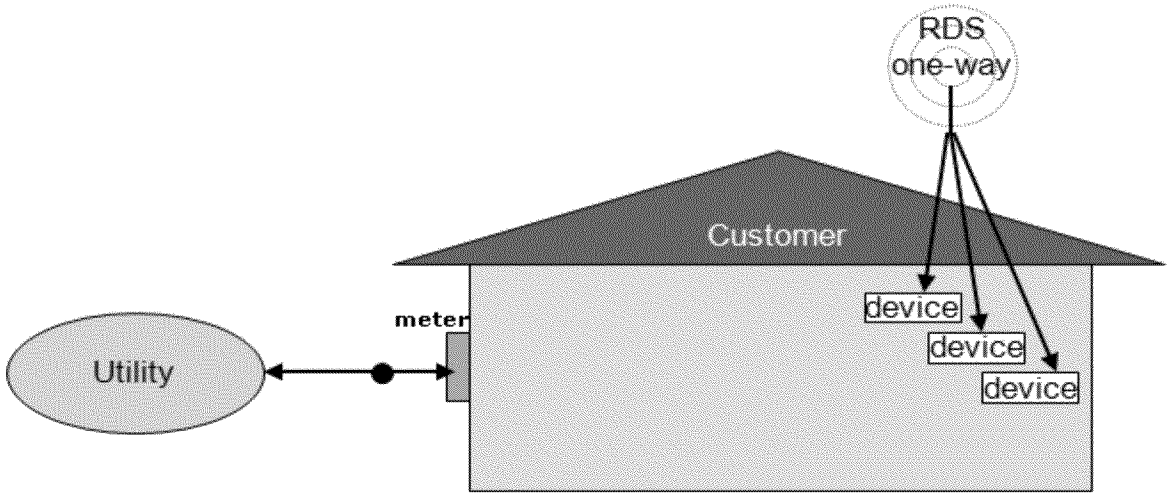

Figure 8. Graphical Scenario 1: Open Market Option – Individual Devices

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.

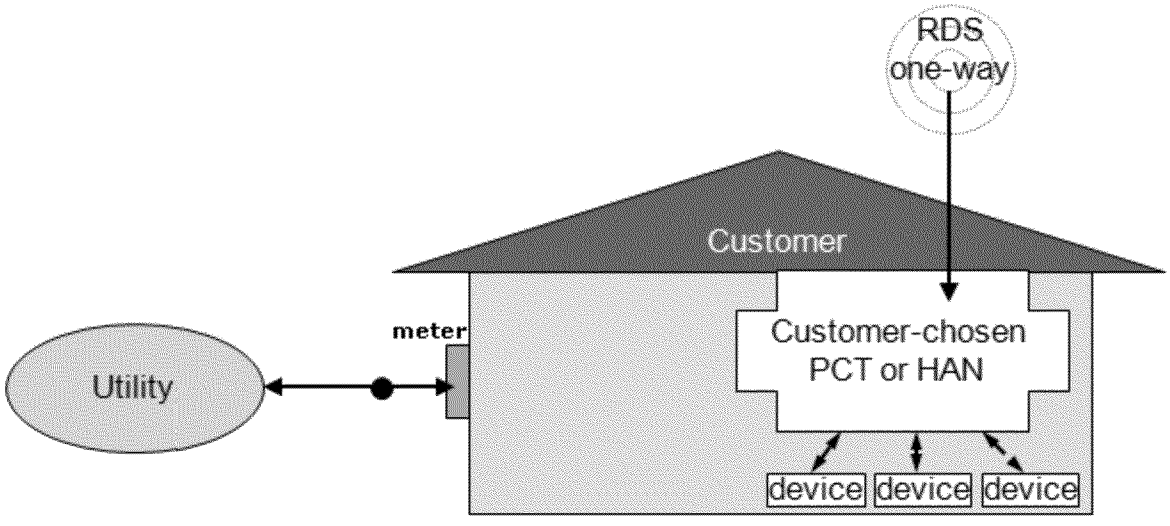

Figure 9. Graphical Scenario 2: Open Market Option – PCT or HAN with Attached Devices

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.

