White Paper based on
Tiger Team Meeting on Price Communications
Held December 14 and15, 2010
@NAESB, Houston, TX

1 Problem Statement

Price is one of the elements of the Smart Grid that is usually easily understood. For commodities like electricity, this boils down to a dollar amount per unit consumed (dollar per kilowatt-hour in the case of electricity). As one moves back up the value stream to the energy source, price is the one constant (per some unit) all the way to dollars per ton of coal, for example.

This being said, what that "number per unit" contains tends to differ at each level through the value stream. Also, electricity is a time-based commodity with (practically) zero storage. It must be consumed at the instant it is generated. This creates special circumstances for the exchange of "price" between entities in the market. In some circumstances "price" contains:

- Simple cost per unit
- Differential vs. absolute changes in current price
- Product
- What it is (product), when it is (schedule), what it costs (price)

Another constraint on price is the reason for it being communicated between two parties (or from one party to many or from many parties to one). The "price" may be

- Part of a market operation
- A demand response event
- A bid for resources
- Tariff, contract, or agreement information sent to customers
- Competitive offers

These differences may then lead to "price" being misunderstood and have created disparate approaches to modeling "price" by various entities in the Smart Grid domain. Because of these differences, a Tiger Team was envisioned to address the differences and provide recommendations to the various entities for better collaboration.

1.1 Tiger Team Activity

The "I" in SGIP is for "Interoperability" (Smart Grid *Interoperability* Panel, or SGIP [1]). The leadership of the standards-setting organizations (SSOs) working on SIGP Priority Action Plans (PAPs) 03, 04, 09 and 10 were contacted by the SGIP Administrator [2] and asked to reserve a time for a face-to-face meeting during GridWeek in Washington, DC. Participants included members from the following SSOs: NAESB (North American Energy Standards Board) [3], OASIS (Organization for the Advancement of Structured Information Standards) [4], UCAIug [5], ZigBee [6], and the meeting included NIST (National Institute of Standards and Technology) [7], SGIP and SGIP Administrator representatives.

These organizations are going full speed to get the specifications out to the community to begin using as quickly as possible. The SGIP Administrator has been following this for the past year and was concerned that there might be interoperability issues, even collisions, that could create havoc for Smart Grid implementers, in turn affecting uptake and deployment. The face-to-face meeting during GridWeek was simple and quick, where discussion centered on the possibility that this may be a problem and brainstormed on how to reduce the possibility of these problems.

It was decided by those in attendance that it would be extremely useful to form a Tiger Team to review all the UML models and XML Schemas together and see where issues may occur, then come up with recommendations for correcting each issue. Those in attendance also agreed that each of the SSO leaders would identify the minimal number of technical representatives (1-2) to be able to support the SSO with its model and schema and also be able to provide the technical expertise to analyze the other models. Each SSO leader identified a representative with the intent of having balanced representation across the Tiger Team (as close as possible) and an expert(s) on the UML model for each SSO. In other words, a limited, but equal number of expert representatives were selected that could provide technical representation and analytical skills for addressing the other SSO models.

The plan focused on tracing a price from the ISO/RTO all the way into consumer facilities (residential homes, commercial businesses, and industrial sites) to map price progression through the different standards involved, then perform an analysis of the specifications/UML to ensure that this can be accomplished without loss or many translations, complex manipulations of data, etc. Essentially, a macro use case was being exercised to look for problems.

The macro use case approach was amenable to the various SSOs, as was the meeting goal of identifying issues and problems, but not solving them. Indeed, if problems or issues are uncovered, the Tiger Team may come up with some recommendations, but the problem-solving should occur in the PAP WGs and SSOs themselves. Whatever findings the Tiger Team comes up with will be made public and shared with the Smart Grid community.

The meeting was held in Houston on Tuesday-Wednesday December 14-15, 2010, hosted by NAESB.

1.2 Tiger Team Activity Components

The Tiger Team activity had both strategic elements (summarized above) and tactical elements (outlined below). The attendees had a pre-meeting call to identify and agree upon the strategic elements, the challenges, the tactical elements and the approach.

1.2.1 Strategic Elements

- Technical approach email dated 11/23/2010 (copied below)
- Administrator scoping email dated 12/7/2010 (copied below)

1.2.2 Challenges

- What problem are we solving
- Adaptors are fine
- Let the market sort it out

1.2.3 Tactical Elements

- Inter-education via half-hour overview of each models (critical elements related to “price” that are needed to be understood, two-way up and down the value chain from market to end consumer)
- White board overlay of the NIST domains → deliverable of the exercise

- Identify what harmonization activities are already in place → deliverable of exercise

1.2.4 Identify problems and potential resolution owners → deliverable of the exercise

1.3 Tiger Team Meeting Resources

The materials provided by the various attendees are located on the NIST TWiki, links below.

1.3.1 ISO/RTO Council

The IRC [8] prepared a UML-based [9] "Information Model for Organized Wholesale Markets" and XML [10] schemas for each of the demand response interactions identified as in-scope for demand response within their domain. The model uses the IEC Common Information Model (CIM) [11] extensively. Both the UML model and the XML Schemas were submitted to OASIS to represent how today's ISO/RTOs markets would account for demand response (and energy storage).

- Enterprise Architect (EAP) [12] model[1] - http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-EAP-Condensed_Rev1_20101014.zip
- XML Schemas - http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-XML_Schemas_Rev1_20101014.zip
- IRC Smart Grid Project page - http://www.isorto.org/site/c.jhKQIZPBImE/b.6368657/k.CCDF/Smart_Grid_Project_Standards.htm

1.3.2 NAESB

NAESB Developed the Energy Usage Information Standard in satisfaction of PAP10 requirements (see the PAP10 page for additional information).

- NAESB Public Review Retail PAP03[2]: NAESB_PR_Retail_PAP03_smart_grid_ssd101410w3.pdf
- NAESB Public Review Wholesale PAP09[3]: NAESB_PR_Wholesale_PAP09_smart_grid_ssd101410w4.pdf
- NAESB Public Review Retail PAP09: NAESB_PR_Retail_PAP09_smart_grid_ssd101410w5.pdf
- NAESB Retail Common Data Elements (link name is wrong, document is Retail): NAESB_PR_Wholesale_Data_Elements_smart_grid_ssd101410w8.pdf:
- NAESB Wholesale Common Data Elements NAESB_PR_Wholesale_Data_Elements_smart_grid_ssd101410w8.pdf

1.3.3 OASIS Energy Interoperation

Energy Interoperation has DR signals including price, product, and communication (See the PAP09 page for additional information).

- OASIS Technical Committee home page for all documents, email, etc.

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[1] Either a license of Enterprise Architect or the Enterprise Architect viewer is needed for this file and all other .EAP files referenced in this document. See [12].

[2] PAP03 is "priority action plan" 03 of the SGIP, http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP03PriceProduct

[3] PAP09 is "priority action plan" 09 of the SGIP, http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP09DRDER

- Energy Interop Public Review Draft (through December 27, 2010): http://docs.oasis-open.org/energyinterop/ei/v1.0/csd01/energyinterop-v1.0-csd01.pdf
- EAP model including Energy Interoperation Public Review, EMIX wd15, IRC, and OpenADR 1.1: http://www.oasis-open.org/committees/download.php/40529/Energy_Interoperation_PR01.eap.zip

1.3.4 OASIS EMIX

EMIX defines Price and Product (cross-cutting) (See the PAP03 page for additional information).

- OASIS Technical Committee home page for all documents, email, etc.
- EMIX Public Review Draft (through December 17): http://docs.oasis-open.org/emix/emix/v1.0/csprd01/emix-v1.0-csprd01.pdf
- EAP model including Energy Interoperation Public Review, EMIX wd15, IRC, and OpenADR 1/1: http://www.oasis-open.org/committees/download.php/40529/Energy_Interoperation_PR01.eap.zip (same for PAPs 03, 04, and 09)

1.3.5 OASIS WS-Calendar

WS-Calendar is concerned with Schedule Communication (cross-cutting) (See the PAP04 page for additional information).

- OASIS Technical Committee home page for all documents, email, etc
- WS-Calendar Public Review Draft (through November 23, 2010) http://docs.oasis-open.org/ws-calendar/ws-calendar/v1.0/CD01/ws-calendar-1.0-spec-cd-01.pdf
- EAP model including Energy Interoperation Public Review, EMIX wd15, IRC, and OpenADR 1.1: http://www.oasis-open.org/committees/download.php/40529/Energy_Interoperation_PR01.eap.zip (same for PAPs 03, 04, and 09)

1.3.6 OpenADR

The Open Smart Grid Open Automated Demand Response (OpenADR) is an industry-led initiative under the Open Smart Grid (OpenSG) subcommittee within the UCA International Users Group (UCAIug).

- UCAIug OpenSG OpenADR Price Message Schema: DR_Event_-_PricePlus.xsd
- UCAIug OpenSG OpenADR Price Message Sample XML: DR_Event_Price.xml
- UCAIug OpenSG OpenADR .eap UML model: OpenADR.EAP
- UCAIug OpenSG OpenADR System Requirements Specification: OpenSG_OpenADR_1.0_SRS_v1.0.pdf
- Connectivity Week 2008 Presentation on OpenADR 1: CW08a.pdf
- UCAIug OpenSG OpenADR DR Event .png file: DR_Event_-_PricePlus2.zipx

1.3.7 ZigBee SEP 2.0

The Smart Energy Profile is primarily a communications protocol; however, it is a protocol specifically designed to enable communication between things. It is based on a set of open protocols with customized application information model structures accessed via RESTful services over HTTP.

- Slides describing ZigBee Smart Energy Profile price and product aspects: 106157r00ZB_ZSE-NIST-PAP3-4-9-Tiger-Team.pptx
- ZigBee Smart Energy Profile UML model: SEP_2.0_UML.eap
- XML Schema from ZigBee SEP 2.0 UML model: sep.xsd

- Sample XML from SEP 2.0: sep_price.xml

2 Specific Issues

2.1 Coexistence of two hard-to-map models of pricing that share messaging space

In the Smart Grid, there are standards and technologies that meet up at well-know interfaces. The interfaces may be logical (e.g., enterprise service bus) or physical (e.g., substation power bus). Often, those standards and technologies cause the need for a translation from one well-known standard to another. This is especially true for information modeling.

The Tiger Team participants worked through a mapping exercise with the OASIS standards (WS-Calendar, EMIX, EI) and the ZigBee/HomePlug SEP 2.0 against the NIST Conceptual Model[4]. This exercise uncovered that the standards can be conceived as meeting up at a customer (residential, commercial, industrial) Energy Services Interface (ESI) [13]. The ESI serves as the communications gateway between the customer and any other entity.

The concept of an ESI may be illustrated in Figure 1 [13] where the "Facility Domain" is synonymous with a "customer".

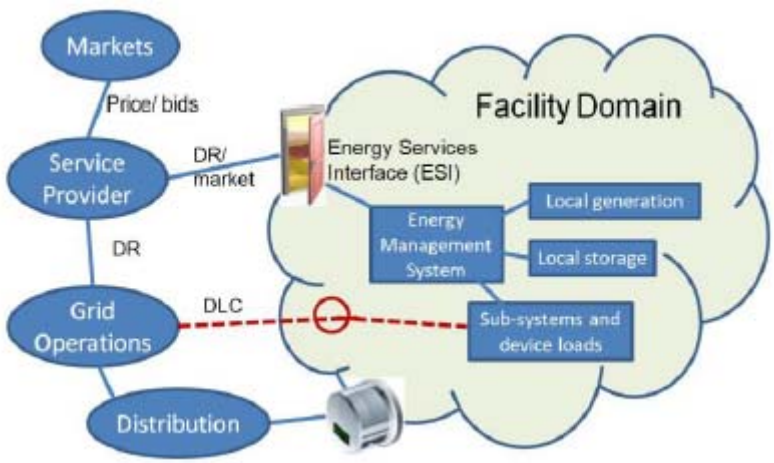

Figure 1: The Facility Interface

While this figure illustrates a connection between the Service Provider and the Facility through the ESI, the reality is that any other actor can communicate to the Facility through that interface. The electrical interface is the meter, and there may be another communications path for direct load control (DLC) as shown in Figure 1. It should be noted that there can be multiple ESIs for a given "facility," and communication for DR and market flows inside a "facility" as well as to the ESI.

