Energy Market Information Exchange (EMIX) Version 1.0

Committee Specification Draft 03

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Technical Committee:

OASIS Energy Market Information Exchange (eMIX) TC

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Related work:

This specification is related to:

- OASIS Specification WS-Calendar V1.0, in process
- OASIS Specification Energy Interoperation V1.0, in process
- XML schema(s): emix/v1.0/csd03/xsd/

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http://docs.oasis-open.org/ns/emix/2011/06/siscale

Abstract:

This specification defines an information model and XML vocabulary for the interoperable and standard exchange of prices and product definitions in transactive energy markets:

- Price information
- Bid information
- Time for use or availability
- Units and quantity to be traded

- Characteristics of what is traded

Status:

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

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

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1 Introduction

This specification defines an information model to exchange Price and Product information 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. It is anticipated to be used for information exchange in a variety of market-oriented interactions.

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

Key to reading this 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 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 model 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” **[NIST 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 TC57]**. 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).

Both the supply and the use of energy, and therefore the market value, are time dependent, so precise communication of time of delivery is a significant component of product definition. EMIX incorporates schedule and interval communication interfaces from Web Services Calendar (**[WS-Calendar]**) to communicate schedule-related information. Practitioners should read the **[WS-Calendar]** specification or the [**WS-Calendar Note]**.

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.
ISO42173	*United Nations Centre for Trade Facilitation and Electronic Business*, Currency codes, ISO 42173A - Code List Schema Module

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SI Units Bureau International des Poids et Mesures (BIPM), The International System of Units, 8th Edition, May 2006. http://www.bipm.org/en/si/si_brochure/general.html

SOA-RM OASIS Standard, *OASIS Reference Model for Service Oriented Architecture 1.0*, October 2006 http://docs.oasis-open.org/soa-rm/v1.0/

URI T. Berners-Lee, R. Fielding, L. Masinter, *Uniform Resource Identifier (URI): Generic Syntax,* http://www.ietf.org/rfc/rfc3986.txt, January 2005

WS-Calendar OASIS Committee Specification Draft 03, *WS-Calendar*, May 2011, http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/csprd02/ws-calendar-spec-v1.0-csprd02.pdf

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1.4 Non-Normative References

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EN50160 EN50160-2000 (2003) Electromagnetic Compatibility (EMC) – Part 4-30: Testing and Measurement Techniques – Power Quality Measurement Methods, Edition 2, June.

FIX Financial Information eXchange (FIX) Protocol, http://www.fixprotocol.org/specifications/FIX.5.0SP2

IEC TC57 IEC TC 57 Power Systems Management and Associated Information Exchange, IEC 61968-9 Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control http://webstore.iec.ch/preview/info_iec61968-9%7Bed1.0%7Den.pdf
IEC 61970-301, Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base http://webstore.iec.ch/Webstore/webstore.nsf/Artnum_PK/42807

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IEEE1519 IEEE1159-2009, *IEEE Recommended Practice for Monitoring Electric Power Quality*, ieee.org

IEEE1547 IEEE 1547, *Standard for Interconnecting Distributed Resources with Electric Power Systems,* ieee.org

IEEEv15#3 Pretorius, van Wyk, Swart. *An Evaluation of Some Alternative Methods of Power Resolution in a Large Industrial Plant*, 1990 IEEE Transactions on Power Delivery, VOL. 15, NO. 3, JULY 2000.

ISO 20022 ISO Standards, Financial Services - Universal financial industry message scheme, http://www.iso20022.org/UNIFI_ISO20022_standard.page

Kingham Brian Kingham**,** *Quality of Supply Standards: Is EN 50160 the Answer?,* 17th Conference of Electrical Power Supply Industry, Macau, 2008; also EPRI Power Quality Conference, 2008; Also available at http://www.oasis-open.org/committees/download.php/37248/Power%20Quality%20White%20Paper%20from%20Schneider.pdf

NAESB PAP03 Requirements Specification for Common Electricity Product and Pricing Definition, North American Energy Standards Board [NAESB], March, 2010
NAESB Wholesale Electrical Quadrant Business Practice http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_6_a_ii.doc
NAESB Retail Electrical Quadrant Business Practice, http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_9_a.doc

NAESB MDL Wholesale Electrical Quadrant Business Practice Master Data Element List, http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_6_a-c.doc
Retail Electrical Quadrant Business Practice Master Data Element List, http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_9_a-c.doc

NAESB PAP10 NAESB Wholesale Electrical Quadrant Business Practice Standard PAP10 http://www.naesb.org/member_login_check.asp?doc=fa_weq_2010_ap_6d.doc
NAESB Retail Electrical Quadrant Business Practice Standard PAP10 http://www.naesb.org/member_login_check.asp?doc=fa_req_2010_retail_ap_9d.doc
Energy Usage Model (freely available): http://www.naesb.org/pdf4/naesb_energy_usage_information_model.pdf

NAESB M&V Measurement and Verification Standards
Wholesale Electrical Quadrant Business Practice Standard: http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_4a_4b.doc
Retail Electrical Quadrant Business Practice Standard: http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_3_c.doc

NIEM NIEM Technical Architecture Committee (NTAC), *National Information Exchange Model Naming and Design Rules v1.3*, October 2008, http://www.niem.gov/pdf/NIEM-NDR-1-3.pdf

OpenADR Mary Ann Piette, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage, Peter Palensky, and Charles McParland. 2009. Open Automated Demand Response Communications Specification (Version 1.0). California Energy Commission, PIER Program. CEC-500-2009-063. http://openadr.lbl.gov/pdf/cec-500-2009-063.pdf

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

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

NIST PAP03 Details of PAP03 can be found at http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP03PriceProduct

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RDDL J Borden, T Bray, *Resource Directory Description Language (RDDL) Version 2.0*, October, 2002, http://www.rddl.org/RDDL2

UML *Unified Modeling Language (UML), Version 2.2*, Object Management Group, February, 2009, http://www.omg.org/spec/UML/2.2/

WS-Calendar Note OASIS Committee Note Public Review Draft, *WS-Calendar Conceptual Overview*, http://docs.oasis-open.org/ws-calendar/ws-calendar/v1.0/CD01/WS-Calendar-Conceptual-Overview-CD01.pdf

1.5 Namespace

XML namespaces and prefixes used in this specification are shown in Table 1-1.

Table 1-1: XML Namespaces in this standard

Prefix	Namespace
emix	http://docs.oasis-open.org/ns/emix/2011/06
scale	http://docs.oasis-open.org/ns/emix/2011/06/siscale
power	http://docs.oasis-open.org/ns/emix/2011/06/power
resource	http://docs.oasis-open.org/ns/emix/2011/06/power/resource
xs	http://www.w3.org/2001/XMLSchema
gml	http://www.opengis.net/gml/3.2
xcal	urn:ietf:params:xml:ns:icalendar-2.0

All OASIS Schemas are permanently accessible through directory structures that include major and minor version numbers. They are also accessible through RDDL files that describe these structures and version in directories below http://docs.oasis-open.org/emix/emix.

The schema document at that URI may however change in the future, in order to remain compatible with the latest version of EMIX Specification. In other words, if the schemas namespaces change, the version of this document at http://docs.oasis-open.org/ns/emix/2011/ will change accordingly.

In keeping with OASIS standard policy, a RDDL document locating the schemas defined in this specification will persist in http://docs.oasis-open.org/ns/emix.

The EMIX schema versioning policy is that namespaces reflect the year and month in which they were released. For this version, this rule results namespaces as indicated in the first four namespaces listed in Table 1-1.

Namespace maintenance as described above also addresses the need for schema versioning; such information is already contained in the directory structures found at http://docs.oasis-open.org/emix/emix/. Versioning beyond that which is required by the namespace maintenance policy is not specified.

1.6 Naming Conventions

The names of EMIX XSD Elements and Attributes follow Lower Camel Case convention.

Example:

```
<element name="componentService" type="emix:ComponentServiceType"/>
```

The names of EMIX Types follow Upper Camel Case convention and Type names are postfixed with “Type“.

Example:

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

1.7 Editing Conventions

For readability, Element names in tables appear as separate words. In the Schemas, they follow the rules as described in Section 1.6.

Terms defined in this specification or used from specific cited references are capitalized; the same term not capitalized has its normal English meaning.

All sections explicitly noted as examples are informational and SHALL NOT be considered normative.

All UML and figures are illustrative and SHALL NOT be considered normative.

1.8 Security Approaches

EMIX will normally be conveyed in messages as part of business processes. Each business process will have its own security needs, including different consequences for failure of security. EMIX relies on the business processes using the standard to ensure secure exchange of Price and Product information in energy market transactions.

2 Overview

2.1 Introduction

Energy markets have been characterized by tariffs and embedded knowledge that makes decision automation difficult. Different market segments use conflicting terms for similar attributes. Smart grids introduce rapidly changing products and product availability, with associated dynamic prices. A lack of a widely understood model conveying market information has been a barrier to development and deployment of technology to respond to changing market conditions.

Price and Product Descriptions are *actionable information.* When presented with standard messages conveying price and product information, 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 not strictly economic processes. These tariffs convey the price and product information to make buying and selling decisions easier. The same information can be derived from market operations in non-tariffed markets. EMIX defines an information model to 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, may not have the same value 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, transactions, and delivery. 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.

2.1.1 Product Terminology

This specification uses a definition of Product that is inclusive of attributes including schedule, location, and source. Some markets define products in a more restricted or general manner. We combine the various attributes of a thing bought or sold, shown graphically in FIGURE 2-1. In this specification we define a product to include both the type of product (e.g., Energy), the response time (e.g. fast enough to qualify as Regulation), and the delivery time as shown by the black arrow. Others (e.g., ISO Wholesale markets) define products at a higher level (e.g. Energy) which is considered the same product regardless of delivery time, as indicated by the gray arrow.

Figure 2-1is illustrative, not normative; the order of significance is not defined in this specification. Moreover, there are attributes such as Source or Power Quality that do not easily fit in a single dimension—and a renewable source typically makes a different Product with different value.

Fortunately, this is often a distinction without moment, as the information needed for a transaction involves the more detailed characteristics as indicated by the black arrow, and the specific definition of a Product is part of the Market Context.

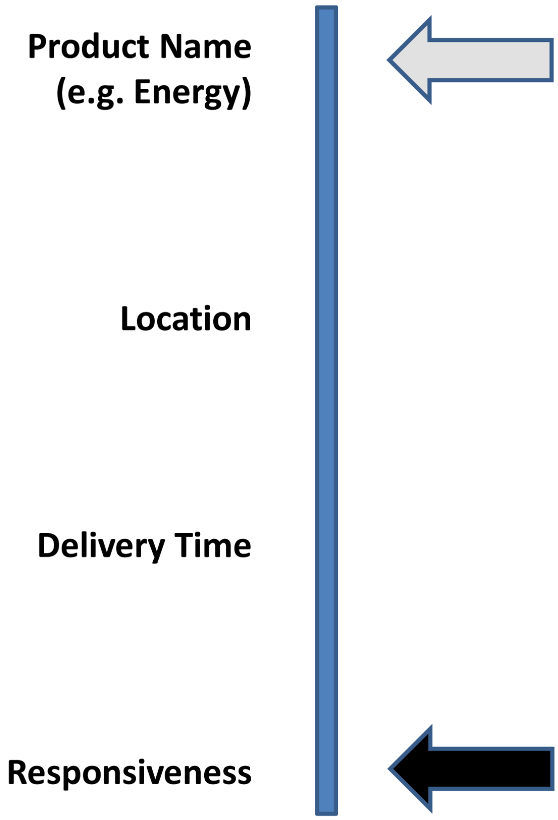


Figure 2-1: Attributes of a Product

2.2 Approach

The EMIX TC has prepared a white paper that provides a context for discussing the use of transactions in forward and futures wholesale energy markets and financial markets. The Transactive Energy Market Information Exchange **([TeMIX])** white paper can be found in the non-normative references. Users of EMIX are strongly encouraged to become familiar with TeMIX when considering this standard.

Transactive Energy Market Information Exchange **([TeMIX])** is a specialization of work within the EMIX TC to address retail and wholesale transactions using approaches common in energy wholesale and financial markets. This specification defines a TeMIX profile as a restricted subset of the EMIX information model.

The TeMIX approach allows only specific tenders and transactions for block power on defined Intervals of time. Any party can be a buyer, seller, or both. Tenders may be offered by any party to any other party, as market rules and regulations may allow. Transactions may include call and put options. TeMIX also describes transport products for transmission and distribution.

The restricted information model and services of the TeMIX profile also support increased automation of transactions using the computer and communications technology of the smart grid. Tenders and Transactions can support dynamic tariffs by retail providers to retail customers. Options perform a similar function to demand response contracts or ancillary service contracts wherein an operator has dispatch control over the exercise of the option. The TeMIX approach assumes interval metering where delivery can be accurately measured.

EMIX has adopted much of TeMIX terminology. EMIX supports current operating models of market operators, utilities, and Demand Response providers while at the same time supporting the TeMIX model and future transitions among the models.

Power is a commodity good 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. EMIX assumes this product differentiation and defines multiple products based on the underlying good.

Throughout this work, the specification refers to the intrinsic and extrinsic properties of an energy product. An intrinsic property is one *"belonging to a thing by its very nature."* An extrinsic property is one *"not forming an essential part of a thing or arising or originating from the outside."* In EMIX, the term intrinsic properties refers to those that can be measured and / or verified at the point of delivery, such as electric power and 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 Artifacts can communicate both intrinsic and extrinsic properties. EMIX is designed to support arrange of markets from those in which extrinsic properties must clear just as do intrinsic properties, to markets may not be concerned with the extrinsic properties.

EMIX is an information model that assumes conveyance within a service-based environment, as defined in the OASIS Reference Model for Service Oriented Architecture 1.0 **[SOA-RM].**

2.3 Time Semantics

Time semantics are critical to EMIX. Consider two sellers that offer the same product. For the first, one must start planning an hour or more in advance. The second may be able to deliver the product within five minutes of a request. The service start time is the time when product delivery begins. Because this service start time and service period are all that matters to product delivery, different providers using quite different technologies can provide equivalent product as specified in EMIX if each is given adequate notice. For other products, timeliness of notice is of the essence, and the first may not be able to provide the service.

EMIX uses semantics from **[WS-Calendar]** to describe Time, Duration, and Schedule. An overview of **[WS-Calendar]** semantics is provided in Appendix E.

2.4 Information Structure

As a conceptual aid, consider 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 of the envelope is meant for high-speed automated processing. The simplest devices, including the proverbial smart toaster, may understand only the intrinsic qualities. 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 immediately or delay energy use until a later time are best made where the value is received for that energy use, that is, at the end device. The smart toaster is shorthand for the smallest, least capable end device that can receive such a message. It is anticipated 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 support the price for the intrinsic qualities on the face of the envelope. These extrinsic qualities are separable from the intrinsic transaction and perhaps can be traded in secondary markets. The contents can include Warrants about the source and the environmental attributes which 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.

The extrinsic information within the envelope may contain information that supports the price among the Extrinsic information conveyed within the envelope. 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.

2.5 Tenders and Transactions for Power Products and Resource Capabilities

The focus of EMIX is on a Price and Product information model for 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.

EMIX is intended for commercial transactions in all types of markets including ISO/RTO markets, exchange markets, regulated markets, regulated retail tariffs, open markets, and wholesale and retail bilateral markets. *(ISO refers to Independent System Operators. ISOs provide non-discriminatory access to transmission, operate spot markets and maintain grid reliability. RTO refers to Regional Transmission Organizations. RTOs perform the ISO functions on a regional basis.)* The commercial practices that determine prices vary in these markets but all markets can benefit from interoperable communication of Price and Product information.

Transactions in most markets begin with tenders (offers to buy or sell) by one 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 4, *"Envelopes: EMIX Base and its Derivatives"* describes EMIX Base Type, the core of EMIX information models.

In many electricity markets, Operators are offered electrical products based on specific resources such as 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 from a point of injection to a grid to a point of takeout to a grid is also described by the EMIX information model. Product transport can be characterized by (1) the quantity transported and price, or (2) the quantity transported and cost detail.

Transport 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 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 services are discussed in Section 11, *"Power Transport Product Description".*

2.7 Verification of Response

Many products, e.g. those transacted for Demand Response, have detailed verification methods. In today's markets, verification can be quite complex.

Verification is out of scope for this specification. Measurement and Verification is fully specified by NAESB Business Practices for Measurement and Verification **[NAESB M&V]**. This specification does not define verification.

