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Chair(s):

Ed Cazalet,
William T. Cox

Editor(s):

Toby Considine

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- OASIS Specification Energy Interoperation V1.0, in process

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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/.

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/emix/ipr.php.

The non-normative errata page for this specification is located at http://www.oasis-open.org/committees/emix/

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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 tne 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.

1.3 Normative References

RFC2119 S. Bradner, *Key words for use in RFCs to Indicate Requirement Levels*, http://www.ietf.org/rfc/rfc2119.txt, IETF RFC 2119, March 1997.

RFC5545 B. Desruisseaux *Internet Calendaring and Scheduling Core Object Specification (iCalendar)*, http://www.ietf.org/rfc/rfc5545.txt, IETF RFC 5545, September 2009.

Calendar Product Schema C. Joy, C. Daboo, M Douglas, *Schema for representing Products for calendaring and scheduling services*, http://tools.ietf.org/html/draft-cal-Product-schema-00, (Internet-Draft), April 2010.

CEFACT Currency codes, e.g. USD or GBP. Add full reference citation to CEFACT or UBL profile of CEFACT

Stoft S. Stoft, *Power System Economics: Designing Markets for Electricity*. Piscataway, NJ: IEEE Press, 2002.

UML *Unified Modeling Language (UML), Version 2.2*, Object Management Group, February, 2009. http://www.omg.org/technology/documents/formal/uml.htm .

WS-Calendar OASIS WS-Calendar Technical Committee, specification in progress

xCal C. Daboo, M Douglas, S Lees *xCal: The XML format for iCalendar,* http://tools.ietf.org/html/draft-daboo-et-al-icalendar-in-xml-05, Internet-Draft, April 2010.

XLINK *XML Linking Language (XLink) Version 1.1. S DeRose, E Maler, D Orchard, N Walsh, http://www.w3.org/TR/xlink11/ May 2010.*

XPOINTER S DeRose, E Maler, R Daniel Jr. *XPointer xpointer Scheme*, http://www.w3.org/TR/xptr-xpointer/ December 2002.

XML Schema PV Biron, A Malhotra, *XML Schema Part 2: Datatypes Second Edition*, http://www.w3.org/TR/xmlschema-2/ October 2004.

1.4 Non-Normative References

EISA Energy Independence and Security Act (EISA), online. Link retrieved 06/23/2010: http://www.nist.gov/smartgrid/upload/EISA-Energy-bill-110-140-TITLE-XIII.pdf

FIX **The FIX protocol (need formal reference)**

IEC TC57 The home of the IEC TC 57 is http://tc57.iec.ch/index-tc57.html (link retrieved 06/23/2010)

ISO20022 **International Standards Organization, ISO 20022 (need full reference)**

TeMIX Transactional Energy Market Information Exchange [TeMIX] an approved White Paper of the EMIX TC. Ed Cazalet et al. http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf

NAESB 03 *Requirements Specification for Common Electricity Product and Pricing Definition*, North American Energy Standards Board [NAESB], March, 2010 (Public Review Draft). http://naesb.org/pdf4/weq_2010_ap6a_retail_2010_ap9a_rec.doc

NIST Roadmap NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, online. Link retrieved 06/23/1010: http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf

PAP03 Details of PAP03 may be found at http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP03PriceProduct (link retrieved 06/23/2010)

White Paper on WS-Calendar Link to final paper here.

1.5 Naming Conventions

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

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

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

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

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

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

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

1.6 Editing Conventions

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

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

Information in the “Specification” column of the tables is normative. Information appearing in the note column is explanatory and non-normative.

2 Overview

2.1 Introduction

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

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

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

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

2.2 Approach

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

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

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

[1] http://wordnet.princeton.edu/

[2] Ibid

price. The term extrinsic properties refers to those that can only be known with prior knowledge, such as the carbon cost, the energy source, or the sulfate load from generation.

EMIX messages communicate both intrinsic and extrinsic properties; extrinsic properties must be able to clear in the market just as does intrinsic energy.

2.3 Information Structure

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

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

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

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

2.4 EMIX Time and Schedules

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

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

[3] 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.

interval. WS-Calendar also defines a schedule entry point, defining how specific performance can be contracted and scheduled.

This document assumes that the reader has a clear understanding of WS-Calendar and its interfaces. The non-normative white paper on the use of the WS-Calendar specification published by that committee is a good place to start.