For the context of the Tiger Team, the OASIS standards are used for price and product (EMIX), schedule (WS-Calendar) and demand and demand response signals (EnergyInterop) and are used both between the actors/domains outside of the facility (from Figure 1, Markets, Service Provider, Grid Operations, Distribution) and communication from those actors/domains to the ESI. The ZigBee/HomePlug SEP 2.0 standard is only concerned with communication between actors/devices within a Facility or "customer" premise. This concept is shown in Figure 2. This construct creates the need for either a one-to-one matching of the information elements, a

[4] NIST Special Publication 1108, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, January 2010.

lossless translation, or “harmonization” leading to one of the former. The analysis in this paper demonstrates a path forward to a future where the standards on either side of the ESI are able to peacefully and purposefully co-exist for the Smart Grid.

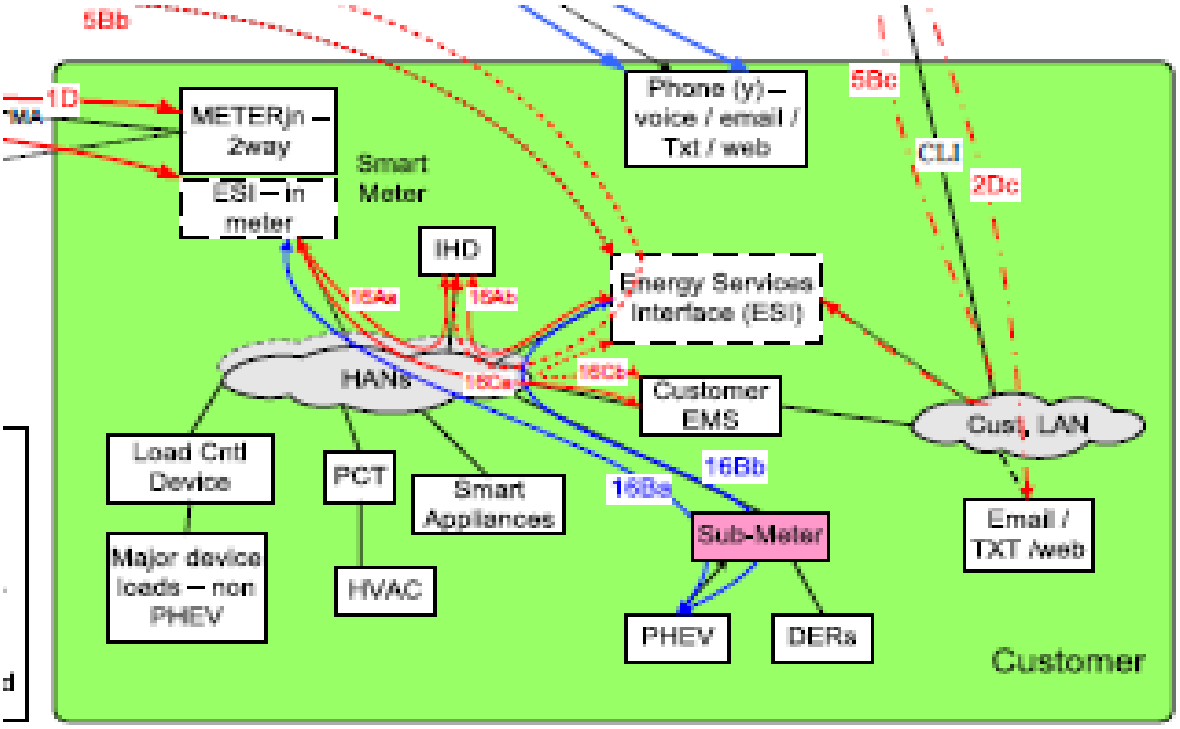

Figure 2: The ZigBee/HomePlug SEP 2.0 Target Deployment Market [14]

2.2 Lack of explicit tag for product information in EMIX calendar sequences

The Tiger Team members reviewed the EMIX draft standard and associated normative schemas which were out for review in December at the Houston Tiger Team meeting. It is not explicit in the schema where one could place a price in the principle EMIX data structure. That is, a review of the principle “`type-emix`” data structure in the schema, there is no child attribute or element that contains the product / price information (note there is a summary price at the top that optionally rolls up components that may be contained). There is a price/product data structure `type-powerProductDescription`. But there is no inherent way to place that data structure within a scheduled interval. While the data structure information is part of the gluon or interval, the *artifact* is the attachment mechanism for WS-Calendar. This attachment mechanism allowed for “any” type of XML element to be placed here. Thus, nothing specific to powerProduct is implied or required.

2.3 Need for specific verification of information model requirements for NAESB, IRC, OpenADR

One of the more difficult to articulate areas of standards development is from where the requirements are received and then how to demonstrate they are addressed by the actual standard. For this exercise, there are three PAPs and six SSOs, not to mention the formal SSO processes and the SGIP PAP Lifecycle to deal with.

The relationship between the requirements sources and the SSO output is shown in Figure 3. The top of the figure shows the "target SGIP standards" being developed (green boxes): Smart Energy Profile (SEP) 2 by ZigBee/HomePlug, WS-Calendar (WSC) EMIX and Energy Interop (EI) by OASIS. These standards are those being modified by an SSO as the direct or indirect result of a SGIP PAP.

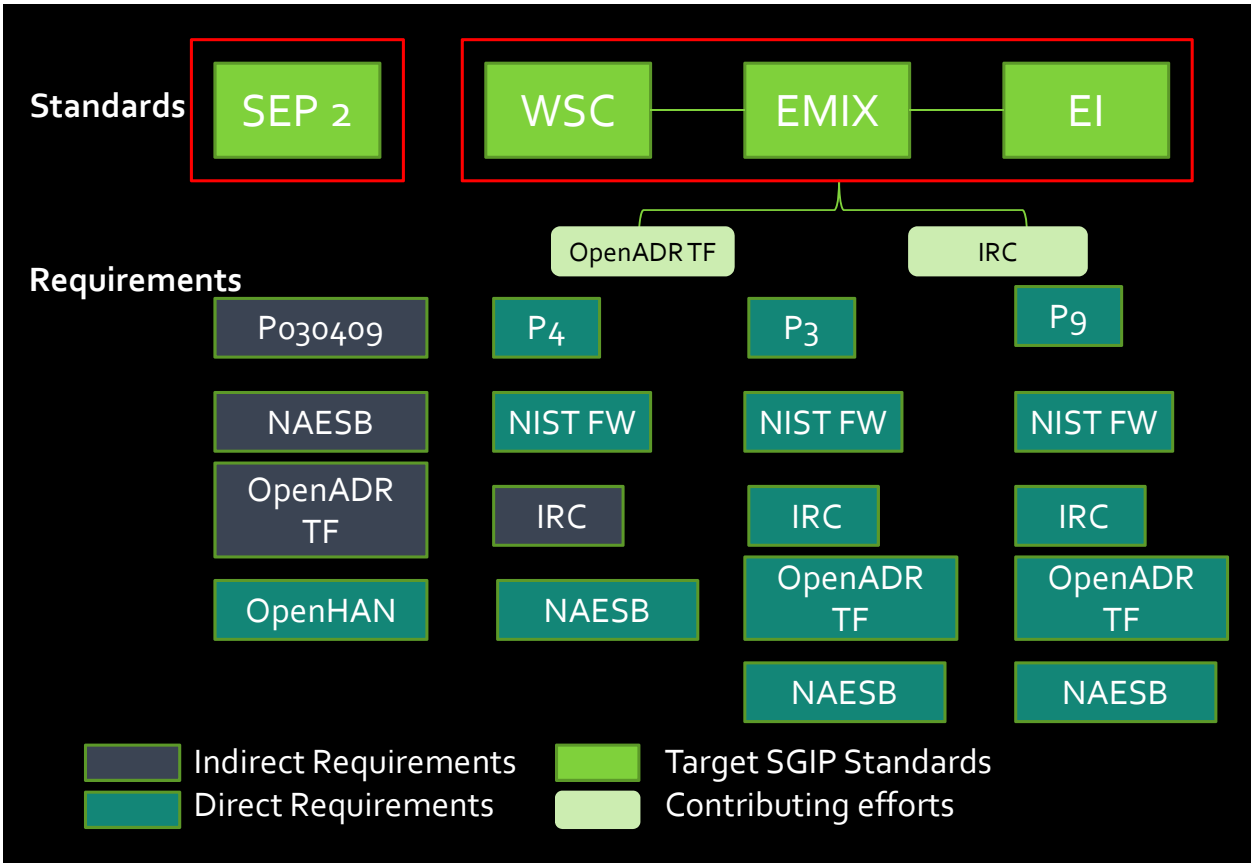

Figure 3: Information Models for Price and Product: Standards and Feeding Requirements

For SEP 2, it is noted that there was a direct feed of requirements from the UCAIug OpenHAN[5] Task Force into its development (orange box), as well as indirect requirements that SEP 2.0 will meet where relevant from PAPs 03, 04 and 09, NAESB and the UCAIug OpenADR[6] Task Force (grey box).

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[5] OpenHAN, for Open Home Area Network, a task force under the UCAIug Open Smart Grid Users Group. The OpenHAN TF has published two Systems Requirements Specifications, v1.0 (http://osgug.ucaiug.org/sgsystems/openhan/HAN%20Requirements/UtilityAMI%20HAN%20SRS%20-%20v1.04%20-%20080819-1.pdf) and v2.0 (http://osgug.ucaiug.org/sgsystems/openhan/Shared%20Documents/OpenHAN%202.0/UCAIug%20HAN%20SRS%20-%20v2.0.pdf).

[6] OpenADR, Open Automated Demand Response, a task force under the UCAIug Open Smart Grid Users Group. The OpenADR TF has published a systems Requirements Specification (http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/SRS/OpenSG%20OpenADR%201.0%20SRS%20v1.0.pdf).

For WS-Calendar, it is noted that there was a direct feed of requirements from the SGIP PAP04 (P4), the NIST Framework[7] (NIST FW) and NAESB as well as indirect requirements from the ISO/RTO Council (IRC). iCalendar [15] is an IETF standard upon which WS-Calendar is based, so there is a requirement that the usage of iCalendar be clearly specified.

For EMIX, it is noted that there was a direct feed of requirements from the SGIP PAP03 (P3), the NIST Framework (NIST FW), the ISO/RTO Council (IRC), the OpenADR Task Force and NAESB.

For EI, it is noted that there was a direct feed of requirements from the SGIP PAP09 (P9), the NIST Framework (NIST FW), the ISO/RTO Council (IRC), the OpenADR Task Force and NAESB.

The OpenADR Task Force and the IRC are also participating in the development of the OASIS standards (indicated by the light blue boxes).