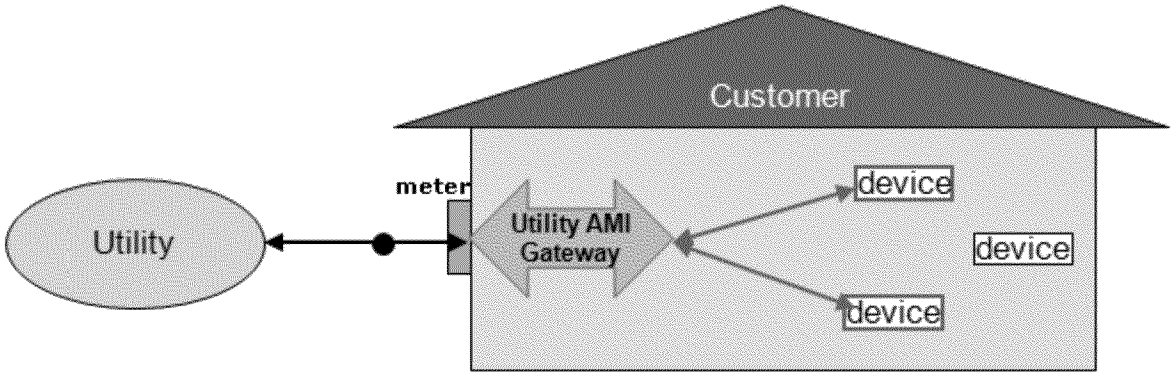

Figure 10. Graphical Scenario 3: Utility Program Op tion – Individual Devices

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.

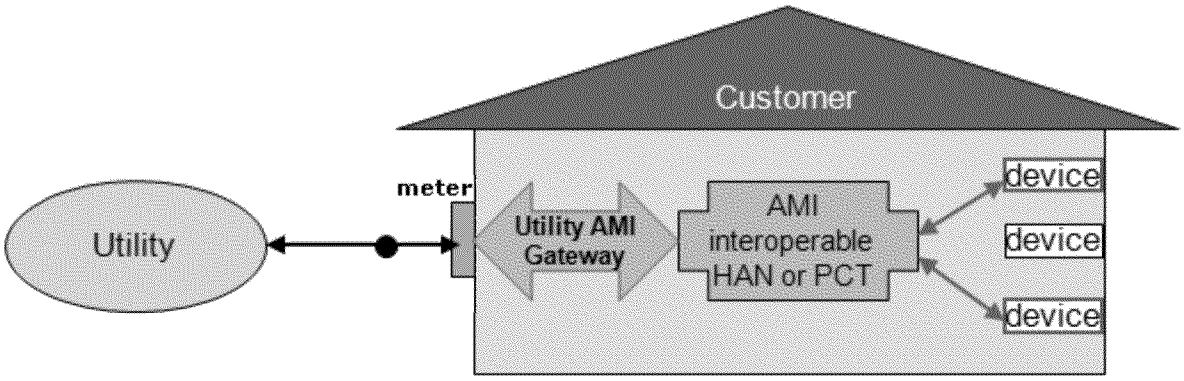

Figure 11. Graphical Scenario 4: Utility Program Op tion – PCT or HAN Plus Attached Devices

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

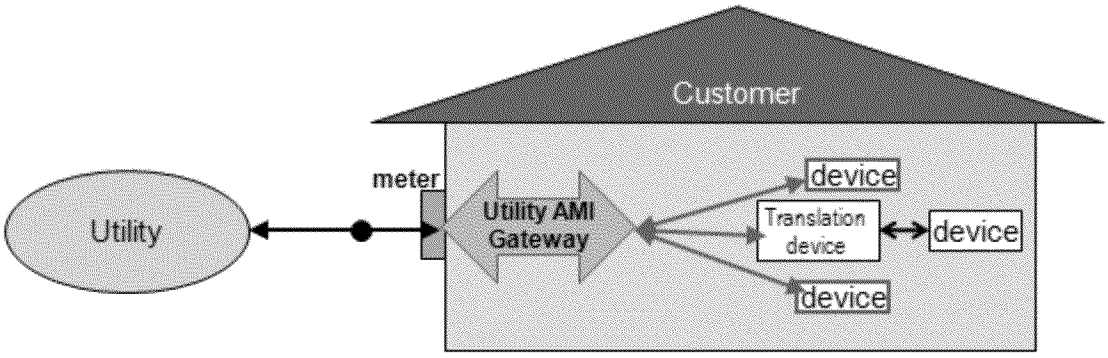

Figure 12. Graphical Scenario 3a: Utility Program E xtended Option – additional translation device

One additional configuration was explored with the graphical scenarios, depicted in Figure 13. This graphical scenario represents 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.