2.5 Tenders and Transactions for Power Products and Resource Capabilities

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

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

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

2.6 Transport

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

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

2.7 Verification

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

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

2.8 Extensibility

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

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

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

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

3 Overview of the Information Elements

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

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

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

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

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

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

3.1 The Intrinsic Elements

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

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

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

Intrinsic Element	Specification	Note
Terms	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
Price	Float. (Optional)	Is the sum of the extended price of intervals only if the intervals are purchased as a single tender or transaction.
Package Discount	Float (Optional)	There may be market reasons for the price to be different than the Extended Price
Market Context	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.
Party	Xs:anyUri. An identifier for one of the parties to a tender or transaction.	
CounterParty	Xs:anyUri. An identifier for one of the parties to a tender or transaction.	
Side	The role (buyer or seller) of the Party. The Counterparty takes the other role.	
Currency	A code that indicates the currency used, as specified in **[CEFACT]**	Examples include USD, CAD, GBP, EUR, CNY. Could be a nominative or shadow price referenced to e.g. microgrids

3.2 Extrinsic Elements

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

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

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

Extrinsic Element	Specification	Note
Envelope	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
Warrant List	The container for array of warrants. Optional.	An array of the warrants included in the envelope. See section 4 for warrants.
Support of Price	Container holding information supporting price information	May include EMIX Terms, if several are combined to produce the intrinsic price.
Program	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.

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

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

EMIX Warrants are assertions about the EMIX Terms.

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

Table 3-3: Examples of Warrant Information

Warrant Element	Specification	Note
Quality Warrant	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.
Environmental Warrant	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.

[4] Ibid

Warrant Element	Specification	Note
Content Warrant	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”.
Source Warrant	Individual source warrants	In aggregate may be the same as Content Warrant
Controllability Warrant	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.

3.3 EMIX Options

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

Table 3-4: Option Elements – another "Face of the Envelope"

Intrinsic Element	Specification	Note
Uid	Identifier of this artifact	The format of this ID varies by the communication is is intended for. For wider markets, the UID should be globally unique.
Created date time	Datetime this artifact was produced	
Transactive State	Enumerated string	Used to aid parsing and conformance testing, e.g., to distinguish between tenders, transactions, and history.
Terms	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
Option Exercise Schedule	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
Option Holder Party	Xs:anyUri	The party which enjoys the benefit of choosing whether or not to exercise the terms specified in the option. The Promisee.
Option Premium	EMIX Price	The price paid to the Promisor for the rights involved
Option Strike Price	EMIX Price	The price at which an option holder (Promisee) has the right to require the option writer (Promisor) to deliver.
Option Exercise Delivery Time	duration	An EMIX Option specifies required lead time before the response as well as the ability to deliver.
Extended Price	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.
Package Discount	EMIX Price. (Optional)	There may be market reasons for the price to be different than the Extended Price
Market Context	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.
Currency	A code that indicates the currency used, as specified in **[CEFACT]**	Examples include USD, CAD, GBP, EUR, CNY. Could be a nominative or shadow price referenced to e.g. microgrids
Envelope	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.

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 becomes 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
Product Description	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 **[WS-Calendar].** The ProductDescription is an extension of the Artifact that is a part of each Interval and Gluon.
Gluon Duration	WS-Calendar duration Optional	Sets default duration for Intervals in the Sequence. Not known in all interactions and nor present in all Gluons.
Gluon Quantity	Float Optional	Sets default Quantity for all Intervals in the Sequence. Not known in all interactions and nor present in all Gluons.
Gluon Unit Price	EMIX Price, Optional	Sets for all Intervals in the Sequence not otherwise priced. Not known in all interactions and nor present in all Gluons.
Sequence	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
Starting DateTime	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 reltions between intervals, and the duration of each.
Associated Interval	From WS-Calendar	Link from the EMIX Gluon into the sequence of Intervals.

4.1 EMIX Intervals

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

Table 4-2: EMIX Product Elements

Product Element	Specification	Note
Product	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.
Duration	WS-Calendar duration Optional	Can be inherited from the Gluon Set
Quantity	Float Optional	Can be inherited from the Gluon Set
Unit Price	Float, Optional	Can be inherited from the Gluon Set
Starting DateTime	Optional	Usually be inherited from the Gluon Set. Only one Interval per sequence gets a Starting DateTime
Temporal Relation	From WS-Calendar	Link from one interval to other intervals in the sequence.

