Energy Interoperation Version 1.0

Candidate OASIS Standard 01 (WD42)

~~19 December 2013~~

18 May 2014

Specification URIs
This version:
http://docs.oasis-open.org/energyinterop/ei/v1.0/cos01/energyinterop-v1.0-cos01.pdf (Authoritative)
http://docs.oasis-open.org/energyinterop/ei/v1.0/cos01/energyinterop-v1.0-cos01.html
http://docs.oasis-open.org/energyinterop/ei/v1.0/cos01/energyinterop-v1.0-cos01.doc

Previous version:
http://docs.oasis-open.org/energyinterop/ei/v1.0/cs02/energyinterop-v1.0-cs02.pdf (Authoritative)
http://docs.oasis-open.org/energyinterop/ei/v1.0/cs02/energyinterop-v1.0-cs02.html
http://docs.oasis-open.org/energyinterop/ei/v1.0/cs02/energyinterop-v1.0-cs02.doc

Latest version:
http://docs.oasis-open.org/energyinterop/ei/v1.0/energyinterop-v1.0.pdf (Authoritative)
http://docs.oasis-open.org/energyinterop/ei/v1.0/energyinterop-v1.0.html
http://docs.oasis-open.org/energyinterop/ei/v1.0/energyinterop-v1.0.doc

Technical Committee:
OASIS Energy Interoperation TC

Chairs:
David Holmberg (david.holmberg@nist.gov), NIST
William T. Cox (wtcox@coxsoftwarearchitects.com), Individual

Editor:
Toby Considine (toby.considine@unc.edu), University of North Carolina at Chapel Hill

Additional artifacts:
This prose specification is one component of a Work Product that also includes:
* XML schemas: http://docs.oasis-open.org/energyinterop/ei/v1.0/cos01/xsd/
    * DocumentationSketches.xsd
    * EIClasses.xsd
    * EiEnrollment.xsd
    * EiPayloads.xsd
    * iCalendar-streams-extensions.xsd
* WSDL files: http://docs.oasis-open.org/energyinterop/ei/v1.0/cos01/wsdl/
    * EnergyInterop-Avail.wsdl
    * EnergyInterop-Delivery.wsdl
    * EnergyInterop-Enroll.wsdl
    * EnergyInterop-Event.wsdl
    * EnergyInterop-MarketContext.wsdl
    * EnergyInterop-Opt.wsdl
    * EnergyInterop-PartyRegistration.wsdl

- EnergyInterop-Quote.wsdl
- EnergyInterop-Report.wsdl
- EnergyInterop-Tender.wsdl
- EnergyInterop-Transaction.wsdl

Related work:

This specification is related to:

- *Energy Market Information Exchange (EMIX) Version 1.0*. Edited by Toby Considine. Latest version. http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html.
- *WS-Calendar Version 1.0*. Edited by Toby Considine and Mike Douglass. Latest version. http://docs.oasis-open.org/ws-calendar/ws-calendar/v1.0/ws-calendar-1.0-spec.html.
- NAESB Actors for Demand Response (DR)

Declared XML namespaces:

- http://docs.oasis-open.org/ns/energyinterop/201110
- http://docs.oasis-open.org/ns/energyinterop/201110/enroll
- http://docs.oasis-open.org/ns/energyinterop/201110/payloads
- http://docs.oasis-open.org/ns/energyinterop/201110/wsdl

Abstract:

Energy interoperation describes an information model and a communication model to enable collaborative and transactive use of energy, service definitions consistent with the OASIS SOA Reference Model **[SOA-RM]**, and XML vocabularies for the interoperable and standard exchange of:

- Dynamic price signals
- Reliability signals
- Emergency signals
- Communication of market participation information such as bids
- Load predictability and generation information

This work facilitates enterprise interaction with energy markets, which:

- Allows effective response to emergency and reliability events
- Allows taking advantage of lower energy costs by deferring or accelerating usage
- Enables trading of curtailment and generation
- Supports symmetry of interaction between providers and consumers of energy
- Provides for aggregation of provision, curtailment, and use

The definition of a price and of reliability information depends on the market context in which it exists. It is not in scope for this TC to define specifications for markets or for pricing models, but the TC has coordinated with others to ensure that commonly used market and pricing models are supported.

While this specification uses Web Services to describe the services, no requirement or expectation of specific messaging implementation is assumed.

Status:

This document was last revised or approved by the OASIS Energy Interoperation TC on the above date. The level of approval is also listed above. Check the "Latest version" location noted above for possible later revisions of this document.

Technical Committee members should send comments on this specification to the Technical Committee's email list. Others should send comments to the Technical Committee by using the "Send A Comment" button on the Technical Committee's web page at http://www.oasis-open.org/committees/energyinterop/.

For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of patent licensing terms, please refer to the

Intellectual Property Rights section of the Technical Committee web page (http://www.oasis-open.org/committees/energyinterop/ipr.php).

Citation format:

When referencing this specification the following citation format should be used:

[ENERGYINTEROP-v1.0]

Energy Interoperation Version 1.0. Edited by Toby Considine. 19 December 2013. Candidate OASIS Standard 01. http://docs.oasis-open.org/energyinterop/ei/v1.0/cos01/energyinterop-v1.0-cos01.html. Latest version: http://docs.oasis-open.org/energyinterop/ei/v1.0/energyinterop-v1.0.html.

Notices

Copyright © OASIS Open 2013. All Rights Reserved.

All capitalized terms in the following text have the meanings assigned to them in the OASIS Intellectual Property Rights Policy (the "OASIS IPR Policy"). The full Policy may be found at the OASIS website.

This document and translations of it may be copied and furnished to others, and derivative works that comment on or otherwise explain it or assist in its implementation may be prepared, copied, published, and distributed, in whole or in part, without restriction of any kind, provided that the above copyright notice and this section are included on all such copies and derivative works. However, this document itself may not be modified in any way, including by removing the copyright notice or references to OASIS, except as needed for the purpose of developing any document or deliverable produced by an OASIS Technical Committee (in which case the rules applicable to copyrights, as set forth in the OASIS IPR Policy, must be followed) or as required to translate it into languages other than English.

The limited permissions granted above are perpetual and will not be revoked by OASIS or its successors or assigns.

This document and the information contained herein is provided on an "AS IS" basis and OASIS DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY OWNERSHIP RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

OASIS requests that any OASIS Party or any other party that believes it has patent claims that would necessarily be infringed by implementations of this OASIS Committee Specification or OASIS Standard, to notify OASIS TC Administrator and provide an indication of its willingness to grant patent licenses to such patent claims in a manner consistent with the IPR Mode of the OASIS Technical Committee that produced this specification.

OASIS invites any party to contact the OASIS TC Administrator if it is aware of a claim of ownership of any patent claims that would necessarily be infringed by implementations of this specification by a patent holder that is not willing to provide a license to such patent claims in a manner consistent with the IPR Mode of the OASIS Technical Committee that produced this specification. OASIS may include such claims on its website, but disclaims any obligation to do so.

OASIS takes no position regarding the validity or scope of any intellectual property or other rights that might be claimed to pertain to the implementation or use of the technology described in this document or the extent to which any license under such rights might or might not be available; neither does it represent that it has made any effort to identify any such rights. Information on OASIS' procedures with respect to rights in any document or deliverable produced by an OASIS Technical Committee can be found on the OASIS website. Copies of claims of rights made available for publication and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this OASIS Committee Specification or OASIS Standard, can be obtained from the OASIS TC Administrator. OASIS makes no representation that any information or list of intellectual property rights will at any time be complete, or that any claims in such list are, in fact, Essential Claims.

The name "OASIS" is a trademark of OASIS, the owner and developer of this specification, and should be used only to refer to the organization and its official outputs. OASIS welcomes reference to, and implementation and use of, specifications, while reserving the right to enforce its marks against misleading uses. Please see http://www.oasis-open.org/policies-guidelines/trademark for above guidance.

Table of Contents

Tables, Figures & Examples

Index to Figures

Index to Tables

1 Introduction

Energy Interoperation describes an information and communication model to coordinate energy supply, transmission, distribution, and use, including power and ancillary services, between any two parties, such as energy suppliers and customers, markets and service providers, in any of the domains indicated in Figure 2.1 below. Energy Interoperation makes no assumptions about which entities will enter those markets, or as to what those market roles will be called in the future. Energy Interoperation supports each of the secure communications interfaces in Figure 1-1, but is not limited to those interfaces.
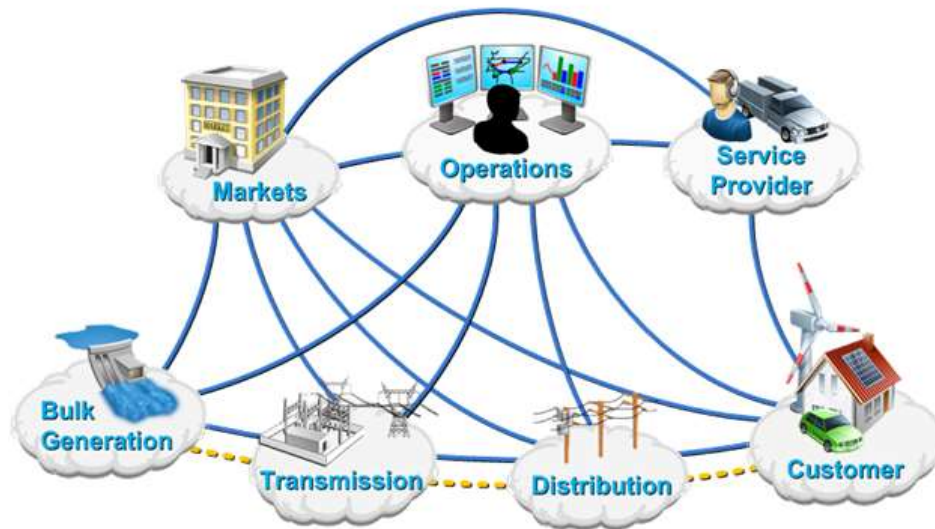
Figure 1-1: Conceptual model for smart grid from [NIST] showing communications requirements

Energy Interoperation defines messages to communicate price, reliability, and emergency conditions over communications interfaces. Energy Interoperation is agnostic as to the technology that a communications interface may use to carry these messages.

Energy Interoperation messages can concern real time interactions, forward projections, or historical reporting. Energy Interoperation is intended to support market-based balancing of energy supply and demand while increasing fluidity of transactions. Increased deployment of distributed and intermittent energy sources will require greater fluidity in both wholesale and retail markets. In retail markets, Energy Interoperation is meant to support greater consumer choice as to energy source.

Energy supplies are becoming more volatile due to the introduction of renewable energy sources. The introduction of distributed energy resources may create localized, volatile, surpluses and shortages. These changes will create more granular energy transactions, require more granularity in temporal price changes, and more granularity in service territory.

Balancing local energy resources brings more kinds of resources into the mix. Natural gas markets share many characteristics with electricity markets. Local thermal energy distribution systems can balance electricity markets while having their own surpluses and shortages. Nothing in Energy Interoperation restricts its use to electricity-based markets.

Energy consumers will need technologies to manage their local energy supply, including curtailment, storage, generation, and time-of-use load shaping and shifting. In particular, consumers will respond to Energy Interoperation messages for emergency and reliability events, or price messages to take advantage of lower energy costs by deferring or accelerating usage, and to trade curtailment, local generation and energy supply rights. Energy Interoperation does not specify which technologies consumers will use; rather it defines a technology agnostic interface to enable accelerated market development of such technologies.

33 To balance supply and demand energy suppliers must be able to schedule resources, manage
34 aggregation, and communicate both the scarcity and surplus of energy supply over time. Suppliers will
35 use Energy Interoperation to inform customers of emergency and reliability events, to trade curtailment
36 and supply of energy, and to provide intermediation services including aggregation of provision,
37 curtailment, and use.

38 Energy Interoperation relies on standard format for communication of time and interval [WS-Calendar]
39 and for energy price and product definition [EMIX]. This document assumes that there is a high degree of
40 symmetry of interaction at any Energy Interoperation interface, i.e., that providers and customers may
41 reverse roles during any period.

42 The OASIS Energy Interoperation Technical Committee is developing this specification in support of the
43 National Institute of Standards and Technology (NIST) Framework and Roadmap for Smart Grid
44 Interoperability Standards, Release 1.0 [Framework] in support of the US Department of Energy (DOE) as
45 described in the Energy Independence and Security Act of 2007 [EISA2007].

46 Under the Framework and Roadmap, the North American Energy Standards Board (NAESB) surveyed
47 the electricity industry and prepared a consensus statement of requirements and vocabulary. This work
48 was submitted to the Energy Interoperation Committee in April 2010 and subsequently updated and
49 delivered in January 2011.

50 All examples and all Appendices are non-normative.

51 1.1 Terminology

52 The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD
53 NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described
54 in **[RFC2119]**

55 1.2 Normative References

56	**[EMIX]**	~~EMIX OASIS Committee Specification Draft 04,~~ *Energy Market Information Exchange (EMIX) Version 1.0,* ~~September 2010.~~ January 2012, OASIS Committee Specification 02, Latest version**: ~~http://docs.oasis-open.org/emix/emix/v1.0/csd04/emix-v1.0-csd04.html~~http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html**
61	**[RFC2119]**	S. Bradner, *Key words for use in RFCs to Indicate Requirement Levels*, **http://www.ietf.org/rfc/rfc2119.txt**, IETF RFC 2119, March 1997.
63	**[RFC2246]**	T. Dierks, C. Allen *Transport Layer Security (TLS) Protocol Version 1.0*, **http://www.ietf.org/rfc/rfc2246.txt**, IETF RFC 2246, January 1999.
65	**[SOA-RM]**	~~SOA-RM OASIS Standard,~~ *OASIS Reference Model for Service Oriented Architecture 1.0*, October 2006 **http://docs.oasis-open.org/soa-rm/v1.0/**
67	~~[Vavailability]~~	~~C. Daboo, B. Desruisseaux, Calendar Availability, http://tools.ietf.org/html/draft-daboo-calendar-availability-02, IETF Internet Draft, April 2011~~
70	**[WS-Calendar]**	WS-Calendar Version 1.0, July 2011, WS-Calendar OASIS Committee Specification ~~1.0, WS-Calendar, July 2011, http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/cs01/ws-calendar-spec-v1.0-cs01.pdf~~01, Latest Version: **http://docs.oasis-open.org/ws-calendar/ws-calendar/v1.0/ws-calendar-1.0-spec.pdf**
75	[XSD]	*W3C XML Schema Definition Language (XSD) 1.1*. **Part 1: Structures,** S Gao, C. M. Sperberg-McQueen, H Thompson, N Mendelsohn, D Beech, M Maloney **http://www.w3.org/TR/xmlschema11-1/**, April 2012, **Part 2: Datatypes**, D Peterson, S Gao, A Malhotra, C. M. Sperberg-McQueen, H Thompson, P Biron, **http://www.w3.org/TR/xmlschema11-2/** April 2012

1.3 Non-Normative References

[BACnet/WS]	Addendum C to ANSI/ASHRAE Standard 135-2004, *BACnet Web Services Interface.*	
[ebXML-MS]	~~OASIS Standard,~~ *Electronic Business XML (ebXML) Message Service Specification v3.0: Part 1, Core Features*, October 2007~~.~~, OASIS Standard, **http://docs.oasis-open.org/ebxml-msg/ebms/v3.0/core/os/ebms_core-3.0-spec-os.pdf**	
[EISA2007]	Energy Independence and Security Act of 2007, **http://nist.gov/smartgrid/upload/EISA-Energy-bill-110-140-TITLE-XIII.pdf**	
[EPRI]	Concepts to Enable Advancement of Distributed Energy Resources, February 2010, **http://my.epri.com/portal/server.pt?Abstract_id=000000000001020432**	
[Framework]	National Institute of Standards and Technology, *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0*, January 2010, **http://nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf**	
[Galvin]	Galvin Electricity Initiative, *Perfect Power*, **http://www.galvinpower.org/perfect-power/what-is-perfect-power**	
[ID-CLOUD]	OASIS Identity in the Cloud Technical Committee **http://www.oasis-open.org/committees/id-cloud**	
[IEC 61968]	Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control	
[IEC 61970-301]	Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base	
[KMIP]	~~OASIS Standard,~~ *Key Management Interoperability Protocol Specification Version 1.0*, October 2010, OASIS Standard. **http://docs.oasis-open.org/kmip/spec/v1.0/kmip-spec-1.0.pdf**	
[OpenADR]	Mary Ann Piette, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage, Peter Palensky, and Charles McParland. 2009. Open Automated Demand Response Communications Specification (Version 1.0). California Energy Commission, PIER Program. CEC-500-2009-063.	
[NAESB-SG]	NAESB Smart Grid Subcommittee, **http://www.naesb.org/smart_grid_standards_strategies_development.asp**	
[OASIS SCA]	OASIS Service Component Architecture Member Section **http://www.oasis-opencsa.org/sca**	
[PMRM]	OASIS Privacy Management Reference Model (PMRM) Technical Committee, **http://www.oasis-open.org/committees/pmrm**	
[SAML]	~~OASIS Standard,~~ *Security Assertion Markup Language 2.0*, March 2005, OASIS Standard. **http://docs.oasis-open.org/security/saml/v2.0/saml-core-2.0-os.pdf**	
[SOA-~~RA]~~	~~OASIS Public Review Draft 01, RAF]~~ *Reference Architecture Foundation for Service Oriented Architecture Version 1.0,* ~~April 2008~~ ~~http://docs.oasis-open.org/soa-rm/soa-ra/v1.0/soa-ra-pr-01.pdf~~December 2012, OASIS Committee Specification 01. **http://docs.oasis-open.org/soa-rm/soa-ra/v1.0/cs01/soa-ra-v1.0-cs01.pdf**	
[SPML]	~~OASIS Standard,~~ *Service Provisioning Markup Language (SPML) v2 - DSML v2 Profile*, April 2006, OASIS Standard. **http://www.oasis-open.org/committees/download.php/17708/pstc-spml-2.0-os.zip**	
[TC57CIM]	IEC Technical Committee 57 Common Information Model (IEC 61968 and IEC 61970, various dates)	
[TeMIX]	TeMIX *Transactive Energy Market Information Exchange [TeMIX] an approved Note of the EMIX TC.* Ed Cazalet et al. http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf	

132 133	**[UML]**	Object Management Group, *Unified Modeling Language (UML), V2.4.1*, August 2011. http://www.omg.org/spec/UML/2.4.1/
134 135 136 137	**[Vavailability]**	C. Daboo, ~~B. Desruisseaux~~M. Douglas, Calendar Availability, ~~http://tools.ietf.org/html/draft-daboo-calendar-availability-02~~http://tools.ietf.org/id/draft-daboo-calendar-availability-05.txt, IETF Internet Draft, ~~April 2011~~January 2014
138 139	**[WS-Addr]**	Web Services Addressing (WS-Addressing) 1.0, W3C Recommendation, **http://www.w3.org/2005/08/addressing**.
140 141 142	**[WSFED]**	~~OASIS Standard,~~ *Web Services Federation Language (WS-Federation) Version 1.2*, 01 May 2009, OASIS Standard. **http://docs.oasis-open.org/wsfed/federation/v1.2/os/ws-federation-1.2-spec-os.doc**
143 144 145	**[WSI-Basic]**	R Chumbley, J Durand, G Pilz, T Rutt , *Basic Profile Version 2.0,* **http://ws-i.org/profiles/BasicProfile-2.0-2010-11-09.html**, The Web Services-Interoperability Organization, November 2010
146 147 148 149	**[WSRM]**	~~OASIS Standard,~~ *WS-Reliable Messaging 1.1*, November 2004, OASIS Standard. **http://docs.oasis-open.org/wsrm/ws-reliability/v1.1/wsrm-ws_reliability-1.1-spec-os.pdf**
150 151 152	**[WS-SecureConversation]**	~~OASIS Standard,~~ *WS-SecureConversation 1.3,* March 2007, OASIS Standard. **http://docs.oasis-open.org/ws-sx/ws-secureconversation/200512/ws-secureconversation-1.3-os.pdf**
153 154 155	**[WS-Security]**	~~OASIS Standard,~~ *WS-Security 2004 1.1*, February 2006, OASIS Standard. **http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf**
156 157	**[WS-SX]**	OASIS Web Services Secure Exchange (WS-SX) Technical Committee **http://www.oasis-open.org/committees/ws-sx**
158 159 160 161	**[XACML]**	~~OASIS Standard,~~ *eXtensible Access Control Markup Language 2.0*, February 2005. ~~http://docs.oasis-open.org/xacml/2.0/access_control-xacml-2.0-core-spec-os.pdf~~, OASIS Standard, **http://docs.oasis-open.org/xacml/2.0/access_control-xacml-2.0-core-spec-os.pdf**

1.4 Contributions

The NIST Roadmap for Smart Grid Interoperability Standards described in the **[Framework]** requested that many standards development organizations (SDOs) and trade associations work together closely in unprecedented ways. An extraordinary number of groups came together and contributed effort, time, requirements, and documents. Each of these groups further gathered together, repeatedly, to review the work products of this committee and submit detailed comments. These groups contributed large numbers of documents to the Technical Committee. These efforts intersected with this specification in ways almost impossible to unravel, and the committee acknowledges the invaluable works below which are essential to understanding the North American Grid and its operation today, as well as its potential futures.

NAESB Smart Grid Standards Development Subcommittee [NAESB-SG]:

The following documents are password protected. For information about obtaining access to these documents, please visit www.naesb.org or contact the NAESB office at (713) 356 0060.

[NAESB EUI]   NAESB REQ Energy Usage Information Model: **http://www.naesb.org/member_login_check.asp?doc=req_rat102910_req_2010_ap_9d_rec.doc**

[NAESB EUI]   NAESB WEQ Energy Usage Information Model: **http://www.naesb.org/member_login_check.asp?doc=weq_rat102910_weq_2010_ap_6d_rec.doc**

The following documents are under development and subject to change.

[NAESB PAP 09]   Phase Two Requirements Specification for Wholesale Standard DR Signals – for NIST PAP09:

183		http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_6_
184		c_ii.doc
185	[NAESB PAP 09]	Phase Two Requirements Specification for Retail Standard DR Signals – for
186		NIST PAP09:
187		http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_9_
188		c.doc

189 *The NAESB Measurement and Verification of Demand Response (WEQ-015) and Measurement and*
190 *Verification of Energy Efficiency Products (WEQ-021) standards were adopted by the US Federal Energy*
191 *Regulatory Commission (FERC) on February 21, 2013 and have been incorporated by reference as*
192 *federal regulation. The complementary standards developed to support the retail markets (REQ.13 and*
193 *REQ.19, respectively) were adopted by NAESB and are available for consideration by state regulatory*
194 *agencies. The NAESB Demand Side Management and Energy Efficiency Subcommittee is currently*
195 *developing a certification program for energy efficiency and demand response measurement and*
196 *verification products that comply with the NAESB standards.*

197 **The ISO / RTO Council Smart Grid Standards Project:**

198 Information Model – HTML: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-**
199 **003829518EBD%7D/IRC-DR-InformationModel-HTML-**
200 **Condensed_Rev1_20101014.zip**

201 Information Model – EAP: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-**
202 **003829518EBD%7D/IRC-DR-InformationModel-EAP-**
203 **Condensed_Rev1_20101014.zip**

204 XML Schemas: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-**
205 **003829518EBD%7D/IRC-DR-XML_Schemas_Rev1_20101014.zip**

206 Eclipse CIMTool Project: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-**
207 **003829518EBD%7D/IRC-DR-CIMTool-Project-**
208 **Workspace_Rev1_20101014.zip**

209 Interactions - Enrollment and Qualification: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-**
210 **40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-**
211 **HTML_Enrollment_And_Qualification_Rev1_20101014.zip**

212 Interactions - Scheduling and Award Notification: **http://www.isorto.org/atf/cf/%7B5B4E85C6-**
213 **7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-**
214 **HTML_Scheduling_And_Award_Notification_Rev1_20101014.zip**

215 Interactions - Deployment and Real Time Notifications: **http://www.isorto.org/atf/cf/%7B5B4E85C6-**
216 **7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-**
217 **HTML_Deployment_And_RealTime_Communications_Rev1_20101014.zip**

218 Interactions - Measurement and Performance: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-**
219 **40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-**
220 **HTML_Measurement_And_Performance_Rev1_20101014.zip**

221 Interactions Non-Functional Requirements: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-**
222 **40A0-8DC3-003829518EBD%7D/IRC-DR-Non-**
223 **Functional_Requirements_Rev1_20100930.pdf**

224 **UCAIug OpenSG OpenADR Task Force:**

225 OpenADR 1.0 System Requirements Specification v1.0
226 **http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/SRS/**
227 **OpenSG%20OpenADR%201.0%20SRS%20v1.0.pdf**

228 OpenADR 1.0 Service Definition - Common Version :R0.91
229 **http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/Servi**
230 **ces/OpenSG%20OpenADR%20SD%20-%20Common%20r0.91.doc**

231 OpenADR 1.0 Service Definition – Web Services Implementation Profile Version: v0.91
232 **http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/Servi**
233 **ces/OpenSG%20OpenADR%20SD%20-%20WS%20r0.91.doc**

1.5 Namespace

The XML namespace [XML-ns] URI that MUST be used by implementations of this specification is:

```
http://docs.oasis-open.org/ns/energyinterop
```

Dereferencing the above URI will produce the Resource Directory Description Language [RDDL 2.0] document that describes this namespace.

Table 1 lists the XML namespaces that are used in this specification. The choice of any namespace prefix is arbitrary and not semantically significant.

Table 1-1: Namespaces Used in this Specification

Prefix	Namespace
xs	http://www.w3.org/2001/XMLSchema
gml	http://www.opengis.net/gml/3.2
xcal	urn:ietf:params:xml:ns:icalendar-2.0
strm	urn:ietf:params:xml:ns:icalendar-2.0:stream
emix	http://docs.oasis-open.org/ns/emix/2011/06
power	http://docs.oasis-open.org/ns/emix/2011/06/power
resource	http://docs.oasis-open.org/ns/emix/2011/06/power/resource
ei	http://docs.oasis-open.org/ns/energyinterop/201110
enrl	http://docs.oasis-open.org/ns/energyinterop/201110/enroll
pyld	http://docs.oasis-open.org/ns/energyinterop/201110/payloads
wsdl	http://docs.oasis-open.org/ns/energyinterop/201110/wsdl

The normative schemas for EMIX can be found linked from the namespace document that is located at the namespace URI specified above.

1.6 Naming Conventions

This specification follows some naming conventions for artifacts defined by the specification, as follows:

For the names of elements and the names of attributes within XSD files, the names follow the lowerCamelCase convention, with all names starting with a lower case letter. For example,

```
<element name="componentType" type="ei:ComponentType"/>
```

For the names of types within XSD files, the names follow the UpperCamelCase convention with all names starting with a lower case letter prefixed by "type-". For example,

```
<complexType name="ComponentServiceType">
```

For the names of intents, the names follow the lowerCamelCase convention, with all names starting with a lower case letter, EXCEPT for cases where the intent represents an established acronym, in which case the entire name is in upper case.

An example of an intent that is an acronym is the "SOAP" intent.

1.7 Editing Conventions

For readability, element names in tables appear as separate words. The actual names are lowerCamelCase, as specified above, and as they appear in the XML schemas.

All elements in the tables not marked as "optional" are mandatory.

260 Information in the "Specification" column of the tables is normative. Information appearing in the note
261 column is explanatory and non-normative.

262 All sections explicitly noted as examples are informational and are not to be considered normative.

1.8 Architectural Background

264 Energy Interoperability defines a service-oriented approach to energy interactions. Accordingly, it
265 assumes a certain amount of definitions of roles, names, and interaction patterns. This document relies
266 heavily on roles and interactions as defined in the OASIS Standard *Reference Model for Service Oriented*
267 *Architecture* **[SOA-~~RA~~RAF]**.

268 Service orientation focuses on the desired results rather than the requested processes. Service
269 orientation complements loose integration. Service orientation organizes distributed capabilities that may
270 be in different ownership domains.

271 The SOA paradigm concerns itself with visibility, interaction, and effect. Visibility refers to the capacity for
272 those with needs and those with capabilities to be able to see each other. Interaction is the activity of
273 using a capability. A service provides a decision point for any policies and transactions without delving
274 into the process on either side of the interface

275 Services are concerned with the public actions of each interoperating system. Service interactions
276 consider private actions, e.g., those on either side of the interface, to be inherently unknowable by other
277 parties. A service is used without needing to know all the details of its implementation. Services are
278 generally paid for results, not effort.

279 While loosely coupled, it is important to understand some typical message exchange patterns to
280 understand how business processes are tied together through an SOA. [SOA-~~RA~~RAF] Section 4.3.2.1
281 describes how message exchange patterns (MEP) are leveraged for this purpose. While [SOA-~~RA~~RAF]
282 describes two types of MEPs, event notification and request response it also notes that, "This is by no
283 means a complete list of all possible MEPs used for inter- or intra-enterprise messaging".

284 Three types of MEPs can inform the discussion on Energy Interoperation integration; a one way MEP,
285 which differs somewhat from an event notification MEP in that no response is required or expected from
286 the service provider, although the service consumer may receive appropriate http messages, e.g. 404
287 error.


```
sd One Way MEP Example

   ┌─────────┐                          ┌───────────────┐
   │  Party  │                          │ Counter Party │
   └─────────┘                          └───────────────┘
        ┊                                      ┊
        ┊          EIOneWayExample()           ┊
        ▣─────────────────────────────────────▶▣
        ┊                                      ┊
```

288
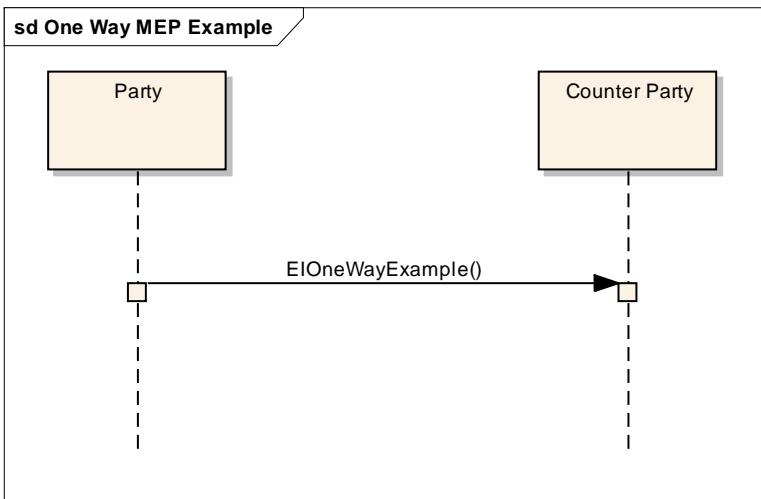
289 *Figure 1-2: One-way MEP where no return is expected*

290 Additionally a two-way MEP and a callback MEP are specific types of request/response MEPs described
291 in [SOA-~~RA~~RAF] that are used in Energy Interoperation. A two way MEP exchange pattern assumes that
292 after a service is consumed an acknowledgement is sent. This acknowledgement is made up of the
293 message header of the returning service, and may include a standardized acknowledgement payload,
294 i.e., for capturing errors, (or no errors if the service was called successfully).

295 The callback MEP is similar to the request/response pattern described in [SOA-~~RA~~RAF] except that it is
296 more specific. In a callback MEP the service provider will send an acknowledgement upon receiving a
297 request. However, once the service provider completes the corresponding business process, it will
298 become a service consumer, by calling a service of the previous consumer, where it turn it will receive its
299 own acknowledgement.

300
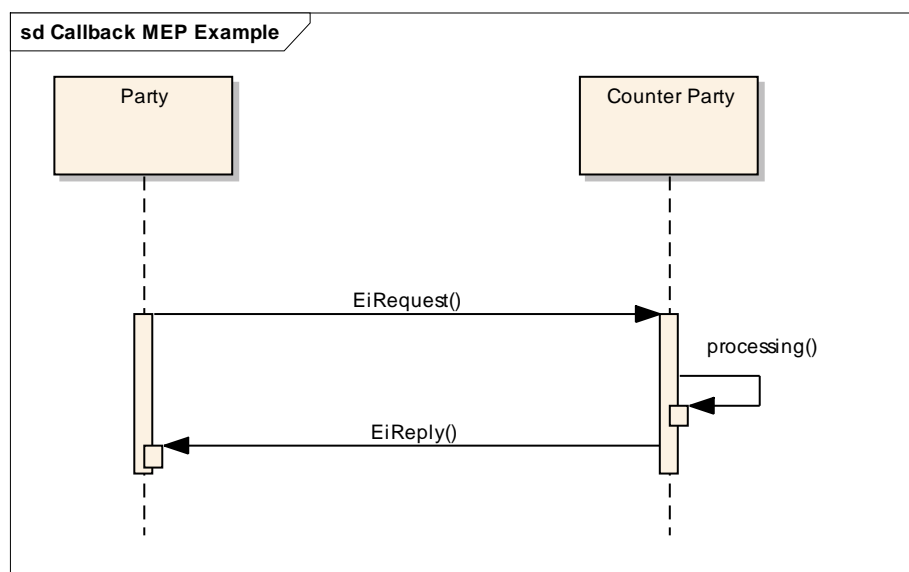
301 *Figure 1-3: Callback MEP where a service provider sends an acknowledgement to the service consumer, performs a*
302 *corresponding activity to act on the service request, then in turn makes a service request to the original initiating*
303 *service consumer and receiving an acknowledgement in return.*

304 *Note: Acknowledgements are normally shown as a dashed arrow return but have been omitted from the figures of*
305 *this specification for brevity. Appropriate returns should be assumed.*

306 While most figures that illustrate a service interaction assume a PUSH paradigm, that is not a
307 requirement. A PULL paradigm may also be employed using Energy Interoperation services. However,
308 the PULL pattern differs slightly. A request is made, responded to, and then once the requestor has the
309 information required, then it acts using a final operation as shown in the following figure.

310
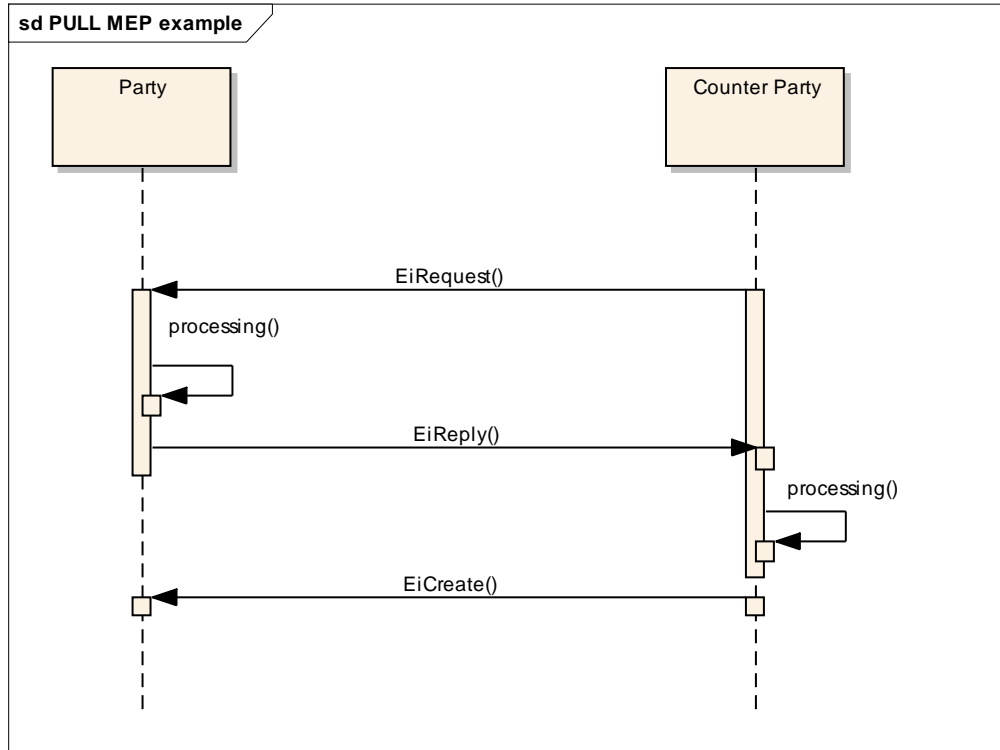
Figure 1-4: PULL MEP where a request is made, responded to, processed and then acted upon. Nominally this could be considered a combination of a callback MEP, followed by a two-way MEP

Loose integration using the SOA style assumes careful definition of security requirements between partners. Size of transactions, costs of failure to perform, confidentiality agreements, information stewardship, and even changing regulatory requirements can require similar transactions be expressed within quite different security contexts. It is a feature of the SOA approach that security is composed in to meet the specific and evolving needs of different markets and transactions. Security implementation must be free to evolve over time and to support different needs. Energy Interoperation allows for this composition, without prescribing any particular security implementation.

2 Overview of Energy Interoperation

2.1 Scope of Energy Interoperation

Energy Interoperation (EI) supports the following:

- Transactive Energy
- Distribution of dynamic and contract prices
- Demand response approaches ranging from dispatch of load resources to price levels embedded in an event.
- Measurement and confirmation of response.
- Projected price, demand, and energy

EI engages Distributed Energy Resources (DER) while making no assumptions as to their processes or technology.

While this specification supports agreements and transactional obligations, this specification offers flexibility of implementation to support specific programs, regional requirements, and goals of the various participants including the utility industry, aggregators, suppliers, and device manufacturers.

It is not the intent of the Energy Interoperation Technical Committee to imply that any particular agreements are endorsed, proposed, or required in order to implement this specification. Energy market operations are beyond the scope of this specification although the interactions that enable management of the actual delivery and acceptance are within scope. Energy Interoperation defines interfaces for use throughout the transport chain of electricity as well as supporting today's intermediation services and those that may arise tomorrow.

2.2 Specific scope statements

Interaction patterns and service definitions to support the following are in scope for Energy Interoperation:

- Market communications to support transactive energy. (see **[TeMIX]**)
- Specific offerings by end nodes to alter energy use.
- Measurement and confirmation of actions taken, including but not limited to curtailment, generation, and storage, including load and usage information, historical, present, and projected.
- Notifications requesting performance on transactions offered or executed.
- Information models for price and product communication.
- Service definitions for Energy Interoperation

The following are out of scope for Energy Interoperation:

- Requirements specifying the type of agreement, or tariff used by a particular market.
- Validation and verification of performance, except for feedback on curtailment and generation.
- Communication (e.g. transport method) other than Web services to carry the messages from one point to another. The messages specified in Energy Interoperation can be transmitted via a variety of transports.

2.3 Goals & Guidelines for Signals and Price and Product Communication

1. There are at least four market types, and signals and price and product standardization must support all four, while allowing for the key differences that exist and will continue to exist in them. The four market types are:

   - no open wholesale and no retail competition
   - open wholesale market only

362   •   open retail competition only

363   •   open wholesale and open retail competition

364   2. Wholesale market DR signals and price and product communication have different characteristics
365   than retail market DR signals and price and product communication, although Energy
366   Interoperation defines a commonality in format.

367   3. It is likely that most end users, with some exceptions among Commercial and Industrial (C&I)
368   customers, will not interact directly with wholesale markets.

369   4. Retail pricing models are complex, due to the numerous tariff rate structures that exist in both
370   regulated and un-regulated markets. Attempts to standardize DR control and pricing signals must
371   not hinder regulatory changes or market innovations when it comes to future tariff or pricing
372   models.

373   5. New business entities such as Energy Service Providers (ESP), Demand Response Providers
374   (DRP), DR Aggregators, and Energy Information Service Providers (EISP), will play an increasing
375   role in DR implementation. Energy Interoperation supports these and new as yet unnamed
376   intermediation services.

377   6. DER may play an increasingly important role in DR, yet the development of tariff and/or pricing
378   models that support DER's role in DR are still in early stages of development.

379   7. The Customer's perspective and ability to react to DR control and price signals must be a key
380   driver during the development of standards to support DR programs.

381 In addition, it is the policy of the Energy Interoperation Technical Committee that:

382   8. Where feasible, customer interfaces and the presentation of energy information to the customer
383   should be left in the hands of the market, systems, and product developers enabled by these
384   specifications.

385 The NAESB Smart Grid Committee **[NAESB-SG]** provided guidance on the Demand Response and the
386 electricity market customer interactions, as a required input under NIST Smart Grid Priority Action Plan 9
387 (PAP09). Energy Interoperation relied on this guidance. The service and class definitions relied on the
388 information developed to support the NAESB effort in the wholesale **[IRC]** and retail **[OpenSG]** markets.

2.4 Scope of Energy Interoperation Communications

390 While the bulk of examples describe the purchase of real power, emerging energy markets must
391 exchange economic information about other time-sensitive services.