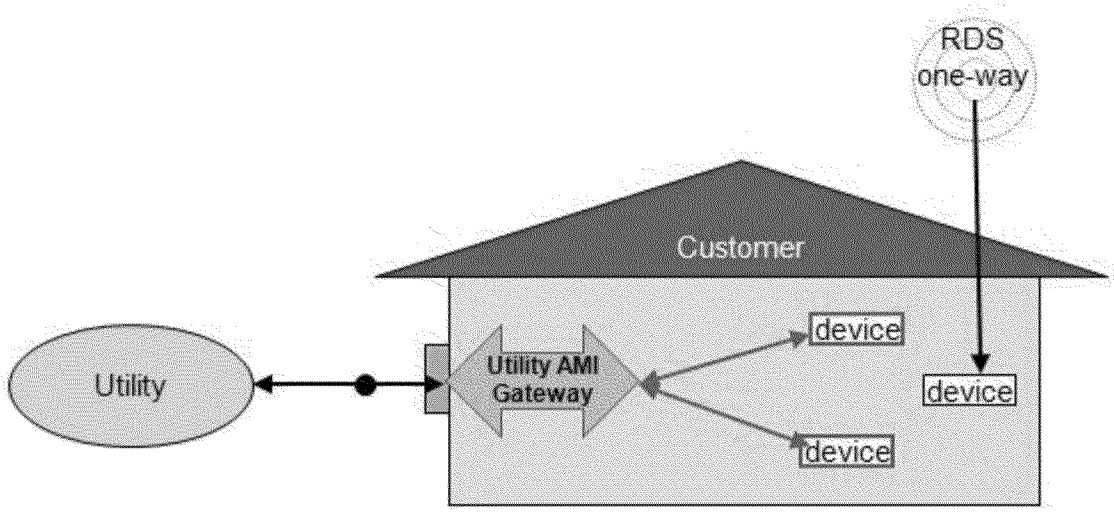

Figure 13. Graphical Scenario 5: Utility Program Op tion + device using RDS one-way system

4.0 Use Case Scenarios

Use case scenarios describe the interactions between a system & 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 about 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 & their AMI systems, and the primary actor is a California residential electricity customer. Two sets of use case scenarios were developed, one for the customer Open Market option and one for the customer Utility Program options. The objective was to explore the validity of customers 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 exist yet, 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.

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 an RDS-enabled device to recognize the correct RDS 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 RDS system, and an RDS-enabled device in the customer premise for receiving and responding to real-time price and emergency signals. Table 2 lists the Open Market option use case scenarios developed.

Use Case #	Primary Actor: Customer Use Case Name – the primary actor's goal with the s ystem	Scope Level
1.1	Prepare RDS-enabled device to recognize correct RDS signals	Summary
1.1.1 Program RDS-enabled device to recognize corre ct RDS price signals		Scenario
1.1.2 Register RDS-enabled device to recognize corr ect RDS signals		Scenario
1.2	Receive signals through one-way RDS system	Summary
1.2.1 Receive real time price signals through one-w ay RDS system		Scenario
1.2.2 Receive emergency signals through one-way RDS system		Scenario

Table 1. Open Market Option Use Case Scenarios

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 3 lists the Utility Program option use case scenarios developed in this project.

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

Table 2. Utility Program Option Use Case Scenarios

4.1. 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 & their systems, referred to as Utility

Preconditions: Utility's RDS system 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. 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 using 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

Rights: Customers have a right to chose if and how they will program their programmable communicating devices to respond to price and reliability signals.

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 & their systems, referred to as Utility

Preconditions: Utility's RDS system is operational.

Utility's RDS system carries several dynamic price rates.

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 that the Customer is eligible for
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. 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

Rights: Customers have a right to program their RDS-enabled device to recognize the correct RDS signals without having to supply the utility with personal information

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 & their systems, referred to as Utility

Preconditions: Utility's RDS system is operational.

RDS-enabled device has a factory set unique ID that can be displayed.

Utility includes registered RDS-enabled device unique IDs in RDS signals.

Scenario:

Step #	Performed by	Action performed
1	Utility	Sends Customer RDS-enabled device registration instructions which include number to call and the utility-location code
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	Enters the utility-location code into the RDS-enabled device and if required, activates the RDS capability in the Device
8	Customer	Programs how the device should respond to the signal. 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 & their systems, referred to as Utility

Preconditions: Utility's RDS system is operational.