Figure 4 indicates the relationship of those standards with the IEC CIM..The SEP 2.0 work is built upon the IEC CIM semantics, extensions were added for new requirements, and they are working iteratively with the TC57 participants for close alignment with the CIM. For the OASIS standards, many concepts were borrowed from CIM, with extensions and new classes offered back to CIM. High-level agreements are in place between OASIS and any number of other SSOs, including the IEC, but there is no formal hand-back of the work to IEC for codification.

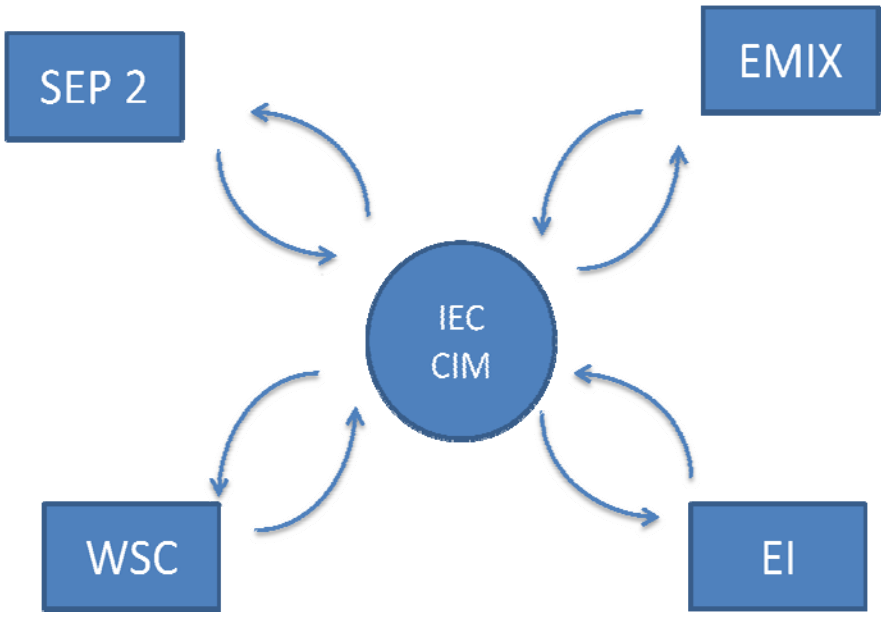

Figure 4: IEC CIM Relationships

2.4 Reference Use Case

In order to illustrate the issues of communications, a reference Use Case was studied:

> Price from the ISO, rolls through a Utility, through to an Aggregator, to the factory and home, and to customer end devices
>
> SubCase 1: Real-time price change
>
> SubCase 2: Day or week ahead scheduling of pricing

[7] NIST Special Publication 1108, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, January 2010.

Based on the experience of EI and OpenADR it was recognized that the following figure encapsulates an abstract Use Case that satisfies all useful permutations.[8] That is, as price information is exchanged from actor to actor, the same complex data structure is needed with only differing information population of that data structure occurring at each exchange.

Figure 5 illustrates this abstraction of the reference Use Case.

Figure 5: Abstraction of reference use case based on discussions at Tiger Team meeting

A simplified sequence diagram below shows an approximate mapping of message and content between the two (SEP 2.0 and EI). It is this approximate mapping that was used in the exercise in the next section below, 3.2 Schema model revisions, to produce suggested schema modifications.

[88] The Use Case might cover all useful permutations for events, but might be missing other areas where EI might apply.

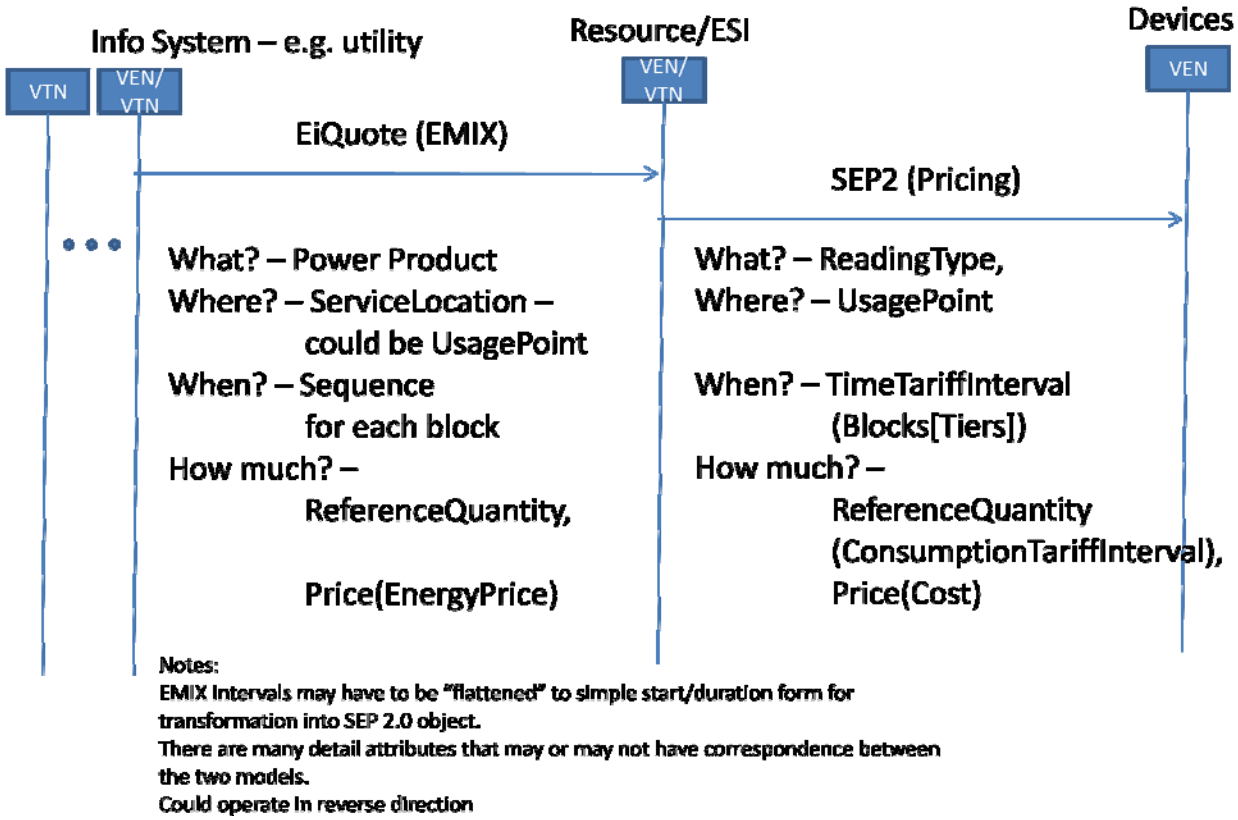

Figure 6: EI and SEP2 Collaboration Map Draft – "Prices to devices"

3 Proposed Resolutions

The proposed resolutions of the issues discussed in the previous section falls into two categories:

1) Information model verifications against NAESB/IRC/OpenADR requirements, and,
2) Schema/model enhancements to improve interoperability

This section provides some resolution to these issues.

3.1 Information Model Verification

Some of the participants in the Tiger Team exercise have complete or nearly complete models. As an exercise, these three SSOs would derive benefit from inspecting their final information models against the stated requirements. This would benefit the developers as a 'second check' and benefit the ultimate users of those standards since this would provide further evidence of the relative maturity of the output and that solitary development of the technical work was actually not performed. This can be accomplished through a simple checklist such as either of the following examples.

						Wholesale			Retail		
Category	Category ID	Category Element ID	Data Element	Short Description	Long Description	PAP 03	PAP 04	PAP 09	PAP 03	PAP 04	PAP 09
14-Price and Product	14	15	**Currency**	Economic unit of exchange in which the total price and price components are stated (e.g. dollars, euros)		Y			Y		Y
14-Price and Product	14	38	**Delivery Interval**	The duration over which the product is available for physical consumption		Y			Y		Y
14-Price and Product	14	37	**Delivery Time**	Time at which the product is available for physical consumption		Y			Y		Y
14-Price and Product	14	20	**Product Identifier**	Identifies specific product associated with the price		Y			Y		
14-Price and Product	14	32	**Product Price Factor**	Terms of use attribute of Product Price	Examples: Price_absolute, Price_relative, Price_multiplier	Y			Y		
14-Price and Product	14	12	**Product Sub-type**	Used to further define product types		Y			Y		
14-Price and Product	14	40	**Source Location Identifier**	The identifier of the source location of the product for which the price applies		Y			Y		

Figure 7: Example NAESB Price and Product Requirements Map to PAPs 03, 04, and 09

Retail	NAESB Data Element	OASIS PAP03 Data Element
x	Currency	currency
x	Delivery Interval	
x	Delivery Time	
	Identifier Source (product)	uid
	Override Unit of Measure	
	Price Component Type	
	Price Component Value	
	Price Location	
	Price Type	
x	Product Identifier	
	Product Name	
	Product Price	
x	Product Price Factor	
x	Product Sub-type	
	Product Type	
x	Source Location Identifier	
	Source Location Identifier Type	
	Unit of Measure	

Figure 8: Example NAESB Data Element to OASIS PAP03 Data Element Map

It is recommended that IRC, NAESB and OpenADR experts review the OASIS schemas against their requirements and prepare an evaluation of whether they can be satisfied as is, with some work, or if there is an unbridgeable gap.

3.2 Schema model revisions

This section outlines proposed changes contributed to the respective SSOs. These changes include those proposed to the EI/EMIX/WSCAL models and SEP 2.0 models that will help to better align these two standards sets. Additionally, assessment was made of current level of alignment of both standards with the recently published NAESB EUI models.

Note that both EI/EMIX/WSCAL and SEP 2.0 are evolving models. Although both standards are in their final stages, major revisions are occurring in both week by week. This section utilizes a snapshot as of December 14, 2010. It is assumed that these concepts can be straightforwardly propagated to the current state of the standards in progress.

It was discovered through some small changes in each standard, substantial alignment can be achieved. Note that while there is not an exact duplication of components, there is a one to one correspondence of elements in SEP 2.0 to EMIX as revised. EMIX being the standard with greater scope and additional requirements beyond those engaged by SEP 2.0, the focus on enhancement was performed principally there.

The sections that follow provide emphasis on the changes to EMIX but also indicate the required changes to SEP 2.0 and NAESB PAP10.

Note that in all cases, care was taken not to add constraints to any schema, only extension and clarification of capabilities were exploited. By all means, there were probably alternate approaches to the same ends but these revisions are examples that do work and illustrate the possibilities for standards harmonization.

3.2.1 EMIX

3.2.1.1 Use of substitution groups to enable explicit use of Power/Resource/Transport product descriptions

The key to making EMIX more explicit as to type comes from a detailed study and analysis of the draft standard.

From the draft standard:

> From the Introduction: “This document defines a set of messages to communicate Price and Product definition for power and energy markets. Product definition includes quantity and quality of supply as well as attributes of interest to consumers distinguishing between power and energy sources. Energy Market Information Exchange (EMIX) is not intended as a stand-alone signal; rather, it is anticipated to be used for information exchange in a variety of market-oriented interactions.”
>
> From chapter 3 Overview of the Information Elements: “EMIX describes the Terms (EMIX Terms) of tenders and transactions for products whose markets are volatile. An energy product typically is delivered over time at a specific location. Five kW at 2:00 AM does not provide the same energy services as five kW at 2:00 PM. EMIX describes the terms of tenders and transactions for which time and location are essential characteristics. For example, the price and quantity (rate of delivery) of energy in each time interval of a sequence of intervals may vary for energy transactions made in a sequence of intervals.
>
> EMIX Terms are defined by applying Product Descriptions to WS-Calendar Sequences. WS-Calendar Sequences embody the same calendaring standards used by most business and personal calendaring systems. This enables greater interoperation between grid systems and business and personal systems. An EMIX Product Description describes the elements of an energy product at a location for one time interval or a sequence of time intervals. An EMIX Product Description for a constant rate of delivery power product over a single interval of time comprises a (1) start time, (2) duration, (3) rate of delivery, (4) price and (5) location. If the rate of delivery (kW) and price ($/kWh) have been messaged in advance, the message to deliver the product is simply “start (reference Uri to product) at 3:00 AM for 0.75 hours.”