4.2 EMIX Product Model

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

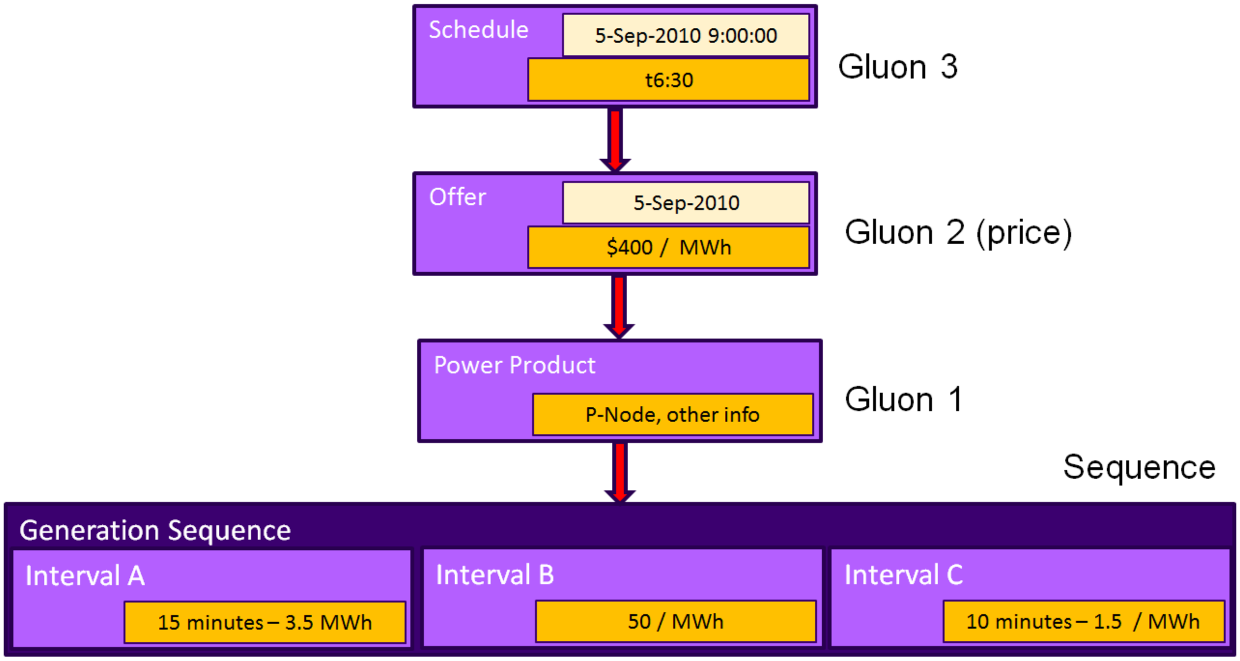

Figure 4-1: EMIX Model

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.*

5 EMIX Electrical Energy and Power Product Descriptions

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

5.1 Taxonomy of EMIX Power Product Descriptions

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

1) Power Product Descriptions
2) Resource Offer Descriptions
3) Transport Product Descriptions

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

5.1.1 Power Product Descriptions

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

5.1.2 Resource Offer Descriptions

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

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

5.1.3 Transport Product Descriptions

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

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

6 Power Product Descriptions

6.1 Transactive Power Product Description

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

Table 6-1: Power Interval Description

Name	Definition	Note
Constant Power Quantity	EMIX.Quantity	Defines Constant Power Intervals. Does not coexist with Starting and Final Power Quantities
Starting Power Quantity	EMIX.Quantity	Defines Ramped Power Intervals. Requires matching Final Power Quantity. Does not coexist with Constant Quantity
Final Power Quantity	EMIX.Quantity	Defines Ramped Power Intervals. Requires matching Starting Power Quantity. Does not coexist with Constant Quantity
Power Units	Power Units	As defined below
Service Location	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
Power Attributes	Power Attributes	As defined below
UnitPrice	EMIX.Price	Price per Unit Quantity. Includes currency
Price	EMIX.Price	Extended price for interval. Includes quantity and currency
Duration	From WS-Calendar	May be nil if inherited from Gluon
Performance	From WS-Calendar	Indicates performance requirements such as fixed run-time, absolute end time, etc.

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

Table 6-2: Power Gluon Description

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

Name	Definition	Note
Service Location	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
Power Attributes	Power Attributes	As define below
UnitPrice	EMIX.Price	Price per Unit Quantity. Includes currency
Price	EMIX.Price	Extended price for interval. Includes quantity and currency
Duration	From WS-Calendar	May be nil if all intervals have duration specified
Performance	From WS-Calendar	Indicates performance requirements such as fixed run-time, absolute end time, etc.

