



# Energy Interoperation Version 1.0

## Committee Specification 03

02 December 2013

### Specification URIs

#### This version:

<http://docs.oasis-open.org/energyinterop/ei/v1.0/cs03/energyinterop-v1.0-cs03.pdf> (Authoritative)  
<http://docs.oasis-open.org/energyinterop/ei/v1.0/cs03/energyinterop-v1.0-cs03.html>  
<http://docs.oasis-open.org/energyinterop/ei/v1.0/cs03/energyinterop-v1.0-cs03.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](mailto:david.holmberg@nist.gov)), NIST  
William T. Cox ([wtcoc@coxsoftwarearchitects.com](mailto:wtcoc@coxsoftwarearchitects.com)), Individual

#### Editor:

Toby Considine ([toby.considine@unc.edu](mailto: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/cs03/xsd/>
  - DocumentationSketches.xsd
  - EIClasses.xsd
  - EiEnrollment.xsd
  - EiPayloads.xsd
  - iCalendar-streams-extensions.xsd
- WSDL files: <http://docs.oasis-open.org/energyinterop/ei/v1.0/cs03/wsd/>
  - 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*. Latest version. <http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html>.
- *WS-Calendar Version 1.0*. 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/wsd1>

### 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*. 02 December 2013. OASIS Committee Specification 03. <http://docs.oasis-open.org/energyinterop/ei/v1.0/cs03/energyinterop-v1.0-cs03.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

1	Introduction.....	13
1.1	Terminology.....	14
1.2	Normative References.....	14
1.3	Non-Normative References.....	14
1.4	Contributions.....	16
1.5	Namespace.....	17
1.6	Naming Conventions.....	18
1.7	Editing Conventions.....	18
1.8	Architectural Background.....	18
2	Overview of Energy Interoperation.....	22
2.1	Scope of Energy Interoperation.....	22
2.2	Specific scope statements.....	22
2.3	Goals & Guidelines for Signals and Price and Product Communication.....	22
2.4	Scope of Energy Interoperation Communications.....	23
2.5	Collaborative Energy [Not Normative].....	23
2.6	Assumptions.....	25
2.6.1	Availability of Interval Metering.....	25
2.6.2	Use of EMIX.....	25
2.6.3	Use of WS-Calendar.....	25
2.6.4	Energy Services Interface.....	25
3	Energy Interoperation Architecture.....	27
3.1	Transactive Energy Interactions.....	27
3.1.1	Transaction Side.....	27
3.1.2	Transactive Interactions among Parties.....	27
3.1.3	Retail Service Interactions.....	28
3.1.4	Wholesale Power Interactions.....	28
3.1.5	Transport Interactions.....	28
3.2	Event Interactions for Demand and Generation Resources.....	29
3.2.1	VTN and VEN Party Roles.....	29
3.2.2	VTN/VEN Interactions.....	29
3.2.3	VTN/VEN Roles and Services.....	31
3.2.4	Demand Response Interactions.....	32
3.3	Roles, Resources and Interactions (Non-Normative).....	32
3.3.1	Choosing a Role.....	33
3.3.2	The relationship between Actors and Resources.....	33
4	Message Composition & Services.....	35
4.1	WS-Calendar in Energy Interoperation.....	35
4.1.1	Schedule Semantics from WS-Calendar (Non-Normative).....	35
4.1.2	Schedules and Inheritance.....	36
4.1.3	Availability and Schedules.....	37
4.1.4	Smoothing Response.....	38
4.2	EMIX in Energy Interoperation.....	38
4.2.1	Core Semantics from EMIX.....	39

4.2.2	Putting EMIX in Context .....	40
4.3	Streams: Adaptations of WS-Calendar for Energy Interoperation.....	41
4.3.1	Information Model for Streams .....	42
4.3.2	Conformance of Streams to WS-Calendar.....	42
4.3.3	Payload Optimization in Streams .....	43
4.3.4	Other elements in Stream Payloads .....	44
4.4	Applying EMIX and WS-Calendar to a Power Event.....	45
4.4.1	Streams in a DR Event.....	46
4.4.2	The Active Period Schedule .....	47
5	Semantics of Energy Interoperation .....	49
5.1	Dramatis Personae: Identifying the Actors .....	49
5.1.1	Actor IDs and Roles .....	50
5.2	Market Context .....	50
5.2.1	Simple Levels .....	51
5.2.2	Application Specific Extensions.....	51
5.2.3	Response Smoothing .....	52
5.3	Event-based Interactions .....	53
5.3.1	The Event Descriptor.....	53
5.3.2	The Active Period .....	54
5.3.3	The Event Signals .....	55
5.3.4	Baselines .....	57
5.3.5	Opt – Making Choices .....	57
5.4	Monitoring, Reporting, and Projection .....	58
5.4.1	The Report Specifier .....	59
5.4.2	Report Scheduler .....	61
5.4.3	UML Diagram of Report Request.....	63
5.5	Reports, Snaps, and Projections .....	63
5.5.1	Elements of the Report.....	64
5.5.2	Report Description.....	66
5.5.3	Report Payloads .....	67
5.5.4	UML Diagram of Report .....	70
5.6	Reponses and Error Reporting.....	70
5.6.1	Event Responses .....	71
5.6.2	References in Responses .....	71
5.7	Availability Behavior.....	72
6	Introduction to Services and Operations .....	73
6.1	Resources, Curtailment, and Generation .....	73
6.2	Structure of Energy Interoperation Services and Operations.....	73
6.3	Naming of Services and Operations .....	74
6.4	Push and Pull Patterns .....	74
6.5	WSDL Integration .....	75
6.6	Description of the Services and Operations .....	75
6.7	Responses .....	75
6.7.1	Terms Violated .....	76
6.7.2	Response Derivations .....	76

6.7.3	Compound Responses .....	77
6.7.4	Requests .....	78
7	Transactive Services .....	80
7.1	EiRegisterParty Service .....	80
7.1.1	Interaction Pattern for the EiRegisterParty Service .....	81
7.1.2	Information Model for the EiRegisterParty Service .....	81
7.1.3	Operation Payloads for the EiRegisterParty Service .....	82
7.2	Pre-Transaction Services .....	83
7.2.1	Interaction Pattern for the EiTender and EiQuote Services .....	84
7.2.2	Information Model for the EiTender and EiQuote Services .....	85
7.2.3	Operation Payloads for the EiTender Service .....	86
7.2.4	Operation Payloads for the EiQuote Service .....	87
7.3	Transaction Management Services .....	87
7.3.1	Interaction Patterns for the EiTransaction Service .....	88
7.3.2	Information Model for the EiTransaction Service .....	88
7.3.3	Operation Payloads for the EiTransaction Service .....	89
7.4	Post-Transaction Services .....	90
7.4.1	Energy Delivery Information .....	90
7.5	Comparison of Transactive Payloads .....	92
8	Enroll Service .....	93
8.1	Interaction Patterns for the EiEnroll Service .....	95
8.2	Information Model for the EiEnroll Service .....	96
8.3	Enrollee Types .....	97
8.4	Operation Payloads for the EiEnroll Service .....	98
9	Event Services .....	99
9.1	Information Model for the EiEvent Service .....	99
9.1.1	Structure of the Event .....	100
9.1.2	UML Model of an Event and its Signals .....	101
9.2	Special Semantics of the Event Request Operations .....	102
9.2.1	Event Ordering .....	102
9.2.2	Event Filter described .....	103
9.2.3	Using EiRequestEvent EiRequestEventPending together .....	103
9.3	Interaction Patterns for the EiEvent Service .....	105
9.4	Operation Payloads for the EiEvent Service .....	107
10	Report Service .....	108
10.1	Overview of Report Services .....	108
10.2	EiHistorian Service .....	109
10.2.1	Interaction Pattern for the EiHistorian Service .....	109
10.2.2	Operations Payloads for the EiHistorian Service .....	110
10.3	EiReport Service .....	111
10.3.1	Information Model for the EiReport Service .....	111
10.3.2	Interaction Pattern for the EiReport Service .....	112
10.3.3	Operation Payloads for the EiReport Service .....	113
10.4	EiProjectionService .....	114
10.4.1	Interaction Pattern for EiProjection Service .....	114

10.4.2	Operation Payloads for the EiProjection Service .....	114
10.5	Summary of Report Payloads.....	115
11	Event Support Services.....	116
11.1	Relationship of Availability and Opt Information .....	116
11.2	EiAvail Service .....	116
11.2.1	Interaction Patterns for the EiAvail Service.....	117
11.2.2	Information Model for the EiAvail Service .....	118
11.2.3	Operation Payloads for the EiAvail Service .....	119
11.3	EiOpt Service.....	120
11.3.1	Interaction Patterns for the EiOpt Service.....	120
11.3.2	Information Model for the EiOpt Service .....	120
11.3.3	Operation Payloads for the EiOpt Service .....	122
12	Market Information.....	123
12.1	The Market Context .....	123
12.2	Market Context Service .....	123
12.3	Information Model for the EiMarketContext Service .....	124
12.4	Operation Payloads for the EiMarket Context Service .....	125
13	Security and Composition [Non-Normative] .....	126
13.1	Security and Reliability Example .....	126
13.2	Composition.....	127
13.3	Energy Interoperation and Security .....	128
14	Profiles [Normative] .....	129
14.1	OpenADR [Normative].....	129
14.2	TeMIX [Normative].....	129
14.3	Price Distribution [Normative] .....	130
15	Conformance and Processing Rules for Energy Interoperation.....	131
15.1	Conformance for Energy Interoperation .....	131
15.1.1	General Conformance Requirements .....	131
15.1.2	Full Conformance to Energy Interoperation .....	131
15.1.3	Conformance to Energy Interoperation .....	131
15.1.4	Full Conformance with Alternate Interoperation to Energy Interoperation.....	132
15.1.5	Conformance with Alternate Interoperation to Energy Interoperation.....	132
15.1.6	Conformance to Named Profiles of Energy Interoperation .....	132
15.2	Conformance with the Semantic Models of EMIX and WS-Calendar .....	133
15.2.1	Recapitulation of Requirements from WS-Calendar and EMIX .....	133
15.3	TeMIX Conformance.....	134
15.4	Inheritance within Events.....	134
15.4.1	Sequence Optimization within Events.....	135
15.5	Version Conformance .....	135
Appendix A.	Background and Development history .....	136
Appendix B.	Glossary .....	138
Appendix C.	Extensibility in Energy Interoperation.....	139
C.1	Extensibility in Enumerated values.....	139
C.2	Extension of Structured Information Collective Items .....	139
Appendix D.	Mapping NAESB Definitions to Terminology of Energy Interoperation .....	140

Appendix E.	Acknowledgements .....	144
Appendix F.	Revision History .....	146



---

# Tables, Figures & Examples

---

## Index to Figures

Figure 1-1: Conceptual model for smart grid from [NIST] showing communications requirements .....	13
Figure 1-2: One-way MEP .....	19
Figure 1-3: Callback MEP .....	20
Figure 1-4: PULL MEP .....	20
Figure 3-1: Parties Interacting Using Tenders for Transactions .....	28
Figure 3-2: Example DR Interaction One .....	29
Figure 3-3: Example DR Interaction Two .....	30
Figure 3-4: Example DR Interaction Three .....	30
Figure 3-5: Web of Example DR Interactions .....	30
Figure 3-6: Service Interactions between a VTN and a VEN .....	31
Figure 3-7: Demand Response Interaction Pattern Example .....	32
Figure 4-1: Basic Power Object from EMIX .....	36
Figure 4-2: WS-Calendar Partition, a simple sequence of 5 intervals .....	36
Figure 4-3: Applying Basic Power to a Sequence .....	37
Figure 4-4: Simplifying back to Power in a Single Interval.....	37
Figure 4-5: Stream as Gluon and Sequence .....	41
Figure 4-6: UML Class Diagram of abstract StreamBase class .....	42
Figure 4-7: Payload Base.....	44
Figure 4-8: Comparing Payloads for Signals, Baselines, Reports, and Delivery.....	45
Figure 4-9 Demand Response Event and associated Streams.....	46
Figure 5-1: EI Target .....	50
Figure 5-2: UML Class Diagram of Party ID and its derivatives .....	50
Figure 5-3: EI Market Context.....	51
Figure 5-4: Event Overview.....	53
Figure 5-5: Active Period Elements .....	55
Figure 5-6: Event Signal Overview .....	56
Figure 5-7: The Report Request .....	58
Figure 5-8: The Report Specifier.....	59
Figure 5-9: Report Scheduler.....	61
Figure 5-10: UML Diagram of Report Scheduler .....	63
Figure 5-11: UML Class Diagram of Report Request .....	63
Figure 5-12: The Report.....	64
Figure 5-13: The Report Description.....	66
Figure 5-14: the Report Payload.....	67
Figure 5-15: Illustrating Aggregate vs. Summary.....	69
Figure 5-16: UML Class Diagram of Reports.....	70
Figure 5-17: UML Diagram showing refID and its derived types .....	72

Figure 6-1: Generalized view of the high-level message structure .....	75
Figure 6-2: Example of generic error response for a service operation .....	76
Figure 6-3: UML for Response.....	78
Figure 7-1: Interaction Diagram for EiRegisterParty Service.....	81
Figure 7-2: EiParty UML Class Diagram.....	81
Figure 7-3: UML Class Diagram for EiRegisterParty Service Operation Payloads .....	82
Figure 7-4: Interaction Diagram for the EiTender Service .....	84
Figure 7-5: Interaction Diagram for the EiQuote Service.....	85
Figure 7-6: UML Class Diagram for the Operation Payloads for the EiTender Service .....	86
Figure 7-7: UML Class Diagram for the EiQuote Service Operation Payloads .....	87
Figure 7-8: Interaction Diagram for the EiTransaction Service.....	88
Figure 7-9: UML Class Diagram of EiTransaction Service Operation Payloads .....	89
Figure 7-10: Interaction Diagram for Delivery Service.....	90
Figure 7-11: UML of EiDelivery Type.....	91
Figure 7-12: UML Class Diagram of Delivery and Delivery Payload .....	91
Figure 7-13: UML Diagram comparing all Transactive Payloads .....	92
Figure 8-1: Interaction Diagram for the EiEnroll Service .....	95
Figure 8-2: UML Model for EiEnrollment Classes.....	96
Figure 8-3: UML Class Diagram showing Enrollee Types .....	97
Figure 8-4: UML Class Diagram for Enrollment Payloads .....	98
Figure 9-1: EiEvent summarized.....	100
Figure 9-2: UML Class Diagram for EiEventType and Related Classes (w/o Signals detail).....	101
Figure 9-3 UML Class Diagram Showing Details of the Signal Payloads or EiEventSignals.....	102
Figure 9-4: Qualified Event ID.....	103
Figure 9-5: UML Interaction Diagram for the EiEvent Service Operations .....	105
Figure 9-6: UML for example PULL pattern for EiEvent .....	106
Figure 9-7: Interaction Diagram for Pending Event operation .....	106
Figure 9-8: UML Class Diagram for EiEvent Service Operation Payloads.....	107
Figure 10-1: Interaction Pattern for Historian Operations (Report Service).....	110
Figure 10-2: UML Diagram of Historian Payloads .....	110
Figure 10-3: UML Class Diagram for the EiReport Class .....	111
Figure 10-4: UML Interaction Diagram for the EiReport Service (Report Service).....	112
Figure 10-5: UML Diagram of Report Payloads.....	113
Figure 10-6: Interaction Pattern for Projection Operations (Report Service).....	114
Figure 10-7: UML Diagram of Projection Payloads .....	114
Figure 10-8: UML Class Diagram for all EiReportService Operation Payloads.....	115
Figure 11-1: Interaction Pattern for the EiAvailability Service.....	117
Figure 11-2: UML Class Diagram for the EiAvail Type .....	118
Figure 11-3: UML Class Diagram for EiAvail Service Operation Payloads .....	119
Figure 11-4: Interaction Diagram for the EiOpt Service.....	120
Figure 11-5: UML Class Diagram for EiOpt Type .....	121
Figure 11-6: UML Class Diagram for EiOpt Service Operation Payloads .....	122

Figure 12-1: Sequence diagram for Market Context service .....	123
Figure 12-2: UML Class Diagram for Market Context.....	124
Figure 12-3: UML of Market Context Service payloads .....	125
Figure 13-1: Web of Example DR Interactions .....	126

---

## Index to Tables

Table 1-1: Namespaces Used in this Specification .....	17
Table 3-1: Interactions and Actors .....	30
Table 4-1: Core Semantics from WS-Calendar .....	35
Table 4-2: WS-Calendar Semantics: Inheritance.....	37
Table 4-3: EMIX Essential Semantics.....	39
Table 4-4: EMIX Market Context.....	40
Table 4-5: Semantics of the Active Period.....	47
Table 5-1: Energy Interoperation Identities .....	49
Table 5-2: Simple Levels.....	51
Table 5-3: Application Specific Extensions .....	52
Table 5-4: Smoothing Terms.....	52
Table 5-5: The Event Descriptor .....	53
Table 5-6: Signal Types .....	56
Table 5-7: Opt .....	57
Table 5-8: Elements of the Report Request.....	58
Table 5-9: Elements of the Report Specifier .....	59
Table 5-10: Report Specifier Payload .....	60
Table 5-11: Report Types .....	60
Table 5-12: Types of Report Scheduler .....	61
Table 5-13: Reports .....	64
Table 5-14: Elements of Reports .....	64
Table 5-15: Elements of the Report Description .....	66
Table 5-16: Report Payload Qualifiers.....	68
Table 5-17: Reading Types.....	68
Table 5-18: Responses .....	70
Table 5-19: Event Response.....	71
Table 5-20: Availability Behavior .....	72
Table 7-1: Register Services.....	80
Table 7-2: Pre-Transaction Tender Services .....	83
Table 7-3: Pre-Transaction Quote Services.....	83
Table 7-4: Transaction Management Service .....	88
Table 7-5: Energy Delivery.....	90
Table 8-1 Enrollee Descriptions .....	93
Table 8-2: EiEnroll Service Operations .....	94
Table 9-1: Event Services .....	99

Table 9-2: Event Filter described .....	103
Table 9-3: Event Requests summarized .....	104
Table 10-1: Report Service .....	108
Table 11-1: Avail Service .....	117
Table 11-2: Opt Service .....	120
Table 12-1: Market Context Service .....	123
Table 13-1: Interactions and Actors for Security and Reliability Example .....	127
Table 14-1: Services used in OpenADR Profile.....	129
Table 14-2: Services used in TeMIX Profile.....	129
Table 14-3: Services used in Price Distribution Profile .....	130

# 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.

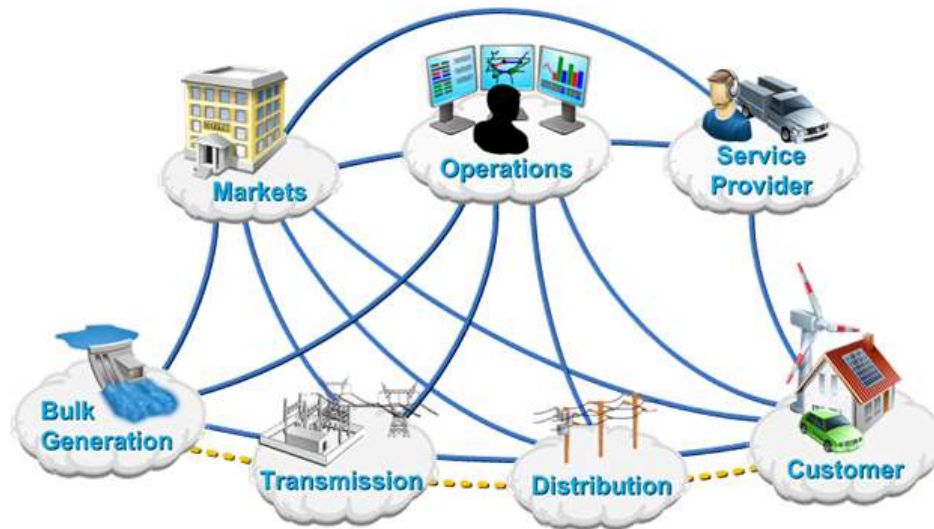


Figure 1-1: Conceptual model for smart grid from [NIST] showing communications requirements

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***  
57 ***Exchange 1.0*, September 2010. [http://docs.oasis-](http://docs.oasis-open.org/emix/emix/v1.0/csd04/emix-v1.0-csd04.html)**  
58 **[open.org/emix/emix/v1.0/csd04/emix-v1.0-csd04.html](http://docs.oasis-open.org/emix/emix/v1.0/csd04/emix-v1.0-csd04.html)**
- 59 [RFC2119] **S. Bradner, *Key words for use in RFCs to Indicate Requirement Levels*,**  
60 **<http://www.ietf.org/rfc/rfc2119.txt>, IETF RFC 2119, March 1997.**
- 61 [RFC2246] **T. Dierks, C. Allen *Transport Layer Security (TLS) Protocol Version 1.0*,**  
62 **<http://www.ietf.org/rfc/rfc2246.txt>, IETF RFC 2246, January 1999.**
- 63 [SOA-RM] **SOA-RM OASIS Standard, *OASIS Reference Model for Service Oriented***  
64 ***Architecture 1.0*, October 2006 <http://docs.oasis-open.org/soa-rm/v1.0/>**
- 65 [Vavailability] **C. Daboo, B. Desruisseaux, *Calendar Availability*,**  
66 **<http://tools.ietf.org/html/draft-daboo-calendar-availability-02>, IETF Internet**  
67 **Draft, April 2011**
- 68 [WS-Calendar] **WS-Calendar OASIS Committee Specification 1.0, *WS-Calendar*, July 2011,**  
69 **[http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/cs01/ws-](http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/cs01/ws-calendar-spec-v1.0-cs01.pdf)**  
70 **[calendar-spec-v1.0-cs01.pdf](http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/cs01/ws-calendar-spec-v1.0-cs01.pdf)**

## 71 1.3 Non-Normative References

- 72 [BACnet/WS] **Addendum C to ANSI/ASHRAE Standard 135-2004, *BACnet Web Services***  
73 ***Interface*.**
- 74 [ebXML-MS] **OASIS Standard, *Electronic Business XML (ebXML) Message Service***  
75 ***Specification v3.0: Part 1, Core Features*, October 2007. [http://docs.oasis-](http://docs.oasis-open.org/ebxml-msg/ebms/v3.0/core/os/ebms_core-3.0-spec-os.pdf)**  
76 **[open.org/ebxml-msg/ebms/v3.0/core/os/ebms\\_core-3.0-spec-os.pdf](http://docs.oasis-open.org/ebxml-msg/ebms/v3.0/core/os/ebms_core-3.0-spec-os.pdf)**
- 77 [EISA2007] **Energy Independence and Security Act of 2007,**  
78 **<http://nist.gov/smartgrid/upload/EISA-Energy-bill-110-140-TITLE-XIII.pdf>**

79 [EPRI] Concepts to Enable Advancement of Distributed Energy Resources,  
80 February 2010,  
81 [http://my.epri.com/portal/server.pt?Abstract\\_id=00000000001020432](http://my.epri.com/portal/server.pt?Abstract_id=00000000001020432)

82 [Framework] National Institute of Standards and Technology, *NIST Framework and*  
83 *Roadmap for Smart Grid Interoperability Standards, Release 1.0*, January  
84 2010,  
85 [http://nist.gov/public\\_affairs/releases/upload/smartgrid\\_interoperability\\_fin](http://nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf)  
86 [al.pdf](http://nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf)

87 [Galvin] Galvin Electricity Initiative, *Perfect Power*,  
88 <http://www.galvinpower.org/perfect-power/what-is-perfect-power>

89 [ID-CLOUD] OASIS Identity in the Cloud Technical Committee  
90 <http://www.oasis-open.org/committees/id-cloud>

91 [IEC 61968] Application integration at electric utilities - System interfaces for  
92 distribution management - Part 9: Interfaces for meter reading and control

93 [IEC 61970-301] Energy management system application program interface (EMS-API) - Part  
94 301: Common information model (CIM) base

95 [KMIP] OASIS Standard, *Key Management Interoperability Protocol Specification*  
96 *Version 1.0*, October 2010  
97 <http://docs.oasis-open.org/kmip/spec/v1.0/kmip-spec-1.0.pdf>

98 [OpenADR] Mary Ann Piette, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage,  
99 Peter Palensky, and Charles McParland. 2009. Open Automated Demand  
100 Response Communications Specification (Version 1.0). California Energy  
101 Commission, PIER Program. CEC-500-2009-063.

102 [NAESB-SG] NAESB Smart Grid Subcommittee,  
103 [http://www.naeb.org/smart\\_grid\\_standards\\_strategies\\_development.asp](http://www.naeb.org/smart_grid_standards_strategies_development.asp)

104 [OASIS SCA] OASIS Service Component Architecture Member Section  
105 <http://www.oasis-open.org/sca>

106 [PMRM] OASIS Privacy Management Reference Model (PMRM) Technical  
107 Committee, <http://www.oasis-open.org/committees/pmrm>

108 [SAML] OASIS Standard, *Security Assertion Markup Language 2.0*, March 2005.  
109 <http://docs.oasis-open.org/security/saml/v2.0/saml-core-2.0-os.pdf>

110 [SOA-RA] OASIS Public Review Draft 01, *Reference Architecture for Service Oriented*  
111 *Architecture Version 1.0*, April 2008  
112 <http://docs.oasis-open.org/soa-rm/soa-ra/v1.0/soa-ra-pr-01.pdf>

113 [SPML] OASIS Standard, *Service Provisioning Markup Language (SPML) v2 - DSML*  
114 *v2 Profile*, April 2006. [http://www.oasis-](http://www.oasis-open.org/committees/download.php/17708/pstc-spml-2.0-os.zip)  
115 [open.org/committees/download.php/17708/pstc-spml-2.0-os.zip](http://www.oasis-open.org/committees/download.php/17708/pstc-spml-2.0-os.zip) [TC57CIM]  
116 IEC Technical Committee 57 Common Information Model (IEC 61968  
117 and IEC 61970, various dates)

118 [TeMIX] TeMIX *Transactive Energy Market Information Exchange [TeMIX] an*  
119 *approved Note of the EMIX TC*. Ed Cazalet et al. [http://www.oasis-](http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf)  
120 [open.org/committees/download.php/37954/TeMIX-20100523.pdf](http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf)

121 [UML] Object Management Group, *Unified Modeling Language (UML), V2.4.1*,  
122 August 2011. <http://www.omg.org/spec/UML/2.4.1/>

123 [Vavailability] C. Daboo, B. Desruisseaux, *Calendar Availability*,  
124 <http://tools.ietf.org/html/draft-daboo-calendar-availability-02>, IETF Internet  
125 Draft, April 2011

126 [WS-Addr] Web Services Addressing (WS-Addressing) 1.0, W3C Recommendation,  
127 <http://www.w3.org/2005/08/addressing>.

128 [WSFED] OASIS Standard, *Web Services Federation Language (WS-Federation)*  
129 *Version 1.2*, 01 May 2009 [http://docs.oasis-](http://docs.oasis-open.org/wsfed/federation/v1.2/os/ws-federation-1.2-spec-os.doc)  
130 [open.org/wsfed/federation/v1.2/os/ws-federation-1.2-spec-os.doc](http://docs.oasis-open.org/wsfed/federation/v1.2/os/ws-federation-1.2-spec-os.doc)



131 [WSI-Basic] R Chumbley, J Durand, G Pilz, T Rutt , *Basic Profile Version 2.0*,  
 132 <http://ws-i.org/profiles/BasicProfile-2.0-2010-11-09.html>,  
 133 The Web Services-Interoperability Organization, November 2010  
 134 [WSRM] OASIS Standard, *WS-Reliable Messaging 1.1*, November 2004.  
 135 [http://docs.oasis-open.org/wsrn/ws-reliability/v1.1/wsrn-ws\\_reliability-1.1-](http://docs.oasis-open.org/wsrn/ws-reliability/v1.1/wsrn-ws_reliability-1.1-spec-os.pdf)  
 136 [spec-os.pdf](http://docs.oasis-open.org/wsrn/ws-reliability/v1.1/wsrn-ws_reliability-1.1-spec-os.pdf)  
 137 [WS-SecureConversation] OASIS Standard, *WS-SecureConversation 1.3*, March 2007.  
 138 [http://docs.oasis-open.org/ws-sx/ws-secureconversation/200512/ws-](http://docs.oasis-open.org/ws-sx/ws-secureconversation/200512/ws-secureconversation-1.3-os.pdf)  
 139 [secureconversation-1.3-os.pdf](http://docs.oasis-open.org/ws-sx/ws-secureconversation/200512/ws-secureconversation-1.3-os.pdf)  
 140 [WS-Security] OASIS Standard, *WS-Security 2004 1.1*, February 2006.  
 141 [http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-](http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf)  
 142 [os-SOAPMessageSecurity.pdf](http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf)  
 143 [WS-SX] OASIS Web Services Secure Exchange (WS-SX) Technical Committee  
 144 <http://www.oasis-open.org/committees/ws-sx>  
 145 [XACML] OASIS Standard, *eXtensible Access Control Markup Language 2.0*,  
 146 February 2005. [http://docs.oasis-open.org/xacml/2.0/access\\_control-xacml-](http://docs.oasis-open.org/xacml/2.0/access_control-xacml-2.0-core-spec-os.pdf)  
 147 [2.0-core-spec-os.pdf](http://docs.oasis-open.org/xacml/2.0/access_control-xacml-2.0-core-spec-os.pdf)

## 148 1.4 Contributions

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

### 157 **NAESB Smart Grid Standards Development Subcommittee [NAESB-SG]:**

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

160 [NAESB EUI] NAESB REQ Energy Usage Information Model:  
 161 [http://www.naesb.org/member\\_login\\_check.asp?doc=req\\_rat102910\\_req\\_2](http://www.naesb.org/member_login_check.asp?doc=req_rat102910_req_2010_ap_9d_rec.doc)  
 162 [010\\_ap\\_9d\\_rec.doc](http://www.naesb.org/member_login_check.asp?doc=req_rat102910_req_2010_ap_9d_rec.doc)  
 163 [NAESB EUI] NAESB WEQ Energy Usage Information Model:  
 164 [http://www.naesb.org/member\\_login\\_check.asp?doc=weq\\_rat102910\\_weq\\_](http://www.naesb.org/member_login_check.asp?doc=weq_rat102910_weq_2010_ap_6d_rec.doc)  
 165 [2010\\_ap\\_6d\\_rec.doc](http://www.naesb.org/member_login_check.asp?doc=weq_rat102910_weq_2010_ap_6d_rec.doc)

166 The following documents are under development and subject to change.

167 [NAESB PAP 09] Phase Two Requirements Specification for Wholesale Standard DR Signals – for  
 168 NIST PAP09:  
 169 [http://www.naesb.org/member\\_login\\_check.asp?doc=fa\\_2010\\_weq\\_api\\_6\\_](http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_6_c_ii.doc)  
 170 [c\\_ii.doc](http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_6_c_ii.doc)  
 171 [NAESB PAP 09] Phase Two Requirements Specification for Retail Standard DR Signals – for  
 172 NIST PAP09:  
 173 [http://www.naesb.org/member\\_login\\_check.asp?doc=fa\\_2010\\_retail\\_api\\_9\\_](http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_9_c.doc)  
 174 [c.doc](http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_9_c.doc)

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



- 183 **The ISO / RTO Council Smart Grid Standards Project:**
- 184 Information Model – HTML: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-HTML-Condensed\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-HTML-Condensed_Rev1_20101014.zip)
- 185
- 186
- 187 Information Model – EAP: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-EAP-Condensed\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-EAP-Condensed_Rev1_20101014.zip)
- 188
- 189
- 190 XML Schemas: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-XML\\_Schemas\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-XML_Schemas_Rev1_20101014.zip)
- 191
- 192 Eclipse CIMTool Project: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-CIMTool-Project-Workspace\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-CIMTool-Project-Workspace_Rev1_20101014.zip)
- 193
- 194
- 195 Interactions - Enrollment and Qualification: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML\\_Enrollment\\_And\\_Qualification\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Enrollment_And_Qualification_Rev1_20101014.zip)
- 196
- 197
- 198 Interactions - Scheduling and Award Notification: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML\\_Scheduling\\_And\\_Award\\_Notification\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Scheduling_And_Award_Notification_Rev1_20101014.zip)
- 199
- 200
- 201 Interactions - Deployment and Real Time Notifications: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML\\_Deployment\\_And\\_RealTime\\_Communications\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Deployment_And_RealTime_Communications_Rev1_20101014.zip)
- 202
- 203
- 204 Interactions - Measurement and Performance: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML\\_Measurement\\_And\\_Performance\\_Rev1\\_20101014.zip](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Measurement_And_Performance_Rev1_20101014.zip)
- 205
- 206
- 207 Interactions Non-Functional Requirements: [http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Non-Functional\\_Requirements\\_Rev1\\_20100930.pdf](http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Non-Functional_Requirements_Rev1_20100930.pdf)
- 208
- 209

210 **UCAIug OpenSG OpenADR Task Force:**

- 211 OpenADR 1.0 System Requirements Specification v1.0
- 212 <http://osgug.ucauiug.org/sghsystems/OpenADR/Shared%20Documents/SRS/OpenSG%20OpenADR%201.0%20SRS%20v1.0.pdf>
- 213
- 214 OpenADR 1.0 Service Definition - Common Version :R0.91
- 215 <http://osgug.ucauiug.org/sghsystems/OpenADR/Shared%20Documents/Services/OpenSG%20OpenADR%20SD%20-%20Common%20r0.91.doc>
- 216
- 217 OpenADR 1.0 Service Definition – Web Services Implementation Profile Version: v0.91
- 218 <http://osgug.ucauiug.org/sghsystems/OpenADR/Shared%20Documents/Services/OpenSG%20OpenADR%20SD%20-%20WS%20r0.91.doc>
- 219

220 **1.5 Namespace**

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

222 <http://docs.oasis-open.org/ns/energyinterop>

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

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

227 *Table 1-1: Namespaces Used in this Specification*

Prefix	Namespace
xs	<a href="http://www.w3.org/2001/XMLSchema">http://www.w3.org/2001/XMLSchema</a>
gml	<a href="http://www.opengis.net/gml/3.2">http://www.opengis.net/gml/3.2</a>

