



# Energy Market Information Exchange (EMIX) Version 1.0

## Committee Specification Draft 01 / Public Review Draft 01

15 November 2010

### Specification URIs:

#### This Version:

<http://docs.oasis-open.org/emix/emix/v1.0/csprd01/emix-v1.0-csprd01.html>  
<http://docs.oasis-open.org/emix/emix/v1.0/csprd01/emix-v1.0-csprd01.doc> (Authoritative)  
<http://docs.oasis-open.org/emix/emix/v1.0/csprd01/emix-v1.0-csprd01.pdf>

#### Previous Version:

N/A

#### Latest Version:

<http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html>  
<http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.doc>  
<http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.pdf>

#### Technical Committee:

OASIS Energy Market Information Exchange TC

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#### Related work:

This specification replaces or supersedes:

- N/A

This specification is related to:

- OASIS Specification WS-Calendar V1.0, in process
- OASIS Specification Energy Interoperation V1.0, in process

#### Declared XML Namespace(s):

<http://docs.oasis-open.org/ns/emix>  
<http://docs.oasis-open.org/ns/emix/power>  
<http://docs.oasis-open.org/ns/emix/power/contract>  
<http://docs.oasis-open.org/ns/emix/power/quality>  
<http://docs.oasis-open.org/ns/emix/power/resource>  
<http://docs.oasis-open.org/ns/emix/power/transport>

#### Abstract:

The data models and XML vocabularies defined by this TC will address issues in energy markets and the Smart Grid, but may be defined so as to support requirements for other markets. The TC

will develop a data model and XML vocabulary to exchange prices and product definitions for transactive energy markets.

- Price information
- Bid information
- Time for use or availability
- Units and quantity to be traded
- Characteristics of what is traded

The definition of a price and of other market information exchanged depends on the market context in which it exists. It is not in scope for this TC to define specifications for markets, nor how prices are determined, nor the mechanisms for interoperation. The TC will coordinate with others to ensure that commonly used market and communication models are supported.

#### Status:

This document was last revised or approved by the Energy Market Information Exchange Technical Committee on the above date. The level of approval is also listed above. Check the “Latest Version” or “Latest Approved 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/emix/>.

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#### Citation Format:

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

**EMIX-v1.0** OASIS Committee Specification Draft 01, *Energy Market Information Exchange (EMIX) Version 1.0*, November 2010. <http://docs.oasis-open.org/emix/emix/v1.0/csd01/emix-v1.0-csd01.doc>

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# 1 Introduction

This document defines a set of messages to communicate Price and Product definition for power and energy markets. Product definition includes quantity and quality of supply as well as attributes of interest to consumers distinguishing between power and energy sources. Energy Market Information Exchange (EMIX) is not intended as a stand-alone signal; rather, it is anticipated to be used for information exchange in a variety of market-oriented interactions.

The Energy Market Information Exchange Technical Committee (TC) is developing this specification in support of the US Department of Commerce National Institute of Standards and Technology (NIST) NIST Framework and Roadmap for Smart Grid Interoperability Standards **[NIST]** and in support of the US Department of Energy (DOE) as described in the Energy Independence and Security Act of 2007 (EISA 2007) **[EISA]**.

This specification defines the following:

- The characteristics of power and energy that along with price define a product
- An information model for Price and Product definition using the Unified Modeling Language **[UML]**
- An XML Schema for Price and Product definition

Key to reading the document:

- **BOLD** terms are the names of referenced standards
- *Italic phrases* are quotes from external material.
- **[bracketed]** are references to the standards listed in listed in the normative or non-normative sections references sections.
- All examples and all Appendices are non-normative.

## 1.1 Terminology

The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in this document are to be interpreted as described in **[RFC2119]**.

## 1.2 Process

This information exchange was developed primarily by integrating requirements and use cases for Price and Product definition developed by the North American Energy Standards Board (NAESB) as part of its response to NIST Priority Action Plan 03 (PAP03), “Develop Common Specification for Price and Product Definition” **[PAP03]**, which was driven by NIST, Federal Energy Regulatory Commission (FERC), and DOE priority items.

Where appropriate, semantic elements from the International Electrotechnical Commission (IEC) Technical Committee (TC) 57 Power systems management and associated information exchange Common Information Model (CIM) are used **[IEC]**. Business and market information was borrowed from the financial instruments Common Information Models as described in International Standards Organization (ISO) **[ISO20022]** standard and in the financial trading protocol, **[FIX]** (Financial Information eXchange).

Energy markets are volatile, so precise time of delivery is always a significant component of product definition. EMIX incorporates schedule and interval communication interfaces from Web Services Calendar (**[WS-Calendar]**) to communicate schedule-related information.

Additional guidance was drawn from subject matter experts familiar with the design and implementation of enterprise and other systems that may interact with smart grids.

## 44 1.3 Normative References

- 45 **RFC2119** S. Bradner, *Key words for use in RFCs to Indicate Requirement Levels*,  
46 <http://www.ietf.org/rfc/rfc2119.txt>, IETF RFC 2119, March 1997.
- 47 **RFC5545** B. Desruisseaux *Internet Calendaring and Scheduling Core Object Specification*  
48 *(iCalendar)*, <http://www.ietf.org/rfc/rfc5545.txt>, IETF RFC 5545, September 2009.
- 49 **Calendar Product Schema** C. Joy, C. Daboo, M Douglas, *Schema for representing Products for*  
50 *calendar and scheduling services*, [http://tools.ietf.org/html/draft-cal-Product-](http://tools.ietf.org/html/draft-cal-Product-schema-00)  
51 [schema-00](http://tools.ietf.org/html/draft-cal-Product-schema-00), (Internet-Draft), April 2010.
- 52 **CEFACT** Currency codes, e.g. USD or GBP. Add full reference citation to CEFACT or UBL  
53 profile of CEFACT
- 54 **Stoft** S. Stoft, *Power System Economics: Designing Markets for Electricity*.  
55 Piscataway, NJ: IEEE Press, 2002.
- 56 **UML** *Unified Modeling Language (UML), Version 2.2*, Object Management Group,  
57 February, 2009. <http://www.omg.org/technology/documents/formal/uml.htm> .
- 58 **WS-Calendar** **OASIS WS-Calendar Technical Committee**, specification in progress
- 59 **xCal** C. Daboo, M Douglas, S Lees *xCal: The XML format for iCalendar*,  
60 <http://tools.ietf.org/html/draft-daboo-et-al-icalendar-in-xml-05>, Internet-Draft, April  
61 2010.
- 62 **XLINK** *XML Linking Language (XLink) Version 1.1*. S DeRose, E Maler, D Orchard, N  
63 Walsh, <http://www.w3.org/TR/xlink11/> May 2010.
- 64 **XPOINTER** S DeRose, E Maler, R Daniel Jr. *XPointer xpointer Scheme*,  
65 <http://www.w3.org/TR/xptr-xpointer/> December 2002.
- 66 **XML Schema** PV Biron, A Malhotra, *XML Schema Part 2: Datatypes Second Edition*,  
67 <http://www.w3.org/TR/xmlschema-2/> October 2004.

## 68 1.4 Non-Normative References

- 69 **EISA** Energy Independence and Security Act (EISA), online. Link retrieved 06/23/2010:  
70 <http://www.nist.gov/smartgrid/upload/EISA-Energy-bill-110-140-TITLE-XIII.pdf>
- 71 **FIX** **The FIX protocol (need formal reference)**
- 72 **IEC TC57** The home of the IEC TC 57 is <http://tc57.iec.ch/index-tc57.html> (link retrieved  
73 06/23/2010)
- 74 **ISO20022** **International Standards Organization, ISO 20022 (need full reference)**
- 75 **TeMIX** Transactional Energy Market Information Exchange [TeMIX] an approved White  
76 Paper of the EMIX TC. Ed Cazalet et al. [http://www.oasis-](http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf)  
77 [open.org/committees/download.php/37954/TeMIX-20100523.pdf](http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf)
- 78 **NAESB 03** *Requirements Specification for Common Electricity Product and Pricing*  
79 *Definition*, North American Energy Standards Board [NAESB], March, 2010  
80 (Public Review Draft).  
81 [http://naesb.org/pdf4/weq\\_2010\\_ap6a\\_retail\\_2010\\_ap9a\\_rec.doc](http://naesb.org/pdf4/weq_2010_ap6a_retail_2010_ap9a_rec.doc)
- 82 **NIST Roadmap** NIST Framework and Roadmap for Smart Grid Interoperability Standards,  
83 Release 1.0, online. Link retrieved 06/23/1010:  
84 [http://www.nist.gov/public\\_affairs/releases/upload/smartgrid\\_interoperability\\_final](http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf)  
85 [.pdf](http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf)
- 86 **PAP03** Details of PAP03 may be found at [http://collaborate.nist.gov/twiki-](http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP03PriceProduct)  
87 [sggrid/bin/view/SmartGrid/PAP03PriceProduct](http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP03PriceProduct) (link retrieved 06/23/2010)
- 88 **White Paper on WS-Calendar** Link to final paper here.

## 89 1.5 Naming Conventions

90 This specification follows some naming conventions for artifacts defined by the specification, as follows:  
91 For the names of elements and the names of attributes within XSD files, the names follow the lower  
92 camelCase convention, with all names starting with a lower case letter. For example,

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

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

96 `<complexType name="type-componentService">`

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

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

## 101 **1.6 Editing Conventions**

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

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

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

---

## 107 2 Overview

### 108 2.1 Introduction

109 Energy markets have been characterized by tariffs and embedded knowledge that make decision  
110 automation difficult. Smart grids introduce rapidly changing products and product availability, with  
111 associated dynamic prices. Lack of standardized of messages conveying market information has been a  
112 barrier to development and deployment of technology to respond to changing market circumstances.

113 Price and product definition are *actionable information*. When presented with standard messages  
114 conveying price and product, automated systems can make decisions to optimize energy and economic  
115 results. In regulated electricity markets, price and products often are defined by complex tariffs, derived  
116 through political processes. These tariffs convey the price and product information to making buying and  
117 selling decisions easier. The same information can be derived from market operations in non-tariffed  
118 markets. EMIX defines the information for use in messages that convey this actionable information.

119 An essential distinction between energy and other markets is that price is strongly influenced by time of  
120 delivery. Energy for sale at 2:00 AM, when energy use is low, is not the same product as energy for sale  
121 at the same location at 2:00 PM, during the working day. EMIX conveys time and interval by incorporating  
122 WS-Calendar into tenders, contracts, and performance calls.