392 For example, delivery of power is often constrained by delivery bottlenecks. The emergence of distributed
393 generation and Plugin Electric Vehicles (PEV) will exacerbate this problem. EMIX includes product
394 definitions for tradable congestion charges and transmission rights. Locational market prices in
395 distribution may come to mirror those already seen in transmission markets.

396 Other services address the direct effects of distribution congestion, including phase imbalances, voltage
397 violations, overloads, etc.

398 These markets introduce different market products, yet the roles and interactions remain the same.
399 Intelligent distribution elements, up to an intelligent transformer take roles in these interactions.

400 A description of the tariffs or market rules to support these interactions is outside the scope of this
401 specification. However, interaction patterns in this specification are defined to provide additional
402 information for markets in which tariffs or market rules are required.

2.5 Collaborative Energy [Not Normative]

404 Collaborative Energy, in this specification, refers to the transactions and management of energy using
405 collaborative approaches, including but not limited to markets, requests for decrease of net demand,
406 while addressing the business goals of the respective parties in arms-length interactions.

407 Transactive energy describes the established process of parties buying and selling energy based on
408 tenders (buy or sell offers) that may lead to transactions among parties. In open wholesale forward

409 energy markets, a generator may tender a quantity of energy at a price over a future delivery interval of
410 time to a customer. Acceptance of a tender results in a binding transaction. In some cases, the
411 transaction requires physical delivery of energy. In other cases, the transaction is settled for cash at a
412 price determined by a prescribed price index. The use of Energy Interoperation to enable present and
413 future wholesale and retail energy markets and retail tariffs, including dynamic and multi-part tariffs is
414 described in [EMIX]. This section reviews the generic roles and interactions of parties involved in energy
415 transactions.

416 In this specification, the information exchanged and the services needed to implement smart energy are
417 defined.

418 Today's markets are not necessarily tomorrow's. Today's retail markets have grown up around conflicting
419 market restrictions, tariffs that are contrary to the goals of Collaborative Energy, and historical practices
420 that pre-date automated metering and e-commerce. Today's wholesale market applications, designed,
421 built and deployed in the absence of standards, has resulted in little or no interchangeability among
422 vendor products, complex integration techniques, and duplicated product development. The Technical
423 Committee opted to avoid direct engagement with these problems. Energy Interoperation aims for future
424 flexibility while it addresses the problems of today.

425 While the focus today is on on-demand load reduction, on-demand load increase is just as critical for
426 Collaborative Energy interactions. Any large component of intermittent energy sources will create
427 temporary surpluses as well as surfeits. Interactions between different smart grids and between smart
428 grids and end nodes must maximize load shifting to reflect changing surpluses or shortages of electricity.
429 Responsibilities and benefits must accrue together to the participants most willing and able to adapt.

430 The Committee, working with the **[EMIX]** Technical Committee developed a component model of an
431 idealized market for electricity transactions. This model assumes timely automated interval metering and
432 an e-commerce infrastructure. TeMIX describes electricity in this normal market context. This model was
433 explained in the **[TeMIX]** paper, an approved work product of the EMIX committee. Using the components
434 in this model, the authors were then able to go back and simulate the market operations of today.

435 Energy Interoperation supports four essential market activities:

1. There is an **indication of interest** (trying to find tenders to buy or sell) when a Party is seeking
   partner Parties for a demand response transaction or for an energy source or sale.
2. There is a **tender** (offer or bid) to buy or sell a service, e.g. production of energy or curtailment of
   use.
3. There is a **transaction** to purchase or supply, generally from the acceptance of a tender.
4. For some transactions, such as Demand Response, there is an **execution** for delivery of the
   subject of a transaction at the agreed-upon price, time, and place.

443 Version 1.0 of Energy Interoperation does not define the critical fifth market activity, **measurement and
444 verification** (M&V). A NAESB task force (Demand Side Management and Energy Efficiency Working
445 Groups) is continuing work to define the business requirements for M&V.

446 Other business models may combine services in novel ways. An aggregator can publish an indication of
447 interest to buy curtailment at a given price. A business willing to respond would offer an agreement to
448 shed load for a specific price. The aggregator may accept some or all of these offers. The performance in
449 this case could be called at the same time as the tender acceptance or later.

450 Communication of price in transactions is at the core of the Energy Interoperation services. Five types of
451 prices are identified in this specification:

1. Priced Offer: a forward offer to buy or sell a quantity of an energy product for a specified future
   interval of time, the acceptance of which by a counterparty results in a binding agreement. This
   includes tariff priced offers where the quantity may be limited only by the service connection and
   DR prices.
2. Ex-Post Price: A price assigned to energy purchased or sold that is calculated or assigned after
   delivery. Price may be set based on market indices, centralized market clearing, tariff calculation
   or any other process.

459　　3.　Priced Indication of Interest: the same as a Priced Offer except that no binding agreement is
460　　　　immediately intended.

461　　4.　Historical Price: A current price, past transaction price, past offered price, and statistics about
462　　　　historical price such as high and low prices, averages and volatility.

463　　5.　Price Forecast: A forecast by a party of future prices that are not a Priced Indication of Interest or
464　　　　Priced Offer. The quality of a price forecast will depend on the source and future market
465　　　　conditions

466　A grid price service is able to answer the following sorts of questions:

467　　1.　What is the price of Electricity now?

468　　2.　What will it be in 5 minutes?

469　　3.　What price will electricity have for each hour of the day tomorrow? What is the confidence level
470　　　　about these predictions?

471　　4.　What will it be at other times in the future?

472　　5.　What was the highest or lowest price for electricity in the last day? Month? Year?

473　　6.　What was the high price for the day the last time it was this hot?

474　Each answer carries with it varying degrees of certainty. The prices may be fixed by contracts or tariffs
475　that change infrequently if at all. The prices may be fixed tariffs, "unless a DR event is called." The prices
476　may even represent wild guesses about open markets. With a standardized price service, technology
477　providers can develop solutions to help grid operators and grid customers manage their energy use
478　portfolios.

479　This specification also encompasses Emergency or "Grid Reliability" events. Grid Reliability events
480　require mandatory participation in today's markets. These events are described as standing pre-executed
481　option agreements. A grid operator need merely call for performance as in any other event.

2.6 Assumptions

2.6.1 Availability of Interval Metering

484　Energy Interoperation for many actions presumes a capability of interval metering where the interval
485　might be smaller than the billing cycle. Intervals are typically one hour or less. Interval metering may be
486　required for settlement or operations for measurement and verification of curtailment, distributed energy
487　resources, and for other Energy Interoperation interactions.

2.6.2 Use of EMIX

489　This specification uses the OASIS Energy Market Information Exchange [EMIX] to communicate product
490　definitions, quantities, and prices. EMIX provides a succinct way to indicate how prices, quantities, or both
491　vary over time.

2.6.3 Use of WS-Calendar

493　This specification uses the OASIS [WS-Calendar] specification to communicate schedules and intervals.
494　WS-Calendar is the standard under the NIST Smart Grid Roadmap for all such communication.

495　WS-Calendar expresses a general approach to communications of sequences and schedules, and their
496　gradual complete instantiation during the transactive process. Despite its name, WS-Calendar does not
497　require that communications use web services.

2.6.4 Energy Services Interface

499　The Energy Services Interface (ESI) is the external face of the energy-consuming node. The ESI may be
500　directly on an energy management system in the end node, or it may be mediated by other business
501　systems. The ESI is the point of communication whereby the entities (e.g. utilities, ISOs) that produce and

502 distribute electricity interact with the entities (e.g. facilities and aggregators) that manage the consumption
503 of electricity. An ESI may be in front of one system or several, one building or several, or even in front of
504 a microgrid.
505 This work assumes that there is no direct interaction across the ESI.

3 Energy Interoperation Architecture

The following sections provide an overview of the interaction structure, and define the roles and actors in electricity markets. Later sections will define the interactions more carefully as services. The section first addresses Transactive Energy Interactions and then addresses Event Interactions for Demand and Generation Resources.

The Energy Interoperation (EI) architecture describes interactions between pairs of actors, and, in a deployment, relationships are established among actors. Actors may perform in chains of pairs of actors.

3.1 Transactive Energy Interactions

Transactive Energy refers to the communication of prospective and completed transactions of energy whether market-based, bilateral or, contract-, agreement-, or tariff-based, and whether of energy or options on energy. The terminology used by Transactive Energy is most evident today in the buying and selling of wholesale energy in bilateral and exchange transactions. This section reviews and interactions of Parties involved in energy transactions.

The actor for all Transactive EI interactions is a Party. A Party can be an end-use customer, a generator, a retail service provider, a demand response provider, a marketer, a distribution system operator, a transmission system operator, a system operator such as an ISO or RTO, a microgrid operator, or any party engaging in transactions for energy or the transport of energy.

Parties may participate in interactions concurrently as well as over time. In theory, any Party can transact with any other Party subject to applicable regulatory restrictions. In practice, markets will establish interactions between Parties based on regulation, convenience, economics, credit, network structure, locations, and other factors.

3.1.1 Transaction Side

A Party can take one of two Sides in a given Transaction:

- Buy, or
- Sell

At any moment, a Party has a position resulting from any previous Transactions. A Party selling power relative to its current position takes the Sell Side of the Transaction. A Party buying power relative to its current position takes the Buy Side of the Transaction.

A generator typically takes the Sell Side of a Transaction, but can also take the Buy Side of a Transaction. A generator may take the Buy Side of a Transaction in order to reduce generation because of a change in generator or market conditions.

An end-use customer typically takes the Buy Side of a Transaction, but if tendered an attractive price may curtail usage and thereby take the Sell Side of a Transaction.

A distributed generator also can take the Side of Buyer or Seller in a Transaction. For example, if a distributed generator sells 2 MW for an hour forward of a given interval, it may decide to buy back all or a portion of the 2 MW for that hour if the price is low enough. A distributed storage device may take the Buy side of a Transaction to store energy and the Sell Side of a Transaction at a different time to release energy from storage.

3.1.2 Transactive Interactions among Parties

Parties may interact using Tenders for Transactions as illustrated in Figure 3-1.

546
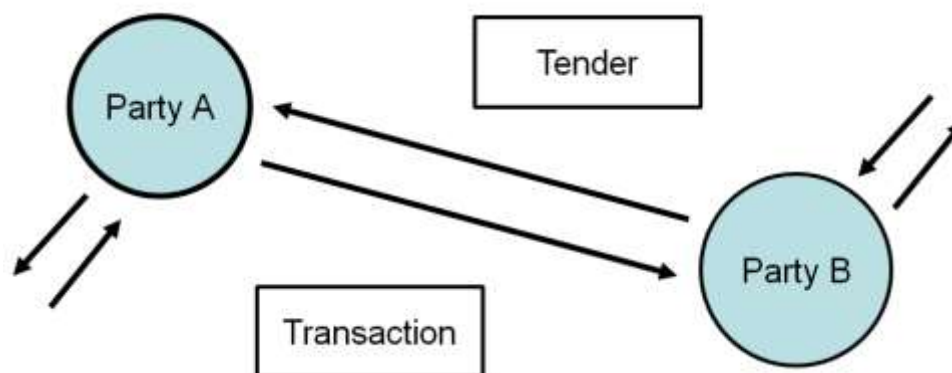
547 *Figure 3-1: Parties Interacting Using Tenders for Transactions*

548 Suppose Party B takes the Buy Side in initiating a Tender to a CounterParty, Party A. Party A has the
549 Sell Side of that Tender. If the Tender is accepted by Party A, Party A takes the Sell Side and Party B
550 takes the Buy Side of the Transaction.

551 Any Party can initiate a Tender to any CounterParty and take on either the Buy or Sell Side. The
552 CounterParty can accept or reject Tenders from Parties and itself initiate Tenders as Party to any
553 CounterParty to the extent allowed by market rules and regulations.

554 Two parties can also engage in an option Transaction. An option is a promise granted by a Party (Option
555 Writer) to a CounterParty (Option Holder) usually for a premium payment. The Option Holder is granted a
556 right to invoke specific Transactions for energy that the Option Writer promises to deliver. Demand
557 response, ancillary services, and price cap Transactions are forms of options. Any Party may take the
558 Buy Side or Sell Side of a Tender for an option Transaction acting either as the Holder or Writer of the
559 option.

560 3.1.3 Retail Service Interactions

561 Retail Customers interact with either tariffed cost-of-service retail providers or competitive retail providers
562 with various service plans. Either way the price of the service must be clearly communicated to the
563 customer. With the introduction of interval metering and dynamic pricing, clear communication of price
564 and the purchasing decisions by customers is essential.

565 EI provides services to communicate both the tendered prices by retailers to customers and the purchase
566 transactions by customers. Customers with distributed energy resources (DER) or storage may often be a
567 seller to retailer or other parties. Transactions may also include call options on customers by a retailer to
568 reduce deliveries and call options by customers on a retailer to provide price insurance.

569 3.1.4 Wholesale Power Interactions

570 Retail Energy Providers, Aggregators, Power Marketers, Brokers, Exchanges, System Operators and
571 Generators all interact in the wholesale market for deliveries on the high voltage transmission grid.
572 Transactions include forward transactions for delivery, near-real time transaction and cash settled futures
573 transactions for hedging risks.

574 EI mirrors the tender and transaction interaction patterns of open forward wholesale power markets. Near
575 real-time wholesale markets for resources provided by independent system operators are also provided
576 for in EI design.

577 3.1.5 Transport Interactions

578 Transmission and Distribution services transport energy from one location to another. Transport is the
579 common term used by EI and EMIX to refer to both Transmission and Distribution. Prices for Transport
580 are dynamic and need careful communication. EI models tenders and transactions for Transport products
581 using the same interactions as for Energy products.

582 EI makes no assumptions about how prices for Transport are determined.

3.2 Event Interactions for Demand and Generation Resources

584 In partial contrast to the transactive model described above, another common interaction model is based
585 on event-based dispatch of resources by Parties. Resources include both generation resources and
586 curtailment resources. Curtailment resources provide reductions in delivery to a customer from a baseline
587 amount; such resources are typically treated as generation resources, usually in the context of events
588 where shortages may occur. Curtailment resources are also called demand response (DR) resources. For
589 DR resources the determination of the baseline is outside the scope of EI.

3.2.1 VTN and VEN Party Roles

591 Similar to the Party interactions of transactive energy, event interactions also have an interoperation
592 model between two or more Actors. One designated Actor (for that given interaction) is called the **Virtual**
593 **Top Node (VTN)** and the remaining one or more actors are called **Virtual End Node(s), or VEN(s)**[1].

594 Parties may participate in many interactions concurrently as well as over time. For example, a particular
595 Actor may participate in multiple Demand Response programs, receive price communication from multiple
596 sources, and may in turn distribute signals to additional sets of Parties.

597 The VTN / VEN Interactions combine and compose multiple sets of pairwise interactions to implement
598 more complex structures. By using simple pairwise interactions, the computational and business
599 complexity for each set of Parties is limited, but the complexity of the overall interaction is not limited.

600 The VTN and VEN Roles are useful beyond event-based interactions because they provide stereotyping
601 of a wide range of behaviors and interactions in energy markets.

3.2.2 VTN/VEN Interactions

603 In this section the terminology for roles in VTN/VEN Energy Interoperation interaction patterns is clarified.
604 The description and approach is consistent with the Service-Oriented Architecture Reference Model
605 **[SOA-RM]**. The role of a Party as a VTN or VEN only has meaning within the context of a particular
606 service interaction.

607 At this level of description the presence of application level acknowledgement of invocations is ignored,
608 as reliable and confirmed delivery would typically be implemented by composition with **[WS-RM]**, **[WS-**
609 **Reliability]**, **[WS-SecureConversation]** or a similar mechanism. For similar reasons, an actual
610 deployment would compose the necessary security, e.g., **[WS-Security]**, **[SAML]**, **[XACML]**, or **[WS-**
611 **SecureConversation**]. See Section 13 for a discussion of compositional security.

612 At this level the typical push or pull patterns for interactions are also ignored but are covered in later
613 sections.

614
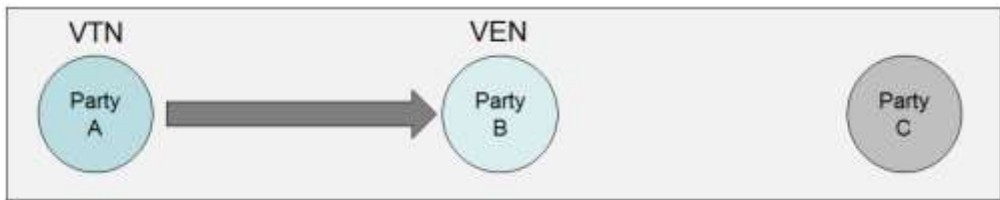
615 *Figure 3-2: Example DR Interaction One*

616 In Figure 3-2, Party A is the VTN with respect to Party B, which acts as the VEN in this interaction. Party
617 C is not a party to this interaction.

---

[1] We are indebted to EPRI for the Virtual End Node term [EPRI]

618 Subsequently, as shown Figure 3-3, Party B may act as the VTN for an interaction with Party C, which is
619 acting as the VEN for interaction two. Party A is not a party to this interaction.

620

621 *Figure 3-3: Example DR Interaction Two*

622 Moreover, the directionality and the roles of the interaction can change as shown in Figure 3-4.

623 Again, Party A is not a party to this interaction, but now Party C is the VTN and Party B is the VEN.

624

625 *Figure 3-4: Example DR Interaction Three*

626 There is no hierarchy implied by these examples. The examples are used to show how the pairwise
627 interaction patterns and the respective roles that entities play can be composed in ways that are limited
628 only by business needs and feasibility, and not by the architecture. From these simple interactions, one
629 can construct more complex interactions such as those shown in Figure 3-5.

630

631 *Figure 3-5: Web of Example DR Interactions*

632 In this figure, certain Parties (B, E, and G) act as both VTN and VEN. This directed graph with arrows
633 from VTN to its VENs could model a Reliability DR Event initiated by the Independent System Operator[2]
634 A who would invoke an operation on its second level VTNs B-E, which could be a group of aggregators.
635 The second level VTN B, in turn invokes the same service on its VENs FGH, who may represent their
636 customers or Transactive resources. Those customers might be industrial parks with multiple facilities,
637 real estate developments with multiple tenants, or a company headquarters with facilities in many
638 different geographical areas, who would invoke the same operation on their VENs.

639 Each interaction can have its own security and reliability composed as needed—the requirements vary for
640 specific interactions.

641 The following table has sample functional names for selected nodes. *(Note: wrt means "with respect to")*

---

[2] Using North American Terminology.

642 *Table 3-1: Interactions and Actors*

Label	Structure Role	Possible Actor Names
A	VTN	System Operator, DR Event Initiator, Microgrid controller, landlord
B	VEN (wrt A), VTN (wrt F, G, H)	Aggregator, microgrid element, tenant, floor, building, factory
G	VEN (wrt B), VTN (wrt I, J, L)	Microgrid controller, building, floor, office suite, process controller, machine
L	VEN (wrt G and wrt E)	Microgrid element, floor, HVAC unit, machine

643 ## 3.2.3 VTN/VEN Roles and Services

644 Two structured roles have been defined for each interaction, the Virtual Top Node (VTN) and the Virtual
645 End Node (VEN). A *VTN* has one or more associated *VENs*.[3]

646 Considering service interactions for Energy Interoperation, each *VTN* may invoke services implemented
647 by one or more of its associated *VENs*, and each *VEN* may invoke services implemented by its
648 associated *VTN*.

649 In later sections abstract services that address common transactions are detailed; Demand Response,
650 price distribution, and other use cases.

651
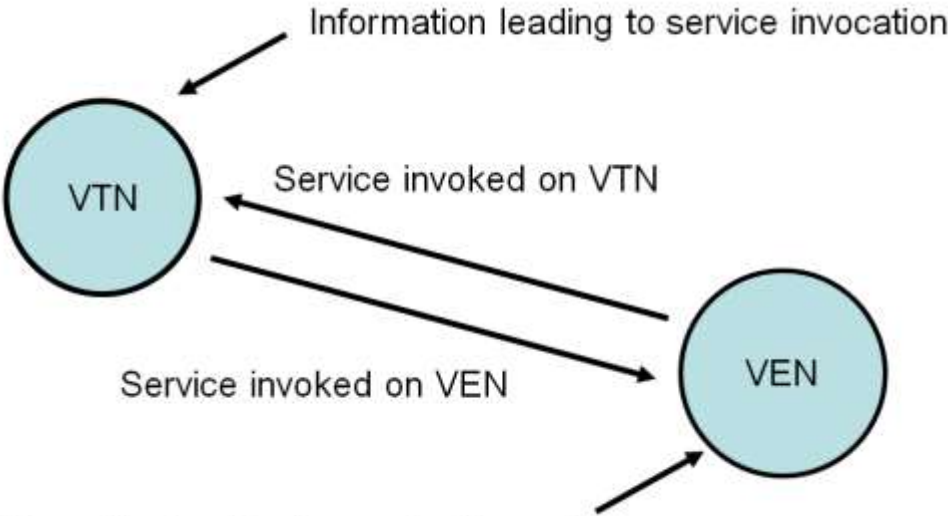
652 *Figure 3-6: Service Interactions between a VTN and a VEN*

653 The interacting pairs can be connected into a more complex structure as shown in Figure 3-5.

---

[3] The case of a VTN with zero VENs may be theoretically interesting but has little practical value, hence in a later section VENs having cardinality 1..n are described

energyinterop-v1.0-~~cos01~~
~~2013~~wd42
Standards Track Work Product   Copyright © OASIS Open ~~2013~~2014. All Rights Reserved.

~~19 December~~
18 May 2014
Page 32 of 152

654 The relationship of one or more **VENs** to a **VTN** mirrors common configurations where a VTN (e.g. an
655 aggregator) has many VENs (say its resources under contract) and each VEN works with one VTN for a
656 particular interaction.[4]

657 Second, as we have seen, each **VEN** can implement the **VTN** interface for another interaction.

658 Third, the pattern is recursive as shown above in Figure 3-3 and allows for more complex structures.[5]

659 Finally, the Parties of the directed interaction graph can be of varying types or classes. In a Reliability DR
660 Event, a System Operator as a VTN may initiate the event with the service invoked on its next level
661 (highest) VENs, and so forth. But the same picture can be used to describe many other kinds of
662 interaction, e.g. interactions to, from, or within a microgrid **[Galvin]**, price and product definition
663 distribution, or distribution and aggregation of projected load and usage.

664 In some cases the structure graph may permit cycles, in others not.

3.2.4 Demand Response Interactions

666 In this section the interaction patterns of the services for demand response respectively invoked by an
667 **VTN** on one or all of its associated **VENs** and vice versa, are described. Figure 3-6: above shows the
668 generic interaction pattern; Figure 3-7 below is specific to Demand Response Events.

669 By applying the recursive definitions of VTN and VEN specific services will be defined in the following
670 sections (See Figure 3-7)

671 The VTN invokes operations on its VENs such as Initiate DR Event and Cancel DR Event, while the VEN
672 invokes operations on its VTN such as Create Tender and Create Feedback.

673 Note not all DR works this way. A customer may be sent a curtailment tender by the DR provider with a
674 price and then can decide to respond. If the customer has agreed to a capacity payment then there may
675 be a loss of payments if he does not respond.

---

[4] The model allows e.g. Demand Resources to participate in more than one interaction, that is, in more than one Demand Response program or offer or with more than one aggregator.

[5] For example, **[OpenADR1.0]** has four actors (the Utility, Demand Response Application Server, the Participant, and the Client (of the Participant). The Energy Interoperation architecture maps clearly to the DRAS-Participant interface, and models the Participant-Client interface as an additional VTN-VEN relationship.
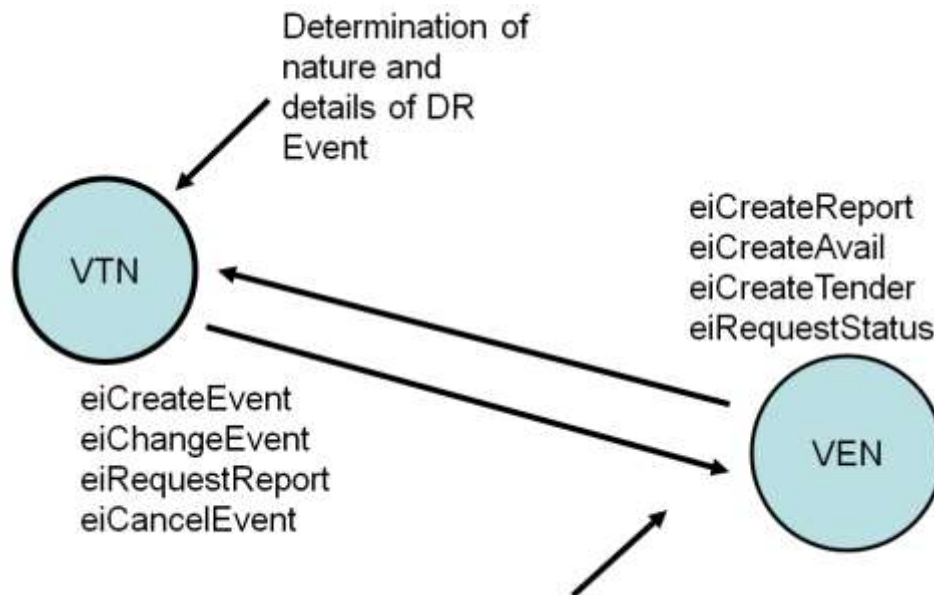
Figure 3-7: Demand Response Interaction Pattern Example

3.3 Roles, Resources and Interactions (Non-Normative)

There are many deployments possible, including many not described here. The Committee has striven to make Energy Interoperation agnostic about business processes or business relationships.

3.3.1 Choosing a Role

An Actor finds, discovers, or is configured to use a particular Registrar. By using the EiRegisterParty service, that Actor obtains a PartyID. With that PartyID, the Actor can implement and interact using the Party Role in the Transactive Services.

One interaction a Party may participate in is Enrollment. An application may, when it has a PartyID and is identified, Enroll. There are a number of Enrollee Types, reflecting different business roles and enrollments, which are out of scope for this specification—only the names are defined. An exception is the Resource which extends the EMIX Resource Description Type.

The information required for Enrollment varies across Enroll Administrators. For example in North American wholesale markets, each ISO may potentially require different information or documentation than another. Since that information is out of scope, a deployment or profile would specify what information is required, and convey that information in an extension of the Enrollee types.

Once Enrolled, a Party may have other capabilities, the definition and description of which is also out of scope. The service operations supported are listed in Section 8 *"Enroll Service"*.

The operations for Party Registration and Enrollment are designed, as are all other operations and data types, to be both extensible and evolvable over time to add new or extended functionality to future versions of Energy Interoperation, or by extension of information definitions in specific profiles.

3.3.2 The relationship between Actors and Resources

There is no definitive way to classify an Actor, or a set of capabilities, as an Actor or a Resource. A VEN that is also a VTN may bundle the VENS it interacts with to offer as Resources. In another business model, that VEN may interact with its internal partners through transactive services. Different business structures will drive different technical deployments.

First, an Actor, representing application code, may assume the Virtual End Node (VEN) role. The same application code may also support the Virtual Top Node (VTN) role. This is how the graph of VTNs and

705 VENs in Figure 3-5 is constructed. In that figure, Actor G implements the role of VEN with respect to Actor
706 B, and the role of VTN with respect to Actors I, J, and L.

707 A Party interacts in transactive environments; the distinction is that a market may have many
708 relationships. While it might seem attractive to make the Actor that interacts with a market take on the
709 VEN role (with the market taking on the VTN role), this is too restrictive. An Actor offers, views, and
710 transacts regardless of the VEN/VTN relationships that it maintains--and so the transactive interfaces use
711 Party and CounterParty.

712 In a deployment one must make decisions about how the roles are selected, discovered, or assigned; this
713 is out of scope of this specification.

714 In contrast, a Resource is treated as a thing, rather than an Actor. A resource does not participate in
715 relationships such as the Actor/application interfaces in the figure. It could be tempting to require that a
716 Resource is related to (or possibly "managed by") exactly one Actor, a VEN in the Energy Interoperation
717 architecture. It could seem clearest to assert a one-to-one relation between this VEN and the Resource.
718 This would allow requests, reports, and other interactions to and from a single VEN which is uniquely
719 related to that Resource.

720 But other business cases would be simpler with potentially many Resources managed by a single VEN.
721 In a transactive environment, that VEN may offer capabilities of its individual or groups of Resources to a
722 market (as a Party), and without requiring the defined structure of collaborating VENs and VTNs.

723 For example, a distributed application conforming to this specification MIGHT deploy in one of the
724 following ways:

  (a) assign a single Actor presenting the VEN role to each floor of a building, and a VTN related to
      them. For external interactions, that VTN for the building would present the VEN interface to
      receive and interact with the Energy Interoperation Services, and could present the Party role to
      tender, buy, and sell in a market,
  (b) assign a single Actor presenting the VEN role to the building controller, and use other services to
      manage or convey information to the floor controllers
  (c) assign a single Actor presenting the VEN role at the building controller, have that same Actor
      present the VTN role to the individual floor controllers. The floor controllers present the VEN role
      to the building controller, while presenting the VTN role to its devices, each of which presents the
      VEN role to the floor controller.

735 Were this specification to require exactly one Resource to one VEN, such multiplicity of deployment
736 would not be possible.

4 Message Composition & Services

Energy Interoperation relies on two other standards, Energy Market Information eXchange (**[EMIX]**) and **[WS-Calendar]** to express intents.

- EMIX describes price and product for electricity markets.
- WS-Calendar communicates schedules and sequences of operations.
- Energy Interoperation uses the vocabulary and information models defined by those specifications to describe many of the services that it provides.

4.1 WS-Calendar in Energy Interoperation

[WS-Calendar] defines how to use the semantics of the enterprise calendar communications within service communications. Energy Interoperation is conformant with the **[WS-Calendar]** specification for communicating duration and time to define a Schedule. **[WS-Calendar]** itself extends the well-known semantics of **[RFC5545]**. The communication of a commonly understood Schedule is essential to Energy Interoperation.

Energy Interoperation also relies on **[EMIX]**, which defines schedules and types conforming to WS-Calendar. Energy Interoperation is conformant with the **[WS-Calendar]** specification for communicating duration and time to define a Schedule.

4.1.1 Schedule Semantics from WS-Calendar (Non-Normative)

Without an understanding of certain terms defined in **[WS-Calendar]**, the reader may have difficulty achieving complete understanding of their use in this standard. The table below provides summary descriptions of certain key terms from that specification. This specification does not redefine these terms; they are listed here solely as a convenience to the reader.

Table 4-1: Core Semantics from WS-Calendar

WS-Calendar Term	Description
Component	In **[iCalendar]**, the primary information structure is a Component, also referred to as a "vcomponent." A Component is refined by Parameters and can itself contain Components. Several RFCs have extended iCalendar by defining new Components using the common semantics defined in that specification. In the list below, Interval, Gluon, and Availability are Components. Duration, Link, and Relationship are Parameters. A Sequence is set of Components, primarily Intervals and Gluons, but is not itself a Type.
Duration	Duration is the length of time for an event scheduled using iCalendar or any of its derivatives. The **[XCAL]** Duration is a data type using the string representation defined in the iCalendar (**[RFC5545]**) Duration.
Interval	The Interval is a single discrete segment, an element of a Sequence, and expressed with a Duration. The Interval is derived from the common calendar Components. An Interval is part of a Sequence.
Sequence	A set of Intervals with defined temporal relationships. Sequences may have gaps between Intervals, or even simultaneous activities. A Sequence is re-locatable, i.e., it does not have a specific date and time. A Sequence may consist of a single Interval, and can be scheduled by scheduling that single Interval in that Sequence.
Gluon	A Gluon influences the serialization of Intervals in a Sequence, through inheritance and through schedule setting. The Gluon is similar to the Interval, but has no service or schedule effects until applied to an Interval or Sequence.

WS-Calendar Term	Description
Artifact	The placeholder in an Component that holds that thing that occurs during an Interval. **[EMIX]** Product Descriptions populate Schedules as Artifacts inside Intervals. In Streams, this specification refers to the Payload conveyed by an Interval.
Link	A reference to an internal object within the same calendar, or an external object in a remote system. The Link is used by one **[WS-Calendar]** Component to reference another.
Relationship	Links between Components.
Availability	Availability in this specification refers to the Vavailability Component, itself a collection of recurring Availability parameters each of which expresses set of Availability Windows. In this specification, these Windows may indicate when an Interval or Sequence can be Scheduled, or when a partner can be notified, or even when it cannot be Scheduled.

759 Normative descriptions of the terms in the table above are in **[WS-Calendar]**.

4.1.2 Schedules and Inheritance

761 Nearly every response, every event, and every interaction in Energy Interoperation (with the exception of
762 all single interval TeMIX profile interactions) can have payloads with values that vary over time, i.e., it is
763 described using a sequence of intervals. Many communications, particularly in today's retail market,
764 involve information about or a request for power delivered over a single interval of time. Simplicity and
765 parsimony of expression must coexist with complexity and syntactical richness.

766 The simplest power description in **[EMIX]** is Transactive power. The simplest demand response is to
767 reduce power. The power object in EMIX can include specification of voltage, and Hertz and quality and
768 other features. There are market interactions where each of those is necessary. Reduced to its simplest,
769 though, the EMIX Power information consists of Power Units and Power Quantity: as in

770

Units:	KW	Quantity	10

771 *Figure 4-1: Basic Power Object from EMIX*

772 At its simplest, though, WS-Calendar expresses repeating intervals of the same duration, one after the
773 other, and something that changes over the course of the schedule

Start:	8:00	Duration:	1Hour		
		Duration:	1Hour		
		Duration:	1Hour		
		Duration:	1Hour		
		Duration:	1Hour		

774

775 *Figure 4-2: WS-Calendar Partition, a simple sequence of 5 intervals*

776 The WS-Calendar specification defines how to spread an object like the first over the schedule. The
777 information that is true for every interval is expressed once only. The information that changes during
778 each interval, is expressed as part of each interval.

Units	KW	Start:	8:00	Duration:	1Hour	Quantity	10
				Duration:	1Hour	Quantity	10
				Duration:	1Hour	Quantity	15
				Duration:	1Hour	Quantity	25
				Duration:	1Hour	Quantity	10

779

780 *Figure 4-3: Applying Basic Power to a Sequence*

781 Many communications communicate requirements for a single interval. When expressing market
782 information about a single interval, the market object (Power) and the single interval collapse to a simple
783 model:

Units	KW	Start:	8:00	Duration:	1Hour	Quantity	10

784

785 *Figure 4-4: Simplifying back to Power in a Single Interval*

786 WS-Calendar calls this pattern Inheritance and specifies a number of rules that govern Inheritance. Table
787 4-2 summarizes those terms defined in WS-Calendar to describe Inheritance that are used in this
788 specification as well. This specification does not redefine these terms; they are listed here solely as a
789 convenience to the reader.

790 *Table 4-2: WS-Calendar Semantics: Inheritance*

Term	Definition
Lineage	The ordered set of Parents that results in a given inheritance or execution context for a Sequence.
Inherit	A Child Inherits attributes (Inheritance) from its Parent.
Inheritance	A pattern by which information in Sequence is completed or modified by information from a Gluon. Information specified in one informational object is considered present in another that is itself lacking expression of that information.
Bequeath	A Parent Bequeaths attributes (Inheritance) to its Children.

791 This specification extends the use of Inheritance as defined in WS-Calendar. Most interactions specify a
792 schedule, whether for price Quote or for Demand Response event. These schedules are expressed in
793 Streams (see Section 4.3). Each Interval in the Schedule contains an information payload. Each of these
794 payloads is completed through inheriting information from the Stream as if from a Gluon. The Stream
795 itself inherits information from the context of the interaction, especially from the Market Context, as if from
796 a Gluon.

797 A Market Context Bequeaths essential information to a Stream, which in turn its information to each
798 Interval in the Stream. This specification uses this pattern of expression throughout.

4.1.3 Availability and Schedules

800 The WS-Calendar component Availability is used throughout Energy Interoperation. Availability expresses
801 recurring patterns of schedule within a bounded period of time. This specification uses Availability in
802 market definitions and in a number of inter-party commitments and communications. Availability is used to
803 define windows for Demand Response, to define when during a given day a Party may receive requests,
804 and for expressing the desire of a Party to place or remove services from markets.

805 While the expression of Availability is defined in WS-Calendar, the Committee recommends the
806 informative discussion of Availability found in **[Vavailability]**.

4.1.4 Smoothing Response

Precision of communication and response causes special problems for large collections of entities and systems, as well as for switching of high electrical demand as in substations or with large electric motors. When devices interact at high speeds to change demand, they can create sharp spikes up or down in demand. These spikes can affect other nodes on a grid, cause a grid to crash, or even destroy equipment.

WS-Calendar defines Tolerance as an optional Property of Intervals that expresses allowable imprecision. Tolerance may have up to 5 parameters: Start Before Tolerance, Start After Tolerance, End Before Tolerance, End After Tolerance, and Precision.

For example, Start Before Tolerance may have a value of ten minutes. In the same Interval, Start After Tolerance may have a value of five minutes. Let us further specify that the Interval starts at 3:00 PM with a Duration of two hours. WS-Calendar then has expressed that the recipient begin its response at 3:00 and continue for two hours, but that a response that begins any time between 2:50 pm and 3:05 pm is acceptable.

For convenience, this specification refers to the Tolerance Interval as either the sum of the starting tolerances (Start Before Tolerance and Start After Tolerance) or the sum of the ending tolerances (End Before Tolerance and End After Tolerance).

Because Sequences are constructed of linked intervals expressed as Durations, Tolerance applied only to the Designated Interval in a Sequence can change the interpretation of the entire Sequence. If the Designated Interval begins five minutes late and lasts one hour, then the second Interval, which is anchored by the first, will also begin five minutes late, and so on.

The Smart Grid is a system of systems, and each system provides its respective class of application. Some systems are aggregates of hundreds or thousands of similar systems. Other Systems contain many internal systems with their own dependencies and interactions. Still others may consist of a single large system. Each of these represents a different application.

- Applications managing small loads may be required to randomize their start time within the Tolerance Interval. Conformance requirements for a deployment must specify how this randomization is demonstrated or evaluated for a particular application.
- Applications internally managing collections of smaller loads may be required to spread the starts and stops of each internal system to produce a load that moves in steps over the Tolerance Interval. Different systems may do this differently. Integrated systems will sequence their internal loads to manage internal cross-dependencies. Less integrated systems may randomize the starts of their internal systems. Conformance for these applications may include a minimum spread of steps or a maximum quantum change of load.
- Applications that front single large loads may be required to gradually ramp between the initial state and the requested response across the Tolerance Interval.

Conformance to these deployment scenarios is outside the scope of this specification.

4.2 EMIX in Energy Interoperation

Energy Interoperation uses EMIX to express the semantics of Power and Energy Markets.

In **[EMIX]** Product Descriptions define Energy and Power. Product Descriptions are applied to Sequences to create Schedules. Schedules conform to the inheritance pattern defined in **[WS-Calendar]** to reduce repetition of these descriptive elements. **[EMIX]** Products include an entire Schedule along with transactive information. **[EMIX]** Options use Availability to describe market information for the right to acquire Energy during certain periods at specified Rates. TeMIX defines communications for transactions of energy delivered at specified rates over specific intervals.

Each of the elements above is associated with a Market Context. A Market Context may be associated with Standard Terms which may define an overriding set of information for products therein. An **[EMIX]** Schedule can inherit information from the Standard Terms in a Market just as a WS-Calendar Sequence inherits from a Gluon.

856 Every Energy Interoperation interaction MAY convey an EMIX Type. Often they convey simplified
857 derivations of **[EMIX]** types that use conformance and inheritance to reduce to a bare minimum, while still
858 using EMIX semantics.

859 Energy Interoperation defines Parties which enroll with Counter-Parties. These Parties may then
860 participate directly in energy transactions, using the Semantics from TeMIX. Others enroll as Resources
861 with certain capabilities. Some of these Resources may share detailed capability and response
862 information with their counter-party using the EMIX Resource semantics.

4.2.1 Core Semantics from EMIX

864 The terms in Table 4-3 are normatively defined in **[EMIX]**. Summary descriptions are provided here for
865 the convenience of the reader only.