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

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

6.2 Requirements Power Product Descriptions

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

Table 6-3: Requirements Power Products

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

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

Table 6-4: Requirements Power Product Description

Name	Definition	Note
Contract Type	Enumerated String	
Power Units	Power Units	As defined below

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

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

Table 6-5: Requirements Power Product Description

Name	Definition	Note
Contract Type	Enumerated String	
Block Power Price	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
Power Units	Power Units	As defined below
Service Location	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
Power Attributes	Power Attributes	As defined below
Price	From EMIX	Price per Unit during the Interval.
Demand Charge	Demand Charge. Optional	See below. There may be multiple demand charges.
Maximum Power	Power	Buyer may not consume at more than this rate
Minimum Power	Power	If buyer consumes than this rate, the buyer is assessed a charge to bring it up to this rate.
Duration	From WS-Calendar	May be nil if all intervals have duration specified

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

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

Table 6-6: Demand Charges Information Model

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

6.3 Semantics of Power Products

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

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

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

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

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

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

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

Name	Definition	Note
Power Attributes	Voltage / Hertz / Ac	Group used in many definitions
Transaction Node	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.
Pnode	Transaction Node	A pricing location for which market participants submit their bids, offers, buy/sell CRRs, and settle.
APnode	Transaction Node	Aggregated Pnode
Service Location	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.
Service Place	Geo-location, i.e. kml:placemark	Typically a geo-referenced polygon that might contain many transaction nodes
Interface Pricing Point	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.

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.