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

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

## 230 1.6 Naming Conventions

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

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

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

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

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

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

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

## 242 1.7 Editing Conventions

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

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

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

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

## 249 1.8 Architectural Background

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

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

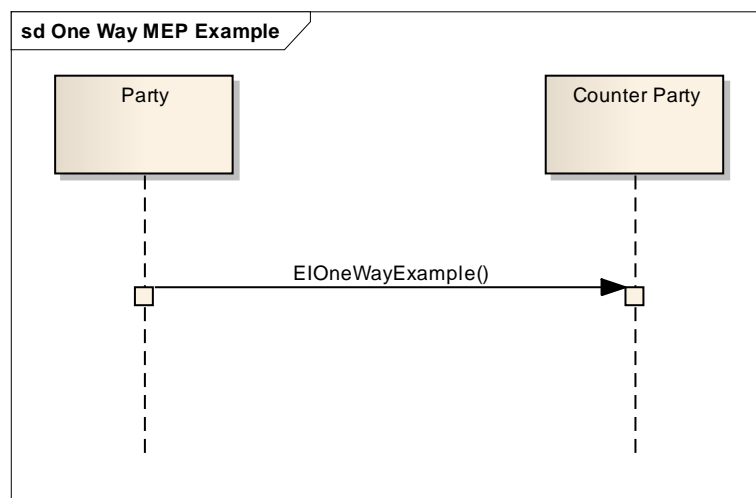
257 The SOA paradigm concerns itself with visibility, interaction, and effect. Visibility refers to the capacity for  
258 those with needs and those with capabilities to be able to see each other. Interaction is the activity of

259 using a capability. A service provides a decision point for any policies and transactions without delving  
260 into the process on either side of the interface

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

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

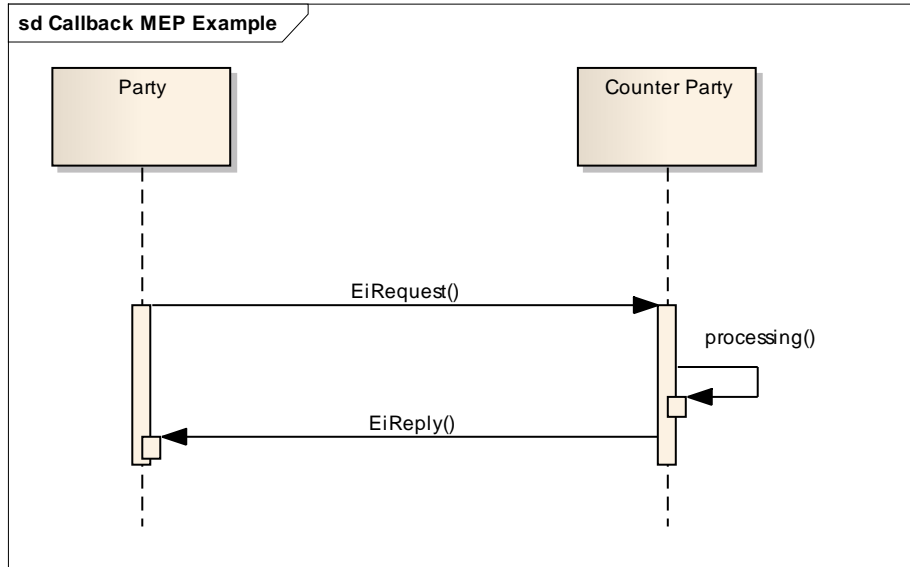
270 Three types of MEPs can inform the discussion on Energy Interoperation integration; a one way MEP,  
271 which differs somewhat from an event notification MEP in that no response is required or expected from  
272 the service provider, although the service consumer may receive appropriate http messages,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



274  
275 *Figure 1-2: One-way MEP where no return is expected*

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

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

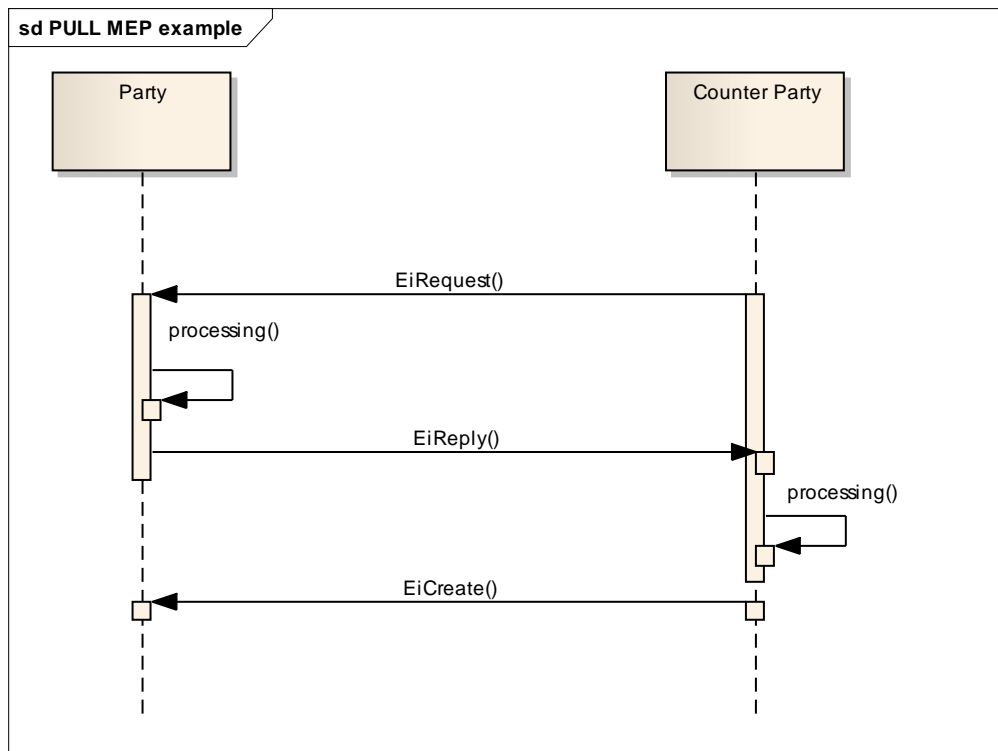


286

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

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

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



296

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

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

---

## 306 2 Overview of Energy Interoperation

### 307 2.1 Scope of Energy Interoperation

308 Energy Interoperation (EI) supports the following:

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

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

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

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

### 326 2.2 Specific scope statements

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

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

335 The following are out of scope for Energy Interoperation:

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

### 341 2.3 Goals & Guidelines for Signals and Price and Product 342 Communication

- 343 1. There are at least four market types, and signals and price and product standardization must  
344 support all four, while allowing for the key differences that exist and will continue to exist in them.  
345 The four market types are:
  - 346 • no open wholesale and no retail competition

- 347 • open wholesale market only
- 348 • open retail competition only
- 349 • open wholesale and open retail competition
- 350 2. Wholesale market DR signals and price and product communication have different characteristics
- 351 than retail market DR signals and price and product communication, although Energy
- 352 Interoperation defines a commonality in format.
- 353 3. It is likely that most end users, with some exceptions among Commercial and Industrial (C&I)
- 354 customers, will not interact directly with wholesale markets.
- 355 4. Retail pricing models are complex, due to the numerous tariff rate structures that exist in both
- 356 regulated and un-regulated markets. Attempts to standardize DR control and pricing signals must
- 357 not hinder regulatory changes or market innovations when it comes to future tariff or pricing
- 358 models.
- 359 5. New business entities such as Energy Service Providers (ESP), Demand Response Providers
- 360 (DRP), DR Aggregators, and Energy Information Service Providers (EISP), will play an increasing
- 361 role in DR implementation. Energy Interoperation supports these and new as yet unnamed
- 362 intermediation services.
- 363 6. DER may play an increasingly important role in DR, yet the development of tariff and/or pricing
- 364 models that support DER's role in DR are still in early stages of development.
- 365 7. The Customer's perspective and ability to react to DR control and price signals must be a key
- 366 driver during the development of standards to support DR programs.

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

- 368 8. Where feasible, customer interfaces and the presentation of energy information to the customer
- 369 should be left in the hands of the market, systems, and product developers enabled by these
- 370 specifications.

371 The NAESB Smart Grid Committee **[NAESB-SG]** provided guidance on the Demand Response and the

372 electricity market customer interactions, as a required input under NIST Smart Grid Priority Action Plan 9

373 (PAP09). Energy Interoperation relied on this guidance. The service and class definitions relied on the

374 information developed to support the NAESB effort in the wholesale **[IRC]** and retail **[OpenSG]** markets.

## 375 **2.4 Scope of Energy Interoperation Communications**

376 While the bulk of examples describe the purchase of real power, emerging energy markets must

377 exchange economic information about other time-sensitive services.

378 For example, delivery of power is often constrained by delivery bottlenecks. The emergence of distributed

379 generation and Plugin Electric Vehicles (PEV) will exacerbate this problem. EMIX includes product

380 definitions for tradable congestion charges and transmission rights. Locational market prices in

381 distribution may come to mirror those already seen in transmission markets.

382 Other services address the direct effects of distribution congestion, including phase imbalances, voltage

383 violations, overloads, etc.

384 These markets introduce different market products, yet the roles and interactions remain the same.

385 Intelligent distribution elements, up to an intelligent transformer take roles in these interactions.

386 A description of the tariffs or market rules to support these interactions is outside the scope of this

387 specification. However, interaction patterns in this specification are defined to provide additional

388 information for markets in which tariffs or market rules are required.

## 389 **2.5 Collaborative Energy [Not Normative]**

390 Collaborative Energy, in this specification, refers to the transactions and management of energy using

391 collaborative approaches, including but not limited to markets, requests for decrease of net demand,

392 while addressing the business goals of the respective parties in arms-length interactions.

393 Transactive energy describes the established process of parties buying and selling energy based on  
394 tenders (buy or sell offers) that may lead to transactions among parties. In open wholesale forward  
395 energy markets, a generator may tender a quantity of energy at a price over a future delivery interval of  
396 time to a customer. Acceptance of a tender results in a binding transaction. In some cases, the  
397 transaction requires physical delivery of energy. In other cases, the transaction is settled for cash at a  
398 price determined by a prescribed price index. The use of Energy Interoperation to enable present and  
399 future wholesale and retail energy markets and retail tariffs, including dynamic and multi-part tariffs is  
400 described in [EMIX]. This section reviews the generic roles and interactions of parties involved in energy  
401 transactions.

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

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

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

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

421 Energy Interoperation supports four essential market activities:

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

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

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

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

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



- 445 3. Priced Indication of Interest: the same as a Priced Offer except that no binding agreement is  
446 immediately intended.
- 447 4. Historical Price: A current price, past transaction price, past offered price, and statistics about  
448 historical price such as high and low prices, averages and volatility.
- 449 5. Price Forecast: A forecast by a party of future prices that are not a Priced Indication of Interest or  
450 Priced Offer. The quality of a price forecast will depend on the source and future market  
451 conditions

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

- 453 1. What is the price of Electricity now?
- 454 2. What will it be in 5 minutes?
- 455 3. What price will electricity have for each hour of the day tomorrow? What is the confidence level  
456 about these predictions?
- 457 4. What will it be at other times in the future?
- 458 5. What was the highest or lowest price for electricity in the last day? Month? Year?
- 459 6. What was the high price for the day the last time it was this hot?

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

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

## 468 **2.6 Assumptions**

### 469 **2.6.1 Availability of Interval Metering**

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

### 474 **2.6.2 Use of EMIX**

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

### 478 **2.6.3 Use of WS-Calendar**

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

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

### 484 **2.6.4 Energy Services Interface**

485 The Energy Services Interface (ESI) is the external face of the energy-consuming node. The ESI may be  
486 directly on an energy management system in the end node, or it may be mediated by other business  
487 systems. The ESI is the point of communication whereby the entities (e.g. utilities, ISOs) that produce and  
488 distribute electricity interact with the entities (e.g. facilities and aggregators) that manage the consumption

489 of electricity. An ESI may be in front of one system or several, one building or several, or even in front of  
490 a microgrid.  
491 This work assumes that there is no direct interaction across the ESI.

---

## 492 **3 Energy Interoperation Architecture**

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

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

### 499 **3.1 Transactive Energy Interactions**

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

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

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

#### 513 **3.1.1 Transaction Side**

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

- 515 • Buy, or
- 516 • Sell

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

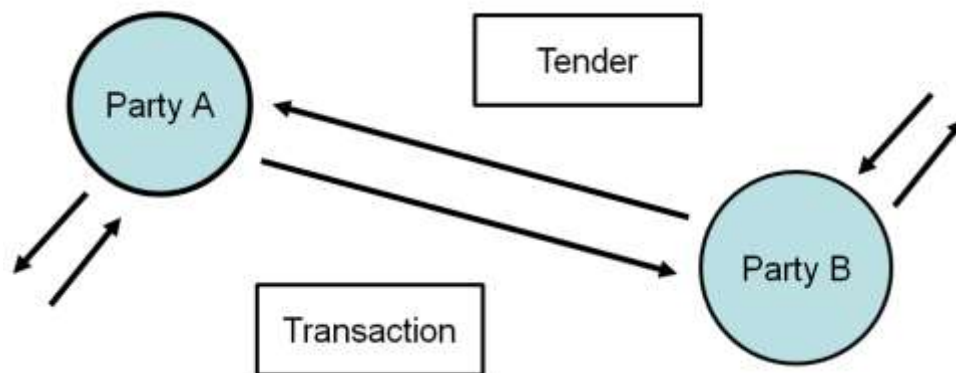
520 A generator typically takes the Sell Side of a Transaction, but can also take the Buy Side of a  
521 Transaction. A generator may take the Buy Side of a Transaction in order to reduce generation because  
522 of a change in generator or market conditions.

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

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

#### 530 **3.1.2 Transactive Interactions among Parties**

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



532  
533 *Figure 3-1: Parties Interacting Using Tenders for Transactions*

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

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

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

### 546 **3.1.3 Retail Service Interactions**

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

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

### 555 **3.1.4 Wholesale Power Interactions**

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

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

### 563 **3.1.5 Transport Interactions**

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

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

## 569 3.2 Event Interactions for Demand and Generation Resources

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

### 576 3.2.1 VTN and VEN Party Roles

577 Similar to the Party interactions of transactive energy, event interactions also have an interoperation  
578 model between two or more Actors. One designated Actor (for that given interaction) is called the **Virtual  
579 Top Node (VTN)** and the remaining one or more actors are called **Virtual End Node(s), or VEN(s)**<sup>1</sup>.

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

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

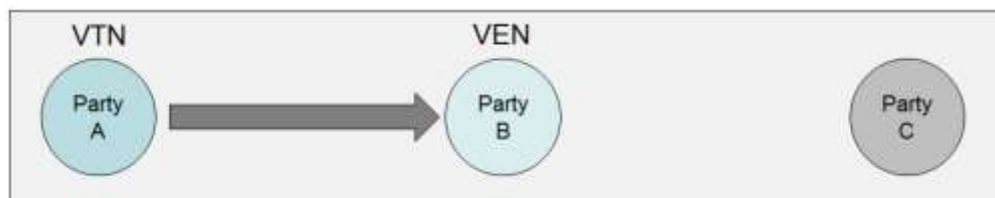
586 The VTN and VEN Roles are useful beyond event-based interactions because they provide stereotyping  
587 of a wide range of behaviors and interactions in energy markets.

### 588 3.2.2 VTN/VEN Interactions

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

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

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



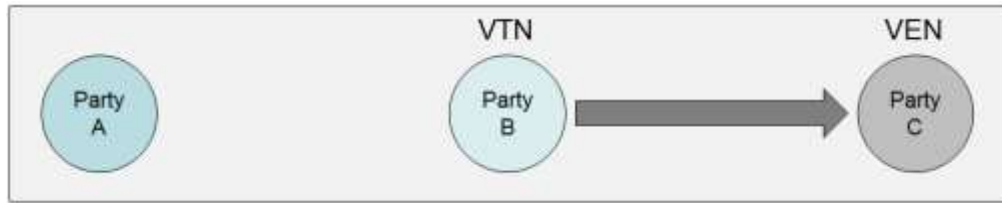
600  
601 *Figure 3-2: Example DR Interaction One*

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

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

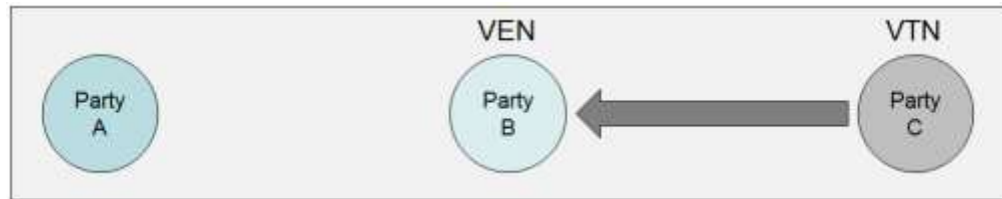
---

<sup>1</sup> We are indebted to EPRI for the Virtual End Node term [EPRI]



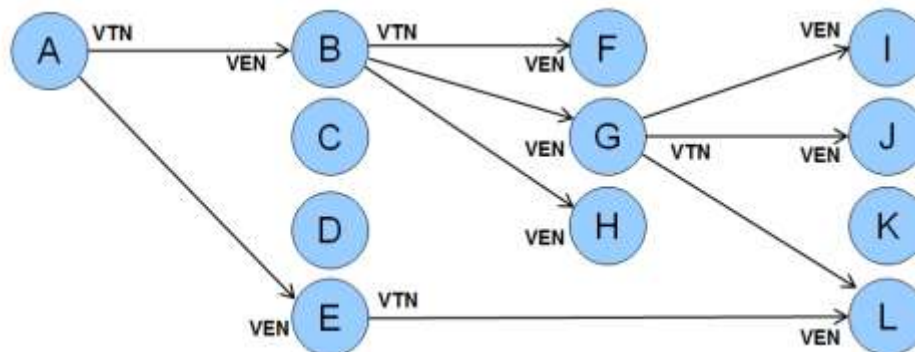
606  
607 *Figure 3-3: Example DR Interaction Two*

608 Moreover, the directionality and the roles of the interaction can change as shown in Figure 3-4.  
609 Again, Party A is not a party to this interaction, but now Party C is the VTN and Party B is the VEN.



610  
611 *Figure 3-4: Example DR Interaction Three*

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



616  
617 *Figure 3-5: Web of Example DR Interactions*

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

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

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

628 *Table 3-1: Interactions and Actors*

<sup>2</sup> Using North American Terminology.



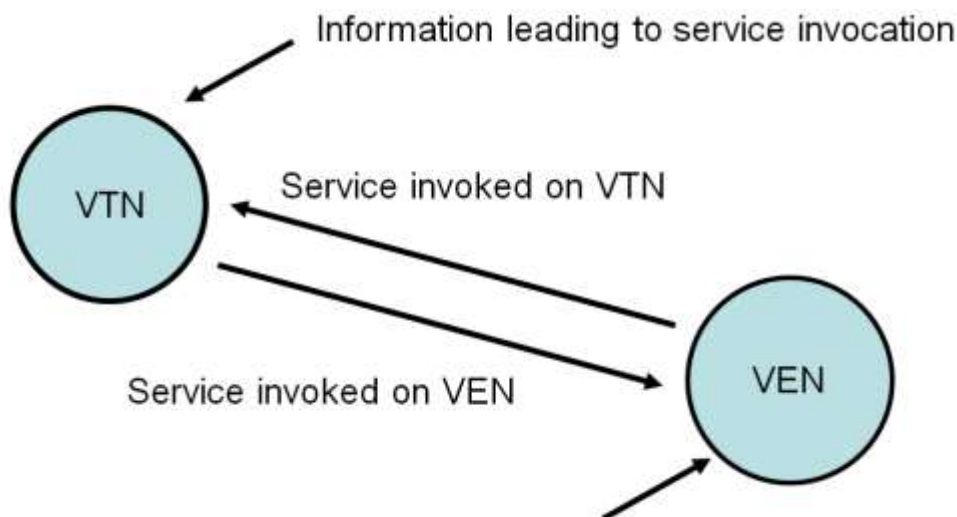
Label	Structure Role	Possible Actor Names
<b>A</b>	VTN	System Operator, DR Event Initiator, Microgrid controller, landlord
<b>B</b>	VEN (wrt A), VTN (wrt F, G, H)	Aggregator, microgrid element, tenant, floor, building, factory
<b>G</b>	VEN (wrt B), VTN (wrt I, J, L)	Microgrid controller, building, floor,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

### 629 3.2.3 VTN/VEN Roles and Services

630 Two structured roles have been defined for each interaction, the Virtual Top Node (VTN) and the Virtual  
631 End Node (VEN). A **VTN** has one or more associated **VENs**.<sup>3</sup>

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

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



637 Information leading to service invocation

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

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

640 The relationship of one or more **VENs** to a **VTN** mirrors common configurations where a VTN (e.g. an  
641 aggregator) has many VENs (say its resources under contract) and each VEN works with one VTN for a  
642 particular interaction.<sup>4</sup>

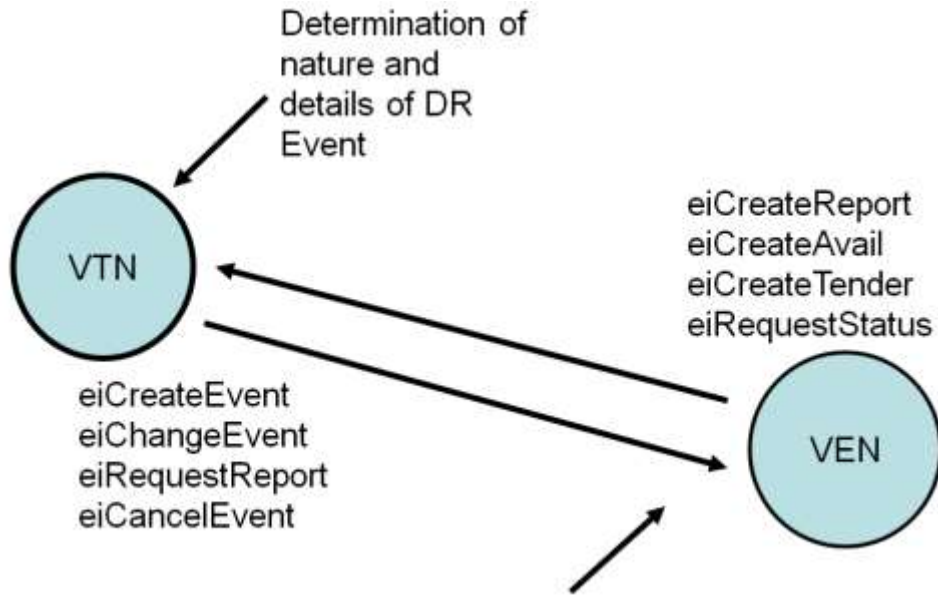
<sup>3</sup> The case of a VTN with zero VENs may be theoretically interesting but has little practical value, hence in a later section VENs having cardinality 1..n are described

<sup>4</sup> 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.

643 Second, as we have seen, each **VEN** can implement the **VTN** interface for another interaction.  
 644 Third, the pattern is recursive as shown above in Figure 3-3 and allows for more complex structures.<sup>5</sup>  
 645 Finally, the Parties of the directed interaction graph can be of varying types or classes. In a Reliability DR  
 646 Event, a System Operator as a VTN may initiate the event with the service invoked on its next level  
 647 (highest) VENS, and so forth. But the same picture can be used to describe many other kinds of  
 648 interaction, e.g. interactions to, from, or within a microgrid [**Galvin**], price and product definition  
 649 distribution, or distribution and aggregation of projected load and usage.  
 650 In some cases the structure graph may permit cycles, in others not.

651 **3.2.4 Demand Response Interactions**

652 In this section the interaction patterns of the services for demand response respectively invoked by an  
 653 **VTN** on one or all of its associated **VENs** and vice versa, are described. Figure 3-6: above shows the  
 654 generic interaction pattern; Figure 3-7 below is specific to Demand Response Events.  
 655 By applying the recursive definitions of VTN and VEN specific services will be defined in the following  
 656 sections (See Figure 3-7)  
 657 The VTN invokes operations on its VENs such as Initiate DR Event and Cancel DR Event, while the VEN  
 658 invokes operations on its VTN such as Create Tender and Create Feedback.  
 659 Note not all DR works this way. A customer may be sent a curtailment tender by the DR provider with a  
 660 price and then can decide to respond. If the customer has agreed to a capacity payment then there may  
 661 be a loss of payments if he does not respond.



662  
 663 *Figure 3-7: Demand Response Interaction Pattern Example*

664 **3.3 Roles, Resources and Interactions (Non-Normative)**

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

<sup>5</sup> 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.



### 667 3.3.1 Choosing a Role

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

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

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

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

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

### 684 3.3.2 The relationship between Actors and Resources

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

689 First, an Actor, representing application code, may assume the Virtual End Node (VEN) role. The same  
690 application code may also support the Virtual Top Node (VTN) role. This is how the graph of VTNs and  
691 VENs in Figure 3-5 is constructed. In that figure, Actor G implements the role of VEN with respect to Actor  
692 B, and the role of VTN with respect to Actors I, J, and L.

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

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

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

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

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

- 711 (a) assign a single Actor presenting the VEN role to each floor of a building, and a VTN related to  
712 them. For external interactions, that VTN for the building would present the VEN interface to  
713 receive and interact with the Energy Interoperation Services, and could present the Party role to  
714 tender, buy, and sell in a market,
- 715 (b) assign a single Actor presenting the VEN role to the building controller, and use other services to  
716 manage or convey information to the floor controllers

717 (c) assign a single Actor presenting the VEN role at the building controller, have that same Actor  
718 present the VTN role to the individual floor controllers. The floor controllers present the VEN role  
719 to the building controller, while presenting the VTN role to its devices, each of which presents the  
720 VEN role to the floor controller.

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

## 723 4 Message Composition & Services

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

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

### 730 4.1 WS-Calendar in Energy Interoperation

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

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

#### 739 4.1.1 Schedule Semantics from WS-Calendar (Non-Normative)

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

744 *Table 4-1: Core Semantics from WS-Calendar*

WS-Calendar Term	Description
<b>Component</b>	In <b>[iCalendar]</b> , 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.
<b>Duration</b>	Duration is the length of time for an event scheduled using iCalendar or any of its derivatives. The <b>[XCAL]</b> Duration is a data type using the string representation defined in the iCalendar ( <b>[RFC5545]</b> ) Duration.
<b>Interval</b>	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.
<b>Sequence</b>	A set of Intervals with defined temporal relationships. Sequences may have gaps between Intervals, or even simultaneous activities. A Sequence is relocatable, 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.

WS-Calendar Term	Description
<b>Gluon</b>	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.
<b>Artifact</b>	The placeholder in an Component that holds that thing that occurs during an Interval. <b>[EMIX]</b> Product Descriptions populate Schedules as Artifacts inside Intervals. In Streams, this specification refers to the Payload conveyed by an Interval.
<b>Link</b>	A reference to an internal object within the same calendar, or an external object in a remote system. The Link is used by one <b>[WS-Calendar]</b> Component to reference another.
<b>Relationship</b>	Links between Components.
<b>Availability</b>	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.

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

#### 746 4.1.2 Schedules and Inheritance

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

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

Units:	KW	Quantity:	10
--------	----	-----------	----

756

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

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

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

760

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

762 The WS-Calendar specification defines how to spread an object like the first over the schedule. The  
763 information that is true for every interval is expressed once only. The information that changes during  
764 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*

765

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

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

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

770

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

772 WS-Calendar calls this pattern Inheritance and specifies a number of rules that govern Inheritance. Table  
773 4-2 summarizes those terms defined in WS-Calendar to describe Inheritance that are used in this  
774 specification as well. This specification does not redefine these terms; they are listed here solely as a  
775 convenience to the reader.

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

Term	Definition
<b>Lineage</b>	The ordered set of Parents that results in a given inheritance or execution context for a Sequence.
<b>Inherit</b>	A Child Inherits attributes (Inheritance) from its Parent.
<b>Inheritance</b>	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.
<b>Bequeath</b>	A Parent Bequeaths attributes (Inheritance) to its Children.

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

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

### 785 **4.1.3 Availability and Schedules**

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

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

#### 793 4.1.4 Smoothing Response

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

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

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

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

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

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

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

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

#### 830 4.2 EMIX in Energy Interoperation

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

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

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



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

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

#### 849 4.2.1 Core Semantics from EMIX

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

852 Table 4-3: EMIX Essential Semantics

EMIX Term	Description
<b>Item Base</b>	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.
<b>Schedule</b>	EMIX Products are delivered for a Duration, at a particular time. EMIX relies on the Interval and the Gluon as defined in [WS-Calendar].
<b>Product Description</b>	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.
<b>EMIX Base</b>	The EMIX Base conveys a Schedule populated with Product Descriptions and is intended to express additional market information sufficient to define Products.
<b>Price Base</b>	The PriceBase conveys a Price, a Relative Price, or a Price Multiplier.
<b>EMIX Interface</b>	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.
<b>Market Context</b>	A URI uniquely identifying a source for market terms, market rules, market prices, etc.
<b>EMIX Product</b>	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.
<b>EMIX Option</b>	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.
<b>Transactive State</b>	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.
<b>Terms</b>	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
<b>Service Area</b>	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.
<b>Power</b>	The EMIX Power schema defines products related to the exchange of Electrical Power using the EMIX semantics.
<b>Resource</b>	The EMIX Resource schema defines the capabilities that a node has to deliver Power products.
<b>Ancillary Service</b>	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.

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

## 855 4.2.2 Putting EMIX in Context

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

858 *Table 4-4: EMIX Market Context*

Expectations and Contexts	Description
<b>Market Context</b>	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.
<b>Availability</b>	Describes when a Resource is available to respond relative to a particular VTN and Market Context
<b>Market Expectations</b>	Market Expectations are associated with a Market Context and consist of a number of Rule Sets.
<b>Standard Terms</b>	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.
<b>Granularity</b>	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.
<b>Non-Standard Terms Handling</b>	Non-Standard terms handling defines what Parties should do with any Term not listed in the Market Rule Sets.
<b>Market Rule-Set</b>	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
<b>Rule Set Purpose</b>	Defines the purpose of a Rule Set, i.e., to define minimum performance, maximum performance, etc.

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

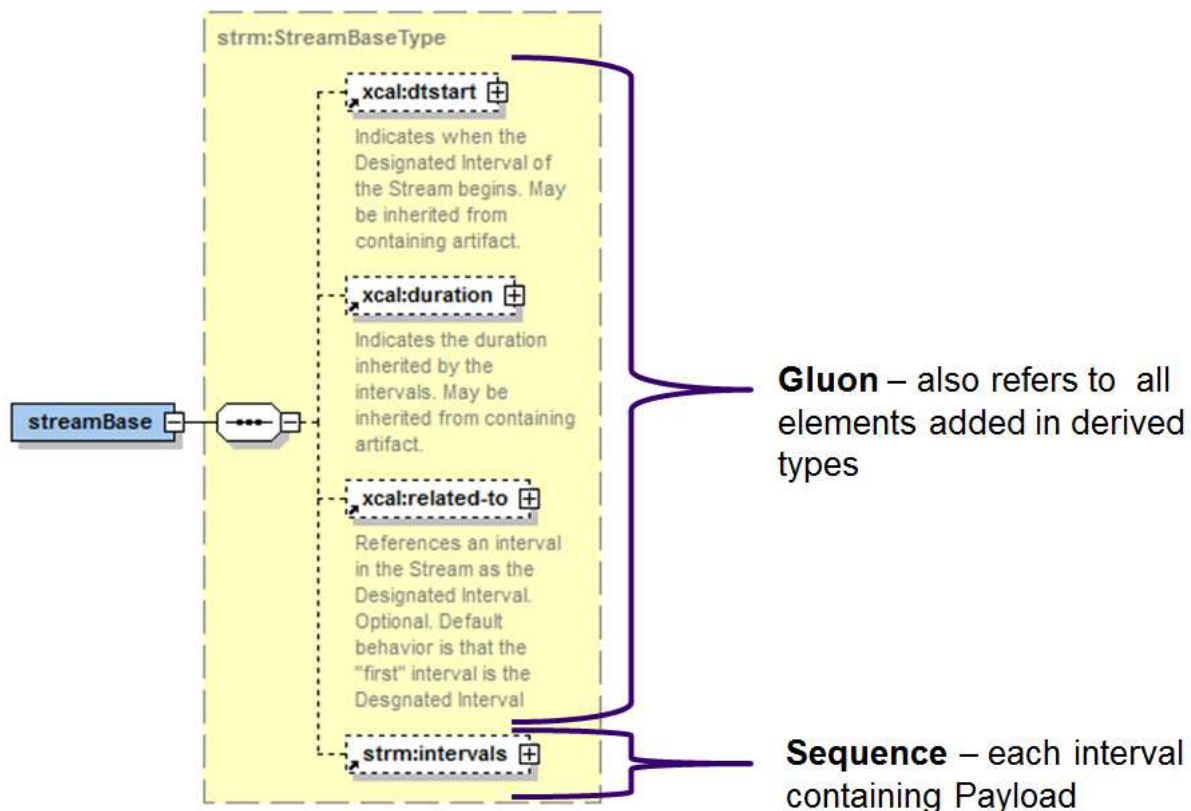
### 861 4.3 Streams: Adaptations of WS-Calendar for Energy Interoperation

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

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

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

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

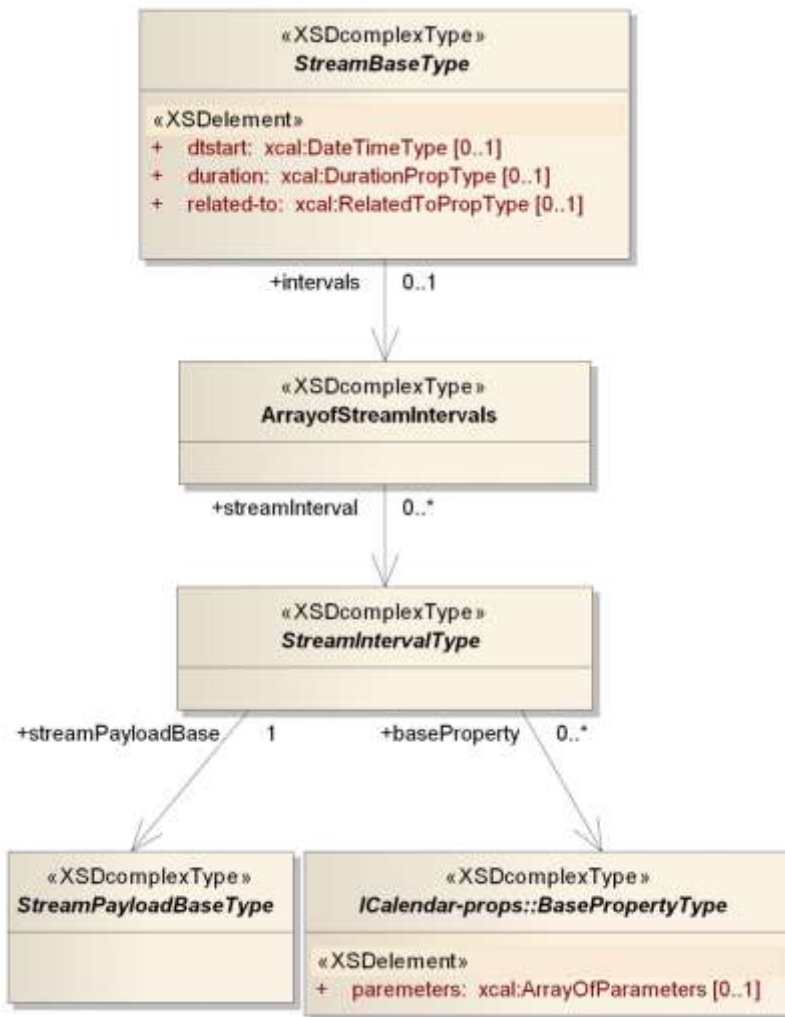


876  
877 *Figure 4-5: Stream as Gluon and Sequence*

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

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

887 **4.3.1 Information Model for Streams**



888  
 889 *Figure 4-6: UML Class Diagram of abstract StreamBase class*

890 **4.3.2 Conformance of Streams to WS-Calendar**

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

#### 895 **4.3.2.1 Stream expression of Intervals expressed as Durations**

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

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

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

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

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

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

#### 919 **4.3.2.2 Observational Data expressed as Streams**

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

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

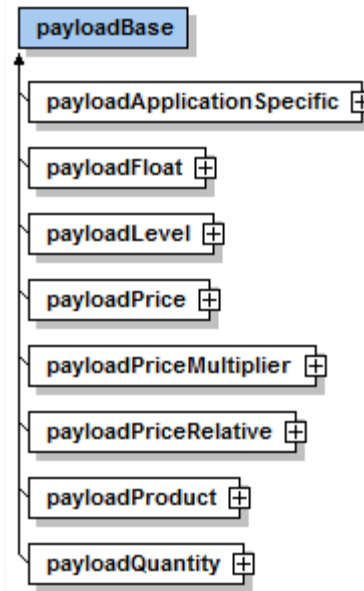
931 Within a Stream expressed using Dates and Times, a virtual UID for each Interval MAY be constructed by  
932 concatenating the Signal Identifier, the PartyID (which may be the VEN ID), and the Date and Time.  
933 Within an Observational Stream, this UID can be expressed within each interval by the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

#### 937 **4.3.3 Payload Optimization in Streams**

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

- 943 1. Unless each interval includes a full EMIX payload, each Interval in a Stream expresses only the  
944 defined subset of the payload that varies over time.