The critical issue is how one applies Product Descriptions to WS-Calendar Sequences. EMIX Terms are defined by applying Product Descriptions to WS-Calendar Sequences. One would expect, therefore that the price and product information should appear in the sequence of “terms” shown in the snapshot of the EMIX schema. When the `wscal:interval` or the `wscal:x-calendargluon` are examined, only generic scheduling and qualifiers of scheduling information are found.

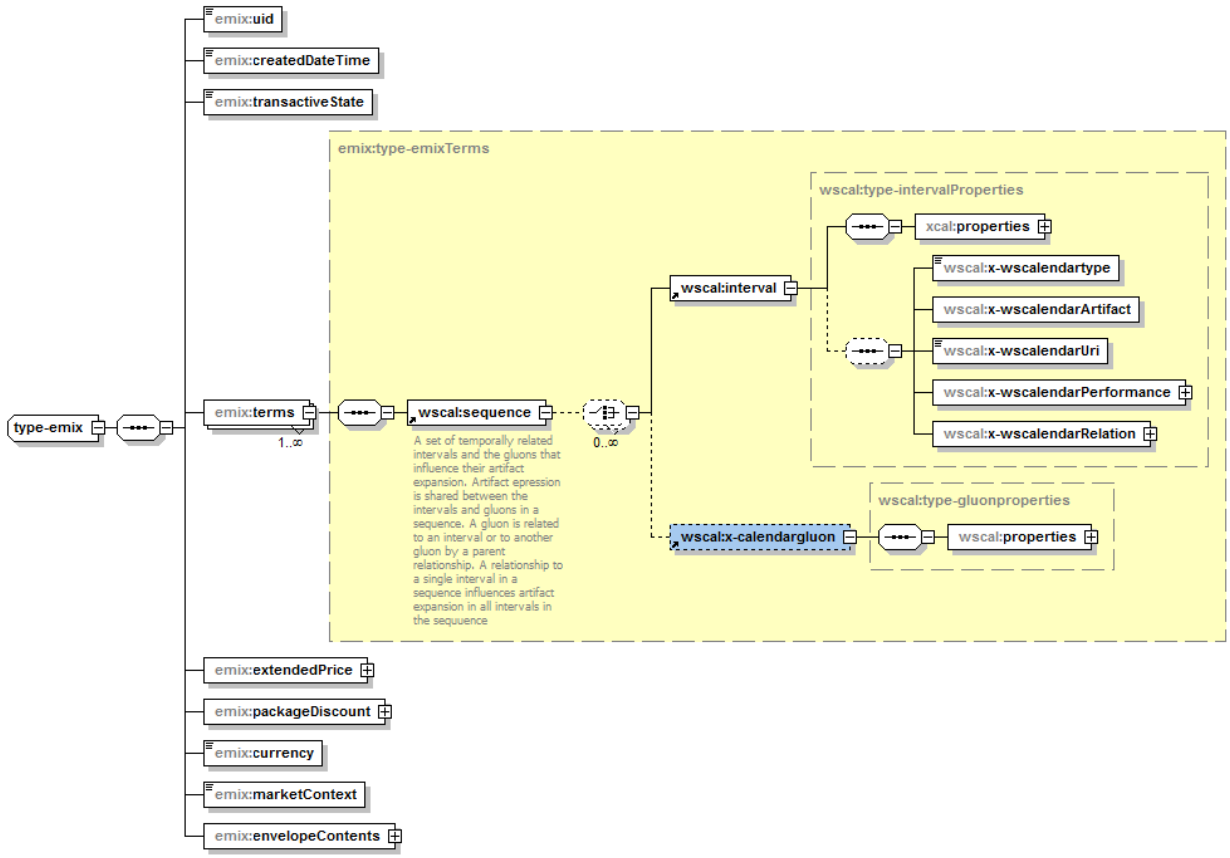

Figure 9: type-emix schema fragment

An approach to improving the type definitions in EMIX utilizing substitution groups[9] is implemented in the appendix. Substitution groups are already part of the schema feature repertoire used in WS-Calendar. To utilize substitution groups for specific kinds of gluons and intervals in EMIX, the following definitions were made:

1) Specializations of sequence, interval, and gluon were made in the emix.xsd file. This permits structures extending gluons and intervals to be substituted in the sequence which is the embodiment of an EMIX "term".
2) Definitions in power.xsd and resource.xsd were made to allow substitution for gluons and intervals[10]
3) Definition of `typePowerProduct` was split into `typePowerProductDescription` (for substitution of gluon) and `typePowerProductData` (for substitution of interval).

The resulting EMIX structure now supports this substitution:

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[9] See http://www.stylusstudio.com/w3c/schema0/SubsGroups.htm for an introduction to substitution groups in XMLSchema

[10] this was only partially completed to prove concept; should also be applied to transport.xsd

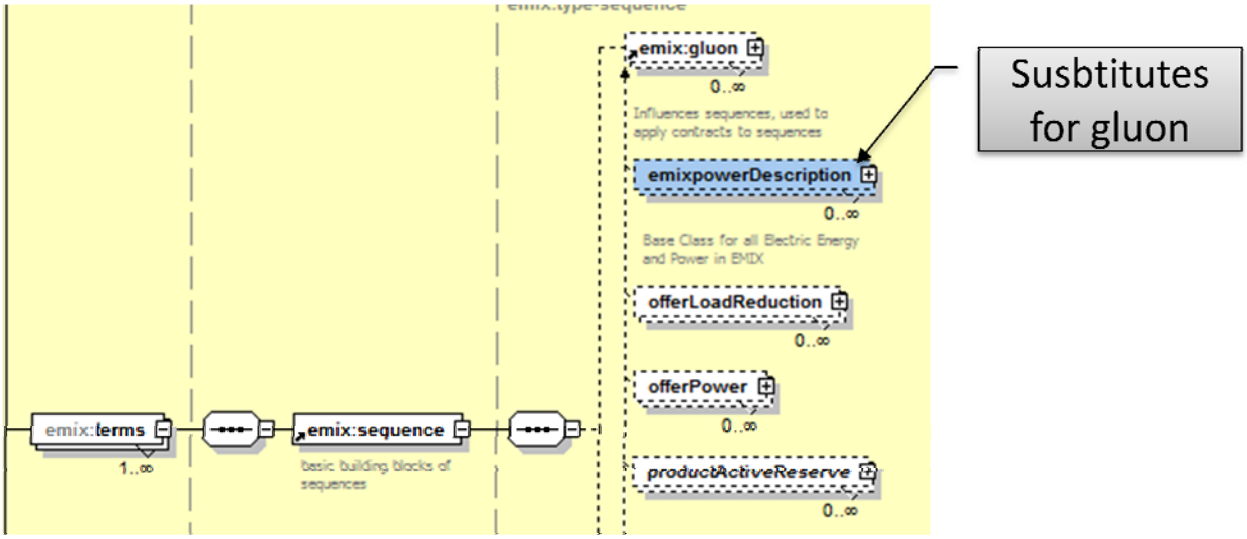


Figure 10: Substitution of emixPower for gluons

3.2.1.2 *Use of ReadingType to capture CIM and EUI standardized type descriptions including non-electricity energy sources*

In order to increase the flexibility of EMIX to represent non-electrical quantities and to increase the use of CIM and NAESB classes for this purpose, ReadingType was substituted where similar unique EMIX constructs were made:

```
<xs:element name="powerUnits" type="power:enum-powerUnits"/>
<xs:element name="attributes" type="power:type-powerAttributes"/>
```

Was replaced with:

```
<xs:element name="ReadingType" type="eui:ReadingType"/>
```

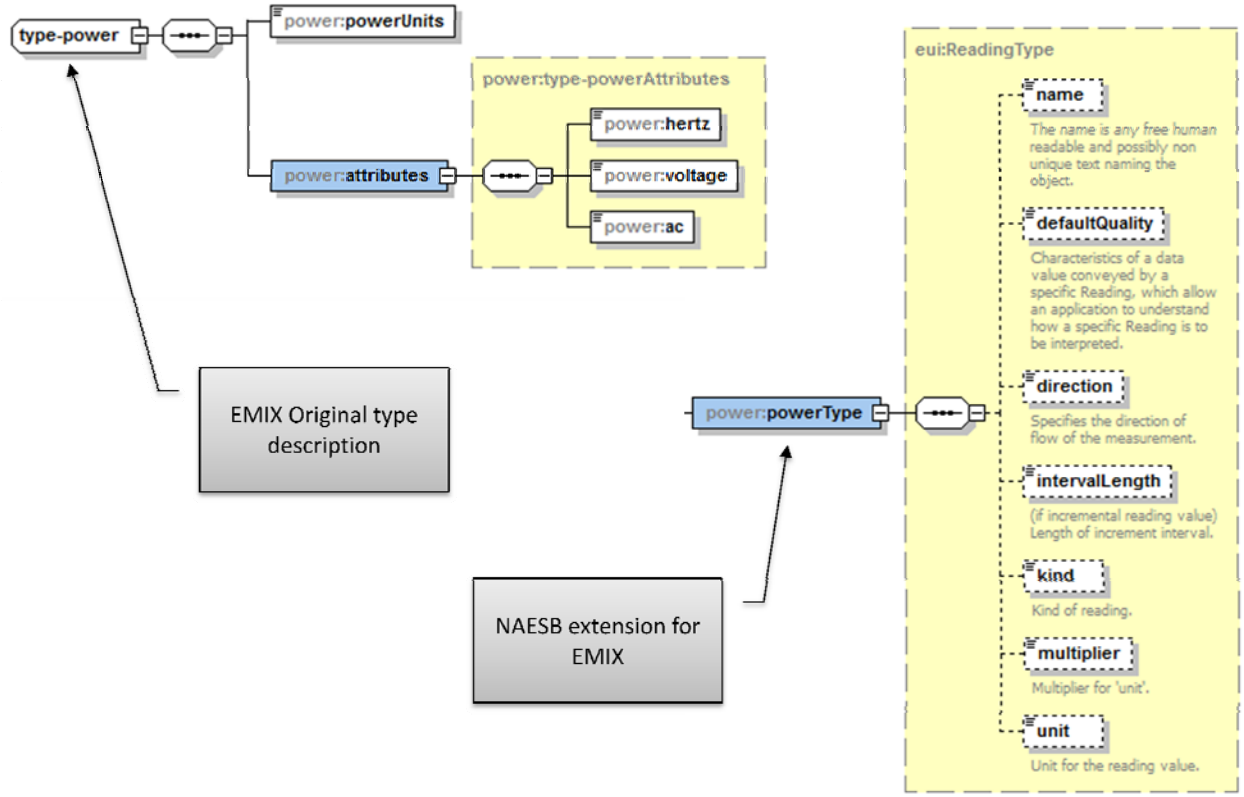


Figure 11: Addition of ReadingType for quantity description

3.2.1.3 Separation of description and data parts of EMIX terms to allow Gluon/Interval split of information

The principle of gluons is to provide information that is “inherited” by all intervals associated with it. By separating product definition and default information from data in a similar fashion to how gluons are a restriction of intervals, easier and more explicit components result to be used in instance documents. The figure below illustrates the resulting gluon/interval split in the `powerProduct` information.