123 Not all market information is available in real time. Present day markets, particularly wholesale markets,  
124 may have deferred charges (e.g. balancing charges) that cannot be determined at point of sale. Other  
125 markets may require additional purchases to allow the use of the energy purchased (e.g. same-time  
126 transmission rights or pipeline fees when accepting delivery on a forward contract). EMIX is useful for  
127 representing available price and product information/

### 128 2.2 Approach

129 The OASIS Energy Market Information Exchange Technical Committee (EMIX TC) has prepared a white  
130 paper which paper provides a context for discussing the use of transactions in retail and wholesale  
131 energy markets. The Transactional Energy Market Information Exchange (TeMIX) white paper can be  
132 found in the non-normative references.

133 Energy is a commodity whose market value may be different based upon how it is produced or  
134 generated. After production, though, the commodity is commingled with production from other sources  
135 with which it is fully fungible. Even so, some energy purchasers distinguish between sources of this  
136 product even as they consume the commingled commodity.

137 Throughout this work, we refer to the intrinsic and extrinsic properties of an energy product. An intrinsic  
138 property is one *“belonging to a thing by its very nature.”*<sup>1</sup> An extrinsic property is one *“not forming an  
139 essential part of a thing or arising or originating from the outside.”*<sup>2</sup> In EMIX, the term intrinsic properties  
140 refers to those that can be measured and / or verified at the point of delivery, i.e., electric power and

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<sup>1</sup> <http://wordnet.princeton.edu/>

<sup>2</sup> Ibid

141 price. The term extrinsic properties refers to those that can only be known with prior knowledge, such as  
142 the carbon cost, the energy source, or the sulfate load from generation.  
143 EMIX messages communicate both intrinsic and extrinsic properties; extrinsic properties must be able to  
144 clear in the market just as does intrinsic energy.

## 145 2.3 Information Structure

146 As a conceptual aid, we discuss the information structure using the metaphor of an *envelope containing*  
147 *warrants*. The intrinsic properties and the price are on the face of the envelope, easy to read by all. The  
148 contents of the envelope are the supporting information and various warrants about the extrinsic qualities.

149 On the face of the envelope, EMIX lists the intrinsic qualities of the energy product. In the simplest model,  
150 the intrinsic qualities are limited to the price and the information a meter can provide. In a market of  
151 homogenous energy sources and commodity energy, only the intrinsic qualities are actionable. In postal  
152 handling, information on the face is meant for high-speed automated processing. The simplest devices,  
153 including the proverbial smart toaster<sup>3</sup>, may understand only the intrinsic qualities. The Committee  
154 anticipates that the information on the face of the envelope will be sufficient for many if not most energy  
155 decisions.

156 The envelope contents are the supporting documents that explain and justify the price for the intrinsic  
157 qualities. These extrinsic qualities are separable from the intrinsic transaction and traded in secondary  
158 markets. The contents can include Warrants about the source and the environmental attributes provide  
159 information about the energy, but they are not the energy. The extrinsic qualities enable traceability and  
160 auditing, increasing public trust in energy markets and on energy differentiation. The simplest gateways  
161 and devices may ignore the warrants, that is, they can forward or process messages without opening the  
162 envelope.

163 Extrinsic information conveyed by the envelope includes supporting information. For example, a  
164 purchaser may opt to buy energy from a particular supplier with advertised rates. Transport loss may  
165 reduce the quantity delivered. Markets may add congestion charges along the way. Such supporting  
166 information can explain why the delivered cost, on the face of the envelope, is different than the purchase  
167 cost.

## 168 2.4 EMIX Time and Schedules

169 Time is an important component of energy product transactions. A product produced in one interval of  
170 time may have to be stored or may not be able to be stored for a later interval of time. Thus the same  
171 product in different intervals of time may have different prices. EMIX uses **[WS-Calendar]** to apply prices  
172 and products to time intervals.

173 WS-Calendar defines a mechanism to apply a schedule to a sequence of time intervals. WS-Calendar  
174 further defines how to use a process analogous to inheritance to apply a single information artifact to  
175 each interval in the sequence, allowing elements of that artifact to be over-ridden within any given

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<sup>3</sup> The phrase “prices to devices” is used in energy policy discussions to describe a market model in which energy use decisions are distributed to each device that uses energy. Under this model, decisions about whether to use energy now or delay energy use until later are best made where the value is received for that energy use, the end device. The smart toaster is shorthand for the smallest, least capable device that can receive such a message.

176 interval. WS-Calendar also defines a schedule entry point, defining how specific performance can be  
177 contracted and scheduled.  
178 This document assumes that the reader has a clear understanding of WS-Calendar and its interfaces.  
179 The non-normative white paper on the use of the WS-Calendar specification published by that committee  
180 is a good place to start.

## 181 **2.5 Tenders and Transactions for Power Products and Resource** 182 **Capabilities**

183 The focus of EMIX is on price and product communication in support of commercial transactions. The  
184 messaging and interaction patterns for commercial transactions are out of scope for EMIX but worth a  
185 brief discussion here to provide context.

186 Transactions in most markets begin with Tenders (offers to buy or sell) by a Party to another Party. Once  
187 an agreement among Parties is reached, the parties agree to a Transaction (contract or award). The  
188 parties to the Transaction then must perform on the Transaction by arranging for supply, transport,  
189 consumption, settlement and payment. At every stage in this process, clear communication of the terms  
190 (price, quantity, delivery schedule and other attributes) of the tender or transaction is essential. Section 3,  
191 “*Overview of the Information Elements*” describes EMIX Terms, the core of EMIX-based communications.

192 In many electricity markets Operators are offered electrical products based on specific resources, i.e.,  
193 generators, load curtailment, and other energy resources. EMIX uses EMIX Resource Descriptions to  
194 describe the responsiveness, capacity, and other aspects of these Resources. EMIX Resource Offers  
195 combine an EMIX Resource Description with a multi-part offer. A Party can use EMIX Resource Offers to  
196 tender to an Operator one or more EMIX Products. Similarly, an EMIX Load Curtailment Offer combines a  
197 Load Curtailment Resource Description with a multi-part offer.

## 198 **2.6 Transport**

199 Product Transport incurs specific costs that vary over time. Delivery costs come in two general forms.  
200 Congestion charges apply to each unit of Product that passes through a particular point in the distribution  
201 system. Congestion charges increase the cost of the Product delivered in a particular Interval. Loss  
202 reduces the Product delivered below the amount contracted for as it passes from the purchase point to  
203 the delivery point. Loss may reduce the amount of Product received or a loss charge may be applied to  
204 purchase replacement energy for the energy loss.

205 If the Product is priced for Delivery to the consumer, transport charges may not apply. Product  
206 descriptions for Transport charges are discussed in Section 10, *Power Transport Products*.

## 207 **2.7 Verification**

208 Many products, particularly those transacted for Demand Response, are distinguished by particular  
209 Verification Methods. In a pure transactive energy market, the meter would be the only Verification  
210 mechanism. In today’s markets, Verification can be more complex.

211 Verification is out of scope for this document. Verification is fully specified under NAESB Business  
212 Practices for Verification. This specification does not describe verification.

## 213 **2.8 Extensibility**

214 EMIX supports a modular model in which extensions to EMIX can easily be propagated into standards the  
215 communicate EMIX. There are multiple EMIX envelopes to participate in different roles; each includes a  
216 set of EMIX Terms that describe what is tendered or transacted. EMIX Terms are described by applying  
217 an EMIX Product Description to a WS-Calendar Sequence.

218 New efforts could specify additional Product Descriptions. These new product Descriptions would  
219 generate new EMIX Terms merely by applying the new Product Descriptions to the WS-Calendar  
220 Sequence. Such Products could then be transported on any EMIX Envelope. Any Specification that  
221 communicates EMIX Terms can then communicate market information about these new Product

222 Descriptions. A new committee can extend EMIX into new products without re-considering any aspects of  
223 the EMIX specification itself.

224 A similar logic applies to the warrants, which are not specified in v1.0. If the warrant information varies  
225 over time, the warrant information can be applied to a WS-Calendar sequence just as if it were a Product  
226 Description.

## 227 3 Overview of the Information Elements

228 EMIX describes the Terms (EMIX Terms) of tenders and transactions for products whose markets are  
229 volatile. An energy product typically is delivered over time at a specific location. Five kW at 2:00 AM does  
230 not provide the same energy services as five kW at 2:00 PM. EMIX describes the terms of tenders and  
231 transactions for which time and location are essential characteristics. For example, the price and quantity  
232 (rate of delivery) of energy in each time interval of a sequence of intervals may vary for energy  
233 transactions made in a sequence of intervals.

234 EMIX Terms are defined by applying Product Descriptions to WS-Calendar Sequences. WS-Calendar  
235 Sequences embody the same calendaring standards used by most business and personal calendaring  
236 systems. This enables greater interoperation between grid systems and business and personal systems.  
237 An EMIX Product Description describes the elements of an energy product at a location for one time  
238 interval or a sequence of time intervals. An EMIX Product Description for a constant rate of delivery power  
239 product over a single interval of time comprises a (1) start time, (2) duration, (3) rate of delivery, (4) price  
240 and (5) location. If the rate of delivery (kW) and price (\$/kWh) have been messaged in advance, the  
241 message to deliver the product is simply "start (reference Uri to product) at 3:00 AM for 0.75 hours."

242 A Product Description included in each interval in a sequence could describe the same elements again  
243 and again. Only a few elements, perhaps only price, or quantity, may change per interval. EMIX uses the  
244 WS-Calendar Sequence to specify product elements once, and then specifies which elements may vary  
245 by the time intervals of a sequence.

246 For example, a responsive load may require 15 minutes lead time between notification and load  
247 reduction. This characteristic may hold true whether the response requested is for a run-time of 10  
248 minutes or for 10 hours. EMIX specifies these invariant characteristics as part of a product, while offering  
249 the variable run-time to the market.

250 EMIX Terms using EMIX Product Descriptions applied to WS-Calendar Sequence provide a very flexible  
251 information model for describing any energy tenders or transaction. New or specialized energy products  
252 can offered and transacted without changing the EMIX standard.

253 EMIX Terms also minimize the size of EMIX-based messages by efficiently describing how information  
254 elements of a tender or a transaction may or may not vary over time. This reduces communication  
255 overhead.