945 2. Each Interval in a Stream uses the same payload subset as all other intervals in that stream.  
946 All streams in this specification share a common Payload base. This commonality is derived from the  
947 commonality of a request for performance (Signal), a report of performance (Report and Delivery),  
948 projections of performance (Projection), and a baseline of performance (Baseline).



949  
950 *Figure 4-7: Payload Base*

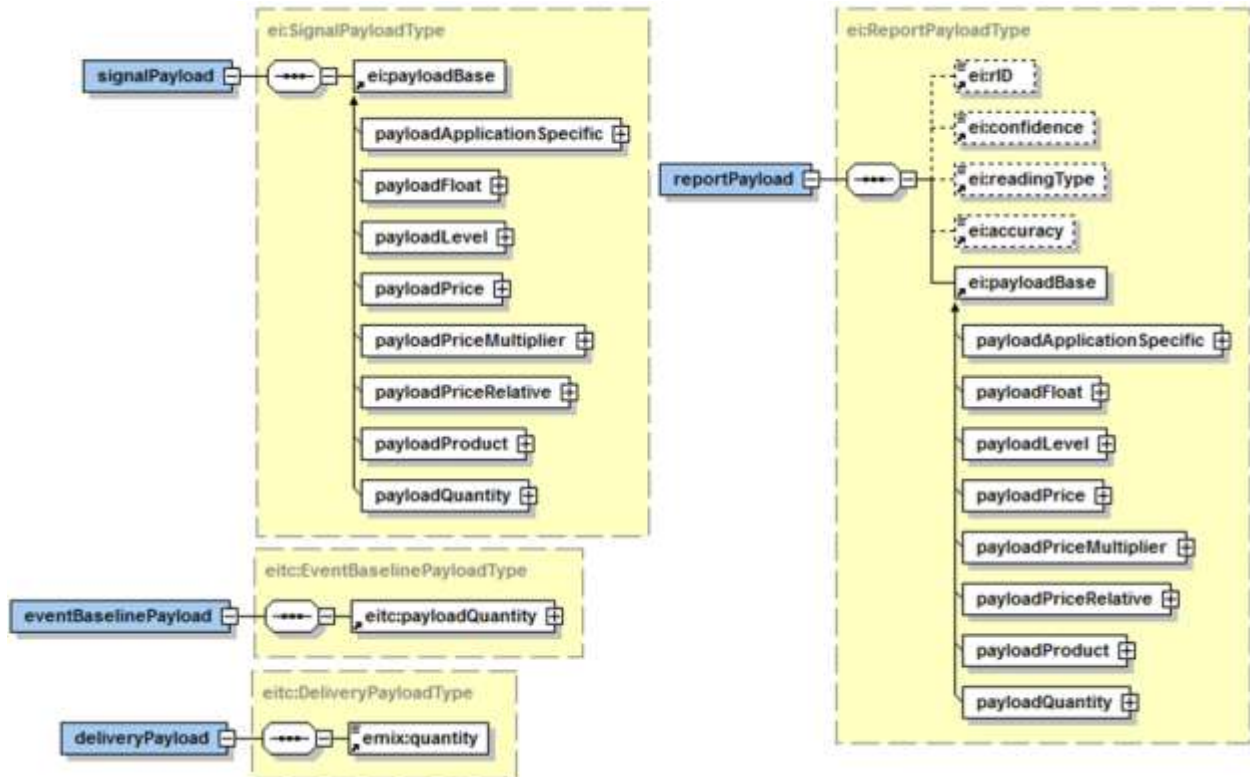
#### 951 **4.3.4 Other elements in Stream Payloads**

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

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

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

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



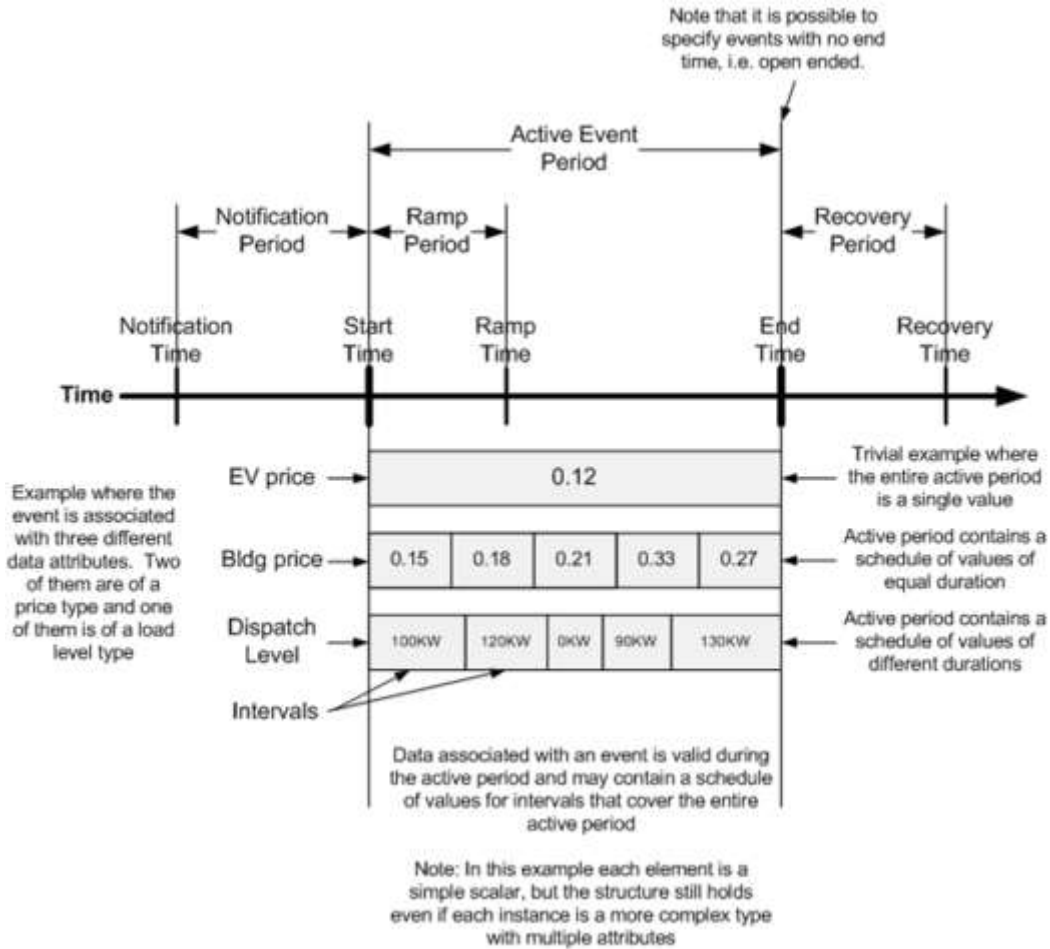
964

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

966 **4.4 Applying EMIX and WS-Calendar to a Power Event**

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





969

970 *Figure 4-9 Demand Response Event and associated Streams*

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

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

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

#### 984 **4.4.1 Streams in a DR Event**

985 The three schedules above are conveyed using Signals which are expressed as Streams as defined  
 986 above.

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

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

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

995 **4.4.2 The Active Period Schedule**

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

1000 The Active period of an event typically includes intervals in which the receiving system prepares for the  
 1001 event, begins its response, maintains its response, and recovers from the response. The schedules for  
 1002 these activities MAY be expressed using EMIX artifacts. For Power communications these can be  
 1003 expressed using artifacts based on EMIX Resources. The schedule for an Event MAY be expressed as  
 1004 can any other Sequence.

1005 More commonly, the Active Period is expressed through a single Interval. The properties of WS-Calendar  
 1006 are extended in this specification to include durations to indicate the notification, ram, and recovery  
 1007 periods. These are interpreted as if they are a normal sequence, constructed as indicated in Table 4-5.

1008 *Table 4-5: Semantics of the Active Period*

Active Period elements	Description
<b>Active Period</b>	The nominal period of the Event. Expressed as a Vcalendar containing the Active Interval and supporting schedule information.
<b>Active Interval</b>	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.
<b>Notification Period</b>	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.
<b>Ramp Up Period</b>	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.
<b>Recovery Period</b>	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.
<b>Tolerance</b>	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.





1010

## 5 Semantics of Energy Interoperation

1011 As stated in in Section 4, much of the core vocabulary for this specification comes from **[EMIX]** and **[WS-**  
1012 **Calendar]**. This section introduces the remaining vocabulary for Energy Interoperation and then defines  
1013 the use of that vocabulary in the higher level types.

1014 The services of Energy Interoperation are built around exchanges of and references to these standard  
1015 information artifacts.

1016 *Table 5-1: Energy Interoperation Identities*

Identity Types	Description
<b>Party</b>	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.
<b>Resource</b>	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.
<b>Market</b>	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.
<b>Market Context</b>	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.
<b>UID</b>	Unique Identifier for every party, role, message, event, etc.

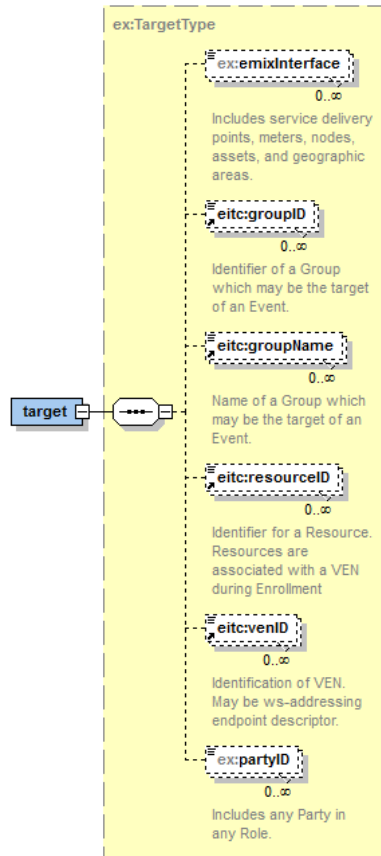
1017 The elements above are used throughout the messages of this specification.

### 5.1 Dramatis Personae: Identifying the Actors

1018 As described in Section 3, each interaction is an interaction between two parties.  
1019

Low Level Identity Types	Description
<b>VEN</b>	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.
<b>VTN</b>	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.
<b>Group</b>	Resources and VENs may be the target of an Event. How group membership is identified or recognized is out of scope.
<b>Target</b>	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.

1020



1021  
1022 *Figure 5-1: EI Target*

1023 **5.1.1 Actor IDs and Roles**

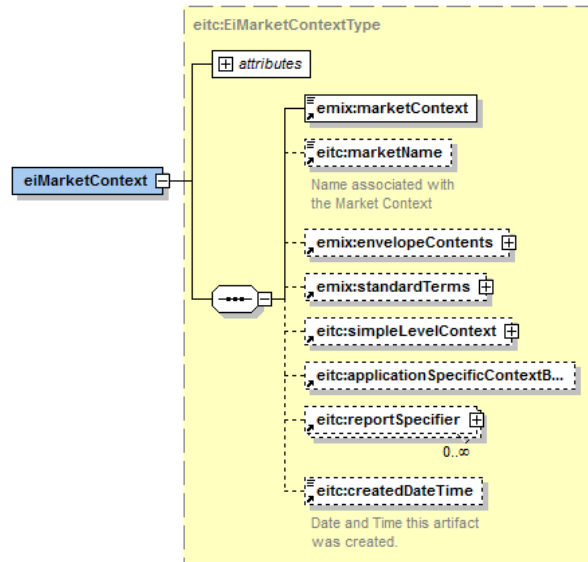
1024 There is a certain fungibility of the Actor IDs in the service payloads. A Party may participate in many  
1025 interactions, yet it is necessary to distinguish each Party by the role it is playing in the current interaction.  
1026 Accordingly, there are named derivatives of the Actor ID for use in each situation.



1027  
1028 *Figure 5-2: UML Class Diagram of Party ID and its derivatives*

1029 **5.2 Market Context**

1030 As defined in [EMIX], a Market Context is a URI, and it can be used to reference Standard Terms. This  
1031 specification describes the expanded set of context information that is part of the EI Market Context.



1032  
1033 *Figure 5-3: EI Market Context*

1034 The Elements of the EI Market Context are, for the most part, defined in [EMIX]. The Market Name  
1035 conveys a human-readable text, perhaps for display in a user interface. As in EMIX, the Envelope  
1036 contains warrants and certificates. For example, if a Market is purported to convey Green Power, however  
1037 defined, that information would be conveyed in the Envelope. Two elements, Simple Levels and  
1038 Application Specific Extensions bear discussion here.

### 1039 5.2.1 Simple Levels

1040 The Simple Level Context is an agreement-based interaction abstracted away from expressions of value  
1041 or actual amounts. Simple Levels define levels of energy scarcity and abundance, at an agreed upon  
1042 granularity. A VEN can discover Specific Levels within a Market Context.

1043 *Table 5-2: Simple Levels*

Level Information	Description
<b>Simple Level Context</b>	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.
<b>Upper Limit</b>	The upper level for this Context. If the Upper Limit is 5, the levels are 1-5, where 5 indicates the greatest scarcity.
<b>Normal Value</b>	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.
<b>Level</b>	Payload used in Signals to convey Simple Level to a VEN

1044 For example, a simple program may have the levels Normal, High, and Critical. The Simple Level Context  
1045 would indicate three levels with a normal value of one.

1046 How a VEN associates particular activities and responses to the Simple Levels is out of scope for this  
1047 specification.

### 1048 5.2.2 Application Specific Extensions

1049 A VTN may wish to communicate with, and a VEN may wish to allow communication with a specific  
1050 Application operating within the VEN. Operating such an Application MAY be part of a specific Market

1051 Context. This specification provides explicit support for these Application Specific Extensions by means of  
 1052 4 abstract types.

1053 *Table 5-3: Application Specific Extensions*

Extensions	Description
<b>Application Specific Extension Base</b>	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.
<b>Application Specific Context Base</b>	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.
<b>Application Specific Signal Base</b>	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.
<b>Application Specific Report Base</b>	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.

1054 The primary concern of the conformance rules for Application Specific Extensions is that they avoid  
 1055 redefinition of the semantics of Energy Interoperation. Prices SHALL be communicated as defines in  
 1056 EMIX Price Base. Schedules SHALL be communicated using the semantics of WS-Calendar. Products  
 1057 and things to be measured SHALL be expressed using the EMIX Item Base.

1058 Parties wishing to exchange Application Specific Extensions SHALL extend the Signal Types and Report  
 1059 Types to indicate they are using their specific Payloads.

### 1060 **5.2.3 Response Smoothing**

1061 Precision of communication and response causes new problems for collections of entities and systems.  
 1062 With WS-Calendar and Energy Interoperation, thousands of systems and devices could respond at the  
 1063 same moment, causing grid instabilities or even equipment damage.

1064 To avoid these problems, Energy Interoperation uses WS-Calendar Tolerances (Start Before, Start After,  
 1065 End Before, and End After) to specify a Duration in which response smoothing MAY be requested.

1066 To further refine the expectation surrounding Smoothing, this specification defines a new Term, i.e., an  
 1067 extension of the EMIX Base Term, to convey expectations for smoothing the aggregate response.  
 1068 Because it is a Term, is can be communicated as part of a Market Context, or as part of an individual  
 1069 Event.

1070 The Smoothing Term provides actionable information; of course the degree of adherence to what is an  
 1071 application or deployment performance characteristic is out of scope for this specification. See also  
 1072 Section 4.1.4.

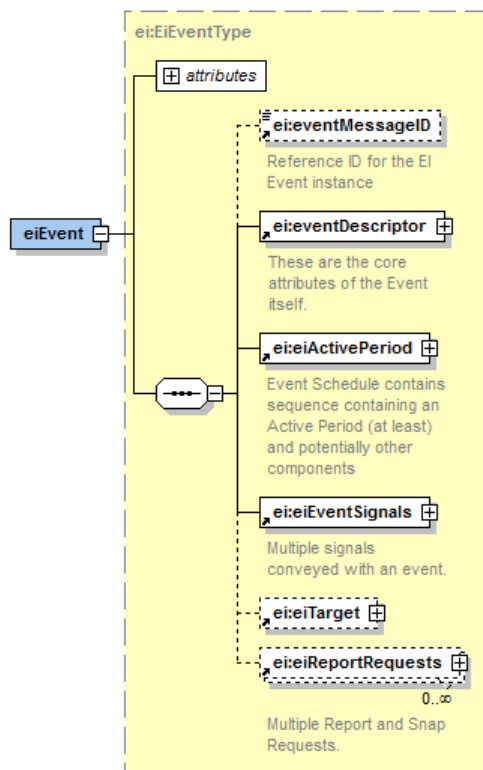
1073 *Table 5-4: Smoothing Terms*

Response Smoothing	Description
<b>Smoothing</b>	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.

Response Smoothing	Description
<b>Ramp</b>	A smooth or uniform step ramp is indicated between the initial and end values in the respective Tolerance Interval
<b>Uniform</b>	A uniform distribution is indicated over the entire respective Tolerance Interval.
<b>None</b>	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.

1074 **5.3 Event-based Interactions**

1075 Events are stylized business interactions that are used in formal demand response environments. As  
 1076 described in Section 3, Events are used in communications between a VTN and a VEN. An Event  
 1077 consists of the time periods, deadlines, and transitions during which Demand Resources perform. The  
 1078 VTN specifies the duration and applicability of an Event. Some deadlines, time periods, and transitions  
 1079 may not be applicable to all products or services.



1080  
 1081 *Figure 5-4: Event Overview*

1082 **5.3.1 The Event Descriptor**

1083 The Event descriptor contains metadata about the event itself.

1084 *Table 5-5: The Event Descriptor*

Event Descriptor Elements	Description
<b>Event Descriptor</b>	A collection of meta-data about an Event
<b>Event ID</b>	Identifier assigned to the Event Descriptor

Event Descriptor Elements	Description
<b>Modification Number</b>	If present, indicates that the event has been modified. Incremented each time the event is modified.
<b>Modification Date and Time</b>	The date and time a modification takes effect.
<b>Modification Reason</b>	Reason describing why the event is being modified. The values for reason are not specified or restricted.
<b>Priority</b>	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.
<b>Market Context</b>	The overall market or program rules that govern this event.
<b>Created Date Time</b>	Indicates when this artifact was created.
<b>Event Status</b>	Indicates the current status of an event as of the descriptor generation. Enumerated values are: <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> <li>• Active: Event has been initiated and is currently active.</li> <li>• Completed: Event has completed.</li> <li>• Cancelled: Event has been canceled.</li> </ul> <p>These values are similar but not identical to those used by the Event Filter as described in Section 9.2 “<i>Special Semantics of the Event Request Operations</i>”. The value is present in Energy Interoperation to support backward compatibility with OpenADR 1.0.</p>
<b>Operating Day</b>	Indicates the nominal date for the event. Important for some market contexts.
<b>Test Event</b>	If present, can indicate that this event is a test event rather than an actual event.
<b>Comment</b>	Free-form information provided by the VTN

### 1085 5.3.2 The Active Period

1086 See Section 4.4 for terminology describing the periods of an event.

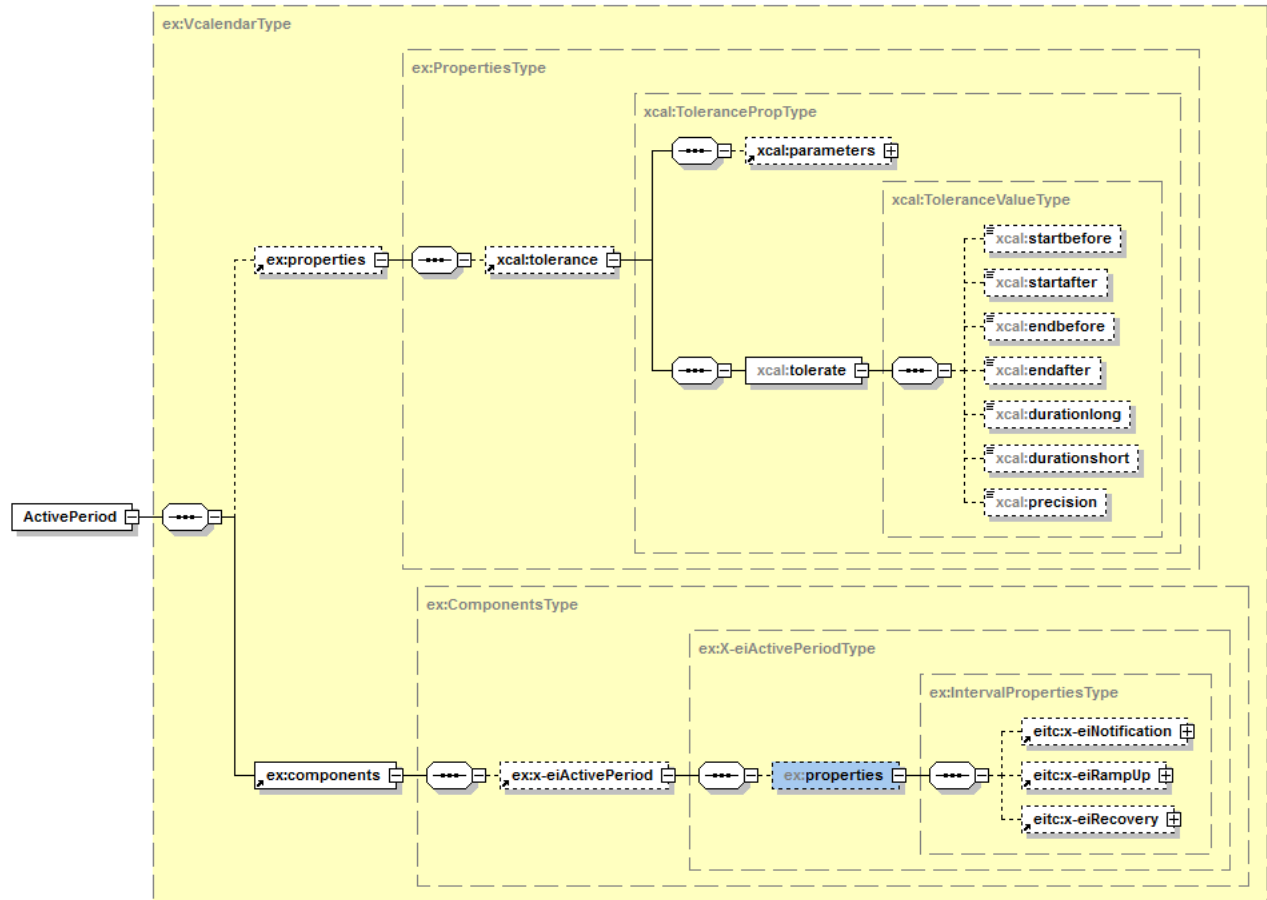
1087 The Active Period is a Sequence that describes the overall schedule for an Event. The Active period is a  
1088 Vcalendar type that contain a Sequence and MAY have its own properties. The Sequence of an Active  
1089 Period generally falls into a common Interval pattern of Notification, Ramp-up, Active, and Recovery. The  
1090 Designated Interval of the Sequence is also referred to as the Active Interval.

1091 This stereotypic pattern can be collapsed with the Intervals for Notification, Ramp-up, and Recovery  
1092 expressed as Properties of the Active Interval. Notwithstanding this common pattern, the Active Period  
1093 can contain any valid Sequence, as long as the meaning conveyed is understood by both parties.

1094 A single Event may be broadcast to many VENs with similar performance characteristics. If the VENs all  
1095 perform in unison, it can create spikes (or sudden drops) in energy use that can be harmful to the  
1096 distribution system. It is necessary for a VEN to be able to ameliorate this issue by requesting response  
1097 smoothing as described in Section 4.1.4.



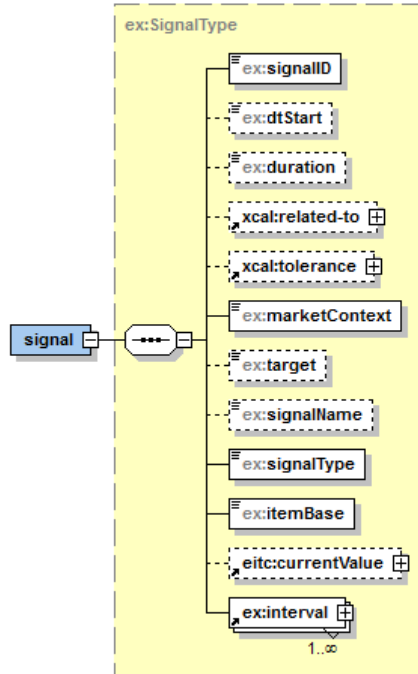
1098 A smoothing request is indicated through the WS-Calendar Tolerance Property. This property is applied  
 1099 to the overall Active Period so its meaning is the same whether the simplified common pattern or a full  
 1100 Sequence is conveyed.



1101  
 1102 *Figure 5-5: Active Period Elements*

1103 **5.3.3 The Event Signals**

1104 Event Signals convey the detailed information about the schedule for an event. Signals are conveyed  
 1105 using Streams as described in Section 4.3. When an Event conveys multiple signals, they may be aimed  
 1106 at different target resources in different Market Contexts, or they may use different semantics, i.e., one  
 1107 use Price and another use Simple Level semantics. All Event Signals have a common form.



1108

1109 *Figure 5-6: Event Signal Overview*

1110 As do all Streams, each Event Signal has a starting time, and a Tolerance (for smoothing); if absent,  
 1111 these are inherited from the Active Interval as if the Active Interval were a Gluon. The Time Zone is  
 1112 inherited from the Market Context. Each Event Signal includes a Related-To parameter to name the  
 1113 Designated Interval; if there is none, the first Interval is the Designated Interval. The Designated Interval  
 1114 has specific meaning for Sequence scheduling as defined in WS-Calendar.

1115 **5.3.3.1 Details of the Signal**

1116 Each signal includes a Market Context and optionally a Target. The Market Context and Target are used  
 1117 by the VEN to select which Signal, if any, to respond to. The Signal Name provides the VEN with a  
 1118 human-friendly description of the Signal, perhaps for display in a user interface. An EMIX Item Base  
 1119 enumerates what is being measured, and perhaps paid for, by the Signal. A Signal Type defines what  
 1120 Payload must be used throughout the signal; all Payloads in a signal MUST be of the same type. Each  
 1121 Interval contains a Payload, as specified by the Signal Type. An optional element, Current Value caches  
 1122 the current value (as of the signal creation) of the Payload.

1123 *Table 5-6: Signal Types*

Signal Types	Description
<b>Delta</b>	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.
<b>Multiplier</b>	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.
<b>Level</b>	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
<b>Price</b>	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.
<b>Product</b>	Signal indicates the Product for each interval. Payload Type is an EMIX Product Description.
<b>Set-point</b>	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.

1124 Parties may choose to exchange application specific payloads in signals as well. Prior to doing so, they  
1125 MUST extend the Application Specific Signal Base and agree upon the Signal Type they will use. The  
1126 Signal Type MUST conform to the EI Extension pattern. See Appendix C for a discussion of conforming  
1127 extension.

### 1128 5.3.4 Baselines

1129 Baselines are streams that can incorporate signals and share many of the same elements. As some  
1130 signals indicate the performance requested is relative to that in another interval, Baselines indicate the  
1131 performance in that Interval.

1132 The Baseline is a signal that expresses the amount as denominated by the Item Base that is the starting  
1133 point for the signal types above. The computational basis for the Baseline is not in scope for this  
1134 specification. The Baseline is compared to the actual metered consumption during the Event to determine  
1135 the value of the Response. Depending on the type of product or service, Baseline calculations may be  
1136 performed in real time or after the fact.

1137 Another form of the Baseline merely indicates the comparable period that is used for comparison. This  
1138 enables the sender to indicate when the Baseline is drawn from without indicating the values for that  
1139 Baseline period, which may not yet be known.

### 1140 5.3.5 Opt – Making Choices

1141 When a VEN enrolls in an event-oriented Market Context, it makes itself Available to respond to events  
1142 on a given schedule. The Availability schedule may be simple (all day, all the time) or complex (weekday  
1143 afternoons, on weekends with a long notice, and not on Thursday mornings during biweekly payroll). No  
1144 matter how simple or complex the Availability, the VEN may choose to change it for a limited period. This  
1145 decision is communicated with an Opt (as in “Opt In” and “Opt Out”).

1146 The primary information payload for an Opt is a collection of Vavailability artifacts. An optional element  
1147 inside each Availability artifact determines whether the particular repeating schedule within indicates  
1148 availability or unavailability.

1149 Business rules require that someone Opting declare their reason, using one of the specific enumerated  
1150 reasons or an extension as allowed by the local Market.

1151 *Table 5-7: Opt*

Opt Element	Description
<b>Opt</b>	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.

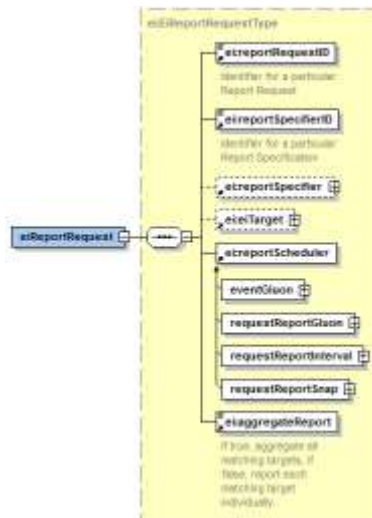
Opt Element	Description
<b>Opt ID</b>	A reference ID for a particular Opt notification. This identifier may be used by other entities to refer to this instance of an Opt.
<b>Opt Type</b>	Either Opt-In or Opt-Out. This element determines the processing of the Vavailability. If Opt In, then any available 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.
<b>Opt Reason</b>	Reason for the Opt. Enumerated reasons include: Economic, Emergency, Must Run, Not Participating, Outage Run Status, Override Status, Participating

- 1152 The Opt Type controls specific differences in how an Opt is processed against the pre-existing  
1153 availability.
- 1154 Opt-In: After processing, the new schedule and availability is added to the existing availability for  
1155 the period bounded by the Opt Availabilities.
- 1156 Opt-Out: After processing, the new schedule and availability replace the existing availability for the  
1157 period bounded by the Opt Availabilities.
- 1158 In either case, when the bounding period is over, Availability reverts to the previous schedule.

## 1159 5.4 Monitoring, Reporting, and Projection

1160 A Party may request that another Party measure something and report back. The thing measured may  
1161 include Power, Voltage, Peak, or any other attribute associated with the products exchanged. These  
1162 measurements may or may not be in relation to an Event. An EiReport is the record of a measurement or  
1163 series of measurements made by one Party and delivered to another.

1164 A Party requests that another Party prepare a Report by means of a Report Request. Report Requests  
1165 can be delivered using the Report service, or can accompany an Event. The Historian and Projection  
1166 services also make use of the Report Request.



1167  
1168 *Figure 5-7: The Report Request*

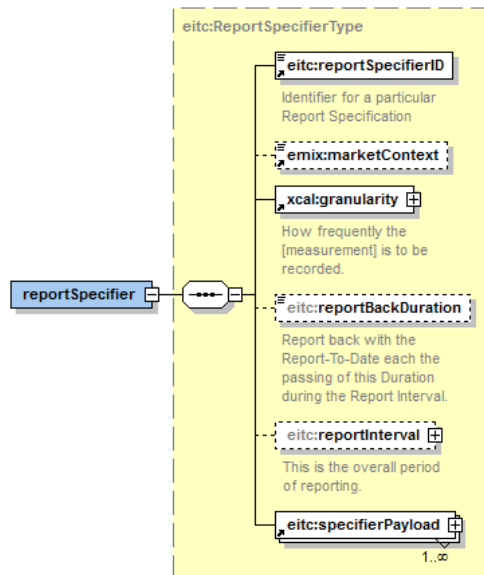
1169  
1170 *Table 5-8: Elements of the Report Request*

Report Specifier	Description
<b>Report Request ID</b>	Identifies this request

Report Specifier	Description
<b>Report Specifier ID</b>	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.
<b>Report Specifier</b>	Request MAY optionally include the Report Specifier as described below.
<b>Target</b>	Standard group of Parties, Resources, Groups, et al. that the Report concerns.
<b>Report Scheduler</b>	Indication of when the report is to be run, for how long, etc.
<b>Aggregate Report</b>	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,

1171 **5.4.1 The Report Specifier**

1172 A Party specifies what reports it wants by means of a Report Specifier. Report Specifiers may be  
 1173 delivered in the Report Request or be known from the Market Context.