866 *Table 4-3: EMIX Essential Semantics*

EMIX Term	Description
Item Base	Abstract base type for units for EMIX Products. Item Base does not include Quantity or Price, because a single Product may have multiple quantities or prices associated with each Interval.
Schedule	EMIX Products are delivered for a Duration, at a particular time. EMIX relies on the Interval and the Gluon as defined in **[WS-Calendar].**
Product Description	The Product Description is the payload inside each Interval of the Schedule. The Product Description conveys the characteristics of the Power or Resource or Transport Product. Each Interval may hold an incomplete Product Description, one that can be completed using the rules of Inheritance described in WS-Calendar.
EMIX Base	The EMIX Base conveys a Schedule populated with Product Descriptions and is intended to express additional market information sufficient to define Products.
Price Base	The PriceBase conveys a Price, a Relative Price, or a Price Multiplier.
EMIX Interface	Abstract base class for the interfaces for EMIX Product delivery, measurement, and/or pricing. The PNode and the Service Area are examples of the EMIX Interface.
Market Context	A URI uniquely identifying a source for market terms, market rules, market prices, etc.
EMIX Product	A Product Description applied to a Schedule. Using the Gluon / Sequence pattern of inheritance, there may be a nearly complete Product Description in the element that acts as a Gluon, and only elements that change in each interval.
EMIX Option	A Type of Product in which for a defined price, a party agrees to make Product available during a schedule (Availability) to be delivered at the counterparty's request, in accord with agreed upon terms and at an agreed upon price.
Transactive State	An indicator included in EMIX Base derived types to aid in processing. The enumerated Transactive States are: Indication Of Interest, Tender, Transaction, Exercise, Delivery, Transport Commitment, and Publication.
Terms	Terms are used in EMIX to describe when and how a product is available. Minimum Notification Duration, Maximum Run Duration, and Minimum Remuneration per Event are all Terms.

EMIX Term	Description
Service Area	The Service Area is the only Interface defined for all derived schemas. The Service Area expresses locations or geographic regions relevant to price communication. For example, a change in price for a power product could apply to all customers in an urban area.
Power	The EMIX Power schema defines products related to the exchange of Electrical Power using the EMIX semantics.
Resource	The EMIX Resource schema defines the capabilities that a node has to deliver Power products.
Ancillary Service	Ancillary Services are typically products provided by a Resource contracted to stand by for a request to deliver changes in power to balance the grid on short notice.

867 The terms in Table 4-3 are defined normatively in EMIX and nothing in this specification changes or
868 overrides those definitions.

4.2.2 Putting EMIX in Context

870 EMIX specifies that information that does not change can be summarized using standard Terms
871 associated with a Market Context.

872 *Table 4-4: EMIX Market Context*

Expectations and Contexts	Description
Market Context	Defines the product, performance expectations and rules for interactions. All Events, Signals, and Transactions occur within a market context. A Market Context acts as a Gluon for all sequences described in the EI Types. Market Contexts are described using the semantics of EMIX Standard Terms.
Availability	Describes when a Resource is available to respond relative to a particular VTN and Market Context
Market Expectations	Market Expectations are associated with a Market Context and consist of a number of Rule Sets.
Standard Terms	Standard Terms apply to all transactions in a Market Context. When they are conveyed as Standard Terms, they do not need to be repeated in individual interactions. A product references a Market Context and all Standard Terms associated with that Market Context.
Granularity	Granularity is the units of time used in operating a market, i.e., a market with a granularity of one hour transacts power in one hour increments. A One hour market is for one-hour purchases of Power with each interval in a one hour modulo offset from the beginning of the business schedule.
Non-Standard Terms Handling	Non-Standard terms handling defines what Parties should do with any Term not listed in the Market Rule Sets.
Market Rule-Set	A collection of Terms and how they are processed within this market. A Rule Set includes a Purpose to guide its interpretation.

Expectations and Contexts	Description
Rule Set Purpose	Defines the purpose of a Rule Set, i.e., to define minimum performance, maximum performance, etc.

873 The terms in Table 4-4 are defined normatively in EMIX and nothing in this specification changes or
874 overrides those definitions.

4.3 Streams: Adaptations of WS-Calendar for Energy Interoperation

876 Streams use WS-Calendar Sequences to convey a time sequence of prices, usage, demand, response,
877 or anything else that varies over time. Streams are used both for projections of the future and for reports
878 about the past; event signals and reports are each instances of Streams.

879 WS-Calendar specifies that Sequences that describe a Service be expressed as Duration within each
880 Interval, Temporal Relations between those intervals, and a single Start or End time for the Sequence.
881 WS-Calendar specifies that each Interval have a unique identifier (UID). WS-Calendar further specifies
882 that each Interval include a Temporal Relation, either direct or transitive, with all other Intervals in a
883 Sequence. A Temporal Relation consists of the Relationship, the UID of the related Interval, and the
884 optional Gap between Intervals.

885 **[WS-Calendar]** defines a Partition as a Sequence of consecutive Intervals.

886 All Streams follow the Gluon-Sequence pattern from WS-Calendar, i.e., the Stream acts as a Gluon that
887 optionally contains a degenerate Sequence. Information valid for the entire stream is indicated in the
888 Gluon, i.e., external to the Intervals of the Sequence. Only information that changes over time is
889 contained within each interval. This changing information is referred to herein as the Payload.
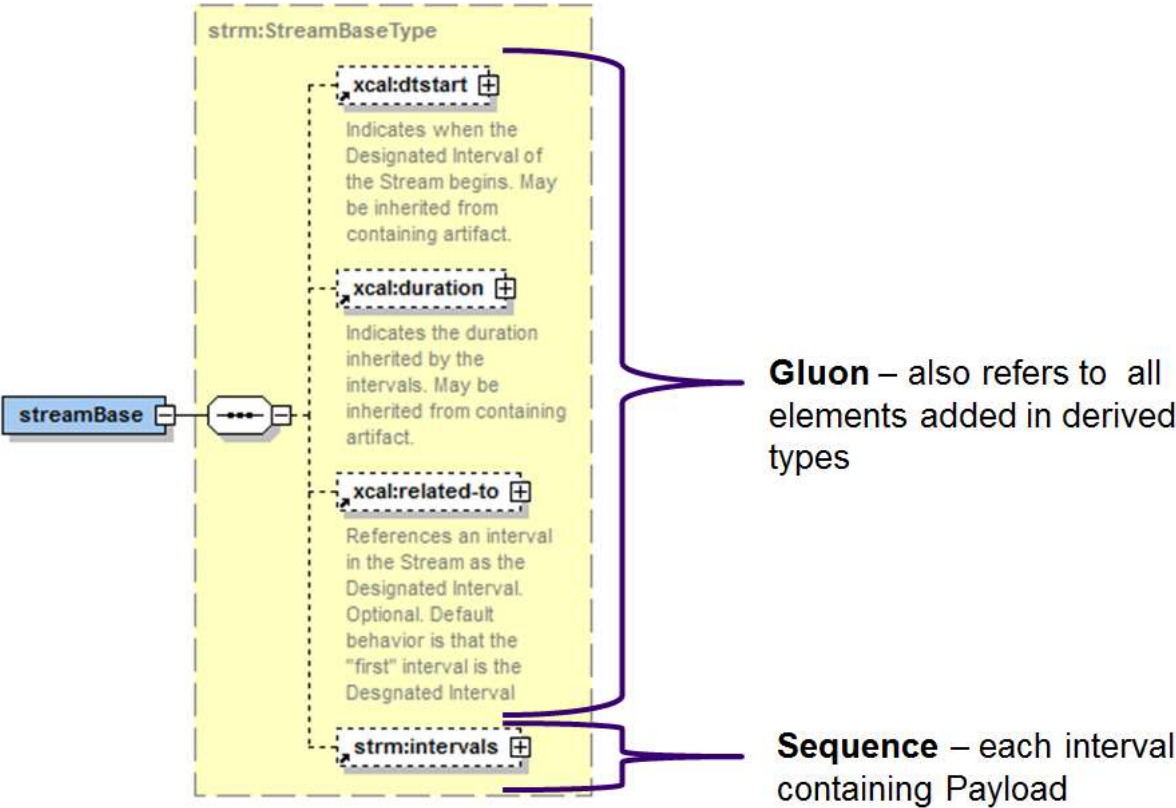
890

891 *Figure 4-5: Stream as Gluon and Sequence*

892 For example, an Event establishes in a context specified by Enrollment and each Signal arises within a
893 Market Context and within that Event Base. The information contained in the Event Base MAY inherit
894 information in the Market Context as an Interval or Gluon inherits information from a Gluon. WS-Calendar
895 calls this the *lineage* of the information.

896 That Market Context may include Standard Terms, Product Description, Time Zone Identifier (TZID), and
897 Simple Level Definition. The Market Context enters the Lineage (as described in WS-Calendar) of the
898 Schedule as if the Market Context were contained in a Gluon. Product Description, TZID, Program
899 Definition, Terms, et al. can be inherited in this manner. Again, following the WS-Calendar inheritance
900 pattern, each Interval in the Sequence inherits from the Lineage described above.

4.3.1 Information Model for Streams

902
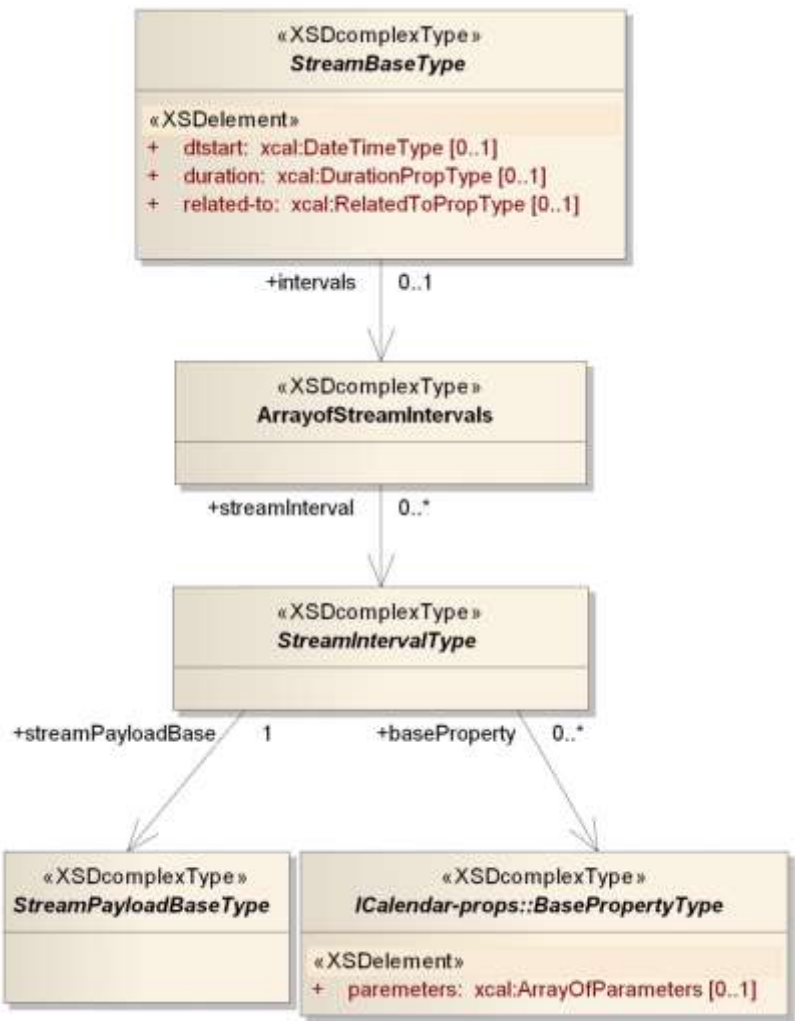
903 *Figure 4-6: UML Class Diagram of abstract StreamBase class*

4.3.2 Conformance of Streams to WS-Calendar

905 If it is necessary to process a Stream through standard Calendar communications, the Stream's GUID is
906 the key and the Stream is processed as if a Gluon. All Sequence information MAY remain internal to that
907 Gluon. If it is necessary to instantiate Interval in the Sequence as a WS-Calendar Interval, the GUID for
908 each is derived by appending the Sequence ID to the Stream's GUID.

4.3.2.1 Stream expression of Intervals expressed as Durations

While conformant communications can include anything expressible in **[WS-Calendar]**, this specification further defines standard profiles of Sequences and Intervals for use in Streams.

Streams describe Partitions. Within a Stream expressed using Durations, a virtual UID for each Interval MAY be constructed by concatenating the Stream Identifier, which may include the identity of the source or recipient, and a sequence number. Within a Stream, this UID can be expressed within each interval by the sequence number alone.

If the Designated Interval in a Sequence within a Stream omits a Temporal Relationship, then all Intervals in the Sequence MAY NOT include a Temporal Relation. Such intervals are sorted by increasing sequence number (expressed in the UID), and each Interval is treated as if it contained an implied FinishToStart relation to the next Interval with a Gap of zero Duration.

Partitions expressed in this way consist of Intervals containing only a Sequence Number, the Duration of the Interval (if not inherited), and the Market Signal Payload. The effect of this is that Stream Intervals are ordered as a Partition in order of increasing UID.

WS-Calendar inheritance defines a Lineage whereby Intervals inherit information from Gluons. In Energy Interoperation, Streams are contained within larger messages. A Stream MAY inherit information from its containing message as if from a Gluon. A Stream-derived Type MAY contain information external to the Sequence. This external information inherits acts as if it were a Gluon; it both MAY inherit from the containing message, and Bequeath information to the Designated Interval in the Stream.

The first (in time and in sequence number) Interval in the Sequence in a Stream is the Designated Interval unless another Interval is explicitly so designated in the Stream Event. Signals, Reports, and many other messages use this pattern of expression. For example, the Active Period of an Event Bequeaths its start date and time to an Event Signal which Bequeaths that to the Designated Interval in the sequence. These terms are defined below.

4.3.2.2 Observational Data expressed as Streams

Observed information may be best communicated as raw data without interpretation. A single set of Observations may be re-purposed or re-processed for multiple uses. For example, a measurement recorded at 3:15 may be a point in both a 5 minute series and a 15 minute series. Observational data may have known errors that can be lost in processing. Low-end sensor systems may not update instantly. For example, a reading taken at 4:30 may be known to actually have been recorded at 4:27. Streams expressing a series of observations MAY use the date and times rather than the duration as their primary temporal element.

When the boundaries of Intervals in a Stream are expressed with Date and Time, then all Intervals in that Sequence SHALL be expressed with a Date and Time and that boundary selected SHALL be the Same, i.e., all Intervals MAY be expressed with a Begin Date and Time OR with an End Date and Time. For observations, use the End Date and Time.

Within a Stream expressed using Dates and Times, a virtual UID for each Interval MAY be constructed by concatenating the Signal Identifier, the PartyID (which may be the VEN ID), and the Date and Time. Within an Observational Stream, this UID can be expressed within each interval by the End Date and Time alone. Intervals in a Sequence expressed this way are treated as if each contains an implied FinishToStart relation to the next Interval with a Gap of zero duration. The Duration of each Interval can be computed by using the Date(s) and Time(s) of adjacent Intervals.

4.3.3 Payload Optimization in Streams

As defined in WS-Calendar and in EMIX, each Interval in a Sequence potentially contains any artifact that inherits/extends the EMIX Product Description Type as a payload. As used in Streams, the EMIX Artifact is expressed once or inherited from the Market Context. Each Interval in a Stream expresses only the common subset of facts that varies within the context of the Stream. For efficient communication and processing, Streams use these explicit processing rules:

957   1.   Unless each interval includes a full EMIX payload, each Interval in a Stream expresses only the
958   defined subset of the payload that varies over time.
959   2.   Each Interval in a Stream uses the same payload subset as all other intervals in that stream.

960 All streams in this specification share a common Payload base. This commonality is derived from the
961 commonality of a request for performance (Signal), a report of performance (Report and Delivery),
962 projections of performance (Projection), and a baseline of performance (Baseline).

963
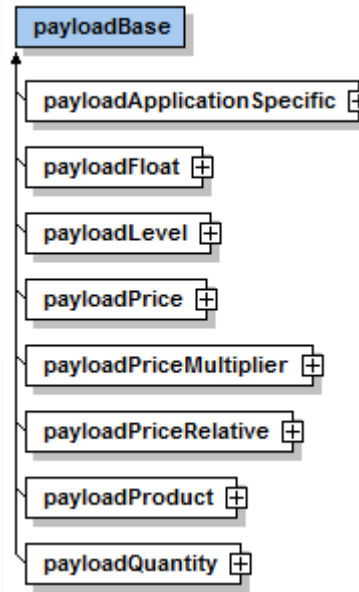
964 *Figure 4-7: Payload Base*

4.3.4 Other elements in Stream Payloads

966 It may be necessary to qualify information about intervals in the future. The element Interval Qualification
967 extends the WS-Calendar Property. [All Intervals have a collection of Properties]. Energy Interoperation
968 uses Qualifications to indicate the originator's indications as to how the sender should rely on the
969 information in the Payload.

970 Qualifications MAY be used in Quotes, in Load and Response projections, and in Observations. They
971 MAY NOT be used in other transactive states.

972 It may be necessary to qualify measurements delivered in a report. Devices have known accuracies.
973 Several Measurements MAY be added together to create a single quantity. To support these
974 uncertainties different payloads are defined for different services.

975 Each use of streams in Energy Interoperation, Signals, Baselines, Reports, and Delivery, is discussed
976 below. All four payloads are shown together in Figure 4-8: Comparing Payloads for Signals, Baselines,
977 Reports, and Delivery.

978
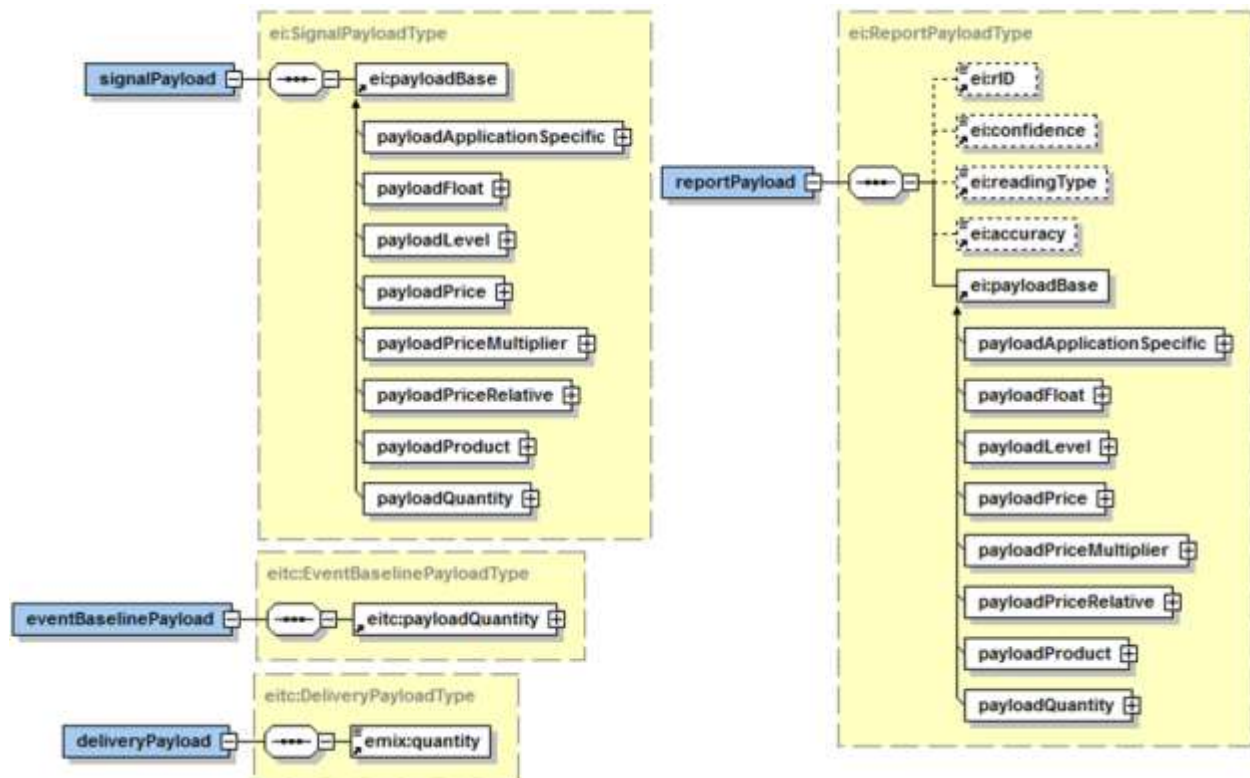
979   *Figure 4-8: Comparing Payloads for Signals, Baselines, Reports, and Delivery*

4.4 Applying EMIX and WS-Calendar to a Power Event

981   Consider the event in Figure 4-9. This event illustrates the potential complexity of marshaling a load
982   response from a VEN, perhaps a commercial building.

983
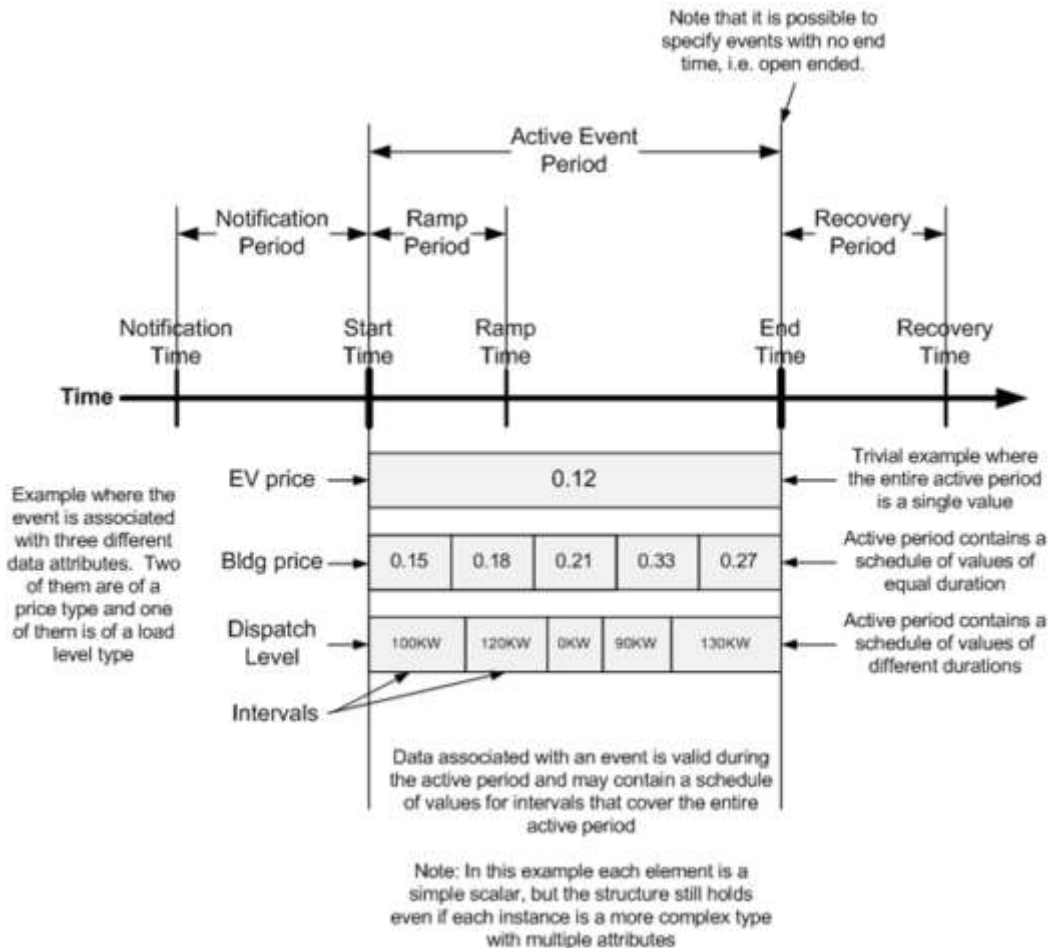
984   *Figure 4-9 Demand Response Event and associated Streams*

985   Note first that there are two schedules of prices. The price of electricity for the building "bldg price" is
986   rising to more than double its original price of $0.15 during the interval. The price for Electric Vehicles
987   (EV) is fixed at the lower-than-market rate of $0.12, perhaps because public policy is set to encourage
988   their use. Each of those price curves has an EMIX description.

989   In the language of EMIX and WS-Calendar, this Event contains two Resources and three Schedules. The
990   Resources are the Electric Vehicle and the Building. The Vehicle receives one schedule of Prices. The
991   Building receives two schedules, one dispatch based, and one price based. Both resources are located
992   within the VEN, and any decisions about how to respond to the event are made within the VEN which is
993   the sole point of communication for the VTN.

994   The duration that encompasses the event is known as the Active Period for the event. Before and after
995   the event, there is a notification period and a recovery period, respectively. These are fixed durations
996   communicated from the VEN to the VTN, which then must respect them in transactions it awards the
997   VEN.

4.4.1 Streams in a DR Event

998

999   The three schedules above are conveyed using Signals which are expressed as Streams as defined
1000   above.

1001   The dispatch level, i.e., the load reduction made by the building, varies over time. This may be tied to
1002   building capabilities, or to maintaining essential services for the occupants. It is not important to the VTN
1003   why it is constrained, only that it is.

1004 Note that the reductions in Figure 4-9 do not line up with the price intervals on the bar above. In this
1005 example, the dispatch level is applied to its own WS-Calendar sequence. There is no requirement that
1006 intervals in separate streams in an event align.

1007 An Event may be associated with Observational Streams to report back to the requester information
1008 measured or derived during the event.

4.4.2 The Active Period Schedule

1010 The Active Period is a special schedule for the overall description of an Event. The Active Period may
1011 have commercial and regulatory meaning, such as a rule requiring that an Event not be longer than two
1012 hours. While an Event as described below may have many schedules as expressed in Streams, it has
1013 one Active Period.

1014 The Active period of an event typically includes intervals in which the receiving system prepares for the
1015 event, begins its response, maintains its response, and recovers from the response. The schedules for
1016 these activities MAY be expressed using EMIX artifacts. For Power communications these can be
1017 expressed using artifacts based on EMIX Resources. The schedule for an Event MAY be expressed as
1018 can any other Sequence.

1019 More commonly, the Active Period is expressed through a single Interval. The properties of WS-Calendar
1020 are extended in this specification to include durations to indicate the notification, ram, and recovery
1021 periods. These are interpreted as if they are a normal sequence, constructed as indicated in Table 4-5.

1022 *Table 4-5: Semantics of the Active Period*

Active Period elements	Description
Active Period	The nominal period of the Event. Expressed as a Vcalendar containing the Active Interval and supporting schedule information.
Active Interval	Interval within the Active Period whose Start Time and Duration define the period. The Active Interval may be the Designated Interval in the Sequence in the Active Period or it may be a specialized Interval as described above.
Notification Period	Nominally, the period expressed as a Duration between notification of the event and the commencement of the Active Interval. In distributed scenarios, a VEN may receive notification before or after this moment. Constrained devices may increase energy use during the Notification Period so as to be able to reduce energy use during the Active Interval.
Ramp Up Period	Period at the beginning of the Active Interval expressed as a Duration, during which a VEN moves from its former state to its requested state. If negative, then the Ramp Up occurs within the bounds of the Active Interval, i.e., it starts at the same moment as the Active Interval. If there is no Ramp Up Period, then all other rules are processed as if there were a Ramp Up Period of zero length.
Recovery Period	Period at the end of the Active Interval expressed as a Duration during which the effect of the response may be reversed while the system returns to its base state. For example, a system that reduces energy use during an Event by raising the air temperature may use additional energy during the recovery period while cooling the air to the normal setting. If negative, then the Recovery Period occurs within the bounds of the Active Interval, i.e., it ends at the same moment as does the Active Interval.
Tolerance	A collection of parameters that indicate whether there is a range of acceptable starting and ending times for the Active Period. Tolerance is used to smooth the response so that thousands of systems do not change state at the same moment.

1023

5 Semantics of Energy Interoperation

As stated in in Section 4, much of the core vocabulary for this specification comes from **[EMIX]** and **[WS-Calendar]**. This section introduces the remaining vocabulary for Energy Interoperation and then defines the use of that vocabulary in the higher level types.

The services of Energy Interoperation are built around exchanges of and references to these standard information artifacts.

Table 5-1: Energy Interoperation Identities

Identity Types	Description
Party	As described in Section 3, all interactions are between two Parties. A Party consists of a Party Id, a Party Name, and a Party Role. The Party ID is a sub-type of the UID.
Resource	Identifies a discrete set of capabilities that a Party may offer to a counterparty. Resources may represent specific equipment, collections of market interactions, or a detailed promise to perform. Resources are associated with a VEN during Enrollment.
Market	When used in this specification, a Market is a set of agreed upon assumptions and business practices. Tariffs and utility programs are examples of Markets. Each negotiation and transaction occurs within the named context of a Market.
Market Context	A collection of machine readable Market rules and assumptions. A Market Context is uniquely identified by a URI as defined by the EMIX Market Context. This URI can be used to retrieve the Context.
UID	Unique Identifier for every party, role, message, event, etc.

The elements above are used throughout the messages of this specification.

5.1 Dramatis Personae: Identifying the Actors

As described in Section 3, each interaction is an interaction between two parties.

Low Level Identity Types	Description
VEN	As described in section 3 above, A Virtual End Node is a Party acting in a specific role in a market managed by a VTN.
VTN	As described in section 3 above, A Virtual Top Node is a Party acting in a specific role that sends events market information to a VEN.
Group	Resources and VENs may be the target of an Event. How group membership is identified or recognized is out of scope.
Target	A set of elements that collectively name which Parties should participate in an event. A Target can include Service Areas, named Groups, VENs, and Resources and other standard identifiers. The Target can be used by VEN's that are also VTN's and must relay event information downstream to other VENs.

1035
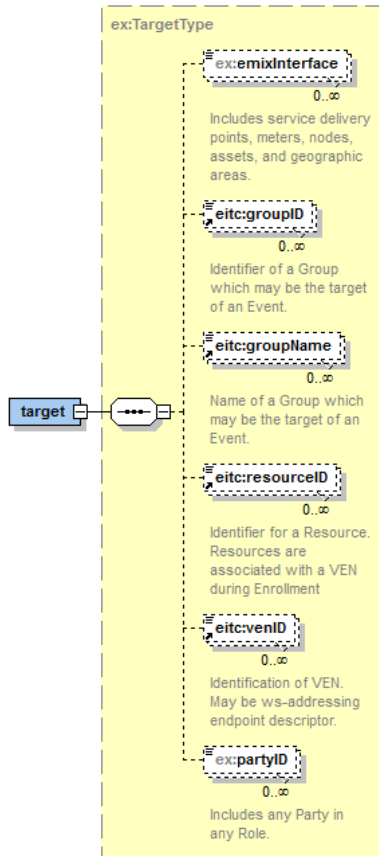
1036 *Figure 5-1: EI Target*

5.1.1 Actor IDs and Roles

1038 There is a certain fungibility of the Actor IDs in the service payloads. A Party may participate in many
1039 interactions, yet it is necessary to distinguish each Party by the role it is playing in the current interaction.
1040 Accordingly, there are named derivatives of the Actor ID for use in each situation.

1041

1042 *Figure 5-2: UML Class Diagram of Party ID and its derivatives*

5.2 Market Context

As defined in **[EMIX]**, a Market Context is a URI, and it can be used to reference Standard Terms. This specification describes the expanded set of context information that is part of the EI Market Context.
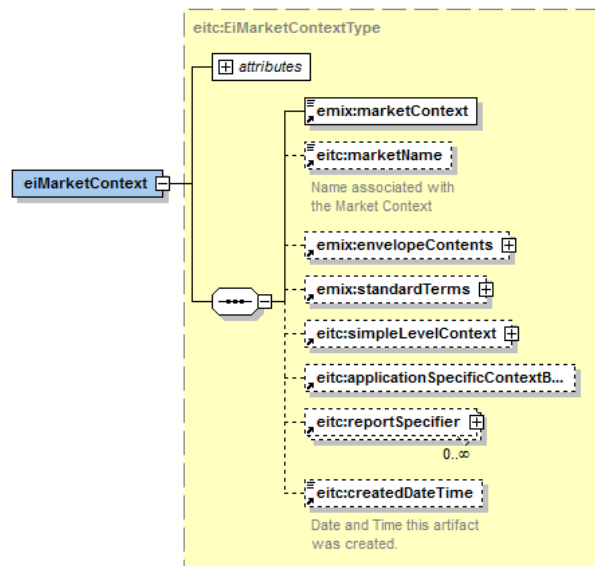
Figure 5-3: EI Market Context

The Elements of the EI Market Context are, for the most part, defined in **[EMIX]**. The Market Name conveys a human-readable text, perhaps for display in a user interface. As in EMIX, the Envelope contains warrants and certificates. For example, if a Market is purported to convey Green Power, however defined, that information would be conveyed in the Envelope. Two elements, Simple Levels and Application Specific Extensions bear discussion here.

5.2.1 Simple Levels

The Simple Level Context is an agreement-based interaction abstracted away from expressions of value or actual amounts. Simple Levels define levels of energy scarcity and abundance, at an agreed upon granularity. A VEN can discover Specific Levels within a Market Context.

Table 5-2: Simple Levels

Level Information	Description
Simple Level Context	Simple Levels are a set of simple indicators about scarcity and value, in which an ordered set of values indicate energy scarcity is above normal, normal, or below normal. Presumably, at higher levels, the VEN will use less.
Upper Limit	The upper level for this Context. If the Upper Limit is 5, the levels are 1-5, where 5 indicates the greatest scarcity.
Normal Value	The "normal" level indicating normal energy availability. Levels below normal indicate surplus, levels above normal indicate increasing scarcity. If the Upper Limit is 7, the levels are 1-7, and the Normal Value might be 3.
Level	Payload used in Signals to convey Simple Level to a VEN

For example, a simple program may have the levels Normal, High, and Critical. The Simple Level Context would indicate three levels with a normal value of one.

How a VEN associates particular activities and responses to the Simple Levels is out of scope for this specification.

5.2.2 Application Specific Extensions

A VTN may wish to communicate with, and a VEN may wish to allow communication with a specific Application operating within the VEN. Operating such an Application MAY be part of a specific Market Context. This specification provides explicit support for these Application Specific Extensions by means of 4 abstract types.

Table 5-3: Application Specific Extensions

Extensions	Description
Application Specific Extension Base	An abstract Base Type for all other Application Specific Extensions. Application Extensions are used to provide hints to or interactions with Applications running on the other side of an interaction. They are not defined in Energy Interoperation, although there are specific conformance rules that must be followed.
Application Specific Context Base	An abstract class to exchange invariant or setup information with an Application running on the other side of an interaction. The Context Base is exchanged as part of a Market Context.
Application Specific Signal Base	An abstract class to exchange current information and varying information with an Application running on the other side of an interaction. The Signal Base is exchanged by means of an Event Signal.
Application Specific Report Base	An abstract class to exchange Reports with an Application running on the other side of an interaction. The Report Base is exchanged by means of an Event Report or by the Report Service.

The primary concern of the conformance rules for Application Specific Extensions is that they avoid redefinition of the semantics of Energy Interoperation. Prices SHALL be communicated as defines in EMIX Price Base. Schedules SHALL be communicated using the semantics of WS-Calendar. Products and things to be measured SHALL be expressed using the EMIX Item Base.

Parties wishing to exchange Application Specific Extensions SHALL extend the Signal Types and Report Types to indicate they are using their specific Payloads.

5.2.3 Response Smoothing

Precision of communication and response causes new problems for collections of entities and systems. With WS-Calendar and Energy Interoperation, thousands of systems and devices could respond at the same moment, causing grid instabilities or even equipment damage.

To avoid these problems, Energy Interoperation uses WS-Calendar Tolerances (Start Before, Start After, End Before, and End After) to specify a Duration in which response smoothing MAY be requested.

To further refine the expectation surrounding Smoothing, this specification defines a new Term, i.e., an extension of the EMIX Base Term, to convey expectations for smoothing the aggregate response. Because it is a Term, is can be communicated as part of a Market Context, or as part of an individual Event.

The Smoothing Term provides actionable information; of course the degree of adherence to what is an application or deployment performance characteristic is out of scope for this specification. See also Section 4.1.4.

Table 5-4: Smoothing Terms

Response Smoothing	Description
Smoothing	Response Smoothing defines a Term that indicates that the recipient is to ensure that the response is not in a single step. Response Smoothing is applied to the tolerance interval[s] indicated by the Start Before, Start After, End Before, and End After tolerances. The enumerated values of Smoothing are below.
Ramp	A smooth or uniform step ramp is indicated between the initial and end values in the respective Tolerance Interval
Uniform	A uniform distribution is indicated over the entire respective Tolerance Interval.
None	No specific smoothing is indicated. Applications need not react in a stepwise manner, so some degree of smoothing MAY occur in response to this request. If the Smoothing Term is absent, the behavior requested is the same as None.

5.3 Event-based Interactions

Events are stylized business interactions that are used in formal demand response environments. As described in Section 3, Events are used in communications between a VTN and a VEN. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. The VTN specifies the duration and applicability of an Event. Some deadlines, time periods, and transitions may not be applicable to all products or services.
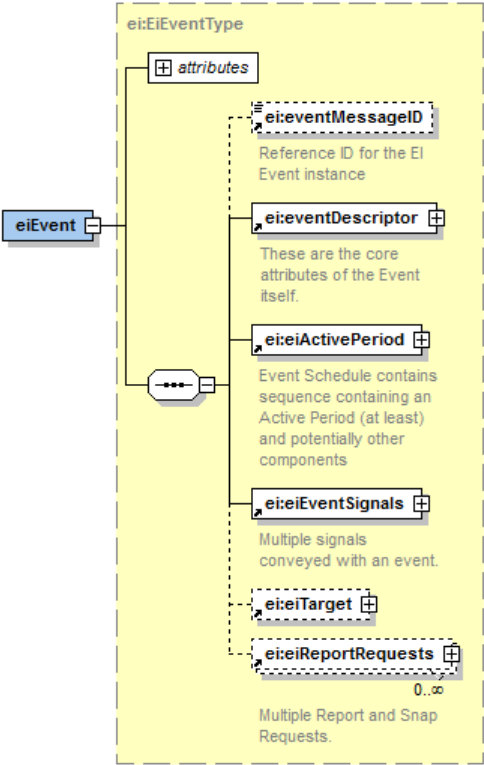
Figure 5-4: Event Overview

5.3.1 The Event Descriptor

The Event descriptor contains metadata about the event itself.

Table 5-5: The Event Descriptor

Event Descriptor Elements	Description
Event Descriptor	A collection of meta-data about an Event
Event ID	Identifier assigned to the Event Descriptor
Modification Number	If present, indicates that the event has been modified. Incremented each time the event is modified.
Modification Date and Time	The date and time a modification takes effect.
Modification Reason	Reason describing why the event is being modified. The values for reason are not specified or restricted.
Priority	Optional indication of the priority of an event. A given VEN or Resource may be eligible for more than one event at the same time.
Market Context	The overall market or program rules that govern this event.
Created Date Time	Indicates when this artifact was created.
Event Status	Indicates the current status of an event as of the descriptor generation. Enumerated values are: • Far: Event is in the far future. The exact definition of how far in the future this refers is dependent upon the market context, but typically means the next day. • Near: Event is in the near future. The exact definition of how near in the future the pending event is active is dependent on the market context. • Active: Event has been initiated and is currently active. • Completed: Event has completed. • Cancelled: Event has been canceled. These values are similar but not identical to those used by the Event Filter as described in Section 9.2 *"Special Semantics of the Event Request Operations"*. The value is present in Energy Interoperation to support backward compatibility with OpenADR 1.0.
Operating Day	Indicates the nominal date for the event. Important for some market contexts.
Test Event	If present, can indicate that this event is a test event rather than an actual event.
Comment	Free-form information provided by the VTN

5.3.2 The Active Period

See Section 4.4 for terminology describing the periods of an event.

The Active Period is a Sequence that describes the overall schedule for an Event. The Active period is a Vcalendar type that contain a Sequence and MAY have its own properties. The Sequence of an Active Period generally falls into a common Interval pattern of Notification, Ramp-up, Active, and Recovery. The Designated Interval of the Sequence is also referred to as the Active Interval.

This stereotypic pattern can be collapsed with the Intervals for Notification, Ramp-up, and Recovery expressed as Properties of the Active Interval. Notwithstanding this common pattern, the Active Period can contain any valid Sequence, as long as the meaning conveyed is understood by both parties.

1108 A single Event may be broadcast to many VENs with similar performance characteristics. If the VENs all
1109 perform in unison, it can create spikes (or sudden drops) in energy use that can be harmful to the
1110 distribution system. It is necessary for a VEN to be able to ameliorate this issue by requesting response
1111 smoothing as described in Section 4.1.4.

1112 A smoothing request is indicated through the WS-Calendar Tolerance Property. This property is applied
1113 to the overall Active Period so its meaning is the same whether the simplified common pattern or a full
1114 Sequence is conveyed.