3 Guide to the Schema Structures

The EMIX 1.0 Specification consists of four schemas:

- The EMIX schema defines the framework and extensibility as well as agreement types common to many markets. The EMIX schema consists of three files—emix.xsd, emix-terms.xsd, and emix-warrants.xsd
- The SI Scale schema, defines a code list enumerating the characters indicating the decadic scale for measurements defined by the System International (SI).
- The Power schema defines the specific information exchanges, based on the EMIX framework, needed for markets in power and energy. The Power schema consists of three files—power.xsd, power-product.xsd, and power-quality.xsd.
- The Resource schema describes specific capabilities of devices and systems, irrespective of the underlying technologies that affect power and energy markets.

Note that EMIX and Power schemas are broken into multiple files for convenience of human readers and editors.

The Power and Resource schemas are, in effect, the first extensions to the EMIX Schema. The Power schema extends the EMIX schema to define products for Power markets. The Resource schema extends the Power schema to provide information on the capabilities and the responsiveness of devices and systems in support of decisions regarding tenders and transactions for products that can be provided by or consumed by Resources.

3.1 Use of Core Type Extension to define EMIX

The core elements of EMIX are abstract types. The concrete types used in exchangeable information models are built by extending those abstract types to create the information exchanges for energy markets. Product Descriptions are built out of lower-level Items. Schedules are populated with Product Descriptions. Top level models, derived from EMIX Base, incorporate Schedules. Top level models can be exchanged at an Interface between systems or owners.

3.1.1 Core Abstract Types

The abstract EMIX Base Type defines a Product Description conveyed by a Schedule. That Schedule may be as simple as a single 5 minute interval on a particular day, or as complex and repeating as you can find in your own personal calendar. Any type derived from the EMIX Base Type contains a Sequence that can contain any Product Description. Information elements derived from the EMIX Base include Products, Options, TeMIX, and Delivery (Metered Information). The definitions in Table 3-1 assume that the reader is familiar with terms defined in **[WS-Calendar]**; as a convenience to the reader, these are summarized in section 3.2.

Table 3-1: EMIX Core Abstract Types

Type	Description
Item Base	Abstract base type for units for EMIX Products. Item Base does not include Quantity or Price, because a single Product may have multiple quantities or prices associated with each Interval.
Schedule	EMIX Products are delivered for a Duration, at a particular time. EMIX relies on the Interval and the Gluon as defined in **[WS-Calendar]** to communicate Schedules. The Schedule names a collection, but is not itself a type.

Type	Description
Product Description	Product Description is derived from an abstract Artifact type that resides within **[WS-Calendar]** Components, and all Product Description-derived types can therefore reside within those Components as well. The Product Description is placed in Components of the Schedule.
EMIX Base	The EMIX Base conveys a Schedule populated with Product Descriptions and is extended to express additional market information sufficient to define Products. All EMIX Products are derived from EMIX Base, but not all derived types are Products. Along with the Schedule, EMIX Base includes an optional Envelope (see 3.1.5).

Conforming specifications can extend the EMIX specification for use in their own domain by extending the core types of EMIX. Within this specification, Electrical Power is a specific extension of EMIX for power markets. Specifications to support energy markets can be created through extension in an analogous manner.

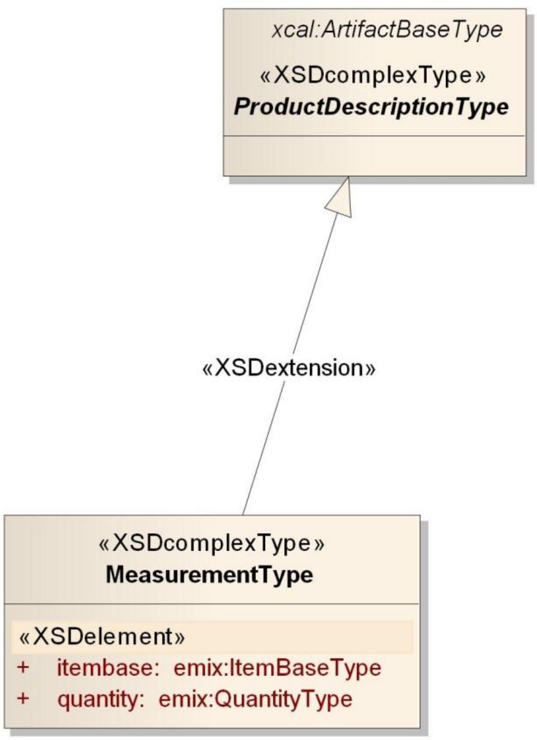


Figure 3-1: The Abstract Product Description Base Type

3.1.2 Price Base and its extensions

Prices in today’s power markets may be communicated other than as a simple price. The Price Base is a low level abstract type which is an element in many other types. Price Base is an extensible type whose extensions include not only a simple or absolute price, but other types that rely on foreknowledge and computation. Unless otherwise specified (as it is in TeMIX which is restricted to only the simple price), wherever an information model requires a Price Base, any type derived from Price Base is supported.

Table 3-2: Elements derived from Price Base

Element	Description
Price	This is the number that quantifies the actual price per unit of the product.
Price Multiplier	A Price Multiplier applied to a reference price produces the actual price. Optionally includes a Market Context for the reference price.
Price Relative	A Price Relative is added to a reference price to compute the actual price. Price Relative may be positive or negative. Optionally includes a Market Context for the reference price.

For extension purposes, a conforming specification can define a new price type that can be used in any EMIX type by extending the abstract Price Base.

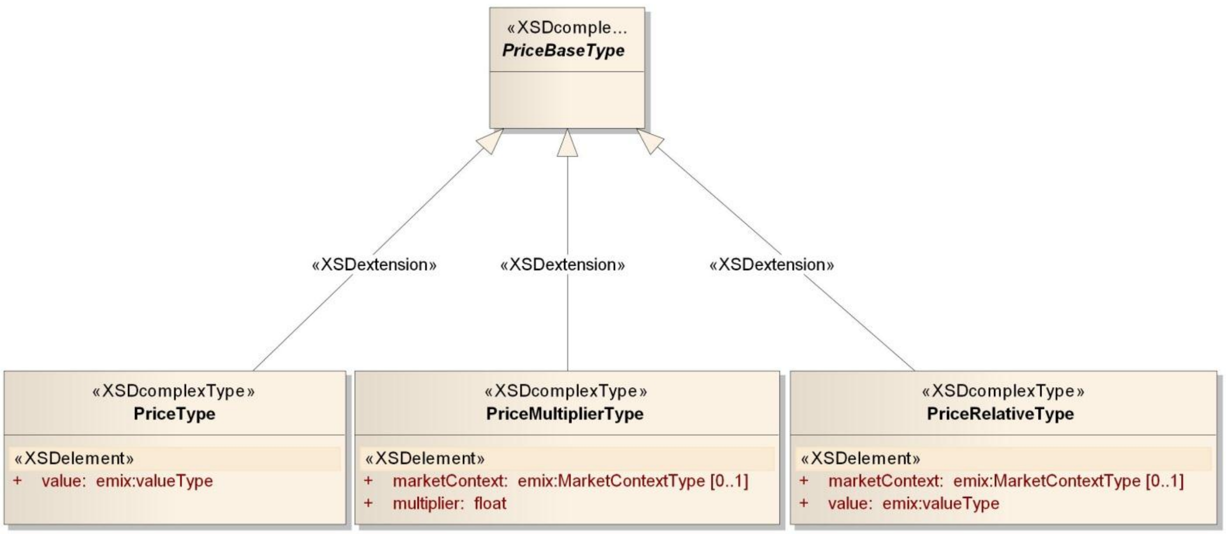


Figure 3-2: Price Base and Extensions

3.1.3 The EMIX Interface

EMIX describes Products whose value is tied to an exchange of ownership or control at a particular location at a particular time. EMIX expresses this locality using the EMIX Interface.

The EMIX Interface is where something transfers ownership. In power, this may be a node or meter, an aggregation of nodes or meters, a pair of nodes, or a geographic area. Other specifications can derive from the base type to support their own needs.

The EMIX Interface is an abstract type. The EMIX Interface can represent a meter or a computation; the EMIX Interface can be real or virtual, the EMIX Interface can be a collection or a singlet.

Table 3-3: The EMIX Interface.

Type	Description
EMIX Interface	Abstract base class for the interfaces for EMIX Product delivery, measurement, and/or pricing

Type	Description
Service Area	The Service Area is the only Interface defined for all derived schemas. The Service Area expresses locations or geographic regions relevant to price communication. For example, a change in price for a power product could apply to all customers in an urban area. Service Areas are defined using **[GML]** in its simplest profile, i.e., level 0.

EMIX interfaces for specific products have product-specific requirements or have characteristics already defined in specific markets. Within this specification, the EMIX Interface has specific extensions for Power markets defined in Section 8.1 *"EMIX Interfaces for Power"*. Other markets can extend the EMIX Interface to support their specific needs.

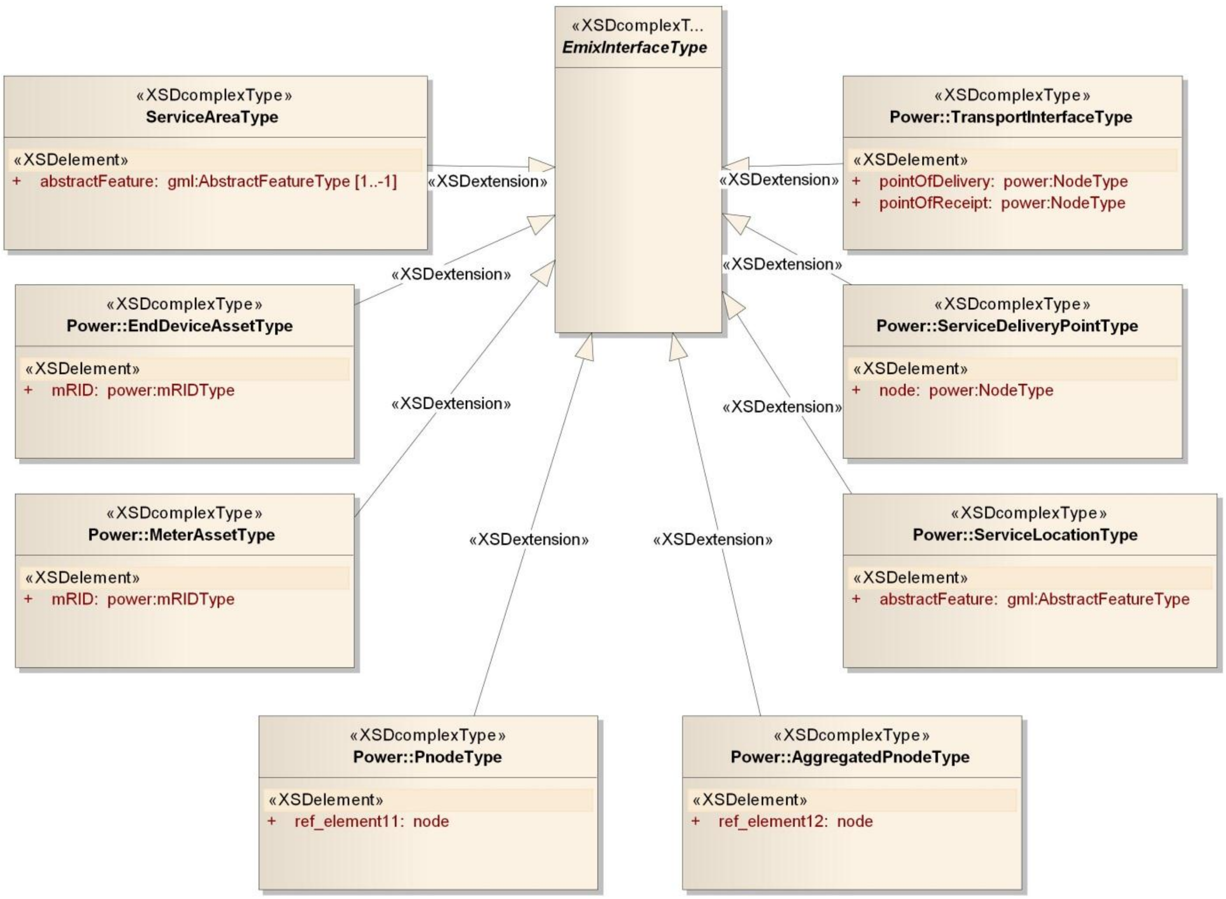


Figure 3-3: Summary of EMIX Interfaces including both Emix and Power

3.1.4 The Item Base

The Item Base is the basis for the lowest level description of each Product and its aspects. The term Item is in common business use for that thing on a line of a purchase order, or of a receipt, or on a bill of lading. Item Base derived types have at least a name, a unit of measure, and a scale factor. The power schema (see 0 See Figure 3-3: Summary of EMIX Interfaces including both Emix and Power for all Interfaces defined in this specification.

Power Items derived from Item Base) defines three power types derived from the Item Base Type.

Items, i.e., types derived from Item Base, reference the International System of Units (SI) to specify a set of alphabetic prefixes known as SI prefixes or metric prefixes. An SI prefix is a name that precedes a basic unit of measure to indicate a decadic multiple or fraction of the unit **[SI Units].**

EMIX requires that conforming specifications use the SI Scale to indicate the size of the unit of measure. The SI Scale is in the external code list siscale.xsd.

3.1.5 The Envelope Contents

While energy markets actually deliver a blended commodity, the customer may value the product differently based upon extrinsic characteristics of the commodity. This distinction may be based, for example, upon the origin of the product or upon its means of production. The product may come with attached credits that may have re-sale value. The buyer may contract for, and the supplier may need to report specific quality of product delivery. In other circumstances, it may be necessary to deliver supporting detail to explain the prices delivered.

In EMIX, the assertions that distinguish the commodity product are called EMIX Warrants. A common definition of a warrant is a written assurance that some product or service will be provided or will meet certain specifications. Sellers may use EMIX Warrants to provide information about the source of the energy or about its environmental characteristics. Buyers may use EMIX 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 information models, including EMIX Warrants, can support such market rules.

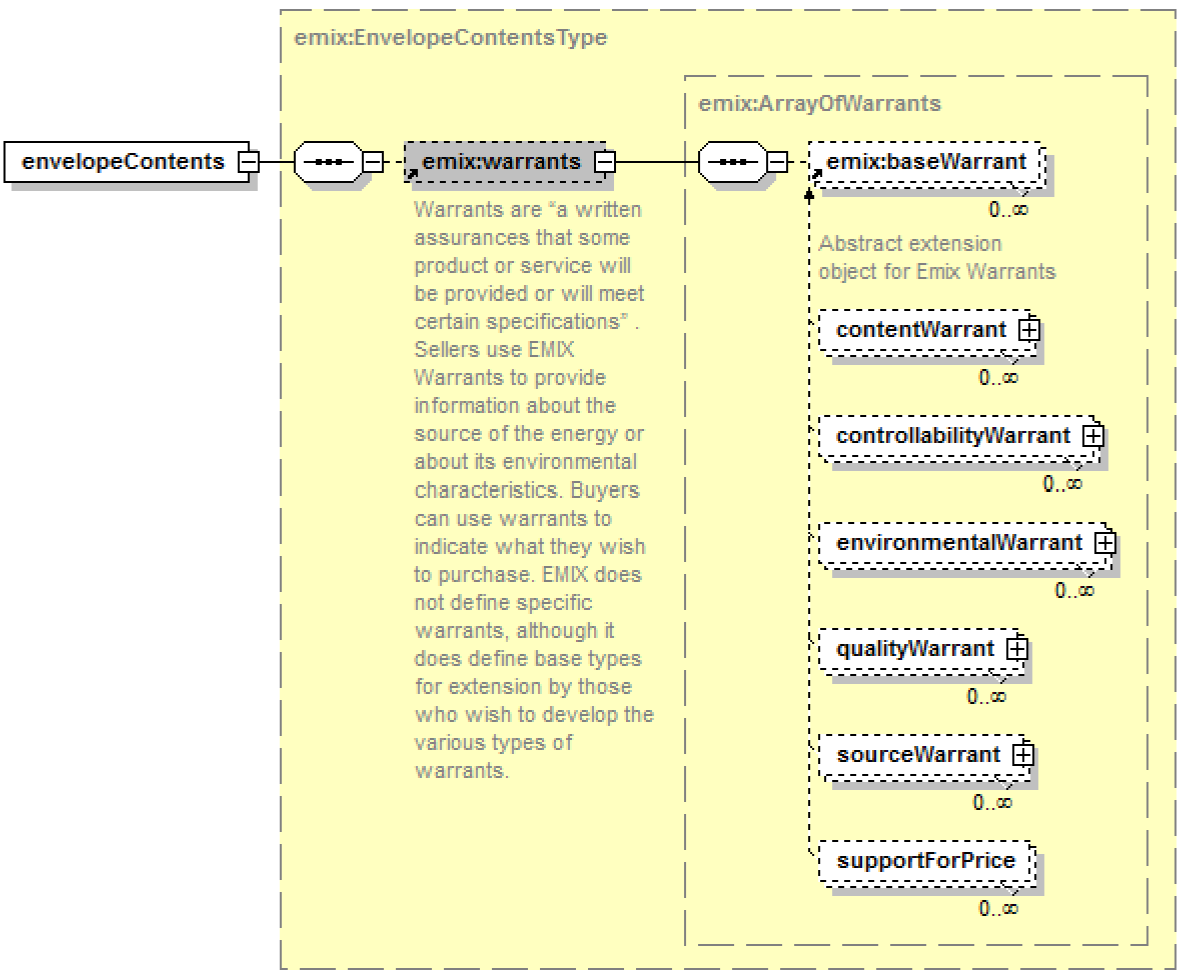


Figure 3-4: Envelope Contents

EMIX Warrants are described in section 15. For now, it is sufficient to know that EMIX Warrants are delivered as Envelope Contents.