### 256 3.1 The Intrinsic Elements

257 The following table (Table 3-1) specifies the Intrinsic Elements in the EMIX information model. Intrinsic  
258 elements make up the face of the envelope.

259 *Table 3-1: Intrinsic Elements - the "Face of the Envelope"*

Intrinsic Element	Specification	Note
<b>Uid</b>	Identifier of this artifact	
<b>Created date time</b>	Datetime this artifact was produced	
<b>Transactive State</b>	Enumerated string	Used to aid parsing and conformance, e.g., to distinguish between tender and transactive communications

Intrinsic Element	Specification	Note
<b>Terms</b>	EMIX Terms artifact as defined in later sections of this specification	EMIX Terms describe the product/ commodity, the location and delivery intervals. EMIX Terms are constructed by the application of a Product Description to the gluons and intervals of a WS-Calendar Sequence. In the simplest case of direct specification of an interval, with no gluon, this leaves only the product description, the performance time, and the duration
<b>Price</b>	Float. (Optional)	Is the sum of the extended price of intervals only if the intervals are purchased as a single tender or transaction.
<b>Package Discount</b>	Float (Optional)	There may be market reasons for the price to be different than the Extended Price
<b>Market Context</b>	Xs:anyUri. An identification of the market in which the product is offered.	This may include standard financial and energy exchanges, markets managed by system operators, markets managed by or for aggregators and distributors, and an identification of the microgrid in which the product is priced.
<b>Party</b>	Xs:anyUri. An identifier for one of the parties to a tender or transaction.	
<b>CounterParty</b>	Xs:anyUri. An identifier for one of the parties to a tender or transaction.	
<b>Side</b>	The role (buyer or seller) of the Party. The Counterparty takes the other role.	
<b>Currency</b>	A code that indicates the currency used, as specified in <b>[CEFACT]</b>	Examples include USD, CAD, GBP, EUR, CNY. Could be a nominative or shadow price referenced to e.g. microgrids

## 260 3.2 Extrinsic Elements

261 Extrinsic elements are those that are not inherent to the nature of the product. Customers or regulations  
262 may value them, and they may affect the price received on the market for a product. Extrinsic elements  
263 are contained within the envelope.

264 Table 3-2 lists defines contents of the envelope, i.e., the extrinsic elements in the EMIX information  
265 model. These items are in the general from of an EMIX Product Description, and can be elaborated using  
266 EMIX Terms if there is a time element to its information.

267 *Table 3-2: Extrinsic Elements - "Contents of the Envelope"*

Extrinsic Element	Specification	Note
<b>Envelope</b>	Optional. Container for extrinsic information as defined in the next section.	The envelope contains supporting information that goes beyond that natively in the transaction or tender.

Extrinsic Element	Specification	Note
<b>Warrant List</b>	The container for array of warrants. Optional.	An array of the warrants included in the envelope. See section 4 for warrants.
<b>Support of Price</b>	Container holding information supporting price information	May include EMIX Terms, if several are combined to produce the intrinsic price.
<b>Program</b>	A possibly structured name for a program in which the price and product are tendered or transacted.	This may be analogous to a contract identifier. The variety of DR “programs” inspired this proposed element.

268 EMIX anticipates that further elements will be defined, and an EMIX envelope containing other elements  
269 is fully compliant.

270 The definition of a warrant is “a written assurance that some product or service will be provided or will  
271 meet certain specifications”<sup>4</sup>. Sellers use EMIX Warrants to provide information about the source of the  
272 energy or about its environmental characteristics. Buyers can use warrants to indicate what they wish to  
273 purchase. It seems a fundamental market rule that a middleman cannot sell more wind power than he has  
274 bought. Such rules are beyond the scope of EMIX, but EMIX-based information exchanges are designed  
275 to support such market rules.

276 EMIX Warrants are assertions about the EMIX Terms.

277 There is a wide variety of warrant types, issuing authorities, and characteristics described by warrants.  
278 For bilateral agreements, there may be self-issued warrants. In larger markets, there may be a  
279 requirement that Warrants be traceable through multiple levels of transactions.

280 *Table 3-3: Examples of Warrant Information*

Warrant Element	Specification	Note
<b>Quality Warrant</b>	A Product-specific assertion of Quality. For Electric Power products, these are based upon [IEEE 1159]-based metrics.	For a tender, this can be a promise of or requirement for quality. For verification, this can be actual measurements. If during an indication of interest, might be a desired minimum standard.
<b>Environmental Warrant</b>	An enumeration of the environmental burden caused by the production of the energy product in the quantity and units indicated	The initial EMIX standard included a non-normative artifact contributed by the Energy Information Standards Alliance (EIS Alliance). It is anticipated that markets will create environmental warrants relevant to their unique needs.

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<sup>4</sup> Ibid

Warrant Element	Specification	Note
<b>Content Warrant</b>	A warrant about the means of production for the energy. These may be used to warrant the content of storage, as the nature of the original input to storage is not altered when drawn from storage.	The proportion of the product defined that is from non-fossil fuel sources, including but not limited to “hydroelectric”, “solar”, and “wind”.
<b>Source Warrant</b>	Individual source warrants	In aggregate may be the same as Content Warrant
<b>Controllability Warrant</b>	An authority warrants that a resource can be controlled to the standards used by that authority	Usually a prerequisite for participation in direct control contracts.

281

### 282 3.3 EMIX Options

283 The EMIX Option is a variation on the EMIX envelope described above in section “The Intrinsic  
 284 Elements”. An option gives the buyer the right, but not the obligation, to buy or sell a product at a set price  
 285 during given time windows. The EMIX option also specifies specific response times. The “face of the  
 286 envelope” displays additional information to support these requirements.

287

*Table 3-4: Option Elements – another “Face of the Envelope”*

Intrinsic Element	Specification	Note
<b>Uid</b>	Identifier of this artifact	The format of this ID varies by the communication it is intended for. For wider markets, the UID should be globally unique.
<b>Created date time</b>	Datetime this artifact was produced	
<b>Transactive State</b>	Enumerated string	Used to aid parsing and conformance testing, e.g., to distinguish between tenders, transactions, and history.
<b>Terms</b>	EMIX Terms artifact as defined in later sections of this specification	EMIX Terms describe the product/ commodity, the location and delivery intervals. EMIX Terms are constructed by the application of a Product Description to the gluons and intervals of a WS-Calendar Sequence. In the simplest case of direct specification of an interval, with no gluon, this leaves only the product description, the performance time, and the duration
<b>Option Exercise Schedule</b>	Vcalendar collection (from [ICalendar])	An option may specify the period or periods in which the option is available for exercise. For example, a reserve power option could specify a schedule of afternoons in July.

Intrinsic Element	Specification	Note
<b>Option Holder Party</b>	Xs:anyUri	The party which enjoys the benefit of choosing whether or not to exercise the terms specified in the option. The Promisee.
<b>Option Premium</b>	EMIX Price	The price paid to the Promisor for the rights involved
<b>Option Strike Price</b>	EMIX Price	The price at which an option holder ( Promisee ) has the right to require the option writer (Promisor) to deliver.
<b>Option Exercise Delivery Time</b>	duration	An EMIX Option specifies required lead time before the response as well as the ability to deliver.
<b>Extended Price</b>	EMIX Price. The sum of all intervals in the Product above. (Optional)	Is the sum of the extended price of intervals only if the intervals are purchased as a single tender or transaction.
<b>Package Discount</b>	EMIX Price. (Optional)	There may be market reasons for the price to be different than the Extended Price
<b>Market Context</b>	Xs:anyUri. An identification of the market in which the product is offered, or the counterparty if part of a bilateral non-market transaction. (Optional)	This may include standard financial exchanges, markets managed by or for aggregators and distributors, and an identification of the microgrid in which the product is priced.
<b>Currency</b>	A code that indicates the currency used, as specified in <b>[CEFACT]</b>	Examples include USD, CAD, GBP, EUR, CNY. Could be a nominative or shadow price referenced to e.g. microgrids
<b>Envelope</b>	Container for extrinsic information as defined in the next section. (Optional).	The envelope contains supporting information that goes beyond that natively in the transaction or tender.

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## 4 Generic EMIX Terms

The generic EMIX Terms are defined by a set of EMIX Elements as described in Table 4-1. The Generic Terms become specific when a Product Description is applied to the Generic Terms. Specific Product Descriptions contain additional EMIX Elements as described Section 5 through 10.

This section also indicates how information from the product description, along with price and quantity, is applied to the gluon and interval. Schedule information can be applied to each as described in **[WS-Calendar]**

Table 4-1: EMIX Product Elements

Product Element	Specification	Note
<b>Product Description</b>	Emix.ProductDescription object	An EMIX ProductDescription describes the energy or services, the location and the price and quantity variables that can be set as a default in the gluon and inherited by the Intervals in the Sequence. Inheritance is as described in <b>[WS-Calendar]</b> . The ProductDescription is an extension of the Artifact that is a part of each Interval and Gluon.
<b>Gluon Duration</b>	WS-Calendar duration Optional	Sets default duration for Intervals in the Sequence. Not known in all interactions and nor present in all Gluons.
<b>Gluon Quantity</b>	Float Optional	Sets default Quantity for all Intervals in the Sequence. Not known in all interactions and nor present in all Gluons.
<b>Gluon Unit Price</b>	EMIX Price, Optional	Sets for all Intervals in the Sequence not otherwise priced. Not known in all interactions and nor present in all Gluons.
<b>Sequence</b>	WS-Calendar:Sequence (collection of Intervals) Mandatory	A sequential set of Intervals including expression of Price, Quantity, or Both. May also include elements of the Product Description
<b>Starting DateTime</b>	Optional	Only required when scheduling a sequence. Applies to the associated interval— starting times of other intervals are computed from the sequence based on the sequence starting time, the temporal relations between intervals, and the duration of each.
<b>Associated Interval</b>	From WS-Calendar	Link from the EMIX Gluon into the sequence of Intervals.

296 **4.1 EMIX Intervals**

297 The Gluons point to a set of intervals with defined temporal relationships. An example of intervals with  
 298 temporal relationships is a set of consecutive intervals. A collection of such intervals is known as a  
 299 Sequence.