1115
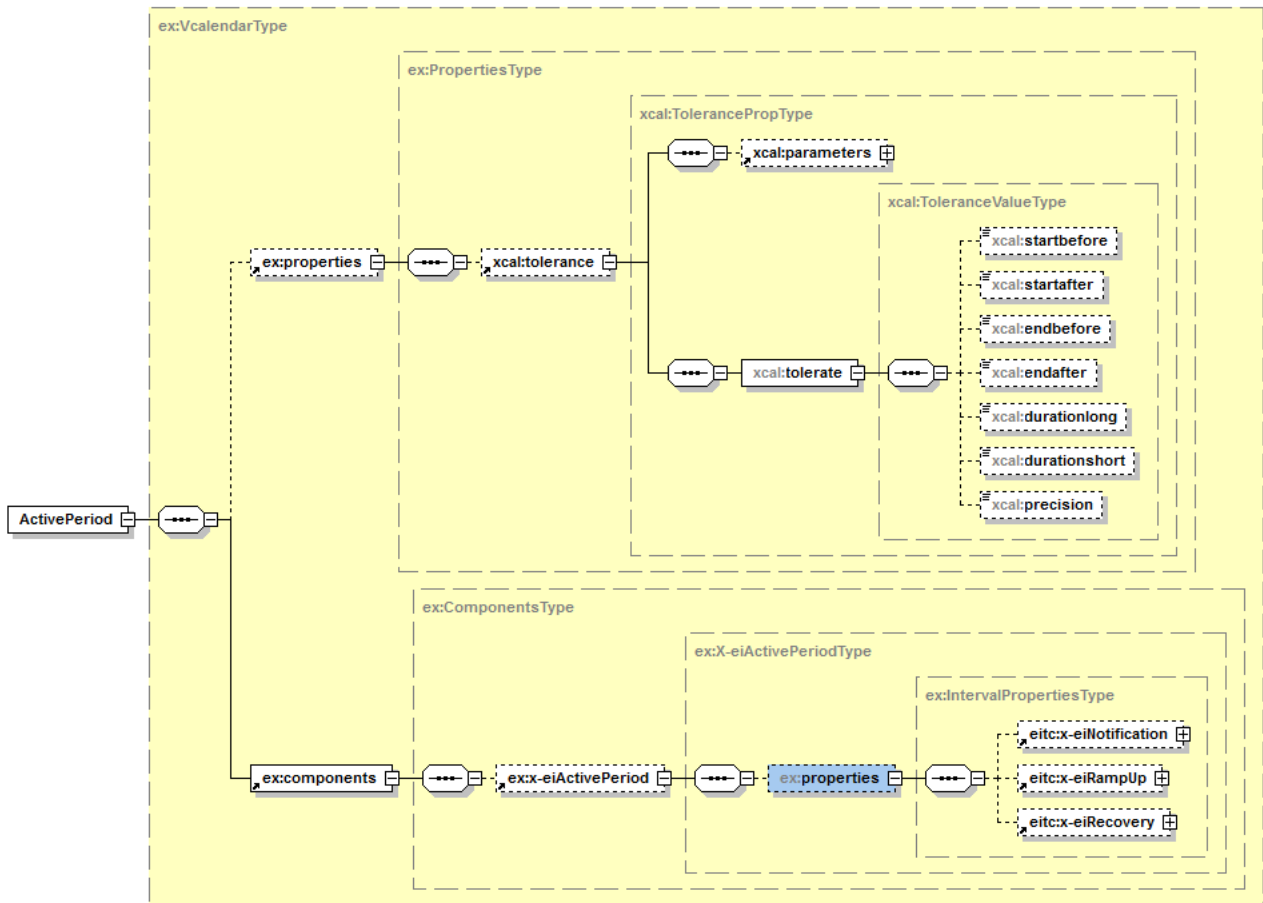
1116 *Figure 5-5: Active Period Elements*

5.3.3 The Event Signals

1118 Event Signals convey the detailed information about the schedule for an event. Signals are conveyed
1119 using Streams as described in Section 4.3. When an Event conveys multiple signals, they may be aimed
1120 at different target resources in different Market Contexts, or they may use different semantics, i.e., one
1121 use Price and another use Simple Level semantics. All Event Signals have a common form.

1122
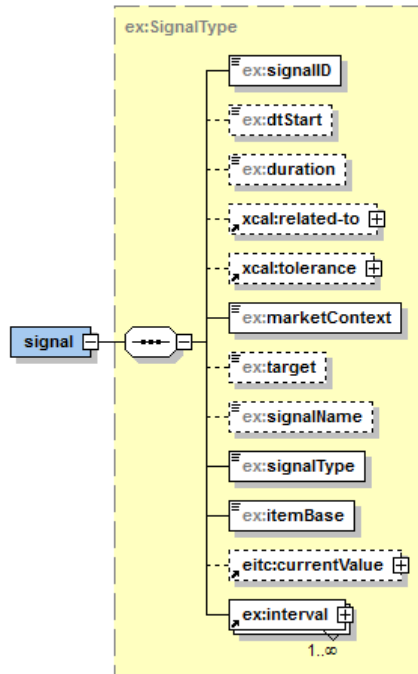
Figure 5-6: Event Signal Overview

1124 As do all Streams, each Event Signal has a starting time, and a Tolerance (for smoothing); if absent,
1125 these are inherited from the Active Interval as if the Active Interval were a Gluon. The Time Zone is
1126 inherited from the Market Context. Each Event Signal includes a Related-To parameter to name the
1127 Designated Interval; if there is none, the first Interval is the Designated Interval. The Designated Interval
1128 has specific meaning for Sequence scheduling as defined in WS-Calendar.

5.3.3.1 Details of the Signal

1130 Each signal includes a Market Context and optionally a Target. The Market Context and Target are used
1131 by the VEN to select which Signal, if any, to respond to. The Signal Name provides the VEN with a
1132 human-friendly description of the Signal, perhaps for display in a user interface. An EMIX Item Base
1133 enumerates what is being measured, and perhaps paid for, by the Signal. A Signal Type defines what
1134 Payload must be used throughout the signal; all Payloads in a signal MUST be of the same type. Each
1135 Interval contains a Payload, as specified by the Signal Type. An optional element, Current Value caches
1136 the current value (as of the signal creation) of the Payload.

1137 *Table 5-6: Signal Types*

Signal Types	Description
Delta	The Payload in each Interval indicates a request to change the amount [used] by the amount in the signal as denominated by the Item Base.
Multiplier	The Payload in each Interval indicates a request to change the amount [used] to an amount computed by the amount in the signal times the Baseline as denominated by the Item Base.
Level	The Payload in each Interval indicates the Level during each Interval. See Section 5.2.1 for a description of Simple Levels.

Signal Types	Description
Price	The Payload in each Interval indicates a price per unit as denominated by the Item Base. Price is conveyed as an EMIX Price, either a Price, a Price Multiplier, or a Price Relative. Each Payload in a Stream must contain the same type of Price. The Currency for each Price is inherited from the Market Context. In EMIX, both Price Multipliers and Prices Relatives include a Market Context; in a Payload in Signal, these are inherited from the Signal's Market Context.
Product	Signal indicates the Product for each interval. Payload Type is an EMIX Product Description.
Set-point	The Payload in each Interval indicates a requested amount [to use] as denominated by the Item Base. The amount may be more or less than the amount in the Baseline.

1138 Parties may choose to exchange application specific payloads in signals as well. Prior to doing so, they
1139 MUST extend the Application Specific Signal Base and agree upon the Signal Type they will use. The
1140 Signal Type MUST conform to the EI Extension pattern. See Appendix C for a discussion of conforming
1141 extension.

5.3.4 Baselines

1143 Baselines are streams that can incorporate signals and share many of the same elements. As some
1144 signals indicate the performance requested is relative to that in another interval, Baselines indicate the
1145 performance in that Interval.

1146 The Baseline is a signal that expresses the amount as denominated by the Item Base that is the starting
1147 point for the signal types above. The computational basis for the Baseline is not in scope for this
1148 specification. The Baseline is compared to the actual metered consumption during the Event to determine
1149 the value of the Response. Depending on the type of product or service, Baseline calculations may be
1150 performed in real time or after the fact.

1151 Another form of the Baseline merely indicates the comparable period that is used for comparison. This
1152 enables the sender to indicate when the Baseline is drawn from without indicating the values for that
1153 Baseline period, which may not yet be known.

5.3.5 Opt – Making Choices

1155 When a VEN enrolls in an event-oriented Market Context, it makes itself Available to respond to events
1156 on a given schedule. The Availability schedule may be simple (all day, all the time) or complex (weekday
1157 afternoons, on weekends with a long notice, and not on Thursday mornings during biweekly payroll). No
1158 matter how simple or complex the Availability, the VEN may choose to change it for a limited period. This
1159 decision is communicated with an Opt (as in "Opt In" and "Opt Out").

1160 The primary information payload for an Opt is a collection of Vavailability artifacts. An optional element
1161 inside each Availability artifact determines whether the particular repeating schedule within indicates
1162 availability or unavailability.

1163 Business rules require that someone Opting declare their reason, using one of the specific enumerated
1164 reasons or an extension as allowed by the local Market.

1165 *Table 5-7: Opt*

Opt Element	Description
Opt	Opts are used by the VEN to temporarily modify availability in the pre-existing agreement. For example, a VEN may Opt In to events during the evening, or Opt Out from events during the World Series.

Opt Element	Description
Opt ID	A reference ID for a particular Opt notification. This identifier may be used by other entities to refer to this instance of an Opt.
Opt Type	Either Opt-In or Opt-Out. This element determines the processing of the Vavailability. If Opt In, then any available time is added to the pre-existing schedule. If Opt-Out, then for the period bracketed by the Availability, the schedule replaces the pre-existing schedule.
Opt Reason	Reason for the Opt. Enumerated reasons include: Economic, Emergency, Must Run, Not Participating, Outage Run Status, Override Status, Participating

1166 The Opt Type controls specific differences in how an Opt is processed against the pre-existing
1167 availability.

1168 Opt-In: After processing, the new schedule and availability is added to the existing availability for
1169   the period bounded by the Opt Availabilities.

1170 Opt-Out: After processing, the new schedule and availability replace the existing availability for the
1171   period bounded by the Opt Availabilities.

1172 In either case, when the bounding period is over, Availability reverts to the previous schedule.

1173 5.4 Monitoring, Reporting, and Projection

1174 A Party may request that another Party measure something and report back. The thing measured may
1175 include Power, Voltage, Peak, or any other attribute associated with the products exchanged. These
1176 measurements may or may not be in relation to an Event. An EiReport is the record of a measurement or
1177 series of measurements made by one Party and delivered to another.

1178 A Party requests that another Party prepare a Report by means of a Report Request. Report Requests
1179 can be delivered using the Report service, or can accompany an Event. The Historian and Projection
1180 services also make use of the Report Request.
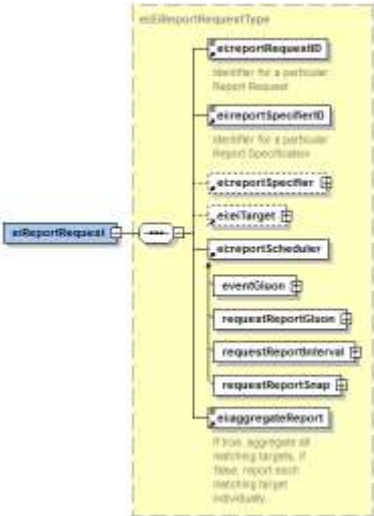
1181

1182 *Figure 5-7: The Report Request*

1183

1184 *Table 5-8: Elements of the Report Request*

Report Specifier	Description
Report Request ID	Identifies this request
Report Specifier ID	References the Report Specifier for this Request. The Specifier may be known from a previous request, or may be a standard Specifier within this Market Context.
Report Specifier	Request MAY optionally include the Report Specifier as described below.
Target	Standard group of Parties, Resources, Groups, et al. that the Report concerns.
Report Scheduler	Indication of when the report is to be run, for how long, etc.
Aggregate Report	As the Target of a Report Request may indicate multiple Parties or Resources, this Boolean indicates whether a single report or one for each entity matching the Target is requested,

5.4.1 The Report Specifier

A Party specifies what reports it wants by means of a Report Specifier. Report Specifiers may be delivered in the Report Request or be known from the Market Context.
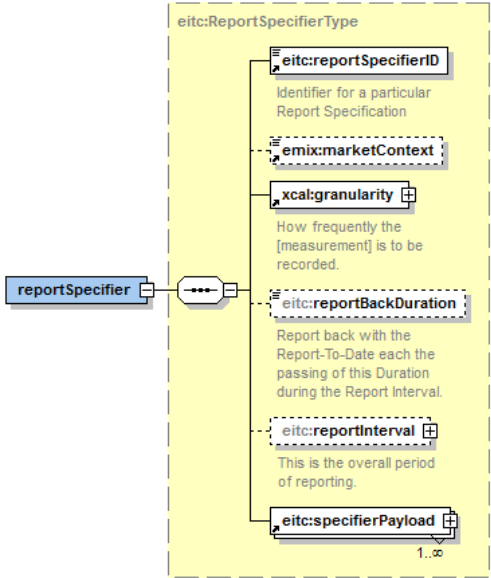
Figure 5-8: The Report Specifier

A single Report Specifier may generate quite different Reports based upon which service it is delivered by and how it is scheduled. The elements of a Report Specifier are as follows:

Table 5-9: Elements of the Report Specifier

Report Specifier	Description
Specifier ID	Identifies this Report Specifier
Market Context	The Optional Market Context MAY provide information about the Product that is being reported, or about where this Specifier came from.
Granularity	Duration defining temporal detail, i.e., "read the meter every 5 minutes"

Report Specifier	Description
Report-Back Duration	Report Back to requestor, with the report-to-date at each passing of this Duration during the Report Interval. If Optional, no Report-Back is expected.
Report Interval	Interval indicating the total span of the report. Parallel to Active Interval. May be influenced by a Gluon in the Report Scheduler. If the Interval contains a Start Date and no Duration, then the Report is to begin at the Start date and continue indefinitely.
Specifier Payload	The Specifier Payload indicates exactly what is to be in the report.

5.4.1.1 The Report Specifier Payload

The Specifier Payload indicates exactly what is in the Report. It consists of an **[EMIX]** ItemBase and a Report Type.

Table 5-10: Report Specifier Payload

Report Specifier	Description
rID	Identifies this Payload. If only one Payload is requested, the rID should be omitted; if multiple Payloads are requested in the same Report, each should have an rID.
Item Base	The Item Base is the core of an EMIX Product Description. Examples of an Item Base denominated value include Real Power, Real Energy, Voltage, et al.
Report Type	Defines what is being measured and reported. Measurements are in units of Item Base unless the Report Type indicates otherwise.

The Report Type specifies what is measured and, sometimes, how it is measured.

5.4.1.2 The Report Types

Report Types are an enumeration that indicates how the Item Base is to be measured. These enumerations parallel the Signal Types used in Events.

Table 5-11: Report Types

Report Types	Description
Reading	Report indicates a Reading, as from a meter. Readings are moments in time-- changes over time can be computed from the difference between successive readings. Payload Type is Float.
Usage	Report indicates an amount of units (denominated in Item Base or in the EMIX Product) over a period. Payload Type is Quantity. A typical Item Base is Real Energy.
Demand	Report indicates an amount of units (denominated in Item Base or in the EMIX Product). Payload Type is Quantity. A typical Item Base is Real Power.
Set Point	Report indicates the amount (denominated in Item Base or in the EMIX Product) currently set. May be a confirmation/return of the set point control value sent from the VTN. Payload Type is Quantity. A typical ItemBase is Real Power.
Delta Usage	Change in Usage as compared to the Baseline

Report Types	Description
Delta Set point	Changes in Set point from previous schedule
Delta Demand	Change in Demand as compared to the Baseline
Baseline	Can be Demand or Usage, as indicated by ItemBase. Indicates what the amount would be if not for the Event or Regulation. Report is of the format Baseline.
Deviation	Difference between some instruction and actual state.
Average Usage	Average usage over the duration indicated by the Granularity
Average Demand	Average usage over the duration indicated by the Granularity
Operating State	Generalized state of a resource such as on/off, occupancy of building, etc. No ItemBase is relevant. Requires an Application Specific Payload Extension.
Up Regulation Capacity Available	Up Regulation capacity available for dispatch, expressed in EMIX Real Power. Payload is always expressed as positive Quantity.
Down Regulation Capacity Available	Down Regulation capacity available for dispatch, expressed in EMIX Real Power. Payload is always expressed as positive Quantity.
Regulation Set point	Regulation set point as instructed as part of regulation services
Current Storage	Item Base is expressed as Real Energy and Payload is expressed as a Quantity.
Target Storage	Item Base is expressed as Real Energy and Payload is expressed as a Quantity.
Available Storage Capacity	Capacity available for further energy storage, presumably to get to Target Storage.
Price	Report Prices per ItemBase at each interval
Level	Report Simple Level at each interval. ItemBase is not meaningful.

1202 Report Type is implemented as an enumerated string with extensibility. Parties wishing to extend the
1203 enumeration MUST defined the report payload requirements.

5.4.2 Report Scheduler
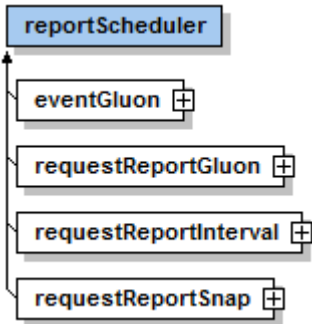
1205
1206 *Figure 5-9: Report Scheduler*

1207 The report scheduler is an abstract type that specifies how often and for how long a report will be
1208 prepared. The Report Scheduler adds flexibility and consistency by enabling a single Report Specifier to
1209 be used in multiple scenarios. One option for Report Scheduler enables a Report Request to be
1210 associated with an Event.

1211 *Table 5-12: Types of Report Scheduler*

Report Scheduler	Description
Event Gluon	Associates a Report Request with a particular event. This type consists of a Gluon and a reference to the Event ID.
	The Gluon sets the Report Interval relative to the Active Interval of the Event. For example:
	SS –T20M. The Report interval starts 20 minutes before (-T20M) the Active Interval starts (Start to Start).
	FF T1H. The Report interval Finishes 1 hour after (T1H) the Active Interval Finishes (Finish to Finish).
	If absent, the Report Interval is the same as the Active Interval, i.e., the Report runs during Active Interval.
	The Event ID indicates the Event this report is related to. If absent, the Report Request must be delivered as part of an EiEvent
Request Report Gluon	Used if the Report Specifier includes a Report Interval to influence the expression of that Interval. Information in the Gluon is inherited by the Report Interval in conformance with WS-Calendar.
Request Report Interval	The Interval in Scheduler is the Report Interval for the Report. If the Specifier included an Interval, it is replaced by the one in the Schedule.
Request Report Snap	Indicates that the readings indicated by the Specifier are to be made once at the Status Date and Time and then returned to the Requester. If the Status Date and Time are omitted, then the Snap is to be made at the time of receipt.

1212   **5.4.2.1 UML Diagram of Report Scheduler**
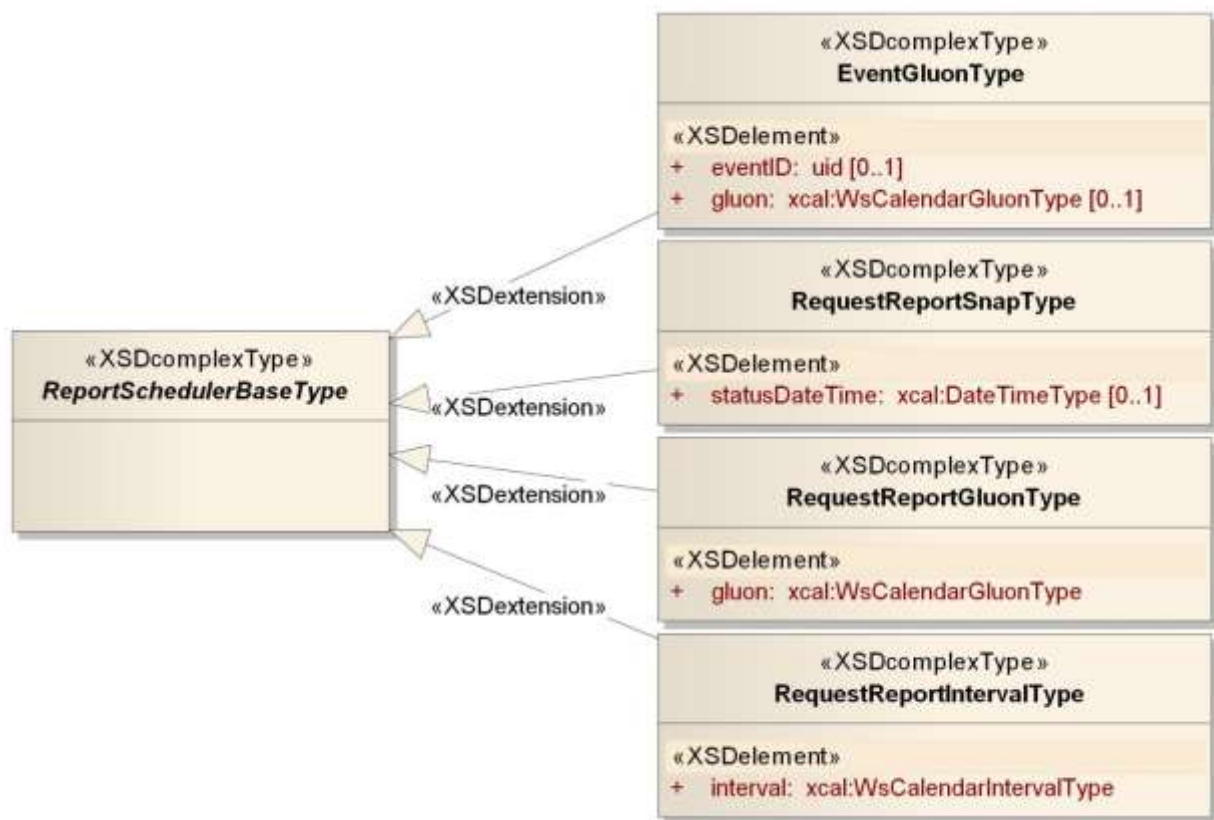
1213

1214   *Figure 5-10: UML Diagram of Report Scheduler*

5.4.3 UML Diagram of Report Request
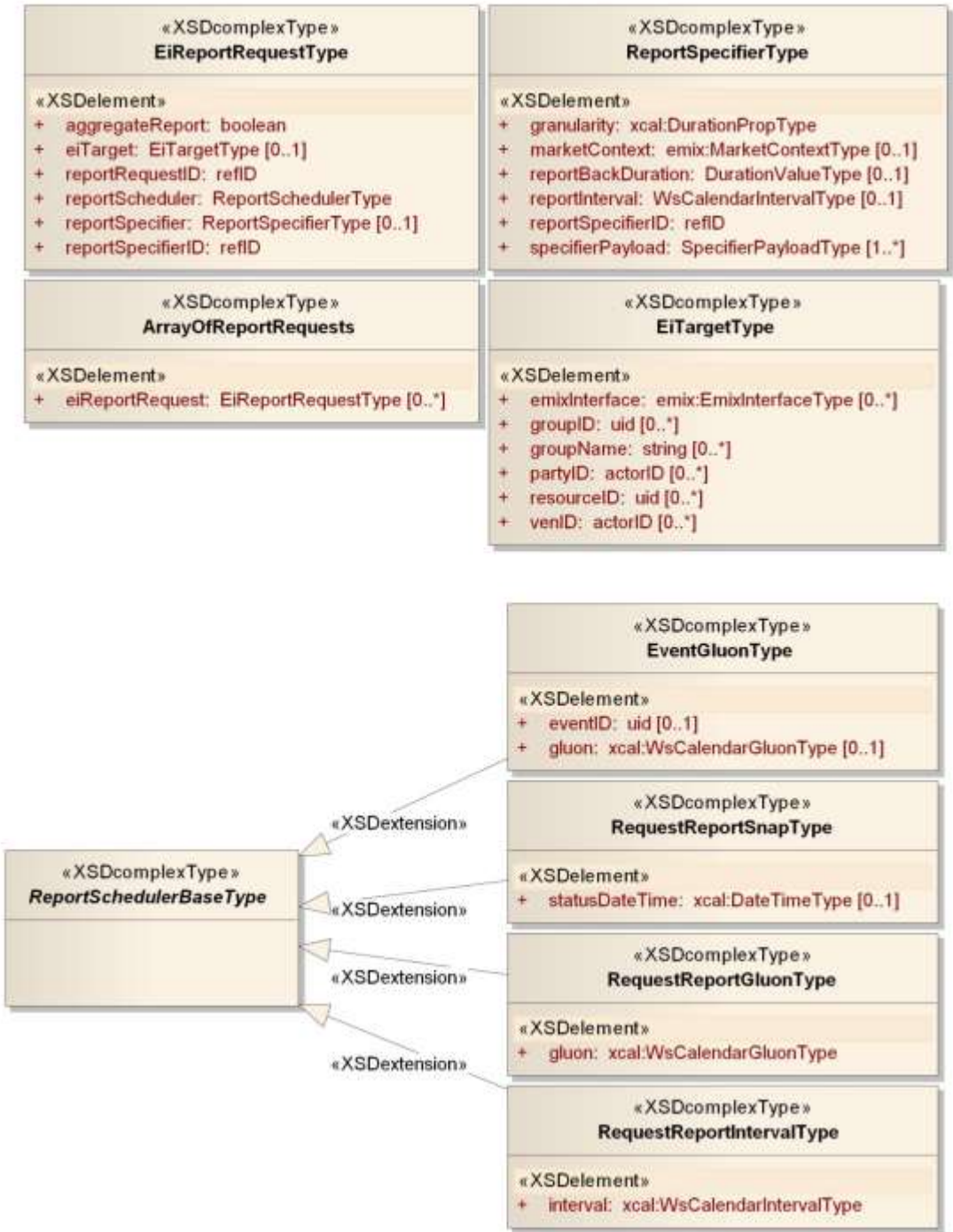
1217 *Figure 5-11: UML Class Diagram of Report Request*

5.5 Reports, Snaps, and Projections

1219 Reports are simple Streams with some metadata identifying the report and a collection of Intervals
1220 containing the Payloads for each [measurement]. Reports can be of the past, the present, or the future. A
1221 Report appears as a series of [measurements] in the past. A Snap is a Report made as of a single

1222   moment. A Projection is in the same form as a report, but it includes projections of what will be in the
1223   future, including a confidence level in the payload.

1224   *Table 5-13: Reports*

Report Metadata	Description
Report ID	Unique identifier for this Report. The Report ID persists over multiple Report-Backs.
Report Request ID	Identifies the Request that resulted in this Report.
Report Specifier ID	Identifies the Report Specifier that resulted in this Report.

1225   The above information is sufficient to uniquely identify each Report, why it was made, and to what
1226   specifications. The full form of a report is as follows in Figure 5-12.
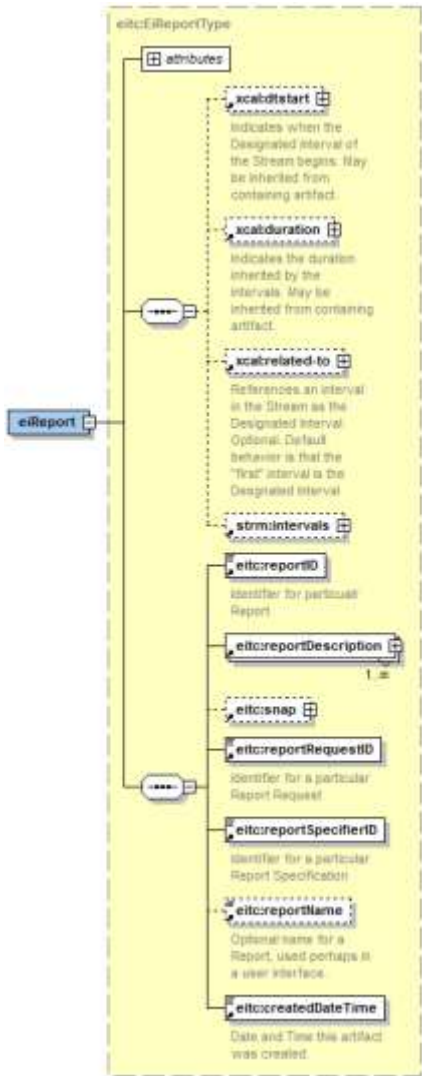
1227
1228   *Figure 5-12: The Report*

5.5.1 Elements of the Report

1230   *Table 5-14: Elements of Reports*

Report Elements	Description
Start Date and Time	Indicates the beginning of the Report
Duration	Indicates the Duration of each Interval in the Report
Related To	Inherited from Stream Base but not used in Reports. Must be Ignored.
Report Name	Optional human-friendly name for the report
Report Description	Type describing the make-up of the report which MAY not be entirely determinable from the Specifier. Also, explains the interpretation of each Value.
Created Date and Time	Indicates when the Report was prepared for delivery to the requestor.

1231 ## 5.5.2 Report Description

1232
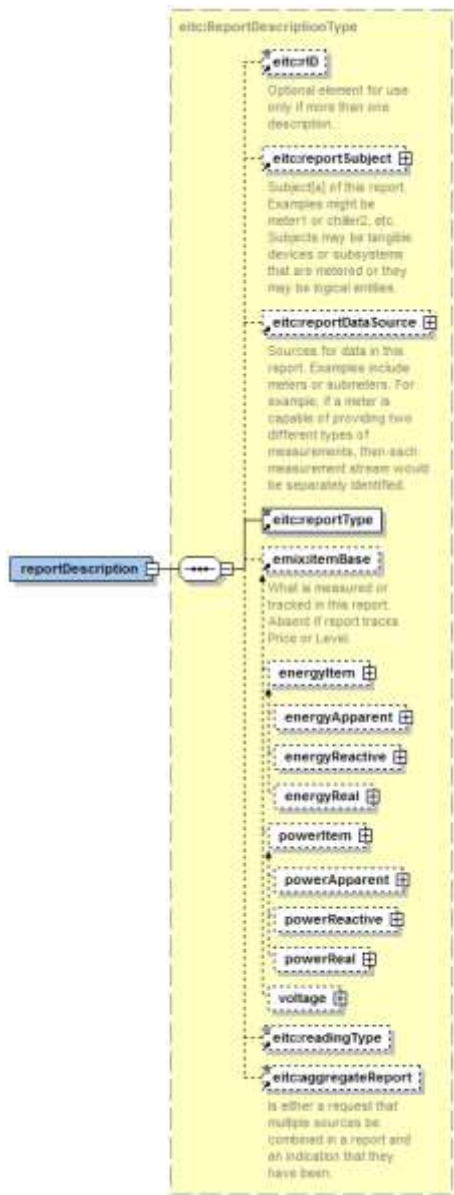
1233 *Figure 5-13: The Report Description*

1234 The Report Description indicates what is in the Report, which may be different from what was specified,
1235 particularly if multiple elements were in the Target. A Report may include multiple Report Descriptions if
1236 multiple payloads are delivered in each interval. Conversely, if the Recipient is able to rely completely on
1237 the Report Specifier, the Report Description MAY be omitted.

1238 The Elements of the Report Description are as follows:

1239 *Table 5-15: Elements of the Report Description*

Report Elements	Description
rID	Optional report identifier required only if multiple payloads are delivered in each Interval.

energyinterop-v1.0-~~cos01~~
~~2013~~wd42
Standards Track Work Product   Copyright © OASIS Open ~~2013~~2014. All Rights Reserved.

~~19 December~~
18 May 2014
Page 68 of 152

Report Elements	Description
Subject	Identifies the specific thing or things being measured in this report. Subject is in the form of a Target, which means it can include one or more Parties, Resources, Assets, Groups, etc.
Data Source	Identifies the Source of the information or measurement provided. A common use is to identify the MRIDs of the meter[s] that apply to the Subject. Data Source is in the form of a Target.
Report Type	Identifies what is the meaning of each measurement, as defined in Section 5.4.1.2.
Item Base	Identifies the Units being measured, unless the Report Type indicates this element is meaningless.
Reading Type	If present, indicates metadata about the Readings, i.e., direct measurement or computation. Conforming profiles MAY ignore Reading Type.
Aggregate Report	Identifies whether each payload represents an individual subject, or the sum of multiple subjects.

5.5.3 Report Payloads

The details in each Interval in a Report bear a lot of similarity to those in the Signals. In many cases, a Signal requests that a system provide something similar to its Signal Value. Reporting back in the same format enables ready comparisons. These values are conveyed in the Payload.

Signals, though, are ideal. Reports describe real world effects, and therefore messy. For this reason, Report Payloads include some additional information.
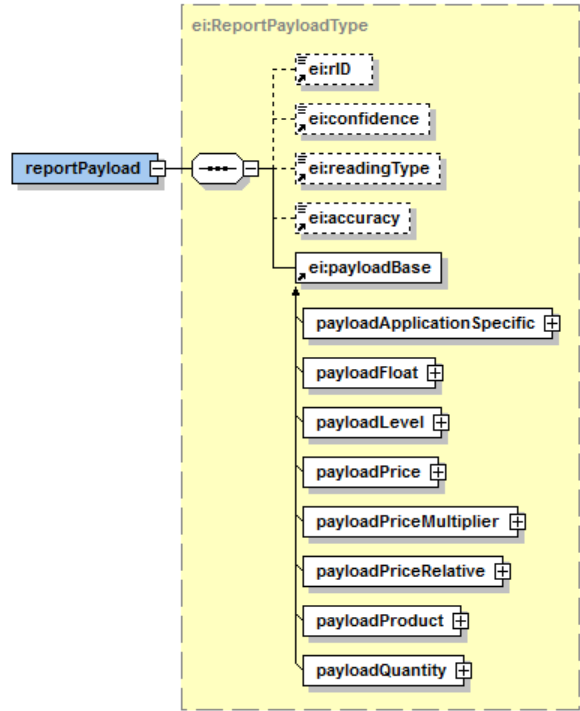
Figure 5-14: the Report Payload

1248 Figure 5-14 shows the information qualifications alongside the Payload. If an Application within a VEN
1249 has specific reporting requirements, a new Payload Type can be derived from the abstract Payload
1250 Application Specific type; a type so derived can be delivered by a conforming report service.

1251 *Table 5-16: Report Payload Qualifiers*

Report Metadata	Description
Confidence	An optional information structure that indicates in each interval how likely the information is to be precise.
Reading Type	An enumerated indication of different ways to derive a reading
Accuracy	An indicator of Payload accuracy

1252 5.5.3.1

1253 The Reading Type describes the information returned in a report. Specifically, the Reading Type
1254 describes how the number in the payload was arrived at. The Reading Type MAY be in the stream Gluon,
1255 and be inherited by each Interval in the Sequence (or by the Snap, if present). The Reading Type MAY
1256 also appear in any Interval where the reporting system is indicating that one payload differs from others in
1257 the Sequence. Reading Types are described in Table 5-17.

1258 *Table 5-17: Reading Types*

Reading Type	Description
Direct Read	Reading is read from a device that increases monotonically, and usage must be computed from pairs of start and stop readings.
Net	Meter or [resource] prepares its own calculation of total use over time
Allocated	Meter covers several [resources] and usage is inferred through some sort of pro rata computation.
Estimated	Used when a reading is absent in a series in which most readings are present.
Summed	Several meters together provide the reading for this [resource]. This is specifically a different than aggregated, which refers to multiple [resources] in the same payload. See also Hybrid.
Derived	Usage is inferred through knowledge of run-time, normal operation, etc.
Mean	Reading is the mean value over the period indicated in Granularity
Peak	Reading is Peak (highest) value over the period indicated in granularity. For some measurements, it may make more sense as the lowest value. May not be consistent with aggregate readings. Only valid for flow-rate Item Bases, i.e., Power not Energy.
Hybrid	If aggregated, refers to different reading types in the aggregate number.
Contract	Indicates reading is pro forma, i.e., is reported at agreed upon rates
Projected	Indicates reading is in the future, and has not yet been measured.

1259 5.5.3.2 Contrasting semantics of Summary and Aggregate in Reports

1260 Consider the following industrial facility with a single ESI acting as a VEN. This facility chose to offer four
1261 Resources to its VTN: one industrial Resource and three office Resources, one for each floor. Two of the

1262   office Resources, Floor 2 and Floor 3, have their own zones and meters. Floor 1 has two zones, 1A and
1263   1B, that are metered separately. The three office Resources are all in a single Group, Office. The single
1264   industrial Resource is in its own Group, Factory.

1265
1266   *Figure 5-15: Illustrating Aggregate vs. Summary*

1267   A Usage report with a Target of Office applies to three Resources, Floor 1, Floor 2, and Floor 3. If the
1268   Aggregate flag is True, the VEN prepares a single report that aggregates the information from all three
1269   Resources. If a report Target indicates Industrial or Factory, Group or Resource, there is no distinction
1270   between an Aggregate or non-Aggregate request.

1271   The Data Sources for the Usage Reports are the Meters, M1-M5. The Report for Floor 3 has a Data
1272   Source of M5. The Report for Floor 2 has a Data Source of M4. The Report for Floor 1 has two data
1273   sources, M2 and M3, and the single Reading for Floor 1 is of the Type "Summary"

1274   Aggregate refers to the combining of multiple Subjects (things named in Target) into a single report;
1275   Summary refers to the combination of multiple Data Sources [meters] into a single value.

5.5.4 UML Diagram of Report

Figure 5-16: UML Class Diagram of Reports

5.6 Reponses and Error Reporting

All Services share a common Response. The Response shares a common extensible code, a readable
description, and a reference to the Message that this is in response to.

Table 5-18: Responses

Response Elements	Description
EI Response	Response is the generic model for responding to any Servicer Request

Response Elements	Description
Response Code	Code consisting of 3 digits for automated processing. The simplest devices need understand only the first digit, others are for extension as needed within the higher order error indicated by the first digit. • 1xx: Informational - Request received, continuing process • 2xx: Success - The Request was successfully received, understood, and accepted • 3xx: Pending - Further action must be taken in order to complete the Request • 4xx: Requester Error - The request contains bad syntax or cannot be fulfilled • 5xx: Responder Error - The responder failed to fulfill an apparently valid request xx is used for defining more fine grained errors. Where possible, the HTTP errors should be used.
Response Description	Optional String describing the response or the reason for the response
Message UID	Reference to the Message that elicited this response
Response Terms Violated	Optional Array of EMIX Terms and Response Descriptions to provide a machine interpretable Response. For example, if the Request fails because it violated the "Minimum Notification Duration" of one hour, the responder could send back the Term (with value) and an Response Description.

1284

5.6.1 Event Responses

1285

1286 Responses to events are not stateless, so they require further information. All Responses regarding
1287 Events have the elements in Table 5-19 in addition to the elements listed in Table 5-18.

1288 *Table 5-19: Event Response*

Event Responses	Description
Event ID	ID of the Event which caused this Response
Modification Number	Modification Number of the Message about an Event that caused this Response
Opt Type	Indicates whether this Response results in a VEN Opting In or Opting Out of the Event.

1289 Some services communicate multiple messages, and the different messages may warrant different
1290 responses. In these cases, there is a single EiResponse (or EiEventResponse) which conveys an overall
1291 response. If this overall response is Success (2xx), then there is no need for the recipient to examine the
1292 message further. If the overall Response is anything other than success, then the response for each
1293 Element in the original Request can be found by examining the array of responses (type responses) or
1294 the array of Event Responses (type eventResponses) for detailed information.

5.6.2 References in Responses

1296 Response is a general Type that must reference any number of messages, reports, requests, etc. These
1297 critical cross interaction types are each identified by a Reference ID. The Reference ID for each is derived
1298 from a common refID type that enables type-safe substitution in Response and in other payloads.