1174  
 1175 *Figure 5-8: The Report Specifier*

1176 A single Report Specifier may generate quite different Reports based upon which service it is delivered by  
 1177 and how it is scheduled. The elements of a Report Specifier are as follows:

1178 *Table 5-9: Elements of the Report Specifier*

Report Specifier	Description
<b>Specifier ID</b>	Identifies this Report Specifier
<b>Market Context</b>	The Optional Market Context MAY provide information about the Product that is being reported, or about where this Specifier came from.
<b>Granularity</b>	Duration defining temporal detail, i.e., “read the meter every 5 minutes”
<b>Report-Back Duration</b>	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 Specifier	Description
<b>Report Interval</b>	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.
<b>Specifier Payload</b>	The Specifier Payload indicates exactly what is to be in the report.

1179 **5.4.1.1 The Report Specifier Payload**

1180 The Specifier Payload indicates exactly what is in the Report. It consists of an **[EMIX]** ItemBase and a  
 1181 Report Type.

1182 *Table 5-10: Report Specifier Payload*

Report Specifier	Description
<b>rID</b>	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.
<b>Item Base</b>	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.
<b>Report Type</b>	Defines what is being measured and reported. Measurements are in units of Item Base unless the Report Type indicates otherwise.

1183 The Report Type specifies what is measured and, sometimes, how it is measured.

1184 **5.4.1.2 The Report Types**

1185 Report Types are an enumeration that indicates how the Item Base is to be measured. These  
 1186 enumerations parallel the Signal Types used in Events.

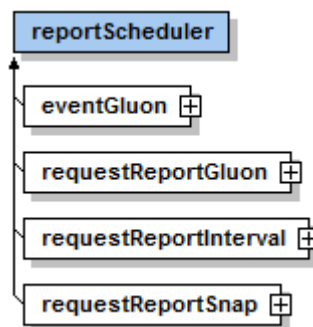
1187 *Table 5-11: Report Types*

Report Types	Description
<b>Reading</b>	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.
<b>Usage</b>	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.
<b>Demand</b>	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.
<b>Set Point</b>	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.
<b>Delta Usage</b>	Change in Usage as compared to the Baseline
<b>Delta Set point</b>	Changes in Set point from previous schedule
<b>Delta Demand</b>	Change in Demand as compared to the Baseline

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

1188 Report Type is implemented as an enumerated string with extensibility. Parties wishing to extend the  
1189 enumeration MUST defined the report payload requirements.

## 1190 5.4.2 Report Scheduler



1191  
1192 *Figure 5-9: Report Scheduler*

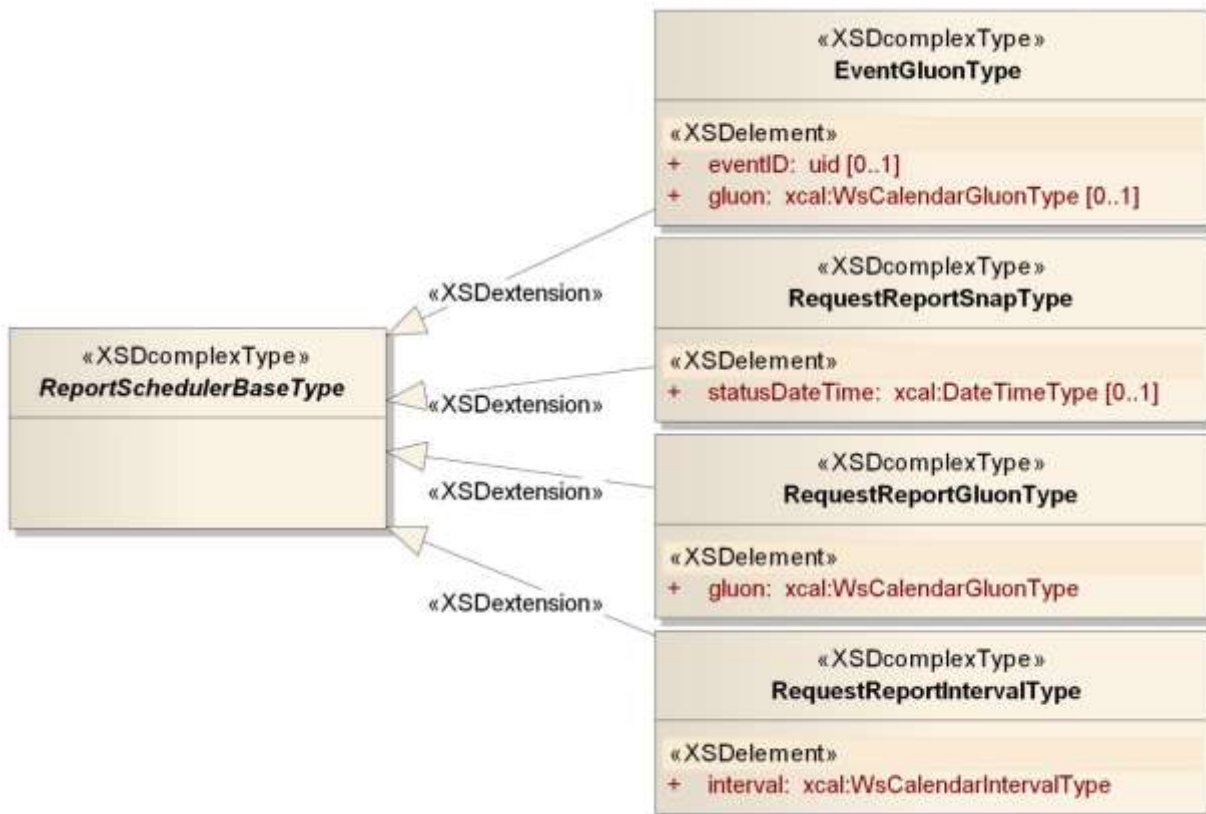
1193 The report scheduler is an abstract type that specifies how often and for how long a report will be  
1194 prepared. The Report Scheduler adds flexibility and consistency by enabling a single Report Specifier to  
1195 be used in multiple scenarios. One option for Report Scheduler enables a Report Request to be  
1196 associated with an Event.

1197 *Table 5-12: Types of Report Scheduler*



Report Scheduler	Description
<b>Event Gluon</b>	<p>Associates a Report Request with a particular event. This type consists of a Gluon and a reference to the Event ID.</p> <p>The Gluon sets the Report Interval relative to the Active Interval of the Event. For example:</p> <p><b>SS -T20M.</b> The Report interval starts 20 minutes before (-T20M) the Active Interval starts (Start to Start).</p> <p><b>FF T1H.</b> The Report interval Finishes 1 hour after (T1H) the Active Interval Finishes (Finish to Finish).</p> <p>If absent, the Report Interval is the same as the Active Interval, i.e., the Report runs during Active Interval.</p> <p>The Event ID indicates the Event this report is related to. If absent, the Report Request must be delivered as part of an EiEvent</p>
<b>Request Report Gluon</b>	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.
<b>Request Report Interval</b>	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.
<b>Request Report Snap</b>	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.

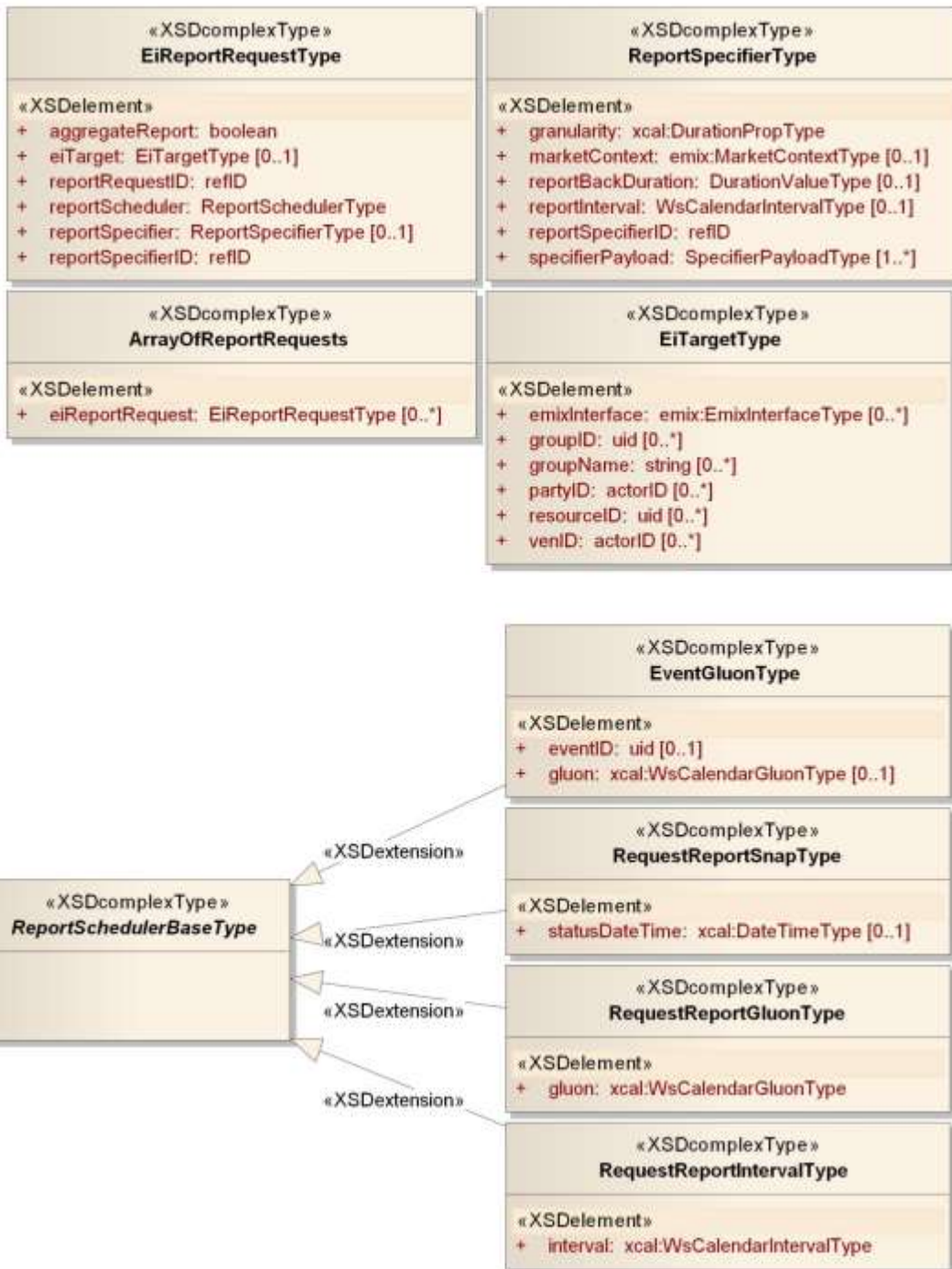
1198 **5.4.2.1 UML Diagram of Report Scheduler**



1199

1200 Figure 5-10: UML Diagram of Report Scheduler

### 1201 5.4.3 UML Diagram of Report Request



1202 Figure 5-11: UML Class Diagram of Report Request

### 1204 5.5 Reports, Snaps, and Projections

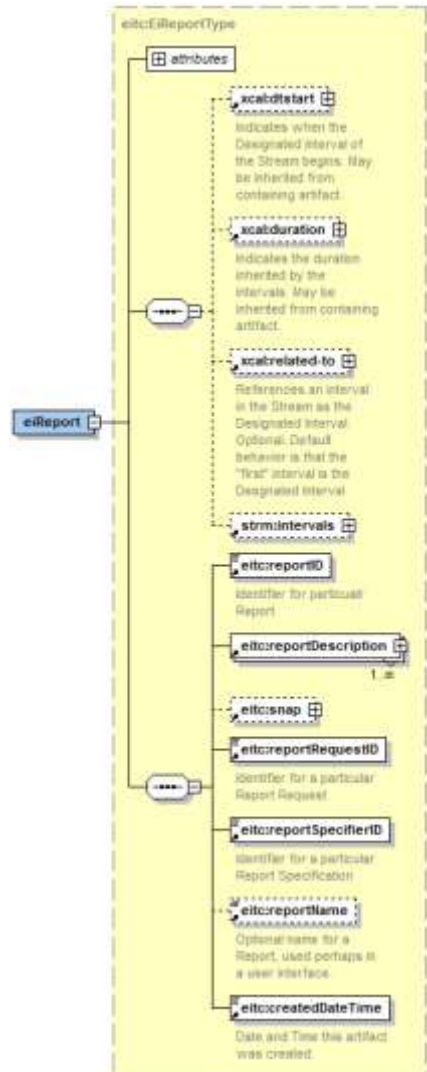
1205 Reports are simple Streams with some metadata identifying the report and a collection of Intervals  
1206 containing the Payloads for each [measurement]. Reports can be of the past, the present, or the future. A  
1207 Report appears as a series of [measurements] in the past. A Snap is a Report made as of a single

1208 moment. A Projection is in the same form as a report, but it includes projections of what will be in the  
 1209 future, including a confidence level in the payload.

1210 *Table 5-13: Reports*

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

1211 The above information is sufficient to uniquely identify each Report, why it was made, and to what  
 1212 specifications. The full form of a report is as follows in Figure 5-12.



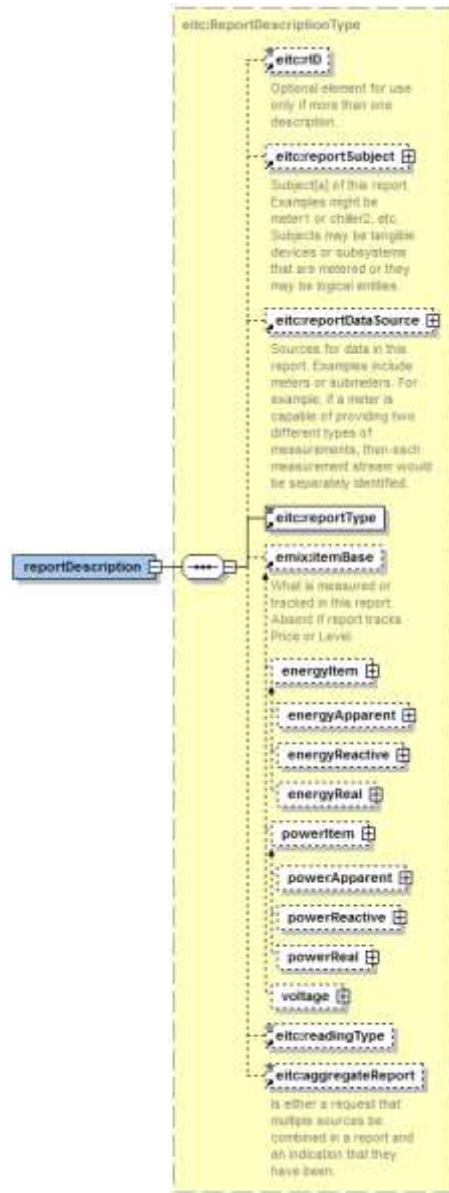
1213  
 1214 *Figure 5-12: The Report*

### 1215 **5.5.1 Elements of the Report**

1216 *Table 5-14: Elements of Reports*

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

1217 **5.5.2 Report Description**



1218  
1219 *Figure 5-13: The Report Description*

1220 The Report Description indicates what is in the Report, which may be different from what was specified,  
1221 particularly if multiple elements were in the Target. A Report may include multiple Report Descriptions if  
1222 multiple payloads are delivered in each interval. Conversely, if the Recipient is able to rely completely on  
1223 the Report Specifier, the Report Description MAY be omitted.

1224 The Elements of the Report Description are as follows:

1225 *Table 5-15: Elements of the Report Description*

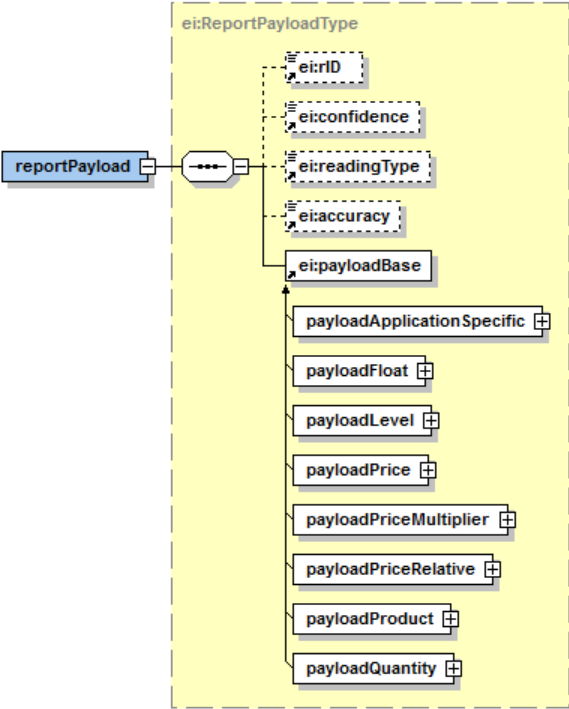
Report Elements	Description
<b>rID</b>	Optional report identifier required only if multiple payloads are delivered in each Interval.

Report Elements	Description
<b>Subject</b>	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.
<b>Data Source</b>	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.
<b>Report Type</b>	Identifies what is the meaning of each measurement, as defined in Section 5.4.1.2.
<b>Item Base</b>	Identifies the Units being measured, unless the Report Type indicates this element is meaningless.
<b>Reading Type</b>	If present, indicates metadata about the Readings, i.e., direct measurement or computation. Conforming profiles MAY ignore Reading Type.
<b>Aggregate Report</b>	Identifies whether each payload represents an individual subject, or the sum of multiple subjects.

1226 **5.5.3 Report Payloads**

1227 The details in each Interval in a Report bear a lot of similarity to those in the Signals. In many cases, a  
 1228 Signal requests that a system provide something similar to its Signal Value. Reporting back in the same  
 1229 format enables ready comparisons. These values are conveyed in the Payload.

1230 Signals, though, are ideal. Reports describe real world effects, and therefore messy. For this reason,  
 1231 Report Payloads include some additional information.



1232  
 1233 *Figure 5-14: the Report Payload*

1234 Figure 5-14 shows the information qualifications alongside the Payload. If an Application within a VEN  
 1235 has specific reporting requirements, a new Payload Type can be derived from the abstract Payload  
 1236 Application Specific type; a type so derived can be delivered by a conforming report service.



1237 *Table 5-16: Report Payload Qualifiers*

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

1238 **5.5.3.1**

1239 The Reading Type describes the information returned in a report. Specifically, the Reading Type  
 1240 describes how the number in the payload was arrived at. The Reading Type MAY be in the stream Gluon,  
 1241 and be inherited by each Interval in the Sequence (or by the Snap, if present). The Reading Type MAY  
 1242 also appear in any Interval where the reporting system is indicating that one payload differs from others in  
 1243 the Sequence. Reading Types are described in Table 5-17.

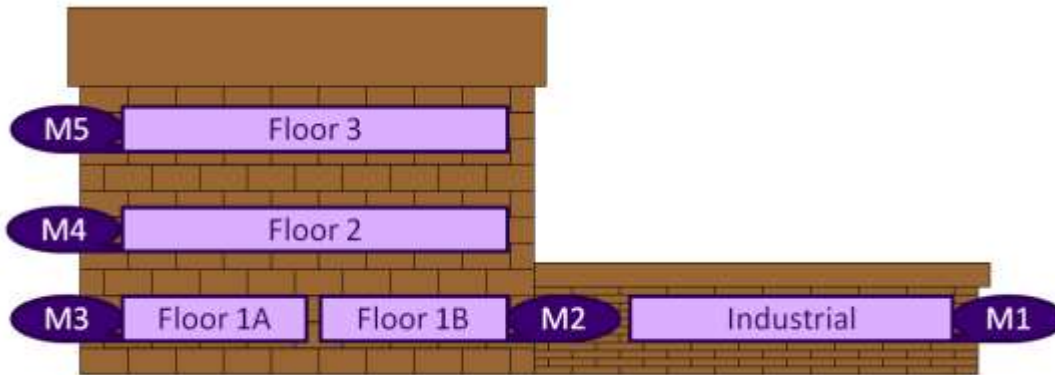
1244 *Table 5-17: Reading Types*

Reading Type	Description
<b>Direct Read</b>	Reading is read from a device that increases monotonically, and usage must be computed from pairs of start and stop readings.
<b>Net</b>	Meter or [resource] prepares its own calculation of total use over time
<b>Allocated</b>	Meter covers several [resources] and usage is inferred through some sort of pro rata computation.
<b>Estimated</b>	Used when a reading is absent in a series in which most readings are present.
<b>Summed</b>	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.
<b>Derived</b>	Usage is inferred through knowledge of run-time, normal operation, etc.
<b>Mean</b>	Reading is the mean value over the period indicated in Granularity
<b>Peak</b>	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.
<b>Hybrid</b>	If aggregated, refers to different reading types in the aggregate number.
<b>Contract</b>	Indicates reading is pro forma, i.e., is reported at agreed upon rates
<b>Projected</b>	Indicates reading is in the future, and has not yet been measured.

1245 **5.5.3.2 Contrasting semantics of Summary and Aggregate in Reports**

1246 Consider the following industrial facility with a single ESI acting as a VEN. This facility chose to offer four  
 1247 Resources to its VTN: one industrial Resource and three office Resources, one for each floor. Two of the  
 1248 office Resources, Floor 2 and Floor 3, have their own zones and meters. Floor 1 has two zones, 1A and  
 1249 1B, that are metered separately. The three office Resources are all in a single Group, Office. The single  
 1250 industrial Resource is in its own Group, Factory.





1251

1252 *Figure 5-15: Illustrating Aggregate vs. Summary*

1253 A Usage report with a Target of Office applies to three Resources, Floor 1, Floor 2, and Floor 3. If the  
 1254 Aggregate flag is True, the VEN prepares a single report that aggregates the information from all three  
 1255 Resources. If a report Target indicates Industrial or Factory, Group or Resource, there is no distinction  
 1256 between an Aggregate or non-Aggregate request.

1257 The Data Sources for the Usage Reports are the Meters, M1-M5. The Report for Floor 3 has a Data  
 1258 Source of M5. The Report for Floor 2 has a Data Source of M4. The Report for Floor 1 has two data  
 1259 sources, M2 and M3, and the single Reading for Floor 1 is of the Type "Summary"

1260 Aggregate refers to the combining of multiple Subjects (things named in Target) into a single report;  
 1261 Summary refers to the combination of multiple Data Sources [meters] into a single value.

1262 **5.5.4 UML Diagram of Report**



1263  
 1264 *Figure 5-16: UML Class Diagram of Reports*  
 1265

1266 **5.6 Repones and Error Reporting**

1267 All Services share a common Response. The Response shares a common extensible code, a readable  
 1268 description, and a reference to the Message that this is in response to.

1269 *Table 5-18: Responses*

Response Elements	Description
<b>EI Response</b>	Response is the generic model for responding to any Servicer Request

Response Elements	Description
<b>Response Code</b>	<p>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.</p> <ul style="list-style-type: none"> <li>• 1xx: Informational - Request received, continuing process</li> <li>• 2xx: Success - The Request was successfully received, understood, and accepted</li> <li>• 3xx: Pending - Further action must be taken in order to complete the Request</li> <li>• 4xx: Requester Error - The request contains bad syntax or cannot be fulfilled</li> <li>• 5xx: Responder Error - The responder failed to fulfill an apparently valid request</li> </ul> <p>xx is used for defining more fine grained errors. Where possible, the HTTP errors should be used.</p>
<b>Response Description</b>	Optional String describing the response or the reason for the response
<b>Message UID</b>	Reference to the Message that elicited this response
<b>Response Terms Violated</b>	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.

1270

## 1271 5.6.1 Event Responses

1272 Responses to events are not stateless, so they require further information. All Responses regarding  
 1273 Events have the elements in Table 5-19 in addition to the elements listed in Table 5-18.

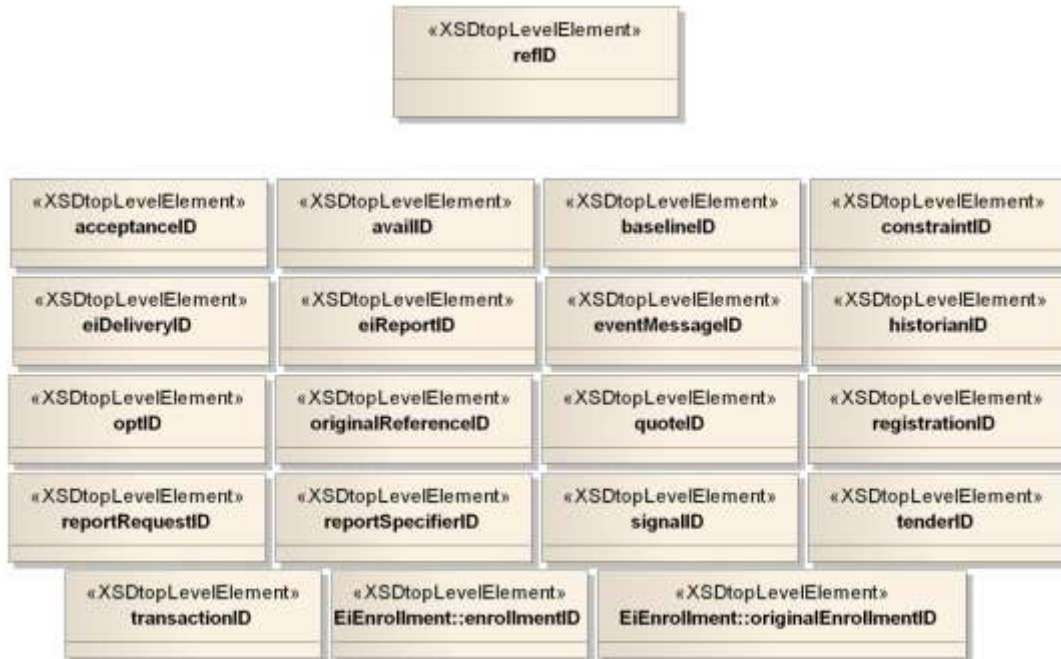
1274 *Table 5-19: Event Response*

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

1275 Some services communicate multiple messages, and the different messages may warrant different  
 1276 responses. In these cases, there is a single EiResponse (or EiEventResponse) which conveys an overall  
 1277 response. If this overall response is Success (2xx), then there is no need for the recipient to examine the  
 1278 message further. If the overall Response is anything other than success, then the response for each  
 1279 Element in the original Request can be found by examining the array of responses (type responses) or  
 1280 the array of Event Responses (type eventResponses) for detailed information.

## 1281 5.6.2 References in Responses

1282 Response is a general Type that must reference any number of messages, reports, requests, etc. These  
 1283 critical cross interaction types are each identified by a Reference ID. The Reference ID for each is derived  
 1284 from a common refID type that enables type-safe substitution in Response and in other payloads.



1285  
1286 *Figure 5-17: UML Diagram showing refID and its derived types*

1287 **5.7 Availability Behavior**

1288 In different Market Contexts, Availability is interpreted differently by the VTN. This availability behavior is  
1289 published as part of the EI Market Context as it is in effect a meta-term for the market.

1290 *Table 5-20: Availability Behavior*

Availability Behavior	Description
<b>Behavior</b>	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.
<b>Accept</b>	Simply accept the issued DR event regardless of any conflicts
<b>Reject</b>	Reject any DR events that conflict with configured Availability
<b>Restrict</b>	Modify the DR event parameters so that they legally fall within the bounds of the configured parameters.

1291

---

## 1292 6 Introduction to Services and Operations

1293 In the following sections services and operations consistent with **[SOA-RM]** are described. For each  
1294 service operation there is an actor that *invokes* the service operation and one that *provides* the service.  
1295 These roles are indicated by the table headings *Service Consumer* for the actor or role that consumes or  
1296 invokes the service operation named in the *Operation* column and *Service Provider* for the actor or role  
1297 that provides or implements the service operation as named in the *Operation* column.

1298 This terminology is used through all service definitions presented in this specification.

1299 The column labeled *Response Operation* lists the name of the service operation invoked as a response.  
1300 Most operations have a response, excepting primarily those operations that broadcast messages. The  
1301 roles of *Service Consumer* and *Service Provider* are reversed for the *Response Operation*.

1302 All communication between customer devices and energy service providers is through the ESI.

1303 For transactive services any party may receive tenders (priced offers) of service and possibly make  
1304 tenders (priced offers) of service.

1305 Any party using Transactive Energy services may own generation or distributed generation or reduce or  
1306 increase energy from previously transacted energy amounts. These activities are not identified in  
1307 transactive services. The dispatch of these resources and the use of energy by a party are influenced by  
1308 tenders between Parties that may result in new Transactions and changes in operations.

1309 The VEN/VTN services provide a characterization of the aggregate resources of a VEN that may be  
1310 communicated to the VTN; that relationship depends also on the EiMarketContext in which the  
1311 interactions take place.

1312 The next section describes the role of Resources, Curtailment and Generation. In a transactive approach  
1313 tendering and prices are used by parties to discover and negotiate transactions that respect the  
1314 preferences of each party and energy usage, generation, storage and controllability directly available to  
1315 each party. There is no formal communication of resource characteristics in the transactive approach.

### 1316 6.1 Resources, Curtailment, and Generation

1317 If the VEN participates in a demand response program or provides distributed energy resources, its ESI is  
1318 the interface to at least one dispatchable resource (Resource), that is, to a single logical entity. A  
1319 Resource may or may not expose any fine structure.<sup>6</sup> The Resource terminology and the duality of  
1320 generation and curtailment are from **[EMIX]**.

1321 Under a demand response program, a Resource is capable of shedding load in response to Demand  
1322 Response Events, Electricity Price Signals or other system events (e.g. detection of under-frequency).  
1323 The VTN can query the actual state of a Resource with the EiReport service and request ongoing  
1324 information. The VEN can query the status of the VTN-VEN relationship using the EiRequestEvent  
1325 operation.

1326 Alternatively, a Resource may provide generation in response to similar information. The net effect is the  
1327 same.

### 1328 6.2 Structure of Energy Interoperation Services and Operations

1329 Energy Interoperation defines a web services implementation to formally describe the services and  
1330 interactions although fully compliant services and operations may be implemented using other  
1331 technologies.

1332 The services presented in this specification are divided into five broad categories:

---

<sup>6</sup> A finer level of granularity is sometimes called an *asset*. Assets are not in scope for this specification.



- 1333 • Transactive Services—for implementing energy transactions, registration, and tenders
- 1334 • Event Services—for implementing events and linked Reports
- 1335 • Report Services—for exchanging remote sensing and feedback.
- 1336 • Enrollment Services—for identifying and qualifying service providers, resources, and more
- 1337 • Support Services—for additional capabilities

1338 The structure of each section is a table with the service name, operations, service provider and  
 1339 consumer, and notes in columns.

1340 The services are grouped so that profiles can be defined for purposes such as price distribution, and  
 1341 Demand Response (with the functionality of **[OpenADR]**). This specification defines three profiles, the  
 1342 OpenADR Profile, the TeMIX (Transactive EMIX) Profile, and the Price Distribution Profile.

1343 The normative XML schemas are in separate files, accessible through the **[namespace]** on the cover  
 1344 page.

### 1345 **6.3 Naming of Services and Operations**

1346 The naming of services and operations follows a pattern. Services are named starting with the letters *Ei*  
 1347 capitalization which follows the Upper Camel Case convention. Operations in each service use one or  
 1348 more of the following patterns. The first listed is a fragment of the name of the initial service operation; the  
 1349 second is a fragment of the name of the response message which acknowledges receipt, describes  
 1350 errors, and may pass information back to the invoker of the first operation.

1351 *Create—Created* An object is created and sent to the other Party

1352 *Cancel—Canceled* A previously created request is canceled

1353 *Request—Reply* A request is made for all objects of the specified type previously created and relevant  
 1354 to this VTN-VEN relationship

1355 *Distribute* An object (such as a price quote, a curtailment or generation request) is created and  
 1356 sent without expectation of response.

1357 For example, to construct an operation name for the *EiEvent* service, "Ei" is concatenated with the name  
 1358 fragment (verb) as listed. For example, an operation to cancel an outstanding operation or event is called  
 1359 *EiCancelEvent*.

1360 The pattern of naming is consistent with current work in the IEC Technical Committee 57 groups  
 1361 responsible for the **[TC57CIM]**.

### 1362 **6.4 Push and Pull Patterns**

1363 The Service Operation naming includes application-level acknowledgements, which in nearly every case  
 1364 carry application-level information, and allow for both push and pull of messages. This description applies  
 1365 to both transactive and VTN/VEN interactions as both are performed by Parties taking on various roles.

1366 Both Push and Pull are with respect to the invoker of the operation. So if a Party produces information  
 1367 that describes a price quote, it can invoke (in the case of Push) an operation to send it to one or more  
 1368 other Parties. In the alternative, each Party (in the case of Pull) can invoke a request for information by  
 1369 polling, or pulling it from another Party.

1370 The Pull operation is performed by the Party invoking the Request service operation pattern and fulfilled  
 1371 with a Reply service operation pattern invoked by the receiving Party.

1372 So a series of Push operations from one Party to a counter-Party is analogous to a series of Pull  
 1373 operations from the counter-Party to the Party.

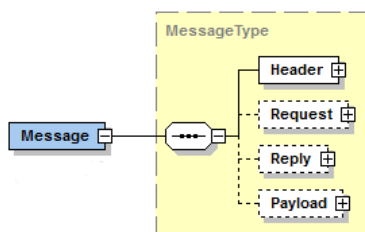
1374 In the VTN-VEN context, a series of Push operations from a VTN to its VENs is analogous to a series of  
 1375 Pull operations from the VEN to its VTN; by examining (e.g.) the absence of an Event that was visible on  
 1376 a previous Pull the VEN can infer that that Event was canceled. The VEN could then send a Canceled  
 1377 service operation as if it had received a Cancel service operation.

1378 One special case is the *Distribute* pattern, which expects no response to the invoker.

1379 The service quality of the Pull operations (and in particular the load on the VTN from repeated polling) is  
1380 not in scope for this specification.

## 1381 6.5 WSDL Integration

1382 A WSDL represents a contract between two systems that are being integrated. As such additional  
1383 attributes may need to be passed in addition to the attributes that are specific to a message payload  
1384 (representing the core set of information being passed). At a high level, any given integration may need  
1385 to include a header, request, and/or reply in addition to the message payload as shown in the figure  
1386 below.



1387

1388 *Figure 6-1: Generalized view of the high-level message structure*

1389 For example, for WSDL-based integration, details regarding the specifics of a demand response event  
1390 are contained in the message payload. However, additional details that work to ensure the successful  
1391 integration may be included in the header, request, or reply.