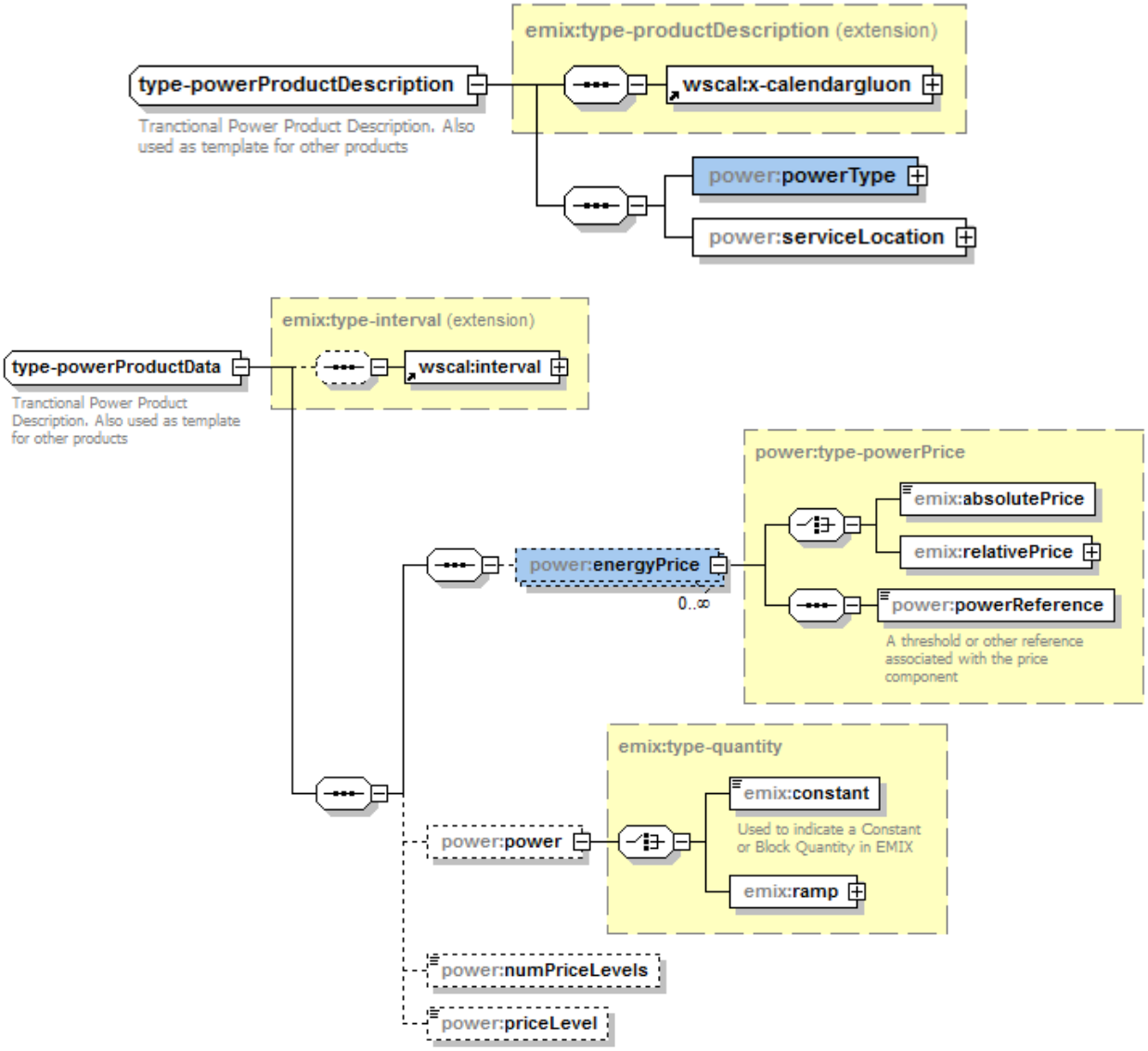


Figure 12: Split of powerProduct into description and data parts

3.2.1.4 Extension of typePowerProduct to enable block and tier structured pricing models.

One of the significant challenges in making a correspondence between the capabilities of EMIX and that of SEP 2.0 is illustrated in Figure 6: EI and SEP2 Collaboration Map Draft – "Prices to devices". The representation of block and tier information is representable in EMIX, though a clean description of how this is achieved is needed. A key proposed improvement that allows this to be accomplished is the extension of the `type-powerPrice` structure to provide a reference element that in the case of block and tier pricing could represent the block threshold. The following figure illustrates this extension.

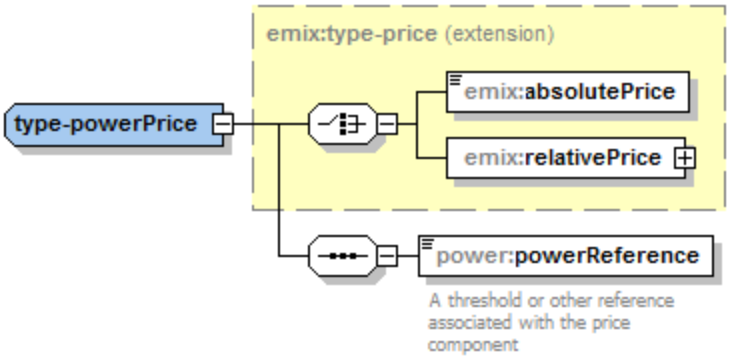


Figure 13: Extension of typePrice to include a reference level

The resulting data structures allows for the following nesting and one to one component mapping from SEP 2.0 to EMIX:

SEP 12/14/2010	EMIX 12/14/2010 Enhanced
TimeTarifInterval	type-powerProductData
ConsumptionTariffInterval	energyPrice
Cost	
fixedPortion	energyPrice.absolutePrice (or relativePrice)
startValue	energyPrice.powerReference
interval	wscal:interval
start	interval.properties.dtstart
duration	interval.properties.duration
numPriceLevels	numPriceLevels
priceLevel	priceLevel

Figure 14: Mapping of EMIX type-powerProductData to SEP 2.0 TimeTariffInterval

3.2.1.5 Revision to type-emixUsage to encapsulate NAESB EUI model

The following modification allows the `type-emixUsage` structure in EMIX to replicate the NAESB UsagePoint structure with the enhancement of needed additional EMIX components. NAESB `UsagePoint` is extended.

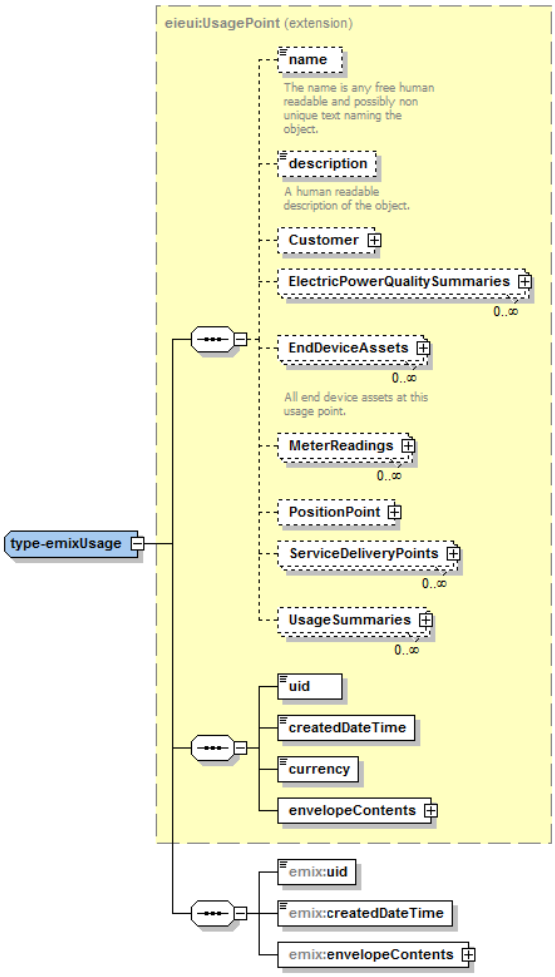


Figure 15: Extension of NAESB UsagePoint to enhance EMIX type-emixUsage

3.2.1.6 Replacement of type-interfacePricingPoint with a harmonized extension of ServiceDeliveryPoint to add the EMIX references.

This proposed extension builds on the NAESB `ServiceDeliveryPoint` data structure (which in turn was an extract of the CIM `ServiceDeliveryPoint`) to add the additional elements identified in EMIX.[11]

[11] It is noted that there is inconsistent use of ServiceLocation and ServiceDeliveryPoint between EMIX and the IEC CIM.

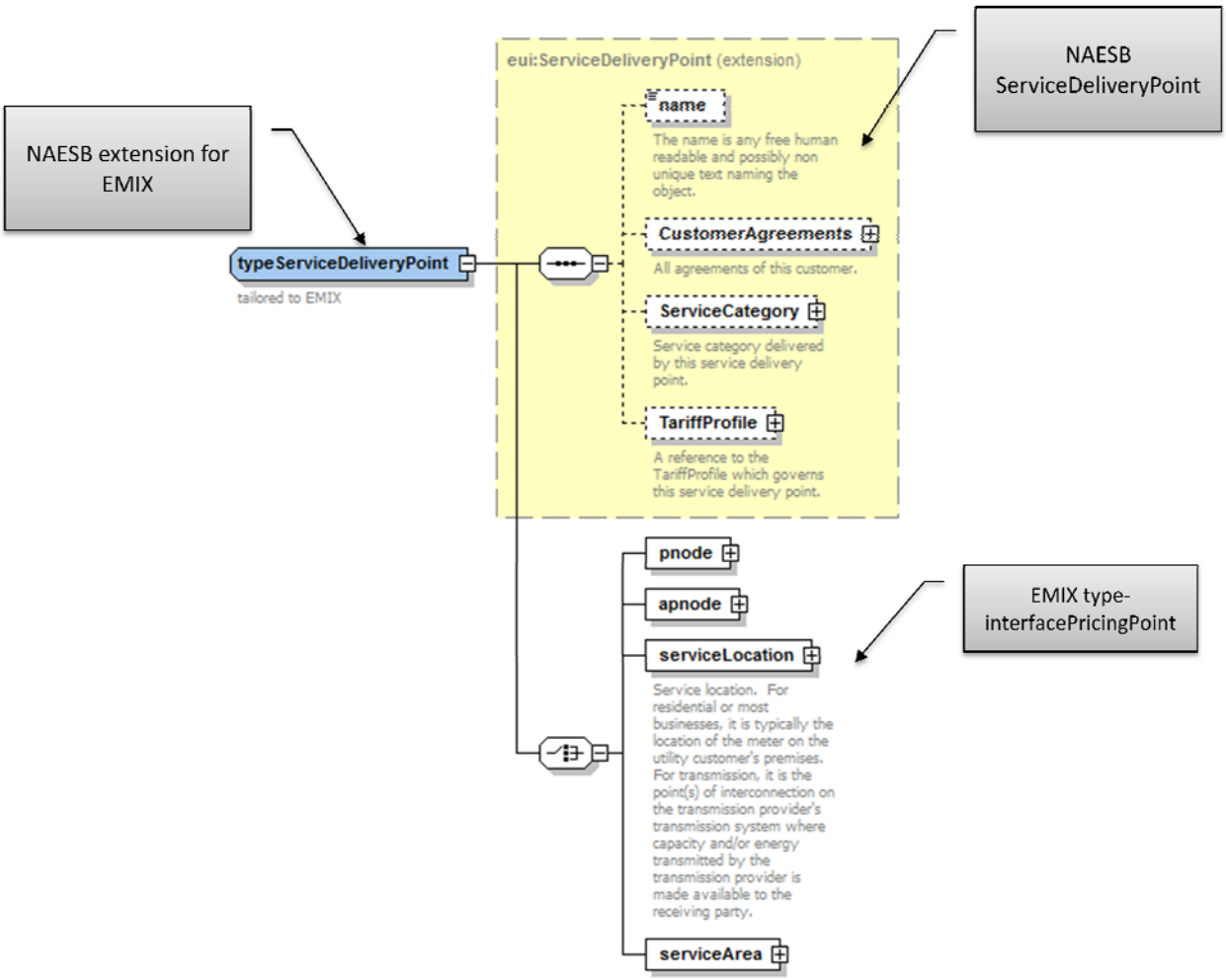


Figure 16: Extension of NAESB Service Delivery Point

3.2.2 SEP 2.0

3.2.2.1 Interval definitions to include fractional second time and duration

CIM, NAESB, and EMIX standards all base timestamps and durations on ISO8601 definitions. These definitions support intervals and time resolution to a fraction of a second. Currently SEP 2.0 only supports integral seconds and this constrains cross functional applications of SEP 2.0 with the others. That is, exchange of information across standards boundaries cannot be "lossless" if all fractions are truncated.