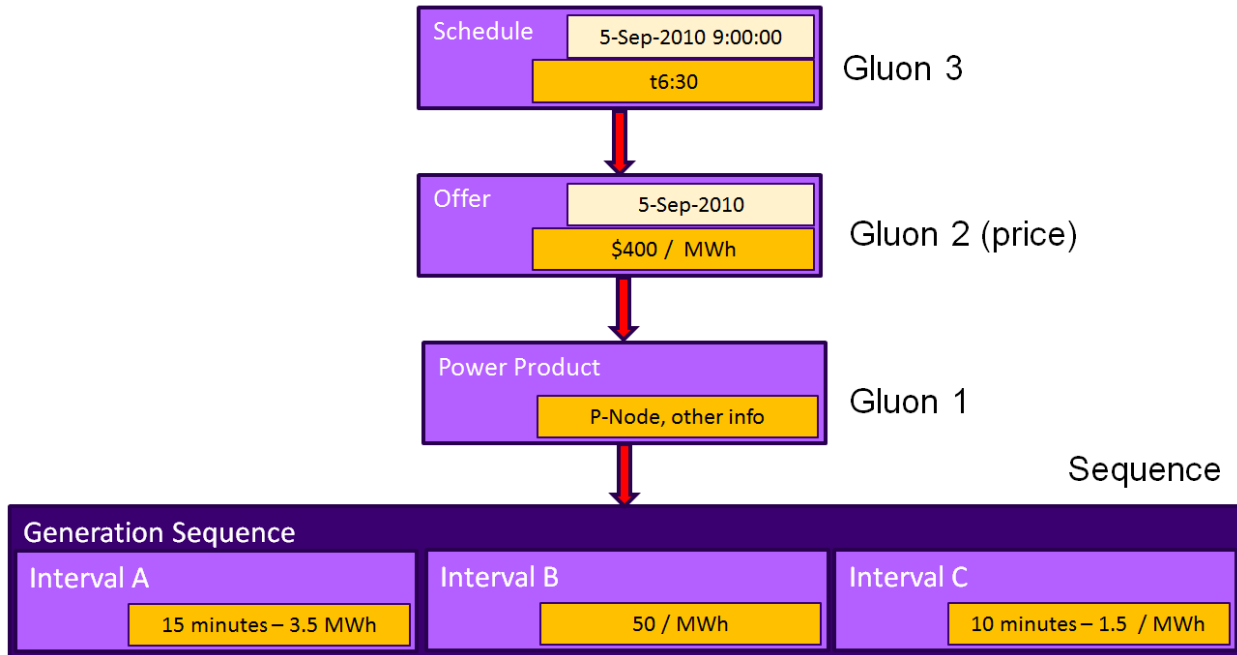
300 *Table 4-2: EMIX Product Elements*

Product Element	Specification	Note
<b>Product</b>	Emix.ProductDescription object	Elements of the Product Description that can be inherited without change from the Gluon need not be expressed in the Interval. The ProductDescription is an extension of the Artifact that is a part of each Interval and Gluon.
<b>Duration</b>	WS-Calendar duration Optional	Can be inherited from the Gluon Set
<b>Quantity</b>	Float Optional	Can be inherited from the Gluon Set
<b>Unit Price</b>	Float, Optional	Can be inherited from the Gluon Set
<b>Starting DateTime</b>	Optional	Usually be inherited from the Gluon Set. Only one Interval per sequence gets a Starting DateTime
<b>Temporal Relation</b>	From WS-Calendar	Link from one interval to other intervals in the sequence.

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302 **4.2 EMIX Product Model**

303 The illustration below provides a model for how this can work.



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Figure 4-1: EMIX Model

1. Power source defines product to market (Sequence and Gluon 1).
2. Product is offered to market on a particular day ([1] and Gluon 2) (Date but not time, required price specified)
3. Transaction specifies start time (9:00) and duration (6:30) (Gluon 3), inherited by Sequence through Gluons 2 and 1. Interval B (linked to Gluon 1) is the interval that starts at 9:00.

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## 311 5 EMIX Electrical Energy and Power Product 312 Descriptions

313 Electrical Energy (measured in MWh, for example) does work. Electrical Power is the rate of delivery of  
314 Energy (measured in MW, for example). Often the terms energy and power are used in conversation  
315 interchangeably without confusion, for EMIX, precision of language for energy and power is crucial. For  
316 convenience, terms associated with electrical power and energy, and the relationships between them, are  
317 reviewed in Appendix C.

### 318 5.1 Taxonomy of EMIX Power Product Descriptions

319 EMIX Product Descriptions are broken down into the following three classes discussed below:

- 320 1) Power Product Descriptions
- 321 2) Resource Offer Descriptions
- 322 3) Transport Product Descriptions

323 All EMIX Electrical Power Products are defined using standard attribute definitions from the Power and  
324 Load Management Common Information Model (CIM). The canonical definitions are in the IEC TC57 CIM.

#### 325 5.1.1 Power Product Descriptions

326 Power Products are the subject of tenders and transactions, i.e., they are what is actually bought and  
327 sold. Depending upon the market, Power can be bought under terms that specify the energy and its rate  
328 of delivery (power), or made available for use up to the maximum amount deliverable by the in-place  
329 infrastructure (also known as “Full-requirements Power”) Power Products for transactions are discussed  
330 in the rest of this section.

#### 331 5.1.2 Resource Offer Descriptions

332 Resources are generators that can produce energy and other services, storage devices that can  
333 consume, store and then produce Power Product, and load curtailment contracts that produce a Power  
334 Product from load curtailment.

335 A Resource Offer describes both the characteristics of the resource and the prices and quantities of  
336 products and services offered as described in Section 7

#### 337 5.1.3 Transport Product Descriptions

338 Product Transport incurs specific costs that vary over time. Delivery costs come in two general forms.  
339 Congestion charges apply to each unit of Product that passes through a particular point in the distribution  
340 system. Congestion charges increase the cost of the Product delivered in a particular Interval. Loss  
341 reduces the Product delivered below the amount contracted for as it passes from the purchase point to  
342 the delivery point. Loss may reduce the amount of Product received or a loss charge may be applied to  
343 purchase replacement energy for the energy loss.

344 If the Product is priced for Delivery to the consumer, transport charges may not apply. Product  
345 descriptions for Transport charges are discussed in Section 10, *Power Transport Products Descriptions*.

## 346 6 Power Product Descriptions

### 347 6.1 Transactive Power Product Description

348 The Transactive Power Product Description is based on a simple product description: Power, Price,  
 349 Attributes, and Service Location. As defined in EMIX, a Power Interval has two potential forms, a ramped  
 350 power interval and for a constant power interval. A constant power interval uses the power quantity  
 351 specified locally or one inherited from the Gluon. A ramped power interval cannot inherit the power  
 352 quantity because it contains two power quantities internally: the starting rate and the final rate. Both  
 353 interval types are reflected in the table below:

354 *Table 6-1: Power Interval Description*

Name	Definition	Note
<b>Constant Power Quantity</b>	EMIX.Quantity	Defines Constant Power Intervals. Does not coexist with Starting and Final Power Quantities
<b>Starting Power Quantity</b>	EMIX.Quantity	Defines Ramped Power Intervals. Requires matching Final Power Quantity. Does not coexist with Constant Quantity
<b>Final Power Quantity</b>	EMIX.Quantity	Defines Ramped Power Intervals. Requires matching Starting Power Quantity. Does not coexist with Constant Quantity
<b>Power Units</b>	Power Units	As defined below
<b>Service Location</b>	Service Location	Should normally be only in the Gluon and omitted from the intervals. If the Product is an aggregated response across multiple locations, one per interval, then it MAY appear in the interval instead
<b>Power Attributes</b>	Power Attributes	As defined below
<b>UnitPrice</b>	EMIX.Price	Price per Unit Quantity. Includes currency
<b>Price</b>	EMIX.Price	Extended price for interval. Includes quantity and currency
<b>Duration</b>	From WS-Calendar	May be nil if inherited from Gluon
<b>Performance</b>	From WS-Calendar	Indicates performance requirements such as fixed run-time, absolute end time, etc.

355 The Gluon shares the same information elements with the exception that ramps are not defined  
 356 for Gluons.

357 *Table 6-2: Power Gluon Description*

Name	Definition	Note
<b>Power Quantity</b>	EMIX.Quantity	Defines Constant Power Intervals. Does not coexist with Starting and Final Power Quantities
<b>Power Units</b>	Power Units, enum	As defined below

Name	Definition	Note
<b>Service Location</b>	Service Location	If response is for a single location, should be in gluon to apply to the entire sequence and be omitted in the intervals
<b>Power Attributes</b>	Power Attributes	As define below
<b>Unit Price</b>	EMIX.Price	Price per Unit Quantity. Includes currency
<b>Price</b>	EMIX.Price	Extended price for interval. Includes quantity and currency
<b>Duration</b>	From WS-Calendar	May be nil if all intervals have duration specified
<b>Performance</b>	From WS-Calendar	Indicates performance requirements such as fixed run-time, absolute end time, etc.

358 No element in the gluon need appear in the interval unless the interval information supercedes the gluon  
359 information.

360 The constant power product is sufficient for all Transactive Energy uses. Many tenders that are offered or  
361 solicited as Resources are normally executed, i.e., contracted for performance, as a constant power  
362 product. (Ancillary Products are an exception—see section 8.) As the Power Quantity varies over intervals  
363 in the sequence, it describes a load curve. As the Price varies over intervals in the sequence, it describes  
364 a price curve.

## 365 6.2 Requirements Power Product Descriptions

366 The Requirements Power Product Descriptions below can successfully describe contracted power in use  
367 today including

368 *Table 6-3: Requirements Power Products*

Name	Note
<b>Full Requirements Power</b>	Traditional power contract to provide all power used. Often used in retail residential rates. Demand Charges Optional
<b>Full Requirements Power with Demand Charges</b>	Often used in mid-sized and small commercial. Same as Full Requirements Power but with demand charges for “excess” use.
<b>Requirements with Maximum and Minimum Power</b>	Customer must draw energy at least the minimum rate (power) and no more than the maximum rate during any measurement interval.
<b>Hourly Day Ahead Pricing</b>	Same Full requirements power but prices potentially change each day.
<b>Ex-Ante Real Time Price</b>	Used to report prices after the fact.
<b>Time of Use Pricing</b>	Similar to Hourly day-ahead pricing but prices may change seasonally and not be at hourly intervals

369 Contracted power products such as these can all be described using the Contracted Power Product  
370 Description

371 *Table 6-4: Requirements Power Product Description*

Name	Definition	Note
<b>Contract Type</b>	Enumerated String	
<b>Power Units</b>	Power Units	As defined below

Name	Definition	Note
<b>Service Location</b>	Service Location	If response is for a single location, should be in gluon to apply to the entire sequence and be omitted in the intervals
<b>Power Attributes</b>	Power Attributes	As defined below
<b>Price</b>	From EMIX	Price per Unit during the Interval.
<b>Demand Charge</b>	Demand Charge. Optional	See below. There may be multiple demand charges.
<b>Maximum Power</b>	Power	Buyer may not consume at more than this rate
<b>Minimum Power</b>	Power	If buyer consumes than this rate, the buyer is assessed a charge to bring it up to this rate.
<b>Duration</b>	From WS-Calendar	May be nil if all intervals have duration specified
<b>Performance</b>	From WS-Calendar	Indicates performance requirements such as fixed run-time, absolute end time, etc.