3.2 WS-Calendar Terms and Descriptions (Non-Normative)

The communication of a commonly understood Schedule is essential to EMIX. EMIX is conformant with the **[WS-Calendar]** specification for communicating duration and time to define a Schedule. **[WS-Calendar]** itself extends the well-known semantics **[RFC5545]**.

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

Table 3-4: WS-Calendar defined Terms used in EMIX

WS-Calendar Term	Description
Component	In **[iCalendar]**, the primary information structure is a Component, also known as "vcomponent." A Component is refined by Parameters and can itself contain Components. Several RFCs have extended iCalendar by defining new components using the common semantics defined in that specification. In the list below, Interval, Gluon, and Availability (Vavailability) are Components. Duration, Link, and Relationship are Parameters. A Sequence is set of Components, primarily Intervals and Gluons, but is not itself a Type.
Duration	Duration is the length of an event scheduled using iCalendar or any of its derivatives. The **[XCAL]** duration is a data type using the string representation defined in the iCalendar (**[RFC5545]**) Duration.
Interval	The Interval is a single Duration derived from the common calendar Components as defined in iCalendar (**[RFC5545]**). An Interval is part of a Sequence.
Sequence	A set of Intervals with defined temporal relationships. Sequences may have gaps between Intervals, or even simultaneous activities. A Sequence is re-locatable, i.e., it does not have a specific date and time. A Sequence may consist of a single Interval, and can be scheduled by scheduling that single Interval in that sequence.
Gluon	A Gluon influences the serialization of Intervals in a Sequence, through inheritance and through schedule setting. The Gluon is similar to the Interval, but has no service or schedule effects until applied to an Interval or Sequence.
Artifact	The thing that occurs during an Interval. **[WS-Calendar]** uses the Artifact as a placeholder. EMIX Product Descriptions populate Schedules as Artifacts inside Intervals.
Link	A reference to an internal object within the same calendar, or an external object in a remote system. The Link is used by one **[WS-Calendar]** Component to reference another.
Relationship	Links between Components.
Availability	Availability in this specification refers to the Vavailability Component, itself a collection of recurring Availability parameters each of which expresses set of Availability Windows. In this specification, these Windows may indicate when an Interval or Sequence can be Scheduled, or when a partner can be notified, or even when it is cannot be Scheduled.

WS-Calendar Term	Description
Inheritance	A pattern by which information in Sequence is completed or modified by information in a Gluon.

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

Using the relation between Gluon and Sequence in WS-Calendar, external information can be applied to an existing Sequence. For example, a resource representing a responsive load may state that 15 minutes lead time is required between notification and load reduction. This characteristic may hold true whether the response requested is for a run-time of 10 minutes or for one of 10 hours. EMIX specifies invariant characteristics as part of a product description or resource, while offering the variable run-time to the market.

A Sequence populated with product descriptions is referred to as a Schedule. Because Schedules embody the same calendaring standards used by most business and personal calendaring systems, there is a base of compatibility between EMIX communications and business and personal systems. For example, the Power Product (see section 10 *Power Product Descriptions*), an EMIX Base-derived type, may convey a Product Description for a constant rate of delivery power product over a single Interval 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 exchanged in advance, the information exchanged to deliver the product is simply “start (reference **[URI]** to product) at 3:00 AM for 0.75 hours.”

3.3 Simple Semantic Elements of EMIX

A number of simple semantic types appear throughout this specification. These are defined here.

Table 3-5: Simple Semantic Elements of EMIX

Element	Definition
Market Context	A URI uniquely identifying a source for market terms, market rules, market prices, etc. The URI may or may not resolve.
Transactive State	An indicator included in an EMIX Base derived types to aid in processing. The enumerated Transactive States are: Indication Of Interest, Tender, Transaction, Exercise, Delivery, Transport Commitment, and Publication.
Currency	Market expressions of price are in the context of a particular currency. Currency is always expressed as the **[ISO 42173]** Alpha Currency Code.
Side	An indicator of the interest of the party originating the artifact. Possible enumerations are Buy and Sell.
Integral Only	An indication that the element described is [tendered] as an all or nothing product. It may apply to an (amount, response, ramp) that is all (true) or nothing (false).
Autonomous	An indicator that the tendering party is able to detect a need and self-dispatch to meet or correct that need.
Envelope	A generic name for all of the EMIX-Base derived types.

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

3.4 Extensibility of EMIX Framework

EMIX is modular by design. EMIX can be extended in conforming standards. Information models from EMIX-conforming standards can be exchanged in any interaction designed to exchange EMIX information models.

New efforts can specify novel Product Descriptions by extending the EMIX Product Description Type. For example, district energy systems distribute and transact thermal energy products. A district energy group could define an EMIX-compliant product definition. These definitions could be used to populate the Schedule of an EMIX Product or EMIX Option without re-considering any aspects of the EMIX specification itself. A specification used to exchange EMIX information could exchange these new information models without change.

Warrants can evolve in a similar way. Some postulate that water costs of energy sources may be of more future interest than the Warrants anticipated in this specification. A water Warrant can be defined that extends the Base Warrant type. This water Warrant can accompany EMIX information models inside the envelope without any change to the underlying specification.

The Power and Resource schemas are, in effect, the first extensions to the EMIX Schema.

Extensibility mechanisms supported in EMIX are discussed in Appendix B.

4 Envelopes: EMIX Base and its Derivatives

EMIX describes the market communications of tenders and transactions for products whose market value varies with time. An energy product is delivered over time at a specific location. Five kW at 2:00 AM does not have the same value as five kW at 2:00 PM due to differences in its composition and potential usage by individual consumers. 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.

A Product Description included in each Interval in a Sequence could describe similar elements repeatedly. 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. A Sequence populated with product descriptions is referred to as a Schedule.

4.1 UML Summary of the EMIX Base and Extensions

Figure 4-1: UML of EMIX Base and its Extensions

4.2 The EMIX Base

The EMIX Base, as defined in *Table 3-1: EMIX Core Abstract Types* and shown in Figure 4-1: UML of EMIX Base and its Extensions is the foundation for the Envelopes. The EMIX Base conveys a **[WS-Calendar]** Sequence populated with Product Descriptions. This populated Sequence, sometimes referred to as the Schedule, provides a flexible information model for describing any energy tender or transaction.

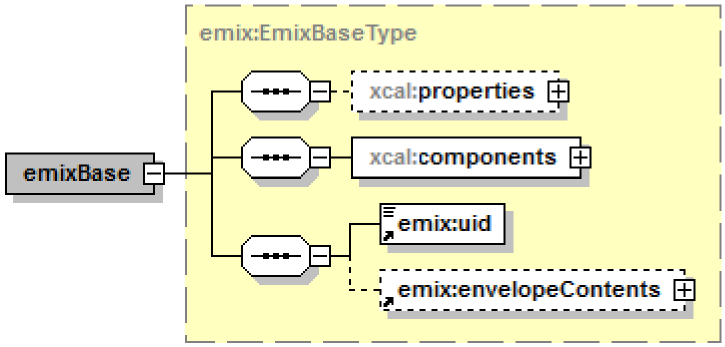


Figure 4-2: EMIX Base Type

There are three types of Envelopes defined in EMIX: the Product, the Option, and the Delivery. Sections 4.3-4.5 define the information on the “face of the envelope”, also referred to as the Intrinsic Information. The Envelope Contents, also referred to as the Extrinsic Information, are discussed in Section 15.

Table 4-1: Elements of the EMIX Base.

Element	Definition
UID	A unique identifier for an EMIX element. Note: different markets and specifications that use EMIX may have their own rules for specifying a UID.
Schedule	A **[WS-Calendar]** Sequence populated with a Product Description. See Table 3-1.
Envelope Contents	The extrinsic information that may distinguish the product from being a pure commodity. See Section 3.1.5.

New or specialized products can be offered and transacted without changing the EMIX standard. A new Type can be derived from the Product Description, be applied to a Schedule, and conveyed with EMIX Envelope.

4.3 The EMIX Product

The EMIX Product is derived from the EMIX Base type and conveys a Schedule as described in Section 4.2. Section 2.1.1 discusses terminology and characteristics of a Product as defined in this specification.

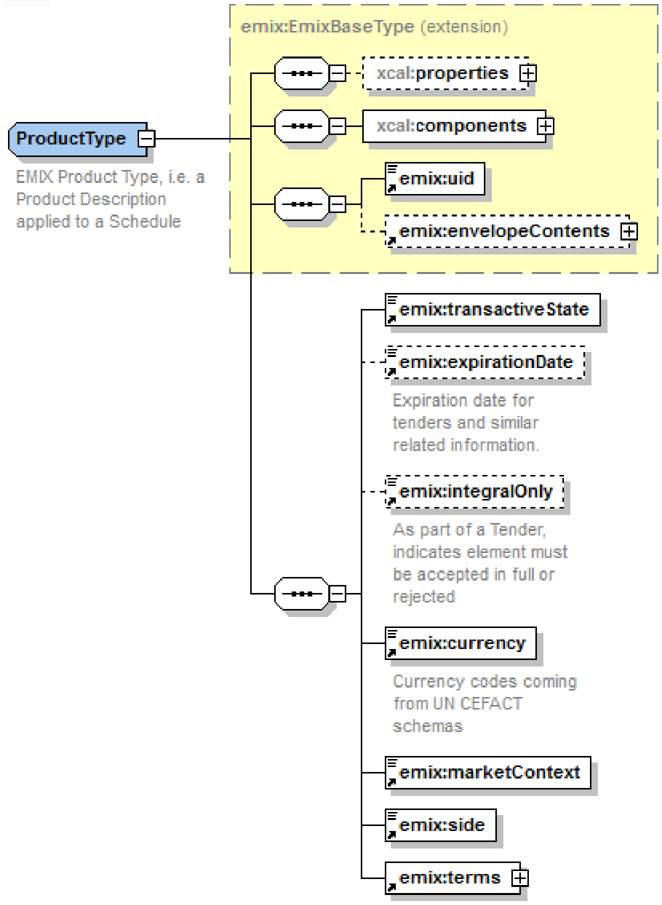


Figure 4-3: EMIX Product

The EMIX Product is the most common of the envelopes. It is used for simple tenders and agreements. It describes specific product delivery.

Table 4-2: Elements of the EMIX Product

Product Element	Description
EMIX Base	Incorporated EMIX Base Type. See *Table 4-1: Elements of the EMIX Base*.
Transactive State	As defined in *Table 3-5: Simple Semantic Elements of EMIX.*
Tender Expiration Date	The date and time when a Tender expires. Meaningful only when the value of Transactive State is Tender.
Integral Only	Indicates that Schedule is accepted entirely or not at all. Meaningful only when the value of Transactive State is Tender.
Market Context	As defined in *Table 3-5: Simple Semantic Elements of EMIX.*
Side	Buyer or Seller.
Currency	Currency denominating product, *Table 3-5: Simple Semantic Elements of EMIX.*
Terms	A collection of business and performance rules that define the product offering. See Section 5, “EMIX Terms”.

4.4 The EMIX Option

The EMIX Option is an elaboration of the EMIX Product described above. An option is an instrument that gives the buyer the right, but not the obligation, to buy or sell a product at a set price during given time windows. Many typical energy agreements, including demand response and reserves, include elements that would give them the name option in any other market.

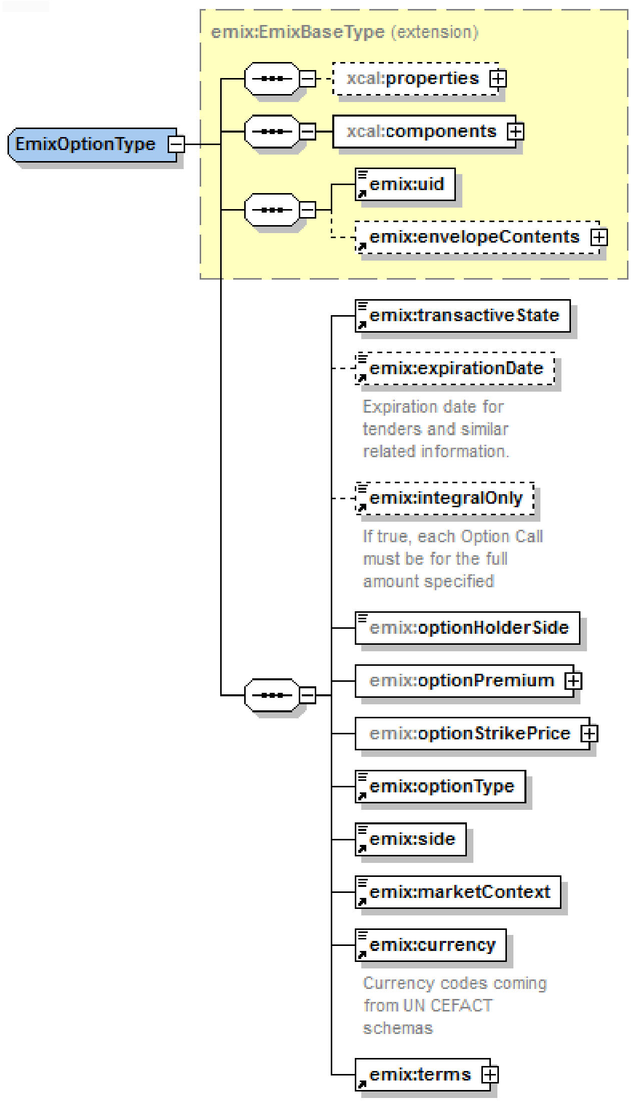


Figure 4-4: EMIX Option Type

The EMIX Option also conveys specific availability and performance. The "face of the Envelope" contains additional information to support these requirements.

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

Option Element	Description
EMIX Base	Incorporated EMIX Base Type. See *Table 4-1: Elements of the EMIX Base*.
Transactive State	As defined in *Table 3-5: Simple Semantic Elements of EMIX.*

Option Element	Description
Tender Expiration Date	The date and time when a Tender expires. Meaningful only when the value of Transactive State is Tender.
Market Context	As defined in *Table 3-5: Simple Semantic Elements of EMIX.*
Currency	Currency denominating product, *Table 3-5: Simple Semantic Elements of EMIX.*
Terms	A collection of business and performance rules that define the product offering. See Section 5, “EMIX Terms”.
Integral Only	Indicates that a Schedule is accepted entirely or not at all. Meaningful only when the value of Transactive State is Tender.
Option Exercise Schedule	The schedule of time windows for the option expressed using the “Availability Schedule” in Terms. See Section 5.2.
Option Holder Side	The side which enjoys the benefit of choosing whether to exercise the terms specified in the option.
Option Premium	The Price paid by the Option Holder Side for the rights involved.
Option Strike Price	The Price that the Option Holder Side pays to exercise the option.
Exercise Lead Time	The minimum Duration in advance of a proposed response that a notification will be accepted for the exercise of the option. Expressed using the “Minimum Notification Duration” in Terms. See Section 5.1.
Side	Identifies whether information originator is on the Buy or Sell side.
Option Type	An enumerated list of Option types.

4.5 EMIX Delivery

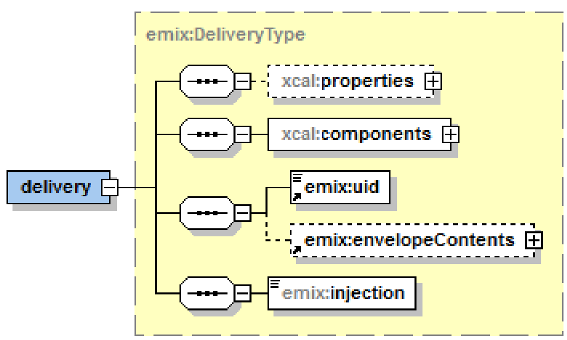


Figure 4-5: Delivery

In any market, order must be matched to delivery. EMIX Delivery reports the historical delivery of product over time.