1299
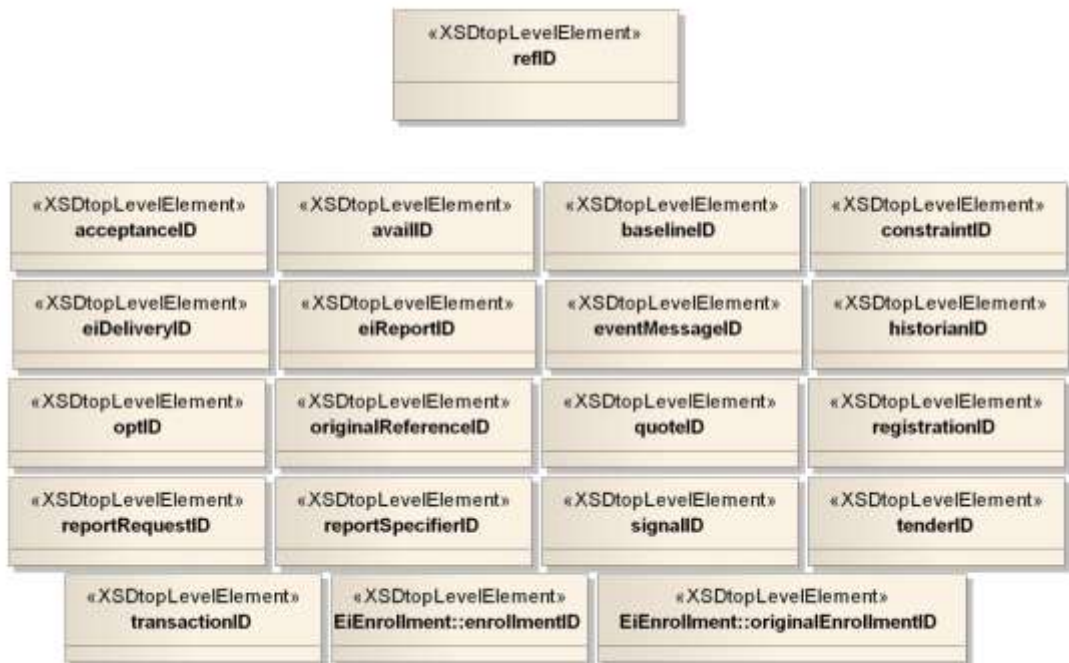
Figure 5-17: UML Diagram showing refID and its derived types

5.7 Availability Behavior

1302 In different Market Contexts, Availability is interpreted differently by the VTN. This availability behavior is
1303 published as part of the EI Market Context as it is in effect a meta-term for the market.

1304 *Table 5-20: Availability Behavior*

Availability Behavior	Description
Behavior	When an Event is issued by the VTN, it is validated against the parameters and constraints that were established when the Market Context was set up, i.e., the market Rules support Events between 12:00 and 16:00. If the Event is not within 12:00 and 16:00 then VEN must take some action to resolve the conflict.
Accept	Simply accept the issued DR event regardless of any conflicts
Reject	Reject any DR events that conflict with configured Availability
Restrict	Modify the DR event parameters so that they legally fall within the bounds of the configured parameters.

1305

6 Introduction to Services and Operations

In the following sections services and operations consistent with **[SOA-RM]** are described. For each service operation there is an actor that *invokes* the service operation and one that *provides* the service. These roles are indicated by the table headings *Service Consumer* for the actor or role that consumes or invokes the service operation named in the *Operation* column and *Service Provider* for the actor or role that provides or implements the service operation as named in the *Operation* column.

This terminology is used through all service definitions presented in this specification.

The column labeled *Response Operation* lists the name of the service operation invoked as a response. Most operations have a response, excepting primarily those operations that broadcast messages. The roles of *Service Consumer* and *Service Provider* are reversed for the *Response Operation*.

All communication between customer devices and energy service providers is through the ESI.

For transactive services any party may receive tenders (priced offers) of service and possibly make tenders (priced offers) of service.

Any party using Transactive Energy services may own generation or distributed generation or reduce or increase energy from previously transacted energy amounts. These activities are not identified in transactive services. The dispatch of these resources and the use of energy by a party are influenced by tenders between Parties that may result in new Transactions and changes in operations.

The VEN/VTN services provide a characterization of the aggregate resources of a VEN that may be communicated to the VTN; that relationship depends also on the EiMarketContext in which the interactions take place.

The next section describes the role of Resources, Curtailment and Generation. In a transactive approach tendering and prices are used by parties to discover and negotiate transactions that respect the preferences of each party and energy usage, generation, storage and controllability directly available to each party. There is no formal communication of resource characteristics in the transactive approach.

6.1 Resources, Curtailment, and Generation

If the VEN participates in a demand response program or provides distributed energy resources, its ESI is the interface to at least one dispatchable resource (Resource), that is, to a single logical entity. A Resource may or may not expose any fine structure.[6] The Resource terminology and the duality of generation and curtailment are from **[EMIX]**.

Under a demand response program, a Resource is capable of shedding load in response to Demand Response Events, Electricity Price Signals or other system events (e.g. detection of under-frequency). The VTN can query the actual state of a Resource with the EiReport service and request ongoing information. The VEN can query the status of the VTN-VEN relationship using the EiRequestEvent operation.

Alternatively, a Resource may provide generation in response to similar information. The net effect is the same.

6.2 Structure of Energy Interoperation Services and Operations

Energy Interoperation defines a web services implementation to formally describe the services and interactions although fully compliant services and operations may be implemented using other technologies.

The services presented in this specification are divided into five broad categories:

- Transactive Services—for implementing energy transactions, registration, and tenders

---

[6] A finer level of granularity is sometimes called an *asset*. Assets are not in scope for this specification.

- Event Services—for implementing events and linked Reports
- Report Services—for exchanging remote sensing and feedback.
- Enrollment Services—for identifying and qualifying service providers, resources, and more
- Support Services—for additional capabilities

The structure of each section is a table with the service name, operations, service provider and consumer, and notes in columns.

The services are grouped so that profiles can be defined for purposes such as price distribution, and Demand Response (with the functionality of **[OpenADR]**). This specification defines three profiles, the OpenADR Profile, the TeMIX (Transactive EMIX) Profile, and the Price Distribution Profile.

The normative XML schemas are in separate files, accessible through the **[namespace]** on the cover page.

6.3 Naming of Services and Operations

The naming of services and operations follows a pattern. Services are named starting with the letters *Ei* capitalization which follows the Upper Camel Case convention. Operations in each service use one or more of the following patterns. The first listed is a fragment of the name of the initial service operation; the second is a fragment of the name of the response message which acknowledges receipt, describes errors, and may pass information back to the invoker of the first operation.

Create—Created   An object is created and sent to the other Party

Cancel—Canceled   A previously created request is canceled

Request—Reply   A request is made for all objects of the specified type previously created and relevant to this VTN-VEN relationship

Distribute   An object (such as a price quote, a curtailment or generation request) is created and sent without expectation of response.

For example, to construct an operation name for the EiEvent service, "Ei" is concatenated with the name fragment (verb) as listed. For example, an operation to cancel an outstanding operation or event is called *EiCancelEvent*.

The pattern of naming is consistent with current work in the IEC Technical Committee 57 groups responsible for the **[TC57CIM]**.

6.4 Push and Pull Patterns

The Service Operation naming includes application-level acknowledgements, which in nearly every case carry application-level information, and allow for both push and pull of messages. This description applies to both transactive and VTN/VEN interactions as both are performed by Parties taking on various roles.

Both Push and Pull are with respect to the invoker of the operation. So if a Party produces information that describes a price quote, it can invoke (in the case of Push) an operation to send it to one or more other Parties. In the alternative, each Party (in the case of Pull) can invoke a request for information by polling, or pulling it from another Party.

The Pull operation is performed by the Party invoking the Request service operation pattern and fulfilled with a Reply service operation pattern invoked by the receiving Party.

So a series of Push operations from one Party to a counter-Party is analogous to a series of Pull operations from the counter-Party to the Party.

In the VTN-VEN context, a series of Push operations from a VTN to its VENs is analogous to a series of Pull operations from the VEN to its VTN; by examining (e.g.) the absence of an Event that was visible on a previous Pull the VEN can infer that that Event was canceled. The VEN could then send a Canceled service operation as if it had received a Cancel service operation.

One special case is the *Distribute* pattern, which expects no response to the invoker.

1393 The service quality of the Pull operations (and in particular the load on the VTN from repeated polling) is
1394 not in scope for this specification.

6.5 WSDL Integration

1396 A WSDL represents a contract between two systems that are being integrated. As such additional
1397 attributes may need to be passed in addition to the attributes that are specific to a message payload
1398 (representing the core set off information being passed). At a high level, any given integration may need
1399 to include a header, request, and/or reply in addition to the message payload as shown in the figure
1400 below.

1401
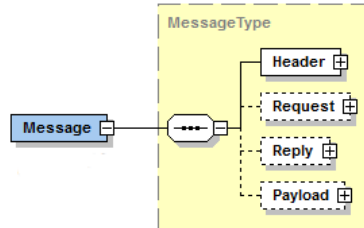
1402 *Figure 6-1: Generalized view of the high-level message structure*

1403 For example, for WSDL-based integration, details regarding the specifics of a demand response event
1404 are contained in the message payload. However, additional details that work to ensure the successful
1405 integration may be included in the header, request, or reply.

1406 A message header contains information about the sender and receiver of the message or other
1407 information used to correlate the service request, to guarantee delivery, or to support non-repudiation as
1408 seen in the [non-normative] figure below.

1409 Message headers are out of scope for this specification.

6.6 Description of the Services and Operations

1411 Each service is described as follows. In the sections that follow, we will:

1412 • Describe the service

1413 • Show the table of operations

1414 • Show the interaction patterns for the service operations in graphic form

1415 • Describe the information model using **[UML]** for key artifacts used by the service

1416 • Describe the operation payloads using **[UML]** for each operation

6.7 Responses

1418 In a service interaction, responses may need to be tracked to determine if the transaction is successful or
1419 not. This may be complicated by the fact that any given transaction may involve the transmission of one
1420 or more information objects.

1421 The class diagram below reflects the generic response.

1422
1423
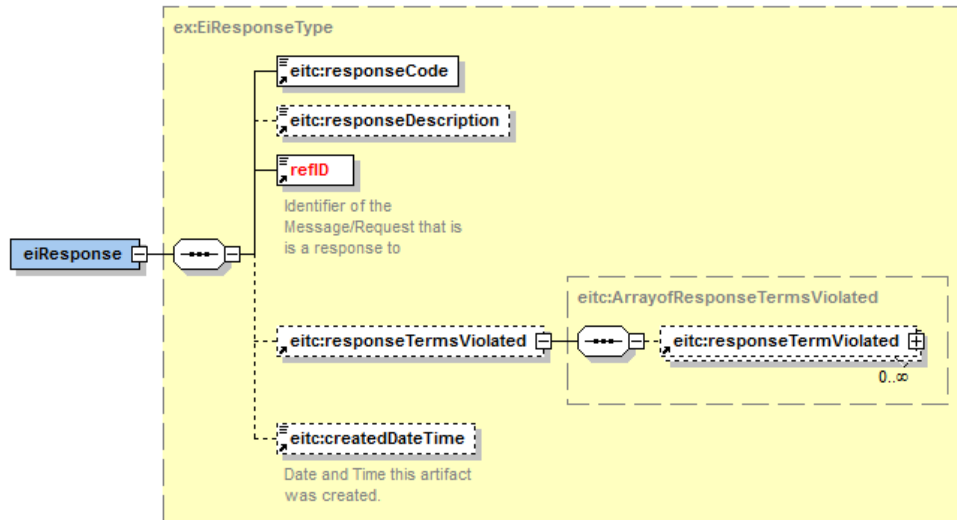
Figure 6-2: Example of generic error response for a service operation

The Reference ID (refID) identifies the artifact or message element that this response is to. The response code indicates success or failure of the operation requested. The Response Description is unconstrained text, perhaps for use in a user interface.

There is no exhaustive list of all possible Response Codes. The Response Codes are intended to enable even the smallest device to interpret Response. This specification uses a pattern consisting of a 3 digit code, with the most significant digit sufficient to interpret success or failure. This pattern is intended to support that smallest device, while still supporting more nuanced messages that may be developed.

- 1xx: Informational - Request received, continuing process
- 2xx: Success - The action was successfully received, understood, and accepted
- 3xx: Pending - Further action must be taken in order to complete the request
- 4xx: Requester Error - The request contains bad syntax or cannot be fulfilled
- 5xx: Responder Error - The responder failed to fulfill an apparently valid request

While the only value of xx that is defined as of this version is 00, conforming specifications may extend these errors to defining more fine grained errors. These errors should extend the pattern above, though. A response code such as 403 should always be within the realm of Requester Error.

6.7.1 Terms Violated

Terms Violated is an optional element of a Response. Terms communicate business expectations. It may be that a Service Request fails not because it is improperly formed, but because it violates one or more of these business rules. For example, a Market Term may indicate a 20 minute notification duration. A Service Request that asks for a performance with only a 5 minute notification violates that Term. By passing that Term back in the Response, that service provider can make known what its requirements are.

It is outside the scope of this specification whether a provider MAY present terms while still accepting a Service.

6.7.2 Response Derivations

Because some responses require additional context relative to the Service requested, the same types derive from and extend the Response type.

6.7.2.1 Event Responses

Event Responses are derived from the Response Type and add elements useful for Event-based interactions. Event Responses include Event ID and Modification Number to indicate exactly which Event they are responding to. Event Responses also include the Opt Type (Opt In or Opt Out) to describe what response is being made to an event.

6.7.2.2 Enrollment Responses

Enrollment Responses are derived from the Response Type and add elements useful for Event-based interactions. The Enrollment response includes an Enrollment ID to indicate which Enrollment is being referenced.

Enrollment establishes a business relationship between a Party and a particular Market Context. A Party may be enrolled in several Market Contexts. Enrollment Responses include the Market Context that is affected by the Response.

A single request to Enroll may create many Enrollment IDs. For example, a Party offering several Resources may get an Enrollment ID for each. Similarly, a single Resource may become enrolled in both a power and a regulation Market Context. An Enrollment Response includes a Market Context to indicate which Market Context was affected.

As stated above, a single request to Enroll may create many Enrollment IDs. It can be helpful to know the original request's reference ID to understand the Response. An Enrollment Response MAY include an Original Reference ID.

6.7.3 Compound Responses

Many service interactions may affect a number of messages. For examples, a single service interaction may include multiple Tenders, or Events. A single Enrollment request may result in multiple Enrollments. All such Responses have the pattern of a single Response (or Event Response, or Enrollment Response) accompanied by a collection of Responses. This specification defines the collections of Responses, Event Responses, and Enrollment Responses.

The end-point receiving a compound Service Payload, including both single Responses and collections of Responses follows these rules:

- If the Response indicates success, there is no need to examine each element in the Responses.
- If some elements fail and other succeed, the Response will indicate the error, and the recipient should evaluate each element in the Responses to discover which components of the operation failed.

1483
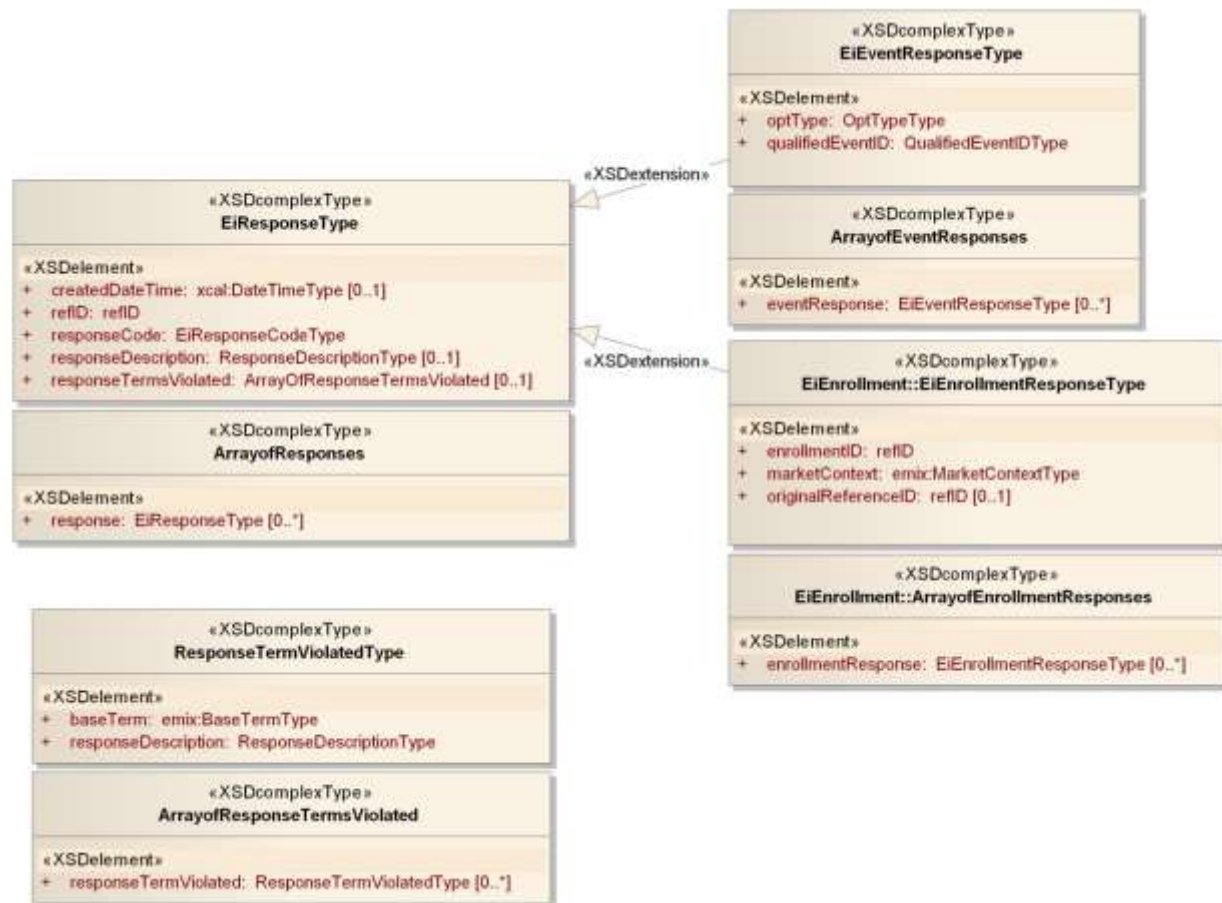
1484   *Figure 6-3: UML for Response*

6.7.3.1 Summary of Response and Responses

1486   A Response returns the success or failure of the entire operation. The Responses returns an ID and a
1487   Response for each.

1488   It is MANDATORY to return errors in responses. It is OPTIONAL to return successes in responses. For
1489   Cancel, in particular, it is not mandatory to return any responses if the entire operation was completed
1490   successfully. The pattern is to return those that have failed (required) and those that succeeded
1491   (optional).

6.7.4 Requests

1493   Each of the Services includes a Request, which is essentially a status update. Consider the Service Foo.
1494   A Request means "tell me all the Foos that we have outstanding." The meaning of outstanding varies
1495   from Service to Service. In general, either party may make invoke the Request Service on the other. Tell
1496   me all the Quotes you have given me is the mirror of Tell me all the Quotes you have received from me.
1497   Each Request shares the same semantics.

1498   Each optional element in a Request refines or narrows the scope of the Request by narrowing the request
1499   to only those Foos for which the named elements match. If there are more than one instance of the same
1500   named element, then this restriction element is treated as if a logical OR were applied, i.e., where
1501   element = A OR element = B. Where more than one type of element is named, then the restriction is
1502   treated as an AND, i.e., element A = "foo" AND element B = "fie".

1503   A special element that is included in most Requests is the Interval. The Interval is treated as a temporal
1504   restriction. For example, an Interval that encompasses a business day can request all Foo for delivery on

1505 that day. Intervals MAY be open-ended. An Interval conveying only a Start Date matches all Foo that are
1506 current from that date and time forward. An Interval conveying only an End Date matches all Foo that are
1507 current at that date and time. If there is any ambiguity about what "matches" means, it is defined within
1508 the Service section below, c.f., the definition of pending Events in Section 9.2 *"Special Semantics of the*
1509 *Event Request Operations"*.

7 Transactive Services

Transactive Services define and support the lifecycle of transactions inside an overarching agreement, from initial quotations and indications of interest to final settlement. The phases are

- Registration—to enable further phases.

- Pre-Transaction —non-binding quotes and binding tenders for transactions.

- Transaction Services—execution and management of transactions including transaction with optionality.

- Post-Transaction—settlement, energy used or demanded, payment, position.

For transactive services, the roles are **Parties** and **Counterparties**. For event and resource services, the Parties adopt a VTN or VEN role for interactions. The terminology of this section is that of business agreements: tenders, quotes, and transaction execution and (possibly delayed) performance under an option or DR transaction.

The register services identify the parties for future interactions. This is not the same as (e.g.) a program registration in a demand response context—here, registration can lead to exchange of tenders and quotes, which in turn may lead to a transaction which will determine the VTN and VEN roles of the respective parties.

7.1 EiRegisterParty Service

The EiRegisterParty service operations create a registration for potential Parties in interactions. This is necessary in advance of an actor interacting with other parties in various roles such as VEN, VTN, tenderer, and so forth.

Table 7-1: Register Services

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiRegisterParty	EiCreateParty Registration	EiCreatedParty Registration	Party	Party	Create and send a Party Registration request
EiRegisterParty	EiRequestParty Registration	EiReplyParty Registration	Party	Party	Request semantics with optional Interval
EiRegisterParty	EiCancelParty Registration	EiCanceledPart yRegistration	Party	Party	Cancel one or more Party Registrations

1533

7.1.1 Interaction Pattern for the EiRegisterParty Service

1534

1535 This is the **[UML]** interaction diagram for the EiRegisterParty Service
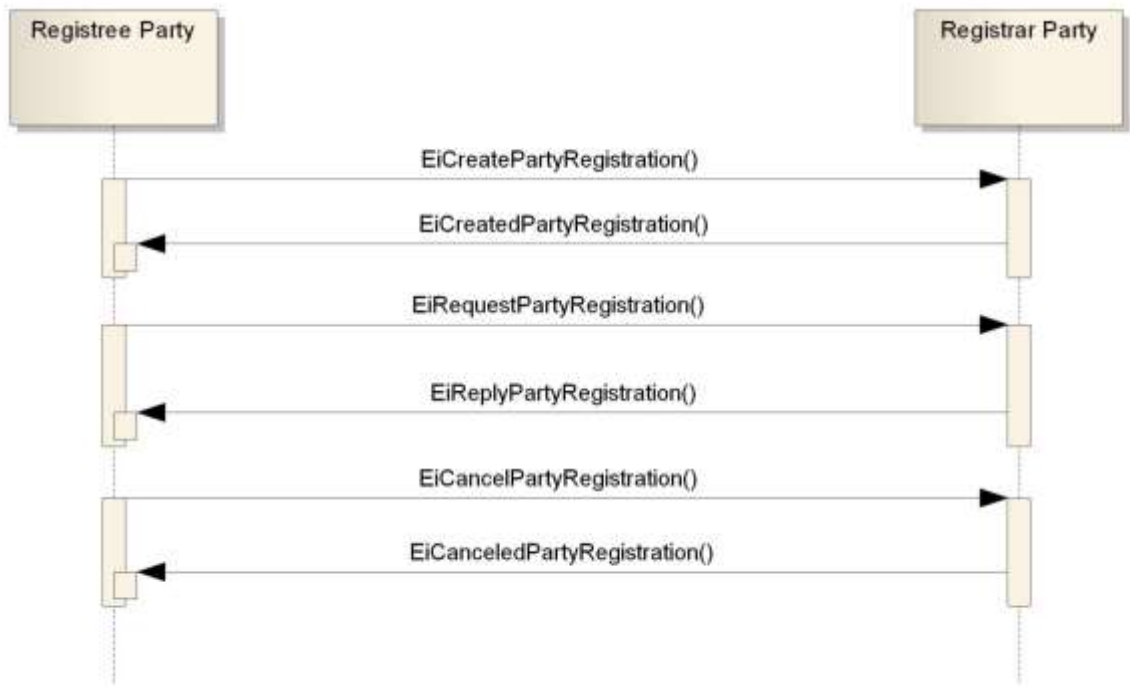
1536

1537 *Figure 7-1: Interaction Diagram for EiRegisterParty Service*

7.1.2 Information Model for the EiRegisterParty Service

1538

1539 The details of a Party are outside the scope of this specification. The application implementation needs to
1540 identify additional information beyond that in the class EiParty.

1541

1542 *Figure 7-2: EiParty UML Class Diagram*

7.1.3 Operation Payloads for the EiRegisterParty Service

1544   The **[UML]** class diagram describes the payloads for the EiRegisterParty service operations.

1545

1546   *Figure 7-3: UML Class Diagram for EiRegisterParty Service Operation Payloads*

7.2 Pre-Transaction Services

Pre-transaction services are those between parties that may or may not prepare for a transaction. The services are EiTender and EiQuote. A quotation is not a tender, but rather a market price or possible price, which needs a tender and acceptance to reach a transaction.

Price distribution, which is sometimes referred to as *price signals,* is accomplished using the EiQuote and EiTender services. Quotes are indications of a possible tender price; they are not actionable. A Tender offers prices at which Transactions may be made; they are actionable.

As with other services, a Party MAY inquire from a counterparty what offers the counterparty acknowledges as open by invoking the EiSendTender service to receive the outstanding tenders.

There is no operation to "delete" a quote; when a quote has been canceled the counterparty MAY delete it at any time. To protect against recycled or dangling references, the counterparty SHOULD invalidate any identifier it maintains for the cancelled quote.

Tenders, quotes, and transactions are **[EMIX]** artifacts, which contain terms such as schedules and prices in varying degrees of specificity or concreteness.

Table 7-2: Pre-Transaction Tender Services

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiTender	EiCreateTender	EiCreatedTender	Party	Party	Create and send Tender
EiTender	EiRequestTender	EiReplyTender	Party	Party	Request outstanding Tenders; request semantics with optional time Interval
EiTender	EiCancelTender	EiCanceledTender	Party	Party	Cancel one or more Tenders
EiTender	EiDistributeTender	—	Party	Party	For broadcast or distribution of Tenders

Table 7-3: Pre-Transaction Quote Services

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiQuote	EiCreateQuote	EiCreatedQuote	Party	Party	Create and send a quote
EiQuote	EiRequestQuote	EiReplyQuote	Party	Party	Request outstanding Tenders; request semantics with optional time Interval
EiQuote	EiCancelQuote	EiCanceledQuote	Party	Party	Cancel one or more quotes
EiQuote	EiDistributeQuote	--	Party	EiTarget	For broadcast or distribution of quotes

1564

7.2.1 Interaction Pattern for the EiTender and EiQuote Services

1565

1566 This is the **[UML]** interaction diagram for the EiTender Service.
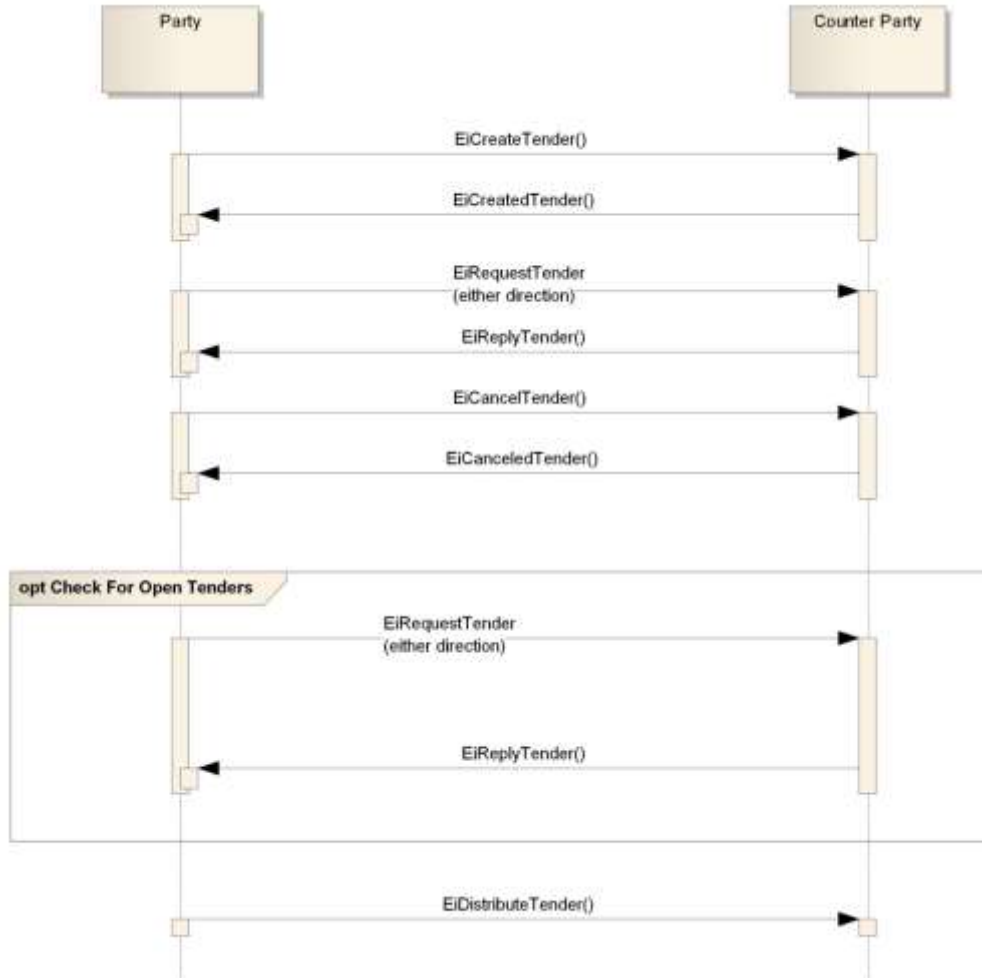
1567

1568 *Figure 7-4: Interaction Diagram for the EiTender Service*

1569   This is the **[UML]** interaction diagram for the EiQuote Service
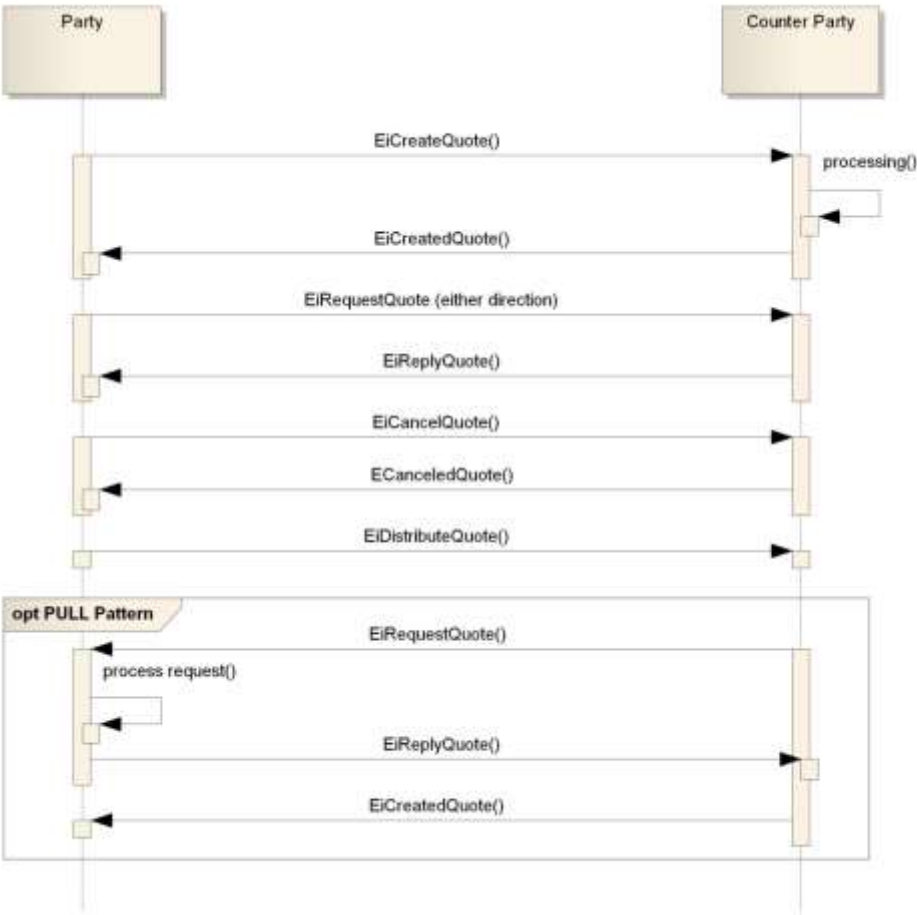
1570

1571   *Figure 7-5: Interaction Diagram for the EiQuote Service*

1572 7.2.2 Information Model for the EiTender and EiQuote Services

1573   The information model for the EiTender Service and the EiQuote Service artifacts is that of **[EMIX]**. EMIX
1574   provides a product description as well as a schedule over time of prices and quantities.

7.2.3 Operation Payloads for the EiTender Service

1576   The **[UML]** class diagram describes the payloads for the EiTender and EiQuote service operations.

1577

1578   *Figure 7-6: UML Class Diagram for the Operation Payloads for the EiTender Service*

1579

7.2.4 Operation Payloads for the EiQuote Service

«XSDcomplexType»
EiCreateQuoteType

«XSDelement»
+ eiQuote: EiQuoteType [1..*]
+ publisherPartyID: actorID
+ requestID: refID
+ subscriberPartyID: actorID

«XSDcomplexType»
EiCreatedQuoteType

«XSDelement»
+ eiResponse: EiResponseType
+ publisherPartyID: actorID [0..1]
+ quoteID: refID [0..*]
+ responses: ArrayOfResponses [0..1]
+ subscriberPartyID: actorID

«XSDcomplexType»
EiRequestQuoteType

«XSDelement»
+ interval: xcal:WsCalendarIntervalType [0..1]
+ marketContext: emix:MarketContextType [0..*]
+ publisherPartyID: actorID
+ quoteID: refID [0..*]
+ requestID: refID
+ requestorPartyID: actorID

«XSDcomplexType»
EiReplyQuoteType

«XSDelement»
+ eiQuote: EiQuoteType [0..*]
+ eiResponse: EiResponseType
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiDistributeQuoteType

«XSDelement»
+ eiQuote: EiQuoteType [1..*]
+ eiTarget: EiTargetType
+ publisherPartyID: actorID
+ requestID: refID

«XSDcomplexType»
EiCancelQuoteType

«XSDelement»
+ publisherPartyID: actorID
+ quoteID: refID [1..*]
+ requestID: refID
+ subscriberPartyID: actorID [0..1]

«XSDcomplexType»
EiCanceledQuoteType

«XSDelement»
+ eiResponse: EiResponseType
+ publisherPartyID: actorID [0..1]
+ responses: ArrayOfResponses [0..1]
+ subscriberPartyID: actorID [0..1]

1581

1582   *Figure 7-7: UML Class Diagram for the EiQuote Service Operation Payloads*

1583   **7.3 Transaction Management Services**

1584   The service operations in this section manage the exchange of transactions. For example, in demand
1585   response, the overarching agreement is the context in which events and response take place—what is
1586   often called a *program.* This agreement is identified by the information element Market Context here and
1587   elsewhere.

1588 There is no EiCancelTransaction or EiChangeTransaction operations. As in distributed agreement
1589 protocols, a compensating transaction SHOULD be created as needed to compensate for any effects.[7]

1590 *Table 7-4: Transaction Management Service*

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiTransaction	EiCreateTransaction	EiCreatedTransaction	Party	Party	Create and send Transaction
EiTransaction	EiRequestTransaction	EiReplyTransaction	Party	Party	Request extant Transactions

1591 7.3.1 Interaction Patterns for the EiTransaction Service

1592 This is the **[UML]** interaction diagram for the EiTransaction Service:

1593
1594 *Figure 7-8: Interaction Diagram for the EiTransaction Service*

1595 7.3.2 Information Model for the EiTransaction Service

1596 Transactions are **[EMIX]** artifacts with the identification of the Parties.

---

[7] This is consistent with the way that distributed agreement protocols such as [WS-BusinessActivity] manage compensation rather than cancelation.

7.3.3 Operation Payloads for the EiTransaction Service

1598   The **[UML]** class diagram describes the payloads for the EiTransaction service operations.

«XSDcomplexType»
EiCreateTransactionType

«XSDelement»
+   counterPartyID: actorID
+   eiTransaction: EiTransactionType [1..*]
+   partyID: actorID
+   requestID: refID

«XSDcomplexType»
EiCreatedTransactionType

«XSDelement»
+   counterPartyID: actorID
+   eiResponse: EiResponseType
+   partyID: actorID
+   responses: ArrayOfResponses [0..1]
+   transactionID: refID [0..*]

«XSDcomplexType»
EiRequestTransactionType

«XSDelement»
+   counterPartyID: actorID [0..*]
+   interval: xcal:WsCalendarIntervalType [0..1]
+   marketContext: emix:MarketContextType [0..*]
+   partyID: actorID
+   requestID: refID
+   requestorPartyID: actorID
+   transactionID: refID [0..*]

«XSDcomplexType»
EiReplyTransactionType

«XSDelement»
+   eiResponse: EiResponseType
+   eiTransaction: EiTransactionType [0..*]
+   responses: ArrayOfResponses [0..1]

1599

1600   *Figure 7-9: UML Class Diagram of EiTransaction Service Operation Payloads*

7.4 Post-Transaction Services

In a market of pure transactive energy, verification would be solely a function of meter readings. The seed standard for smart grid meter readings is the NAESB Energy Usage Information **[NAESB EUI]** specification.

In today's markets, with most customers on Full Requirements tariffs, the situation is necessarily more complex. Full Requirements describes the situation where purchases are not committed in advance. The seller is generally obligated to provide all that the buyer requires. Full requirements tariffs create much of the variance in today's DR markets.

These sections will apply a measurement model consistent with the **[NAESB EUI]** as in the EiReport Services.

7.4.1 Energy Delivery Information

These service operations respond with Energy Usage Information or any other single item of interest to the caller. This is very simple, requesting one thing measured for one interval, and waiting to return a value until the information is available. For anything more complex the Report Services should be used.

Table 7-5: Energy Delivery

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiDelivery	EiCreateDelivery	EiCreatedDelivery	Party	Party	Party-to-Party, specifying interval, what is to be measured, and the direction for the measurement

7.4.1.1 Interaction Pattern for the EiDelivery Service

Figure 7-10: Interaction Diagram for Delivery Service

7.4.1.2 Information Model for the EiDelivery Service

1621   The EiDelivery Type is a simplified EiReport.

1622

1623   *Figure 7-11: UML of EiDelivery Type*

1624   **7.4.1.3 Operation Payloads for the EiDelivery Service**

1625

1626   *Figure 7-12: UML Class Diagram of Delivery and Delivery Payload*

1627

7.5 Comparison of Transactive Payloads

«XSDcomplexType»
EiCreateQuoteType

«XSDelement»
+ eiQuote: EiQuoteType [1..*]
+ publisherPartyID: actorID
+ requestID: refID
+ subscriberPartyID: actorID

«XSDcomplexType»
EiCreateTenderType

«XSDelement»
+ counterPartyID: actorID
+ eiTender: EiTenderType [1..*]
+ partyID: actorID
+ requestID: refID

«XSDcomplexType»
EiCreateTransactionType

«XSDelement»
+ counterPartyID: actorID
+ eiTransaction: EiTransactionType [1..*]
+ partyID: actorID
+ requestID: refID

«XSDcomplexType»
EiCreatedQuoteType

«XSDelement»
+ eiResponse: EiResponseType
+ publisherPartyID: actorID [0..1]
+ quoteID: refID [0..*]
+ responses: ArrayOfResponses [0..1]
+ subscriberPartyID: actorID

«XSDcomplexType»
EiCreatedTenderType

«XSDelement»
+ counterPartyID: actorID [0..1]
+ eiResponse: EiResponseType
+ partyID: actorID
+ responses: ArrayOfResponses
+ tenderID: refID [0..*]

«XSDcomplexType»
EiCreatedTransactionType

«XSDelement»
+ counterPartyID: actorID
+ eiResponse: EiResponseType
+ partyID: actorID
+ responses: ArrayOfResponses [0..1]
+ transactionID: refID [0..*]

«XSDcomplexType»
EiRequestQuoteType

«XSDelement»
+ interval: xcal:WsCalendarIntervalType [0..1]
+ marketContext: emix:MarketContextType [0..*]
+ publisherPartyID: actorID
+ quoteID: refID [0..*]
+ requestID: refID
+ requestorPartyID: actorID

«XSDcomplexType»
EiRequestTenderType

«XSDelement»
+ counterPartyID: actorID [0..*]
+ interval: xcal:WsCalendarIntervalType [0..1]
+ marketContext: emix:MarketContextType [0..*]
+ partyID: actorID
+ requestID: refID
+ requestorPartyID: actorID
+ tenderID: refID [0..*]

«XSDcomplexType»
EiRequestTransactionType

«XSDelement»
+ counterPartyID: actorID [0..*]
+ interval: xcal:WsCalendarIntervalType [0..1]
+ marketContext: emix:MarketContextType [0..*]
+ partyID: actorID
+ requestID: refID
+ requestorPartyID: actorID
+ transactionID: refID [0..*]

«XSDcomplexType»
EiReplyQuoteType

«XSDelement»
+ eiQuote: EiQuoteType [0..*]
+ eiResponse: EiResponseType
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiReplyTenderType

«XSDelement»
+ eiResponse: EiResponseType
+ eiTender: EiTenderType [0..*]
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiReplyTransactionType

«XSDelement»
+ eiResponse: EiResponseType
+ eiTransaction: EiTransactionType [0..*]
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiCancelQuoteType

«XSDelement»
+ publisherPartyID: actorID
+ quoteID: refID [1..*]
+ requestID: refID
+ subscriberPartyID: actorID [0..1]

«XSDcomplexType»
EiCancelTenderType

«XSDelement»
+ counterPartyID: actorID [0..1]
+ partyID: actorID
+ requestID: refID
+ tenderID: refID [1..*]

«XSDcomplexType»
EiCreateDeliveryType

«XSDelement»
+ delivery: emix:DeliveryType [1..*]
+ requestID: refID
+ requestorPartyID: actorID

«XSDcomplexType»
EiCanceledQuoteType

«XSDelement»
+ eiResponse: EiResponseType
+ publisherPartyID: actorID [0..1]
+ responses: ArrayOfResponses [0..1]
+ subscriberPartyID: actorID [0..1]

«XSDcomplexType»
EiCanceledTenderType

«XSDelement»
+ counterPartyID: actorID [0..1]
+ eiResponse: EiResponseType
+ partyID: actorID
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiCreatedDeliveryType

«XSDelement»
+ eiDelivery: EiDeliveryType [0..*]
+ eiResponse: EiResponseType
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiDistributeQuoteType

«XSDelement»
+ eiQuote: EiQuoteType [1..*]
+ eiTarget: EiTargetType
+ publisherPartyID: actorID
+ requestID: refID

«XSDcomplexType»
EiDistributeTenderType

«XSDelement»
+ eiTarget: EiTargetType
+ eiTender: EiTenderType [1..*]
+ partyID: actorID
+ requestID: refID

1629

Figure 7-13: UML Diagram comparing all Transactive Payloads

1631

8 Enroll Service

Enrollment is distinct from Registration in Energy Interoperation. Registration establishes an identity for an actor (a party or a device such as a generator or a meter on a premise). Enrollment establishes a relationship between two actors as a basis for further interactions. Energy Interoperation supports two classes of interactions; Transactive and VTN/VEN interactions.