372 Requirements Power may not match well with future smart energy scenarios. Requirements Power has  
373 no fixed forward obligation to take-and-pay for energy. Thus, there is no defined baseline for demand  
374 response or dynamic pricing. However, Requirements Power Descriptions are necessary for current  
375 legacy communications.

376

Table 6-5: Requirements Power Product Description

Name	Definition	Note
<b>Contract Type</b>	Enumerated String	
<b>Block Power Price</b>	Multiple occurs	Sequence of components defining the price of successive blocks of power. Each block has a Price, and a maximum energy quantity. If the contract is for an increasing block price, blocks are interpreted in order of increasing price, and for a decreasing block price contract, blocks are interpreted in order of decreasing price
<b>Power Units</b>	Power Units	As defined below
<b>Service Location</b>	Service Location	If response is for a single location, should be in gluon to apply to the entire sequence and be omitted in the intervals
<b>Power Attributes</b>	Power Attributes	As defined below
<b>Price</b>	From EMIX	Price per Unit during the Interval.
<b>Demand Charge</b>	Demand Charge. Optional	See below. There may be multiple demand charges.
<b>Maximum Power</b>	Power	Buyer may not consume at more than this rate
<b>Minimum Power</b>	Power	If buyer consumes than this rate, the buyer is assessed a charge to bring it up to this rate.
<b>Duration</b>	From WS-Calendar	May be nil if all intervals have duration specified

Name	Definition	Note
<b>Performance</b>	From WS-Calendar	Indicates performance requirements such as fixed run-time, absolute end time, etc.

377

378 Demand Charges assess additional costs based peak rate of use by the buyer. Demand charges often  
 379 extend beyond the current billing period.

380

*Table 6-6: Demand Charges Information Model*

Name	Definition	Note
<b>Demand Charge Units</b>	Power units	Single units used by all quantities
<b>Demand Charge Floor</b>	Quantity	Above this floor is exceeded, demand charges are applied
<b>Demand Charge Rate</b>	Price / Power	Incremental charge applied power if floor is exceeded.
<b>Measurement Interval</b>	Duration	Granularity or Power Use readings.
<b>Collection Interval</b>	Duration	Period during which power usage is summed for comparison to Demand Floor.
<b>Collection Period</b>	Duration	Usually the same as the billing period
<b>Charge Duration</b>	Duration	Period during which Demand Charges will be applied after incurred.

381

### 6.3 Semantics of Power Products

382 The product descriptions refer to terms and data structures that had not yet been defined. These  
 383 elements are defined below.

384 First, there are simple base elements used again in defining power products, including those in the next  
 385 sections.

386

*Table 6-7: Simple Elements for use in Power Products*

Name	Definition	Note
<b>Voltage</b>	Decimal, May be measured or nominal	One of three elements hereafter referred to as the Power Attributes.
<b>Hertz</b>	Decimal, May be measured or nominal	One of three elements hereafter referred to as the Power Attributes. Always 0 for DC
<b>AC</b>	Boolean, true for AC, false for DC	One of three elements hereafter referred to as the Power Attributes.
<b>Power Units</b>	String	Enumeration of Power Units, e.g., MW
<b>Energy Units</b>	String	Enumeration of Energy Units, e.g., MWh
<b>Voltage Units</b>	String	Enumeration of Voltage Units, e.g., MV
<b>VAR Units</b>	String	Enumeration of volt amperes reactive (var) units, e.g., Kvar

Name	Definition	Note
<b>Meter Asset</b>	String	Identifier for an actual or virtual meter
<b>Node</b>	String	Grid Location identifier

387 Often, multiple simple units do or should appear together in specifications for constancy and  
388 completeness. These are named and defined as below.

389

390

*Table 6-8: Compound Elements for use in Power Products*

Name	Definition	Note
<b>Power Attributes</b>	Voltage / Hertz / Ac	Group used in many definitions
<b>Transaction Node</b>	Node & Meter Asset	Location of a meter and the Service location the point of interconnection where capacity and/or energy transmitted by the provider is made available to the receiving party.
<b>Pnode</b>	Transaction Node	A pricing location for which market participants submit their bids, offers, buy/sell CRRs, and settle.
<b>APnode</b>	Transaction Node	Aggregated Pnode
<b>Service Location</b>	Transaction Node	For residential or most businesses, it is typically the location of the meter on the utility customer's premises. For transmission, it is the point(s) of interconnection on the transmission provider's transmission system where capacity and/or energy transmitted by the transmission provider is made available to the receiving party.
<b>Service Place</b>	Geo-location, i.e. kml:placemark	Typically a geo-referenced polygon that might contain many transaction nodes
<b>Interface Pricing Point</b>	Pnode or APnode or Service Location or Service Place	Typically the location of the meter on the customer's premises. For transmission, it is the point(s) of interconnection on the transmission provider's transmission system where capacity and/or energy transmitted by the transmission provider is made available to the receiving party. May also be a place containing nodes.

391

## 7 Resource Offer Descriptions

Resources offer potential services to others in smart grid. Resource tenders are either requesting services or offering services. In a pure transactive market, these tenders might be identical to the services provided, i.e., they could be fully described using the same language used to contract execution and performance.

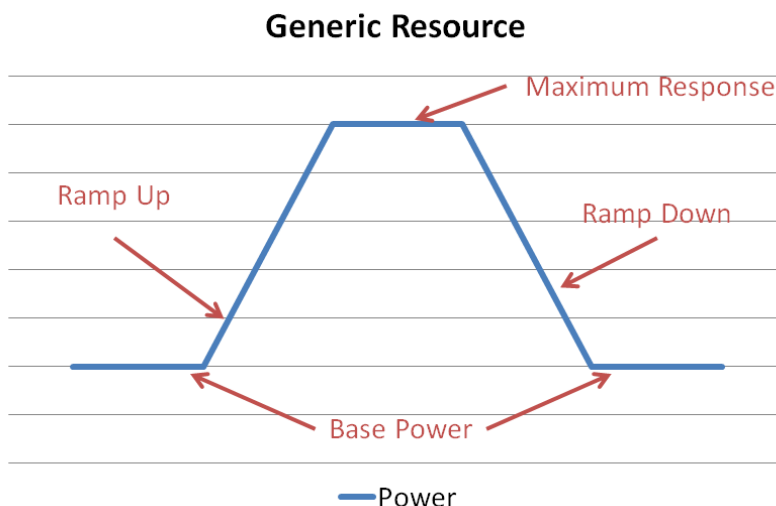
Resources often enter or are called enter the market to meet specific needs. These needs can include a range of performance requirements; resources might be able to perform a range of capabilities. These performance capabilities are described using the information in Resources Offers. Resource offers are less specific than a single transactive request, and may thereby present the resource to more than a single market.

When making a tender for products and services, it is useful to describe the capabilities of a resource, so the counter party can determine if a resource can meet the requirements. A notice of interest may specify performance expectations. A resource may compare its own capabilities to those requirements before submitting a bid.

Resource Capabilities may describe a ramp rate, or maximum run time, or any number of elements useful to energy schedulers. A Resource Offer associates offers for power produces with a Resource Capability.

### 7.1 Resource Capabilities

Resources have capabilities rather than schedules. Resource descriptions describe what could be done, as distinguished from a transaction in which specific performance is requested or agreed to.



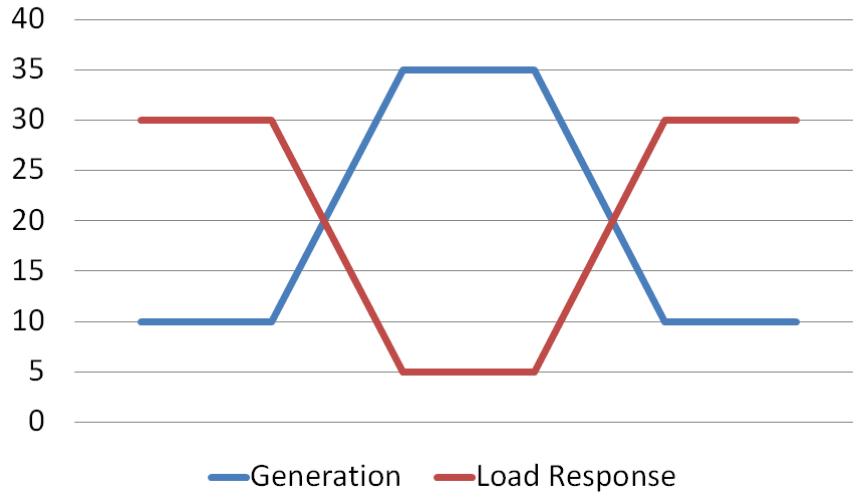
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412 *Figure 7-1: Attributes of a Generic Resource*

413 In the resource illustration above, there is some base level of energy, a status quo ante. When invoked,  
414 the resource takes some period of time to change to a different level. If the response is binary, then it can  
415 only go up to the maximum response, and that ramp rate takes a fixed time. If a resource is able to  
416 provide several layers of response, then the ramp time also varies. The ramp time can be computed from  
417 the ramp rate and the difference between the base power and the maximum response.

418 As electricity is fungible, a critical key element of power resources is that generation, that is the  
419 production of power, and load shedding, the reduction of power use are similar products with similar  
420 value.