Table 4-4: Elements of the EMIX Delivery

Delivery Element	Description
EMIX Base	Incorporated EMIX Base Type. See *Table 4-1: Elements of the EMIX Base*.
Injection	True means positive Delivery is injection into the grid. False means positive Delivery is extraction from Grid

5 EMIX Terms

EMIX Products can be subject to a number of Terms and Market Requirements. These Terms can apply at each transactive state. Terms are extensible, so additional schemas, specifications, and standards can extend the list while remaining in conformance.

Terms are extrinsic to the product delivery but affect how a partner may request performance of a service. Terms may originate in the basic mechanical needs of the Resource or in the business needs of the source. These Terms can affect the market value of the resource or the repeated invocation of a resource. It is possible for a given underlying resource to be offered to the market with different terms and therefore different values.

5.1 EMIX Performance Oriented Terms

Some terms indicate the ability of a side to perform. As many market interactions may have a penalty for non-performance or for performance that is not timely, it is essential for parties using EMIX information to negotiate services to be able to define performance.

Table 5-1: Performance-Oriented Terms

Term	Description
Minimum Response Duration	The shortest Duration for which a request will be accepted.
Maximum Response Duration	The longest Duration for which a request will be accepted.
Minimum Recovery Duration	The minimum Duration after completion of a response before a new response can be begun.
Minimum Duration Between Invocations	The minimum Duration between successive responses that will be accepted.
Minimum Notification Duration	The minimum Duration in advance of a proposed response that a notification will be accepted.
Maximum Notification Duration	The maximum Duration in advance of a proposed response that a notification will be accepted.
Response Time	Duration required from receipt of a request to supplying the full requested level of response; i.e., notification time plus response time.
Maximum Invocations Per Duration	Maximum number of requests for response that will be accepted during a Duration.
Maximum Consecutive Durations	Maximum consecutive Durations in which a notification will be accepted; e.g., it will not accept requests on more than three consecutive days.
Maximum Run Duration	Maximum acceptable Duration for a proposed response
Minimum Run Duration	Minimum acceptable Duration for a proposed response

5.2 EMIX Schedule Oriented Terms

Schedule related terms indicate schedules when a product may be available or when an interaction may occur. A product may only be available on weekends, or a party may not be able to respond outside of normal office hours.

Table 5-2: Schedule-Oriented Terms

Term	Description
Availability Schedule	A schedule of time windows during which a response may be scheduled. A scheduled Duration must be entirely within a single instance of an availability window.
Unavailability Schedule	A schedule of time windows for which no request for response will be accepted. No part of a requested Duration must coincide with an unavailability window.
Notification Schedule	A schedule of time windows during which requests can be made.

5.3 Market Requirements

Market Requirements are terms tied to the economic expectations expressed in certain market tenders. Market Requirements are the market portion of Terms, i.e., they are used to state the offeror's expectations about a tender. It is possible for a given underlying resource to be offered to the market with different Requirements and therefore different values.

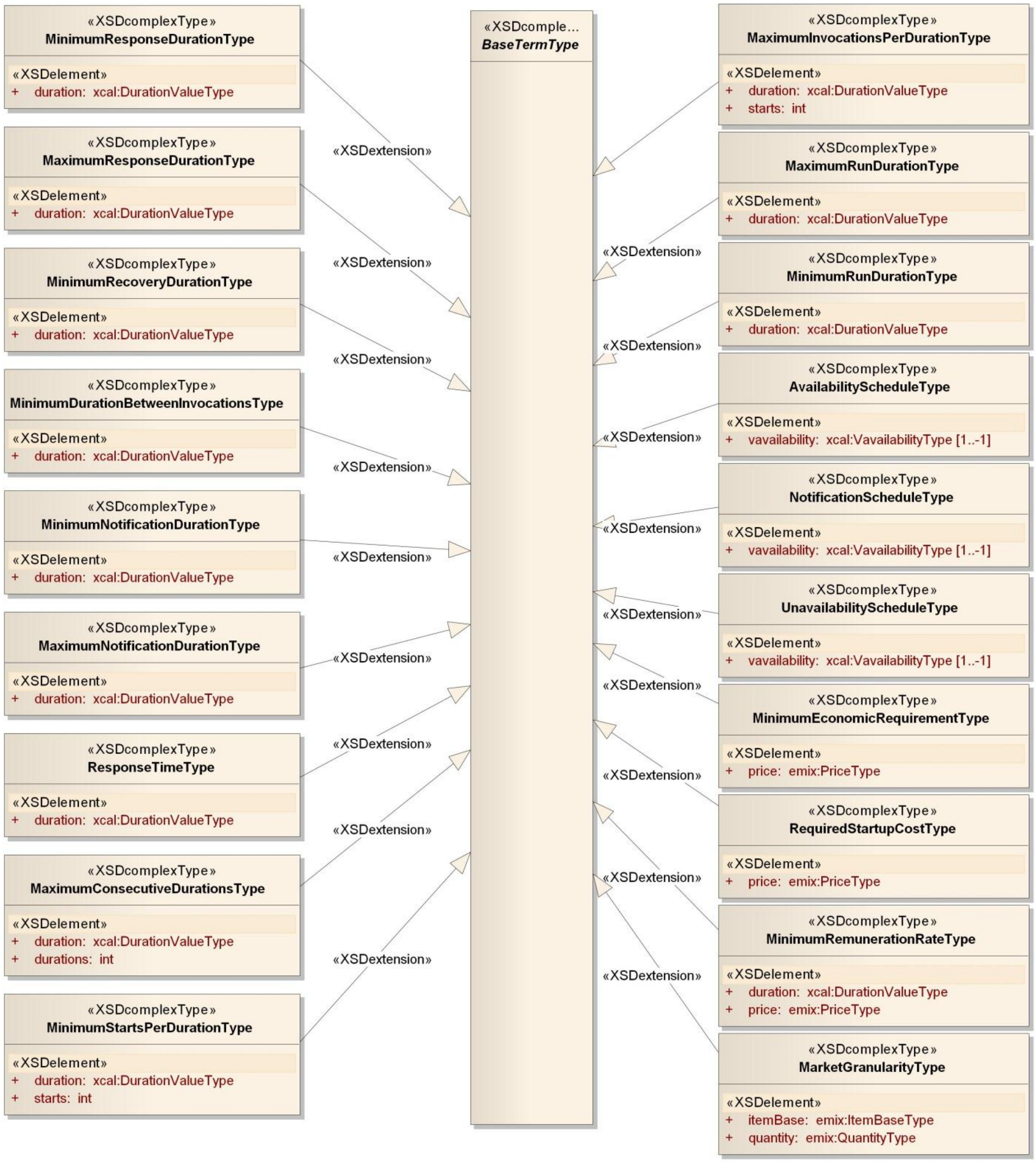
Table 5-3: Market Requirements for EMIX Products

Market Requirement	Description
Market Granularity	The size of a market “bundle”. For example, a Market with a granularity of 10 MW, will only accept tenders, process transactions, and pay for delivery of Power in multiples of 10MW.
Minimum Economic Requirement	Minimum net remuneration for any single response
Required Startup Remuneration	Minimum remuneration required for initiating a response.
Minimum Starts Per Duration	The fewest requests that the resource will accept during any Duration.
Minimum Remuneration Rate	Minimum remuneration acceptable per stated Duration of response. For example, a minimum remuneration of $100 per hour.

5.4 Extensibility of Terms

The EMIX Terms above are not tied to any particular kind of Product or Resource. All are based on the abstract Base Term type. Specifications that require additional terms can create them by extending the Base Term Type to create new terms.

Specific Terms for use with Power Products created by extending the Base Term Type are found in *Table 13-2: Terms unique to Power Resources.*



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574 *Figure 5-1: Summary of EMIX Terms*

6 Schedules in EMIX: Intervals, Gluons, and WS-Calendar

This section discusses how EMIX uses **[WS-Calendar]** to create Schedules. EMIX does not "schedule". EMIX includes information to communicate Schedules. Algorithms and methods are completely outside the scope of EMIX. EMIX uses **[WS-Calendar]** to create information models that describe schedules and that are populated with Product Descriptions. The Semantics drawn from **[WS-Calendar]** are summarized in *Table 3-4: WS-Calendar defined Terms used in EMIX.* This section describes how EMIX uses the recombination and conformance rules from **[WS-Calendar]** to create Schedules.

6.1 Intervals, Gluons, and Sequences

Types derived from the abstract EMIX Base contain a Schedule created by populating a Sequence with Product Descriptions. The terms Duration, Interval, Sequence, and Gluon are defined in **[WS-Calendar]**. **[WS-Calendar]** defines a model for inheritance wherein a fixed description of a product is refined with additional information as it becomes actionable. The Intervals in a Sequence can inherit information from a Gluon related to that Sequence.

The iCalendar standard, with which **[WS-Calendar]** conforms, is an information model of a "bag of Components". Each Component can include an attachment for passing some kind of information. Intervals and Gluons are two of the **[WS-Calendar]** Components. The schema type for Product Descriptions is derived from the attachment so Product Description-derived types are valid contents of these Components.

In **[WS-Calendar]**, a Gluon relates to a Sequence by relating to a specific Designated Interval within that sequence. All other Intervals have defined temporal relationships, directly or indirectly, to the Designated Interval. If a Gluon contains a start date and time, that start date and time is inherited only by the Designated Interval; the start dates and times for all other Intervals in the Sequence can be computed from that single date and time. In this way, a set of Intervals containing EMIX Product Descriptions can define what is in effect a schedule sub-routine, invoked by starting the Designated Interval.

In EMIX, when a Gluon contains a Product Description, it can then be inherited by each of the Intervals. If an Interval already contains a Product Description, then it refuses the Inheritance from the Gluon. This model of inheritance mimics that defined in **[WS-Calendar]** for inheriting Duration.

Duration, Product Description, Price, and Quantity for each Interval in a Sequence can each be inherited from a Gluon in EMIX. The Start Date and Time can be inherited only by the Designated Interval. This follows and extends the rules of inheritance defined in **[WS-Calendar]**.

There is no requirement for the Designated Interval to be the "first" interval. If a Sequence describes a ramp-up, peak operation (of whatever service), and ramp down, it may be more useful to designate the Interval containing peak operation. In this scenario, the Durations of all Intervals other than the Designated Interval may be fixed, that is encoded in each interval. A communication to "start" the Sequence, then, could contain the start date and time and the run Duration.

The rules of inheritance are described in *Section 17.1 EMIX Conformance with [*WS-Calendar. Inheritance in **[WS-Calendar]** is described in that specification.

6.2 Availability (Vavailability) and Temporal Granularity

[WS-Calendar] defines the expression of the Vavailability information model for repeating instances of time (Availability Windows) within a period that may or may not have an end date. Vavailability is a Component of iCalendar. EMIX uses Vavailability primarily in Terms.

One party MAY use Vavailability to indicate to another party when a service can be requested. This may be a contracted part of an EMIX Option or it may define the Demand Response window (afternoons during summer months) of a regulated tariff. EMIX does not define the interactions or negotiations that lead to either of those circumstances.

Availability communicates acceptable schedule times for Sequences. The semantics of scheduling a Sequence to comply with previously stated Availability in **[WS-Calendar]** is that the Designated Interval must be inside one of the Availability Windows. While it is possible that not all information regarding Intervals in a Sequence may be exposed in interactions, a party requesting an EMIX product does know the Duration and Start Date and Time of the Designated Interval.

WS-Calendar EMIX are information models, and do not create market rules or define interactions. The specification makes no statement about how a market, or even how a market participant handles receipt of a Schedule which does not comply with a stated availability. Such an Availability and Schedule are likely in separate communications, each containing valid informational artifacts. The word "comply" in the previous paragraph describes the meaning of the information exchanged, and not any behavior or market rule.

Again, see **[WS-Calendar]** for a complete description.

6.3 Temporal Granularity

[WS-Calendar] defines temporal Granularity which is expressed as a Duration. When Granularity is applied to a Vavailability object, then:

1) The valid start times are offsets from the start of the availability window that are integral multiples of that duration. For an Availability of 14:00 to 16:00, with a granularity of fifteen minutes *"PT15M"*, there are 8 valid starting times (14:00, 14:15, 14:30, 14:45, 15:00, 15:15, 15:30, 15:45).
2) If duration is specified by the requestor, it must be an integral multiple of the Granularity. In the example above, "PT15M", "PT30M", "PT45M", "PT1H", PT1H15M", etc. are valid Durations.
3) The Start Date and Time plus the Duration must complete no later than the end of the Availability window.

6.4 Illustration of WS-Calendar and EMIX

The illustration below provides a model demonstrating a sequence of three Intervals, and the successive application of Gluons to bring them to market.

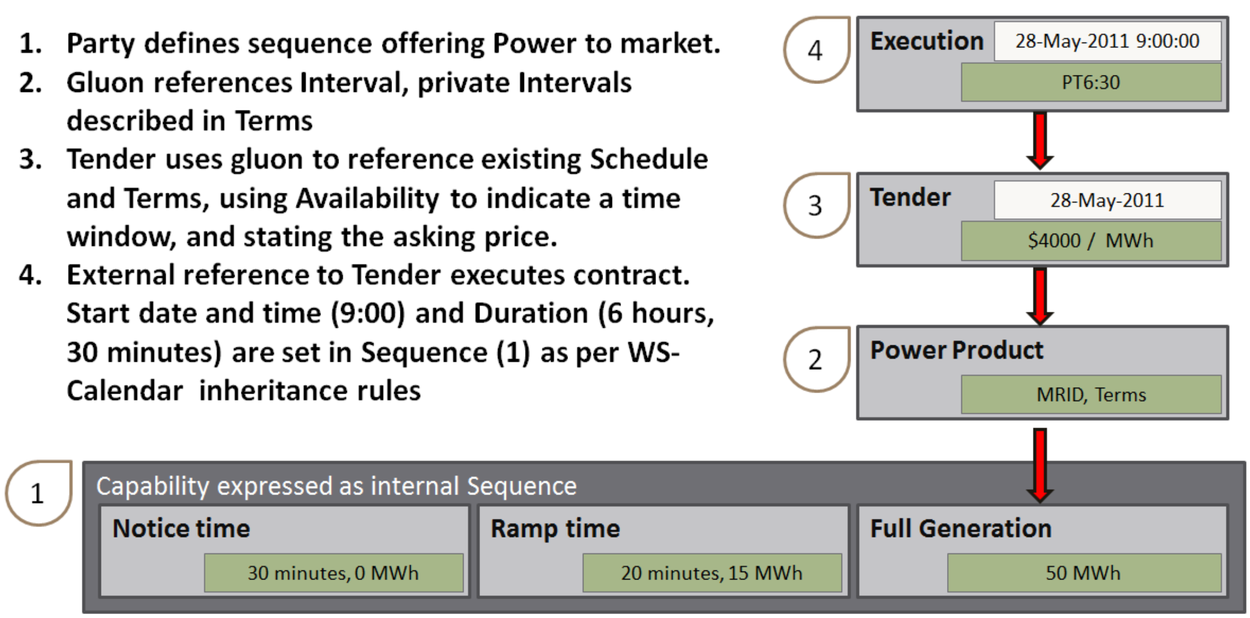

Figure 6-1: EMIX Schedule and Building a Product

7 Standardizing Terms for Market Context

In any market context, there are standing terms and expectations about product offerings. If these standing terms and expectations are not known, many exchanges need to occur of products that do not meet those expectations. If those expectations are only known by local knowledge, then then national and international products need to be re-configured for each local market that they enter. If all market information is transmitted in every information exchange, messages based on EMIX would be repetitious.

As defined in *Table 3-5: Simple Semantic Elements of EMIX*, a Market Context is no more than a URI uniquely identifying a source for market terms, market rules, market prices, etc. This section defines an information model for the common rules and expectations for all interactions within a single Market Context.

7.1 Overview of Standard Terms

Standard Terms defines an information model for exchanging these common expectations outside of any single product-related artifact. The TC acknowledges that these can be only a small portion the total market rules.

The basis of Standard Terms is the Standard Terms Set shown in the following table.

Table 7-1: Elements of the Standard Term Set

Component	Description
Terms	A collection of Terms as defined in Section 5: *EMIX Terms.*
Availability	**[WS-Calendar]** Vavailability (see Table 3-4: WS-Calendar defined Terms used in EMIX) indicating when this Market Term Set is valid, i.e., weekdays from 11:00 AM to 6:00 PM.. If absent, the Market Term Set is valid at all times.
Non-Standard Terms Handling	A string enumeration indicating how to handle terms received that are different than those in the Market Term Set. Permissible values are: Reject (the information artifact), Ignore (the terms), Must Understand, Must Accept.
Side	“Buy” or “Sell”. Note: Some Terms can have different interpretations based on who is offering them. A Buyer may indicate "meet or exceed" while a seller expressing the same term may indicate "no worse than".

Standard Terms Sets can be assembled with other information to create the Standard Terms shown in the following table.