Recognizing that initial SEP 2.0 deployments consider only a small set of use cases within the residential premise, an optional extension to the SEP 2.0 schemas is useful to provide a migration path (initial deployed devices might be ignorant of and not populate fractional extensions) but yet the definitions are part of the standard to enable the applications to need it to interoperate.

3.2.2.2 Addition of optional cost attribute to allow for cost annotated interval data (power:energyPrice)

This modification allows for an optional inclusion of cost annotated usage data in SEP 2.0 supporting devices. As optional, it adds no overhead to SEP 2.0 messaging for the limited set of use cases SEP 2.0 addresses, yet, it supports directly the ability of devices and services to expose the results of complex cost allocation models without having to have the capability to compute those costs.

3.2.2.3 Support for extension of service delivery point specification APnode etc…

This extension of description to include the optional elements identified as important by EMIX would facilitate cross-protocol propagation of information for relevant use cases.

3.2.3 NAESB

3.2.3.1 Addition of EMIX ids and optional extrinsic property structure

Enumerations in the EMIX standard should be reviewed and used to extend those in the NAESB standard to ensure a union of values for covered types.

3.2.3.2 Extension of ServiceDeliveryPoint to include EMIX attributes

As described in 3.2.1.6, this would be a useful enhancement to the NAESB standard and would harmonize better with EMIX.

3.2.4 Validation of changes to schemas

In order to test the modified schemas, two test cases were implemented:

1) Verify that EMIX Use Cases can be implemented with the proposed schema modifications
2) Verify that the reference Use Case can be implemented in SEP 2.0 and EMIX with a one to one correspondence of content

3.2.4.1 Verifying EMIX Schemas

Using the EMIX schemas, an xml example file implementing figure 4-1 EMIX Model from the standard was produced. Here is the figure from the EMIX draft standard:

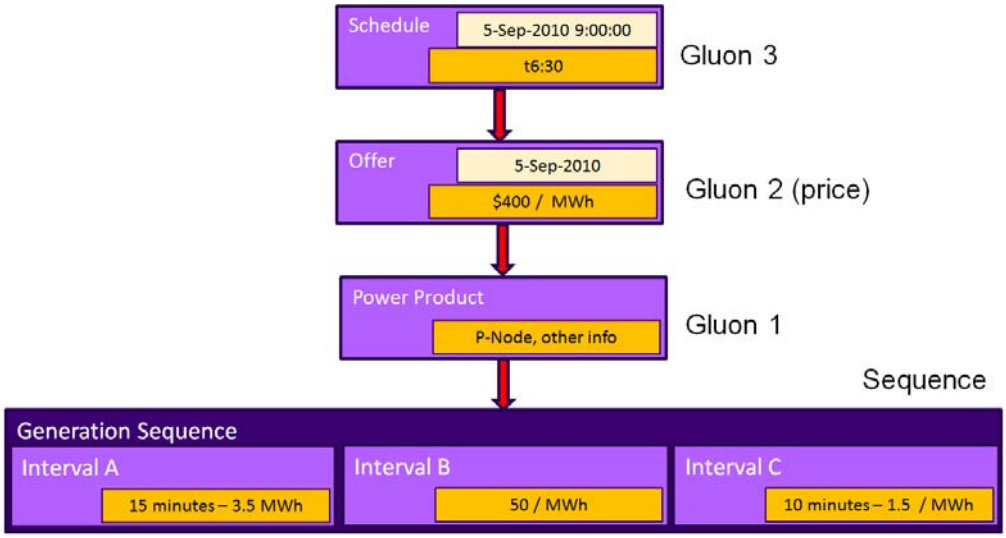


Figure 17: Copy of figure 4-1 from EMIX working draft

Here is an XMLSpy rendition of an XML example implementing that use case:

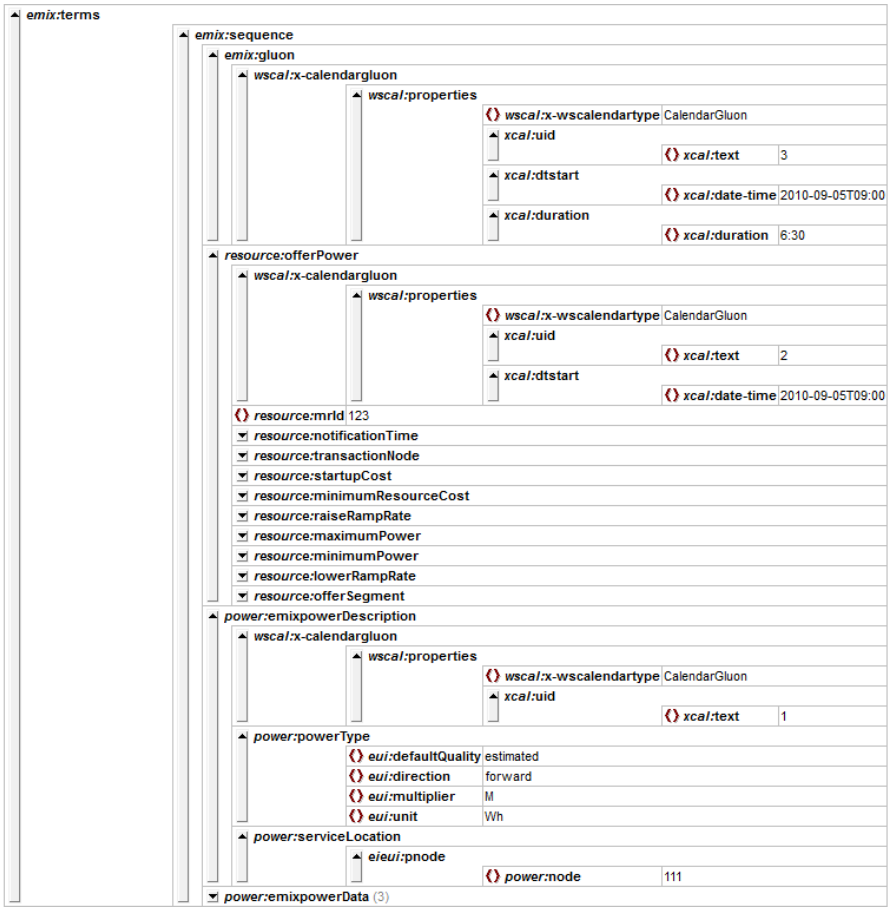


Figure 18: XML file implementing figure 4-1 from EMIX draft

3.2.4.2 Verifying correspondence between XML files implementable based on SEP 2.0 and EMIX enhanced schemas

Using same schemas produce an xml example file that implements the same data as the SEP2.0 example presented at the Tiger Team meeting.

First, here is an XMLSpy view of the sample SEP 2.0 price schedule:

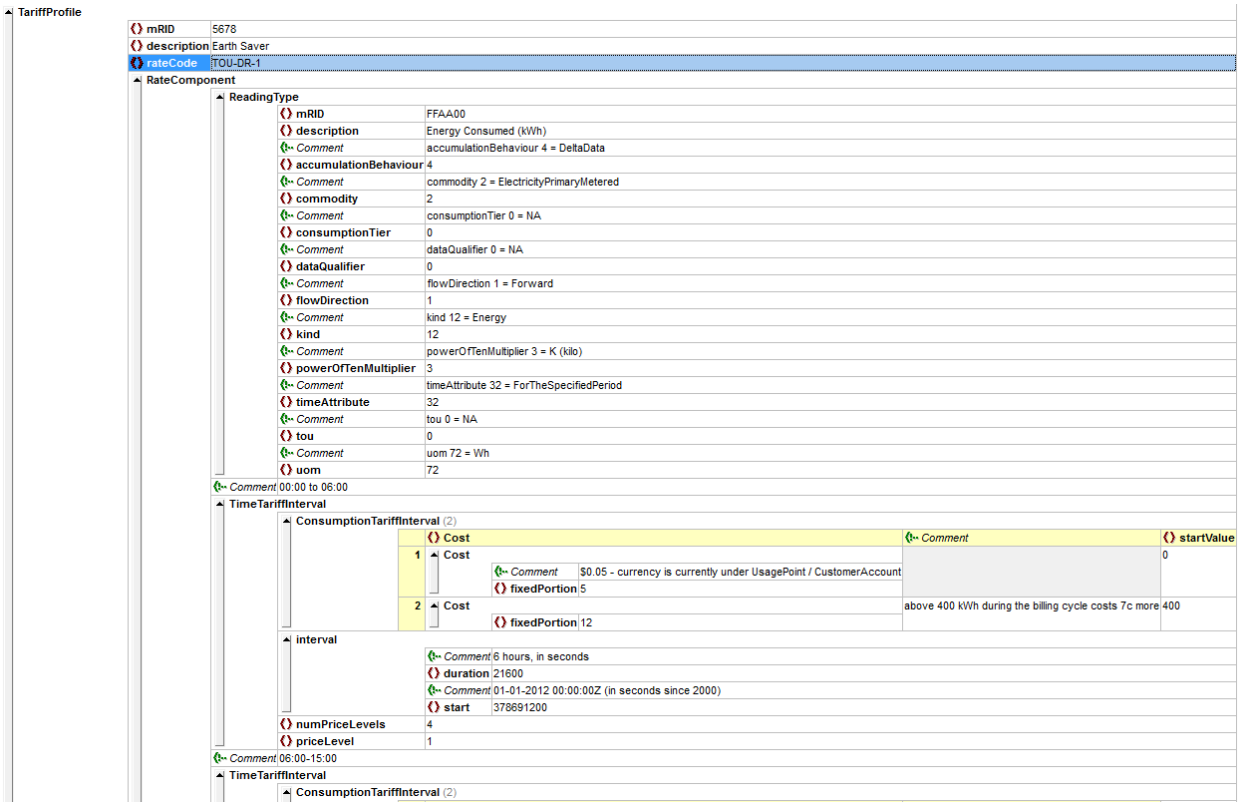


Figure 19: SEP2.0 TT Example Use Case

Here is the equivalent implemented from the EMIX modified schemas:

```
emix:terms
  emix:sequence
    power:emixpowerDescription
      wscal:x-calendargluon
        wscal:properties
          wscal:x-wscalendartype  CalendarGluon
          xcal:uid
            xcal:text  1
          xcal:dtstart
            xcal:date-time  2012-01-01:0:0Z
          xcal:duration
            xcal:duration  2678400
      power:powerType
        eui:defaultQuality  estimated
        eui:direction  forward
        eui:multiplier  k
        eui:unit  Wh
      power:serviceLocation
        eieui:pnode
          power:node  111
    power:emixpowerData (4)
```

	wscal:interval	power:energyPrice	power:numPriceLevels	power:priceLevel
1	wscal:interval xcal:properties xcal:duration xcal:duration 21600 xcal:dtstart xcal:date-time 2012-01-01:0:0Z	power:energyPrice (2) 1 emix:absolutePrice 5, power:powerReference 0 2 emix:absolutePrice 12, power:powerReference 400	4	1
2	wscal:interval xcal:properties xcal:duration xcal:duration 32400 xcal:dtstart xcal:date-time 2012-01-01:0:0Z	power:energyPrice (2) 1 emix:absolutePrice 10, power:powerReference 0 2 emix:absolutePrice 17, power:powerReference 400	4	2
3	wscal:interval xcal:properties xcal:duration xcal:duration 18000 xcal:dtstart xcal:date-time 2012-01-01:0:0Z	power:energyPrice (2) 1 emix:absolutePrice 20, power:powerReference 0 2 emix:absolutePrice 27, power:powerReference 400	4	3
4	wscal:interval xcal:properties xcal:duration xcal:duration 14400 xcal:dtstart xcal:date-time 2012-01-01:0:0Z	power:energyPrice (2) 1 emix:absolutePrice 10, power:powerReference 0 2 emix:absolutePrice 17, power:powerReference 400	4	4