1392 A message header contains information about the sender and receiver of the message or other  
1393 information used to correlate the service request, to guarantee delivery, or to support non-repudiation as  
1394 seen in the [non-normative] figure below.

1395 Message headers are out of scope for this specification.

## 1396 6.6 Description of the Services and Operations

1397 Each service is described as follows. In the sections that follow, we will:

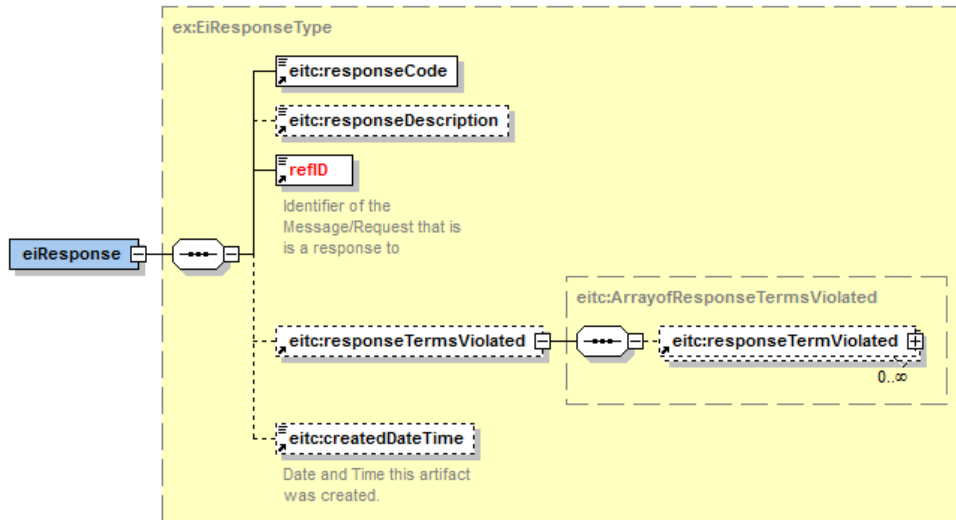
- 1398 • Describe the service
- 1399 • Show the table of operations
- 1400 • Show the interaction patterns for the service operations in graphic form
- 1401 • Describe the information model using [UML] for key artifacts used by the service
- 1402 • Describe the operation payloads using [UML] for each operation

## 1403 6.7 Responses

1404 In a service interaction, responses may need to be tracked to determine if the transaction is successful or  
1405 not. This may be complicated by the fact that any given transaction may involve the transmission of one  
1406 or more information objects.

1407 The class diagram below reflects the generic response.





1408  
1409

1410 *Figure 6-2: Example of generic error response for a service operation*

1411 The Reference ID (refID) identifies the artifact or message element that this response is to. The response  
1412 code indicates success or failure of the operation requested. The Response Description is unconstrained  
1413 text, perhaps for use in a user interface.

1414 There is no exhaustive list of all possible Response Codes. The Response Codes are intended to enable  
1415 even the smallest device to interpret Response. This specification uses a pattern consisting of a 3 digit  
1416 code, with the most significant digit sufficient to interpret success or failure. This pattern is intended to  
1417 support that smallest device, while still supporting more nuanced messages that may be developed.

- 1418 • 1xx: Informational - Request received, continuing process
- 1419 • 2xx: Success - The action was successfully received, understood, and accepted
- 1420 • 3xx: Pending - Further action must be taken in order to complete the request
- 1421 • 4xx: Requester Error - The request contains bad syntax or cannot be fulfilled
- 1422 • 5xx: Responder Error - The responder failed to fulfill an apparently valid request

1423 While the only value of xx that is defined as of this version is 00, conforming specifications may extend  
1424 these errors to defining more fine grained errors. These errors should extend the pattern above, though.  
1425 A response code such as 403 should always be within the realm of Requester Error.

### 1426 **6.7.1 Terms Violated**

1427 Terms Violated is an optional element of a Response. Terms communicate business expectations. It may  
1428 be that a Service Request fails not because it is improperly formed, but because it violates one or more of  
1429 these business rules. For example, a Market Term may indicate a 20 minute notification duration. A  
1430 Service Request that asks for a performance with only a 5 minute notification violates that Term. By  
1431 passing that Term back in the Response, that service provider can make known what its requirements  
1432 are.

1433 It is outside the scope of this specification whether a provider MAY present terms while still accepting a  
1434 Service.

### 1435 **6.7.2 Response Derivations**

1436 Because some responses require additional context relative to the Service requested, the same types  
1437 derive from and extend the Response type.

### 1438 **6.7.2.1 Event Responses**

1439 Event Responses are derived from the Response Type and add elements useful for Event-based  
1440 interactions. Event Responses include Event ID and Modification Number to indicate exactly which Event  
1441 they are responding to. Event Responses also include the Opt Type (Opt In or Opt Out) to describe what  
1442 response is being made to an event.

### 1443 **6.7.2.2 Enrollment Responses**

1444 Enrollment Responses are derived from the Response Type and add elements useful for Event-based  
1445 interactions. The Enrollment response includes an Enrollment ID to indicate which Enrollment is being  
1446 referenced.

1447 Enrollment establishes a business relationship between a Party and a particular Market Context. A Party  
1448 may be enrolled in several Market Contexts. Enrollment Responses include the Market Context that is  
1449 affected by the Response.

1450 A single request to Enroll may create many Enrollment IDs. For example, a Party offering several  
1451 Resources may get an Enrollment ID for each. Similarly, a single Resource may become enrolled in both  
1452 a power and a regulation Market Context. An Enrollment Response includes a Market Context to indicate  
1453 which Market Context was affected.

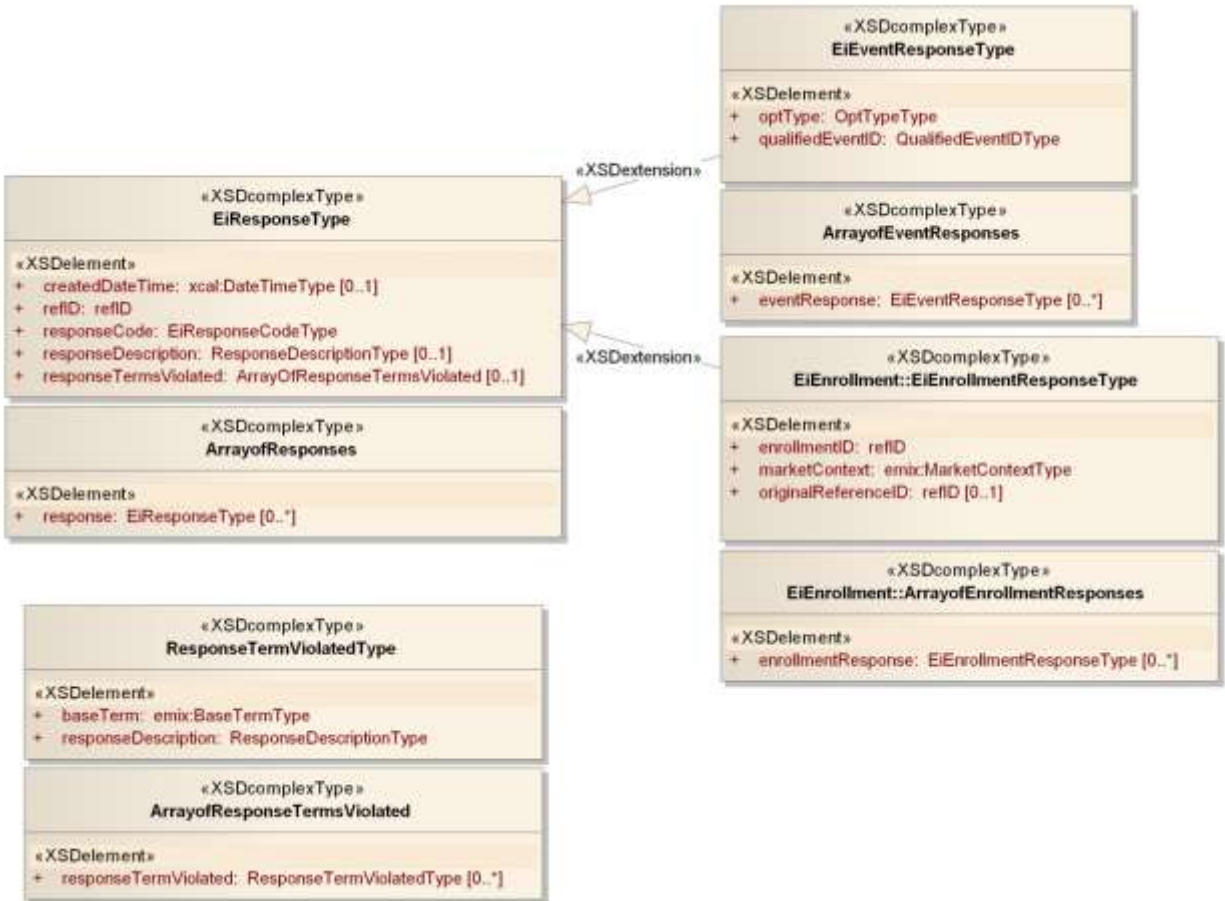
1454 As stated above, a single request to Enroll may create many Enrollment IDs. It can be helpful to know the  
1455 original request's reference ID to understand the Response. An Enrollment Response MAY include an  
1456 Original Reference ID.

### 1457 **6.7.3 Compound Responses**

1458 Many service interactions may affect a number of messages. For examples, a single service interaction  
1459 may include multiple Tenders, or Events. A single Enrollment request may result in multiple Enrollments.  
1460 All such Responses have the pattern of a single Response (or Event Response, or Enrollment Response)  
1461 accompanied by a collection of Responses. This specification defines the collections of Responses,  
1462 Event Responses, and Enrollment Responses.

1463 The end-point receiving a compound Service Payload, including both single Responses and collections of  
1464 Responses follows these rules:

- 1465 - If the Response indicates success, there is no need to examine each element in the Responses.
- 1466 - If some elements fail and other succeed, the Response will indicate the error, and the recipient  
1467 should evaluate each element in the Responses to discover which components of the operation  
1468 failed.



1469  
1470 *Figure 6-3: UML for Response*

1471 **6.7.3.1 Summary of Response and Responses**

1472 A Response returns the success or failure of the entire operation. The Responses returns an ID and a  
1473 Response for each.

1474 It is MANDATORY to return errors in responses. It is OPTIONAL to return successes in responses. For  
1475 Cancel, in particular, it is not mandatory to return any responses if the entire operation was completed  
1476 successfully. The pattern is to return those that have failed (required) and those that succeeded  
1477 (optional).

1478 **6.7.4 Requests**

1479 Each of the Services includes a Request, which is essentially a status update. Consider the Service Foo.  
1480 A Request means “tell me all the Foes that we have outstanding.” The meaning of outstanding varies  
1481 from Service to Service. In general, either party may make invoke the Request Service on the other. Tell  
1482 me all the Quotes you have given me is the mirror of Tell me all the Quotes you have received from me.  
1483 Each Request shares the same semantics.

1484 Each optional element in a Request refines or narrows the scope of the Request by narrowing the request  
1485 to only those Foes for which the named elements match. If there are more than one instance of the same  
1486 named element, then this restriction element is treated as if a logical OR were applied, i.e., where  
1487 element = A OR element = B. Where more than one type of element is named, then the restriction is  
1488 treated as an AND, i.e., element A = “foo” AND element B = “fie”.

1489 A special element that is included in most Requests is the Interval. The Interval is treated as a temporal  
1490 restriction. For example, an Interval that encompasses a business day can request all Foo for delivery on  
1491 that day. Intervals MAY be open-ended. An Interval conveying only a Start Date matches all Foo that are

1492 current from that date and time forward. An Interval conveying only an End Date matches all Foo that are  
1493 current at that date and time. If there is any ambiguity about what “matches” means, it is defined within  
1494 the Service section below, c.f., the definition of pending Events in Section 9.2 “*Special Semantics of the*  
1495 *Event Request Operations*”.

---

## 1496 7 Transactive Services

1497 Transactive Services define and support the lifecycle of transactions inside an overarching agreement,  
1498 from initial quotations and indications of interest to final settlement. The phases are

- 1499 • Registration—to enable further phases.
- 1500 • Pre-Transaction —non-binding quotes and binding tenders for transactions.
- 1501 • Transaction Services—execution and management of transactions including transaction with  
1502 optionality.
- 1503 • Post-Transaction—settlement, energy used or demanded, payment, position.

1504 For transactive services, the roles are **Parties** and **Counterparties**. For event and resource services, the  
1505 Parties adopt a VTN or VEN role for interactions. The terminology of this section is that of business  
1506 agreements: tenders, quotes, and transaction execution and (possibly delayed) performance under an  
1507 option or DR transaction.

1508 The register services identify the parties for future interactions. This is not the same as (e.g.) a program  
1509 registration in a demand response context—here, registration can lead to exchange of tenders and  
1510 quotes, which in turn may lead to a transaction which will determine the VTN and VEN roles of the  
1511 respective parties.

### 1512 7.1 EiRegisterParty Service

1513 The EiRegisterParty service operations create a registration for potential Parties in interactions. This is  
1514 necessary in advance of an actor interacting with other parties in various roles such as VEN, VTN,  
1515 tenderer, and so forth.

1516 *Table 7-1: Register Services*

<i>Service</i>	<i>Operation</i>	<i>Response</i>	<i>Service Consumer</i>	<i>Service Provider</i>	<i>Notes</i>
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	EiCanceledPartyRegistration	Party	Party	Cancel one or more Party Registrations

1517

1518

1519

### 1520 7.1.1 Interaction Pattern for the EiRegisterParty Service

1521 This is the [UML] interaction diagram for the EiRegisterParty Service



1522

1523 Figure 7-1: Interaction Diagram for EiRegisterParty Service

### 1524 7.1.2 Information Model for the EiRegisterParty Service

1525 The details of a Party are outside the scope of this specification. The application implementation needs to  
1526 identify additional information beyond that in the class EiParty.

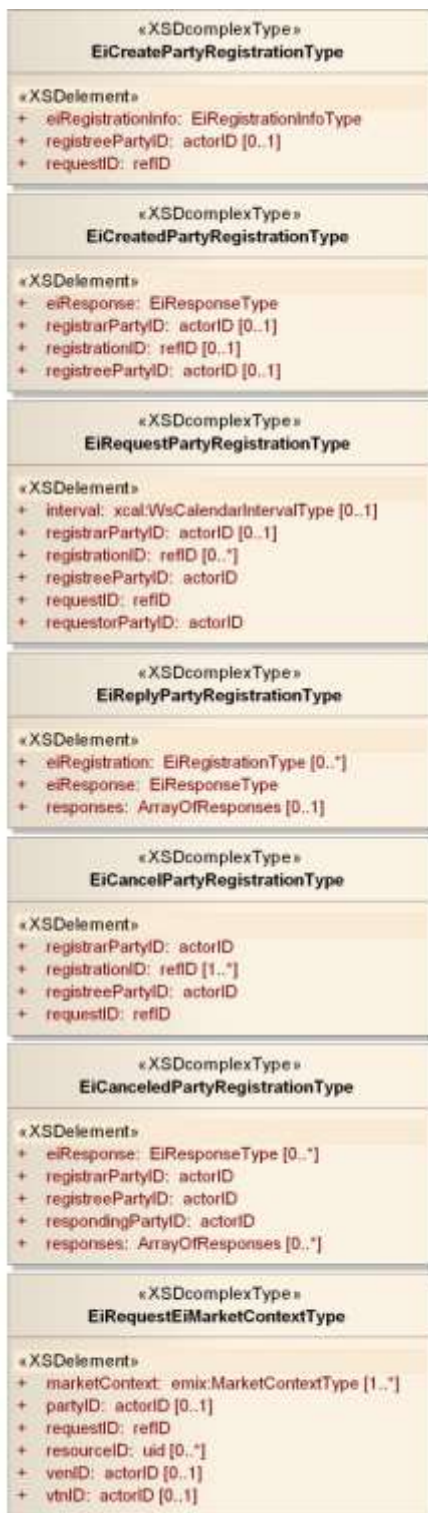


1527

1528 Figure 7-2: EiParty UML Class Diagram

1529 **7.1.3 Operation Payloads for the EiRegisterParty Service**

1530 The [UML] class diagram describes the payloads for the EiRegisterParty service operations.



1531

1532 *Figure 7-3: UML Class Diagram for EiRegisterParty Service Operation Payloads*



1533 **7.2 Pre-Transaction Services**

1534 Pre-transaction services are those between parties that may or may not prepare for a transaction. The  
 1535 services are EiTender and EiQuote. A quotation is not a tender, but rather a market price or possible  
 1536 price, which needs a tender and acceptance to reach a transaction.

1537 Price distribution, which is sometimes referred to as *price signals*, is accomplished using the EiQuote and  
 1538 EiTender services. Quotes are indications of a possible tender price; they are not actionable. A Tender  
 1539 offers prices at which Transactions may be made; they are actionable.

1540 As with other services, a Party MAY inquire from a counterparty what offers the counterparty  
 1541 acknowledges as open by invoking the EiSendTender service to receive the outstanding tenders.

1542 There is no operation to “delete” a quote; when a quote has been canceled the counterparty MAY delete  
 1543 it at any time. To protect against recycled or dangling references, the counterparty SHOULD invalidate  
 1544 any identifier it maintains for the cancelled quote.

1545 Tenders, quotes, and transactions are **[EMIX]** artifacts, which contain terms such as schedules and prices  
 1546 in varying degrees of specificity or concreteness.

1547 *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

1548

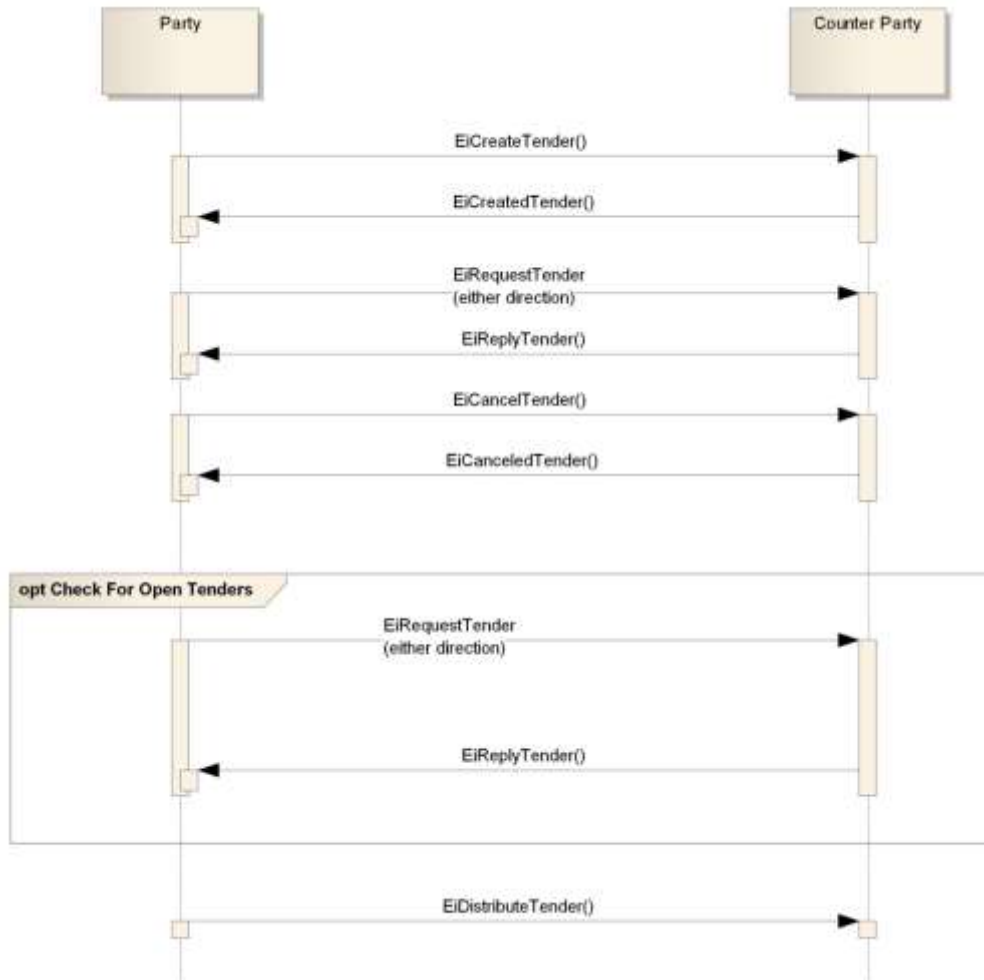
1549 *Table 7-3: Pre-Transaction Quote Services*

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

1550

### 1551 7.2.1 Interaction Pattern for the EiTender and EiQuote Services

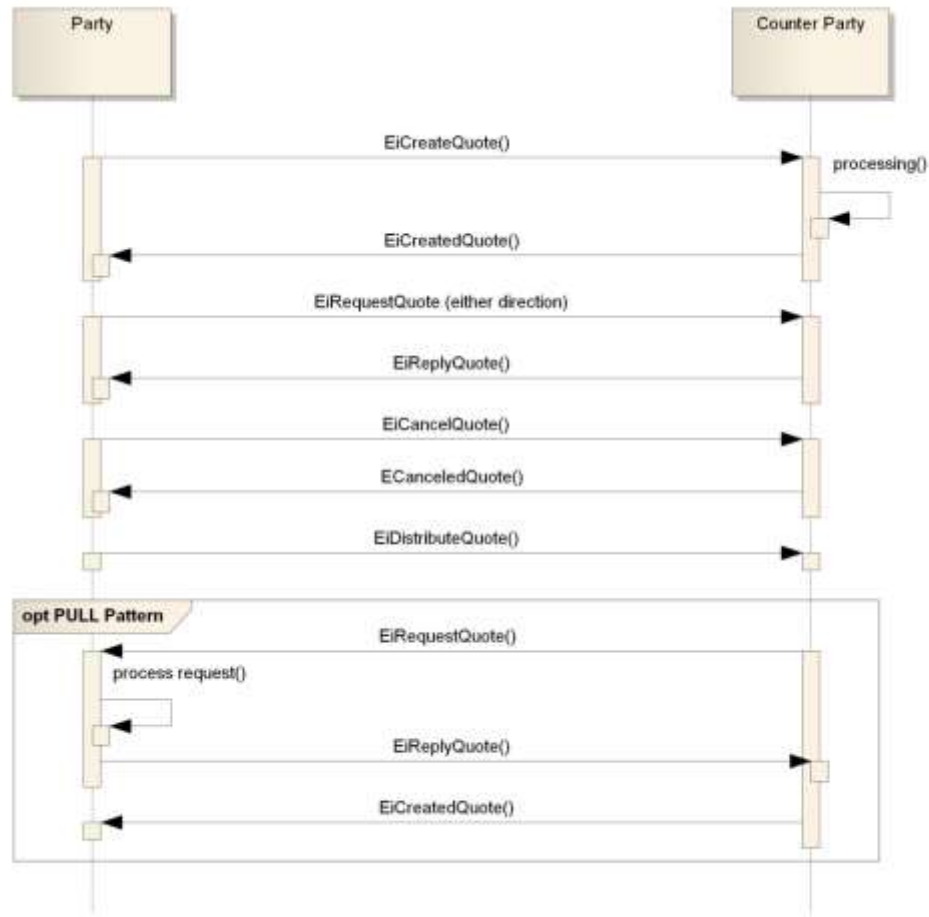
1552 This is the [UML] interaction diagram for the EiTender Service.



1553

1554 *Figure 7-4: Interaction Diagram for the EiTender Service*

1555 This is the [UML] interaction diagram for the EiQuote Service



1556

1557 *Figure 7-5: Interaction Diagram for the EiQuote Service*

## 1558 7.2.2 Information Model for the EiTender and EiQuote Services

1559 The information model for the EiTender Service and the EiQuote Service artifacts is that of [EMIX]. EMIX  
1560 provides a product description as well as a schedule over time of prices and quantities.

1561 **7.2.3 Operation Payloads for the EiTender Service**

1562 The [UML] class diagram describes the payloads for the EiTender and EiQuote service operations.



1563  
1564 *Figure 7-6: UML Class Diagram for the Operation Payloads for the EiTender Service*

1565

1566 **7.2.4 Operation Payloads for the EiQuote Service**



1567  
1568 *Figure 7-7: UML Class Diagram for the EiQuote Service Operation Payloads*

1569 **7.3 Transaction Management Services**

1570 The service operations in this section manage the exchange of transactions. For example, in demand  
 1571 response, the overarching agreement is the context in which events and response take place—what is  
 1572 often called a *program*. This agreement is identified by the information element Market Context here and  
 1573 elsewhere.

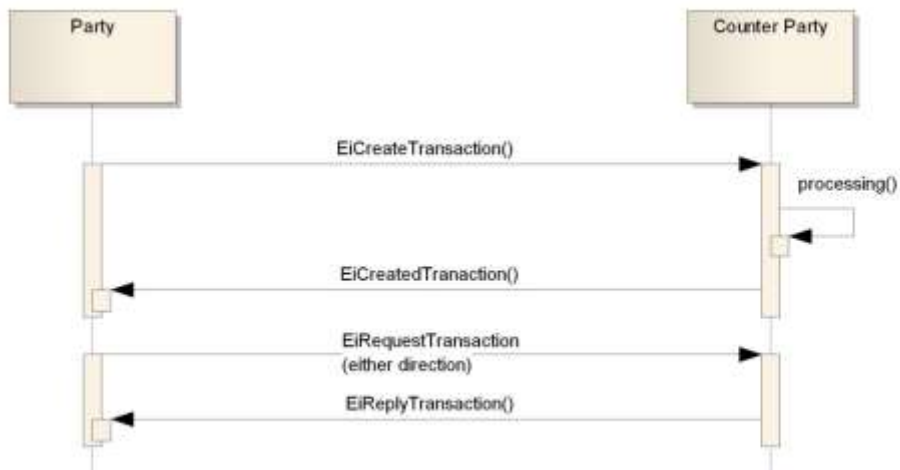
1574 There is no EiCancelTransaction or EiChangeTransaction operations. As in distributed agreement  
 1575 protocols, a compensating transaction SHOULD be created as needed to compensate for any effects.<sup>7</sup>

1576 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

1577 **7.3.1 Interaction Patterns for the EiTransaction Service**

1578 This is the [UML] interaction diagram for the EiTransaction Service:



1579  
 1580 Figure 7-8: Interaction Diagram for the EiTransaction Service

1581 **7.3.2 Information Model for the EiTransaction Service**

1582 Transactions are [EMIX] artifacts with the identification of the Parties.

---

<sup>7</sup> This is consistent with the way that distributed agreement protocols such as [WS-BusinessActivity] manage compensation rather than cancellation.

1583 **7.3.3 Operation Payloads for the EiTransaction Service**

1584 The [UML] class diagram describes the payloads for the EiTransaction service operations.



1585

1586 *Figure 7-9: UML Class Diagram of EiTransaction Service Operation Payloads*



1587 **7.4 Post-Transaction Services**

1588 In a market of pure transactive energy, verification would be solely a function of meter readings. The seed  
 1589 standard for smart grid meter readings is the NAESB Energy Usage Information **[NAESB EUI]**  
 1590 specification.

1591 In today's markets, with most customers on Full Requirements tariffs, the situation is necessarily more  
 1592 complex. Full Requirements describes the situation where purchases are not committed in advance. The  
 1593 seller is generally obligated to provide all that the buyer requires. Full requirements tariffs create much of  
 1594 the variance in today's DR markets.

1595 These sections will apply a measurement model consistent with the **[NAESB EUI]** as in the EiReport  
 1596 Services.

1597 **7.4.1 Energy Delivery Information**

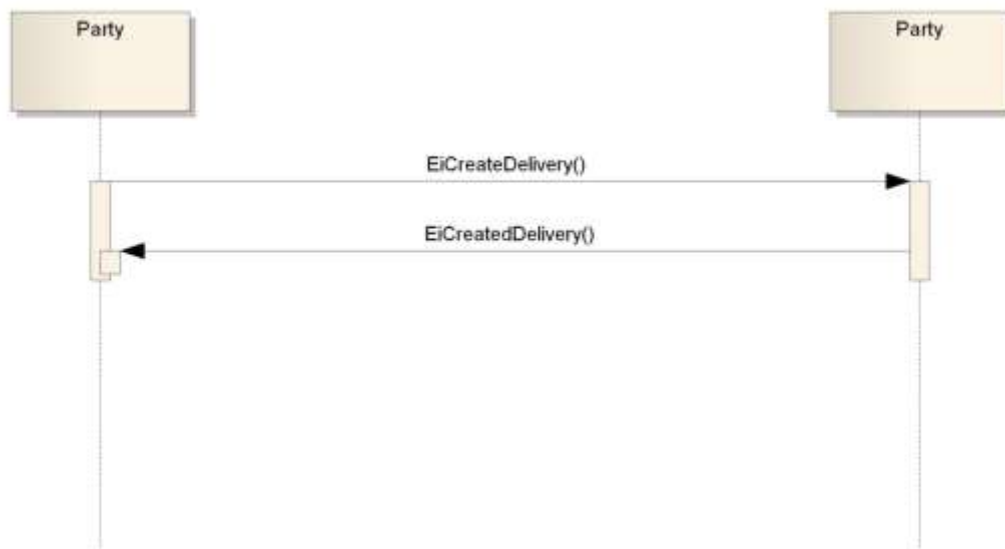
1598 These service operations respond with Energy Usage Information or any other single item of interest to  
 1599 the caller. This is very simple, requesting one thing measured for one interval, and waiting to return a  
 1600 value until the information is available. For anything more complex the Report Services should be used.

1601 *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

1602

1603 **7.4.1.1 Interaction Pattern for the EiDelivery Service**

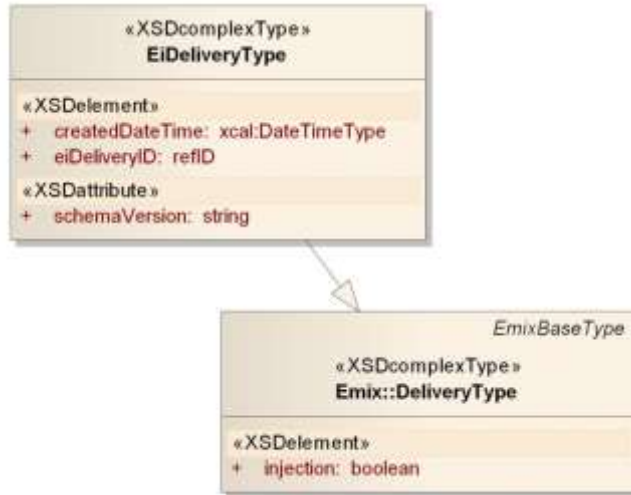


1604

1605 *Figure 7-10: Interaction Diagram for Delivery Service*

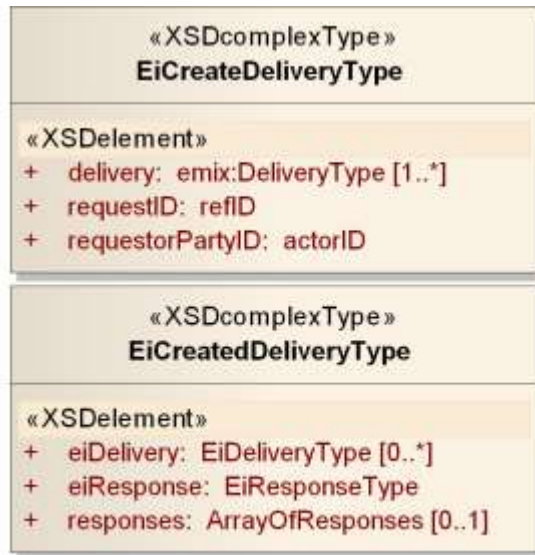
1606 **7.4.1.2 Information Model for the EiDelivery Service**

1607 The EiDelivery Type is a simplified EiReport.



1608  
1609 *Figure 7-11: UML of EiDelivery Type*

1610 **7.4.1.3 Operation Payloads for the EiDelivery Service**



1611  
1612 *Figure 7-12: UML Class Diagram of Delivery and Delivery Payload*

1613

## 7.5 Comparison of Transactive Payloads



1615

1616 Figure 7-13: UML Diagram comparing all Transactive Payloads

1617

## 1618 8 Enroll Service

1619 Enrollment is distinct from Registration in Energy Interoperation. Registration establishes an identity for  
 1620 an actor (a party or a device such as a generator or a meter on a premise). Enrollment establishes a  
 1621 relationship between two actors as a basis for further interactions. Energy Interoperation supports two  
 1622 classes of interactions; Transactive and VTN/VEN interactions.

1623 In the case of enrollment in Transactive Interactions, the Enrollment Service identifies the two parties and  
 1624 the Enabling Agreement, Market, Tariff, Purchasing, Selling, etc. that the parties agree to use for their  
 1625 interactions.

1626 In the case of enrollment in a VTN/VEN relationship the enrollment service identifies the two actors,  
 1627 generally a registered Resource and a Service Provider acting as a Designated Dispatch Entity (DDE).  
 1628 Registration of a Resource may sometimes be automatic with enrollment of the Resource.

1629 The entities described in the following table can be enrolled. These are described in the **[UML]** diagrams  
 1630 as concrete classes that inherit from the Enrollee type. The strings are used to describe the entity; the  
 1631 standard approach to extensibility where a prefix of “x-” indicates an extension SHALL be used.