Table 7-2: Elements of Standard Terms

Element	Description
Market Context	URI uniquely identifying context, per Table 3-5: Simple Semantic Elements of EMIX.
Standard Terms Set	Zero (0) to many. As defined in Table 1-1
Product Description	As defined in *Table 10-1: Summary of Power Product Description Types*. If present, this is the only Product Description in this market context. If Product Quantity is included, it SHALL be ignored.

Element	Description
Temporal Granularity	As defined in **[WS-Calendar]**. For example, this may be the temporal granularity of market; i.e., a 5-minute market operates in 5-minute chunks, with a fixed offset from the beginning of the Availability time window.
Time Zone	TZID as defined in **[WS-Calendar].** Time Zone for communications in this market. Note: this applies to "floating" time, that is expressions of time that are not in UTC or do not have a Time Zone indicated.
Currency	Currency for all information models. If present, becomes the default for all information models. As defined in Table 3-5: Simple Semantic Elements of EMIX.
Non-Standard Terms Handling	As defined in *Table 7-1: Elements of the Standard Term Set*

Specifications that claim conformance with EMIX MAY define inheritance patterns by which EMIX compliant information models inherit certain information from the Standard Terms.

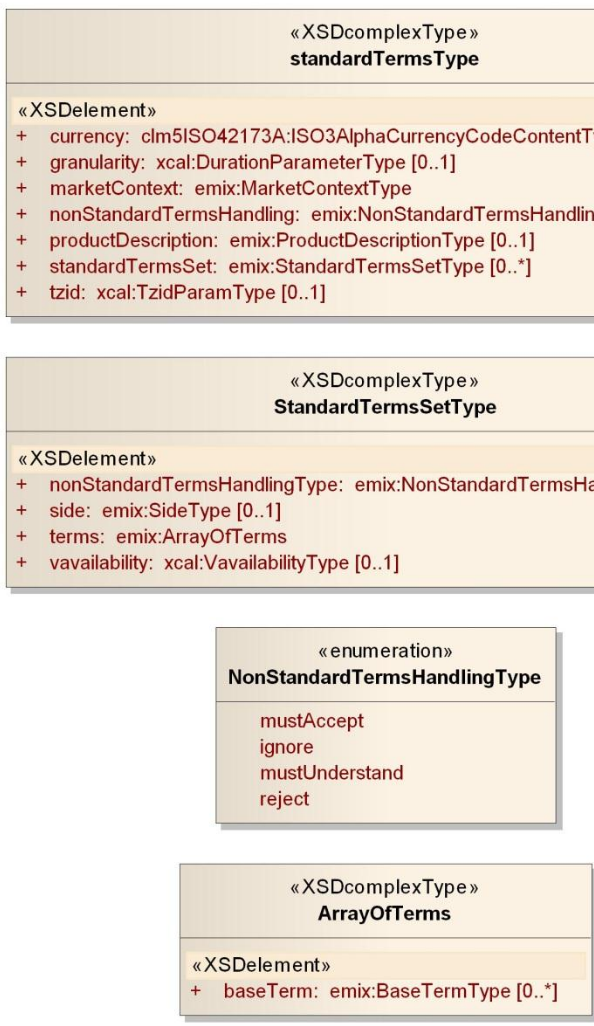

Figure 7-1: Standard Terms

8 Extending EMIX for Electrical Power

EMIX provides an abstract information model that can be extended to convey Price and Product information for commodities whose value varies with the time and location of delivery.

The EMIX Power schema (POWER.XSD) can be viewed as the first extension of EMIX into a particular domain. The schema extends the Base EMIX Product Descriptions to define a variety of power products, in particular extending the Item Base to create Items for Real Power, Apparent Power, and Reactive Power among others. The schema derives new Product Descriptions products with ways to describe levels and tiers.

Electrical power markets have their own definitions for where the transaction occurs. The EMIX Power schema (POWER.XSD) extends the EMIX Interface to accommodate these definitions.

The resulting extensions can populate a Schedule and define EMIX Products, Options, and Delivery.

8.1 EMIX Interfaces for Power

Every market transaction occurs at an interface, where beneficial rights to or use of a product are transferred between buyer and seller. This is often the point at which the flow of product is measured although it may not be.

In power markets, described in the sections below, the Interface can be a node or meter, an aggregation of nodes or meters, a pair of nodes, or a geographic area. The Service area defined in the underlying EMIX.XSD schema is also available for use by power-based products.

Table 8-1: Elemental types of EMIX Interfaces defined in POWER

Elemental Type	Description
MRID	As defined in the **[IEC TC57]**, can identify a physical device that may be a Customer Meter or other types of End Devices."
Node	As defined in the **[IEC TC57]**, a place where something changes (often ownership) or connects on the grid. Many nodes are associated with meters, but not all are.

Power Interfaces are, for the most part, named instances of one of the elements above included in the EMIX Interface.

Table 8-2: EMIX Interfaces defined in POWER

Power Interface	Description
EMIX Interface	Each of the interfaces below derives from the abstract class as defined in *.* *Table 3-3: The EMIX* Interface.
Service Area	Inherited from EMIX schema. See *.* *Table 3-3: The EMIX* Interface.
End Device Asset	Physical device or devices, which could be meters or other types of devices that may be of interest. Examples of End Device Assets include a Meter Asset that can perform metering, load management, connect/disconnect, accounting functions, etc. Some End Device Assets may be connected to a Meter Asset.
Meter Asset	Physical device or devices that perform the role of the meter.

Power Interface	Description
Pricing Node (PNode)	Pricing location for which market participants submit their bids, offers, buy/sell CRRs, and settle. Note: a pricing node is directly associated with a connectivity node.
Aggregated Pricing Node	Specialized type of Pricing Node used to model items such as system zone, default price zone, custom price zone, control area, aggregated generation, aggregated participating load, aggregated non-participating load, trading hub, or DCA zone.
Service Location	A location on the network where the ownership of the service changes hands, expressed as a **[GML]** Abstract Feature. Note: it potentially has many Service Delivery Points, delivering service in accordance with a Customer Agreement. Each Service Location may have zero to many Meter Assets.
Service Delivery Point	Logical point on the network where the ownership of the service changes hands. There is only one Service Location for each Service Delivery Point, delivering service in accordance with a Customer Agreement. Used at the place where a meter may be installed. Each Service Delivery Point may have zero to many Meter Assets.
Transport Interface	Delineates the edges at either end of a transport segment. Note: unique among Interfaces in that it names two Nodes rather than one: point of receipt and point of delivery.

See Figure 3-3: Summary of EMIX Interfaces including both Emix and Power for all Interfaces defined in this specification.

8.2 Power Items derived from Item Base

Types derived from the abstract Item Base type are used not only to quantify the items, but potential attributes of items as well.

8.2.1 Power Items

The POWER.XSD schema defines a number of items to define the exchange of POWER. These Power Items are derived from the abstract Power Item, itself derived from Item Base.

Table 8-3: Elements of the Power Item

Power Element	Description
Item Base	Abstract Item as defined in *Table 4-1: Elements of the EMIX Base*.
Item Description	Name of the Power Item.
Item Units	String representation of Units.
Scale Code	Alphabetic representations of Scale from the SI Scale code list; e.g., M for Mega, K for Kilo, etc.
Power Attributes	Gross attributes of Power: AC/DC, Hertz, nominal Voltage.

The named Items derived from the Power Item type are shown in the table below.

Table 8-4: Defined Power Items

Item Name	Units	Description
Real Power	W or J/s	Real power, expressed in Watts (W) or Joules/second (J/s).

Item Name	Units	Description
Reactive Power	VAR	Reactive power, expressed in volt-amperes reactive (VAR).
Apparent Power	VA	Apparent power, expressed in volt-amperes (VA).

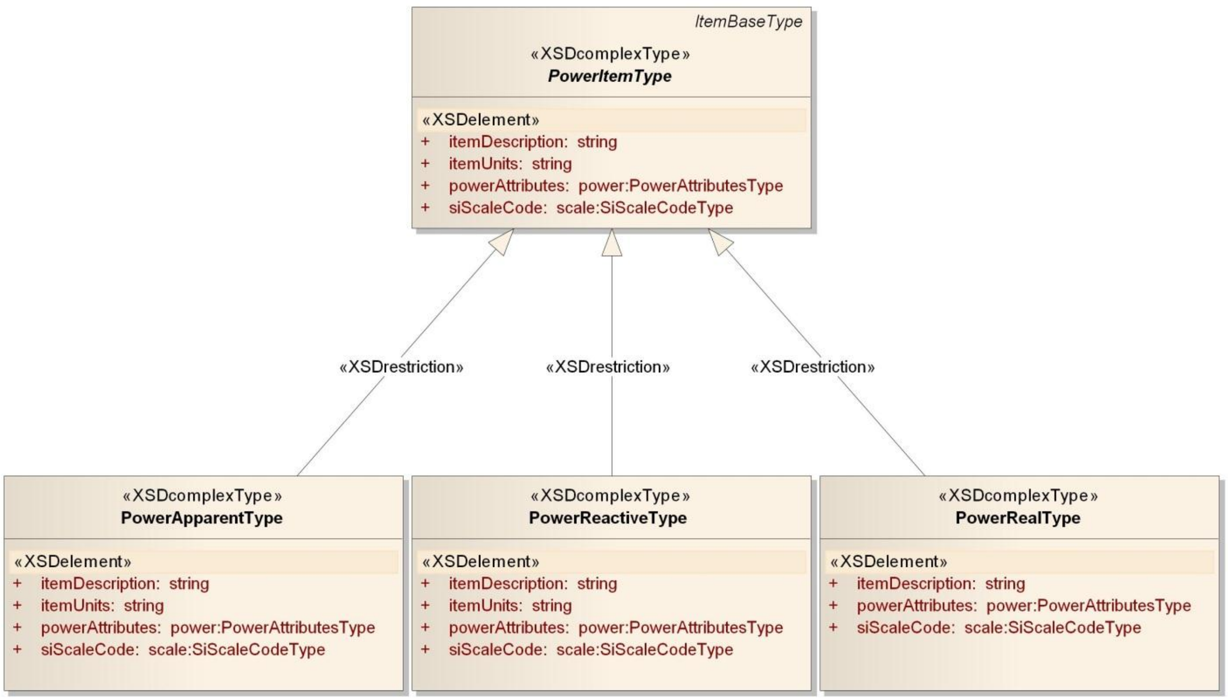

Figure 8-1: UML Summary of Power Items

8.3 Energy Items derived from Item Base

Types derived from the abstract Item Base type are used not only to quantify the items, but potential attributes of Energy as well.

8.3.1 Energy Items

The POWER.XSD schema defines a number of items to define the exchange of electrical energy. These Energy Items are derived from the abstract Energy Item, itself derived from Item Base. The following table enumerates the Energy Elements.

Table 8-5: Elements of the Energy Item

Energy Element	Description
Item Base	Abstract Item as defined in *Table 4-1: Elements of the EMIX Base*.
Item Description	Name of the Energy Item.
Item Units	String representation of Units.
Scale Code	Alphabetic representations of Scale from the SI Scale code list; e.g., M for Mega, K for Kilo, etc.

The named Items derived from the Energy Item type are shown in the following table.

Table 8-6: Defined Energy Items

Item Name	Units	Description
Real Energy	Wh or J	Real energy, expressed in Watt Hours (Wh) or Joules (J).
Reactive Energy	VARh	Reactive energy, expressed in volt-amperes reactive hours (VARh).
Apparent Energy	VAh	Apparent energy, expressed in volt-ampere hours (VAh).

8.3.2 Illustrative Diagram of Energy Items

Many types in POWER.XSD derive from the Item Base. Figure 8-2 shows the Energy Item Type, from which Real Energy, Apparent Energy, and Reactive Energy are derived.

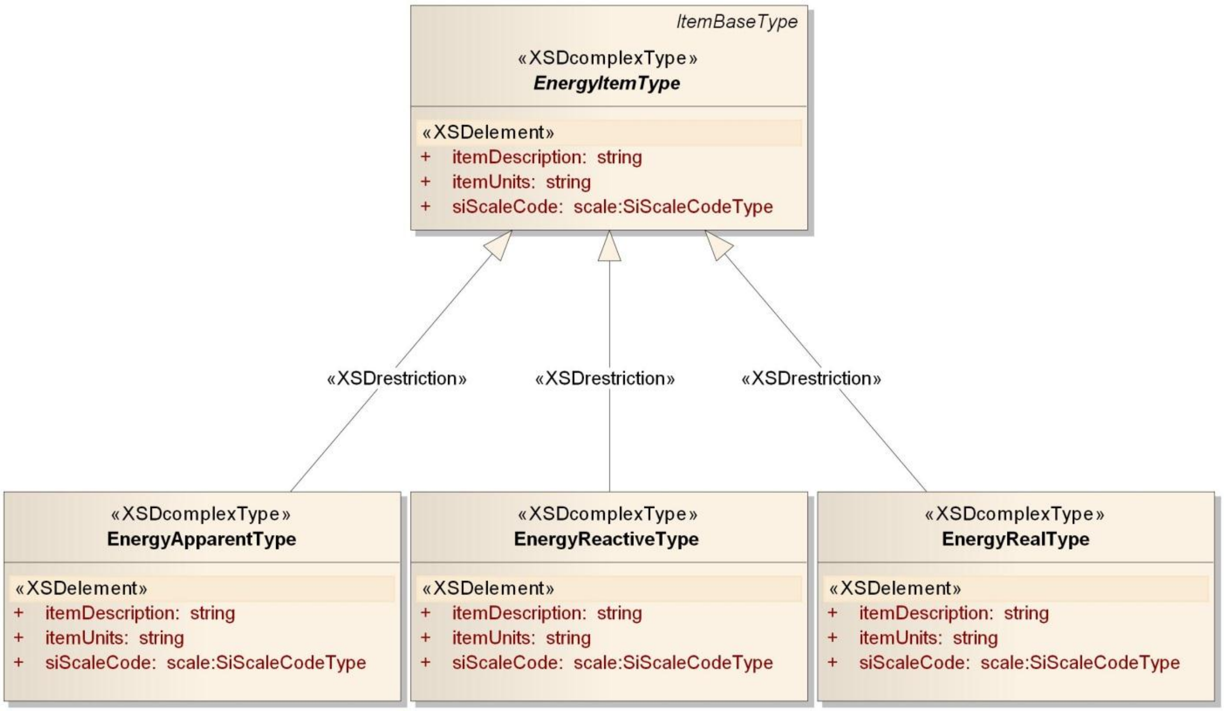

Figure 8-2: UML summary of Energy Item Types

8.4 Other Item-derived types

Voltage is another type in POWER.XSD derived directly from the underlying Item Base. The Elements of Voltage are shown in the table below.

Table 8-7: Voltage as an Item

Voltage Element	Description
Item Base	Abstract Item as defined in *Table 4-1: Elements of the EMIX Base*.
Item Description	Voltage
Item Units	V
Scale Code	Alphabetic representations of Scale from the SI Scale code list; e.g., M for Mega, K for Kilo, etc.

9 EMIX Power Product Descriptions

This section provides a guide to the rest of the Specification.

Electrical power and energy must be described precisely as it comes to market. Different products can provide total power, real power, or reactive power. Products delivering the same Power at a different voltage, or in DC rather than AC, may be valued differently. For the convenience of the readers, terms associated with electrical power and energy, and the relationships between them, are reviewed in Appendix E.

EMIX provides an information model for exchanging Price and Product information for power and energy markets, where the value of the Products is tied closely to the time of delivery. EMIX Power defines specific EMIX Products for Power delivery. EMIX Resources define capabilities that could be brought to market and the performance characteristics those resources will have, and thus enable a buyer to determine with which resources to seek agreements.

EMIX Products consist of Product Descriptions applied to the EMIX Base Product. There are three classes of Product Description defined as:

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

EMIX Power Products are defined using standard attribute definitions from **[IEC TC57],** where the canonical definitions also reside.

9.1 Power Product Descriptions

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”). While the underlying commodity good is identical, the Product is differentiated based on how it is purchased. Common distinctions include:

a) Specify the rate of delivery over a Duration.
b) Specify the amount of energy over an Interval with no restrictions on the rate of delivery at any instant within the Interval.
c) Made available as Full Requirements Power, the same as b, except that the amount of energy transacted is measured after delivery.

Product Descriptions for transacting Power are found in Section 10 *“Power Product Descriptions”*

9.2 Resource Offer Descriptions

Resources include generators that can produce power and other services, storage devices that can consume, store and then produce power, and loads that produce power through 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 13: *Energy Resources*.