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

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. 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

Rights: Customers have a right to receive real-time price signals using RDS-enabled devices.

Customers have a right to be on a real-time price tariff with minimum effort.

Obligations: Utilities are obligated to send real time price signals through RDS as well as the utility's AMI communication system

Utilities are obligated to provide a real-time price rate that is easily accessible to all customers.

Use Case ID: 1.2.2

Use Case Name: Receive emergency signals through o ne-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 & their systems, referred to as Utility

Preconditions: An emergency event has occurred.

California's RDS system 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 curt ail load, and displays emergency signal alarms
5	Customer Turns	off other loads in response to eme rgency indications 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 & indicates emergency is over
10	Customer	Turns loads back to normal after notici ng emergency is over 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	…	

Rights: Customers have a right to chose if and how they will program their programmable communicating devices to respond to emergency signals.

Rights: Customers have a right to receive emergency signals using the RDS system built into their programmable communicating devices.

Obligations: Utilities are obligated to provide emergency signals using the RDS system in addition to their preferred AMI communication methodology to reach the widest number of customers and avoid outages.

4.2. Utility Program Options Use Case Scenarios

Use Case ID: 2.1.1

Use Case Name: Enroll in utility DR program withou t any programmable communicating devices

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

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

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

Scenario:

Step #	Performed by	Action performed
1	Utility	Sends Customer information about DR progr am 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 i f 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 co mmunication system from retail store	
3b	Utility	Provides Customer with AMI communication module
3c	Customer Installs AMI communication module in th eir Device	
4…		

Rights: Customers have the right to purchase and use programmable communicating devices of their own choosing for participating in utility DR programs.

Utilities have a right to require that customers enrolled in a utility DR program use programmable communicating devices that can communicate using the AMI communication protocol.

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 e xisting 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 & 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

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 progr am offerings
2	Customer Enrolls in the Utility's DR program, wit h their existing HAN	
3	Utility	Finds that HAN does not use the AMI commu nication protocol and tells Customer that they must provide a translation devic e 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 & 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 & registers Device with their AMI system

Rights: Customers have a right to choose what translation device they use in their system to communicate between the utility AMI and their HAN.

Obligations: Customers are obligated to provide and operate a translation device if they are enrolled in a utility DR program and their HAN or programmable communicating device does not use the utility AMI communication protocol.

Use Case ID: 2.1.3

Use Case Name: Change connection to AMI by signing up with a 3rd party load aggregator who will provide price & reliability signaling

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

System: California investor-owned utility & 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 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 w 3rd party aggregator but want to continue participating in the Utility DR program.
2a	Utility	Informs the Customer that they can stay in the DR program.
3	…	

Use Case ID: 2.2.1

Use Case Name: Receive real-time price signals thr ough 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 & 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 real-time price AMI signal with a price that is very high due to peak loads
2	Device	Receives the real-time price AMI signal & 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 ver y high price indication NOTE: This is optional and voluntary
7	Utility	Sends real-time price AMI signal with a lower price
8	Device	Receives real-time price AMI signal & 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 notici ng price decrease 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 t he 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 & 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 emergency start AMI signal
2	Device	Receives emergency start AMI signal & 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 NOTE: This is optional and voluntary
6	Utility	Sends emergency stop AMI signal
7	Device	Receives emergency stop AMI signal & 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 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 & 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 they have a sick child

5.0 Rights and Obligations

Throughout the development of the different models, customer, utility and vendor rights and obligations were identified and evaluated. 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 of them, 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 guildelines[7] which is the approach taken in this project.

Activity models of balanced right-obligation pairs were created to identify implicit rights and obligations for each explicit right and obligation. This process is also improvee the logical expression of the rights and obligations. After a final evaluation and reworking, the following rights and obligations with their associated activity models were identified as essential to the Open Market option and the Utility Program options.

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 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.