Figure 20: Extended EMIX implementation of same Use Case

4 Recommendations and Conclusions

The Tiger Team documented conclusions on what they knew needed work and what extra work was needed to complete the analysis and recommendations at the end of the two-day meeting. Those items are detailed on the Tiger Team TWiki page[12].

The process going forward identified that IRC, NAESB and OpenADR would need to analyze and confirm that the OASIS work meets their requirements and that truly independent information models would not be needed.

Several of the Tiger Team attendees committed to producing output (see the TWiki page) beneficial to the ongoing efforts of the related PAPs and SSOs. The process going forward is to use defined revisions of this white paper to document the analyses and recommendations and as formal feedback to the relative SSO groups.

4.1 What this white paper accomplishes

- Proposed schema modification that makes EMIX schema more explicit with regard to price and product with WS-Calendar
- Arrange for SEP2.0 Pricing to be a proper subset of EMIX
- Provide verification matrix for OpenADR and IRC to EI/EMIX/WSC
- IRC performs and make statement of satisfaction of their requirements against OASIS standards
- OpenADR TF performs and make statement of satisfaction of their requirements against OASIS standards
- OpenADR TF might be able to make a statement of satisfaction of their requirements against SEP 2.0 for Price
- Identifies key NAESB Requirements to feed back into SEP2.0
- Note that much of this is active work in progress as of December 2010/January 2011

5 Appendix: Standards Examples

This section shows snapshots from the individual bodies of work that can be used to exchange price information. They are presented only to be illustrative of the fact that each can do a similar job although targeted at a different audience. While a hammer may be designed for a carpenter, many others may find it a useful tool. Thus, if a specification can be applied beyond its original intent it probably will be. In essence the explosive growth of the Internet is the ultimate example of this concept.

5.1 Smart Energy Profile 2.0 (SEP2)

[12] http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/TTMeetingOnPriceCommunications#Meeting_Conclusions_What_we_know

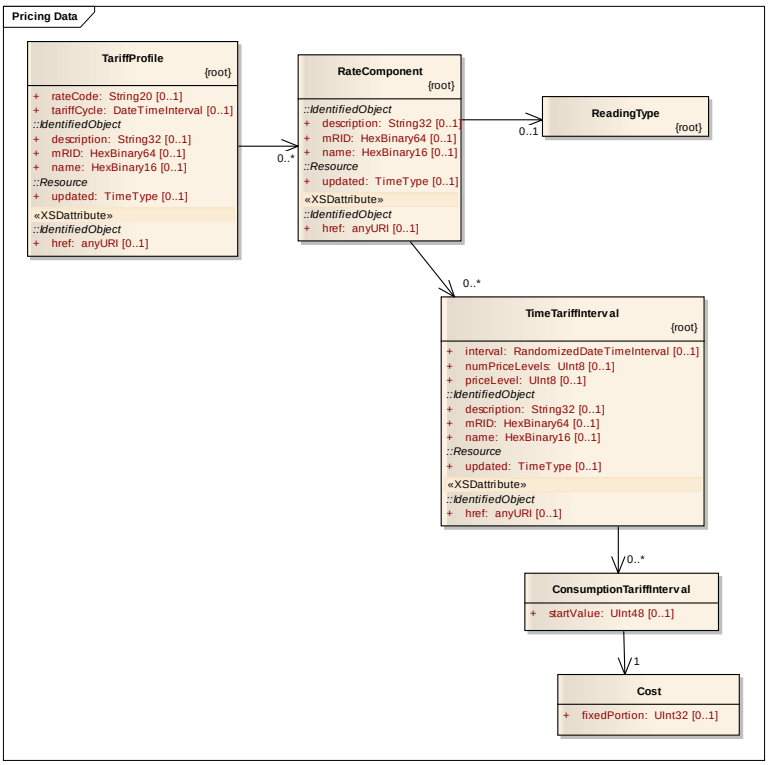


Figure 21: Sample SEP2.0 UML Model Snapshot

5.2 OpenADR

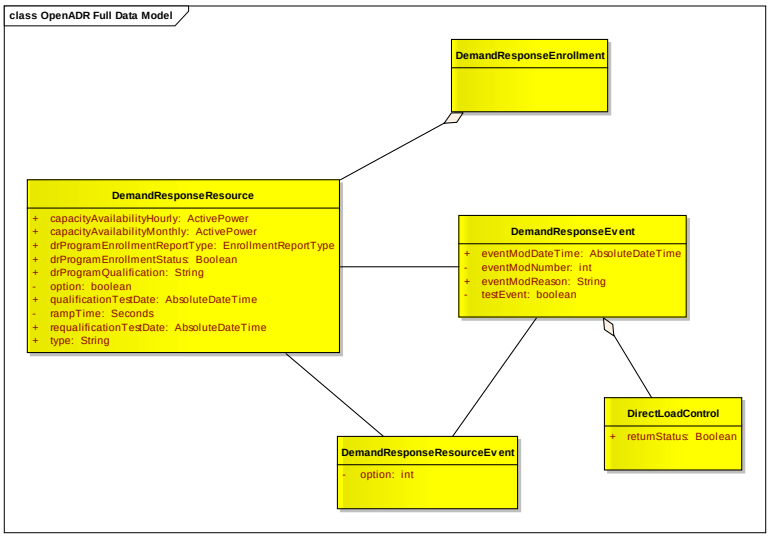
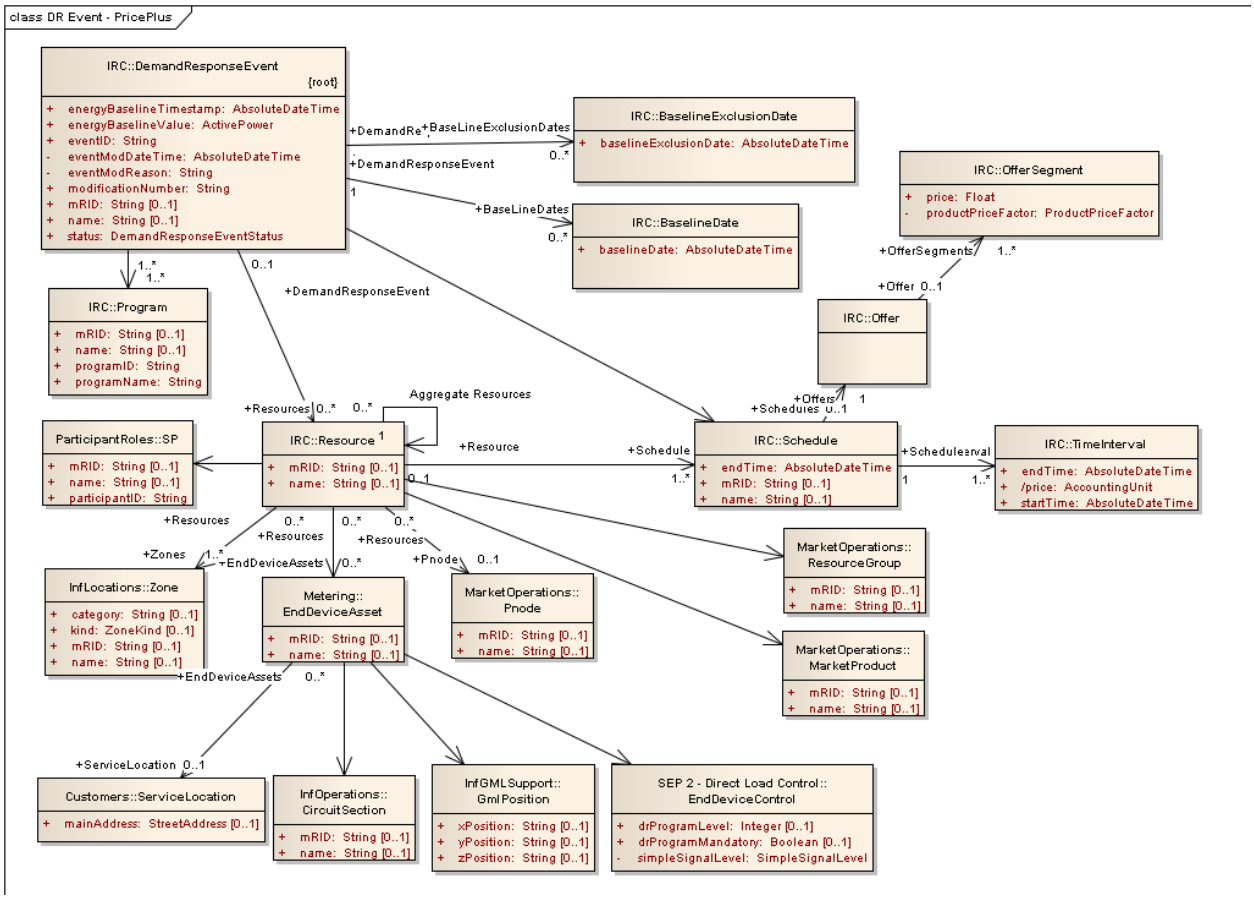


Figure 22: Sample OpenADR UML Model Snapshot



(bruce bartell)