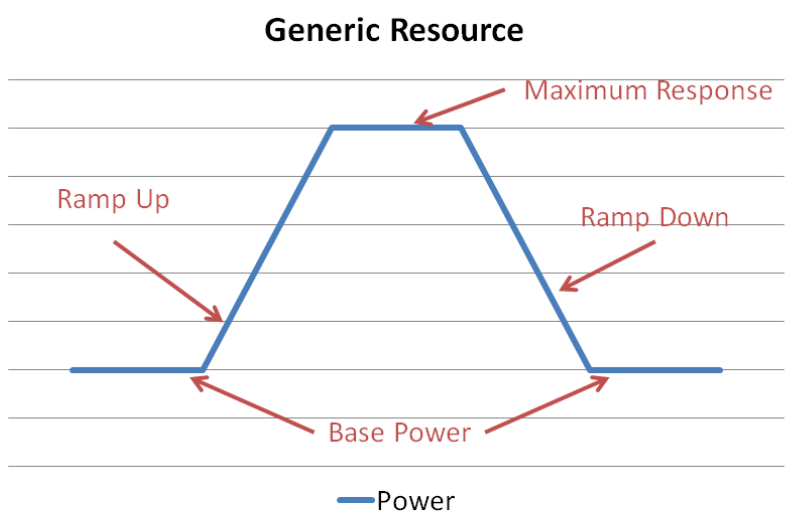

Figure 7-1: Attributes of a Generic Resource

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

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

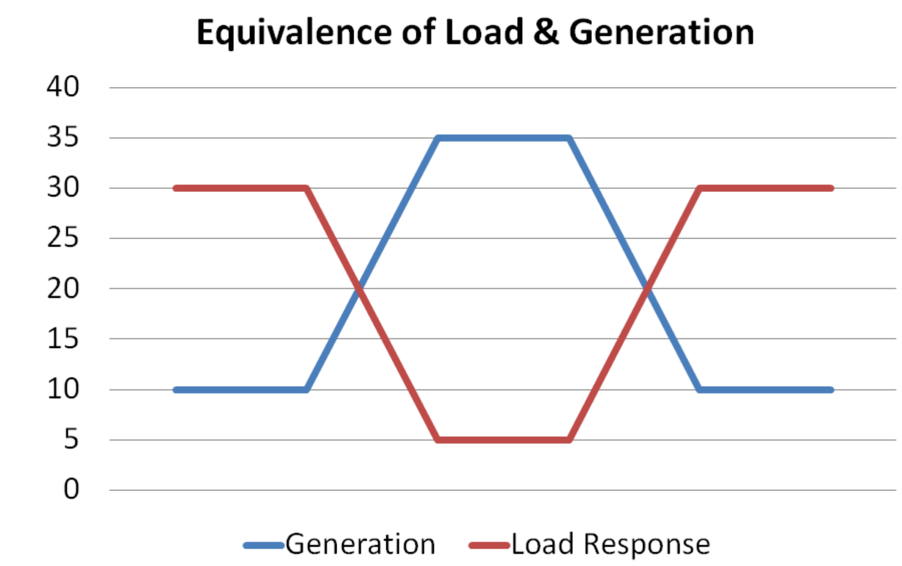

Figure 7-2: Equivalence of Load Shed and Generation

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

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

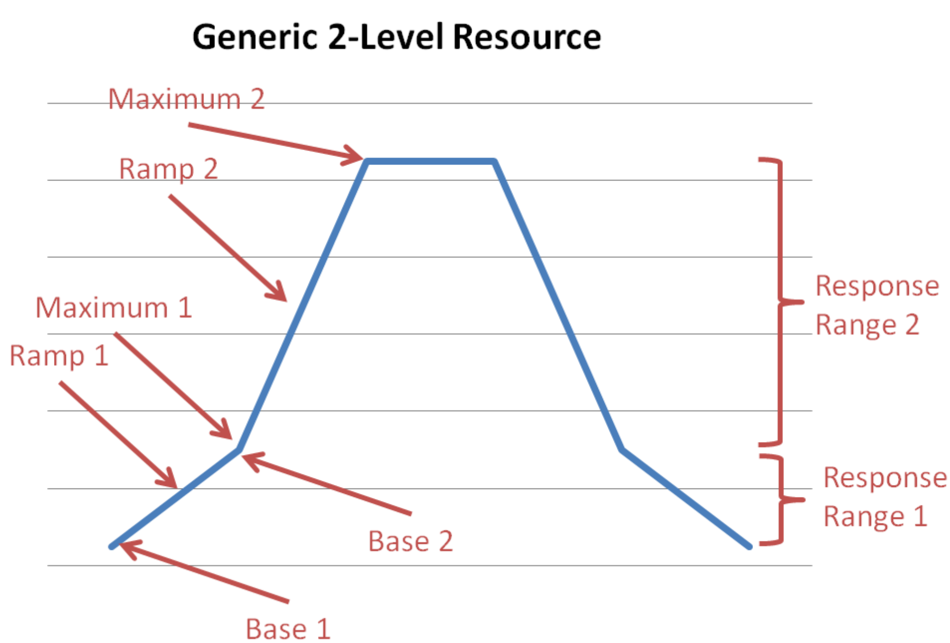

Figure 7-3: Combining Response Capabilities

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

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

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

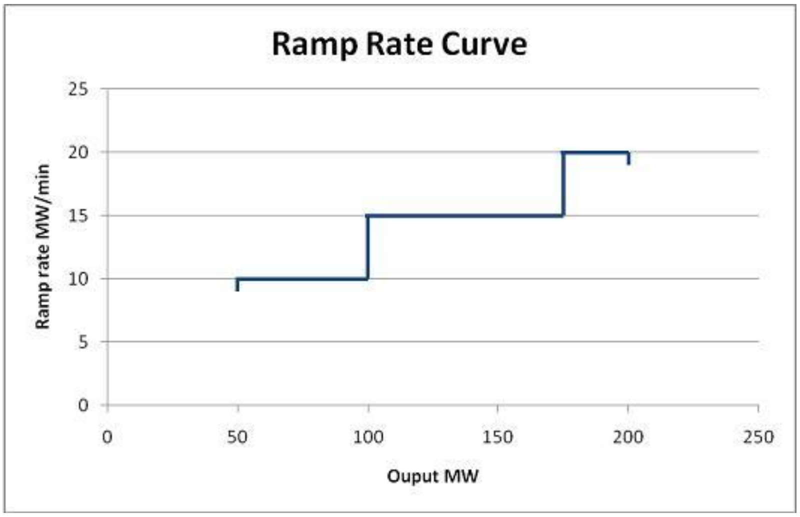

Figure 7-4: Ramp Rate Curve—CIM Style

By expressing resources in terms of capabilities and ramp rates, a potential purchaser can determine of a resource meets his or her needs, tendering a single resource to a variety of purchase scenarios.

Picture several resources each able to generate 10 MW of additional power. One can increase power at 1 MW/minute, one at 2 MW/minute, one at 5. MW/minute. The latter two each can be contracted to supply 10 MW in 5 minutes. Only the last can be contracted to supply an increase of 10 MW within 2 minutes. All three can be contracted to supply an increase of 10 MW within 15 minutes.