In the case of enrollment in Transactive Interactions, the Enrollment Service identifies the two parties and the Enabling Agreement, Market, Tariff, Purchasing, Selling, etc. that the parties agree to use for their interactions.

In the case of enrollment in a VTN/VEN relationship the enrollment service identifies the two actors, generally a registered Resource and a Service Provider acting as a Designated Dispatch Entity (DDE). Registration of a Resource may sometimes be automatic with enrollment of the Resource.

The entities described in the following table can be enrolled. These are described in the **[UML]** diagrams as concrete classes that inherit from the Enrollee type. The strings are used to describe the entity; the standard approach to extensibility where a prefix of "x-" indicates an extension SHALL be used.

The types of entity used may depend on the implementation. All implementations SHALL support Resources.

Table 8-1 Enrollee Descriptions

Entity	String	Description	Comment
Aggregator	aggregator	An entity that combines or aggregates generation or consumption	
Consumer	customer	An entity that is generally a net consumer of electricity	
Distribution	distribution	An entity that distributes electricity	E.g. a distribution utility
Enrolling Authority	enrollingAuthority	An entity that can perform enrolling services	
Generator	generator	An entity that is generally a net producer of electricity	
Load Serving Entity	lse	An entity which supports loads rather than generation	
Market	market	A Market that enrolls in another Market Context	
Meter Authority	meterAuthority	An entity that provides metering services	
Resource	resource	An EMIX Resource with additional information	A Resource including performance envelope and additional information including Resource Name

Entity	String	Description	Comment
Scheduling Entity	schedulingEntity	An entity that provides scheduling services	
Service Provider	serviceProvider	An entity that provides services	A potential provider of services to the VTN in support of VTN business processes
Supplier	supplier	An entity that is generally a net supplier of electricity	
System Operator	systemOperator	An entity that operates a grid	
TDSP	tdsp	An entity which supports transmission and distribution of electricity	
Transmission	transmission	An entity which supports transmission of electricity	

1649

1650   *Table 8-2: EiEnroll Service Operations*

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiEnroll	EiCreateEnroll	EiCreatedEnroll	Party	Party	Create and send Enrollment
EiEnroll	EiRequestEnroll	EiReplyEnroll	Party	Party	Requests outstanding Enrollment information; request semantics with no time Interval.
EiEnroll	EiCancelEnroll	EiCanceledEnroll	Party	Party	Cancel one or more Enrollments

1651

8.1 Interaction Patterns for the EiEnroll Service

This is the **[UML]** interaction diagram for the EiEnroll Service.
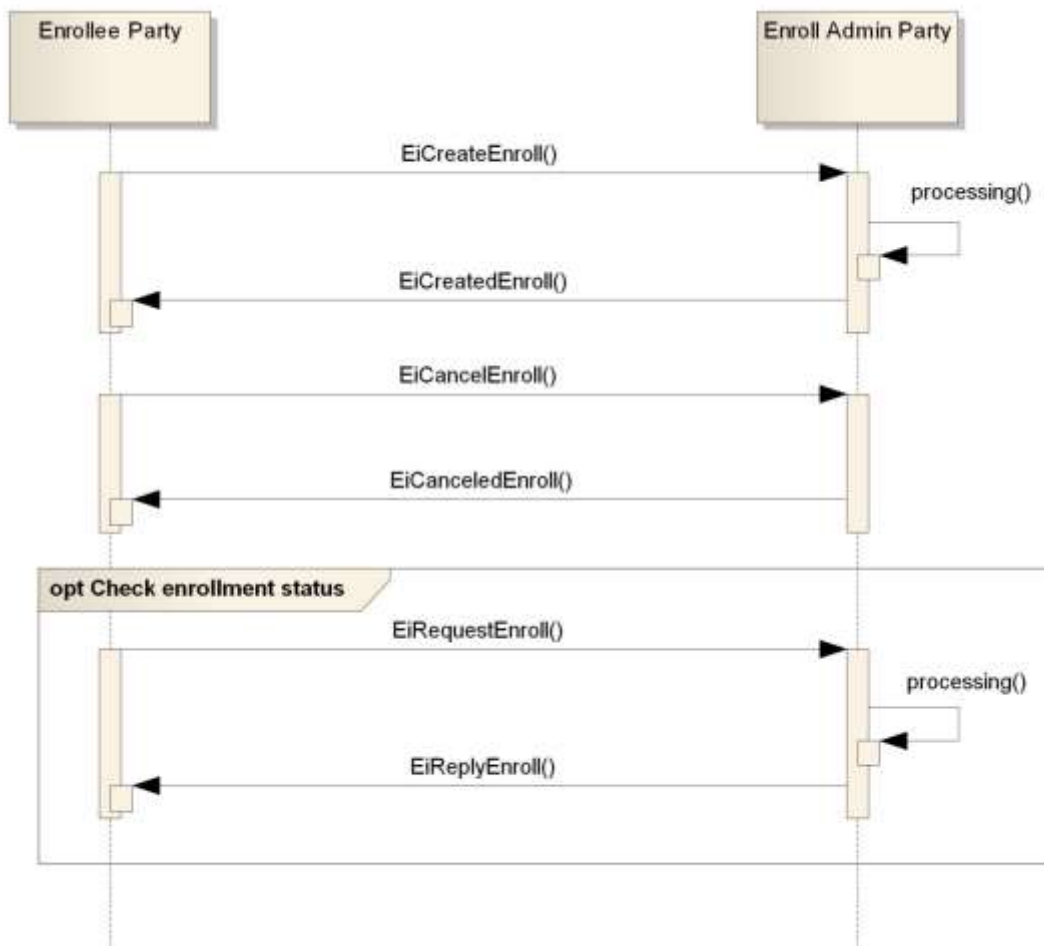
Figure 8-1: Interaction Diagram for the EiEnroll Service

8.2 Information Model for the EiEnroll Service

The EiEnroll service has an abstract class for the respective types. The abstract class also has the entity identifier, type (as a string), and name. The standard values for the type are listed in Table 8-1 Enrollee Descriptions. Other values MAY be used but MUST be prefixed by "x-" as described in Appendix C
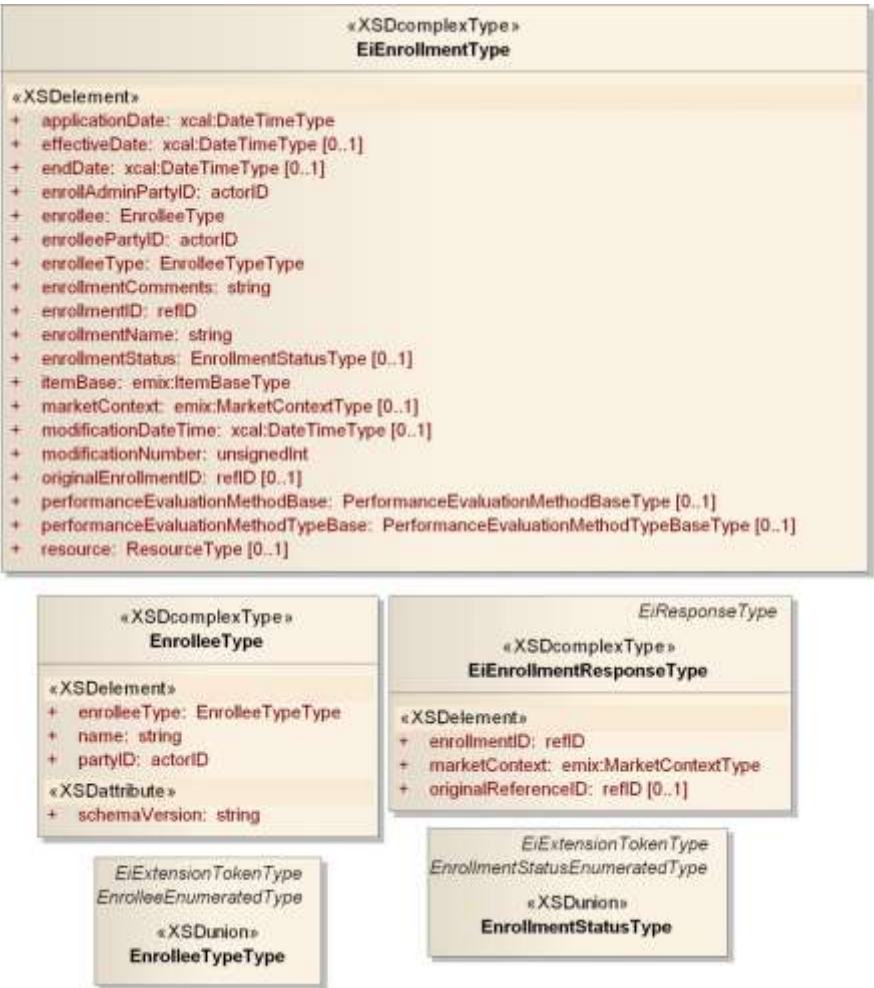
Figure 8-2: UML Model for EiEnrollment Classes

energyinterop-v1.0-cos01
2013wd42
Standards Track Work Product   Copyright © OASIS Open 20132014. All Rights Reserved.
19 December
18 May 2014
Page 98 of 152

8.3 Enrollee Types

1666   The **[UML]** class diagram describes the Enrollee Types.

1667
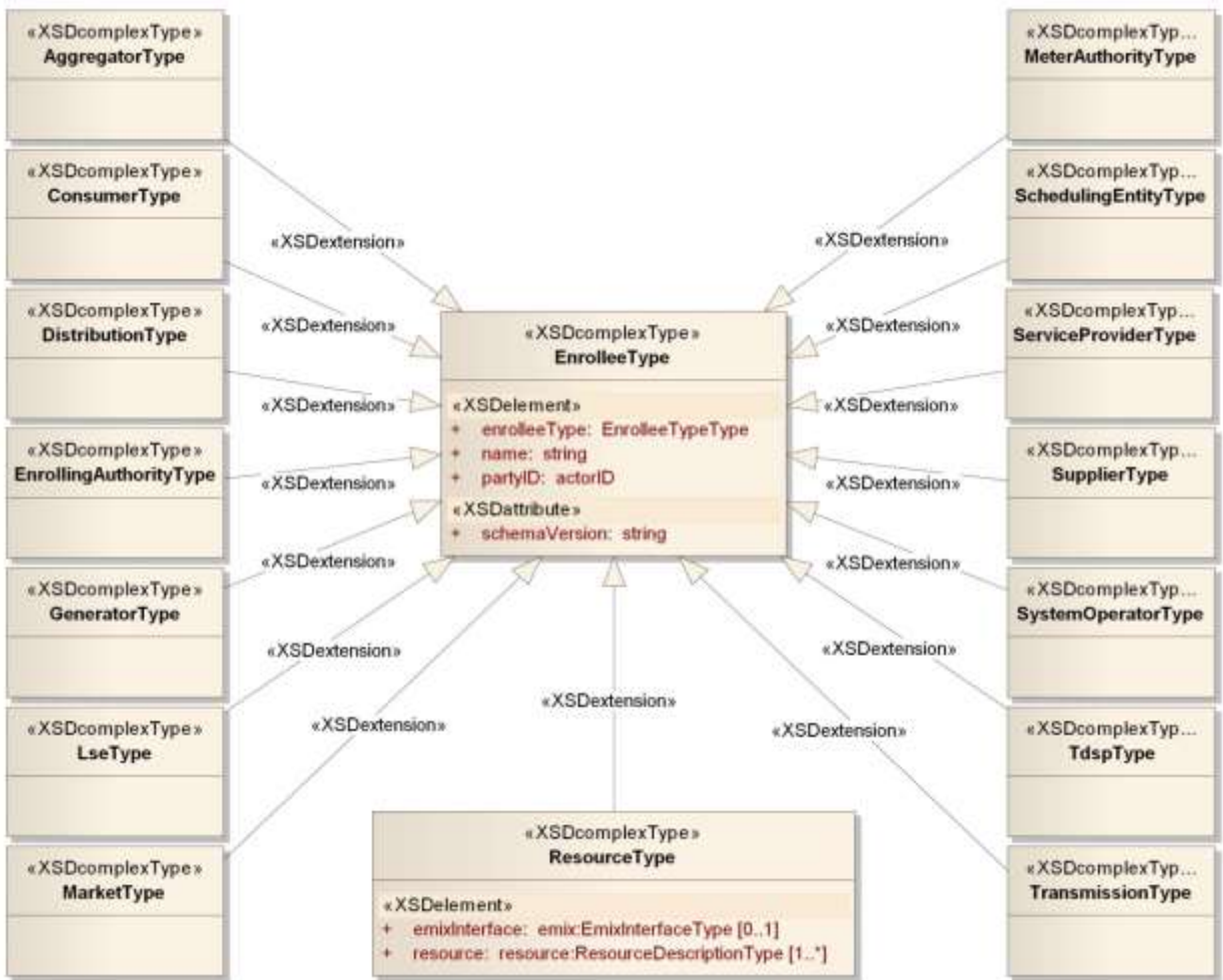
1668   *Figure 8-3: UML Class Diagram showing Enrollee Types*

8.4 Operation Payloads for the EiEnroll Service

1670   The **[UML]** class diagram describes the payloads for the EiEnroll service operations.

«XSDcomplexType»
EiCreateEnrollType

«XSDelement»
+   eiEnrollment: EiEnrollmentType
+   enrolleePartyID: actorID
+   requestID: refID

«XSDcomplexType»
EiCreatedEnrollType

«XSDelement»
+   eiResponse: EiResponseType
+   enrollAdminPartyID: actorID
+   enrollmentID: refID [0..*]
+   enrollmentResponses: ArrayOfEnrollmentResponses [0..1]

«XSDcomplexType»
EiRequestEnrollType

«XSDelement»
+   enrollAdminPartyID: actorID [0..*]
+   enrolleePartyID: actorID
+   enrollmentID: refID [0..*]
+   marketContext: emix:MarketContextType [0..*]
+   requestID: refID
+   requestorPartyID: actorID

«XSDcomplexType»
EiReplyEnrollType

«XSDelement»
+   eiEnrollment: EiEnrollmentType [0..1]
+   eiResponse: EiResponseType
+   enrollmentResponses: ArrayOfEnrollmentResponses [0..1]

«XSDcomplexType»
EiCancelEnrollType

«XSDelement»
+   enrolleePartyID: actorID
+   enrollmentID: refID [1..*]
+   requestID: refID

«XSDcomplexType»
EiCanceledEnrollType

«XSDelement»
+   eiResponse: EiResponseType
+   responses: ArrayOfResponses [0..1]

1671

1672   *Figure 8-4: UML Class Diagram for Enrollment Payloads*

9 Event Services

1674 The Event Service is used to call for performance under a transaction. The service parameters and event
1675 information distinguish different types of events. Event types include reliability events, emergency events,
1676 and more—and events MAY be defined for other actions under a transaction. For transactive services,
1677 two parties may enter into a call option. Invocation of the call option by the Promissee on the Promissor
1678 can be thought of as raising an event. But typically the Promissee may raise the event at its discretion as
1679 long as the call is within the terms of the call option transaction.

1680 For example, an ISO that has awarded an ancillary services transaction to a Party may issue dispatch
1681 orders, which can also be viewed as Events. In this specification, what is sometimes called a *price event*
1682 would typically be communicated using the EiSendQuote operation (see 7.2 *"Pre-Transaction Services"*).

1683 *Table 9-1: Event Services*

Service	Operation	Response Operation	Service Consumer	Service Provider	Notes
EiEvent	EiCreateEvent	EiCreatedEvent	VTN	VEN	Create and send a new Event
EiEvent	EiChangeEvent	EiChangedEvent	VTN	VEN	Modify an existing Event
EiEvent	EiRequestEvent	EiReplyEvent	Either	Either	Request outstanding Events; request semantics with optional time Interval
EiEvent	EiRequestPendingEvent	EiReplyPendingEvent	Either	Either	Similar to Request Events except that Reply returns Event IDs and Modification Numbers only.
EiEvent	EiCancelEvent	EiCanceledEvent	VTN	VEN	Cancel one or more Events
EiEvent	EiDistributeEvent	—	VTN	VEN	Broadcast of Event.

9.1 Information Model for the EiEvent Service

1685 The event is the core Demand Response information structure, and the most complex of the payloads.
1686 Understanding the information model of the Event is critical to understanding the operations of the Event
1687 Services. This section reviews the Event semantics as defined in Section 5.3 *"Event-based Interactions"*.

1688 The sub-sections below provide a reprise of the Event structure (9.1.1) and a UML description of the
1689 event (9.1.2)

9.1.1 Structure of the Event

The semantics of the Event are defined Section 5.3 *"Event-based Interactions"*.
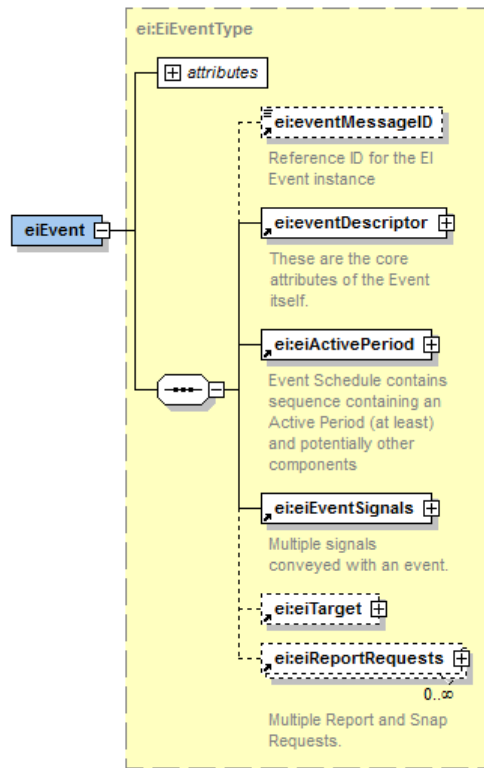
Figure 9-1: EiEvent summarized

The type EiEvent MAY be identified by an Event Message ID and which has associations with the classes Active Period, Event Descriptor, and Event Signals, a collection of Signals and Baselines.

As the event is the core Demand Response information structure, we begin with Unified Modeling Language **[UML]** diagrams for the EiEvent class and for each of the operation payloads. Core semantics for the Event are defined in Section 5.3 *"Event-based Interactions".*

9.1.2 UML Model of an Event and its Signals
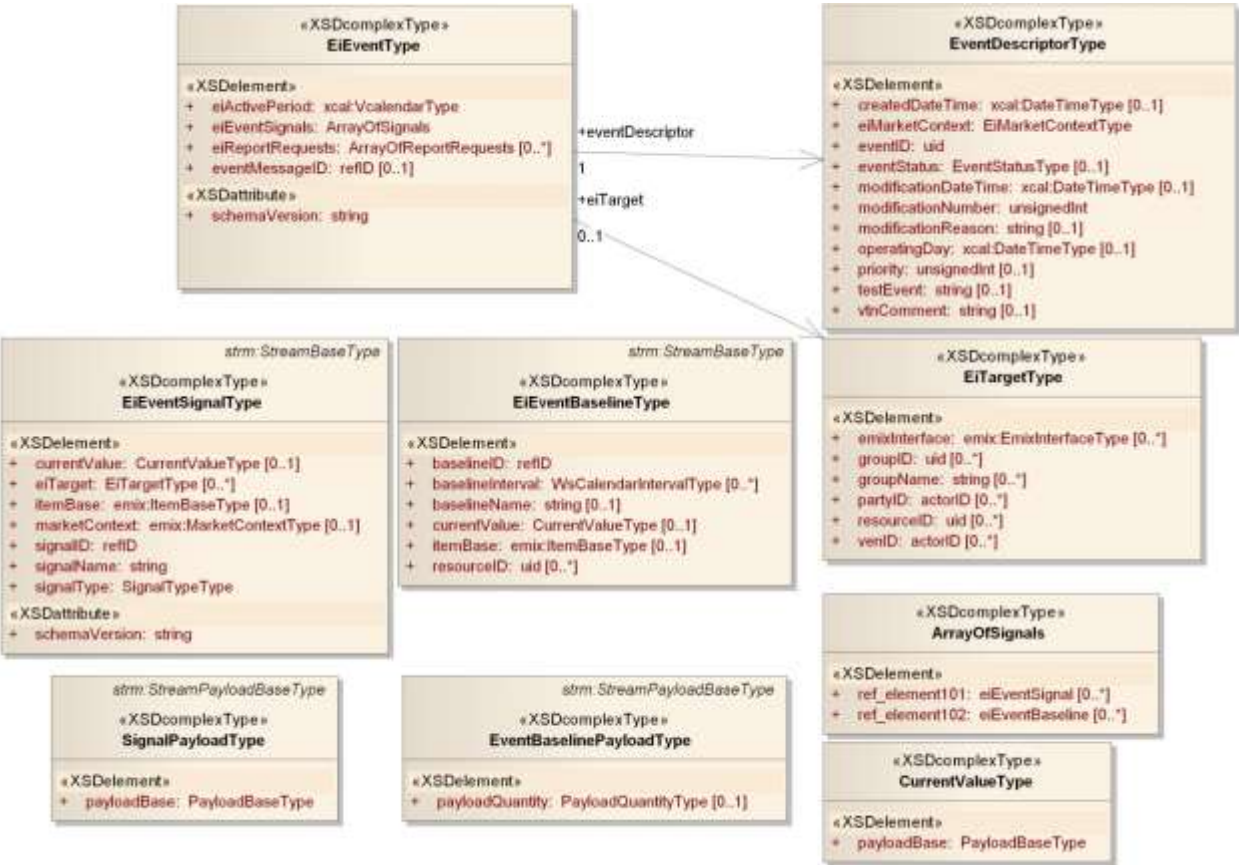
1702

Figure 9-2: UML Class Diagram for EiEventType and Related Classes (w/o Signals detail)

1704

1705

An Event may include a number of Schedules, which are expressed as Streams. These schedules are
the Signals, the Baselines, and they may return Baselines, Reports, and Delivery. The EI Event Signal
derives from the Streams element and conveys elements of the Type Signal Payload in its Schedule.
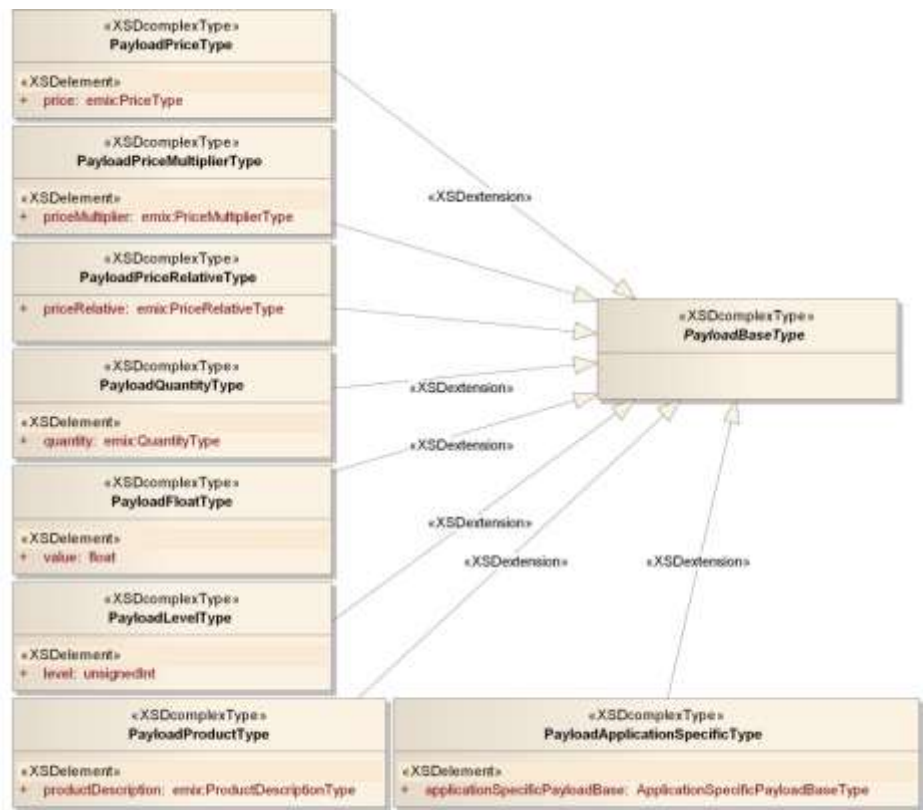
1709

Figure 9-3 UML Class Diagram Showing Details of the Signal Payloads or EiEventSignals

9.2 Special Semantics of the Event Request Operations

The Events are the largest messages exchanged in Energy Interoperation. They exist in two forms, the
EiEventRequest, and EiEventRequestPending. EiEventReply returns entire Events in response to a
Request, following the general pattern of all Energy Interoperation Services. EiEventRequestPending
returns the Event IDs and Modification Numbers only. EiEventRequestPending is useful for black-start
and other situations in which the VEN and VTN need to assess the information shared with its partner.

The Modification Number returned in the Replies is for assessment only. The recipient MAY use it to
determine that the sender is using out-of-date information, but any replacement or update SHALL convey
the current Modification.

9.2.1 Event Ordering

The Event Requests include an option to restrict the number of Events returned in Reply to any Request.
For consistency, this requires that a VTN or VEN be able to order Events. The rules for ordering Events
are applied sequentially as follows:

1. Active events have priority over pending events
2. Within Active Events, priority is determined by Priority in the Event Descriptor.
3. Between active events with the same priority, the one with the earlier start time has the higher
   priority.
4. Between pending events the one with the earlier start time has the higher priority

1729   5. After processing rules 1-4, if Priority is still indeterminate within a set of Intervals, then the order is
1730   indeterminate within that set. A Reply containing Events with indeterminate Order MUST maintain
1731   that order in response to successive Requests while they remain indeterminate.

1732 The definitions of Active and Pending are consistent with those described for the Event Filter in Table 9-2.

1733 9.2.2 Event Filter described

1734 Both the Event Request operations MAY use of the Event Filter to restrict the Events exchanged during
1735 Request and Reply.

1736 *Table 9-2: Event Filter described*

Event Filter	Description
Active	An event qualifies if the Active Interval coincides with the Interval in the Request. An Event qualifies if any part of the Active Interval occurs within the specifying Interval; without accompanying Interval, "now" is treated as an infinitesimal Interval with a current starting date and time.
Pending	An event qualifies if the Active Interval starting date and time is in the future. If specified with an accompanying Interval, the Event qualifies if the Active Interval has not started (is not Active) at the Start of the Interval, and the Active Interval start is within the bounds of the specifying Interval.
All	An event qualifies if it would qualify as either Active or Pending.
Completed	An Event qualifies if the Active Interval is completed before the Request. If specified with an Interval in the Request, an Event qualifies if the end of the Active Interval occurs before the start of the Requested Interval. Conforming profiles MAY return a NULL set in response to a Request for Completed Intervals, as there is no requirement to store or be able to retrieve Completed Events.
Cancelled	An Event qualifies if it has been Cancelled. If specified with an accompanying Interval, and Event qualifies if the Event would have qualified as Active during the Interval. Conforming profiles MAY return a NULL set in response to a request for Completed Intervals as there is no requirement to store or be able to retrieve Cancelled Events.

1737 9.2.3 Using EiRequestEvent EiRequestEventPending together

1738 EiRequestEvent and EiRequestPendingEvent are essentially the same. Each enables a VEN or VTN to
1739 query its partner about what Events it knows. The difference is in the Replies. EIReplyEvent returns a
1740 collection of Events, EIReplyEventPending returns a collection of Qualified Event IDs. i.e., an Event ID
1741 and the Modification Number.

1742

1743 *Figure 9-4: Qualified Event ID*

1744 With a list of Qualified Event IDs either one can reconstruct what the other knows. Events that are missing
1745 can be requested or sent. A VEN can infer cancellation when its VTN removes an Event ID. Using the
1746 Modification Number, a VTN can know to re-send the latest version, or a VEN can know to request an
1747 update.

1748   While the Event Requests follow the pattern common to all EI Requests, because of the extra options,
1749   they are summarized in table [reference] below. All query elements are optional.

1750

1751   *Table 9-3: Event Requests summarized*

Request Element	Description
VEN ID	Names the VEN that is Requesting or currently knows of these Events
Event ID	A list of Event IDs to be returned. If present, all other filters are ignored.
Market Context	Request is to return Events that are in a Market Context. For example, in a given Program, a VEN could request all Electric Vehicle (EV) related Events.
Filter	As described above (Table 9-2). Can be combined with Interval
Interval	Requests Events "within" an Interval. Interval may contain only a Start Date to request all Events from that date forward, or may include only an End Date to include events before that Date. If no Interval is present, this is interpreted as if the Filter were "all".
Reply Limit	Return only the first N matching events, where N is the Reply Limit. "First is defined according to the Order as described above.

1752   A common pattern for either a VEN or a VTN is to request Event IDs with the EiRequestPending, and to
1753   then request information about events that it are missing or that need updates using EiRequestEvent. A
1754   VTN after a similar query might use EiCreateEvent to pass the missing or updated Events to the VEN.

1755 ## 9.3 Interaction Patterns for the EiEvent Service

1756 This is the **[UML]** interaction diagram for the EiEvent Service.

1757
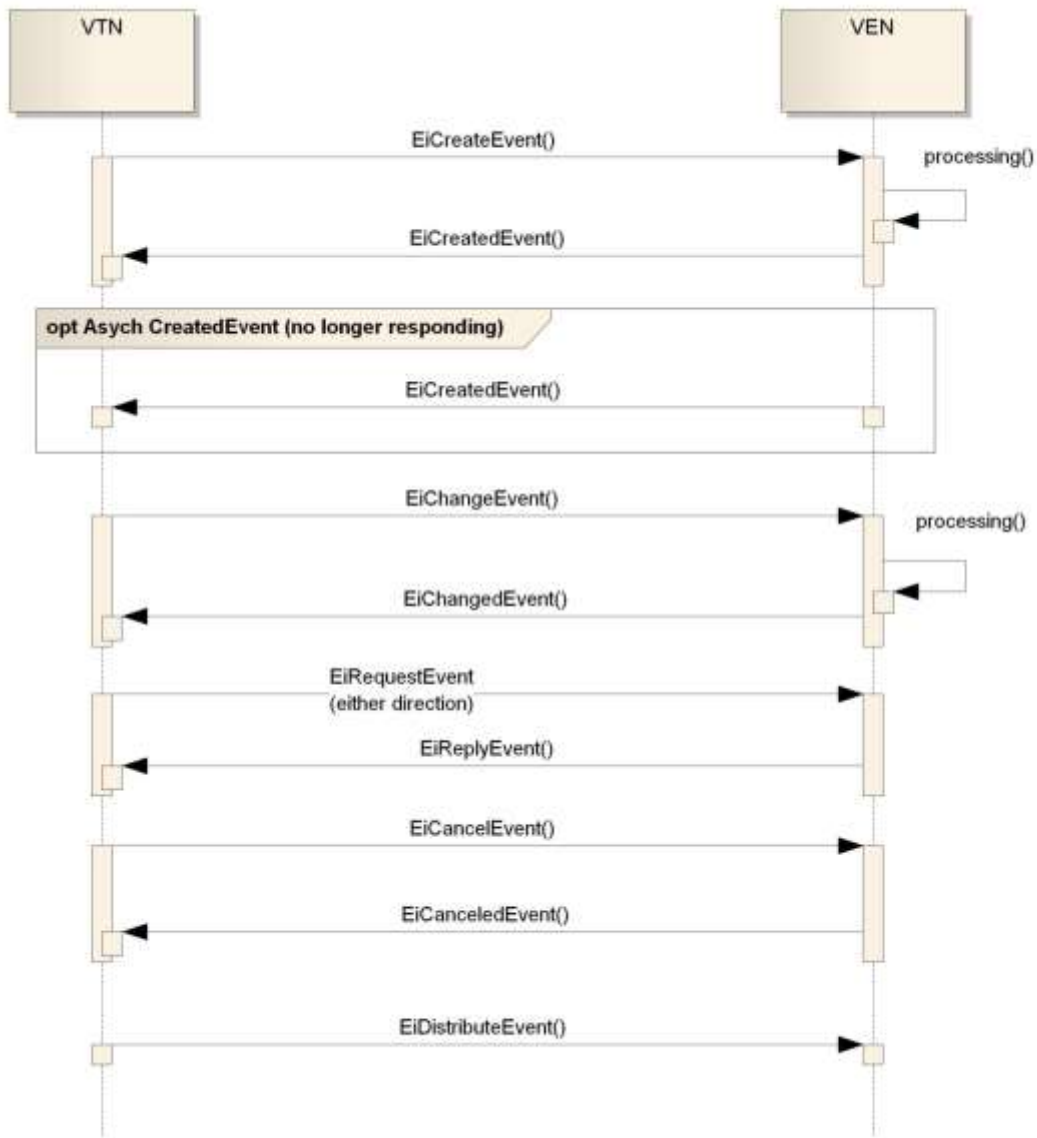
1758 *Figure 9-5: UML Interaction Diagram for the EiEvent Service Operations*

1759

1760
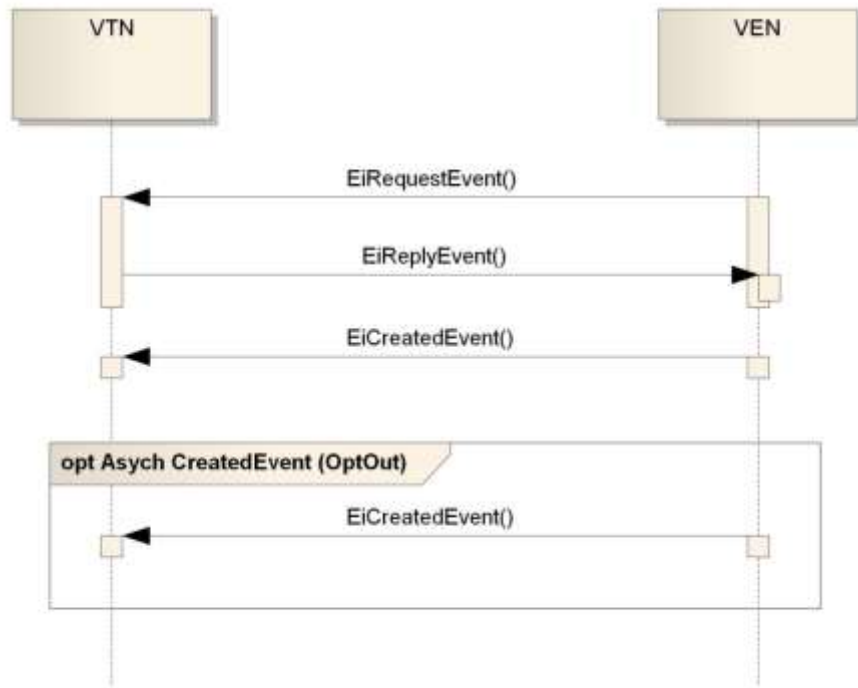
1761   *Figure 9-6: UML for example PULL pattern for EiEvent*

1762

1763

1764

1765   *Figure 9-7: Interaction Diagram for Pending Event operation*

9.4 Operation Payloads for the EiEvent Service

1767   The **[UML]** class diagram describes the payloads for the EiEvent service operations.

1768
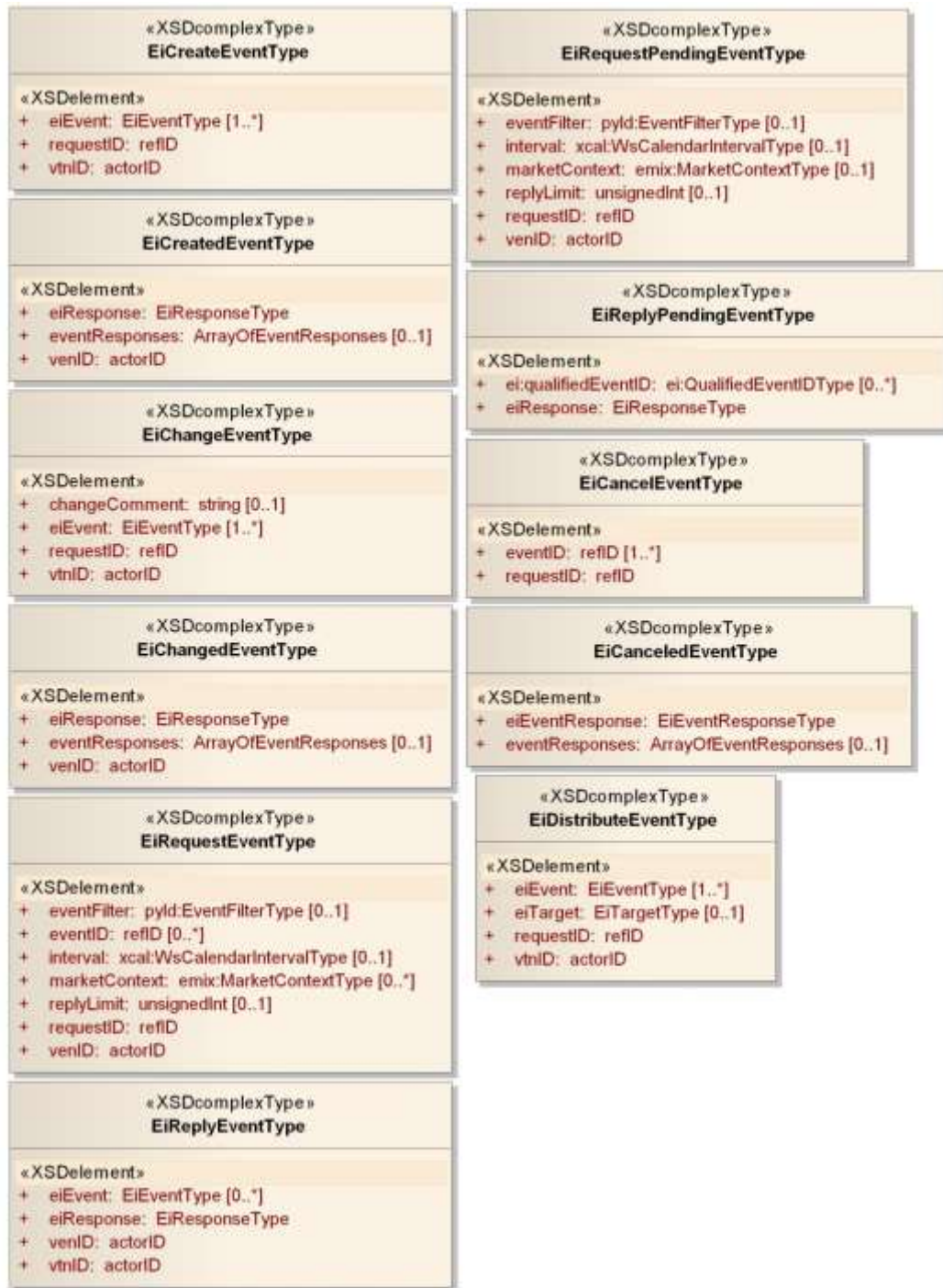
1769   *Figure 9-8: UML Class Diagram for EiEvent Service Operation Payloads*

10 Report Service

Energy Interoperation Reports convey information from remote sensing or about remote state back to the requester. The Historian operations support the collection of data for Reports. Reports can be associated with an Event or can be requested through the Report Services described in this section.