9.3 Transport Product Descriptions

Product Transport provides for the transport of a product from one Interface location to another generally using transmission and distribution facilities. Transport prices may cover recovery of investment and energy loses incurred during transport as well as congestion prices. A single price may characterize a Transport Product or a set of charges. Product descriptions for Transport are discussed in Section 11 *Power Transport Product Description.*

10 Power Product Descriptions

The information model in this section is described in POWER-PRODUCTS.XSD

Almost all Power Products are based on core abstract class, the Power Product Description. The Power Products also share core semantic elements, used throughout the Descriptions and their associated charges. Several of these were described in *Section 8: Extending EMIX for Electrical Power.*

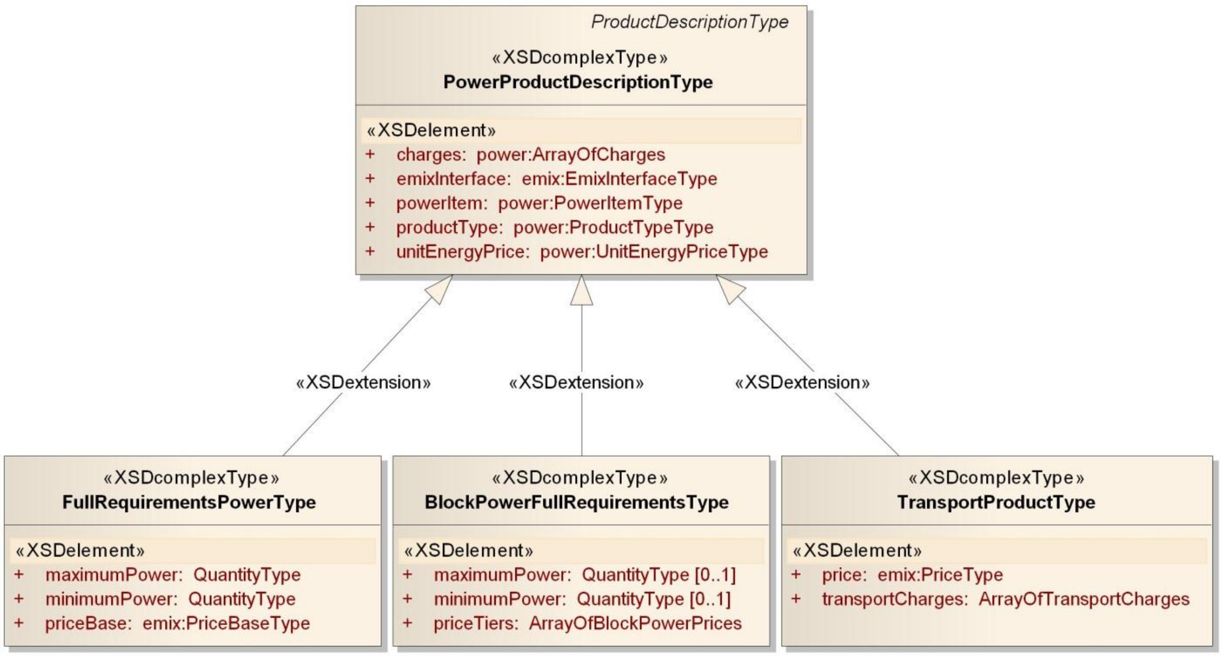

Figure 10-1: UML Summary of Power Product Descriptions

10.1 Overview of Power Product Descriptions

The following sections define the Power Product Descriptions. A summary of those descriptions is provided in the following table..

Table 10-1: Summary of Power Product Description Types

Name	Description
Product Description	All Power Product Descriptions are derived from the EMIX base Product Description type See *Table 3-1: EMIX Core Abstract Types*.
Power Product Description	Used for simple power transactions; also used as template for other Power Product Description Types. After a specified duration, energy has been delivered at a price per unit of energy.
Full Requirements Power	Used to provide for full requirements of buyer. Simple price, will supply all used. Demand Charges optional. Often used in retail residential rates.
Block Power Full Requirements	Used to provide for full requirements of buyer in "blocks". Price is constant within a block, but changes as each block is used during a period. Demand Charges MAY be included. Often used in retail residential rates.

Name	Description
Transport Product	Used for charges and revenue related to Transport Services for a Power Product; i.e., the movement of Power through Transmission and Distribution. The Interface used matches a segment of the transport infrastructure, usually identified by an injection node and a delivery node. Transport Products are discussed in Section 11.
TeMIX Power	Used for a specific sized block of Power at a constant rate of delivery. Derived directly from EMIX Product Description rather than Power Product Description because only Price and Quantity are required.

10.1.1 Enumerated Power Contract Types

Because different Power Product Descriptions use the same informational elements, and because different transaction states may not require all elements be present in every exchange, each Power Product Description includes a Power Contract Type. Different Power Contract Types MAY have different conformance requirements in different market contexts.

Table 10-2: Power Contract Types

Power Contract Type	Note
Energy	Used in TeMIX for simple block of Energy agreement.
Transport	Used in TeMIX for simple transport agreement.
Energy Option	Used in TeMIX for Option to transact simple block of Energy.
Transport Option	Used in TeMIX for Option to acquire rights to Transport.
Full Requirements Power	Used for supplier to provide for full requirements of buyer. Simple price, will supply all used. Often used in retail residential rates.
Full Requirements Power with Demand Charge	Similar to Full Requirements except specific and perhaps recurring Demand Charges are incurred for exceeding set demand limit(s).
Full Requirements Power with Maximum and Minimum	Customer must draw power at no less than the minimum rate and no more than the maximum rate during any measurement Interval.
Hourly Day Ahead Pricing	Same as Full Requirements Power but prices potentially change each hour.
Ex-Ante Real Time Price	Used to report prices after the fact.
Time of Use Pricing	Strategy where the price may change based on time of day on a schedule set by the provider. The provider may define schedule and pricing differences depending upon day of week, holiday or not, month of year and season.
Transport Service	Used to acquire Transport including factors for congestion, loss, charges, fees, etc.
Congestion Revenue Rights	Used to hedge against future Transport / Congestion costs.

The Power Contract Type MAY be extended per the extensibility rules. See Appendix B-1 for a discussion of extending string enumerations.

10.1.2 Power Product Charges

Power Products are often encumbered with a number of special charges. Some charges may be intrinsic to the product, and specifically incorporated into the Power Product Descriptions below. Others arise from specific market conditions and can be applied through a generic charges collection.

Each of the products from Table 10-2, with the exception of TeMIX, can be subject to one or more Power Charges. All Charges are based on the Base Charge abstract type, meaning markets that require non-standard Charges have the means to define extensions to the set of Power Charges.

Table 10-3 summarizes the Power Product Charges.

Table 10-3: Power Product Charges

Charge Type	Description
Base Charge	Null abstract type from which all charges are derived.
Block Power Price	A Price and a Maximum Energy Quantity. When arranged in order by Maximum Energy Quantity, they represent a set or prices for different levels of Energy.
Demand Charge	Charges meant to offset infrastructure needed to support peak use. The structure that describes a Demand Charge is described in Section 10.1.2.1.

10.1.2.1 Demand Charges

The Demand Charge as defined above has a more complex structure than the other Charges. The Demand Charge is defined in *Table 10-4: Elements of Demand Charges.*

Table 10-4: Elements of Demand Charges

Demand Charge Element	Description
Consumption Units	Units of product consumed upon which Demand Charges will be computed.
Consumption Ceiling	Below this quantity, a Consumption Penalty is not applied.
Consumption Penalty	Incremental charge applied if Consumption Ceiling Floor is exceeded.
Measurement Interval	Duration over which average peak demand is measured (e.g., 15 minutes, 30 minutes...)
Collection Interval	Collection of Measurement Intervals. Consumption Penalty is based on single highest average peak demand taken from all the Measurement Intervals contained in the Collection Interval.
Penalty Period	Duration to which the Penalty applies, often a billing cycle.
Penalty Duration	Duration during which consecutive Consumption Penalties will continue to be applied after incurred.

10.1.2.2 Summary of Power Product Charges

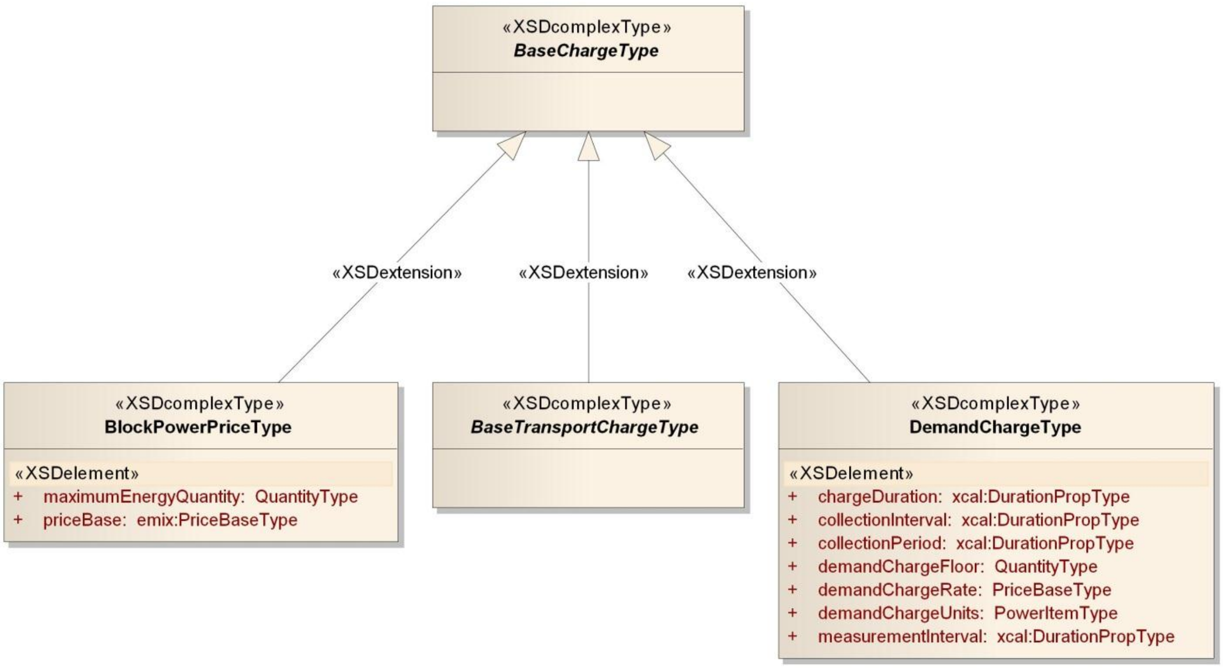

Figure 10-2: UML Summary of Power Product Charges

10.2 The Power Product Description

The Base Power Contract is the foundation for all the other Power Contracts. Each of them has the characteristics of the Base Power Contract plus their own additional elements:

Table 10-5: Base Power Product Description

Name	Description
Product Description	Base type for derivation. See *Table 3-1: EMIX Core Abstract Types*.
Power Product Type	Used to determine conformance and processing. See Table 10-2
EMIX Interface	See Table 8-2: *EMIX Interfaces defined in POWER*.
Unit Energy Price	Price Base, see *Table 3-2: Elements derived from Price Base.*
Power Item	See *Table 8-4: Defined Power Items.*
Charges	Any number of Charges as defined in *Table 10-3: Power Product Charges*

Each Power Product is applied to the EMIX Base Product before it is fully described. Because each element can be set for the whole Sequence, or applied to individual Intervals, each can vary over time.

10.3 Full Requirements Power

Full Requirements Power products are the traditional “all-you-can-eat” electrical contract. Maximum delivery is limited by the physical infrastructure. Demand Charges may apply. This type of product often appears in Residential markets.

As well as the attributes in the base Power Contract, the Full Requirements Product has the elements defined below.

Table 10-6: Full Requirements Power Product Description

Name	Description
Power Product Description	As described in *Table 10-5: Base Power Product Description.*
Maximum Power	The most power available for transacting during the period. Often determined by physical limits.
Minimum Power	The least power that must be transacted during the Interval. Buyer is responsible for making up the difference if the stated value is not consumed.

10.4 Block Power Full Requirements

Block Power Full Requirements products provide for full buyer requirement, but prices the power in “blocks”. Price is constant within a block, but each block may have a different price within a period. Demand Charges MAY be included. This type of Product is often used in retail residential rates.

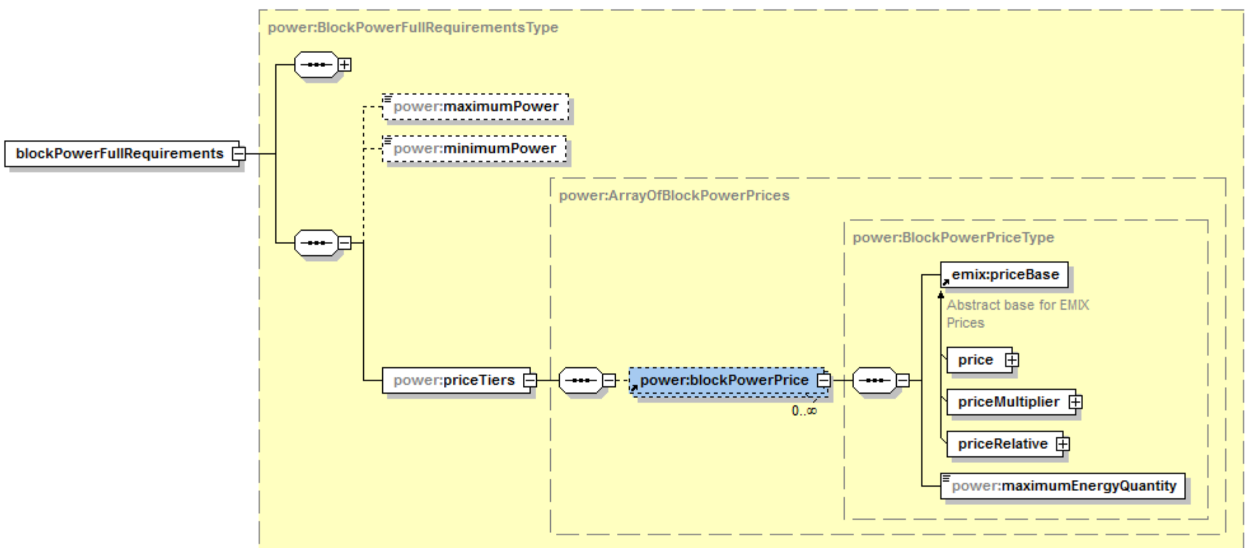

Figure 10-3: Block Power Full Requirements

As well as the attributes in the base Power Contract, the Block Power Full Requirements Product has these additional elements:

Table 10-7: Block Power Full Requirements

Block Power Element	Description
Power Product Description	As described in *Table 10-5: Base Power Product Description.*
Maximum Power	Denominates the most power available for transacting during the period.
Minimum Power	Denominates the least power that must be transacted during the Interval. Buyer is responsible for making up the difference if the stated value is not consumed.
Price Tiers	Any number of Block Power Prices as described in *Table 10-3: Power Product Charges.*

10.5 TeMIX Power Product

The TeMIX (Transactive Energy Market Information Exchange) is a model for balancing power markets with pure economic trading. It uses the simplest of the Power Product Descriptions.

The TeMIX profile allows only specific tenders and transactions for block power on defined Intervals of time. Tenders may be offered by any party to any other party, as market rules and regulations may allow. Any party can be a buyer, seller, or both. Transactions may include call and put options. TeMIX Options perform a similar function to demand response contracts or ancillary service contracts where an operator has dispatch control over the exercise of the option. TeMIX products also include transmission and distribution (transport) products.

TeMIX tenders and transactions can support dynamic tariffs by retail providers to retail customers. TeMIX is designed for interval metering where delivery can be accurately measured. The simplified information model and services of the TeMIX profile also support increased automation of transactions using the computer and communications technology of the smart grid.

TeMIX Products are specified by Power (rate of delivery of energy) over an Interval. TeMIX Products are obligations in that a TeMIX Product is a commitment by the seller to deliver and the buyer to take the Power (Energy) over the Interval. When the Interval includes more than one measurement or metering Interval, the TeMIX product is defined as a constant rate over each of those metering Intervals. An example is the sale of 1 MW tomorrow between 3 and 5 PM that may be measured every 15 minutes (The energy is 1 MWh). The power in each 15 minute Interval is 1 MW and the Energy in each 15 minute Interval is 0.25 MWh. A position in a TeMIX product may be sold or added to. Depending on local market rules, differences between the Power purchased and the actual delivery may be delivered from or to spot markets at spot market prices.

TeMIX is derived directly from the base Product Description because TeMIX is simpler and with less optionality than other Power Product Descriptions.