Activity Model 1	Right 1	Obligation 1
Actor	Customer	Utility
Action	Receive	provide
Object	real-time price & emergency signals	real-time price & emergency signals
Purpose (optional)	save money, avoid outages	manage loads & avoid outages
Target (optional)	Enabling technologies (e.g., PCT)	Enabling technologies (e.g., PCT)
Method (optional)	using RDS system	using RDS system

Table 3. Activity Model for R1-O1 Balanced Right-Ob ligation pair

7

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

O2. Vendors are obligated to provide a means in their programmable communicating devices for deactivating the communications capability and a means of overriding programming

Activity Model 2	Right 2	Obligation 2
Actor	Customer	Vendors
Action	chose	provide
Object	response to signals	deactivating or overriding ability
Purpose (optional)	Customer choice	Customer choice
Target (optional)	Enabling technologies (e.g., PCT)	Enabling technologies (e.g., PCT)
Method (optional)	Programming or doing nothing	Programming or default

Table 4. Activity Model for R2-O2 Balanced Right-Ob ligation pair

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 and does not unduly restrict customer choice of customer equipment or services that support performing DR.

Activity Model 3	Right 3	Obligation 3
Actor	Customer	Utilities
Action	Purchase, rent, select	provide
Object	Devices and services	Customer choice of equipment
Purpose (optional)	Customer choice	Customer choice, open market
Target (optional)	Energy management, other purposes	AMI communications
Method (optional)	From any vendor	Open communications protocol

Table 5. Activity Model for R3-O3 Balanced Right-Ob ligation pair

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

O4. Utilities are obligated to not restrict customers enrolled in utility programs to equipment that uses the AMI communication protocol.

Activity Model 4	Right 4	Obligation 4
Actor	Vendor	Utilities
Action	sell	provide
Object	HAN systems, devices services	Customer choice of equipment
Purpose	Open market	Open market
Target	Utility customers	Utility programs
Method (optional)	Open market	Allow devices w/ different comm.

Table 6. Activity Model for R4-O4 Balanced Right-Ob ligation pair

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 participating in utility programs are obligated to maintain correct working of customer equipment that communicates with the AMI system and provide any communications translation device if needed.

Activity Model 5	Right 5	Obligation 5
Actor	Utility	Customer
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 comm. abilities	.by maintaining, providing needed translation device

Table 7. Activity Model for R5-O5 Balanced Right-Ob ligation pair

6.0 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 ca ses and rights-obligation activity models, was very effective in analyzing the AMI-customer eq uipment interface and producing verified customer, utility and vendor rights and obligations that need to be supported by California 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 t he three California investor owned utilities. 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 opti on. 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, if they are not 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 by adding a 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 five fundamental right-obligation pairs were identified in the AMI customer equipment interface.

6.2. Recommendations

As a result of these findings, it is recommended that following customer, utility and vendor rights and obligations identified through this research project should be established as policy 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 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 chose if and how they will program their programmable communicating devices to respond to price and reliability signals.

O2. Vendors are obligated to provide a means in their programmable communicating devices for deactivating the communications capability 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 and does not unduly restrict customer choice of customer equipment or services that support performing DR.

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

O4. Utilities are obligated to not restrict customers enrolled in utility programs to equipment that uses 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 participating in utility programs are obligated to maintain correct working of customer equipment that communicates with the AMI system and provide any communications translation device if needed.

It is also recommended that the California IOU's demonstrate in their AMI proposals how they will provide for the Open Market option and Utility Program Extended option which support the customer and vendor rights defined in this report, and would foster the widest support for customer's voluntary participation in DR.

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 repo rt, 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 Calikfornia 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 satisfy customer and vendor rights.

6.3.4. State Energy Management Benefits

Demand Response has been identified as a critical c omponent of the California's Energy Action Plan II because it has the potential to increase re liability of the California's electric grid and avoid the expense of building new generation capaci ty to meet peak demand. The success of Demand Response depends to a large extent on how ea sy 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 the customer, vendor and utility right s recommended in this report, the utilities will expand the range of customer DR options. Increasing customer opportunities to participate in DR, will have a positive effect on electric grid reliability and California's ability to manage peak demand without incurring the significant expen se of building new generation capacity.

7.0 References

Cockburn, Alistair Writing Effective Use Cases. Addison-Wesley, 2001. ISBN: 0-201-70225-8.

California Energy Commission 2008 Building Energy Efficiency Standards for Residential and NonResidential Buildings. Express Terms – 45 Day Language. November 2007.

California Energy Commission, and California Public Utilities Commission Energy Action Plan II. 2005.

T.D.Breaux, M.W. Vail, A.I.Anton, Towards Regulatory Compliance: Extracting Rights and Obligations to Align Requirements with Regulations. IEEE Requirements Engineering Conference, Minneapolis, MN, pp49-58, 2006.