## Equivalence of Load & Generation



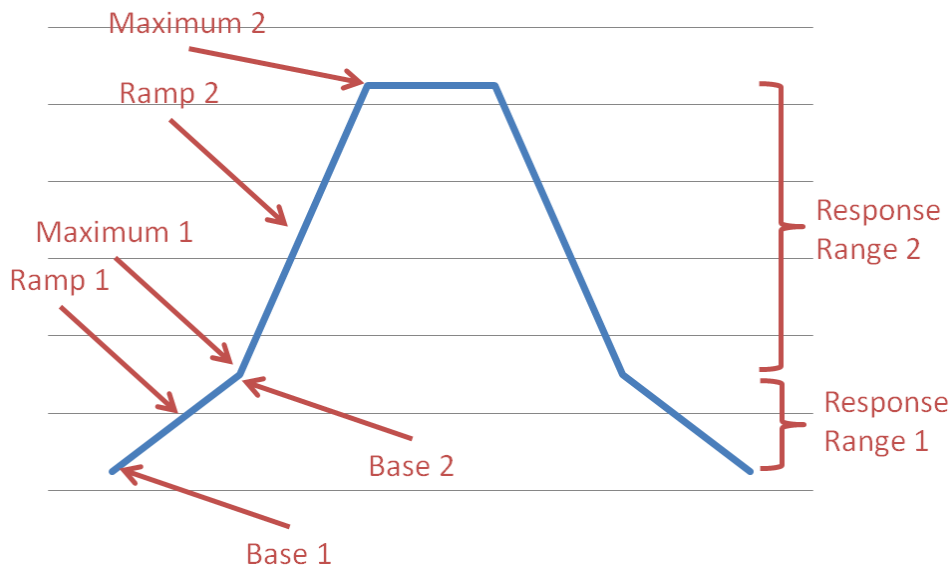
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Figure 7-2: Equivalence of Load Shed and Generation

423 As shown above, generation and load response are similar and can be described using the same  
424 language.

425 Many resources have capabilities that change over the range of response. A generator may have one  
426 ramp speed until it gets up to half speed, and then another as it goes to full. Load response can have  
427 similar characteristics. Such resources can be described by combining simple response characteristics.

## Generic 2-Level Resource



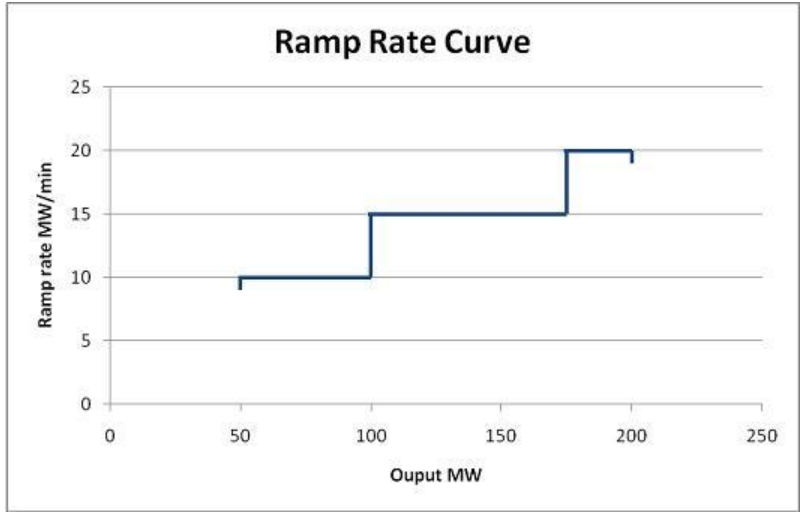
428  
429

Figure 7-3: Combining Response Capabilities

430 Resources as in Figure 7-3 can be communicated as an array of ramp up rates, a maximum power  
431 offered, and an array of ramp down rates. Between the Base 1 and Maximum 1, expressed in MW, the  
432 resource can ramp up at Ramp 1 expressed in MW/min. Between the Base 2 and Maximum 2, expressed  
433 in MW, the resource can ramp up at Ramp 1 expressed in MW/min.

434 With capabilities expressed as above, to capabilities of a resource can be found by the time indicated  
435 (moving along the X axis) between Base 1 and wherever the ramp up line passes through desired output  
436 level.

437 CIM users express this with a Ramp Rate Curve. Figure 7-4 expresses similar information as does  
 438 Figure 7-3, showing Base1 at 50 MW of power and Maximum 1 at 100 MW with a ramp rate pf 10  
 439 MW/minute. Ramp 2, at 15 MW/minute goes from 100MW to 180 MW.



440  
 441 *Figure 7-4: Ramp Rate Curve—CIM Style*

442 By expressing resources in terms of capabilities and ramp rates, a potential purchaser can determine of a  
 443 resource meets his or her needs, tendering a single resource to a variety of purchase scenarios.  
 444 Picture several resources each able to generate 10 MW of additional power. One can increase power at 1  
 445 MW/minute, one at 2 MW/minute, one at 5. MW/minute. The latter two each can be contracted to supply  
 446 10 MW in 5 minutes. Only the last can be contracted to supply an increase of 10 MW within 2 minutes. All  
 447 three can be contracted to supply an increase of 10 MW within 15 minutes.

448 **7.2 Power Resource Semantics**

449 The only aspects of a resource that matters to the energy market are the effects it can provide, the  
 450 likelihood it will be able adequately to provide what it promises, and the financial incentives required to  
 451 acquire them. The technology and process control details are many, and new ones may be required for  
 452 each new power technology. Unless the market for the resource requires direct control, such details are  
 453 irrelevant. The limited semantic set herein is sufficient to describe the capabilities of a resource.

454 EMIX bases its resource capability descriptions on the semantics in Table 7-1.

455 *Table 7-1 Semantics for Power Resources*

Name	Definition	Note
<b>Mrid</b>	String	multi-part resource id as defined in the ISO TC57 CIM uniquely identifies each resource.
<b>Notification Time</b>	Duration	Time required for notification prior to beginning of response.
<b>Response Time</b>	Duration	Time required from notification to full response by the resource
<b>Minimum Down Time</b>	Duration	Minimum time interval between unit shut-down and start-up
<b>Power Ramp Rate</b>	Float & Power Units	Change up or down in units/minute between a starting power and an ending power.

Name	Definition	Note
<b>Required Notice Time</b>	Duration	Time period that is required from an order to reduce a load to the time that it takes to get to the minimum load reduction.
<b>Shutdown Cost</b>	Price	The fixed cost associated with committing a load reduction.
<b>Offer Segment</b>	Price, Maximum Power	Compound unit describing components of a tender. If multiple segments are offered (1 <sup>st</sup> 50MW, next 100MW), Maximum Power is cumulative (50MW, 150MW). Offers are evaluated by sorting in order of increasing Maximum Power (for power) or decreasing Maximum Power (for load reduction) and must be purchased in order.
<b>Minimum Resource Cost</b>	Price per Duration	Resource requires this amount per period, i.e., a minimum requirement for \$100 / hour at whatever power rate
<b>Minimum Time Between Load Reductions</b>	Duration	Shortest time that load must be left at normal levels before a new load reduction.
<b>Minimum Load Reduction Interval</b>	Duration	Shortest period load reduction must be maintained before load can be restored to normal levels.
<b>Minimum Load Reduction</b>	Power	Minimum units for a load reduction (e.g., MW rating of a discrete pump)
<b>Minimum Load Reduction Cost</b>	Price	Cost in currency at the minimum reduced load
<b>Maximum Operating Power</b>	power quantity	The maximum operating power the purchaser can request from this unit
<b>Maximum Load</b>	power quantity	Maximum load below which it may not be increased
<b>Minimum Load</b>	power quantity	Minimum load below which it may not be reduced.
<b>Power Ramp Rate</b>	Power Quantity (rate), Duration, Begin Quantity, End Quantity	Between the Begin Quantity and End Quantity, Power can ramp at Quantity per Duration
<b>Drop Ramp Rate</b>	powerRampRate multipleoccurs	Maximum rate that load can be reduced. Begin Power must be greater than End Power
<b>Raise Ramp Rate</b>	powerRampRate multipleoccurs	Maximum rate that load may be restored. Begin Power must be less than End Power
<b>Is Controllable</b>	Bool	Resource can be direct controlled. Warrant must be in envelope

Name	Definition	Note
<b>Resource Class</b>	Enumerated string	While a diverse set of resources can reduce risk, some resources may present covariant risk. For example, solar power in a region may ebb and flow in synchrony.

456 In addition, voltage regulation services have their own semantics to specify voltvar.

457 *Table 7-2 Semantics for Voltage Regulation Services*

Name	Definition	Note
<b>VMin</b>	varQuantity	VMin is the IEEE 1547 minimum voltage level of 88% of nominal voltage where the PV inverter must disconnect
<b>VMax</b>	varQuantity	VMax is the IEEE 1547 maximum voltage level of 110% of nominal voltage where the PV inverter must disconnect.
<b>QMax</b>	varQuantity	Qmax is the inverter's current var capability and may be positive (capacitive) or negative (inductive). It would be the VA capability left after supporting the W demand.
<b>voltVar</b>	voltageQuantity & varQuantity	

458

## 459 7.3 Resource Capability Descriptions

460 Resource Capability Products describe the capabilities of the resource using the semantics as above.  
 461 The simpler of these interfaces mimic those found in traditional markets. Offer Load and Offer Generation  
 462 describe more complete and abstract interfaces.

### 463 7.3.1 Load Curtailment Resource Capability Descriptions

464 *Table 7-3 Responsive Load Resource – Simple Form*

Name	Definition	Note
<b>Mrid</b>	mrid	
<b>Base Load</b>	powerQuantity	Load of system before request
<b>Drop Ramp Rate</b>	rampDown multipleoccurs	Ramp rates are sorted by Descending maxima.
<b>Minimum Load</b>	powerQuantity	Load of system under full response
<b>Raise Ramp Rate</b>	rampUp multipleoccurs	Ramp rates are sorted by ascending maxima.

465 The resource load is a simplified version of the market interface that appears in the TC57 CIM.  
 466 Note that some of the terms are different because EMIX unifies terms across interfaces..