Table 10-8: TeMIX Power Product Description

TeMIX Element	Description
Product Description	Base type for derivation. See *Table 3-1: EMIX Core Abstract Types*.
Power Product Type	Used to determine conformance and processing. See Table 10-2
EMIX Interface	An EMIX Interface is any of a number of market exchange points including a point, an aggregate point, or a geographic area at which a product exchanges ownership
Price	Price per Unit of Energy. For TeMIX, this is always the actual price and not an offset.
Energy Item	Total Energy being transacted. Energy Type (Real, Apparent, or Reactive) must match Energy Type of Power Item.
Power Item	Rate of Delivery of Energy. Power Type (Real, Apparent, or Reactive) must match type of Energy Item.

TeMIX Product-based information exchanges are a little different from those for other products; they are discussed by themselves in Section 12 *Transactive Energy (TeMIX) Products.*

11 Power Transport Product Description

The information model in this section is described in POWER-PRODUCTS.XSD

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. Future markets, including those for microgrids and virtual service providers, may not make the same distinctions between transmission and distribution as have been made in the past. Distributed Energy Resources (DER) may create new business models for use of the existing distribution networks.

11.1 Power Transport Elements

The information model below merges the charges and approaches used in the respective transmission and distribution networks today. It anticipates that potential source selection markets may result in passage through multiple networks. The resulting Schedule can either stand-alone in transport products, or be conveyed inside the Envelope as price support information, in support of Locational Marginal Pricing (LMP).

Table 11-1: Transport Description

Transport Product Element	Description
Point of Receipt	Where power enters a network or changes ownership.
Point of Delivery	Where power exits a network or changes ownership.
Price	As defined in Table 3-2: Elements derived from Price Base.
Transport Charges	An array of Transport Charges, as defined in . Table 11-2: Transport Product Charges.

There MAY be multiple instances of the above Artifacts in a single Price instance. For example, in a given transaction, power may pass through multiple distribution nodes and congestion points.

The items listed in the table above are each derived from the base charge type. All other charges, previously described, are available for inclusion within a Transport Product.

Table 11-2: Transport Product Charges

Charge Type	Description
Base Transport Charge	A sub-set of Charges for Transport-related Charges. Derived from Base Charge.
Congestion Revenue Rights	A financial hedge for congestion; i.e., a forward contract for congestion revenues potentially to offset congestion charges. Also known as financial transmission rights. (Transport Charge)
Congestion Charge	The cost of purchasing the right to transfer power over a given segment of the grid. (Transport Charge)
Transport Access Fee	A simple charge (not dependent on congestion) to access transport system. (Transport Charge)
Transport Congestion Fee	Assessment per unit of energy for energy flowing from receipt to delivery point. Can be a positive or negative price. (Transport Charge)
Marginal Loss Fee	A Marginal Loss Fee is assessed per unit of energy to pay to replace Power lost during transport. (Transport Charge)

Charge Type	Description
Transport Loss Factor	A multiplier applied to a transacted quantity of energy to reduce delivery quantity due to loss during transport. (Transport Charge)
Conversion Loss Factor	A multiplier applied to a transacted quantity of energy to reduce delivery quantity due to loss as product voltage is changed or as converted from AC to DC or DC to AC. (Transport Charge)

11.2 UML Summary of Transport Charges

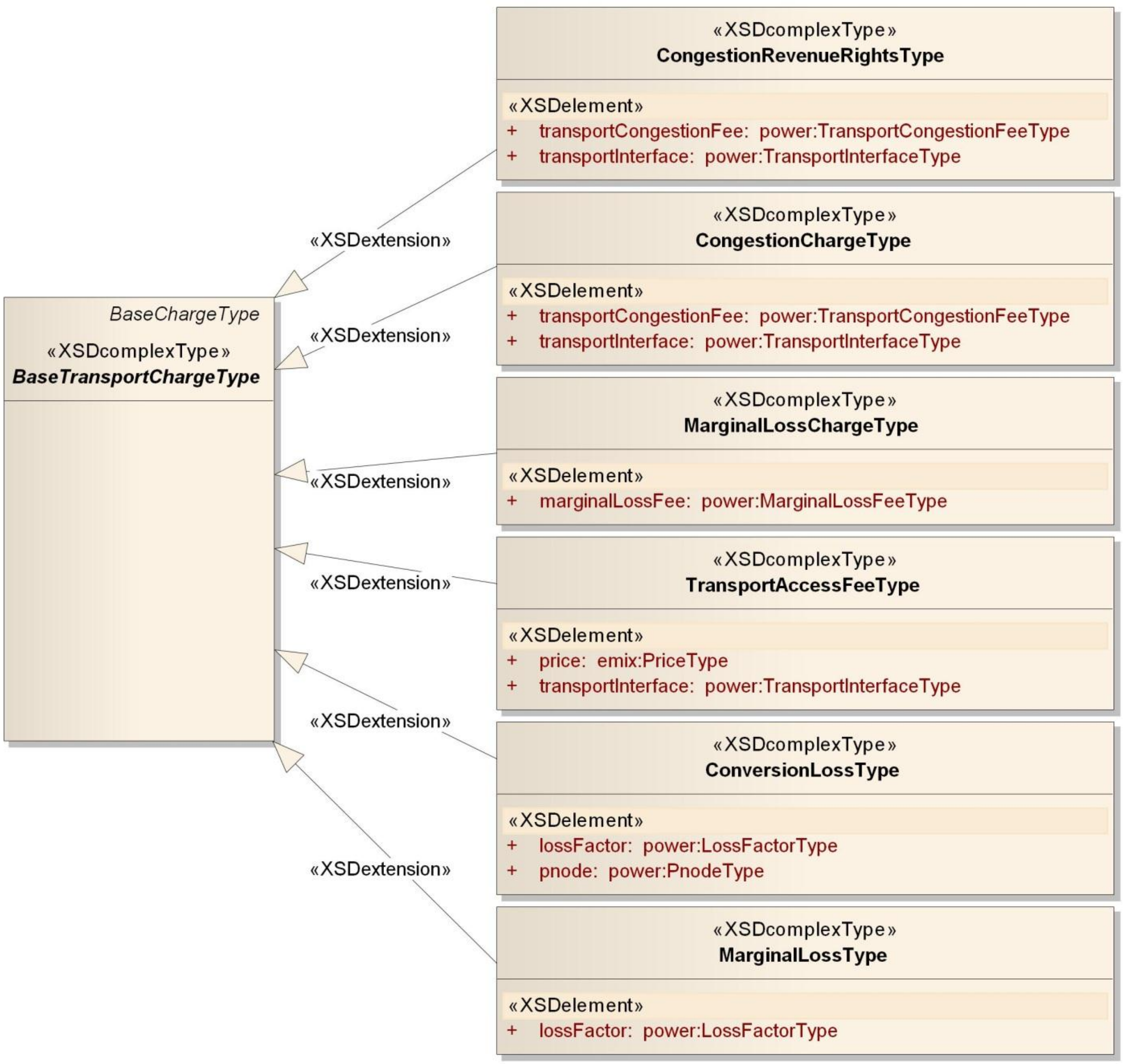

Figure 11-1: UML Summary of Transport Charges

12 Transactive Energy (TeMIX) Products

TeMIX is a subset or profile of the EMIX Power Products. This section describes the TeMIX profile of EMIX.

The TeMIX model is based on blocks of Power with a constant rate of delivery (subscription) over a single Interval. All TeMIX Products are transactions for Power delivered over the course of a single Interval. Each transaction imposes an obligation on the buyer to purchase and the seller to deliver a TeMIX Power Product. This simplicity reduces the number of products and interactions.

There are only four types of TeMIX Products:

1. TeMIX Power Product
2. TeMIX Transport Product
3. TeMIX Option Power Product
4. TeMIX Option Transport Product

The Transactive States for a TeMIX Product are:

- Indication of Interest
- Tender
- Transaction
- Delivery
- Price Publishing

A TeMIX Delivery Interval is specified by a Duration and Start Time. When a TeMIX Product specifies a set of Delivery Intervals, then the elements that do not vary by Delivery Interval may be specified in a Gluon or the Standard Terms. Each TeMIX Delivery Interval is transacted independently of the others.

12.1 TeMIX Overview

The rate of delivery of a TeMIX Power Product is constant over all measured (metered) Intervals within a TeMIX Delivery Interval. For example the transaction could be for 1 hour, but the meter reads every 5 minutes. These market rules are outside the scope of this specification/

For example, 1 MW of power transacted for delivery tomorrow for two hours between 3 and 5 PM provides 1 MWh of energy over each hour and 2 MWh over the two hours. If delivery is measured every 15-minutes, then the power transacted in each 15 minute Interval is 1 MW. The energy transacted in each 15-minute Interval is 0.25 MWh. If the energy delivered in each 15-minute Interval is greater or less than 0.25 MWh then the balance (positive or negative) will be sold or purchased in a subsequent balancing transaction.

The Price of a TeMIX Product is expressed in energy units. For the example above, when the price is $80 per MWh of energy, the extended price (cost) of 1 MW of Power for two hours between 3 and 5 PM is $160; the extended price for 1 MW of Power in each 15-minute Interval of the two hours is $20.

A TeMIX Transport Product is a subscription for Transport (transmission or distribution) to transport a TeMIX Power Product from one EMIX Interface to another. A TeMIX Transport Product is a subscription for power transport at a constant power over the interval.

A TeMIX Option Product provides the Option Holder the right to instruct the option writer to deliver (call) or take (put) a TeMIX Power or Transport Product up to the transacted quantity (rate of delivery) of the Option at a Strike Price.

TeMIX Options are either Call or Put Options on TeMIX Power and Transport Products. A TeMIX Option can be exercised during the Delivery Interval of the Option for any sub-Interval not smaller than the Option Interval Granularity.

For example, a TeMIX Option for 10 MW for a Day and an Option Interval Granularly of 1-hour and an Option Lead Time of 30 minutes would allow the Holder to exercise the option for any or all hours of the Day at the Strike Price by giving notice 30 minutes before each hour.

12.2 TeMIX Products

The elements of a TeMIX Power and Transport Product are shown in Table 11-1: Transport Description. When the Product Description (from the Section *Power Product Descriptions*) is applied to the EMIX Base types, the TeMIX elements are as shown in that table.

Table 12-1: TeMIX Product Description

TeMIX Element	Description
Power Product Type	Enumerated type of Power Product. Used to determine conformance requirements.
EMIX Interface	The Interface where the transaction occurs. Generally, the Interface for a Power Product has one node and the Interface for a Transport Product has two nodes.
Start Date and Time	When the Interval begins.
Duration	The extent of time of the Interval.
Price	The Unit Energy Price for the Interval. TeMIX does not allow Relative Prices or Price Multipliers.
Energy Item	Total Energy (Power * Time), Real, Apparent, or Reactive, delivered over the Interval.
Power Item	Units for the Rate of Delivery of Energy for the Delivery Interval. Includes Power Attributes.
Power Quantity	Rate of Delivery of Energy for the Delivery Interval.
Transactive State	TeMIX Transactive state is conformed to Indication of Interest, Tender, Transaction, Delivery or Publish.
Currency	Currency for the exchange.
Side	Indicates which side of the agreement the information originator is on. Buy or Sell.
Expires Date	Date and Time Tender expires. Not present if the Transactive State is anything other than Tender.
Envelope	As defined in Section 3.1.5: *The Envelope Contents*.

The TeMIX Option extends the TeMIX Product by adding these additional elements:

Table 12-2: TeMIX Power Option Product Description

TeMIX Element	Description
Option Holder Side	The side (buy or sell side of the option) which enjoys the benefit of choosing whether or not to exercise the option. The other side is the option writer.
Option Strike Price	The price at which the Option Holder can require option writer to deliver.
Exercise Lead Time	(Term) The Minimum Notification Duration expressed as an EMIX Term.

TeMIX Element	Description
Option Exercise Schedule	(Term) The Availability Schedule expressed as an EMIX Term.
Temporal Granularity	If present, expresses the temporal granularity of requests as a Duration. For example, if the Duration is 15 Minutes, the option can be called at 10:00, 10:15, 10:30, or 10:45. Granularity is a Property of the Option Schedule.

In TeMIX, very few terms are used, and they are homogenous for the entire market. See 7 *Standardizing Terms for Market Context* for a discussion of exchanging market-wide information.

12.3 Conformance Rules for TeMIX

The following comprise the conformance rules for TeMIX:

1. All allowed TeMIX Product Elements are named in Tables 7-1, 7-2, 12-1 and 12-2.
2. For a given Market Context, all Product Elements MUST be Defined in Standard Terms EXCEPT FOR
    - Starting Date and Time
    - Quantity
    - Price
    - Side
    - Tender Expiration Date and Time
3. All TeMIX Product Elements MUST BE UNDERSTOOD
4. All Elements NOT in the TeMIX Product Elements MUST BE IGNORED
5. All TeMIX Intervals are transacted separately MUST NOT have Links to other Intervals.
6. TeMIX MUST conform to all EMIX Conformance Requirements

12.3.1 Valid TeMIX Product Types

The allowed TeMIX Products are:

- TeMIX Power Product
- TeMIX Transport Product
- TeMIX Option Power Product
- TeMIX Option Transport Product

12.3.2 Transactive States for TeMIX

The Transactive States for a TeMIX are:

- Indication of Interest (IOI)
- Tender
- Transaction
- Delivery
- Publish

13 Energy Resources

The information model in this section is described in RESOURCE.XSD

The Resource information model describes information that MAY be used to offer product(s) in a market. The Resource model describes a range of potential operational responses. The model allows parties to describe a wide range operations, both generation and curtailment. Resource descriptions are used tenders either to buy or tenders to sell Energy or Power products.

When making a tender for products and services, it is useful to describe the operational characteristics 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.

Parties can potentially exchange these models, until they come to an agreement. The rules for exchanging these models are outside the scope of this specification. Resource tenders are less specific than a single transactive request, and one Resource tender may be able offer the Resource to more than one market.

Resources may represent a generator or a load responses or aggregations. In interactions involving Resources it may be useful to describe either (1) the proposed or actual operation of a Resources, or (2) the range of capability of a Resource.

13.1 Resource Capabilities

The following curve characterizes the a schedule for operation of a generic Resource

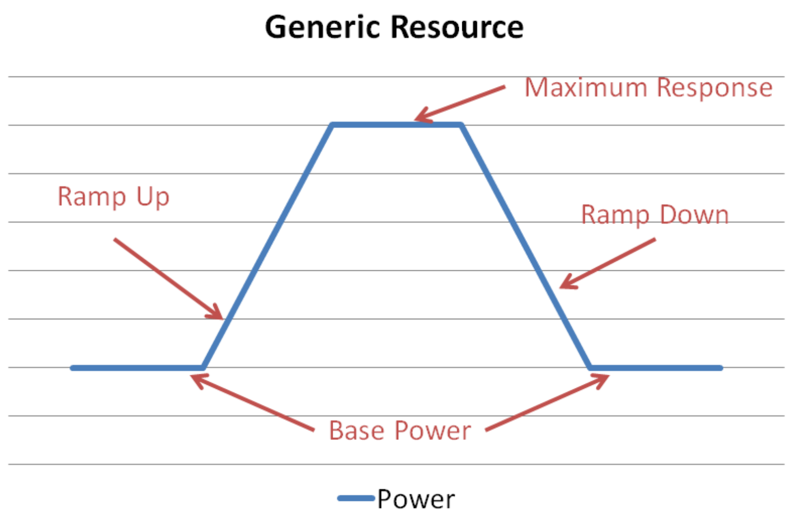

Figure 13-1:Operational Profile of a Generic Resource

In the Resource illustration above, there is some base level of power, a *status quo ante*. When invoked, the resource takes a 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 the information model in Power Resources is that generation, that is the production of power, and load shedding, the reduction of power use are similar products.

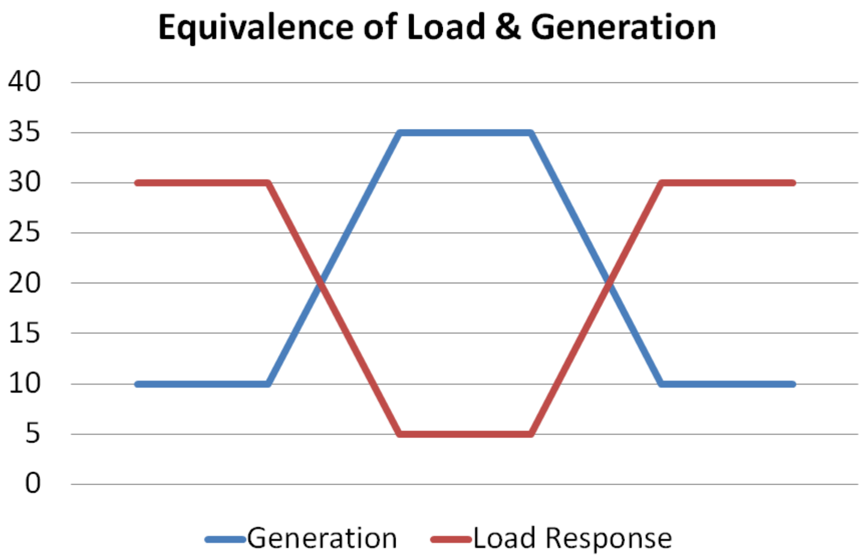

Figure 13-2: Equivalence of Load Shed and Generation

As shown in the example above, generation and load response are similar and can be described using the same information model.