5.3 EI/EMIX/WSC

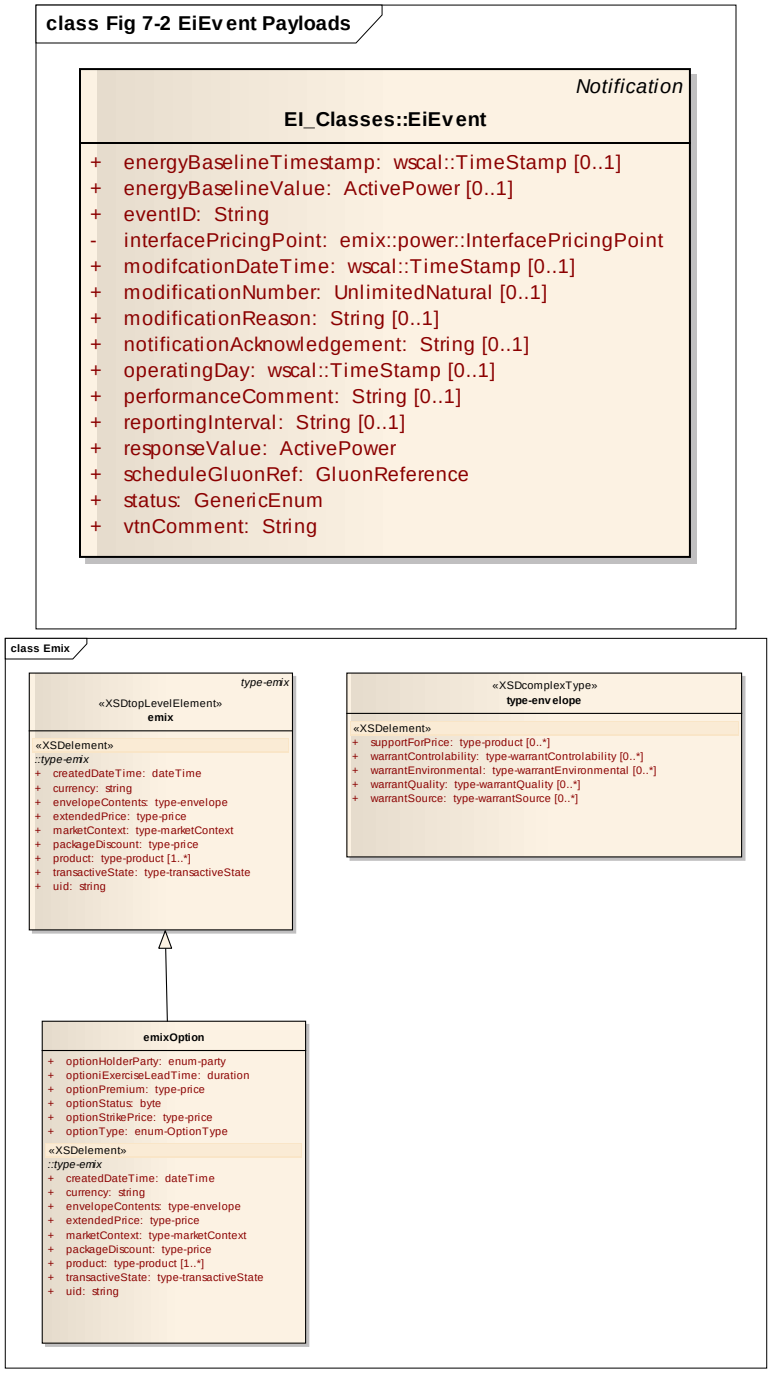


Figure 23: Sample EMIX UML Model Snapshot

5.4 IRC

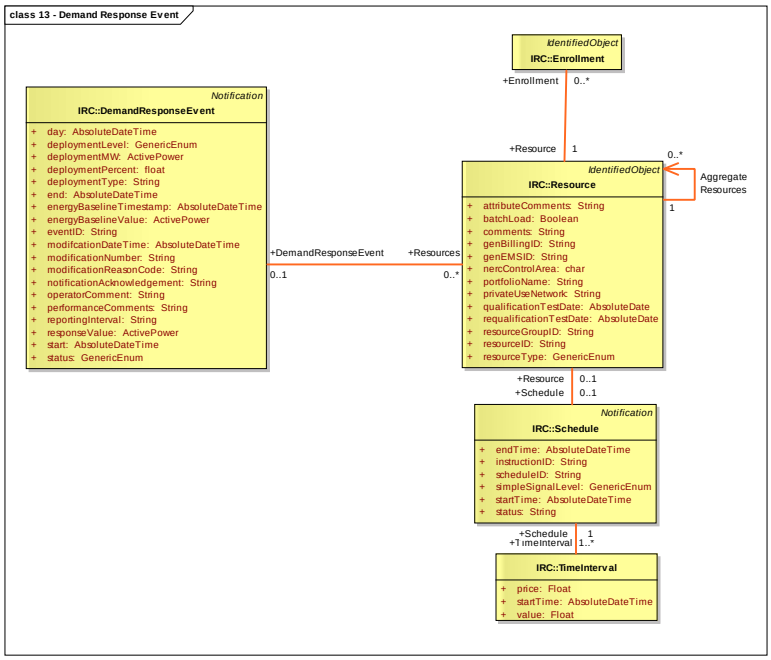


Figure 24: Sample IRC UML Model Snapshot

6 References

[1] Smart Grid Interoperability Panel (SGIP), http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIP. Web retrieved 01/12/2011.

[2] EnerNex Corporation, http://www.enernex.com/news_releases/EnerNex-NIST.html

[3] North American Energy Standards Board (NAESB), http://www.naesb.org/

[4] Organization for the Advancement of Structured Information Standards (OASIS), http://www.oasis-open.org/

[5] UCAIug, http://www.ucaiug.org/

[6] ZigBee, http://www.zigbee.org/

[7] National Institute of Standards and Technology (NIST), http://www.nist.gov/, http://www.nist.gov/smartgrid

[8] ISO/RTO Council (IRC), http://www.isorto.org/. ISO stands for “Independent System Operator” and RTO stands for “Regional Transmission Operator”.

[9] Unified Modeling Language, a standard codified and maintained by the Object Management Group, http://www.uml.org/.

[10] eXtensible Markup Language, a markup language standard codified and maintained by the World Wide Web Consortium (W3C), http://www.w3.org/XML/.

[11] IEC 61970 “Energy Management System Application Program Interfaces” and IEC 61968 “Application Integration at Electric Utilities - System Interfaces for Distribution Management”

[12] “EAP” is a file format used by the Enterprise Architect software program from Sparx Systems, http://www.sparxsystems.com/. [Free Enterprise Architect Viewer]

[13] D. Holmberg, “Facility Interface to the Smart Grid,” Proceedings Grid-Interop 2009, online, http://www.gridwiseac.org/

[14] D. Sturek and S. Van Ausdall, “ZigBee Smart Energy 2 PAP03, 04 and 09 Review,” online, http://collaborate.nist.gov/twiki-sggrid/pub/SmartGrid/TTMeetingOnPriceCommunications/106157r00ZB_ZSE-NIST-PAP3-4-9-Tiger-Team.pptx

[15] IETF RFC5545, iCalendar, http://datatracker.ietf.org/doc/rfc5545/

7 Technical Scoping Email

November 23, 2010

PAP03, PAP04, PAP09 combine to afford a critical and substantial set of standards for implementation of demand response. There are a number of interrelated standards including EMIX / Energy Interop, Smart Energy Profile 2.0, OpenADR, and the IRC Wholesale models. These standards can be used to exchange a price for a commodity between prototypical actors. That is, given a use case like distributing a real time (now) price to devices, you could do it with IRC, EI, SEP 2.0, or OpenADR. The degree of overlap is likely to be somewhere between 60 and 90% we are guessing.

Figure 1: Overlap between OpenADR, EMIX/EI, SEP 2.0, IRC

The fact that it is possible to do this implies that there will be applications that want to do so. The purpose of this tiger team workshop is to investigate the potential overlap of these standards and determine what to do about it. It is better when creating new standards to build standards that directly complement each other, rather than compete with each other.

A simplified description of the goals of this meeting are to:

- Determine the actual level of overlap
- Identify if/what harmonization activities might be pursued.
- Determine if there is some good application scope partitioning that might make sense.

Some simplified Use Cases:

1. Utility sends next day hourly prices and home EMS schedules appliance, lighting, and thermostat settings for that day
2. Energy aggregator sends customer enrolled in third party demand response program a super peak price for the next hour to end consumer thermostat via eRadio operated FM subcarrier signal
3. Home EMS upon receipt of day ahead or hour ahead prices sends prices along to smart appliances under control of the EMS
4. Utility sends current day ahead, hours ahead, and real time prices to in home display device via AMI network
5. Utility sends real time reactive power prices to residential or commercial photovoltaic system controller capable of generating reactive power for local volt/var control

Out of these, we synthesize a single composite reference Use Case with two (2) sub cases:

Reference Use Case: Price from the ISO, rolls through a Utility, through to an Aggregator, to the factory and home, and to customer end devices

SubCase 1: Real-time price change

SubCase 2: Day or week ahead scheduling of pricing

To prepare for the meeting:

1) Provide in advance your standard's current draft or final models in EA
2) Provide sample schemas that can be used to define message contents
3) Produce an example xml file that has typical message contents for the Reference Use Case. Note we don't need messaging syntax and stuff, just the encoding of the data elements transferred.

At the meeting we can:

- Put all 4 models into same EA file
- Review at high level how/whether each one can implement one of several reference use cases
- Review at low level (XML message prototypes) how to implement the reference use case

8 Stuart McCafferty email

From: SGIP PAP09 Working Group [mailto:SGIP-PAP09WG@SMARTGRIDLISTSERV.ORG] On Behalf Of Stuart McCafferty

Sent: Tuesday, December 07, 2010 10:03 AM

To: SGIP-PAP09WG@SMARTGRIDLISTSERV.ORG

Subject: [PAP09] Meeting in Houston

PAP 3,4, and 9 WG members,

I have been getting some questions from several of you on a Tiger Team meeting on price standards that I asked to be set up in Houston. In fact, at Grid-Interop, I had a few people come to me and inform me of some rumors that apparently are flying around. So, I want to briefly explain what the meeting is about and how it came to be.

The “I” in SGIP is for “Interoperability”. In mid-October at GridWeek, I contacted the leads for all the SSOs that are working on price-related specifications. This includes NAESB, OASIS, ZigBee Smart Energy Profile, IRC, and OpenADR. These organizations are going full speed to get the specifications out to the community to begin using as quickly as possible. I have been following this for the past year and was concerned that we might have interoperability issues, even collisions, that could create havoc for Smart Grid implementers.

I contacted the leadership of each of these organizations and asked to meet with them at GridWeek. It was a simple, quick meeting where we got most of the leaders of these SSOs together and alerted them of the possibility that this may be a problem and brainstormed on how to reduce the possibility of these problems.

We decided that the best way to address this was to form a Tiger Team to review all the UML models together and see where issues may occur, then come up with recommendations for correcting each issue. We also agreed that each of the SSO leaders would identify the minimal number of technical representatives (1-2) to be able to support the SSO with its UML model and also be able to provide the technical expertise to analyze the other UML models. Each SSO leader identified a representative with the intent of having equality across the Tiger Team (as close as possible) and an expert(s) on the UML model for each SSO. In other words, we were looking for a small, but equal number of expert representatives that could provide technical representation and analytical skills for addressing the other SSO models.

The plan is to walk a price from the ISO/RTO all the way into facilities to map price progression through the different standards involved, then perform an analysis of the specifications/UML to ensure that this can be accomplished without loss or a whole lot of

translations, complex manipulations of data, etc. Essentially, we are planning to exercise a macro use case and look for problems.

I have spoken to most of the SSO leaders and expressed this concept to them. I have also told them that we are not trying to solve problems in this meeting, but rather identify them. If problems are uncovered, the team may come up with some recommendations, but the problem-solving should occur in the PAP WGs and SSOs themselves. Whatever findings the Tiger Team comes up with will be made public and shared with all of you.

The meeting is being held in Houston next week, hosted by NAESB. The Administrator will have 2 representatives there to facilitate the meeting – Marty Burns and Aaron Snyder.

I hope that this email helps everyone understand the intent of the Tiger Team. This is not the first time we have done this and the TT process has proven an effective, reasonable way to accelerate efforts. If you hear rumors or speculation different from what I have described, please discount it.

Thanks and best regards,

Stuart McCafferty

EnerNex, SGIP Program Manager, PMP

9 Sample schemas and xml files

The following embedded object contains the sample schemas and xml files described in this white paper:

TTWhitePaperXML20110118.zip