467 *Table 7-4 Offer Load Reduction*

Name	Definition	Note
------	------------	------

Name	Definition	Note
<b>Mrid</b>	Mrid	
<b>Drop Ramp Rate</b>	dropRampRate, multipleoccurs	Ramp rates are sorted by descending maxima to assess response.
<b>Min Load</b>	powerQuantity	Minimum Load system will accept
<b>Min Load Reduction</b>	powerQuantity	Minimum reduction request resource will accept
<b>Min Load Reduction Cost</b>	Price	Minimum price to get resource to make minimal response
<b>Min Load Reduction Interval</b>	Duration	Minimum time for which resource will accept a load reduction
<b>Min Time Bet Load Red</b>	Duration	Shortest time that load must be left at normal levels before a new load reduction.
<b>Raise Ramp Rate</b>	raiseRampRate multipleoccurs	Ramp rates are sorted by ascending maxima to assess recovery.
<b>Shutdown Cost</b>	Price	Fixed cost associated with committing a load reduction

468

### 469 7.3.2 Generation Resource Capability Description

470 Generation resources are very similar to load resources. As to grid effect, adding 10 MW of generation  
471 and gaining 10 MW less of load are similar.

472 *Table 7-5 Registered Generation Capabilities*

Name	Definition	Note
<b>Mrid</b>	mrid	
<b>Lower Ramp Rate</b>	dropRampRate multipleoccurs	Regulation down response rate in power units / minute
<b>Maximum Operating Power</b>	maxOperatingPower	Resource cannot be requested to operate at higher than maximum operating power
<b>Minimum Operating Power</b>	minOperatingPower	Resource cannot be requested to operate at lower than minimum operating power
<b>Raise Ramp Rate</b>	raiseRampRate multipleoccurs	Apply ramp rates consecutively to find power capabilities.
<b>Spin Reserve Ramp</b>	powerRampRate	

473

### 474 7.3.3 Power Offer Description

475 The Power Offer is the most complete and generic description of a power resource, including performanc  
476 and economic requirements.

477

Table 7-6 Power Offer Capabilities

Name	Definition	Note
<b>Mrid</b>	mrid	
<b>Startup Cost</b>	Price	Cost to initiate any resource
<b>Minimum Resource Cost</b>	Price	Minimum cost to elicit response from Resource
<b>Raise Ramp Rate</b>	raiseRampRate multipleoccurs	Apply ramp rates consecutively to find power capabilities.
<b>Maximum Power</b>	maxOperatingPower	Resource cannot be requested to operate at higher than maximum operating power
<b>Minimum Operating Power</b>	minOperatingPower	Resource cannot be requested to operate at lower than minimum operating power
<b>Lower Ramp Rate</b>	dropRampRate multipleoccurs	Apply ramp rates consecutively to find power capabilities.
<b>Offer Segment</b>	offerSegment	Economic requirements for incremental power, sorted by maximum power rate ascending.

478

479

480

## 481 8 Ancillary Services Products

482 Ancillary Services Products are typically products provided by a Resource Capability and used by a  
483 system operator to stand by to deliver changes in power to balance the grid on very short notice. Ancillary  
484 services include Regulation Up, Regulation Down, Spinning Reserve, and Non-Spinning Reserve.  
485 Ancillary services are different from other power and energy services in that they must be paid for  
486 availability, whether or not they perform. Of course, they must also perform when called. The ancillary  
487 services products described below are typical of ancillary service products defined by and procured by  
488 US ISO/RTO markets.

489 Ancillary Services descriptions are applied to a WS-Calendar Sequence to create the EMIX Terms used  
490 for exchange with other parties

### 491 8.1.1.1 Ancillary Services – Regulation Products

492 Regulation services are used to maintain accumulated frequency error within allowable bounds.

493 *Table 8-1 Power Regulation Product Description*

Name	Definition (Normative)	Note (Non-Normative)
Product Type	String, enumerated	Regulation Down Regulation Up Regulation Up & Down
Availability Period	ws-calendar interval	Interval during which the resource is warranted to be ready to perform.
Autonomous Dispatch	Bool	If true, service notes local conditions and dispatches itself. If false, it waits for dispatch request from Operator.
Delivery Rate Units	Typically kW or MW.	Unit is normally kilowatt-hours (kW) or megawatt-hours (MW)
Dispatch Up	Integer seconds	Time in which resource can respond to a request to increase energy provided. If zero, no dispatchUp available. Can also be startup delay for non-spinning reserve.
Dispatch Down	Integer seconds	Time in which resource can respond to a request to decrease energy provided. If zero, no dispatchDown available
voltage	Integer	Expressed in KV
hertz	Integer	
Ac/dc	AC or DC	

### 494 8.1.1.2 Ancillary Services Reserve Products

495 Ancillary Services are used for short term balancing of supply and demand by a system operator.

Table 8-2 Reserves Product Description

Name	Definition (Normative)	Note (Non-Normative)
<b>Product Type</b>	String, enumerated	Regulation Down Regulation Up Regulation Up & Down Spinning Reserve Non-Spinning-Reserve
<b>Availability Period</b>	vcalendar	Interval during which the resource is warranted to be ready to perform
<b>Maximum Delivery Rate</b>	Integer	In home contracts this is limited by service size
<b>Minimum Delivery Rate</b>	Integer.	Determines minimum charges during period
<b>Delivery Rate Units</b>	Typically kWh or MWh.	Unit is normally kilowatt-hours (kWh) or megawatt-hours (MWh)
<b>Maximum Delivery Time</b>	Duration	When called on, for how long can this asset deliver
<b>Cycle Time</b>	Duration	When called on, how long until this asset can be called on again.

499

## 9 Power Quality

500 Higher quality power can obtain a market premium. A buyer willing to accept lower quality power may be  
 501 able to obtain inexpensive power. Power Qualities must be measurable, discrete, and on a spectrum  
 502 allowing the buyers to make choices. They must also be verifiable, measurable by defined protocols, so  
 503 performance can be compared to promise.

### 504 9.1.1 Electrical Power Quality

505

Table 9-1: AC Power Quality

Name	Definition	Type	Note
<b>Measurement Protocol</b>	A string containing an identification of the standard or other protocol used to measure power quality	String	Text string with formal number of the standard used, e.g., "EN 50160", "IEEE 1549-2009"
<b>Power Frequency</b>	A floating point number describing the nominal Power frequency	Float	Measured rather than nominal value, e.g. 50.4, 59.9. 0 for DC
<b>Supply Voltage Variations</b>	An unsigned integer count of Supply Voltage Variations during the period	Float	See referenced standards for definition, measurement protocol and period. E.g., 7 in the billing period.
<b>Rapid Voltage Changes</b>	An unsigned integer count of Rapid Voltage Change events during the period	Ulong	See referenced standards for definition, measurement protocol and period. E.g., 0 in the billing period.
<b>Flicker</b>	An unsigned integer count of Flicker events during the period	Ulong	See referenced standards for definition, measurement protocol and period. E.g., 0 in the billing period.
<b>Supply Voltage Dips</b>	An unsigned integer count of Supply Voltage Dip events during the period	Ulong	See referenced standards for definition, measurement protocol and period. E.g., 0 in the billing period.
<b>Short Interruptions</b>	An unsigned integer count of Short Interruption events during the period	Ulong	See referenced standards for definition, measurement protocol and period. E.g., 0 in the billing period.
<b>Long Interruptions</b>	An unsigned integer count of Long Interruption events during the period	Ulong	See referenced standards for definition, measurement protocol and period. E.g., 0 in the billing period.
<b>Temp Overvoltage</b>	An unsigned integer count of Temporary Overvoltage events during the period	Ulong	See referenced standards for definition, measurement protocol and period.

<b>Supply Voltage Imbalance</b>	An unsigned integer count of Supply Voltage Imbalance events during the period. Optional, and not meaningful for DC.	Ulong	See referenced standards for definition, measurement protocol and period.
<b>Harmonic Voltage</b>	A floating point number for the Harmonic Voltage during the period. For DC, distortion is with respect to a signal of 0 Hz	Float	See referenced standards for definition, measurement protocol and period. The period is usually much shorter than other power quality measures.
<b>Mains Voltage</b>	A floating point number Mains [Signaling] Voltage	Float	Nominal value, e.g, 110, 130, 220, 208. See referenced standards for definition and protocol.

506

507 **10 Power Transport Products**

508 Transport costs affect the delivery of energy in all markets. Today’s electrical power markets use different  
 509 terms in transmission and delivery, but the underlying elements are the same. Like the other products,  
 510 aspects of transport charges may change over time, and so can be expressed as EMIX Terms by  
 511 applying the Transport Description to the WS-Calendar Sequence.

512 *Table 10-1: Transport Description*

Name	Definition (Normative)	Note (Non-Normative)
<b>Point of Receipt</b>	Transaction Node	Where power enters a network or changes ownership
<b>Point of Delivery</b>	Transaction Node	Where power exits a network or changes ownership
<b>Transport Access Fee</b>	Price	Fixed Charge (not dependent on congestion) to access transport system
<b>Transport Congestion Fee</b>	Price.	Congestion fee per unit of energy for energy flowing from receipt to delivery point. Can be a positive or negative price. e.
<b>Transport Congestion Fee Units</b>	Energy Units	
<b>Marginal Loss Fee</b>	Price	Marginal Loss Fee
<b>Marginal Loss Fee Units</b>	Energy Units	
<b>Transport Loss Factor</b>	Float	Reduction in amount delivered due to loss during transport. (Loss Factor * purchase amount) = delivered amount
<b>Conversion Loss Factor</b>	Float	Reduction in amount delivered as product voltage is changed or as converted from AC to DC or DC to AC. (Loss Factor * purchase amount) = delivered amount
<b>currency</b>	From CEFAC. Optional	Usually inherited, but allowed to permit stand-alone artifact

513  
 514 There MAY be multiple instances of the above Artifacts in a single Price instance.

## 515 11 EMIX Warrants

516 Warrants are specific assertions about the extrinsic characteristics of power that may affect market  
 517 pricing. Warrants are in effect Product artifacts as defined in EMIX. Warrants start as Product  
 518 Descriptions that are applied to the intervals in a sequence and to the gluon. There may be zero intervals  
 519 in a product if the unchanged product description applies to all. The intervals in a warrant may differ from  
 520 those of the product on the outside of the envelope.

521 Sometime warrants are only applicable within certain jurisdictions. For example, in today's energy  
 522 markets (2010) energy warranted as renewable in the Pacific Northwest can include Hydro power.  
 523 Energy markets in California exclude Hydro Power from their definition of Renewables. The means credits  
 524 or mandates for renewable energy in California, are not met by Products warranted as Renewable in the  
 525 Northwest.

526 Some warrants may be separable from the underlying energy. For example a warrant that a source of  
 527 energy is generated by a source that is certified as "green" by an authority, may be issued a "green  
 528 certificate". Such a certificate can be separately traded, so the Warrant information for a product should  
 529 specify if the "green certificate" is (1) accompanying the energy, (2) sold to a third party, or (3) the source  
 530 is not green but a green certificate has been purchased and accompanies the energy.