UtilityAMI OpenHAN task force Joint IOU HAN Use Case Definitions / Assumptions / Actors. published on the website, http://sharepoint.ucausersgroup.org/OpenHAN/default.aspx. Version Dated 9/25/07.

8.0 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	OpenHAN is 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
Open Market option	customer equipment interface that provides unrestricted access to utility price and reliability signals via communication channels available to the open market which must include RDS broadcast and may 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
RDS	Radio Data System
regulator	California Energy Commission and California Public Utility Commission regulatory bodies
utility	California investor-owned utilities
UtilityAMI	UtilityAMI is is a forum to define serviceability, security and interoperability guidelines for advanced metering infrastructure (AMI) and demand responsive infrastructure (DRI) from a utility / energy service provider perspective.
Utility Program options	utility AMI – customer equipment interface that provides access to utility price and reliability signals via utility controlled communication channels and requires customer to enroll in a utility program order to get the signal.
vendors	vendors & service providers of HAN or DR related products and services

9.0 Bibliography

California Energy Commission reports:

1. Reference design For Programmable Communicating Thermostats Complia nt with Title 24-2008 March 26, 2007 Erich Gunther, Editor, Enernex

2. A VISION OF DEMAND RESPONSE – 2015 prepared by L evy Associates, January, 2006 CEC-500-2006-001

3. CA IOU's Industry Standard HAN Development CPUC and CEC Update, June 26, 2007 PowerPoint presentation

State of Demand Response in California, Ahmad Faruqui and Ryan Hledik, The Brattle Group, Draft 4/07 CEC 200-2007-003D

CPUC OIR's including those in process:

Rulemaking 02-06-001 (Filed June 6, 2002)Order Insti tuting Rulemaking on policies and practices

for advanced metering, demand response, and dynamic pricing.

2/19/04 JOINT ASSIGNED COMMISSIONER AND ADMINISTRATIVE LAW JUDGE'S RULING PROVIDING GUIDANCE FOR THE ADVANCED METERING INFRAS TRUCTURE BUSINESS CASE ANALYSIS

7/21/2004 ADMINISTRATIVE LAW JUDGE AND ASSIGNED C OMMISSIONER'S RULING ADOPTING A BUSINESS CASE ANALYSIS FRAMEWORK FOR ADV ANCED METERING INFRASTRUCTURE [particularly the scenarios in Attachment A]

ORDER ADOPTING CHANGES TO 2007 UTILITY DEMAND RESPO NSE PROGRAMS, Decision 06-11-049 November 30, 2006

Order Instituting Rulemaking Regarding Policies and Protocols for Demand Response Load Impact Estimates, Cost-Effectiveness Methodologies, M egawatt Goals and Alignment with California Independent System Operator Market Design Protocols DRAFT

Appendix A: Project Charter

Mission Statement

Provide guidance and clear policy direction to encourage customer-driven DR and 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 AMI requirements should not unduly control the 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 & 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

CEC: Dave Hungerford in his communications with CPUC and utilities

CPUC:

California investor owned utilities: SCE, SDG&E, PG&E

Creators of use cases and project materials

PI: Diane Pepetone

Project team: Dave Hungerford, Margaret Sheridan, Kristy Chew, Roger Levy, Ron Hofmann

Advisors on project:

T24 PCT standards: Maziar Shirakh, CEC; Karen Herter, H-M-G

OpenHAN & CA IOU's: Erich Gunther, Enernex

Sponsor of project:

PIER ESI: Mike Gravely, CEC

Appendix B Actor Table from the OpenHAN Document

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 throughou t 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 dis play information related to load management and/or Utili ty 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. Ma y be an Energy Management System such as HomeSeer.”
AMI	System	The AMI system is made up of systems tha t 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.
Utility AMI Gateway	Device	The logical network interface between the AMI and t he 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 abili ty to view customer specific information regarding billing, tar iffs, 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 credentia ls for AMI to HAN interaction(s).
Automated Data Collection System (ADCS)	System	System that can communicate with AMI re motely (e.g. program meters, test meters, retrieve data). This system is a component of the AMI.
Utility HAN	Devices	Equipment directly connected to load device s 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) AM I 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 event s or messages communicated by the AMI system (AMI Meter). At least one device needs to follow the pr e-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 that interfaces to, and routes network traffic between, th e 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 Custome r 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/provisionin g 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 settop box, “smart” IHD, or other computing device with ability to display parameters and accept user input.