The general pattern of the Report service is to request that a Historian gather data, and for the Report Service to return the Report when it is Ready. A Historian may generate only a final Report, or it may report-back periodically. The report requester MAY ask the Historian for the report-to-date, or for a time-constrained portion of the Report at any time while it is running.

One interaction pattern for the Report service is what one may call "Set and Forget". Under this pattern, the Requester asks that information be logged, but specifies no Report delivery. Under this pattern, the Requester can, at any time, request delivery of a Report for a specified Interval.

Projections are a special class of Reports, i.e., Reports about the future. Projections follow the general form of Reports and include additional metadata about the reliability of the future information in each window.

The semantics of Reports are described in sections 5.4 *"Monitoring, Reporting"* and 5.5 *"Reports, Snaps, and Projections".*

The range of Payloads that can be delivered by means of a Report can be extended by deriving new types from the Payload Base Type, and defining a new Report Type not in Enumerated Report Types, and requesting such a Report.

10.1 Overview of Report Services

Event-based reports are requested as part of the EiEvent service. EI Report operations request Reports independently of any Event. Whether created as part of an Event or independently, all Reports support the same post-creation operations.

EiReport operations are independent of EiEvent operations in that they can be requested at any time independent of the status or history of EiEvents.

Table 10-1: Report Service

Service	Operation	Response	Service Con-sumer	Service Provi-der	Notes
EiReport	eiCreateHistorian	eiCreatedHistorian	any	any	Create a new Historian and start it recording indicated information
EiReport	eiRequestHistorian	eiReplyHistorian	any	any	Reply with HistorianIDs that meet the criteria
EiReport	eiCancelHistorian	eiCanceledHistorian	any	any	Cancel Historian recording, optionally requesting a final report
EiReport	eiCreateProjection	eiCreatedProjection	any	any	Creates a projection, returned as a report stream

Service	Operation	Response	Service Con-sumer	Service Provi-der	Notes
EiReport	eiCreateReport	eiCreatedReport	any	any	One time and/or periodic response
EiReport	eiUpdateReport	eiUpdatedReport	any	any	Used to update the Report, e.g. periodic responses
EiReport	eiRequestReport	eiReplyReport	any	any	The carrier for periodic response
EiReport	eiCancelReport	eiCanceledReport	any	any	Cancel pending reports, optionally requesting a final report

1796

10.2 EiHistorian Service

10.2.1 Interaction Pattern for the EiHistorian Service
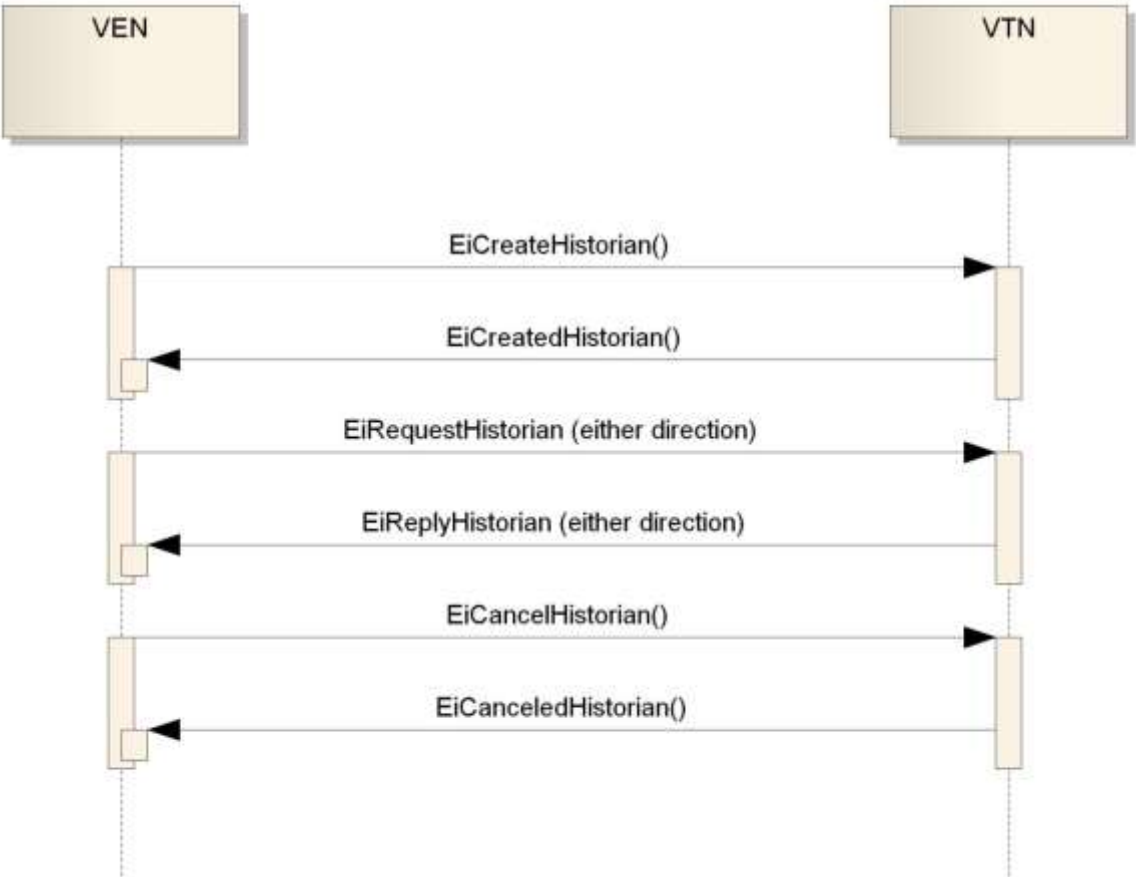
1799

1800 *Figure 10-1: Interaction Pattern for Historian Operations (Report Service)*

10.2.2 Operations Payloads for the EiHistorian Service

«XSDcomplexType»
EiCreateHistorianType

«XSDelement»
+ eiReportRequest: EiReportRequestType [1..*]
+ partyID: actorID
+ requestID: refID
+ requestorPartyID: actorID
+ vtnID: actorID [0..1]

«XSDcomplexType»
EiCreatedHistorianType

«XSDelement»
+ eiResponse: EiResponseType
+ historianID: refID [0..*]
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiRequestHistorianType

«XSDelement»
+ interval: xcal:WsCalendarIntervalType [0..1]
+ marketContext: emix:MarketContextType [0..*]
+ partyID: actorID [0..1]
+ requestID: refID
+ requestorPartyID: actorID
+ vtnID: actorID

«XSDcomplexType»
EiReplyHistorianType

«XSDelement»
+ eiResponse: EiResponseType
+ historianID: refID
+ marketContext: emix:MarketContextType [0..*]
+ responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiCancelHistorianType

«XSDelement»
+ eiTarget: EiTargetType
+ historianID: refID [1..*]
+ reportToFollow: boolean

«XSDcomplexType»
EiCanceledHistorianType

«XSDelement»
+ eiResponse: EiResponseType
+ historianID: refID [0..*]
+ responses: ArrayOfResponses [0..1]

1802

1803   *Figure 10-2: UML Diagram of Historian Payloads*

1804

10.3 EiReport Service

1806   ### 10.3.1 Information Model for the EiReport Service

1807   An EiReport is prepared by a Party upon request and supplied to the requesting party. It may also be
1808   defined in the expectations of the Market Context.

strm:StreamBaseType
«XSDcomplexType»
EiReportType

«XSDelement»
+ createdDateTime: xcal:DateTimeType
+ eiReportID: refUD
+ reportDescription: ReportDescriptionType [1..*]
+ reportName: string [0..1]
+ reportRequestID: refID
+ reportSpecifierID: refID
+ snap: SnapType [0..1]

«XSDattribute»
+ schemaVersion: string

«XSDcomplexType»
ReportDescriptionType

«XSDelement»
+ aggregateReport: boolean [0..1]
+ itemBase: emix:ItemBaseType [0..1]
+ readingType: ReadingTypeType [0..1]
+ reportDataSource: EiTargetType [0..1]
+ reportSubject: EiTargetType [0..1]
+ reportType: ReportTypeType
+ rID: rIDType [0..1]

«enumeration»
ReportEnumeratedType

reading
usage
demand
setPoint
deltaUsage
deltaSetPoint
deltaDemand
baseline
deviation
avgUsage
avgDemand
operatingState
upRegulationCapacityAvailable
downRegulationCapacityAvailable
regulationSetpoint
storedEnergy
targetEnergyStorage
availableEnergyStorage
price
level

strm:StreamPayloadBaseType
«XSDcomplexType»
ReportPayloadType

«XSDelement»
+ accuracy: AccuracyType [0..1]
+ confidence: ConfidenceType [0..1]
+ payloadBase: PayloadBaseType
+ readingType: ReadingTypeType [0..1]
+ rID: rIDType [0..1]

«XSDcomplexType»
SnapType

«XSDelement»
+ reportPayload: ReportPayloadType
+ statusDateTime: xcal:DateTimeType

1809

1810   *Figure 10-3: UML Class Diagram for the EiReport Class*

1811

1812 ## 10.3.2 Interaction Pattern for the EiReport Service

1813 This is the **[UML]** interaction diagram for the EiReport Service.

1814
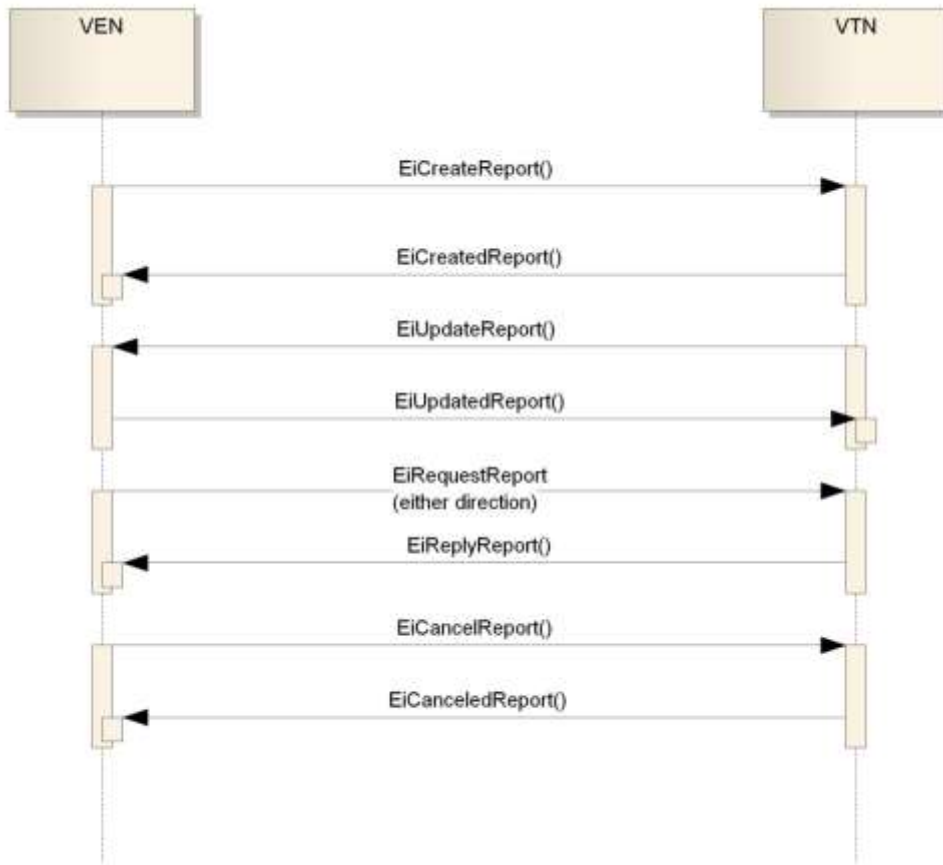
1815 *Figure 10-4: UML Interaction Diagram for the EiReport Service (Report Service)*

1816

energyinterop-v1.0-~~cos01~~
~~2013~~wd42
Standards Track Work Product   Copyright © OASIS Open ~~2013~~2014. All Rights Reserved.

~~19 December~~
18 May 2014
Page 115 of 152

10.3.3 Operation Payloads for the EiReport Service

«XSDcomplexType»
EiCreateReportType

«XSDelement»
+   eiReportRequest: EiReportRequestType [1..*]
+   partyID: actorID
+   requestID: refID
+   requestorPartyID: actorID
+   vtnID: actorID [0..1]

«XSDcomplexType»
EiCreatedReportType

«XSDelement»
+   eiReport: EiReportType [0..*]
+   eiReportID: refID [0..*]
+   eiResponse: EiResponseType
+   responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiRequestReportType

«XSDelement»
+   eiTarget: EiTargetType [0..1]
+   interval: xcal:WsCalendarIntervalType [0..1]
+   partyID: actorID [0..1]
+   reportRequestID: refID [0..1]
+   requestID: refID
+   requestorPartyID: actorID
+   vtnID: actorID [0..1]

«XSDcomplexType»
EiReplyReportType

«XSDelement»
+   eiReportID: refID [0..*]
+   eiResponse: EiResponseType
+   responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiUpdateReportType

«XSDelement»
+   eiReport: EiReportType [0..*]
+   eiResponse: EiResponseType
+   requestID: refID
+   responses: ArrayOfResponses [0..1]

«XSDcomplexType»
EiUpdatedReportType

«XSDelement»
+   eiResponse: EiResponseType

«XSDcomplexType»
EiCancelReportType

«XSDelement»
+   eiReportID: refID [1..*]
+   eiTarget: EiTargetType [0..1]
+   partyID: actorID
+   reportRequestID: refID [0..*]
+   reportToFollow: boolean
+   requestID: refID

«XSDcomplexType»
EiCanceledReportType

«XSDelement»
+   eiReportID: refID [1..*]
+   eiResponse: EiResponseType
+   reportRequestID: refID [0..*]
+   responses: ArrayOfResponses [0..1]

1818

Figure 10-5: UML Diagram of Report Payloads

1820

energyinterop-v1.0-~~cos01~~
~~2013~~wd42
Standards Track Work Product   Copyright © OASIS Open ~~2013~~2014. All Rights Reserved.

~~19 December~~
18 May 2014
Page 116 of 152

10.4 EiProjectionService

10.4.1 Interaction Pattern for EiProjection Service

Figure 10-6: Interaction Pattern for Projection Operations (Report Service)

10.4.2 Operation Payloads for the EiProjection Service
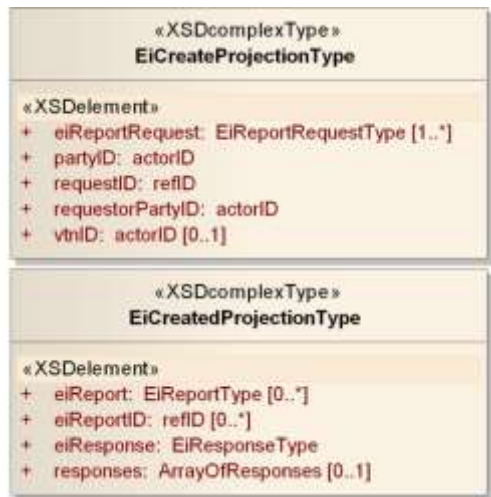
Figure 10-7: UML Diagram of Projection Payloads

10.5 Summary of Report Payloads

The **[UML]** class diagram below recaps the payloads for all operations of the EiReportService.

1832
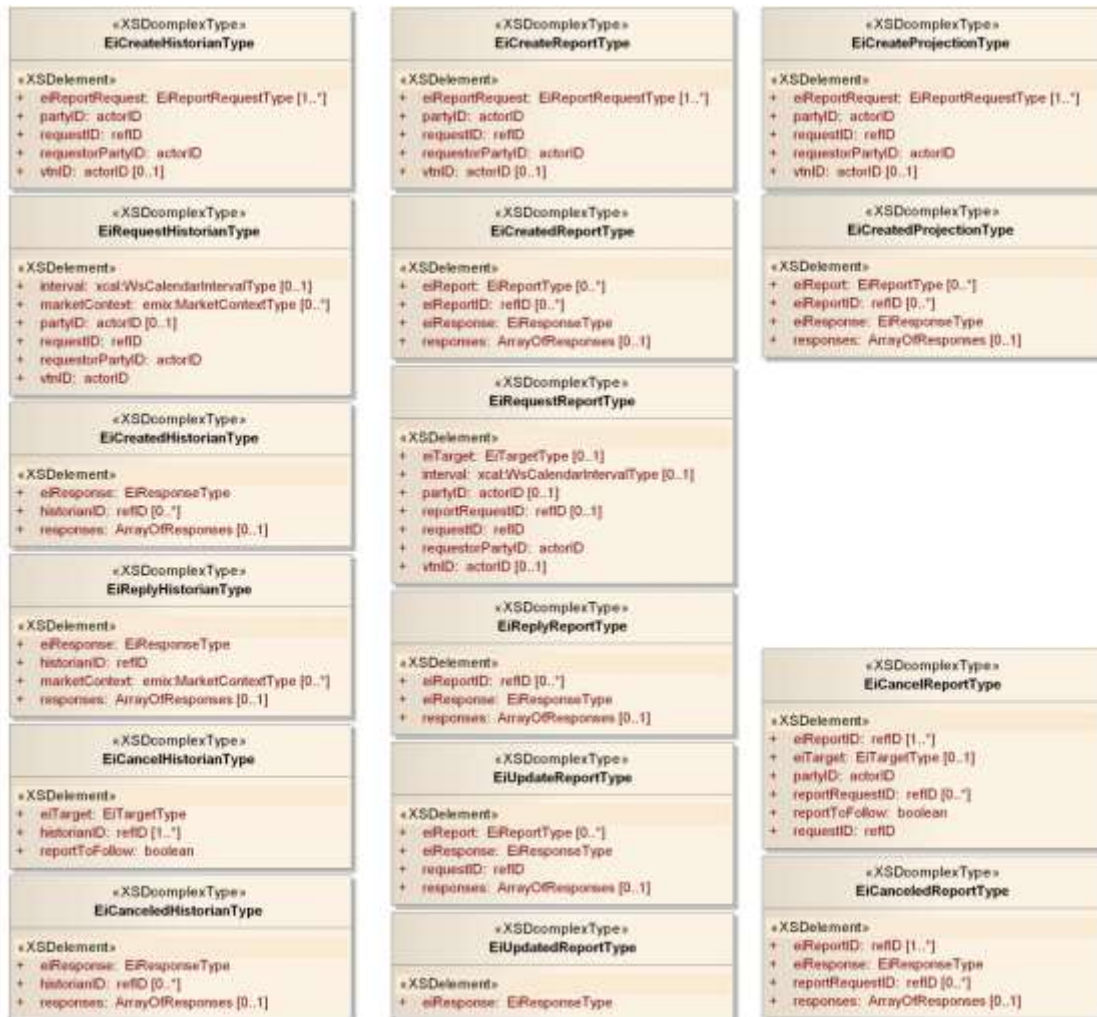
1833   *Figure 10-8: UML Class Diagram for all EiReportService Operation Payloads*

11 Event Support Services

Users of **[OpenADR]** found that they needed to be able to constrain the application of remote DR services. For The DR Operator, advanced knowledge of these constraints improved the ability to predict results. The services in this section are based on the services used to tailor expectations in **[OpenADR]**.

Availability and Opt are similar in that they communicate when a Party is willing to receive an Event. Availability is a long-term schedule for when a Party will consider a response. Availability could be set in the Market Context or at program enrollment. Opt (as in *opt in* or *opt out*) encompasses short-term additions to or replacement of the schedule in Availability.

The combination of Availability and Opt states together define the times during which a committed response from the VEN is possible or likely.

11.1 Relationship of Availability and Opt Information

Availability and Opt apply to interactions where an action is requested (e.g. curtailment and DER actions), and only indirectly to (e.g.) price distribution interactions.

Availability is a long-term description and may be complex. Opt is a short-term description that replaces or is combined into the long-term availability description.

Availability and Opt-In and Opt-Out, as well as Market Rules, use the *VavailabilityType* defined in **[WS-Calendar]** which in turn is an XML serialization of **[Vavailability]**. The semantics are defined in **[Vavailability]**.

The behavior of the Availability schedule is defined as follows. We call the parameter passed for Opt-In and Opt-Out the *Opt Vavailability*.

- The EiAvailability class describes when the VEN expects/commits/plans to be available to respond to a request for performance, generally an EiEvent.
- Exactly one *Vavailability* is included in the *EiAvailability* and the *EiOpt* objects.
- An *EiOpt* that is used in a message MUST have a bounded interval (the *Opt Interval*) in the *Opt Vavailability*[8]
- An **Opt-In** while in effect adds the available times of the *Opt Vavailability* to the available times in the bounded interval for the VEN with respect to a MarketContext, effectively performing a logical OR operation on the available times but only within the opt Interval
- An **Opt-Out** while in affect replaces the entire portion of the EiAvailability within the opt interval
- Exactly zero or one Opt functions MAY be in effect at any time

In short, Opt-In adds the *Opt Vavailability* available times to the overall VEN vavailability; Opt-Out replaces the entirety of its *opt Intervals* with the contents of the Opt-Out Vavailability.

11.2 EiAvail Service

The Availability[9] is set by the VEN and indicates when an event may or may not be accepted and executed by the VEN with respect to a Market Context. Knowing the Availability and Opt information for its VENs improves the ability of the VTN to estimate response to an event or request.

When Availability is set, opt-in or opt-out does not affect the Availability except for the specific interval(s) described by the Opt—opting out is temporary unavailability, which may have transaction and business consequences if an event is created during the opt-out period.

The modeling for Availability includes behavior indications for the situation where an EiEvent overlaps a constrained time interval.

---

[8] By defining an end time for the *Vavailability*

[9] Called *Constraints* in **[OpenADR1]**

1875 EiAvailability describes only the available times, using the patterns defined in **[WS-Calendar]** and
1876 **[Vavailability]**.

1877 *Table 11-1: Avail Service*

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiAvail	EiCreateAvail	EiCreatedAvail	VEN	VTN	Create an Avail for this VEN; return the AvailID
EiAvail	EiRequestAvail	EiReplyAvail	VEN	VTN	Request Avail information for this VEN; request semantics with no time Interval
EiAvail	EiCancelAvail	EiCanceledAvail	VEN	VTN	Cancel the Avail referenced by the AvailID

1878 The element EiAvailBehavior defines how an issued EiEvent that conflicts with the current EiAvail is
1879 performed:

1880   • ACCEPT – accept the issued EiEvent regardless of conflicts with the EiAvail

1881   • REJECT – reject any EiEvent whose schedule conflicts with the EiAvail

1882   • RESTRICT – modify the EiEvent parameters so that they fall within the bounds of the EiAvail

1883 11.2.1 Interaction Patterns for the EiAvail Service

1884 This is the **[UML]** interaction diagram for the EiAvail Service.
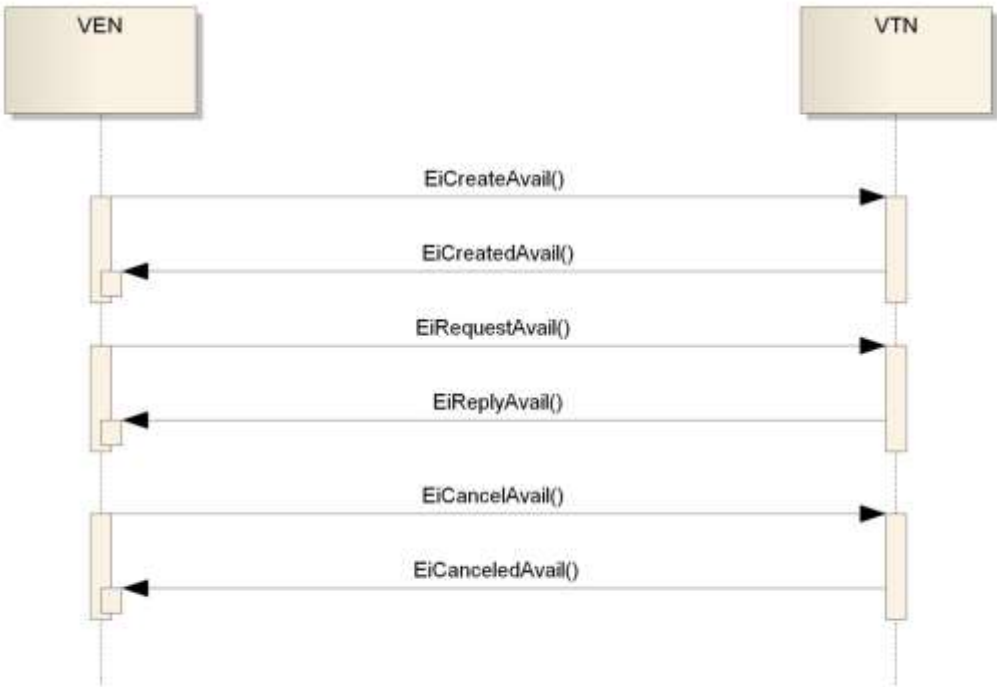
1885

1886 *Figure 11-1: Interaction Pattern for the EiAvailability Service.*

1887

11.2.2 Information Model for the EiAvail Service

1889

1890 *Figure 11-2: UML Class Diagram for the EiAvail Type*

1891

11.2.3 Operation Payloads for the EiAvail Service

1893   The **[UML]** class diagram describes the payloads for the EiAvail service operations.

1894

1895   *Figure 11-3: UML Class Diagram for EiAvail Service Operation Payloads*

11.3 EiOpt Service

The Opt service creates and communicates Opt-In and Opt-Out schedules from the VEN to the VTN. Schedules are combined with EiAvailability and the Market Context requirements to give a complete picture of the willingness of the VEN to respond to EiEvents received by the VEN.

- Exactly one Vavailability MUST be provided in EiCreateOptIn and EiCreateOptOut.
- Opt schedules SHALL override any Availability in place while there is an Opt in effect. See Section 11.1

Applying EiCreateOptIn or EiCreateOptOut if an Opt is currently in effect replaces the current Opt in effect with that in the Opt Vavailability, which effectively cancels the current Opt state and Creates a new one.

Table 11-2: Opt Service

Service	Operation	Response	Service Consumer	Service Provider	Notes
EiOpt	EiCreateOpt	EiCreatedOpt	VEN	VTN	Create and send an Opt, receiving an Opt ID
EiOpt	EiRequestOpt	EiReplyOpt	VEN	VTN	Request the Opts from the VTN that are currently in effect, at most one per Market Context.
EiOpt	EiCancelOpt	EiCanceledOpt	VEN	VTN	Cancel the identified Opt

11.3.1 Interaction Patterns for the EiOpt Service

This is the **[UML]** interaction diagram for the EiOpt Service.
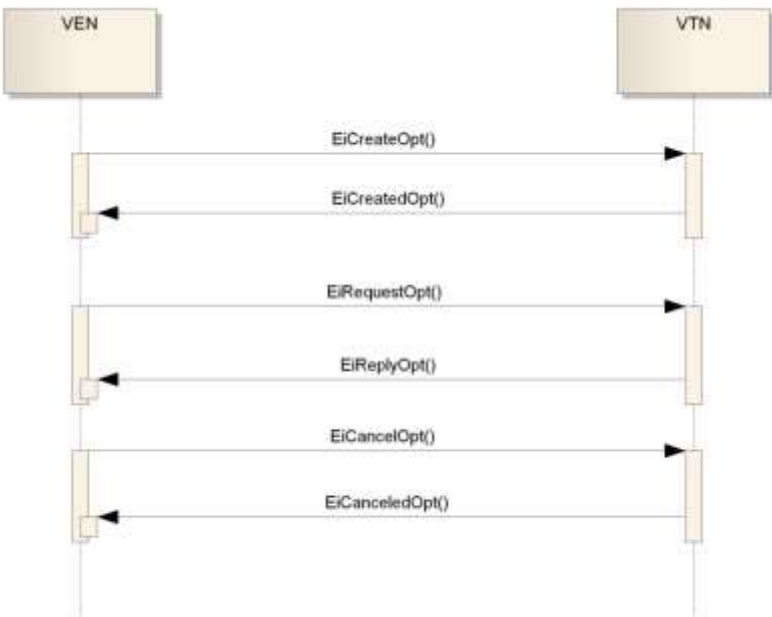
Figure 11-4: Interaction Diagram for the EiOpt Service

11.3.2 Information Model for the EiOpt Service

1911 Opting in or out is a temporary situation indicating that the VEN will or will not respond to a an event or in
1912 a specific time period, without changing the potentially complex Availability. The *EiOpt* schedule is a **[WS-**
1913 **Calendar]** VavailabilityType.

1914

1915 *Figure 11-5: UML Class Diagram for EiOpt Type*

11.3.3 Operation Payloads for the EiOpt Service

1917   The **[UML]** class diagram describes the payloads for the EiOpt service operations.

```
«XSDcomplexType»
EiCreateOptType

«XSDelement»
+   eiOpt: EiOptType
```

```
«XSDcomplexType»
EiCreatedOptType

«XSDelement»
+   eiResponse: EiResponseType
+   optID: refID [0..1]
```

```
«XSDcomplexType»
EiCancelOptType

«XSDelement»
+   optID: refID
+   venID: actorID
```

```
«XSDcomplexType»
EiCanceledOptType

«XSDelement»
+   eiResponse: EiResponseType
+   optID: refID
```

```
«XSDcomplexType»
EiRequestOptType

«XSDelement»
+   marketContext: emix:MarketContextType [0..1]
+   optID: refID
+   requestID: refID
+   requestorPartyID: actorID
+   resourceID: uid [0..1]
+   venID: actorID
```

```
«XSDcomplexType»
EiReplyOptType

«XSDelement»
+   eiOpt: EiOptType [0..*]
+   eiResponse: EiResponseType
+   venID: actorID
+   vtnID: actorID
```

1918

1919   *Figure 11-6: UML Class Diagram for EiOpt Service Operation Payloads*

12 Market Information

1921 Each Event and Service in Energy Interoperation takes place within a Market Context. This Context
1922 defines the behaviors that that each Party can expect from the other.

12.1 The Market Context

1924 Market Contexts are used to express market information that rarely changes, and thereafter not need to
1925 communicate it with each message.

1926 In any market context, there are standing terms and expectations about product offerings. If these
1927 standing terms and expectations are not known, many exchanges may need to occur before finding
1928 products that meet those expectations. If these expectations are only known through local knowledge,
1929 then then national and international products need to be re-configured for each local market that they
1930 enter. If all market information were to be transmitted in every information exchange, messages based on
1931 EMIX would be overly repetitious.

1932 As described in Section 5.2 "Market Context", The EI Market Contexts is a super-set of the **[EMIX]**
1933 Standard Terms, and they can be referenced using the EMIX Market Context as an identifier. The EMIX
1934 Market Context is expressed as an URI.

12.2 Market Context Service

1936 The Market Context Service enables a Party to request the details of a Market Context. These MAY be
1937 mandatory in many of today's interactions. Parties MAY be able to request and compare Market Contexts
1938 to select which markets to participate in. Such Interactions are out of scope for this specification.

1939

1940 *Figure 12-1: Sequence diagram for Market Context service*

1941 The Market Context service can retrieve the full information in an EiMarketContext given the identifier, an
1942 EMIX Market Context. There is one operation and a responding operation.

1943 *Table 12-1: Market Context Service*

Service	Operation	Response	Service Consumer	Service Provider	Notes

EiMarketContext	EiRequest MarketContext	EiReply MarketContext	Party	Party	Respond with the full EiMarketContext for each EMIX Market Context sent.

1944

12.3 Information Model for the EiMarketContext Service

1946

1947   *Figure 12-2: UML Class Diagram for Market Context*

12.4 Operation Payloads for the EiMarket Context Service

«XSDcomplexType»
EiRequestEiMarketContextType

«XSDelement»
+ marketContext: emix:MarketContextType [1..*]
+ partyID: actorID [0..1]
+ requestID: refID
+ resourceID: uid [0..*]
+ venID: actorID [0..1]
+ vtnID: actorID [0..1]

«XSDcomplexType»
EiReplyEiMarketContextType

«XSDelement»
+ eiResponse: EiResponseType
+ responses: ArrayOfResponses [0..1]

1949

1950   *Figure 12-3: UML of Market Context Service payloads*

13 Security and Composition [Non-Normative]

This section describes the enterprise software approach to security and composition as applied to this Energy Interoperation specification.

Service orientation has driven a great simplification of interoperation, wherein software is no longer based on Application Programming Interfaces (APIs) but is based on exchange of information in a defined pattern of services and service operations **[SOA-RM]**.

The approach for enterprise software has evolved to defining key services and information to be exchanged, without definitively specifying how to communicate with services and how to exchange information—there are many requirements for distributed applications in many environments that cannot be taken into account in a service and information standard. To make such choices is the realm of other standards for specific areas of practice, and even there due care must be taken to avoid creating a monoculture of security.[10]

13.1 Security and Reliability Example

Different interactions require different choices for security, privacy, and reliability. Consider the following set of specifics. (This figure is here repeated and re-labeled.)
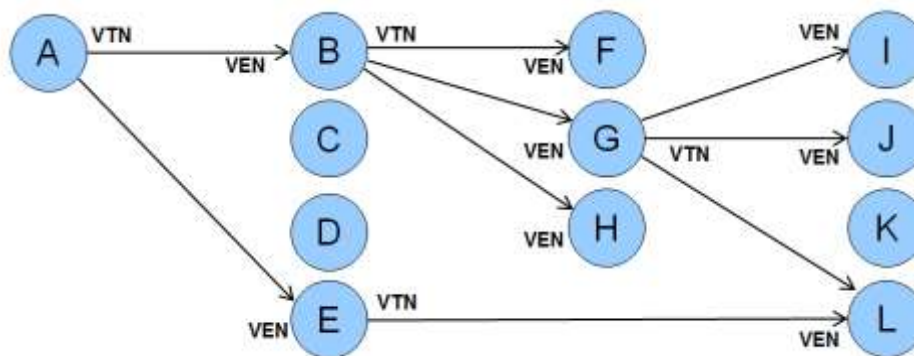
Figure 13-1: Web of Example DR Interactions

We specifically model a Reliability DR Event initiated by the Independent System Operator[11] A, who sends a reliability event to its first-level aggregators B through E. Aggregator B, in turn invokes the same service on its customers (say real estate landlords) F, G, and H.

Those customers might be industrial parks with multiple facilities, real estate developments with multiple tenants, or a company headquarters with facilities in many different geographical areas, which would invoke the same operation on their VENs.

For our example, say that G is a big-box store regional headquarters and I, J, and L are their stores in the affected area.

Each interaction will have its own security and reliability composed as needed—the requirements vary for specific interactions. For example

- For service operations between A to B, typical implementations include secure private frame-relay networks with guaranteed high reliability and known latency. In addition, rather than relying on the highly reliable network, in this case A requires an acknowledgment message from B back to A proving that the message was received.

---

[10] See e.g. the STUXNET worm effects on a monoculture of software SCADA systems, 2010. See http://en.wikipedia.org/wiki/Stuxnet

[11] Using North American Terminology.

1982	•	From the perspective of the ISO, the communication security and reliability between B and its
1983		customers F, G, and H may be purely the responsibility of B, who in order to carry out B's
1984		transaction commitments to A will arrange its business and interactions to meet B's business
1985		needs.
1986	•	G receives the signal from aggregator B. In the transaction between G and B, there are service,
1987		response, and likely security and other requirements. To meet its transactional requirements, the
1988		service operations between B and G will be implemented to satisfy the business needs of both B
1989		and G. For our example, they will use the public Internet with VPN technology and explicit
1990		acknowledgement, with a backup of pagers and phone calls in the unlikely event that the primary
1991		communication fails. And each message gets an explicit application level acknowledgement.
1992	•	Security between B and G depends on the respective security models and infrastructure
1993		supported by B and G—no one size will fit all. So that security will be used for that interaction
1994	•	The big box store chain has its own corporate security architecture and implementation, as well
1995		as reliability that meets its business needs—again, no one size will fit all, and there is tremendous
1996		variation; there is no monoculture of corporate security infrastructures.
1997	•	Store L has security, reliability, and other system design and deployment needs and
1998		implementations within the store. These may or may not be the same as the WAN connection
1999		from regional headquarters G, and in fact are typically not the same (although some security
2000		aspects such as federated identity management and key distribution might be the same).
2001	•	Store L also has a relationship with aggregator E, which for this example is Store L's local utility;
2002		the Public Utility Commission for the state in which L is located has mandated (in this example)
2003		that all commercial customers will use Energy Interoperation to receive certain mandated signals
2004		and price communications from the local utility. The PUC, the utility, and the owner of the store L
2005		have determined the security and reliability constraints. Once again, one size cannot fit all—and if
2006		there were one "normal" way to accommodate security and reliability, there will be a different
2007		"normal" way in different jurisdictions.

2008   So for a simple Demand Response event distribution, we have potentially four different security profiles

2009   The following table has sample functional names for selected nodes.

2010   *Table 13-1: Interactions and Actors for Security and Reliability Example*

Label	Structure Role	Possible Actor Names
A	VTN	*System Operator*
B	VEN (wrt A), VTN (wrt F, G, H)	*Aggregator*
G	VEN (wrt B), VTN (wrt I, J, L)	*Regional Office*
L	VEN (wrt G and wrt E)	*Store*
E	VEN (wrt A, VTN wrt L)	*Local Utility*

2011   *(Note: wrt means "with respect to")*

13.2 Composition

2012

2013   In state-of-the art software architecture, we have moved away from monolithic implementations and
2014   standards to ones that are composed of smaller parts. This allows the substitution of a functionally similar
2015   technology where needed, innovation in place, and innovation across possible solutions.

2016   In the rich ecosystem of service and applications in use today, we *compose* or (loosely) *assemble*
2017   applications rather than craft them as one large thing. See for example OASIS Service Component
2018   Architecture **[OASIS SCA]**, which addresses the assembly, substitution, and independent evolution of
2019   components.

2020 A typical web browser or email system uses many standards from many sources, and has evolved rapidly
2021 to accommodate new requirements by being structured to allow substitution. The set of standards
2022 (information, service, or messaging) is said to be *composed* to perform the task of delivery of email.
2023 Rather than creating a single application that does everything, perhaps in its own specific way, we can
2024 use components of code, of standards, and of protocols to achieve our goal. This is much more efficient
2025 to produce and evolve than large integrated applications such as older customized email systems.

2026 In a similar manner, we say we *compose* the required security into the applications—say an aspect of
2027 OASIS **[WS-Security]** and OASIS Security Access Markup Language **[SAML]**—and further *compose* the
2028 required reliability, say by using OASIS **[WS-ReliableMessaging]** or perhaps the reliable messaging
2029 supported in an Enterprise Service Bus that we have deployed.

2030 A service specification, with specific information to be exchanged, can take advantage of and be used in
2031 many different business environments without locking some in and locking some out, a great benefit to
2032 flexibility, adoption, and re-use.

13.3 Energy Interoperation and Security

2034 In this section we describe some specific technologies and standards in our palette for building a secure
2035 and reliable implementation of Energy Interoperation. Since Energy Interoperation defines only the core
2036 information exchanges and services, and other technologies are composed in, there is no optionality
2037 related to security or reliability required or present in Energy Interoperation.

2038 The information model in Energy Interoperation 1.0 is just that—an information model without security
2039 requirements. Each implementation must determine the security needs (outside the scope of this
2040 standard) broadly defined, including privacy (see e.g. OASIS Privacy Management Reference
2041 Model**[PMRM]**), identity (see e.g. OASIS Identity in the Cloud, OAISIS Key Management Inteoperability,
2042 OASIS Enterprise Key Management Infrastructure, OASIS Provisioning Services, OASIS Web Services
2043 Federation TC, OASIS Web Services Secure Exchange and more)

2044 Energy Interoperation defines services together with service operations, as is now best practice in
2045 enterprise software. The message payloads are defined as information models, and include such artifacts
2046 as Energy Market Information Exchange **[EMIX]** price and product definition, tenders, and transactions,
2047 the EiEvent artifacts defined in this specification, and all information required to be exchanged for price
2048 distribution, program event distribution, demand response, and distributed energy resources.

2049 This allows the composition and use of required interoperation standards without restriction, drawing from
2050 a palette of available standards, best practices, and technologies. The requirements to be addressed for
2051 a deployment are system issues and out of scope for this specification.

2052 As in other software areas, if a particular approach is commonly used, then a separate standard (or
2053 standardized profile) may be created. In this way, WS-SecureConversation composes WS-Reliability and
2054 WS-Security.