531

### 532 11.1 Warrant List Definition

Warrant Element	Definition	Note
<b>Product Quality</b>	A Product-specific assertion of Quality	If during an offer, can be a promise of quality. If during verification, and be actual measurements. If during an indication of interest, might be a minimum standard.
<b>Warrant Environmental</b>	Quantifies the environmental burden created during the generation of the electric power.	These are as identified as per the artifact environmental.rdf
<b>Warrant Content</b>	The proportion of the product defined that is from non-fossil fuel sources, including but not limited to "hydroelectric", "solar", and "wind".	The nature of the original input to storage is not altered when drawn from storage.
<b>Warrant Source</b>	Individual source warrants	In aggregate may be the same as a warrantContent
<b>Warrant Controllability</b>	Assertion that a resource referenced on the face of the envelope can be controlled and/or operated by or to some standard.	For example, some ISOs will accept a resource as direct load controllable if so asserted by a third party aggregator.

533

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534 **12Conformance**

535 If the first interval in a series has a price only, all Intervals in the Sequence have a price only and there is  
536 no price in the Product

537 If the first interval in a series has a quantity only, all Intervals in the Sequence have a quantity only and  
538 there is no quantity in the Product

539 If the first interval in a series has a price & quantity, all Intervals in the Sequence MUST have a Price and  
540 Quantity and there is neither Price nor Quantity in the Product

541 All intervals in a sequence may be restricted to single service location. What are the rules?

542

---

## 543 A. Acknowledgements

544 The following individuals have participated in the creation of this specification and are gratefully  
545 acknowledged:

### 546 **Participants:**

547 Bruce Bartell, Southern California Edison  
548 Timothy Bennett, Drummond Group Inc.  
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553 Phil Davis, Schneider Electric  
554 Sharon Dinges, Trane  
555 Pim van der Eijk, Sonnenglanz Consulting  
556 Girish Ghatikar, Lawrence Berkeley National Laboratory  
557 Todd Graves, Microsoft Corporation  
558 Anne Hendry, Individual  
559 David Holmberg, NIST\*  
560 Gale Horst, Electric Power Research Institute (EPRI)  
561 Ali Ipakchi, Open Access Technology International Inc. (OATi)  
562 Perry Krol, TIBCO Software Inc.  
563 Derek Lasalle, JPMorganChase  
564 Jeremy Laundergren, Southern California Edison  
565 Alex Levinson, Lockheed Martin\*  
566 Dirk Mahling, CPower  
567 Scott Neumann, Utility Integration Solutions Inc.  
568 Robert Old, Siemens AG  
569 John Petze, Individual  
570 Donna Pratt, ISO/RTO Council  
571 Ruchi Rajasekhar, Midwest Independent Transmission System Operator, Inc.  
572 Carl Reed, Open Geospatial Consortium, Inc. (OGC)\*  
573 Jeremy Roberts, LonMark International\*  
574 Anno Scholten, Individual  
575 Pornsak Songkakul, Siemens AG  
576 Bill Stocker, ISI/RTO Council (IRC)  
577 David Sun, Alstom Power Inc.  
578 Jake Thompson, EnerNOC  
579 Matt Wakefield, Electric Power Research Institute (EPRI)  
580 David Webber, Individual  
581 Leighton Wolffe, Individual  
582 Brian Zink, New York Independent System Operator (NYISO)

583

## B. Notes on Ancillary Services (non-normative)

584 Some markets, known as ancillary services, can offer substantially more for the same load than does the  
585 traditional market. Suitability of an offering for these diverse markets is determined by aspects of the  
586 response such as how fast the Product can offer the power, how long it can offer the power, how  
587 frequently the Product can offer the power, etc. Higher prices come with higher risks; the costs of non-  
588 performance in ancillary markets can be substantially higher as well.

589 Ancillary services require detailed interval metering. For the regulation product, 4 to 6 second interval  
590 metering and direct control of the generator is today required by the balancing system operator. However,  
591 there are current initiatives by FERC and many ISOs to allow loads and storage to provide ancillary  
592 services. One of the potential applications of the metering and communications infrastructure of the  
593 smart grid is to facilitate the participation of loads and distributed energy Products such as storage in  
594 providing balancing / ancillary services to the grid.

595 There is general agreement across North America on the names of ancillary services. There is general  
596 agreement on the performance profile for each ancillary service as well. There are minor differences in  
597 some of the actual performance profiles from region to region. Periodically, the performance requirements  
598 are changed for named services.

599 Ancillary service performance can be characterized as “meet or exceed” requirements. A given service  
600 level may meet the requirements for more than one named service. A power product that can be sold in  
601 more than one market has more potential value to the seller. Transparent service and performance  
602 requirements associated with market prices are likely to encourage sellers to make minor upgrades when  
603 they can thereby reach new markets.

604 For these reasons, we opted not to name the ancillary services in the standard, but instead to exchange  
605 the actual performance requirements either offered or required.

### 606 B.1 Common Requirements today

607 For reference, here are some common performance requirements in use today. These are non-normative.  
608 They are include here to assist the practitioner in thinking about ancillary services as a deliverable.

609 Regulation

610 Spinning Reserve

611 Non-Spinning Reserve

612

## C. Electrical Power and Energy

613 Each type of Electrical Power and Energy product has its own definitions and its own descriptive  
614 parameters. These artifacts are the specific descriptions relevant to defining the potential utility of the  
615 power and energy product. The Power and Energy Artifacts describe the intrinsic information. There may  
616 be cases when an Artifact is held in the envelop contents, perhaps as supporting information supporting  
617 the intrinsic prices.

618 To put the terms “Power” and “Energy” into the proper context for this specification, the following  
619 definitions will be used:

- 620 • Apparent Power: mathematical product of root-mean-square voltage and root-mean-square  
621 current, vector sum of Real Power and Reactive Power, absolute value of Complex Power, unit:  
622 volt-ampere, VA
- 623 • Complex Power (S): square root of sum of squares of Real Power and Reactive Power, unit: volt-  
624 ampere, VA
- 625 • Current: flow of electric charge, or rate of flow of electric charge, unit: ampere, A
- 626 • Energy: the production or consumption of Real Power over time, unit: Watt-hour, Wh (note: this is  
627 the contextual unit)
- 628 • Power Factor (p.f.): ratio of Real Power to Complex Power, cosine of the phase angle between  
629 Current and Voltage, expressed as a number between 0 and 1, expressed as a percentage (i.e.,  
630 50% = 0.5), unit: dimensionless
- 631 • Reactive Power (Q): mathematical product of the root-mean-square voltage and root-mean-  
632 square current multiplied by the sine of the angle between the voltage and current, unit: volt-  
633 amperes reactive, VAR, VA-r, var
- 634 • Real Power (P): rate at which electricity is produced or consumed, mathematical product of  
635 Voltage and Current, unit: Watt, W
- 636 • Voltage: difference in electric potential between two points, unit: volt, V

637 Generically, the use of the term “Power” refers to “Real Power” and is expressed in Watts. Otherwise, one  
638 talks of Apparent Power or Complex Power in VA, or Reactive Power in VARs.

639 In the context of this specification, the price of Power and Energy will be expressed in the same unit,  
640 \$/MWh. The argument for this comes from **[Stoff, p. 32]**. The use of Power is as a flow, and its total cost  
641 is measured in unit currency (i.e., dollars) per hour, not just unit currency. The price per unit cost of Power  
642 is measured in unit currency per hour per megawatt (MW) of Power flow, or unit currency/MWh. In the  
643 same manner, the total cost of a certain quantity of Energy is measured in unit currency. The price per  
644 unit cost of energy is measured in unit currency/MWh, which is the same as for Power.

645 To clear up confusion on units for pricing, refer to definitions on pp. 30-33 in **[Stoff]**.

## D. Revision History

Revision	Date	Editor	Changes Made
WD01	2009-12-08	Toby Considine	Initial Draft from templates and outline
WD02	2010-01-12	William Cox	Inserted information model details from TC discussions
WD03	2010-03-10	William Cox	Change to envelope and certificate metaphor. Changes in mandatory and optional definitions.
WD04	2010-03-24	William Cox	Updates based on TC comments and corrections. Additional open issues in TC agenda.
WD05	2010-05-18	Toby Considine	Aligned elements with current draft if WS-Calendar, cleaned up some language to align with the last two months of conversation. Extended envelop and intrinsic/extrinsic language
WD06	2010-05-21	Toby Considine	Began incorporating TeMIX language. Changed Certificates to Warrants. Fleshed out Energy Artifacts
WD07	2010-07-07	Toby Considine	Incorporated Aaron Snyder's extensive re-write into Power & Energy section
WD08	2010-08-10	Toby Considine	Extensive re-write for narrative quality, responded to first 52 comments, Updated to include WS-Calendar WD08 language, added tables of table, examples
WD09	2010-08-18	Toby Considine	Incorporated recent WS-Calendar changes to update Products. Added explanation of WS-Calendar. Cleaned up double entry of Partitions.
WD10	2010-08-30	Toby Considine	Reduced argumentation in intro, excluded WS-Calendar re-writes, pointed to WS-Calendar appendices. Merged AC and DC
WD11	2010-09-05	Toby Considine	Distinguished between Intrinsic elements and Generic Product, incorporated inheritance language into GP, Re-created T&D as a much smaller Transport Artifact, changed envelope language to face and contents.
WD12	2010-10-26	Toby Considine	Responded to many Jira comments. Re-created T&D as a much smaller Transport Artifact, changed envelope language to face and contents. Responded to many Jira comments. Descriptions now based on WD12 Schema.

<b>Revision</b>	<b>Date</b>	<b>Editor</b>	<b>Changes Made</b>
WD13	2010-11-01	Toby Considine Ed Cazalet Dave Holmberg	Removed repetitive discussion of WS-Calendar objects. Reflect new use of WS-Calendar Sequence in Schema. Recast Options to describe reserves.
WD14	2010-11-09	Toby Considine Ed Cazalet	Changes to resources, block power, misc. tightening of document
WD15	2010-11-14	Toby Considine Ed Cazalet Sean Crimmins	EMIX Sequence changed to EMIX Terms. General tightening. Addition of Load and Power Offers, including 3-part bids for each.
CD01	2010-11-15	Toby Considine	Minor changes as per comments

648