1632 The types of entity used may depend on the implementation. All implementations SHALL support  
 1633 Resources.

1634 *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	

1635

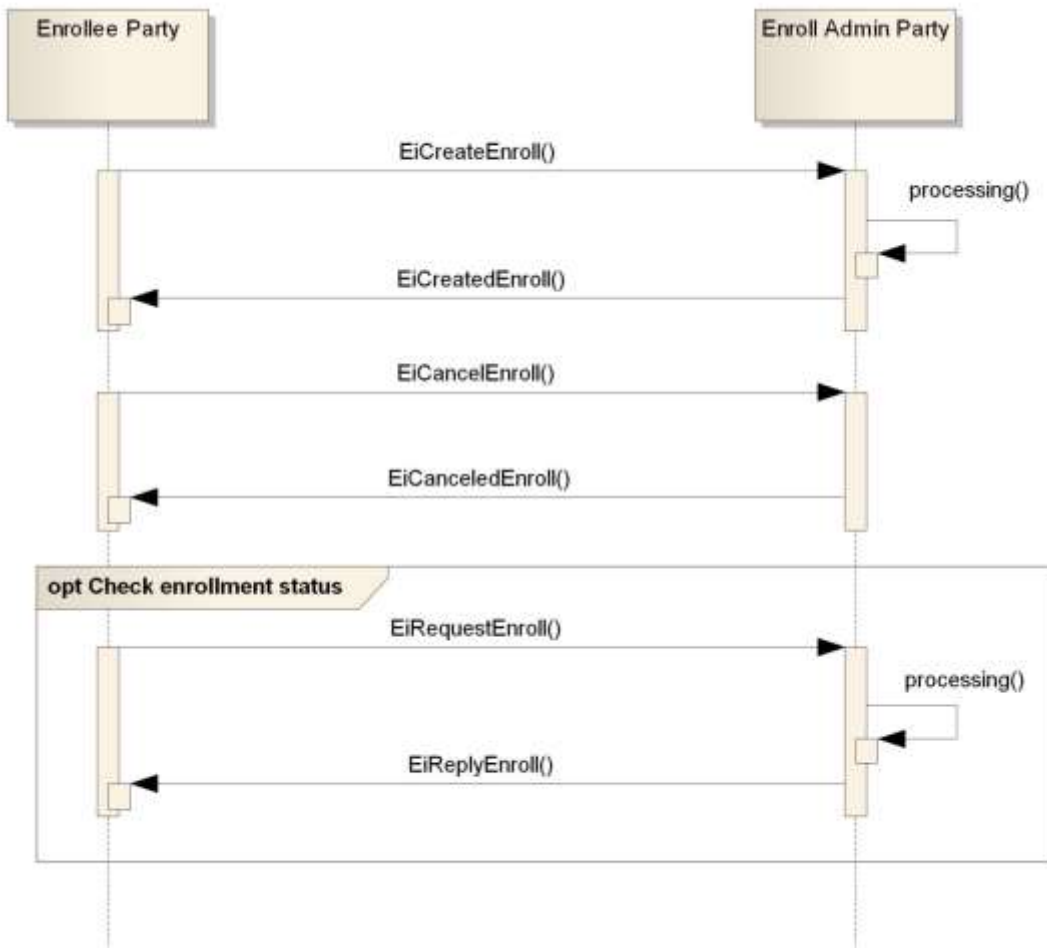
1636 *Table 8-2: EiEnroll Service Operations*

<i>Service</i>	<i>Operation</i>	<i>Response</i>	<i>Service Consumer</i>	<i>Service Provider</i>	<i>Notes</i>
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

1637

1638 **8.1 Interaction Patterns for the EiEnroll Service**

1639 This is the [UML] interaction diagram for the EiEnroll Service.



1640  
1641 *Figure 8-1: Interaction Diagram for the EiEnroll Service*  
1642  
1643



1644 **8.2 Information Model for the EiEnroll Service**

1645 The EiEnroll service has an abstract class for the respective types. The abstract class also has the entity  
 1646 identifier, type (as a string), and name. The standard values for the type are listed in Table 8-1 Enrollee  
 1647 Descriptions. Other values MAY be used but MUST be prefixed by "x-" as described in Appendix C

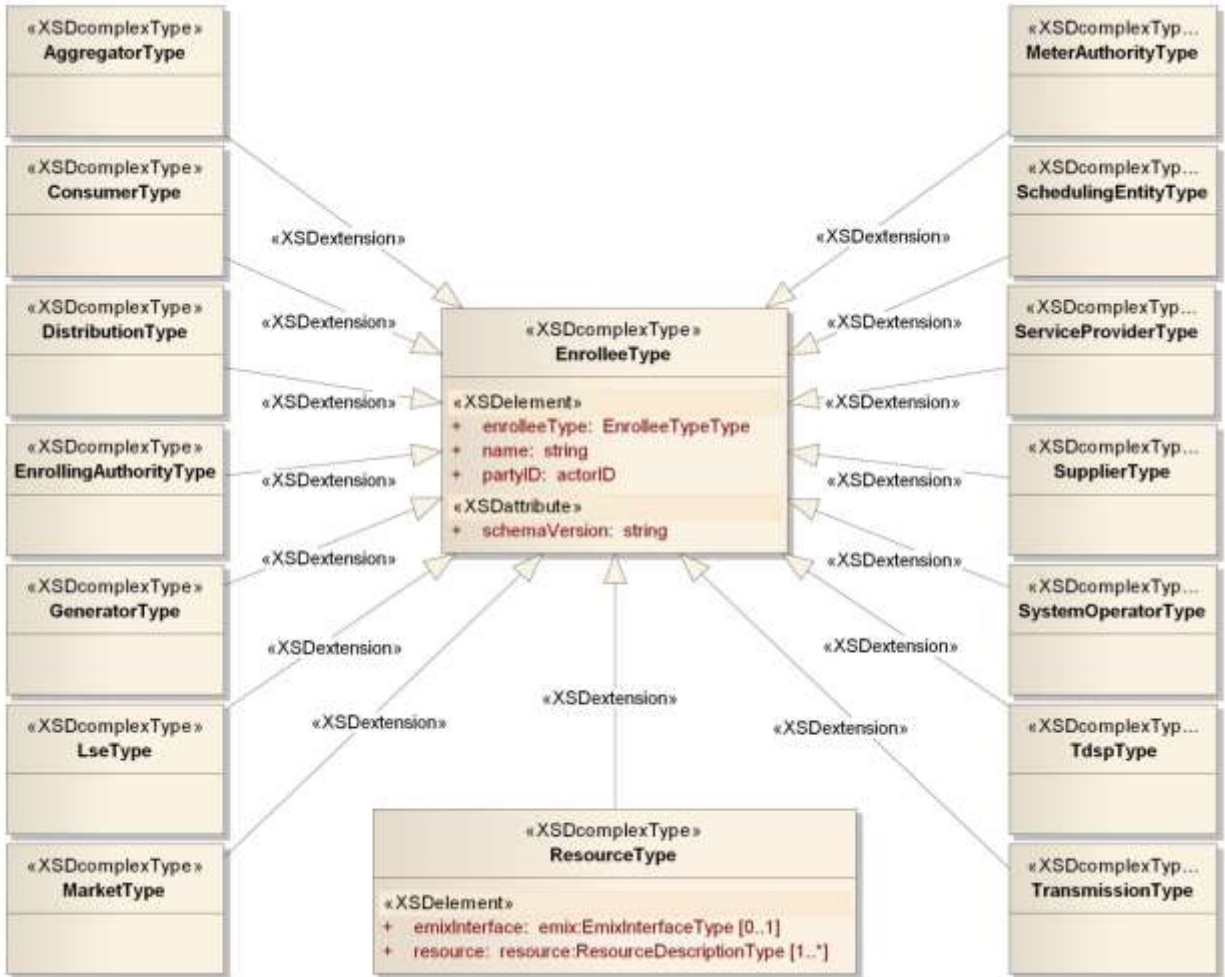


1648  
 1649 *Figure 8-2: UML Model for EiEnrollment Classes*  
 1650



1651 **8.3 Enrollee Types**

1652 The [UML] class diagram describes the Enrollee Types.



1653  
1654 *Figure 8-3: UML Class Diagram showing Enrollee Types*

1655 **8.4 Operation Payloads for the EiEnroll Service**

1656 The [UML] class diagram describes the payloads for the EiEnroll service operations.



1657

1658 *Figure 8-4: UML Class Diagram for Enrollment Payloads*

1659

## 9 Event Services

1660 The Event Service is used to call for performance under a transaction. The service parameters and event  
1661 information distinguish different types of events. Event types include reliability events, emergency events,  
1662 and more—and events MAY be defined for other actions under a transaction. For transactive services,  
1663 two parties may enter into a call option. Invocation of the call option by the Promisee on the Promisor  
1664 can be thought of as raising an event. But typically the Promisee may raise the event at its discretion as  
1665 long as the call is within the terms of the call option transaction.

1666 For example, an ISO that has awarded an ancillary services transaction to a Party may issue dispatch  
1667 orders, which can also be viewed as Events. In this specification, what is sometimes called a *price event*  
1668 would typically be communicated using the EiSendQuote operation (see 7.2 “Pre-Transaction Services”).

1669 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	EiRequestPending Event	EiReplyPending Event	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.

1670

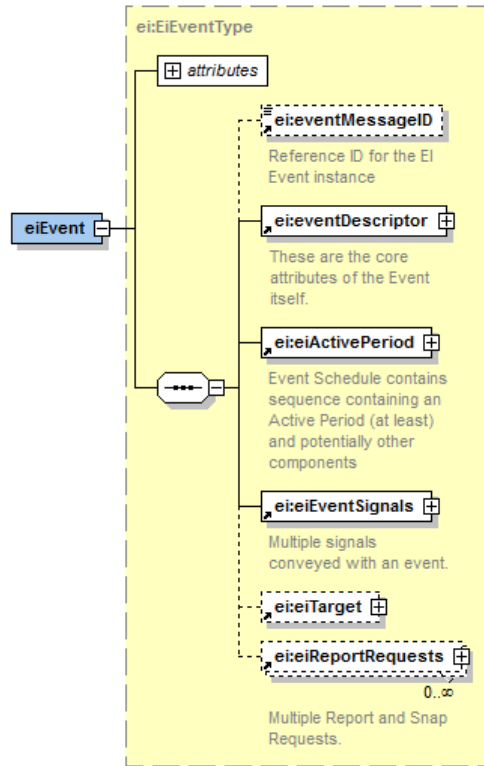
### 9.1 Information Model for the EiEvent Service

1671 The event is the core Demand Response information structure, and the most complex of the payloads.  
1672 Understanding the information model of the Event is critical to understanding the operations of the Event  
1673 Services. This section reviews the Event semantics as defined in Section 5.3 “Event-based Interactions”.

1674 The sub-sections below provide a reprise of the Event structure (9.1.1) and a UML description of the  
1675 event (9.1.2)

1676 **9.1.1 Structure of the Event**

1677 The semantics of the Event are defined Section 5.3 “Event-based Interactions”.



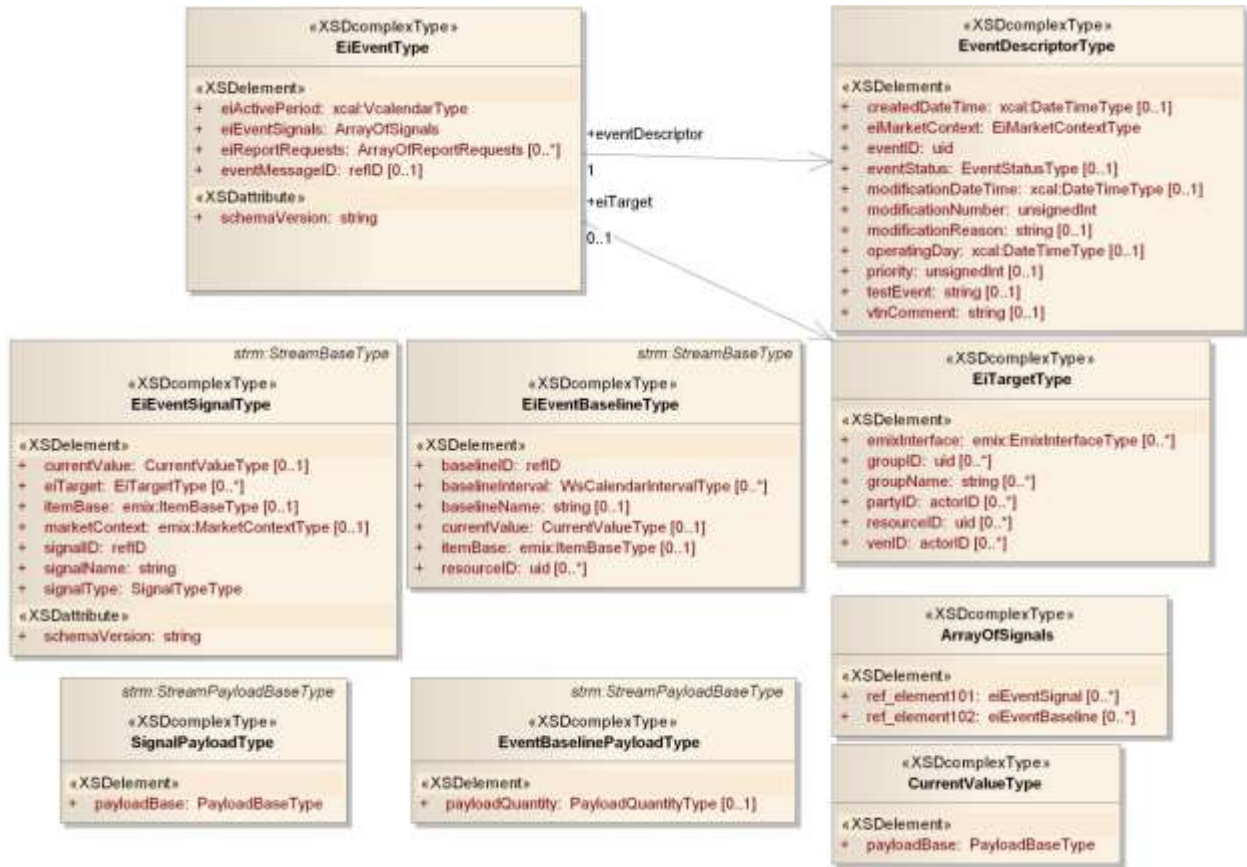
1678  
1679 *Figure 9-1: EiEvent summarized*

1680 The type EiEvent MAY be identified by an Event Message ID and which has associations with the classes  
1681 Active Period, Event Descriptor, and Event Signals, a collection of Signals and Baselines.

1682 As the event is the core Demand Response information structure, we begin with Unified Modeling  
1683 Language [UML] diagrams for the EiEvent class and for each of the operation payloads. Core semantics  
1684 for the Event are defined in Section 5.3 “Event-based Interactions”.

1685  
1686

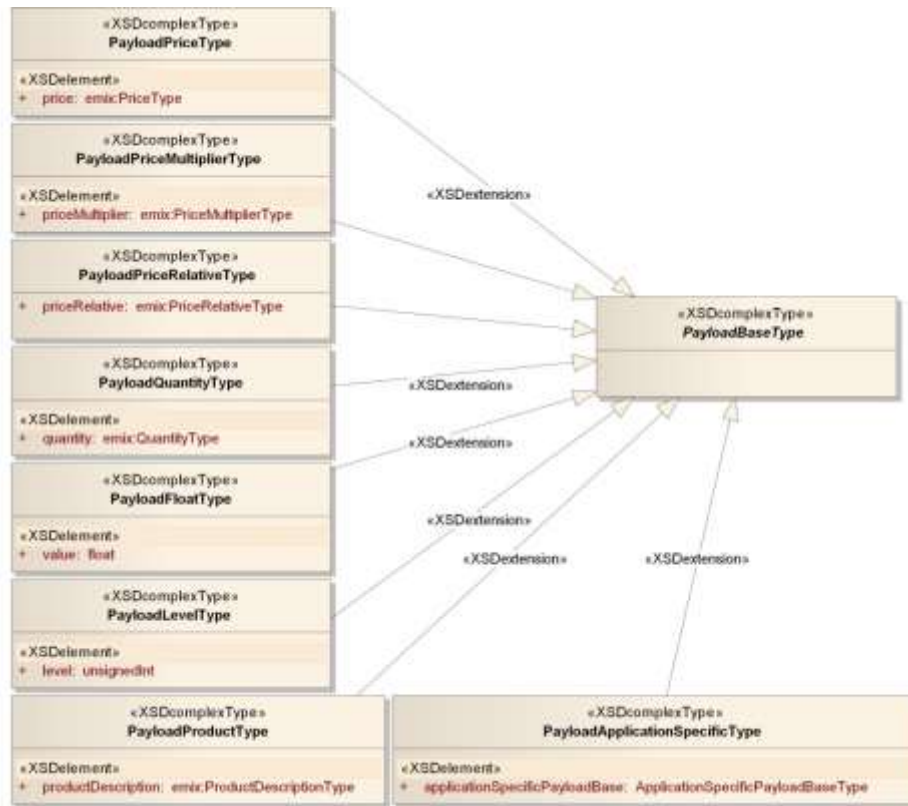
1687 **9.1.2 UML Model of an Event and its Signals**



1688  
1689 *Figure 9-2: UML Class Diagram for EiEventType and Related Classes (w/o Signals detail)*  
1690

1691

1692 An Event may include a number of Schedules, which are expressed as Streams. These schedules are  
1693 the Signals, the Baselines, and they may return Baselines, Reports, and Delivery. The EI Event Signal  
1694 derives from the Streams element and conveys elements of the Type Signal Payload in its Schedule.



1695

1696 Figure 9-3 UML Class Diagram Showing Details of the Signal Payloads or EiEventSignals

## 1697 9.2 Special Semantics of the Event Request Operations

1698 The Events are the largest messages exchanged in Energy Interoperation. They exist in two forms, the  
1699 EiEventRequest, and EiEventRequestPending. EiEventReply returns entire Events in response to a  
1700 Request, following the general pattern of all Energy Interoperation Services. EiEventRequestPending  
1701 returns the Event IDs and Modification Numbers only. EiEventRequestPending is useful for black-start  
1702 and other situations in which the VEN and VTN need to assess the information shared with its partner.

1703 The Modification Number returned in the Replies is for assessment only. The recipient MAY use it to  
1704 determine that the sender is using out-of-date information, but any replacement or update SHALL convey  
1705 the current Modification.

### 1706 9.2.1 Event Ordering

1707 The Event Requests include an option to restrict the number of Events returned in Reply to any Request.  
1708 For consistency, this requires that a VTN or VEN be able to order Events. The rules for ordering Events  
1709 are applied sequentially as follows:

- 1710 1. Active events have priority over pending events
- 1711 2. Within Active Events, priority is determined by Priority in the Event Descriptor.
- 1712 3. Between active events with the same priority, the one with the earlier start time has the higher  
1713 priority.
- 1714 4. Between pending events the one with the earlier start time has the higher priority



1715 5. After processing rules 1-4, if Priority is still indeterminate within a set of Intervals, then the order is  
 1716 indeterminate within that set. A Reply containing Events with indeterminate Order MUST maintain  
 1717 that order in response to successive Requests while they remain indeterminate.

1718 The definitions of Active and Pending are consistent with those described for the Event Filter in Table 9-2.

### 1719 9.2.2 Event Filter described

1720 Both the Event Request operations MAY use of the Event Filter to restrict the Events exchanged during  
 1721 Request and Reply.

1722 *Table 9-2: Event Filter described*

Event Filter	Description
<b>Active</b>	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.
<b>Pending</b>	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.
<b>All</b>	An event qualifies if it would qualify as either Active or Pending.
<b>Completed</b>	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.
<b>Cancelled</b>	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.

### 1723 9.2.3 Using EiRequestEvent EiRequestEventPending together

1724 EiRequestEvent and EiRequestPendingEvent are essentially the same. Each enables a VEN or VTN to  
 1725 query its partner about what Events it knows. The difference is in the Replies. EiReplyEvent returns a  
 1726 collection of Events, EiReplyEventPending returns a collection of Qualified Event IDs. i.e., an Event ID  
 1727 and the Modification Number.



1728  
 1729 *Figure 9-4: Qualified Event ID*

1730 With a list of Qualified Event IDs either one can reconstruct what the other knows. Events that are missing  
 1731 can be requested or sent. A VEN can infer cancellation when its VTN removes an Event ID. Using the  
 1732 Modification Number, a VTN can know to re-send the latest version, or a VEN can know to request an  
 1733 update.



1734 While the Event Requests follow the pattern common to all EI Requests, because of the extra options,  
1735 they are summarized in table [reference] below. All query elements are optional.

1736

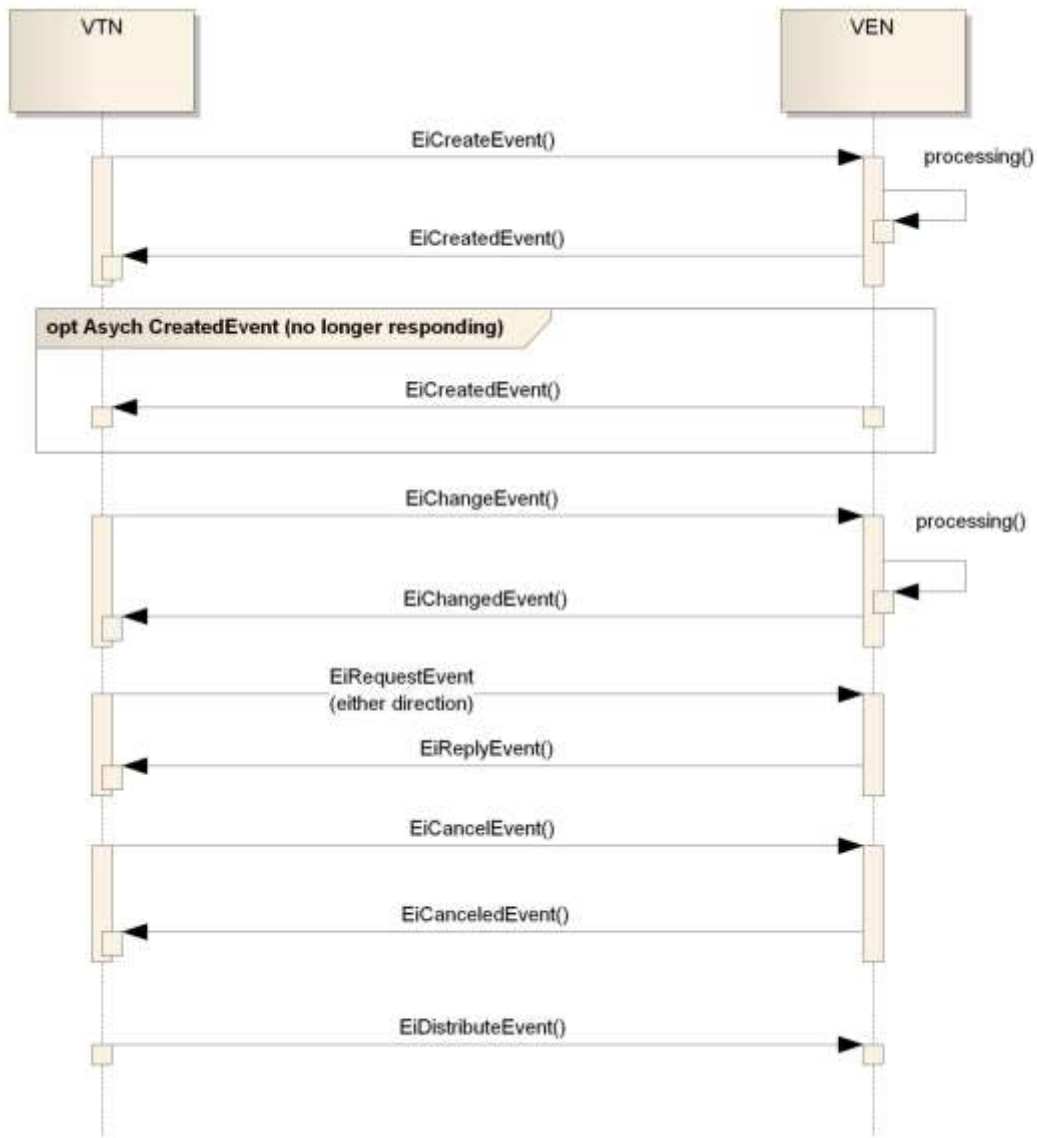
1737 *Table 9-3: Event Requests summarized*

Request Element	Description
<b>VEN ID</b>	Names the VEN that is Requesting or currently knows of these Events
<b>Event ID</b>	A list of Event IDs to be returned. If present, all other filters are ignored.
<b>Market Context</b>	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.
<b>Filter</b>	As described above (Table 9-2). Can be combined with Interval
<b>Interval</b>	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”.
<b>Reply Limit</b>	Return only the first N matching events, where N is the Reply Limit. “First is defined according to the Order as described above.

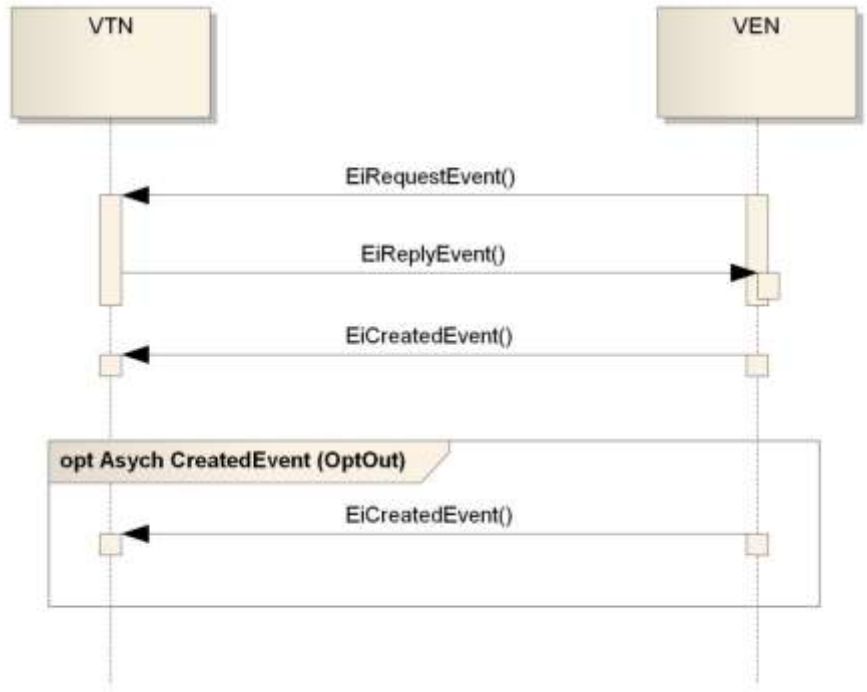
1738 A common pattern for either a VEN or a VTN is to request Event IDs with the EiRequestPending, and to  
1739 then request information about events that it are missing or that need updates using EiRequestEvent. A  
1740 VTN after a similar query might use EiCreateEvent to pass the missing or updated Events to the VEN.

1741 **9.3 Interaction Patterns for the EiEvent Service**

1742 This is the [UML] interaction diagram for the EiEvent Service.



1743  
1744 *Figure 9-5: UML Interaction Diagram for the EiEvent Service Operations*  
1745



1746  
 1747 *Figure 9-6: UML for example PULL pattern for EiEvent*  
 1748  
 1749



1750  
 1751 *Figure 9-7: Interaction Diagram for Pending Event operation*

1752 **9.4 Operation Payloads for the EiEvent Service**

1753 The [UML] class diagram describes the payloads for the EiEvent service operations.



1754  
1755 *Figure 9-8: UML Class Diagram for EiEvent Service Operation Payloads*

1756

## 10 Report Service

1757 Energy Interoperation Reports convey information from remote sensing or about remote state back to the  
1758 requester. The Historian operations support the collection of data for Reports. Reports can be associated  
1759 with an Event or can be requested through the Report Services described in this section.

1760 The general pattern of the Report service is to request that a Historian gather data, and for the Report  
1761 Service to return the Report when it is Ready. A Historian may generate only a final Report, or it may  
1762 report-back periodically. The report requester MAY ask the Historian for the report-to-date, or for a time-  
1763 constrained portion of the Report at any time while it is running.

1764 One interaction pattern for the Report service is what one may call “Set and Forget”. Under this pattern,  
1765 the Requester asks that information be logged, but specifies no Report delivery. Under this pattern, the  
1766 Requester can, at any time, request delivery of a Report for a specified Interval.

1767 Projections are a special class of Reports, i.e., Reports about the future. Projections follow the general  
1768 form of Reports and include additional metadata about the reliability of the future information in each  
1769 window.

1770 The semantics of Reports are described in sections 5.4 “Monitoring, Reporting” and 5.5 “Reports, Snaps,  
1771 and Projections”.

1772 The range of Payloads that can be delivered by means of a Report can be extended by deriving new  
1773 types from the Payload Base Type, and defining a new Report Type not in Enumerated Report Types,  
1774 and requesting such a Report.

### 10.1 Overview of Report Services

1776 Event-based reports are requested as part of the EiEvent service. Ei Report operations request Reports  
1777 independently of any Event. Whether created as part of an Event or independently, all Reports support  
1778 the same post-creation operations.

1779 EiReport operations are independent of EiEvent operations in that they can be requested at any time  
1780 independent of the status or history of EiEvents.

1781 *Table 10-1: Report Service*

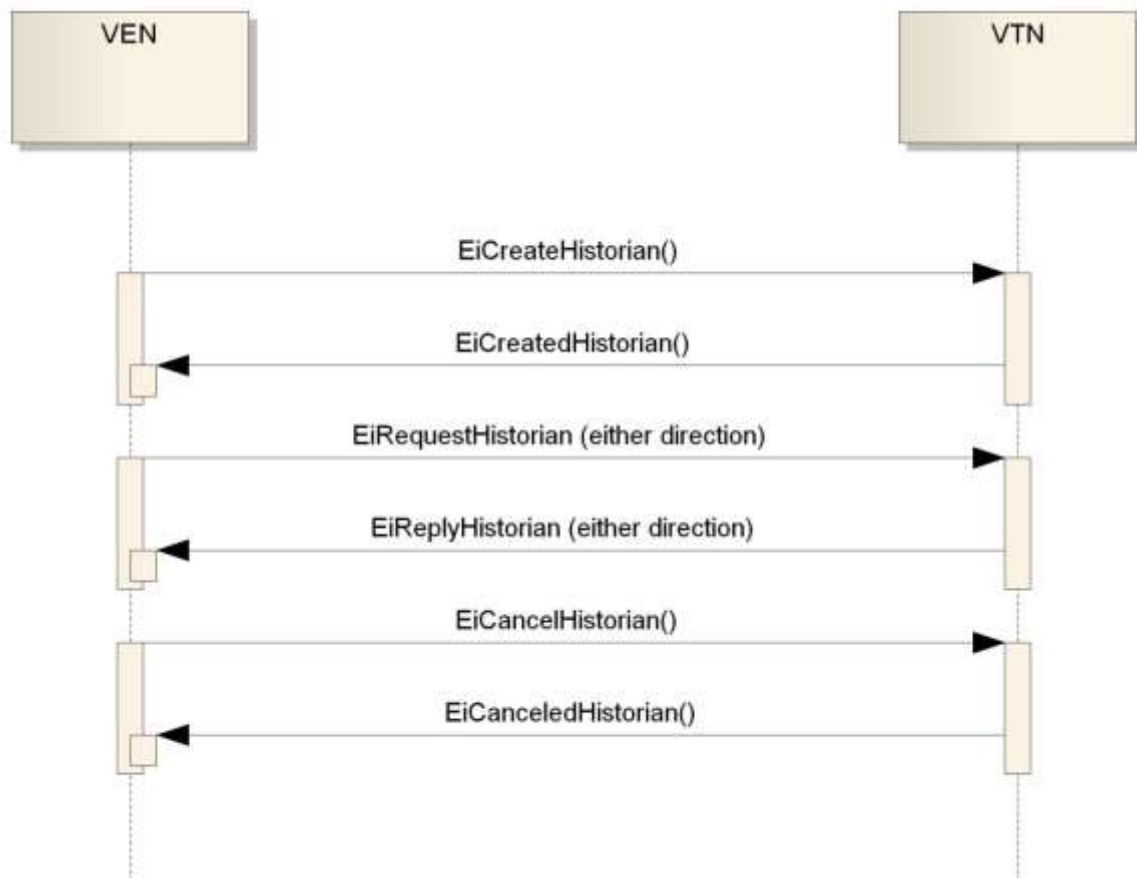
Service	Operation	Response	Service Consumer	Service Provider	Notes
EiReport	eiCreateHistorian	eiCreatedHistorian	any	any	Create a new Historian and start it recording indicated information
EiReport	eiRequestHistorian	eiReplyHistorian	any	any	Reply with HistorianIDs that meet the criteria
EiReport	eiCancelHistorian	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 Consumer	Service Provider	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

1782

1783 **10.2 EiHistorian Service**

1784 **10.2.1 Interaction Pattern for the EiHistorian Service**



1785

1786 Figure 10-1: Interaction Pattern for Historian Operations (Report Service)

1787 **10.2.2 Operations Payloads for the EiHistorian Service**



1788

1789 Figure 10-2: UML Diagram of Historian Payloads

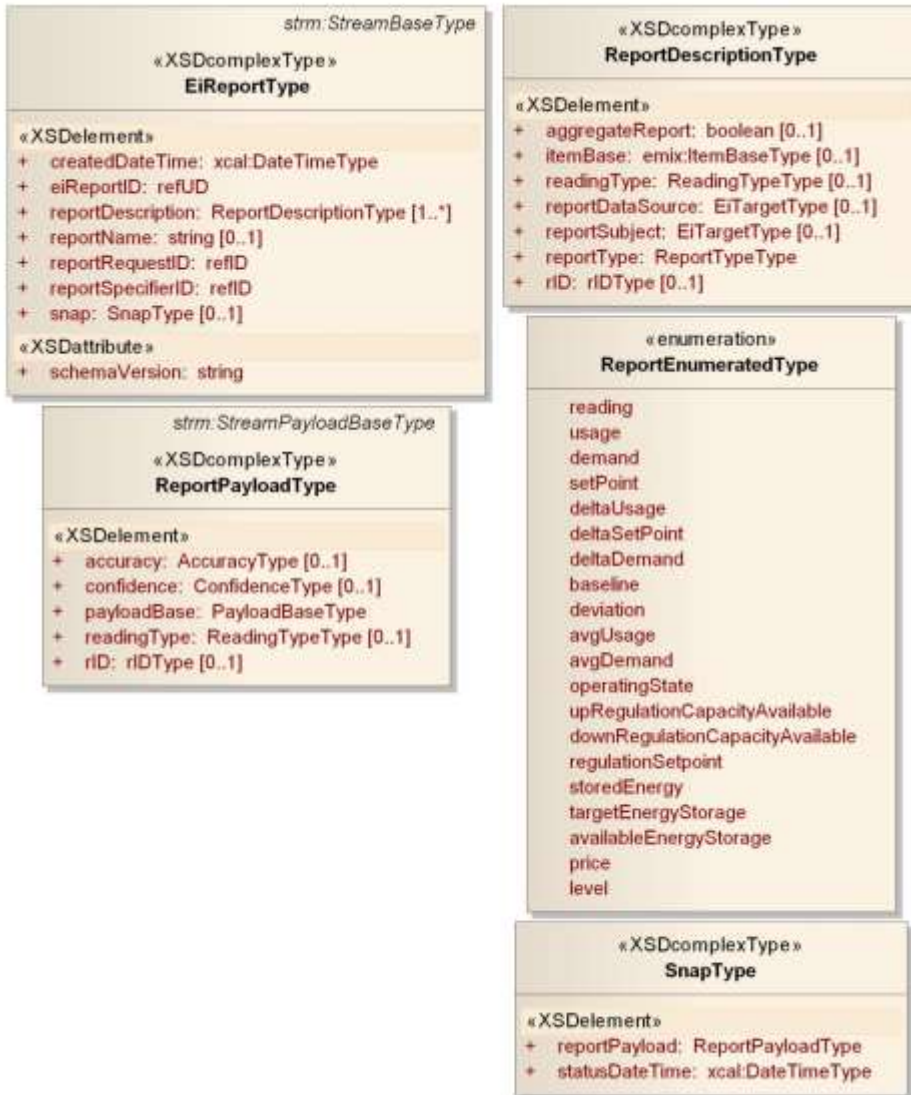
1790



1791 **10.3 EiReport Service**

1792 **10.3.1 Information Model for the EiReport Service**

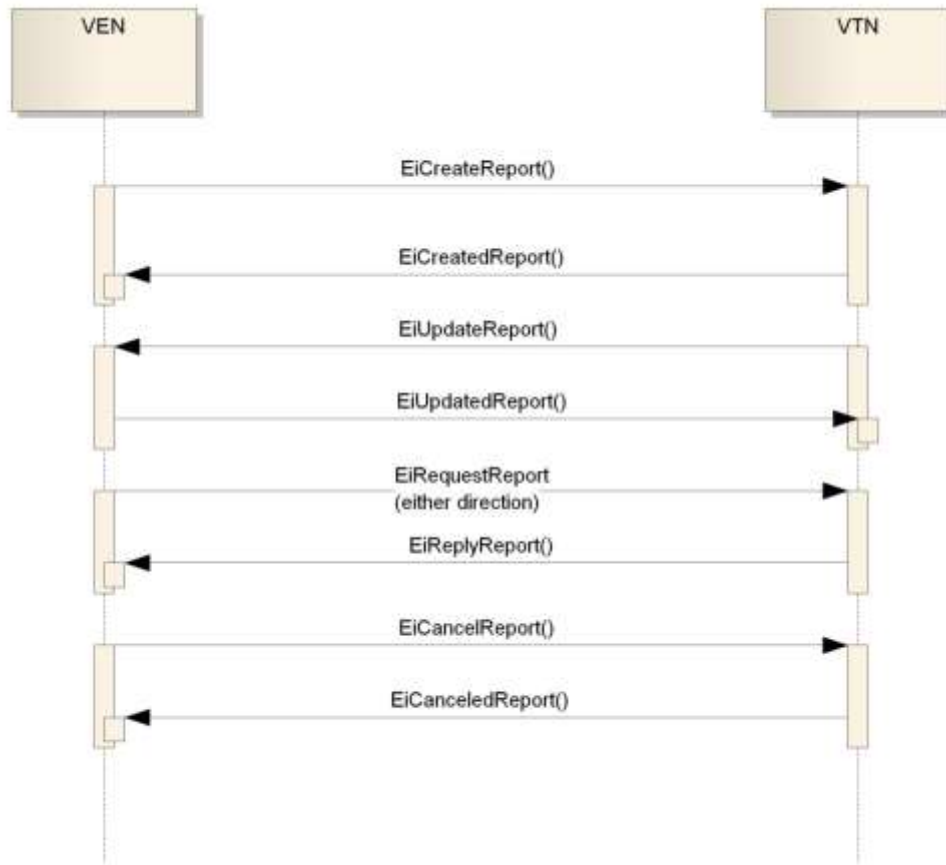
1793 An EiReport is prepared by a Party upon request and supplied to the requesting party. It may also be  
1794 defined in the expectations of the Market Context.