7.2 Power Resource Semantics

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

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

Table 7-1 Semantics for Power Resources

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

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

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

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

Table 7-2 Semantics for Voltage Regulation Services

Name	Definition	Note
VMin	varQuantity	VMin is the IEEE 1547 minimum voltage level of 88% of nominal voltage where the PV inverter must disconnect
VMax	varQuantity	VMax is the IEEE 1547 maximum voltage level of 110% of nominal voltage where the PV inverter must disconnect.
QMax	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.
voltVar	voltageQuanity & varQuantity	

7.3 Resource Capability Descriptions

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

7.3.1 Load Curtailment Resource Capability Descriptions

Table 7-3 Responsive Load Resource – Simple Form

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

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

Table 7-4 Offer Load Reduction

Name	Definition	Note

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

7.3.2 Generation Resource Capability Description

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

Table 7-5 Registered Generation Capabilities

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

7.3.3 Power Offer Description

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

Table 7-6 Power Offer Capabilities

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

8 Ancillary Services Products

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

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

8.1.1.1 Ancillary Services – Regulation Products

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

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	

8.1.1.2 Ancillary Services Reserve Products

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

9 Power Quality

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

9.1.1 Electrical Power Quality

Table 9-1: AC Power Quality

Name	Definition	Type	Note
Measurement Protocol	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”
Power Frequency	A floating point number describing the nominal Power frequency	Float	Measured rather than nominal value, e.g. 50.4, 59.9. 0 for DC
Supply Voltage Variations	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.
Rapid Voltage Changes	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.
Flicker	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.
Supply Voltage Dips	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.
Short Interruptions	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.
Long Interruptions	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.
Temp Overvoltage	An unsigned integer count of Temporary Overvoltage events during the period	Ulong	See referenced standards for definition, measurement protocol and period.

Supply Voltage Imbalance	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.
Harmonic Voltage	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.
Mains Voltage	A floating point number Mains [Signaling] Voltage	Float	Nominal value, e.g, 110, 130, 220, 208. See referenced standards for definition and protocol.

10 Power Transport Products

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

Table 10-1: Transport Description

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

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

11 EMIX Warrants

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

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

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

11.1 Warrant List Definition

Warrant Element	Definition	Note
Product Quality	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.
Warrant Environmental	Quantifies the environmental burden created during the generation of the electric power.	These are as identified as per the artifact environmental.rdf
Warrant Content	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.
Warrant Source	Individual source warrants	In aggregate may be the same as a warrantContent
Warrant Controllability	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.

12 Conformance

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

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

If the first interval in a series has a price & quantity, all Intervals in the Sequence MUST have a Price and Quantity and there is neither Price not Quantity in the Product

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

A. Acknowledgements

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Participants:

Bruce Bartell, Southern California Edison
Timothy Bennett, Drummond Group Inc.
Edward Cazalet, Individual
Toby Considine, University of North Carolina at Chapel Hill*
William Cox, Individual
Sean Crimmins, California Independent System Operator
Phil Davis, Schneider Electric
Sharon Dinges, Trane
Pim van der Eijk, Sonnenglanz Consulting
Girish Ghatikar, Lawrence Berkeley National Laboratory
Todd Graves, Microsoft Corporation
Anne Hendry, Individual
David Holmberg, NIST*
Gale Horst, Electric Power Research Institute (EPRI)
Ali Ipakchi, Open Access Technology International Inc. (OATi)
Perry Krol, TIBCO Software Inc.
Derek Lasalle, JPMorganChase
Jeremy Laundergren, Southern California Edison
Alex Levinson, Lockheed Martin*
Dirk Mahling, CPower
Scott Neumann, Utility Integration Solutions Inc.
Robert Old, Siemens AG
John Petze, Individual
Donna Pratt, ISO/RTO Council
Ruchi Rajasekhar, Midwest Independent Transmission System Operator, Inc.
Carl Reed, Open Geospatial Consortium, Inc. (OGC)*
Jeremy Roberts, LonMark International*
Anno Scholten, Individual
Pornsak Songkakul, Siemens AG
Bill Stocker, ISI/RTO Council (IRC)
David Sun, Alstom Power Inc.
Jake Thompson, EnerNOC
Matt Wakefield, Electric Power Research Institute (EPRI)
David Webber, Individual
Leighton Wolffe, Individual
Brian Zink, New York Independent System Operator (NYISO)

B. Notes on Ancillary Services (non-normative)

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

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

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

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

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

B.1 Common Requirements today

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

Regulation

Spinning Reserve

Non-Spinning Reserve

C. Electrical Power and Energy

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

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

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

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

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

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

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.

Revision	Date	Editor	Changes Made
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	2010-11-12	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.