2055 So Energy Interoperation defines the exchanged information, the services and operations, and as a
2056 matter of scope and broad use does not address any specific application as the security, privacy,
2057 performance, and reliability needs cannot be encompassed in one specification. Many of the TCs named
2058 above have produced OASIS Standards,

2059 (SEE http://www.oasis-open.org/committees/tc_cat.php?cat=security)

14 Profiles [Normative]

2061 These sections define the three normative profiles that are part of Energy Interoperation 1.0.

2062 A profile includes a selection of interfaces, services, and options for a particular purpose.

14.1 OpenADR [Normative]

2064 The OpenADR Profile defines the services required to implement functionality similar to that in
2065 **[OpenADR]**. The inclusion of the Energy Interoperation structure of VTNs and VENs, as well as use of
2066 the Energy Market Information Exchange **[EMIX]** cross-cutting price and product definition standard and
2067 WS-Calendar **[WS-Calendar]** based on the IETF **[iCalendar]** RFC updates and gives a broader range of
2068 applicability in what has been described as the *OpenADR 2 Profile*.

2069 We present in simplified tabular form the Energy Interoperation services required as part of the OpenADR
2070 Profile. When a service is included, all of the listed operations are included, so we list only the service
2071 name and the section of this document.

2072 *Table 14-1: Services used in OpenADR Profile*

Service	Section	Notes
EiRegisterParty	7.1	Register to identify and receive information
EiQuote	7.2	EiDistributeQuote for distributing dynamic prices (push), other operations for pull including block and tier tariff communication
EiEvent	9	The core event functions and information models
EiReport	10	The ability to set periodic or one-time information on the state of a Resource
EiAvail	11.2	Constraints on the possible time a Resources is available or not
EiOpt	11.3	Overrides the EiAvail; addresses short-term changes in availability
EiEnroll	8	Used to enroll a Resource for participation in Events.
EiMarketContext	12.2	Used to discover program rules, standard reports, etc.

2073

14.2 TeMIX [Normative]

2075 The Transactive EMIX (TeMIX) Profile defines the services required to implement functionality for energy
2076 market interactions.

2077 We present in simplified tabular form the Energy Interoperation services required as part of the TeMIX
2078 Profile. When a service is included, all of the listed operations are required, so we list only the service
2079 name and the section of this document.

2080 *Table 14-2: Services used in TeMIX Profile*

Service	Section	Notes
EiRegisterParty	7.1	Register to identify and receive information
EiQuote	7.2	EiDistributeQuote for distributing dynamic prices (push), other components for pull

Service	Section	Notes
EiTender	7.2	The basic offer of agreement is called a tender
EiTransaction	7.3	The core services to reach agreement
EiEnroll	8	Used to enroll a Resource for participation in Events.
EiMarketContext	12.2	Used to discover program rules, standard reports, etc.
EiDelivery	7.4.1	Post-Transaction delivery information

2081

14.3 Price Distribution [Normative]

2082

2083 Many current initiatives envision Price Distribution as a separate Profile requiring neither transactive
2084 energy nor event-based interactions. The Price Distribution profile defines the minimal set of services
2085 required to interact with a pure Price Distribution context.

2086 We present in simplified tabular form the Energy Interoperation services required as part of the Price
2087 Distribution Profile. When a service is included, all of the listed operations are required, so we list only the
2088 service name and the section of this document.

2089 *Table 14-3: Services used in Price Distribution Profile*

Service	Section	Notes
EiRegisterParty	7.1	Register to interact with other Parties
EiQuote	7.2	EiDistributeQuote for distributing dynamic prices (push), other components for pull
EiEnroll	8	Used to enroll in a Market to receive Price Distribution.
EiMarketContext	12.2	Used to discover program rules, standard terms, etc.

2090

15 Conformance and Processing Rules for Energy Interoperation

15.1 Conformance for Energy Interoperation

We define four conformance points for Energy Interoperation 1.0, modified by the networking technology used

- Full Conformance
- Conformance

And further define

- Conformance to a Named Profile
- Conformance with Alternate Interoperation

In this section Named Profile is one of the profiles defined in Section 14 *"Profiles [Normative]"*.

15.1.1 General Conformance Requirements

The version of Energy Interoperation to which conformance is claimed MUST be specified in the implementation's conformance statement.

Any extension(s) used by the implementation, whether of information structures, services, service operations, or payloads MUST be described in the Implementation's conformance statement including the service operations, payloads, and information artifacts.

The phrase "support all XML artifacts" includes the support of XML artifacts as extended; similarly, message headers (SOAP Headers for Web services) MAY be extended as needed to compose other technologies including but not limited to reliability and security. The payloads defined in this specification are for required information exchanges, and a Conforming implementation MAY extend the data types, payloads, or message headers appropriate to their transport/networking as necessary. It is required that those extensions, restrictions, and so forth be documented in the conformance statement.

15.1.2 Full Conformance to Energy Interoperation

An implementation claiming **Full Conformance to Energy Interoperation 1.0** MUST do all of the following as defined in this Work Product including specification, schemas, and WSDL files:

- Implement all services and service operations ("Services and Operations")
- Support all XML artifacts as defined in the schemas ("XML")
- Interoperate using Web services and the **[WSDL]** files ("Web Services Interoperation")
- Conform to all of Sections 13.2 through the end of Section 13 ("Additional Conformance")
- Describe how any relevant XML artifacts are derived from the Work Product

It is RECOMMENDED that interoperation be achieved using the WSI Basic Profile **[WSI-Basic]**

15.1.3 Conformance to Energy Interoperation

An implementation claiming **Conformance to Energy Interoperation 1.0** MUST do all of the following as defined in this Work Product including specification, schemas, and WSDL files:

- Interoperate using Web services and the **[WSDL]** files ("Web Services Interoperation")
- Conform to all of Sections 13.2 through the end of Section 13 ("Additional Conformance")
- Describe how any relevant XML artifacts are derived from the Work Product

In addition, if the application claiming conformance does not support one or more Services or Operations as defined in this specification, then the conformance statement for the implementation must:

- List all Services and Operations that are supported in the implementation.
- List all Services and Operations that are not supported in the implementation.

2133 • For each Operation that is not supported, define the error response that will be returned if
2134 invoked.

2135 For those operations that are supported by an implementation, but whose use or semantics are restricted,
2136 a conforming implementation SHALL

2137 • List the subset of XML artifacts as defined by the schemas used in the implementation
2138 • List the subset of XML artifacts as defined by the schemas that are not used in the specification
2139 • State any restrictions, i.e., in cardinality or optionality, that is applied to artifacts defined herein

15.1.4 Full Conformance with Alternate Interoperation to Energy Interoperation

2142 An implementation claiming **Full Conformance with Alternate Interoperation to Energy Interoperation**
2143 **1.0** MUST be able to claim **Full Conformance to Energy Interoperation**, except that networking
2144 technologies other than Web services MAY be used by the implementation. A description of networking
2145 technologies used MUST be included in the implementation's conformance statement.

2146 An implementation MAY claim Full Conformance as well as Full Conformance with Alternate
2147 Interoperation. The Conformance statement MUST describe the extensions or departures from Full
2148 Conformance.

15.1.5 Conformance with Alternate Interoperation to Energy Interoperation

2150 An implementation claiming **Conformance with Alternate Interoperation to Energy Interoperation 1.0**
2151 MUST be able to claim **Conformance to Energy Interoperation**, except that networking technologies
2152 other than Web services MAY be used by the implementation. A description of networking technologies
2153 used MUST be included in the implementation's conformance statement.

2154 An implementation MAY claim Conformance as well as Conformance with Alternate Interoperation. The
2155 Conformance statement MUST describe the extensions or departures from Full Conformance.

15.1.6 Conformance to Named Profiles of Energy Interoperation

2157 In this section Named Profile refers to one of the profiles defined in Section 14 *"**Profiles [Normative]**"*.

15.1.6.1 Full Conformance to a Named Profile of Energy interoperation

2159 An implementation claiming **Full Conformance to a Named Profile of Energy Interoperation** MUST be
2160 able to claim **Full Conformance to Energy Interoperation** excepting only the following:

2161 • Services and Operations in sections not included in the named Profile as defined in Section 14
2162 [wd35 – should be link]

2163 It is RECOMMENDED that Web services interoperation be achieved using the WSI Basic Profile **[WSI-**
2164 **Basic]**

15.1.6.2 Conformance to a Named Profile of Energy interoperation

2166 An implementation claiming **Conformance to a Named Profile of Energy Interoperation** MUST be able
2167 to claim **Conformance to Energy Interoperation** excepting only the following:

2168 • Services and Operations in sections not included in the named Profile

2169 It is RECOMMENDED that Web services interoperation be achieved using the WSI Basic Profile **[WSI-**
2170 **Basic]**

15.1.6.3 Full Conformance or Conformance with Alternate Interoperation to a Named Profile

2173 An implementation claiming **Conformance with Alternate Interoperation** or **Full Conformance with**
2174 **Alternate Interoperation to a Named Profile of Energy Interoperation** MUST be able to claim the

2175 respective **Full Conformance with Alternate Interoperation** or **Conformance with Alternate**
2176 **Interoperation to Energy Interoperation** excepting only the following:

2177 • Services and Operations in sections not included in the Named Profile

2178 In addition, interoperation payloads MUST be used as defined or extended; in the event that payloads are
2179 extended a description of the extension(s) SHALL be included in the Implementation's conformance
2180 statement.

15.2 Conformance with the Semantic Models of EMIX and WS-Calendar

2183 This section specifies conformance with the semantic models of **[EMIX]** and **[WS-Calendar]**. Energy
2184 Interoperation is strongly dependent on each of these information models.

2185 **[WS-Calendar]** is a general specification and makes no assumptions about how its information model is
2186 used. **[WS-Calendar]** has specific rules which define Inheritance as a means to reduce the conveyance
2187 of repetitive information. As this specification constrains schedule communications to specific business
2188 interactions, these inheritance rules are extended to embrace rules of interaction and rules of process
2189 that further reduce the information that must be expressed in each interval.

2190 Implementations of Energy Interoperation SHALL conform to the rules of **[WS-Calendar]** and **[EMIX]**.
2191 These rules include the following conformance types:

2192 • Conformance to the *inheritance rules* in **[WS-Calendar]**, including the direction of inheritance

2193 • *Specific attributes* for each type that MUST or MUST NOT be inherited.

2194 • *Conformance rules* that Referencing Specifications MUST follow

2195 • Description of *Covarying attributes* with respect to the Reference Specification

2196 • *Semantic Conformance* for the information within the Artifacts exchanged.

2197 • Conformance to the *inheritance rules* in **[EMIX]**, including inheritance of Product Definitions and
2198 Standard Terms.

2199 Energy Interoperation implementations also use the EMIX Products and Resources also extend the
2200 Inheritance patterns of **[WS-Calendar]** as specified in the EMIX information model. We address each of
2201 these in the following sections.

15.2.1 Recapitulation of Requirements from WS-Calendar and EMIX

2203 **[WS-Calendar]** uses the term Sequence to refer to one or more Intervals with Temporal Relations
2204 defined between them that may inherit from zero or more Gluons. **[EMIX]** introduced the term Schedule to
2205 refer to Product Descriptions applied to a Sequence. Streams recapitulate these rules with specific
2206 addenda as they include both Gluon and Sequence.

15.2.1.1 Specific Attribute Inheritance within Schedules

2208 The rules that define inheritance, including direction in **[WS-Calendar]**, are recapitulated.

2209 **I1: Proximity Rule** Within a given lineage, inheritance is evaluated though each Parent to the Child
2210 before what the Child bequeaths is evaluated.

2211 **I2: Direction Rule** Intervals MAY inherit attributes from the nearest Gluon subject to the Proximity Rule
2212 and Override Rule, provided those attributes are defined as Inheritable.

2213 **I3: Override Rule** If and only if there is no value for a given attribute of a Gluon or Interval, that Gluon or
2214 Interval SHALL inherit the value for that attribute from its nearest Ancestor in conformance to the
2215 Proximity Rule.

2216 **I4: Comparison Rule** Two Sequences are equivalent if a comparison of the respective Intervals
2217 succeeds as if each Sequence were fully Bound and redundant Gluons are removed.

2218 **I5: Designated Interval Inheritance** [To facilitate composition of Sequences] the Designated Interval in
2219 the ultimate Ancestor of a Gluon is the Designated Interval of the composed Sequence. Special
2220 conformance rules for Designated Intervals apply only to the Interval linked from the Designator Gluon.

2221 **I6: Start Time Inheritance** When a start time is specified through inheritance, that start time is inherited
2222 only by the Designated Interval; the start times of all other Intervals are computed through the durations
2223 and temporal; relationships within the Sequence. The Designated Interval is the Interval whose parent is
2224 at the end of the lineage. In Events, the Active Interval is the Designated Interval.

15.2.1.2 Time Zone Specification

2226 The time zone MUST be explicitly known in any conforming Energy Interoperation artifact.

2227 This may be accomplished in two ways:

- 2228 The time, date, or date and time MUST be specified using **[ISO8601]** utc-time (also called
  2229 *zulu time*)
- 2230 The **[WS-Calendar]** Time Zone Identifier, TZID, MUST be in the Lineage of the artifact, as
  2231 extended by the Market Context. Generally, the Market Context acts as a Gluon
  2232 bequeathing the TZID. See Section 15.3 below.

2233 If neither expression is included, the Artifact does not conform to this specification and its attempted use
2234 in information exchanges MUST result in an error condition.

15.2.1.3 Specific Rules for Optimizing Inheritance

2236 If the Designated Interval in a Series has a Price only, all Intervals in the Sequence have a Price only and
2237 there is no Price in the Product.

- 2238 If the Designated Interval in a Series has a Quantity only, all Intervals in the Sequence have a
  2239 Quantity only and there is no quantity in the Product.
- 2240 If the Designated Interval in a Series has a Price & Quantity, all Intervals in the Sequence MUST
  2241 have a Price and Quantity and there is neither Price not Quantity in the Product.

15.3 TeMIX Conformance

2243 The TeMIX Profile MUST apply the conformance rules for TeMIX described in **[EMIX]**.

15.4 Inheritance within Events

2245 For purposes of processing, inheritance, and conformance, Signal Information is treated as an **[EMIX]**
2246 Product Description, applied to a Sequence, and the Active Period is considered as a **[WS-Calendar]**
2247 Schedule. The Streams in Signals and Event-linked Reports inherit from the Active Interval as if it were a
2248 Gluon.

2249 Signals within an Event arrive in a setting established by a Market Context. Within an event, there may be
2250 multiple Signal types. For purposes of inheritance, An Event may include multiple Stream-derived
2251 information elements each with an associated Sequence. For purposes of processing, the body of the
2252 Stream is treated as a [WS-Calendar] Gluon, and the Signal Information in each Interval in the Sequence
2253 inherits from that Gluon.

2254 Each Specifies a Market Context. If that Market Context is associated with Standard Terms, then those
2255 Terms enter the Lineage of the Schedule and are inherited by each Interval. Standard Terms associated
2256 with a Market Context enter the Lineage of the Schedule as if the Market Context were a Gluon. Product
2257 Description, TZID, Level Definition, Terms, et al. can be inherited in this way.

15.4.1 Sequence Optimization within Events

2259 As described in 4.3.2 "Conformance of Streams to WS-Calendar", Signals, Reports, and Baselines MUST
2260 conform to WS-Calendar.

15.5 Version Conformance

Implementations that use the Schema Version attribute, and that claim full conformance to this specification, MAY use the use the value "1.0.2011.11" for that attribute.

energyinterop-v1.0-cos01 2013wd42

Standards Track Work Product

19 December
18 May 2014
Copyright © OASIS Open 20132014. All Rights Reserved.

Page 138 of 152

Appendix A. Background and Development history

2265 There is a significant disconnect between customer load and the value of energy. The demand is not
2266 sensitive to supply constraints; the load is not elastic; and the market fails to govern consumer behavior.
2267 In particular, poor communications concerning high costs at times of peak use cause economic loss to
2268 energy suppliers and consumers. There are today a limited number of high demand periods (roughly ten
2269 days a year, and only a portion of those days) when the failure to manage peak demand causes immense
2270 costs to the provider of energy; and, if the demand cannot be met, expensive degradations of service to
2271 the consumer of energy.

2272 As the proportion of alternative energies on the grid rises, and more energy comes from intermittent
2273 sources, the frequency and scale of these problems will increase and there will be an increasing need for
2274 24/7 coordination of supply and demand. In addition, new electric loads such as electric vehicles will
2275 increase the need for electricity and with new load characteristics and timing.

2276 Energy consumers can use a variety of technologies and strategies to shift energy use to times of lower
2277 demand as well as to reduce use during peak periods. This shifting and reduction can reduce the need for
2278 new power plants, and transmission and distribution systems. These changes will reduce the overall
2279 costs of energy through greater economic efficiency. This process is known by various names, including
2280 load shaping, demand shaping, and demand response (DR). Consistent interfaces and messages for DR
2281 is a high priority cross-cutting issue identified in the NIST Smart Grid Interoperability Roadmap.

2282 Distributed energy resources, including generation and storage, now challenge the traditional hierarchical
2283 relationship of supplier and consumer. Alternative and renewable energy sources may be located closer
2284 to the end nodes of the grid than traditional bulk generation, or even within the end nodes. Wind and solar
2285 generation, as well as industrial co-generation, allow end nodes to sometimes supply. Energy storage,
2286 including mobile storage in plug-in hybrid vehicles, means that even a device may be sometimes a
2287 supplier, sometime a customer. As these sources are all intermittent, they increase the challenge of
2288 coordinating supply and demand to maintain the reliability of the electric grid. These resource, with their
2289 associated issues, are generally named distributed energy resources (DER). The NIST Smart Grid
2290 Interoperability Roadmap, this specification, and **[EMIX]** see a continuum between DR and DER.

2291 Better communication of energy prices addresses growing needs for lower-carbon, lower-energy
2292 buildings, net zero-energy systems, and supply-demand integration that take advantage of dynamic
2293 pricing. Local generation and local storage require that the consumer (in today's situation) make
2294 investments in technology and infrastructure including electric charging and thermal storage systems.
2295 People, buildings, businesses and the power grid will benefit from automated and timely communication
2296 of energy prices, capacity information, and other grid information.

2297 Consistency of interface for interoperation and standardization of data communication will allow
2298 essentially the same model to work for homes, small businesses, commercial buildings, office parks,
2299 neighborhood grids, and industrial facilities, simplifying interoperation across the broad range of energy
2300 providers, distributors, and consumers, and reducing costs for implementation.

2301 These communications will involve energy consumers, producers, transmission systems, and distribution
2302 systems. They must enable aggregation of production, consumption, and curtailment resources. These
2303 communications must support market makers, such as Independent System Operators (ISOs), utilities,
2304 and other evolving mechanisms while maintaining interoperation as the Smart Grid evolves. On the
2305 consumer side of these interfaces, building and facility agents will be able to make decisions on energy
2306 sale, purchase, and use that fit the goals and requirements of their home, business, or industrial facility.

2307 The new symmetry of energy interactions demands symmetry of interaction. A net consumer of energy
2308 may be a producer when the sun is shining, the wind is blowing, or an industrial facility is cogenerating[12].

---

[12] Cogeneration refers the combined generation of multiple energy resources, i.e., a boiler that both spins
a turbine to generate electricity and produces team to run an industrial process. Cogeneration can include
any number of energy distributions, including heat, cold, pressure, et al.

2309 Each interface must support symmetry as well, with energy and economic transactions able to flow each
2310 way.

2311 Energy Interoperation defines the market interactions between smart grids and their end nodes
2312 (Customers), including Smart Buildings and Facilities, Enterprises, Industry, Homes, and Vehicles. Market
2313 interactions are defined here to include all informational communications and to exclude direct process
2314 control communications. This document defines signals to communicate interoperable dynamic price,
2315 reliability, and emergency signals to meet business and energy needs, and scale, using a variety of
2316 communication technologies.

Appendix B. Glossary

No definition in this glossary supplants normative definitions in this or other specifications. They are here merely to provide a guidepost for readers at to terms and their special uses. Implementers will want to be familiar with all referenced standards.

Agreement is broad context that incorporates market context and programs. Agreement definitions are out of scope in Energy Interoperation.

DR Resource: see Resource.

EMIX: As used in this document, EMIX objects are descriptions applied to a WS-Calendar Sequence. EMIX defines Resource capabilities, used in tenders to match capabilities to need, and in Products, used in tenders and in specific performance and execution calls.

Feedback: Information about the state of a Resource; typically in relation to planning or executing a response to an Event

Resource (as used in Energy Interoperation): a Resource is a logical entity that is dispatchable. The Resource is solely responsible for its own response. A resource description specifies the performance envelope for a Resource. If a Resource can participate in multiple markets, it may have multipledescriptions.

Resource (as defined in EMIX): A Resource is something that can describe its capabilities in a Tender into a market. How those Capabilities vary over time is defined by application of the Capability Description to a WS-Calendar Sequence. See **[EMIX]**.

Status: Information about an Event, perhaps in relation to a specific Resource.

Sequence: A set of temporally related intervals with a common relation to some informational artifact as defined in WS-Calendar. Time invariant elements are in the artifact (known as a gluon) and time-varying elements are in each interval.

Tender: A tender is an offering for a Transaction. See Transaction.

Transaction: A binding commitment between parties entered into under an agreement.

VEN – see Virtual End Node

Virtual End Node (VEN): The VEN has operational control of a set of resources and/or processes and is able to control the output or demand of these resources in affect their generation or utilization of electrical energy intelligently in response to an understood set of smart grid messages. The VEN may be either a producer or consumer of energy. The VEN is able to communicate (2-way) with a VTN receiving and transmitting smart grid messages that relay grid situations, conditions, or events. A VEN may take the role of a VTN in other interactions.

Virtual Top Node (VTN): a Party that is in the role of aggregating information and capabilities of distributed energy resources. The VTN is able to communicate with both the Grid and the VEN devices or systems in its domain. A VTN may take the role of a VEN interacting with another VTN.

VTN – see Virtual Top Node

Appendix C. Extensibility in Energy Interoperation

Extensibility was a critical design constraint for Energy Interoperation. Extensibility allows the Energy Interoperation specification to be used in markets and in interactions that were not represented on the Technical Committee. Formal extensibility rules also create a set of complaint extensions for incorporation into later versions that are already compliant.

C.1 Extensibility in Enumerated values

EI defines a number of enumerations. Some of these, such as measurements of power, are predictably stable. Others, such as market contracts or energy sources, may well have new elements added. In general, these accept any string beginning with "x-" as a legal extension. In particular, these are defined using the following mechanism in the formal schemas (XSD's).

In ei.xsd, the extensibility pattern is defined. This pattern look like:

```
<xs:simpleType name="EiExtensionType">
        <xs:annotation>
                <xs:documentation>Pattern used for extending string
enumeration, where allowed</xs:documentation>
        </xs:annotation>
        <xs:restriction base="xs:string">
                <xs:pattern value="x-\S.*"/>
        </xs:restriction>
</xs:simpleType>
```

Non-extensible enumerated types look like this:

```
<xs:simpleType name="VoltageUnitsType">
        <xs:restriction base="xs:string">
                <xs:enumeration value="MV"/>
                <xs:enumeration value="KV"/>
                <xs:enumeration value="V"/>
        </xs:restriction>
</xs:simpleType>
```

In this case, we use the suffix "EnumeratedType" to allow for the possibility of other Measurement Protocols that are not enumerated. Actual compliance, though, is based upon the type:

```
<xs:simpleType name="MeasurementProtocolType">
        <xs:union memberTypes="power:MeasurementProtocolEnumeratedType
emix:EmixExtensionType"/>
</xs:simpleType>
```

That is, valid values for the measurement protocol are the enumerated values, and any that match the extension pattern "x-*"

C.2 Extension of Structured Information Collective Items

EI anticipates adding some information structures that are more complex than simple strings can be extended as well. A challenge for these items is that they are more complicated and so require formal definition. Formal definitions, expressed as additions to schema, could require changes to the specification. Without formal definition, it is difficult for trading partners to agree on valid messages.

EI uses abstract classes for many information exchanges. For example, trading partners could agree on the exchange of additional Payloads. The existing list of Payloads are derived from the empty, abstract Payload Base Type. Parties that wish to exchange other Payloads can derive new Types from Payload Base and use them in Signals, Baselines, Reports, and Delivery.

The resulting schema, which references the approved EI schemas, but does not change them, can then be distributed to business partners to validate the resulting message exchanges.

Appendix D. Mapping NAESB Definitions to Terminology of Energy Interoperation

2403 Energy Interoperation can be used in today's markets and business interactions. Generally accepted
2404 business terms for these markets were defined for both the retail and wholesale electrical quadrants in
2405 the **NAESB PAP09 Requirements Phase 2 [NAESB PAP09]**.

2406 Because Energy Interoperation describes a general-purpose mechanism that can be used by parties for
2407 today's market interactions at several levels of today's markets as well as for new and extended future
2408 interactions, the terms do not determinatively map to the NAESB semantics. Symmetric use of the
2409 interfaces in this specification can make some mappings ambiguous.

2410 There are several kinds of definitions used in Energy Interoperation and in EMIX.

2411 Abstraction over a class of similar information (for example, the EMIX Interface, the *EmixInterfaceType*
2412 abstract type, addresses all locational information including geospatial, P-Node, AP-Node, and more.)

2413 Simplification (for example, Party addresses all Business Entities as the focus is on the service
2414 interaction; a Business Entity presents and assumes various roles and interfaces)

2415 Algebraic combination (for example, a Resource summarizes characteristics from both curtailment and
2416 generation/battery draw-down as equivalent, though the market values and markets may vary)

2417 Some terms are outside the scope of Energy Interoperation, hence neither used nor defined (for example,
2418 Asset, Resource Object, Regulator).

2419 With these caveats, most of the terms defined by NAESB can be mapped to those in this specification.

2420 *NOTE: Market Participant is not defined explicitly in the NAESB document. Party is the generalization of*
2421 *business entities. A Party enrolls and some of the Parties enrolled, (possibly with a separate qualification*
2422 *step) are roles such as LSE, MA. We use the phrase "Party enrolled as …" in the table below to describe*
2423 *that situation.*

2424

2425

NAESB Term	Definition from NAESB	Energy Interoperation Term
Asset	A logical entity with measurable and reportable consumption, e.g. an Asset may be a physical device with its own meter, or the main meter at the Service Delivery Point of a Service Location.	Not used in 1.0
Asset Group	A logical entity that has a reportable interval level consumption, e.g. an Asset Group may be a physical entity with its own meter, a neighborhood of homes that has a net meter, or an estimate of consumption of an aggregation of retail customers.	Not used in 1.0
Business Entity	The wholesale or retail entity that interacts with other entities in its market.	**Party**

NAESB Term	Definition from NAESB	Energy Interoperation Term
Communication Method	The method by which an object communicates with another object to instruct, measure, report or control.	Out of scope. Energy Interoperation defines SOA Web Services
Control	The role associated with the control of an end device.	Out of scope
Designated Dispatch Entity (DDE)	A role which carries the responsibility of receiving and processing demand resource dispatch instructions or market information and (optionally) providing response information.	Party enrolled as DDE
Distributed Energy Resources (DER)	DERs are small, modular, energy generation and storage technologies that provide electric capacity or energy where it is needed. Definition of DER provided by the Department of Energy, http://www1.eere.energy.gov/femp/pdfs/31570.pdf	**Resource**
Environmental Authority (EA)	A regulatory authority responsible for the development, reporting and enforcement of environmental activities.	Out of scope
Federal Regulator (FR)	A federal regulatory authority.	Out of scope
Load-Serving Entity (LSE)	The responsible entity that secures energy and Transmission Service (and related Interconnected Operations Services) to serve the electrical demand and energy requirements of its end-use customers.	**Party** enrolled as LSE
Local Authority (LA)	A regulatory authority responsible for the oversight and administration of utility service-related functions within its jurisdiction.	Out of scope
Market Enrollment	The collection of enrollment or tariff data for a Resource Object to provide a specific market product or service.	Enrollment of a **Resource** combined with **Market Standard Terms**

NAESB Term	Definition from NAESB	Energy Interoperation Term
Market Participant (MP)	An organization registered with the System Operator that may take on roles such as SP, LSE, TDSP, DDE, SE, and/or MA in accordance with the SO's market rules.	**Party** enrolled as an MP
Measurement	The role associated with the device or algorithm that measures the consumption or supply of an end device.	**Measurement**
Meter Authority (MA)	A role which carries the responsibility of providing data necessary to determine the performance of a Resource.	**Party** enrolled as an MA
P-Node	The price location of the Premise in the transmission and/or distribution network.	**EMIX Interface** is superclass
Participant	The entity that represents resources to a market or distribution operator.	Party
Regulator	A rule-making and enforcement entity.	Out of scope
Resource	A market-dependent group of Response Method Aggregations that represents a dispatchable entity.[13]	**EMIX Resource**
Resource Object	Physical and logical types of demand response resource objects.	Out of scope
Scheduling Entity(SE)	A role which carries the responsibility of submitting bids/offers and receives schedules and awards.	**Party** enrolled an SE
Service Delivery Point	The identifier of the location where electric service is delivered to the Service Location.	**EMIX Interface** is superclass
Service Location	The physical location at which connection to the transmission or distribution system is made.	**EMIX Interface** is superclass
Service Provider (SP)	A role which carries the responsibility of coordinating resources to deliver electricity products and services to a market or distribution operator.	**Party** enrolled as an SP. All roles offer services.
State Regulator (SR)	A regulatory authority responsible for the oversight and administration of electric utilities.	Out of scope
Supporting Objects	Objects that support the interaction of Business Entities and Resource Objects.	Out of scope

---

[13] This presumably is a DDE earlier in the table, as Dispatch Entity is not defined here.

NAESB Term	Definition from NAESB	Energy Interoperation Term
Transmission/Distribution Service Provider (TDSP)	A role which carries the responsibility of operating a local electricity transmission and/or distribution system.	**Party** enrolled as a TDSP
Utility Customer (UC)	An end-use customer of the Utility Distribution Operator that takes on roles such as Premise or Resource.	Not defined explicitly. **Party** may take role
Utility Distribution Operator (UDO)	An entity which carries the responsibility of operating an electricity distribution system.	Not defined explicitly. **Party** that provides transport products
Zone	A physical or electrical region.	**EMIX Interface** is the superclass

2426

Appendix E. Acknowledgements

The following individuals have participated in the creation of this specification and are gratefully acknowledged:

Participants:

Hans Aanesen, Individual
Bruce Bartell, Southern California Edison
Timothy Bennett, Drummond Group Inc.
Carl Besaw, Southern California Edison
Anto Budiardjo, Clasma Events, Inc.
Edward Cazalet, Individual
Joon-Young Choi, Jeonju University
Kevin Colmer, California Independent System Operator
Toby Considine, University of North Carolina
William Cox, Individual
Sean Crimmins, California Independent System Operator
Phil Davis, Schneider Electric
Sharon Dinges, Trane
Robert Dolin, Echelon Corporation
Rik Drummond, Drummond Group Inc.
Ernst Eder, LonMark International
Thomas Ferrentino, Individual
Craig Gemmill, Tridium, Inc.
Girish Ghatikar, Lawrence Berkeley National Laboratory
Gerald Gray, Southern California Edison / Electric Power Research Institute (EPRI)
Anne Hendry, Individual
Thomas Herbst, Cisco Systems, Inc.
David Holmberg, NIST
Gale Horst, Electric Power Research Institute (EPRI)
Ali Ipakchi, Open Access Technology International Inc. (OATi)
Oliver Johnson, Tendril Networks, Inc.
Sila Kiliccote, Lawrence Berkeley National Laboratory
Ed Koch, Akuacom Inc
Michel Kohanim, Universal Devices, Inc.
Larry Lackey, TIBCO Software Inc.
Derek Lasalle, JPMorganChase
Jeremy Laundergan, Southern California Edison
Benoit Lepeuple, LonMark International
Edgardo Luzcando, Midwest ISO and ISO/RTO Council (IRC)
Carl Mattocks, Individual
Dirk Mahling, CPower
Kyle Meadors, Drummond Group Inc.
Scott Neumann, Utility Integration Solutions Inc.
Robert Old, Siemens AG
Mary Ann Piette, Lawrence Berkeley National Laboratory
Joshua Phillips, Southwest Power Pool and ISO/RTO Council (IRC)
Donna Pratt, New York ISO and ISO/RTO Council (IRC)
Ruchi Rajasekhar, Midwest Independent System Operator
Jeremy Roberts, LonMark International
Anno Scholten, Individual
Pornsak Songkakul, Siemens AG
Jane Snowdon, IBM
Aaron Snyder, NIST
William Stocker, New York ISO and ISO/RTO Council (IRC)

2480   Pornsak Songkakul, Siemens AG
2481   Robert Stayton, Individual
2482   Jake Thompson, EnerNOC
2483   Matt Wakefield, Electric Power Research Institute (EPRI)
2484   Douglas Walker, California Independent System Operator
2485   Evan Wallace, NIST
2486   Dave Watson, Lawrence Berkeley National Laboratory
2487   David Wilson, Trane
2488   Leighton Wolffe, Individual
2489   Brian Zink, New York Independent System Operator

2490   The Technical Committee also acknowledges the work of the contributing groups who did so much to
2491   bring requirements and use cases to the attention of the Committee. In particular, the ISO/RTO Council
2492   task force on Demand Response, the UCAIug OpenSG Task Force on OpenADR, and the NAESB Smart
2493   Grid Task Force provided invaluable guidance and frequent feedback.

2494   The following individuals have participated in the creation of this specification and are gratefully
2495   acknowledged:

2496   **UCAIug OpenSG OpenADR Task Force:**
2497   Albert Chiu, Pacific Gas & Electric
2498   Bruce Bartell, Southern California Edison
2499   Gerald Gray, Southern California Edison
2500

2501   **The ISO / RTO Council Smart Grid Standards Project:**

2502   We want to thank the IRC team, in particular those who directly participated in this Technical Committee:

2503   Edgardo Luzcando, Midwest ISO and ISO/RTO Council (IRC)
2504   Donna Pratt, New York ISO and ISO/RTO Council (IRC)
2505   William Stocker, New York ISO and ISO/RTO Council (IRC)

2506   The IRC team consisted of a large group of participants from ISOs and RTOs. See the IRC Smart Grid
2507   Standards web site for additional details about the project and team members -
2508   http://www.isorto.org/site/c.jhKQIZPBImE/b.6368657/k.CCDF/Smart_Grid_Project_Standards.htm

2509

2510   **NAESB Smart Grid Standards Development Subcommittee Co-chairs:**
2511   Brent Hodges, Reliant
2512   Robert Burke, ISO New England
2513   Wayne Longcore, Consumers Energy
2514   Joe Zhou, Xtensible Solutions

Appendix F. Revision History

2516

Revision	Date	Editor	Changes Made
1.0 WD 01		Toby Considine	Initial document, largely derived from OpenADR
1.0 WD 02		Toby Considine	
1.0 WD 03		Toby Considine	
1.0 WD 04		Toby Considine	
1.0 WD 05		Toby Considine	
1.0 WD 06		Toby Considine	
1.0 WD 07		Toby Considine	
1.0 WD 08	2010-03-09	Toby Considine	Reduced core functions to two service groups, transactive energy and eliminated references to managed energy
1.0 WD 09	2010-03-23	Toby Considine	
1.0 WD 10	2010-05-11	William Cox	Updated interaction model per analysis and drawings in TC meetings in April and early May
1.0 WD 11	2010-05-18	William Cox and David Holmberg	Improved model; editorial and clarity changes. Addressed comments on interaction and service model from TC meetings in May 2010.
1.0 WD 12	2010-05-21	William Cox	Editorial and content corrections and updates. Consistency of tone; flagged portions that are more closely related to EMIX.
1.0 WD 13	2010-08-31	Toby Considine Ed Cazalet	Recast to meet new outline, Removed much of the "marketing" content or moved, for now, to appendices. Re-wrote Sections 2, 3. Created placeholders in 4, 5,6 for services definitions.
1.0 WD 14	2010-10-31	William Cox	Completed service descriptions and restructured the middle of the document. Completed the EiEvent service and included UML diagrams. Deleted no longer relevant sections.

1.0 WD 15	2010-11-15	William Cox Toby Considine	Re-wrote sections 5, 7. Re-cast and combined to divergent sections 3. Misc Jira responses
1.0 WD 16	2010-11-18	William Cox	Added missing Section 6
1.0 WD 17	2010-11-22	Toby Considine, William Cox	Responded to many comments, added Program Services, added description of Resources and EMIX and WS-Calendar (4). Added Glossary
1.0 WD 18	2010-11-24	Toby Considine	Responded to formal comments Added additional language on WS-Calendar Incorporated missing Program Call Added Simple Market Model to Interactions
1.0 WD 19	2011-02-06	Toby Considine	"Clearing the Underbrush" – numerous trivial edits from PR process
1.0 WD20	2011-03-03	Ed Cazalet, Toby Considine	Reorganization of material into new document structure
1.0 WD21	2011-03-06	Ed Cazalet, Toby Considine	Completion of reorganization (transitional material) and repair of all (I hope) links and cross-references
1.0 WD22	2011-03-07	William Cox Toby Considine	Update of UML and Services Repaired documents (links & numbering broken again)
1.0 WD23	2011-05-10	David Holmberg William Cox Toby Considine	Update to add interaction diagrams, improve text, and add sections on service operation naming, push, and pull.
1.0 WD24	2011-06-28	William Cox Toby Considine	Updates to EiEvent, EiOpt, EiAvail, EiFeedbak, EiStatus. Deleted EiProgram. Updated model, schemas, and diagrams.
1.0 WD25	2011-07-04	Toby Considine William Cox	Numerous Jira issues, new schemas, new UML,
1.0 WD26	2011-07-08	Toby Considine	No changes to Spec, updated schemas to refer to EMIX PR03
1.0 WD27	2011-08-21	Gerald Gray Ed Cazalet David Holmberg	Updated to include Interaction work by Gerald Gray, Ed Cazalet, Appendix mapping to NAESB terms by Holmberg, Cazalet, Cox. Note that the Cazalet and Gray interaction models for Enrollment are different in approach. I have included them both for Committee discussion (Tables 7.1, 7.2).

1.0 WD28	2011-08025	Gerald Gray	Service Interactions re-written, re-titled to meet CIM expectations. All new interaction diagrams from Gray.
WD29	2011-10-10	Toby Considine	Expanded section on Composition, WS-Calendar, EMIX (4) Added section on Semantics of EI (5) Fixed broken references
WD30	2011-10-15	Toby Considine	Edits of first 5 sections for clarity, update of pictures
WD31	2011-10-17	Toby Considine William T Cox	New Section 10 Revised Reports discussion
WD32	2011-10-22	Toby Considine William T Cox Ed Koch Ed Cazalet	Re-wrote Streams and Reports for more clarity, to eliminate snaps, and to allow multiplicity. Refined Event description Defined Report Types New introduction to section 3
WD33	2011-10-28	Toby Considine William T. Cox Gerry Gray	Many niggling edits. Jira Issues as per log New Service Operation tables Updated namespaces Clean up of References Added general discussion of Requests and Responses to the intro to Services Split Reports into their own section (10) New UML, Interaction diagrams
WD34	2011-11-04	Toby Considine	Reordered section on Event Services, incorporating event Filter and Order New Figures throughout Section 3.3 added to discuss Roles and Resources Numerous small edits in response to Jira
WD35	2011-11-08	Toby Considine	Misc, Small Edits Added conformance section 1
WD36	2011-11-08	Toby Considine	Changes to Conformance Section 1 Misc formatting errors Figures 7-8, 7-10, 8-3 updated
WD37	2011-12-11	Toby Considine	Errata
WD38	2011-12-11	Toby Considine	Additional Errata
WD39	201301107	Toby Considine	non-substantive changes, primarily editorial

WD40	2014-05-13	Toby Considine	Updated references (normative & informative) to most consistent pattern, final version when WD was previously referenced (and appropriate) following COS1
			• Updated OSA-RA to SOA-RF at request of the chair of that TC. Moved from non-normative to normative as per accepted public comment
			• Added normative reference to XSD, which is used throughout, but never appeared as a reference
			• vAvailability had appeared in both normative and non-normative references. While it is incorporated in normatively referenced WS-Calendar, the TC considers reading the original useful to user. Removed normative reference, leaving only the non-normative.
			Misc minor proofing
WD41	2014-04-14	Toby Considine	Fixed footers to match rest of document
WD42	2014-04-17	Toby Considine	Addressed issues in correctness and substantiveness raised, to wit:
			• Use SOA-RAF abbreviation for reference throughout to match SOA TC requests
			• SOA-RAF moved back from Normative to non-Normative, where it was until WD40

2517