1795  
1796 *Figure 10-3: UML Class Diagram for the EiReport Class*  
1797

1798 **10.3.2 Interaction Pattern for the EiReport Service**

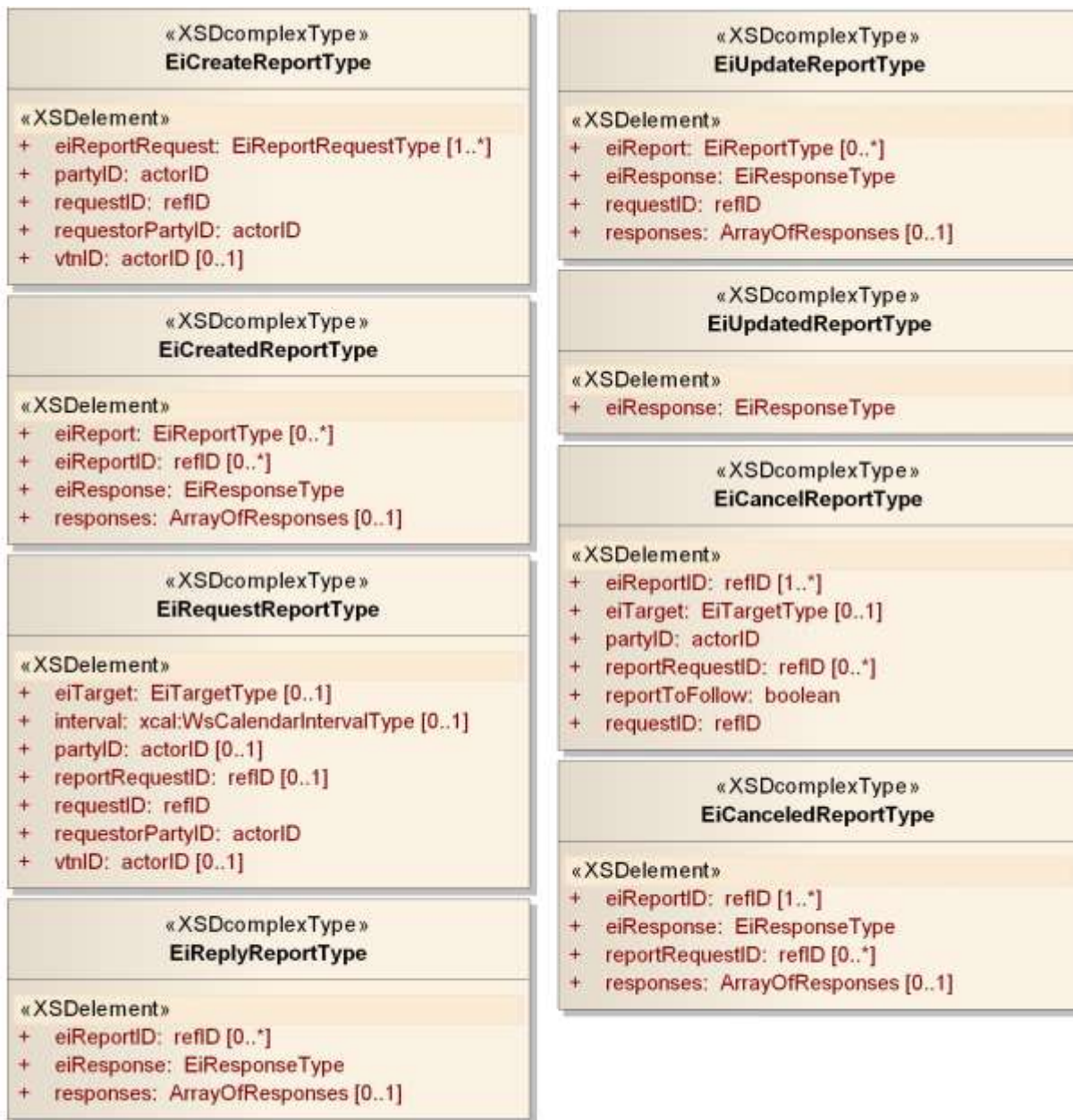
1799 This is the [UML] interaction diagram for the EiReport Service.



1800  
1801 *Figure 10-4: UML Interaction Diagram for the EiReport Service (Report Service)*

1802

### 10.3.3 Operation Payloads for the EiReport Service



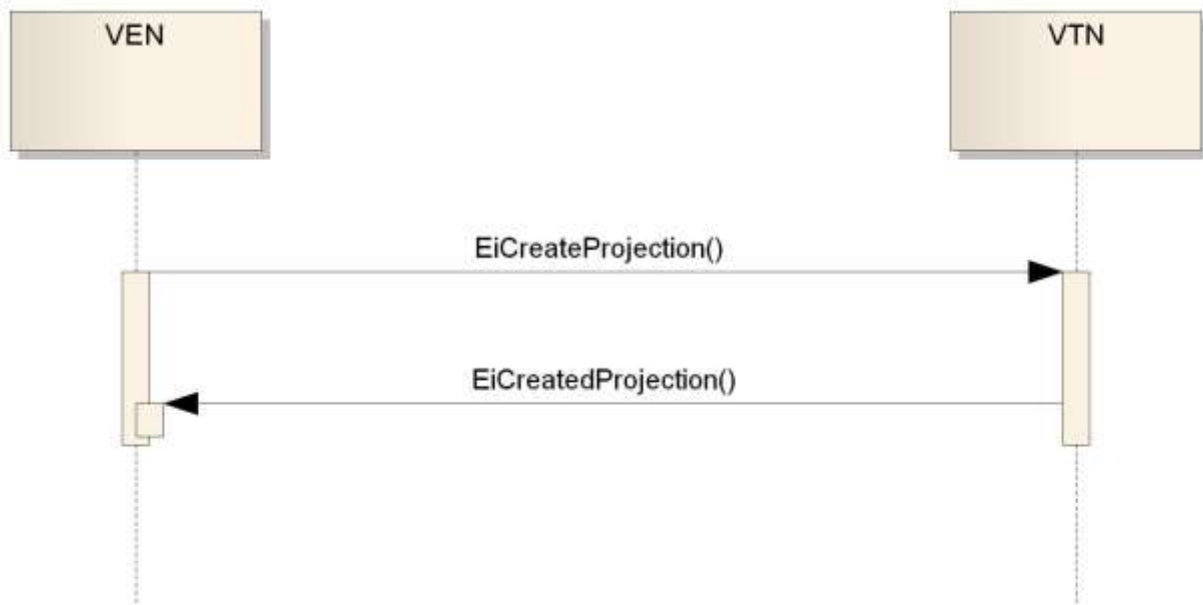
1804

1805 *Figure 10-5: UML Diagram of Report Payloads*

1806

1807 **10.4 EiProjectionService**

1808 **10.4.1 Interaction Pattern for EiProjection Service**



1809  
1810 *Figure 10-6: Interaction Pattern for Projection Operations (Report Service)*

1811

1812 **10.4.2 Operation Payloads for the EiProjection Service**

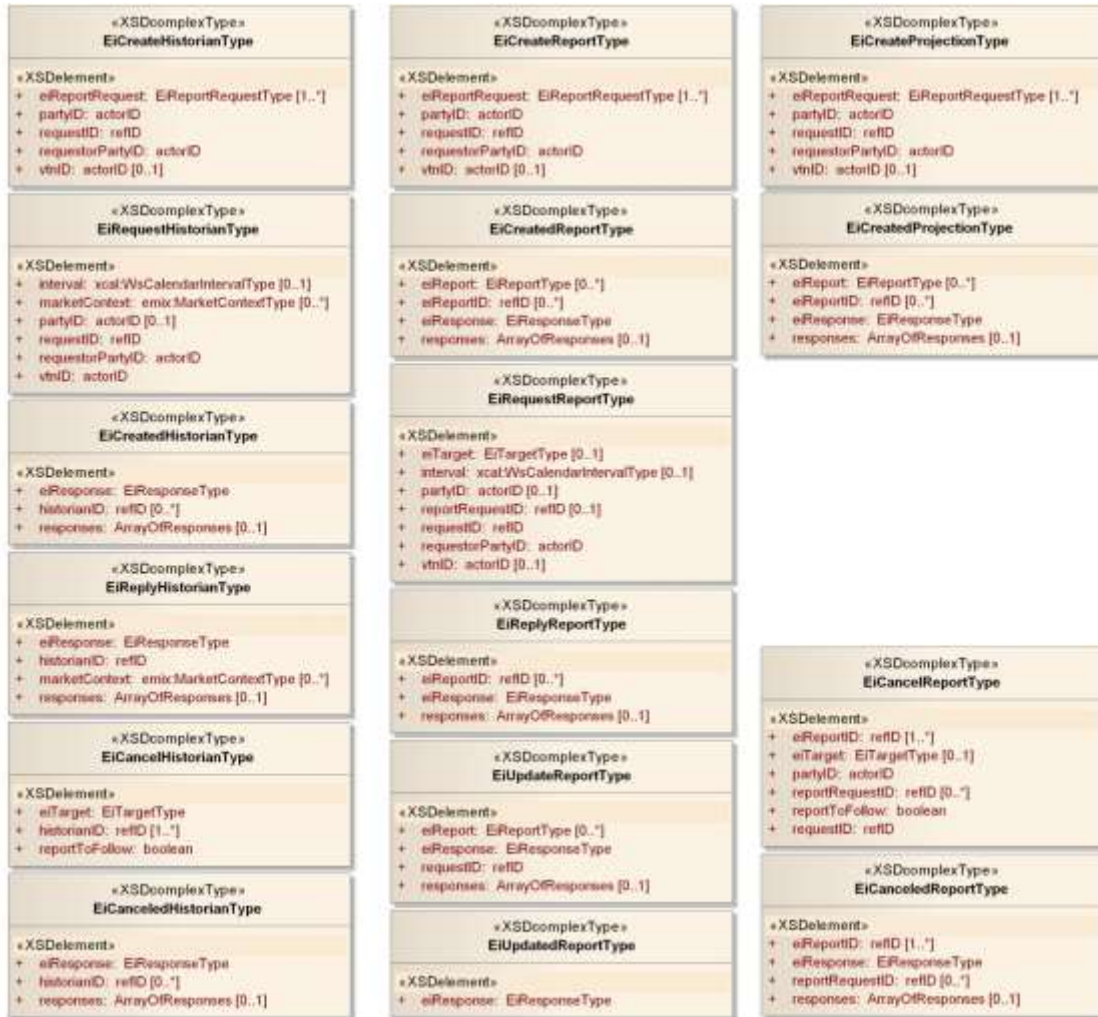


1813  
1814 *Figure 10-7: UML Diagram of Projection Payloads*

1815

1816 **10.5 Summary of Report Payloads**

1817 The [UML] class diagram below recaps the payloads for all operations of the EiReportService.



1818  
1819 *Figure 10-8: UML Class Diagram for all EiReportService Operation Payloads*



---

## 1820 11 Event Support Services

1821 Users of **[OpenADR]** found that they needed to be able to constrain the application of remote DR  
1822 services. For The DR Operator, advanced knowledge of these constraints improved the ability to predict  
1823 results. The services in this section are based on the services used to tailor expectations in **[OpenADR]**.  
1824 Availability and Opt are similar in that they communicate when a Party is willing to receive an Event.  
1825 Availability is a long-term schedule for when a Party will consider a response. Availability could be set in  
1826 the Market Context or at program enrollment. Opt (as in *opt in* or *opt out*) encompasses short-term  
1827 additions to or replacement of the schedule in Availability.  
1828 The combination of Availability and Opt states together define the times during which a committed  
1829 response from the VEN is possible or likely.

### 1830 11.1 Relationship of Availability and Opt Information

1831 Availability and Opt apply to interactions where an action is requested (e.g. curtailment and DER actions),  
1832 and only indirectly to (e.g.) price distribution interactions.  
1833 Availability is a long-term description and may be complex. Opt is a short-term description that replaces or  
1834 is combined into the long-term availability description.  
1835 Availability and Opt-In and Opt-Out, as well as Market Rules, use the *VavailabilityType* defined in **[WS-**  
1836 **Calendar]** which in turn is an XML serialization of **[Vavailability]**. The semantics are defined in  
1837 **[Vavailability]**.  
1838 The behavior of the Availability schedule is defined as follows. We call the parameter passed for Opt-In  
1839 and Opt-Out the *Opt Vavailability*.  
1840

- The *EiAvailability* class describes when the VEN expects/commits/plans to be available to
- 1841 respond to a request for performance, generally an *EiEvent*.
- 1842 • Exactly one *Vavailability* is included in the *EiAvailability* and the *EiOpt* objects.
- 1843 • An *EiOpt* that is used in a message MUST have a bounded interval (the *Opt Interval*) in the *Opt*
- 1844 *Vavailability*<sup>8</sup>
- 1845 • An **Opt-In** while in effect adds the available times of the *Opt Vavailability* to the available times in
- 1846 the bounded interval for the VEN with respect to a *MarketContext*, effectively performing a logical
- 1847 OR operation on the available times but only within the *opt Interval*
- 1848 • An **Opt-Out** while in affect replaces the entire portion of the *EiAvailability* within the *opt interval*
- 1849 • Exactly zero or one *Opt* functions MAY be in effect at any time

1850 In short, Opt-In adds the *Opt Vavailability* available times to the overall VEN *vavailability*; Opt-Out  
1851 replaces the entirety of its *opt Intervals* with the contents of the Opt-Out *Vavailability*.

### 1852 11.2 EiAvail Service

1853 The *Availability*<sup>9</sup> is set by the VEN and indicates when an event may or may not be accepted and  
1854 executed by the VEN with respect to a *Market Context*. Knowing the *Availability* and *Opt* information for  
1855 its VENs improves the ability of the VTN to estimate response to an event or request.  
1856 When *Availability* is set, *opt-in* or *opt-out* does not affect the *Availability* except for the specific interval(s)  
1857 described by the *Opt*—*opting out* is temporary unavailability, which may have transaction and business  
1858 consequences if an event is created during the *opt-out* period.

---

<sup>8</sup> By defining an end time for the *Vavailability*

<sup>9</sup> Called *Constraints* in **[OpenADR1]**

1859 The modeling for Availability includes behavior indications for the situation where an EiEvent overlaps a  
 1860 constrained time interval.

1861 EiAvailability describes only the available times, using the patterns defined in **[WS-Calendar]** and  
 1862 **[Vavailability]**.

1863 *Table 11-1: Avail Service*

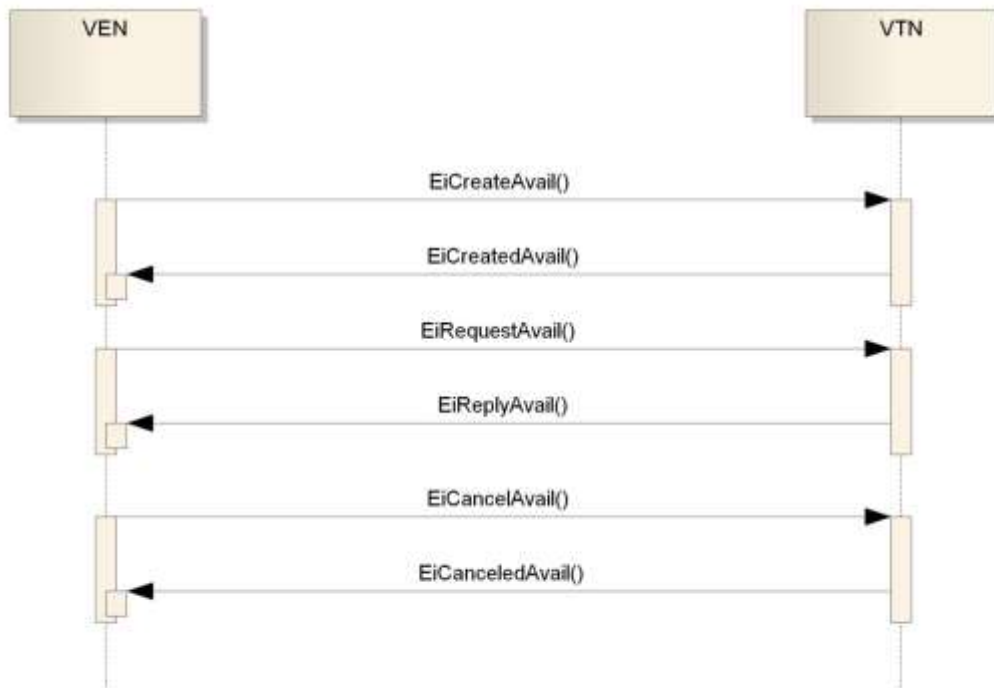
Service	Operation	Response	Service Consumer	Service Provider	Notes
EiAvail	EiCreateAvail	EiCreatedAvail	VEN	VTN	Create an Avail for this VEN; return the AvailID
EiAvail	EiRequestAvail	EiReplyAvail	VEN	VTN	Request Avail information for this VEN; request semantics with no time Interval
EiAvail	EiCancelAvail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

1864 The element EiAvailBehavior defines how an issued EiEvent that conflicts with the current EiAvail is  
 1865 performed:

- 1866 • ACCEPT – accept the issued EiEvent regardless of conflicts with the EiAvail
- 1867 • REJECT – reject any EiEvent whose schedule conflicts with the EiAvail
- 1868 • RESTRICT – modify the EiEvent parameters so that they fall within the bounds of the EiAvail

### 1869 11.2.1 Interaction Patterns for the EiAvail Service

1870 This is the **[UML]** interaction diagram for the EiAvail Service.



1871  
 1872 *Figure 11-1: Interaction Pattern for the EiAvailability Service.*

1873



1874 **11.2.2 Information Model for the EiAvail Service**



1875

1876 *Figure 11-2: UML Class Diagram for the EiAvail Type*

1877

1878 **11.2.3 Operation Payloads for the EiAvail Service**

1879 The [UML] class diagram describes the payloads for the EiAvail service operations.



1880  
1881 *Figure 11-3: UML Class Diagram for EiAvail Service Operation Payloads*

1882 **11.3 EiOpt Service**

1883 The Opt service creates and communicates Opt-In and Opt-Out schedules from the VEN to the VTN.  
 1884 Schedules are combined with EiAvailability and the Market Context requirements to give a complete  
 1885 picture of the willingness of the VEN to respond to EiEvents received by the VEN.

- 1886 • Exactly one Vavailability MUST be provided in EiCreateOptIn and EiCreateOptOut.
- 1887 • Opt schedules SHALL override any Availability in place while there is an Opt in effect. See  
 1888 Section 11.1

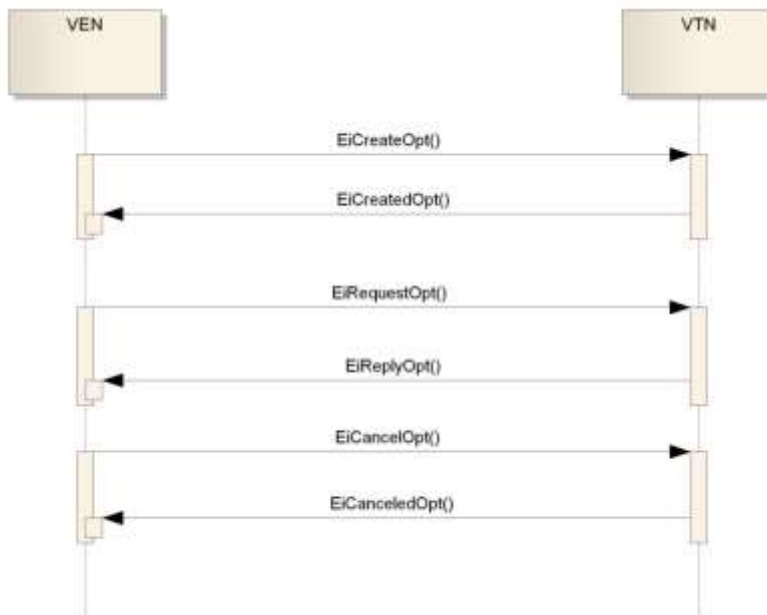
1889 Applying EiCreateOptIn or EiCreateOptOut if an Opt is currently in effect replaces the current Opt in effect  
 1890 with that in the Opt Vavailability, which effectively cancels the current Opt state and Creates a new one.

1891 *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

1892 **11.3.1 Interaction Patterns for the EiOpt Service**

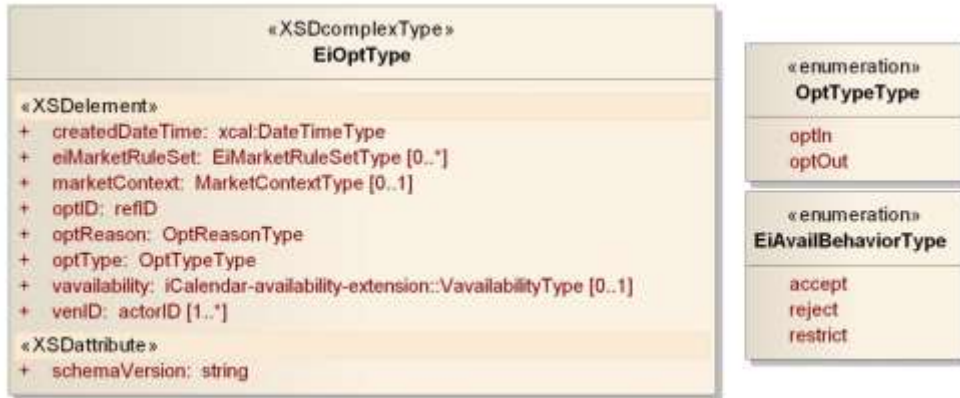
1893 This is the [UML] interaction diagram for the EiOpt Service.



1894  
 1895 *Figure 11-4: Interaction Diagram for the EiOpt Service*

1896 **11.3.2 Information Model for the EiOpt Service**

1897 Opting in or out is a temporary situation indicating that the VEN will or will not respond to a an event or in  
 1898 a specific time period, without changing the potentially complex Availability. The *EiOpt* schedule is a [WS-  
 1899 **Calendar**] VavailabilityType.



1900

1901 *Figure 11-5: UML Class Diagram for EiOpt Type*

1902 **11.3.3 Operation Payloads for the EiOpt Service**

1903 The [UML] class diagram describes the payloads for the EiOpt service operations.



1904  
1905 *Figure 11-6: UML Class Diagram for EiOpt Service Operation Payloads*

1906 **12Market Information**

1907 Each Event and Service in Energy Interoperation takes place within a Market Context. This Context  
 1908 defines the behaviors that that each Party can expect from the other.

1909 **12.1 The Market Context**

1910 Market Contexts are used to express market information that rarely changes, and thereafter not need to  
 1911 communicate it with each message.

1912 In any market context, there are standing terms and expectations about product offerings. If these  
 1913 standing terms and expectations are not known, many exchanges may need to occur before finding  
 1914 products that meet those expectations. If these expectations are only known through local knowledge,  
 1915 then then national and international products need to be re-configured for each local market that they  
 1916 enter. If all market information were to be transmitted in every information exchange, messages based on  
 1917 EMIX would be overly repetitious.

1918 As described in Section 5.2 "Market Context", The EI Market Contexts is a super-set of the [EMIX]  
 1919 Standard Terms, and they can be referenced using the EMIX Market Context as an identifier. The EMIX  
 1920 Market Context is expressed as an URI.

1921 **12.2 Market Context Service**

1922 The Market Context Service enables a Party to request the details of a Market Context. These MAY be  
 1923 mandatory in many of today's interactions. Parties MAY be able to request and compare Market Contexts  
 1924 to select which markets to participate in. Such Interactions are out of scope for this specification.



1925  
 1926 *Figure 12-1: Sequence diagram for Market Context service*

1927 The Market Context service can retrieve the full information in an EiMarketContext given the identifier, an  
 1928 EMIX Market Context. There is one operation and a responding operation.

1929 *Table 12-1: Market Context Service*

Service	Operation	Response	Service	Service	Notes
---------	-----------	----------	---------	---------	-------

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

1930

1931 **12.3 Information Model for the EiMarketContext Service**



1932

1933 *Figure 12-2: UML Class Diagram for Market Context*



1934

## 12.4 Operation Payloads for the EiMarket Context Service



1935

1936 *Figure 12-3: UML of Market Context Service payloads*

1937 **13 Security and Composition [Non-Normative]**

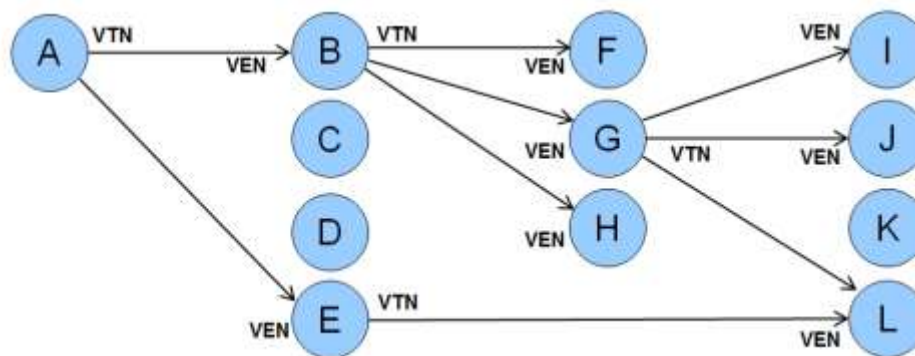
1938 This section describes the enterprise software approach to security and composition as applied to this  
1939 Energy Interoperation specification.

1940 Service orientation has driven a great simplification of interoperation, wherein software is no longer based  
1941 on Application Programming Interfaces (APIs) but is based on exchange of information in a defined  
1942 pattern of services and service operations [SOA-RM].

1943 The approach for enterprise software has evolved to defining key services and information to be  
1944 exchanged, without definitively specifying how to communicate with services and how to exchange  
1945 information—there are many requirements for distributed applications in many environments that cannot  
1946 be taken into account in a service and information standard. To make such choices is the realm of other  
1947 standards for specific areas of practice, and even there due care must be taken to avoid creating a  
1948 monoculture of security.<sup>10</sup>

1949 **13.1 Security and Reliability Example**

1950 Different interactions require different choices for security, privacy, and reliability. Consider the following  
1951 set of specifics. (This figure is here repeated and re-labeled.)



1952  
1953 *Figure 13-1: Web of Example DR Interactions*

1954 We specifically model a Reliability DR Event initiated by the Independent System Operator<sup>11</sup> A, who  
1955 sends a reliability event to its first-level aggregators B through E. Aggregator B, in turn invokes the same  
1956 service on its customers (say real estate landlords) F, G, and H.

1957 Those customers might be industrial parks with multiple facilities, real estate developments with multiple  
1958 tenants, or a company headquarters with facilities in many different geographical areas, which would  
1959 invoke the same operation on their VENs.

1960 For our example, say that G is a big-box store regional headquarters and I, J, and L are their stores in the  
1961 affected area.

1962 Each interaction will have its own security and reliability composed as needed—the requirements vary for  
1963 specific interactions. For example

- 1964 • For service operations between A to B, typical implementations include secure private frame-  
1965 relay networks with guaranteed high reliability and known latency. In addition, rather than relying

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

<sup>11</sup> Using North American Terminology.

- 1966 on the highly reliable network, in this case A requires an acknowledgment message from B back  
 1967 to A proving that the message was received.
- 1968 • From the perspective of the ISO, the communication security and reliability between B and its  
 1969 customers F, G, and H may be purely the responsibility of B, who in order to carry out B's  
 1970 transaction commitments to A will arrange its business and interactions to meet B's business  
 1971 needs.
  - 1972 • G receives the signal from aggregator B. In the transaction between G and B, there are service,  
 1973 response, and likely security and other requirements. To meet its transactional requirements, the  
 1974 service operations between B and G will be implemented to satisfy the business needs of both B  
 1975 and G. For our example, they will use the public Internet with VPN technology and explicit  
 1976 acknowledgement, with a backup of pagers and phone calls in the unlikely event that the primary  
 1977 communication fails. And each message gets an explicit application level acknowledgement.
  - 1978 • Security between B and G depends on the respective security models and infrastructure  
 1979 supported by B and G—no one size will fit all. So that security will be used for that interaction
  - 1980 • The big box store chain has its own corporate security architecture and implementation, as well  
 1981 as reliability that meets its business needs—again, no one size will fit all, and there is tremendous  
 1982 variation; there is no monoculture of corporate security infrastructures.
  - 1983 • Store L has security, reliability, and other system design and deployment needs and  
 1984 implementations within the store. These may or may not be the same as the WAN connection  
 1985 from regional headquarters G, and in fact are typically not the same (although some security  
 1986 aspects such as federated identity management and key distribution might be the same).
  - 1987 • Store L also has a relationship with aggregator E, which for this example is Store L's local utility;  
 1988 the Public Utility Commission for the state in which L is located has mandated (in this example)  
 1989 that all commercial customers will use Energy Interoperation to receive certain mandated signals  
 1990 and price communications from the local utility. The PUC, the utility, and the owner of the store L  
 1991 have determined the security and reliability constraints. Once again, one size cannot fit all—and if  
 1992 there were one “normal” way to accommodate security and reliability, there will be a different  
 1993 “normal” way in different jurisdictions.

1994 So for a simple Demand Response event distribution, we have potentially four different security profiles

1995 The following table has sample functional names for selected nodes.

1996 *Table 13-1: Interactions and Actors for Security and Reliability Example*

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

(Note: wrt means “with respect to”)

## 13.2 Composition

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

In the rich ecosystem of service and applications in use today, we *compose* or (loosely) *assemble* applications rather than craft them as one large thing. See for example OASIS Service Component

2004 Architecture [**OASIS SCA**], which addresses the assembly, substitution, and independent evolution of  
2005 components.

2006 A typical web browser or email system uses many standards from many sources, and has evolved rapidly  
2007 to accommodate new requirements by being structured to allow substitution. The set of standards  
2008 (information, service, or messaging) is said to be *composed* to perform the task of delivery of email.  
2009 Rather than creating a single application that does everything, perhaps in its own specific way, we can  
2010 use components of code, of standards, and of protocols to achieve our goal. This is much more efficient  
2011 to produce and evolve than large integrated applications such as older customized email systems.

2012 In a similar manner, we say we *compose* the required security into the applications—say an aspect of  
2013 OASIS [**WS-Security**] and OASIS Security Access Markup Language [**SAML**]  
2014—and further *compose* the required reliability, say by using OASIS [**WS-ReliableMessaging**] or perhaps the reliable messaging  
2015 supported in an Enterprise Service Bus that we have deployed.

2016 A service specification, with specific information to be exchanged, can take advantage of and be used in  
2017 many different business environments without locking some in and locking some out, a great benefit to  
2018 flexibility, adoption, and re-use.

### 2019 **13.3 Energy Interoperation and Security**

2020 In this section we describe some specific technologies and standards in our palette for building a secure  
2021 and reliable implementation of Energy Interoperation. Since Energy Interoperation defines only the core  
2022 information exchanges and services, and other technologies are composed in, there is no optionality  
2023 related to security or reliability required or present in Energy Interoperation.

2024 The information model in Energy Interoperation 1.0 is just that—an information model without security  
2025 requirements. Each implementation must determine the security needs (outside the scope of this  
2026 standard) broadly defined, including privacy (see e.g. OASIS Privacy Management Reference  
2027 Model[**PMRM**]), identity (see e.g. OASIS Identity in the Cloud, OASIS Key Management Inteoperability,  
2028 OASIS Enterprise Key Management Infrastructure, OASIS Provisioning Services, OASIS Web Services  
2029 Federation TC, OASIS Web Services Secure Exchange and more)

2030 Energy Interoperation defines services together with service operations, as is now best practice in  
2031 enterprise software. The message payloads are defined as information models, and include such artifacts  
2032 as Energy Market Information Exchange [**EMIX**] price and product definition, tenders, and transactions,  
2033 the EiEvent artifacts defined in this specification, and all information required to be exchanged for price  
2034 distribution, program event distribution, demand response, and distributed energy resources.

2035 This allows the composition and use of required interoperation standards without restriction, drawing from  
2036 a palette of available standards, best practices, and technologies. The requirements to be addressed for  
2037 a deployment are system issues and out of scope for this specification.

2038 As in other software areas, if a particular approach is commonly used, then a separate standard (or  
2039 standardized profile) may be created. In this way, WS-SecureConversation composes WS-Reliability and  
2040 WS-Security.

2041 So Energy Interoperation defines the exchanged information, the services and operations, and as a  
2042 matter of scope and broad use does not address any specific application as the security, privacy,  
2043 performance, and reliability needs cannot be encompassed in one specification. Many of the TCs named  
2044 above have produced OASIS Standards,

2045 (SEE [http://www.oasis-open.org/committees/tc\\_cat.php?cat=security](http://www.oasis-open.org/committees/tc_cat.php?cat=security))

## 2046 **14 Profiles [Normative]**

2047 These sections define the three normative profiles that are part of Energy Interoperation 1.0.

2048 A profile includes a selection of interfaces, services, and options for a particular purpose.

### 2049 **14.1 OpenADR [Normative]**

2050 The OpenADR Profile defines the services required to implement functionality similar to that in  
2051 **[OpenADR]**. The inclusion of the Energy Interoperation structure of VTNs and VENs, as well as use of  
2052 the Energy Market Information Exchange **[EMIX]** cross-cutting price and product definition standard and  
2053 WS-Calendar **[WS-Calendar]** based on the IETF **[iCalendar]** RFC updates and gives a broader range of  
2054 applicability in what has been described as the *OpenADR 2 Profile*.

2055 We present in simplified tabular form the Energy Interoperation services required as part of the OpenADR  
2056 Profile. When a service is included, all of the listed operations are included, so we list only the service  
2057 name and the section of this document.

2058 *Table 14-1: Services used in OpenADR Profile*

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

2059

### 2060 **14.2 TeMIX [Normative]**

2061 The Transactive EMIX (TeMIX) Profile defines the services required to implement functionality for energy  
2062 market interactions.

2063 We present in simplified tabular form the Energy Interoperation services required as part of the TeMIX  
2064 Profile. When a service is included, all of the listed operations are required, so we list only the service  
2065 name and the section of this document.

2066 *Table 14-2: Services used in TeMIX Profile*

Service	Section	Notes
<b>EiRegisterParty</b>	7.1	Register to identify and receive information
<b>EiQuote</b>	7.2	EiDistributeQuote for distributing dynamic prices (push), other

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

2067

### 2068 **14.3 Price Distribution [Normative]**

2069 Many current initiatives envision Price Distribution as a separate Profile requiring neither transactive  
 2070 energy nor event-based interactions. The Price Distribution profile defines the minimal set of services  
 2071 required to interact with a pure Price Distribution context.

2072 We present in simplified tabular form the Energy Interoperation services required as part of the Price  
 2073 Distribution Profile. When a service is included, all of the listed operations are required, so we list only the  
 2074 service name and the section of this document.

2075 *Table 14-3: Services used in Price Distribution Profile*

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

2076



---

2077 **15 Conformance and Processing Rules for Energy**  
2078 **Interoperation**

2079 **15.1 Conformance for Energy Interoperation**

2080 We define four conformance points for Energy Interoperation 1.0, modified by the networking technology  
2081 used

- 2082 • Full Conformance
- 2083 • Conformance

2084 And further define

- 2085 • Conformance to a Named Profile
- 2086 • Conformance with Alternate Interoperation

2087 In this section Named Profile is one of the profiles defined in Section 14 “**Profiles [Normative]**”.

2088 **15.1.1 General Conformance Requirements**

2089 The version of Energy Interoperation to which conformance is claimed MUST be specified in the  
2090 implementation’s conformance statement.

2091 Any extension(s) used by the implementation, whether of information structures, services, service  
2092 operations, or payloads MUST be described in the Implementation’s conformance statement including the  
2093 service operations, payloads, and information artifacts.

2094 The phrase “support all XML artifacts” includes the support of XML artifacts as extended; similarly,  
2095 message headers (SOAP Headers for Web services) MAY be extended as needed to compose other  
2096 technologies including but not limited to reliability and security. The payloads defined in this specification  
2097 are for required information exchanges, and a Conforming implementation MAY extend the data types,  
2098 payloads, or message headers appropriate to their transport/networking as necessary. It is required that  
2099 those extensions, restrictions, and so forth be documented in the conformance statement.

2100 **15.1.2 Full Conformance to Energy Interoperation**

2101 An implementation claiming **Full Conformance to Energy Interoperation 1.0** MUST do all of the  
2102 following as defined in this Work Product including specification, schemas, and WSDL files:

- 2103 • Implement all services and service operations (“Services and Operations”)
- 2104 • Support all XML artifacts as defined in the schemas (“XML”)
- 2105 • Interoperate using Web services and the **[WSDL]** files (“Web Services Interoperation”)
- 2106 • Conform to all of Sections 13.2 through the end of Section 13 (“Additional Conformance”)
- 2107 • Describe how any relevant XML artifacts are derived from the Work Product

2108 It is RECOMMENDED that interoperation be achieved using the WSI Basic Profile **[WSI-Basic]**

2109 **15.1.3 Conformance to Energy Interoperation**

2110 An implementation claiming **Conformance to Energy Interoperation 1.0** MUST do all of the following as  
2111 defined in this Work Product including specification, schemas, and WSDL files:

- 2112 • Interoperate using Web services and the **[WSDL]** files (“Web Services Interoperation”)
- 2113 • Conform to all of Sections 13.2 through the end of Section 13 (“Additional Conformance”)
- 2114 • Describe how any relevant XML artifacts are derived from the Work Product

2115 In addition, if the application claiming conformance does not support one or more Services or Operations  
2116 as defined in this specification, then the conformance statement for the implementation must:

- 2117 • List all Services and Operations that are supported in the implementation.



- 2118       • List all Services and Operations that are not supported in the implementation.  
2119       • For each Operation that is not supported, define the error response that will be returned if  
2120       invoked.

2121 For those operations that are supported by an implementation, but whose use or semantics are restricted,  
2122 a conforming implementation SHALL

- 2123       • List the subset of XML artifacts as defined by the schemas used in the implementation  
2124       • List the subset of XML artifacts as defined by the schemas that are not used in the specification  
2125       • State any restrictions, i.e., in cardinality or optionality, that is applied to artifacts defined herein

#### 2126 **15.1.4 Full Conformance with Alternate Interoperation to Energy** 2127 **Interoperation**

2128 An implementation claiming **Full Conformance with Alternate Interoperation to Energy Interoperation**  
2129 **1.0** MUST be able to claim **Full Conformance to Energy Interoperation**, except that networking  
2130 technologies other than Web services MAY be used by the implementation. A description of networking  
2131 technologies used MUST be included in the implementation's conformance statement.

2132 An implementation MAY claim Full Conformance as well as Full Conformance with Alternate  
2133 Interoperation. The Conformance statement MUST describe the extensions or departures from Full  
2134 Conformance.

#### 2135 **15.1.5 Conformance with Alternate Interoperation to Energy Interoperation**

2136 An implementation claiming **Conformance with Alternate Interoperation to Energy Interoperation 1.0**  
2137 MUST be able to claim **Conformance to Energy Interoperation**, except that networking technologies  
2138 other than Web services MAY be used by the implementation. A description of networking technologies  
2139 used MUST be included in the implementation's conformance statement.

2140 An implementation MAY claim Conformance as well as Conformance with Alternate Interoperation. The  
2141 Conformance statement MUST describe the extensions or departures from Full Conformance.

#### 2142 **15.1.6 Conformance to Named Profiles of Energy Interoperation**

2143 In this section Named Profile refers to one of the profiles defined in Section 14 "**Profiles [Normative]**".

##### 2144 **15.1.6.1 Full Conformance to a Named Profile of Energy interoperation**

2145 An implementation claiming **Full Conformance to a Named Profile of Energy Interoperation** MUST be  
2146 able to claim **Full Conformance to Energy Interoperation** excepting only the following:

- 2147       • Services and Operations in sections not included in the named Profile as defined in Section 14  
2148       [wd35 – should be link]

2149 It is RECOMMENDED that Web services interoperation be achieved using the WSI Basic Profile [**WSI-**  
2150 **Basic**]

##### 2151 **15.1.6.2 Conformance to a Named Profile of Energy interoperation**

2152 An implementation claiming **Conformance to a Named Profile of Energy Interoperation** MUST be able  
2153 to claim **Conformance to Energy Interoperation** excepting only the following:

- 2154       • Services and Operations in sections not included in the named Profile

2155 It is RECOMMENDED that Web services interoperation be achieved using the WSI Basic Profile [**WSI-**  
2156 **Basic**]

2157 **15.1.6.3 Full Conformance or Conformance with Alternate Interoperation to a**  
2158 **Named Profile**

2159 An implementation claiming **Conformance with Alternate Interoperation** or **Full Conformance with**  
2160 **Alternate Interoperation to a Named Profile of Energy Interoperation** MUST be able to claim the  
2161 respective **Full Conformance with Alternate Interoperation** or **Conformance with Alternate**  
2162 **Interoperation to Energy Interoperation** excepting only the following:

- 2163 • Services and Operations in sections not included in the Named Profile

2164 In addition, interoperation payloads MUST be used as defined or extended; in the event that payloads are  
2165 extended a description of the extension(s) SHALL be included in the Implementation's conformance  
2166 statement.

2167 **15.2 Conformance with the Semantic Models of EMIX and WS-**  
2168 **Calendar**

2169 This section specifies conformance with the semantic models of **[EMIX]** and **[WS-Calendar]**. Energy  
2170 Interoperation is strongly dependent on each of these information models.

2171 **[WS-Calendar]** is a general specification and makes no assumptions about how its information model is  
2172 used. **[WS-Calendar]** has specific rules which define Inheritance as a means to reduce the conveyance  
2173 of repetitive information. As this specification constrains schedule communications to specific business  
2174 interactions, these inheritance rules are extended to embrace rules of interaction and rules of process  
2175 that further reduce the information that must be expressed in each interval.

2176 Implementations of Energy Interoperation SHALL conform to the rules of **[WS-Calendar]** and **[EMIX]**.  
2177 These rules include the following conformance types:

- 2178 • Conformance to the **inheritance rules** in **[WS-Calendar]**, including the direction of inheritance
- 2179 • **Specific attributes** for each type that MUST or MUST NOT be inherited.
- 2180 • **Conformance rules** that Referencing Specifications MUST follow
- 2181 • Description of **Covarying attributes** with respect to the Reference Specification
- 2182 • **Semantic Conformance** for the information within the Artifacts exchanged.
- 2183 • Conformance to the **inheritance rules** in **[EMIX]**, including inheritance of Product Definitions and  
2184 Standard Terms.

2185 Energy Interoperation implementations also use the EMIX Products and Resources also extend the  
2186 Inheritance patterns of **[WS-Calendar]** as specified in the EMIX information model. We address each of  
2187 these in the following sections.

2188 **15.2.1 Recapitulation of Requirements from WS-Calendar and EMIX**

2189 **[WS-Calendar]** uses the term Sequence to refer to one or more Intervals with Temporal Relations  
2190 defined between them that may inherit from zero or more Gluons. **[EMIX]** introduced the term Schedule to  
2191 refer to Product Descriptions applied to a Sequence. Streams recapitulate these rules with specific  
2192 addenda as they include both Gluon and Sequence.

2193 **15.2.1.1 Specific Attribute Inheritance within Schedules**

2194 The rules that define inheritance, including direction in **[WS-Calendar]**, are recapitulated.

2195 **I1: Proximity Rule** Within a given lineage, inheritance is evaluated though each Parent to the Child  
2196 before what the Child bequeaths is evaluated.

2197 **I2: Direction Rule** Intervals MAY inherit attributes from the nearest Gluon subject to the Proximity Rule  
2198 and Override Rule, provided those attributes are defined as Inheritable.

2199 **I3: Override Rule** If and only if there is no value for a given attribute of a Gluon or Interval, that Gluon or  
2200 Interval SHALL inherit the value for that attribute from its nearest Ancestor in conformance to the  
2201 Proximity Rule.

2202 **I4: Comparison Rule** Two Sequences are equivalent if a comparison of the respective Intervals  
2203 succeeds as if each Sequence were fully Bound and redundant Gluons are removed.

2204 **I5: Designated Interval Inheritance** [To facilitate composition of Sequences] the Designated Interval in  
2205 the ultimate Ancestor of a Gluon is the Designated Interval of the composed Sequence. Special  
2206 conformance rules for Designated Intervals apply only to the Interval linked from the Designator Gluon.

2207 **I6: Start Time Inheritance** When a start time is specified through inheritance, that start time is inherited  
2208 only by the Designated Interval; the start times of all other Intervals are computed through the durations  
2209 and temporal; relationships within the Sequence. The Designated Interval is the Interval whose parent is  
2210 at the end of the lineage. In Events, the Active Interval is the Designated Interval.

### 2211 **15.2.1.2 Time Zone Specification**

2212 The time zone MUST be explicitly known in any conforming Energy Interoperation artifact.

2213 This may be accomplished in two ways:

- 2214 • The time, date, or date and time MUST be specified using **[ISO8601]** utc-time (also called  
2215 *zulu time*)
- 2216 • The **[WS-Calendar]** Time Zone Identifier, TZID, MUST be in the Lineage of the artifact, as  
2217 extended by the Market Context. Generally, the Market Context acts as a Gluon  
2218 bequeathing the TZID. See Section 15.3 below.

2219 If neither expression is included, the Artifact does not conform to this specification and its attempted use  
2220 in information exchanges MUST result in an error condition.

### 2221 **15.2.1.3 Specific Rules for Optimizing Inheritance**

2222 If the Designated Interval in a Series has a Price only, all Intervals in the Sequence have a Price only and  
2223 there is no Price in the Product.

- 2224 • If the Designated Interval in a Series has a Quantity only, all Intervals in the Sequence have a  
2225 Quantity only and there is no quantity in the Product.
- 2226 • If the Designated Interval in a Series has a Price & Quantity, all Intervals in the Sequence MUST  
2227 have a Price and Quantity and there is neither Price nor Quantity in the Product.

## 2228 **15.3 TeMIX Conformance**

2229 The TeMIX Profile MUST apply the conformance rules for TeMIX described in **[EMIX]**.

## 2230 **15.4 Inheritance within Events**

2231 For purposes of processing, inheritance, and conformance, Signal Information is treated as an **[EMIX]**  
2232 Product Description, applied to a Sequence, and the Active Period is considered as a **[WS-Calendar]**  
2233 Schedule. The Streams in Signals and Event-linked Reports inherit from the Active Interval as if it were a  
2234 Gluon.

2235 Signals within an Event arrive in a setting established by a Market Context. Within an event, there may be  
2236 multiple Signal types. For purposes of inheritance, An Event may include multiple Stream-derived  
2237 information elements each with an associated Sequence. For purposes of processing, the body of the  
2238 Stream is treated as a **[WS-Calendar]** Gluon, and the Signal Information in each Interval in the Sequence  
2239 inherits from that Gluon.

2240 Each Specifies a Market Context. If that Market Context is associated with Standard Terms, then those  
2241 Terms enter the Lineage of the Schedule and are inherited by each Interval. Standard Terms associated  
2242 with a Market Context enter the Lineage of the Schedule as if the Market Context were a Gluon. Product  
2243 Description, TZID, Level Definition, Terms, et al. can be inherited in this way.

2244 **15.4.1 Sequence Optimization within Events**

2245 As described in 4.3.2 “Conformance of Streams to WS-Calendar”, Signals, Reports, and Baselines MUST  
2246 conform to WS-Calendar.

2247 **15.5 Version Conformance**

2248 Implementations that use the Schema Version attribute, and that claim full conformance to this  
2249 specification, MAY use the use the value “1.0.2011.11” for that attribute.

---

## Appendix A. Background and Development history

2251 There is a significant disconnect between customer load and the value of energy. The demand is not  
2252 sensitive to supply constraints; the load is not elastic; and the market fails to govern consumer behavior.  
2253 In particular, poor communications concerning high costs at times of peak use cause economic loss to  
2254 energy suppliers and consumers. There are today a limited number of high demand periods (roughly ten  
2255 days a year, and only a portion of those days) when the failure to manage peak demand causes immense  
2256 costs to the provider of energy; and, if the demand cannot be met, expensive degradations of service to  
2257 the consumer of energy.

2258 As the proportion of alternative energies on the grid rises, and more energy comes from intermittent  
2259 sources, the frequency and scale of these problems will increase and there will be an increasing need for  
2260 24/7 coordination of supply and demand. In addition, new electric loads such as electric vehicles will  
2261 increase the need for electricity and with new load characteristics and timing.

2262 Energy consumers can use a variety of technologies and strategies to shift energy use to times of lower  
2263 demand as well as to reduce use during peak periods. This shifting and reduction can reduce the need for  
2264 new power plants, and transmission and distribution systems. These changes will reduce the overall  
2265 costs of energy through greater economic efficiency. This process is known by various names, including  
2266 load shaping, demand shaping, and demand response (DR). Consistent interfaces and messages for DR  
2267 is a high priority cross-cutting issue identified in the NIST Smart Grid Interoperability Roadmap.

2268 Distributed energy resources, including generation and storage, now challenge the traditional hierarchical  
2269 relationship of supplier and consumer. Alternative and renewable energy sources may be located closer  
2270 to the end nodes of the grid than traditional bulk generation, or even within the end nodes. Wind and solar  
2271 generation, as well as industrial co-generation, allow end nodes to sometimes supply. Energy storage,  
2272 including mobile storage in plug-in hybrid vehicles, means that even a device may be sometimes a  
2273 supplier, sometime a customer. As these sources are all intermittent, they increase the challenge of  
2274 coordinating supply and demand to maintain the reliability of the electric grid. These resource, with their  
2275 associated issues, are generally named distributed energy resources (DER). The NIST Smart Grid  
2276 Interoperability Roadmap, this specification, and **[EMIX]** see a continuum between DR and DER.

2277 Better communication of energy prices addresses growing needs for lower-carbon, lower-energy  
2278 buildings, net zero-energy systems, and supply-demand integration that take advantage of dynamic  
2279 pricing. Local generation and local storage require that the consumer (in today's situation) make  
2280 investments in technology and infrastructure including electric charging and thermal storage systems.  
2281 People, buildings, businesses and the power grid will benefit from automated and timely communication  
2282 of energy prices, capacity information, and other grid information.

2283 Consistency of interface for interoperation and standardization of data communication will allow  
2284 essentially the same model to work for homes, small businesses, commercial buildings, office parks,  
2285 neighborhood grids, and industrial facilities, simplifying interoperation across the broad range of energy  
2286 providers, distributors, and consumers, and reducing costs for implementation.

2287 These communications will involve energy consumers, producers, transmission systems, and distribution  
2288 systems. They must enable aggregation of production, consumption, and curtailment resources. These  
2289 communications must support market makers, such as Independent System Operators (ISOs), utilities,  
2290 and other evolving mechanisms while maintaining interoperation as the Smart Grid evolves. On the  
2291 consumer side of these interfaces, building and facility agents will be able to make decisions on energy  
2292 sale, purchase, and use that fit the goals and requirements of their home, business, or industrial facility.

2293 The new symmetry of energy interactions demands symmetry of interaction. A net consumer of energy  
2294 may be a producer when the sun is shining, the wind is blowing, or an industrial facility is cogenerating<sup>12</sup>.

---

<sup>12</sup> Cogeneration refers the combined generation of multiple energy resources, i.e., a boiler that both spins a turbine to generate electricity and produces steam to run an industrial process. Cogeneration can include any number of energy distributions, including heat, cold, pressure, et al.

2295 Each interface must support symmetry as well, with energy and economic transactions able to flow each  
2296 way.

2297 Energy Interoperation defines the market interactions between smart grids and their end nodes  
2298 (Customers), including Smart Buildings and Facilities, Enterprises, Industry, Homes, and Vehicles. Market  
2299 interactions are defined here to include all informational communications and to exclude direct process  
2300 control communications. This document defines signals to communicate interoperable dynamic price,  
2301 reliability, and emergency signals to meet business and energy needs, and scale, using a variety of  
2302 communication technologies.

2303

---

## Appendix B. Glossary

- 2304 No definition in this glossary supplants normative definitions in this or other specifications. They are here  
2305 merely to provide a guidepost for readers at to terms and their special uses. Implementers will want to be  
2306 familiar with all referenced standards.
- 2307 Agreement is broad context that incorporates market context and programs. Agreement definitions are  
2308 out of scope in Energy Interoperation.
- 2309 DR Resource: see Resource.
- 2310 EMIX: As used in this document, EMIX objects are descriptions applied to a WS-Calendar Sequence.  
2311 EMIX defines Resource capabilities, used in tenders to match capabilities to need, and in  
2312 Products, used in tenders and in specific performance and execution calls.
- 2313 Feedback: Information about the state of a Resource; typically in relation to planning or executing a  
2314 response to an Event
- 2315 Resource (as used in Energy Interoperation): a Resource is a logical entity that is dispatchable. The  
2316 Resource is solely responsible for its own response. A resource description specifies the  
2317 performance envelope for a Resource. If a Resource can participate in multiple markets, it may  
2318 have multiple descriptions.
- 2319 Resource (as defined in EMIX): A Resource is something that can describe its capabilities in a Tender  
2320 into a market. How those Capabilities vary over time is defined by application of the Capability  
2321 Description to a WS-Calendar Sequence. See [EMIX].
- 2322 Status: Information about an Event, perhaps in relation to a specific Resource.
- 2323 Sequence: A set of temporally related intervals with a common relation to some informational artifact as  
2324 defined in WS-Calendar. Time invariant elements are in the artifact (known as a gluon) and time-  
2325 varying elements are in each interval.
- 2326 Tender: A tender is an offering for a Transaction. See Transaction.
- 2327 Transaction: A binding commitment between parties entered into under an agreement.
- 2328 VEN – see Virtual End Node
- 2329 Virtual End Node (VEN): The VEN has operational control of a set of resources and/or processes and is  
2330 able to control the output or demand of these resources in affect their generation or utilization of  
2331 electrical energy intelligently in response to an understood set of smart grid messages. The VEN  
2332 may be either a producer or consumer of energy. The VEN is able to communicate (2-way) with a  
2333 VTN receiving and transmitting smart grid messages that relay grid situations, conditions, or  
2334 events. A VEN may take the role of a VTN in other interactions.
- 2335 Virtual Top Node (VTN): a Party that is in the role of aggregating information and capabilities of  
2336 distributed energy resources. The VTN is able to communicate with both the Grid and the VEN  
2337 devices or systems in its domain. A VTN may take the role of a VEN interacting with another  
2338 VTN.
- 2339 VTN – see Virtual Top Node



---

## 2340 Appendix C. Extensibility in Energy Interoperation

2341 Extensibility was a critical design constraint for Energy Interoperation. Extensibility allows the Energy  
2342 Interoperation specification to be used in markets and in interactions that were not represented on the  
2343 Technical Committee. Formal extensibility rules also create a set of complaint extensions for incorporation  
2344 into later versions that are already compliant.

### 2345 C.1 Extensibility in Enumerated values

2346 EI defines a number of enumerations. Some of these, such as measurements of power, are predictably  
2347 stable. Others, such as market contracts or energy sources, may well have new elements added. In  
2348 general, these accept any string beginning with “x-“ as a legal extension. In particular, these are defined  
2349 using the following mechanism in the formal schemas (XSD’s).

2350 In ei.xsd, the extensibility pattern is defined. This pattern look like:

```
2351 <xs:simpleType name="EiExtensionType">  
2352   <xs:annotation>  
2353     <xs:documentation>Pattern used for extending string  
2354 enumeration, where allowed</xs:documentation>  
2355   </xs:annotation>  
2356   <xs:restriction base="xs:string">  
2357     <xs:pattern value="x-\.S.*"/>  
2358   </xs:restriction>  
2359 </xs:simpleType>
```

2360 Non-extensible enumerated types look like this:

```
2361 <xs:simpleType name="VoltageUnitsType">  
2362   <xs:restriction base="xs:string">  
2363     <xs:enumeration value="MV"/>  
2364     <xs:enumeration value="KV"/>  
2365     <xs:enumeration value="V"/>  
2366   </xs:restriction>  
2367 </xs:simpleType>
```

2368 In this case, we use the suffix “EnumeratedType” to allow for the possibility of other Measurement  
2369 Protocols that are not enumerated. Actual compliance, though, is based upon the type:

```
2370 <xs:simpleType name="MeasurementProtocolType">  
2371   <xs:union memberTypes="power:MeasurementProtocolEnumeratedType  
2372 emix:EmixExtensionType"/>  
2373 </xs:simpleType>
```

2374 That is, valid values for the measurement protocol are the enumerated values, and any that match the  
2375 extension pattern “x-”

### 2376 C.2 Extension of Structured Information Collective Items

2377 EI anticipates adding some information structures that are more complex than simple strings can be  
2378 extended as well. A challenge for these items is that they are more complicated and so require formal  
2379 definition. Formal definitions, expressed as additions to schema, could require changes to the  
2380 specification. Without formal definition, it is difficult for trading partners to agree on valid messages.

2381 EI uses abstract classes for many information exchanges. For example, trading partners could agree on  
2382 the exchange of additional Payloads. The existing list of Payloads are derived from the empty, abstract  
2383 Payload Base Type. Parties that wish to exchange other Payloads can derive new Types from Payload  
2384 Base and use them in Signals, Baselines, Reports, and Delivery.

2385 The resulting schema, which references the approved EI schemas, but does not change them, can then  
2386 be distributed to business partners to validate the resulting message exchanges.

2387  
 2388  
 2389  
 2390  
 2391  
 2392  
 2393  
 2394  
 2395  
 2396  
 2397  
 2398  
 2399  
 2400  
 2401  
 2402  
 2403  
 2404  
 2405  
 2406  
 2407  
 2408  
 2409  
 2410  
 2411

## Appendix D. Mapping NAESB Definitions to Terminology of Energy Interoperation

Energy Interoperation can be used in today's markets and business interactions. Generally accepted business terms for these markets were defined for both the retail and wholesale electrical quadrants in the **NAESB PAP09 Requirements Phase 2 [NAESB PAP09]**.

Because Energy Interoperation describes a general-purpose mechanism that can be used by parties for today's market interactions at several levels of today's markets as well as for new and extended future interactions, the terms do not determinatively map to the NAESB semantics. Symmetric use of the interfaces in this specification can make some mappings ambiguous.

There are several kinds of definitions used in Energy Interoperation and in EMIX.

Abstraction over a class of similar information (for example, the EMIX Interface, the *EmixInterfaceType* abstract type, addresses all locational information including geospatial, P-Node, AP-Node, and more.)

Simplification (for example, Party addresses all Business Entities as the focus is on the service interaction; a Business Entity presents and assumes various roles and interfaces)

Algebraic combination (for example, a Resource summarizes characteristics from both curtailment and generation/battery draw-down as equivalent, though the market values and markets may vary)

Some terms are outside the scope of Energy Interoperation, hence neither used nor defined (for example, Asset, Resource Object, Regulator).

With these caveats, most of the terms defined by NAESB can be mapped to those in this specification.

*NOTE: Market Participant is not defined explicitly in the NAESB document. Party is the generalization of business entities. A Party enrolls and some of the Parties enrolled, (possibly with a separate qualification step) are roles such as LSE, MA. We use the phrase "Party enrolled as ..." in the table below to describe that situation.*

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.	<b>Party</b>

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, <a href="http://www1.eere.energy.gov/femp/pdfs/31570.pdf">http://www1.eere.energy.gov/femp/pdfs/31570.pdf</a>	<b>Resource</b>
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.	<b>Party</b> 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 <b>Resource</b> combined with <b>Market Standard Terms</b>

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.	<b>Party</b> enrolled as an MP
Measurement	The role associated with the device or algorithm that measures the consumption or supply of an end device.	<b>Measurement</b>
Meter Authority (MA)	A role which carries the responsibility of providing data necessary to determine the performance of a Resource.	<b>Party</b> enrolled as an MA
P-Node	The price location of the Premise in the transmission and/or distribution network.	<b>EMIX Interface</b> 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. <sup>13</sup>	<b>EMIX Resource</b>
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.	<b>Party</b> enrolled as an SE
Service Delivery Point	The identifier of the location where electric service is delivered to the Service Location.	<b>EMIX Interface</b> is superclass
Service Location	The physical location at which connection to the transmission or distribution system is made.	<b>EMIX Interface</b> 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.	<b>Party</b> 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

<sup>13</sup> 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.	<b>Party</b> 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. <b>Party</b> may take role
Utility Distribution Operator (UDO)	An entity which carries the responsibility of operating an electricity distribution system.	Not defined explicitly. <b>Party</b> that provides transport products
Zone	A physical or electrical region.	<b>EMIX Interface</b> is the superclass

2412

2413

---

## Appendix E. Acknowledgements

2414 The following individuals have participated in the creation of this specification and are gratefully  
2415 acknowledged:

2416 **Participants:**

2417 Hans Aanesen, Individual  
2418 Bruce Bartell, Southern California Edison  
2419 Timothy Bennett, Drummond Group Inc.  
2420 Carl Besaw, Southern California Edison  
2421 Anto Budiardjo, Clasma Events, Inc.  
2422 Edward Cazalet, Individual  
2423 Joon-Young Choi, Jeonju University  
2424 Kevin Colmer, California Independent System Operator  
2425 Toby Considine, University of North Carolina  
2426 William Cox, Individual  
2427 Sean Crimmins, California Independent System Operator  
2428 Phil Davis, Schneider Electric  
2429 Sharon Dinges, Trane  
2430 Robert Dolin, Echelon Corporation  
2431 Rik Drummond, Drummond Group Inc.  
2432 Ernst Eder, LonMark International  
2433 Thomas Ferrentino, Individual  
2434 Craig Gemmill, Tridium, Inc.  
2435 Girish Ghatikar, Lawrence Berkeley National Laboratory  
2436 Gerald Gray, Southern California Edison / Electric Power Research Institute (EPRI)  
2437 Anne Hendry, Individual  
2438 Thomas Herbst, Cisco Systems, Inc.  
2439 David Holmberg, NIST  
2440 Gale Horst, Electric Power Research Institute (EPRI)  
2441 Ali Ipakchi, Open Access Technology International Inc. (OATi)  
2442 Oliver Johnson, Tendril Networks, Inc.  
2443 Sila Kiliccote, Lawrence Berkeley National Laboratory  
2444 Ed Koch, Akuacom Inc  
2445 Michel Kohanim, Universal Devices, Inc.  
2446 Larry Lackey, TIBCO Software Inc.  
2447 Derek Lasalle, JPMorganChase  
2448 Jeremy Laundergan, Southern California Edison  
2449 Benoit Lepeuple, LonMark International  
2450 Edgardo Luzcando, Midwest ISO and ISO/RTO Council (IRC)  
2451 Carl Mattocks, Individual  
2452 Dirk Mahling, CPower  
2453 Kyle Meadors, Drummond Group Inc.  
2454 Scott Neumann, Utility Integration Solutions Inc.  
2455 Robert Old, Siemens AG  
2456 Mary Ann Piette, Lawrence Berkeley National Laboratory  
2457 Joshua Phillips, Southwest Power Pool and ISO/RTO Council (IRC)  
2458 Donna Pratt, New York ISO and ISO/RTO Council (IRC)  
2459 Ruchi Rajasekhar, Midwest Independent System Operator  
2460 Jeremy Roberts, LonMark International  
2461 Anno Scholten, Individual  
2462 Pornsak Songkakul, Siemens AG  
2463 Jane Snowdon, IBM  
2464 Aaron Snyder, NIST  
2465 William Stocker, New York ISO and ISO/RTO Council (IRC)

2466 Pornsak Songkakul, Siemens AG  
2467 Robert Stayton, Individual  
2468 Jake Thompson, EnerNOC  
2469 Matt Wakefield, Electric Power Research Institute (EPRI)  
2470 Douglas Walker, California Independent System Operator  
2471 Evan Wallace, NIST  
2472 Dave Watson, Lawrence Berkeley National Laboratory  
2473 David Wilson, Trane  
2474 Leighton Wolfe, Individual  
2475 Brian Zink, New York Independent System Operator

2476 The Technical Committee also acknowledges the work of the contributing groups who did so much to  
2477 bring requirements and use cases to the attention of the Committee. In particular, the ISO/RTO Council  
2478 task force on Demand Response, the UCAIug OpenSG Task Force on OpenADR, and the NAESB Smart  
2479 Grid Task Force provided invaluable guidance and frequent feedback.

2480 The following individuals have participated in the creation of this specification and are gratefully  
2481 acknowledged:

2482 **UCAIug OpenSG OpenADR Task Force:**

2483 Albert Chiu, Pacific Gas & Electric  
2484 Bruce Bartell, Southern California Edison  
2485 Gerald Gray, Southern California Edison  
2486

2487 **The ISO / RTO Council Smart Grid Standards Project:**

2488 We want to thank the IRC team, in particular those who directly participated in this Technical Committee:

2489 Edgardo Luzcando, Midwest ISO and ISO/RTO Council (IRC)  
2490 Donna Pratt, New York ISO and ISO/RTO Council (IRC)  
2491 William Stocker, New York ISO and ISO/RTO Council (IRC)

2492 The IRC team consisted of a large group of participants from ISOs and RTOs. See the IRC Smart Grid  
2493 Standards web site for additional details about the project and team members -  
2494 [http://www.isorto.org/site/c.jhKQIZPBlmE/b.6368657/k.CCDF/Smart\\_Grid\\_Project\\_Standards.htm](http://www.isorto.org/site/c.jhKQIZPBlmE/b.6368657/k.CCDF/Smart_Grid_Project_Standards.htm)  
2495

2496 **NAESB Smart Grid Standards Development Subcommittee Co-chairs:**

2497 Brent Hodges, Reliant  
2498 Robert Burke, ISO New England  
2499 Wayne Longcore, Consumers Energy  
2500 Joe Zhou, Xtensible Solutions



2501

## Appendix F. Revision History

2502

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

2503