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

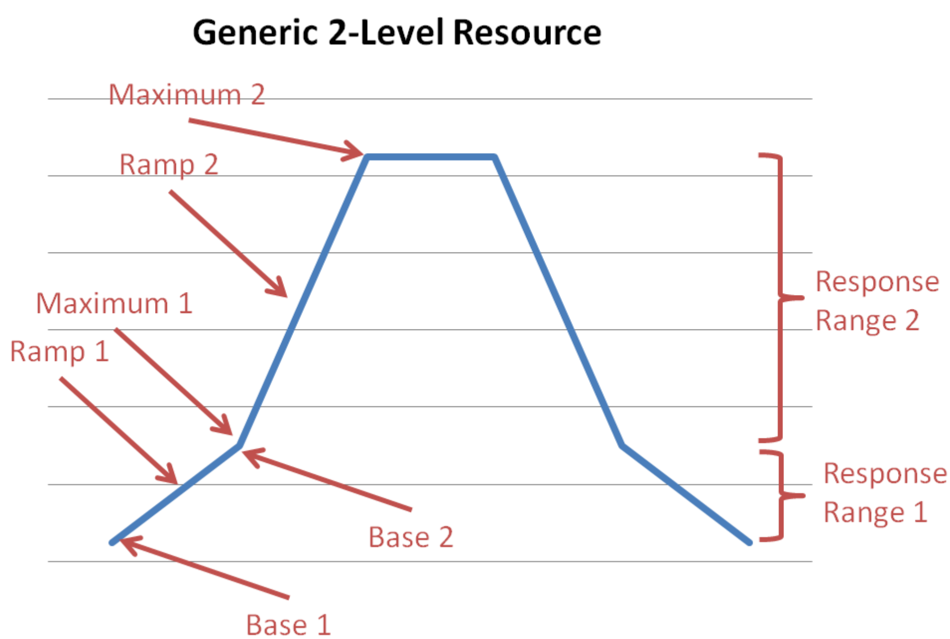

Figure 13-3: Combining Resource Operational Responses

13.2 Resource Capability Description

Resource capability descriptions describe what could be done, as distinguished from a transaction in which specific performance is requested or agreed to.

Resources capabilities may 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 ramps up at Ramp 1 expressed in MW/minute. Between the Base 2 and Maximum 2, expressed in MW, the resource can ramp up at Ramp 2 expressed in MW/minute.

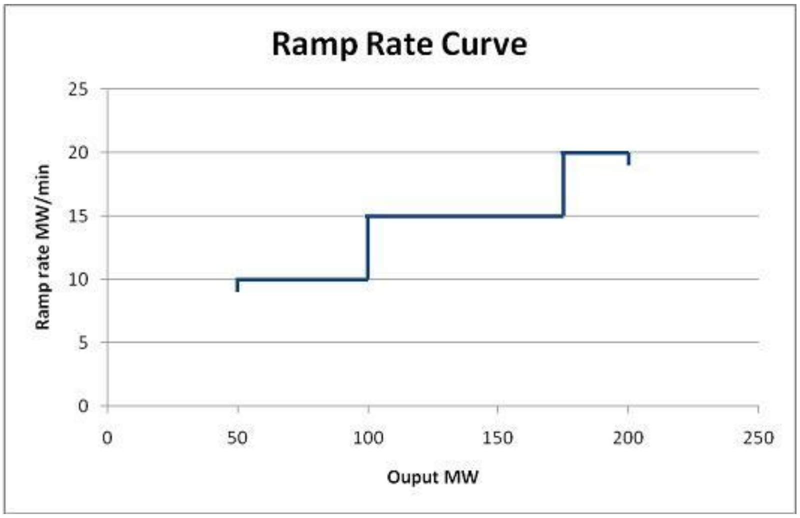

Figure 13-4: Ramp Rate Curve—CIM Style

As described in **[IEC 62325-301],** a given resource may publish multiple ramp rate curves for different circumstances. This resource capability description may be preferred to the resource operation description in some interactions.

13.3 Contrasting Operation and Capability Descriptions

Assume the Resource is operated at the ramp rates as in Figure 13-4 then an operation as described in Figure 13-1. A capability description is generally used to guide resource dispatch. Once the dispatch is computed, an operational description can be used to tender or transact the power that is the result of the dispatch from the market.

This specification describes market interactions, i.e., the operational profiles. Only the description in Section 13.1 is in this specification. When a single resource offers different ramp rates for different circumstances, this specification considers the resulting operational profiles to be distinct products.

The description in Section 13.2 may be considered at a later date by the committee.

13.4 Resource Description Semantics

EMIX Resource Descriptions are an extension of the EMIX Product Description. As an extension of the Product Description, resources can be applied inside any EMIX schedule.

The only aspects of a Resource that matter 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.

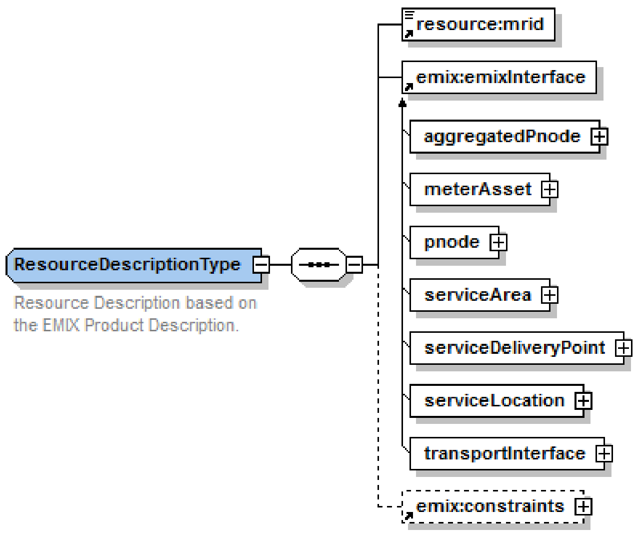

Figure 13-5: Resource Description base

The EMIX Resource Description base consists of the elements shown in the table below.

Table 13-1: Resource Description Elements

Resource Description Element	Note
MRID	The Master Resource ID as defined in the [**IEC TC57**] IEC 61970-301.
EMIX Interface	The Interface is where the Resource injects or extracts power. Note: for many transactions, reduced extraction is equivalent to injection.
Terms	In addition to the Terms listed for Product performance, Resources have additional Terms, listed in Table 10-2.

Power Resources descriptions can use any of the Terms or requirements defined in EMIX. Power Resource descriptions can also use additional Terms that are specific to Power:

Table 13-2: Terms unique to Power Resources

Power Term	Note
Minimum Load	Minimum Load that a Resource can maintain.
Maximum Power	Maximum Power available from a resource.
Maximum Energy	Maximum Energy available from a resource.
Minimum Load Reduction	Minimum Load Reduction resource can make.

13.5 UML Summary of Resource Descriptions

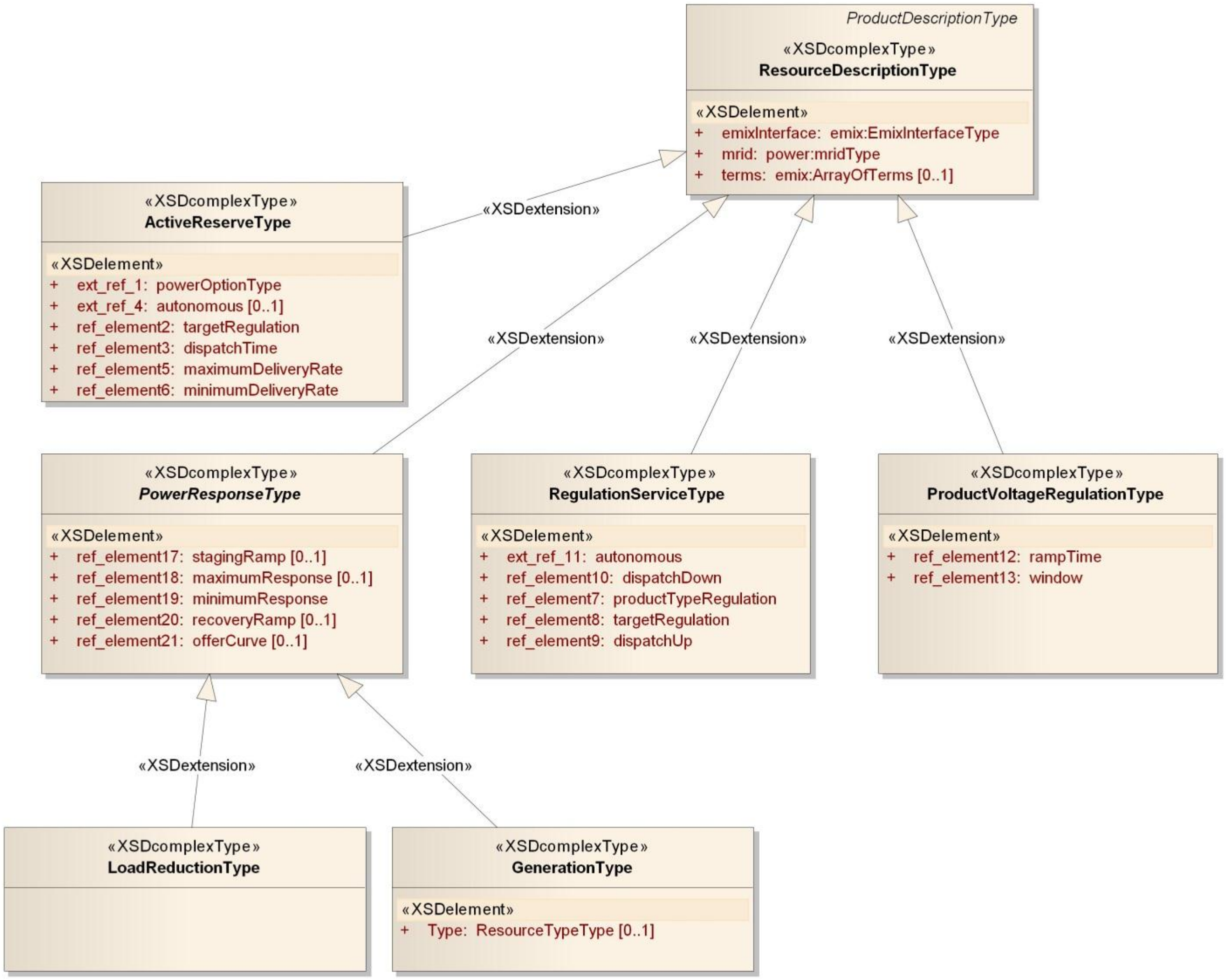

Figure 13-6: UML Summary of Resource Descriptions

13.6 Generic Power Resource

The Generic Power Resource description is used both for generation and for load Resources. The common Resource model is shown in the following table.

Table 13-3: Generic Power Response Resource

Generic Resource Element	Note
Staging Ramp	An array of Power Ramp Segments describing a Resource’s ability to change level at the initiation of a Response.
Minimum Response	The least Response for which this resource will accept a request.
Maximum Response	The greatest Response for which this resource will accept a request.
Recovery Ramp	An array Power Ramp Segments describing how a Resource’s returns to its original state following a response.

A Power Response Description MAY be accompanied by an Offer Curve *(described in section 13.6.2 Offer Curves)*. Each Ramp consists of zero to many Power Ramp Segments (see *Figure 13-3: Combining Resource Operational Responses)*.

13.6.1 Power Ramp Segments

Power Ramp Segments consist of the following elements shown in the table below.

Table 13-4: Power Ramp

Power Ramp Element	Note
Rate	Power Units for the Ramp.
Begin Ramp Quantiyu	Power Quantity at the beginning of the Segment.
End Ramp Quantity	Power Quantity at the end of the Segment.
Duration	The time between the begin ramp and the end ramp.
Integral Only	If true, one can't stop between the begin and end rates.

While Power Ramps are generic, specific instances within derived Resource Descriptions are subject to different conformance rules.

For a Generation Resource, Staging Ramps are processed in order of increasing End Power. The quantity of End Power MUST be greater than the quantity of the Begin Power for each Ramp in the Staging Ramp. Recovery Ramps are processed in order of decreasing End Power. The quantity of End Power MUST be less than the quantity of Begin Power for each Ramp in the Recovery Ramp.

For a Load Resource, Staging Ramps are processed in order of decreasing End Power. The quantity of End Power MUST be less than the quantity of Begin Power for each Ramp in the Staging Ramp. Recovery Ramps are processed in order of increasing End Power. The quantity of End Power MUST be greater than the quantity of the Begin Power for each Ramp in the Recovery Ramp.

Load Resources and Power Resources are conformed instances of the Generic Power Resource.

13.6.2 Offer Curves

When the capability of Power Resource tendered, it may be accompanied by an Offer Curve. An Offer Curve is comprised of a number of Offer Segments. An Offer Segment defines the offer price (as expressed in EMIX Requirements) for the quantity offered in each segment. A sequence number indicates the order of the segments. Each segment may be offered in any partial amount or all-or-none.

Table 13-5: Resource Offer Segment

Resource Offer Element	Note
Price	Energy Price for this Segment.
Quantity	Power Quantity for this Segment.
Duration	Duration of the Segments.
Units	Power Units in which Segment is denominated.
Units	Energy Units in which Segment is denominated.
Integral Only	If true, offer is all or none; no partial acceptance of this segment.

13.7 Voltage Regulation Resources

Voltage regulation services have their own particular semantics as described in the following table.

Table 13-6: Semantics for Voltage Regulation Services

Voltage Regulation Element	Note
VMin	VMin is the minimum voltage level of 88% of nominal voltage where the photovoltaic (PV) inverter must disconnect, as defined in **[IEE1547]**.
VMax	VMax is maximum voltage level of 110% of nominal voltage where the photovoltaic (PV) inverter must disconnect, as defined in **[IEE1547].**
QMax	QMax is the inverter's present reactive power (VAR) capability and may be positive (capacitive) or negative (inductive). It can also be considered as the apparent power (VA) capability left after supporting the real power (W) demand. See **[Budeanu]** and **[IEEEv15#3]**.

14 Ancillary Services Products

Ancillary Services are typically products provided by a Resource Capability, and historically are contracted to stand by for a request to deliver changes in power to balance the grid on very short notice. Ancillary services include Regulation Up, Regulation Down, Spinning Reserve, Non-Spinning Reserve and Volt/Var support (Reactive Power). These Ancillary services are different from other power products in that they are paid for availability, whether or not they are dispatched. Of course, if dispatched, they must perform.

In general, Ancillary services support grid stability by stabilizing specific aspects of grid power attributes. There are several types of ancillary services, each defined by local market rules or utility tariffs. Ancillary services tend to be used frequently but for short durations. Common characteristics are that the Resource must have a secure, often dedicated, link to the dispatcher, must be able to respond very quickly (sub second to ten minutes), respond with accuracy, and provide rapid and accurate performance reporting. Because of the specialized and critical nature of Ancillary Services, this type of Resource Capability is tightly integrated with grid operations. Dispatch must be completely automated and utterly reliable. Failure in this area will result in a range of issues from equipment malfunction to widespread outage. For these reasons, Ancillary Services historically have been performed by specialized generators or capacitor banks. More recently, wholesale markets have piloted the origination of Ancillary Services from Demand Side Resources.

Each market or local utility will define Ancillary Services it will buy from third parties as well as the compensation mechanism for those service and the tests Resource Providers must pass to become certified, “ready to perform”. General types of Ancillary Services are Frequency Regulation, Load Following, Reactive Power (Volt/VAR), Contingency Reserves (Spin and Non-Spin), and Black Start.

Frequency Regulation/Load Following services are fast acting continuously performing resources that respond nearly instantly to compensate for fluctuations in grid power. In contrast, Contingency Reserves (Spin or Non Spin) are off-line until needed, but must be able to react quickly to a dispatch signal (usually ten minutes or less depending on type) sent when another resource suddenly stops performing.

Black Start Resources are generator based sub-grids that can start independently and produce reference grade power without relying on integration with the wider grid. These are used to restore service after outages because they can provide a reference signal required by non-black start resources.

Reactive Power offsets certain types of loads (coils or capacitors) that are capable of sending power back to the grid from what normally would be a load. Uncompensated, this potentially can be damaging to neighboring loads on the grid.

In EMIX, Reserves are described using the market semantics of Options within the EMIX Option type. Performance expectations are expressed using terms. Strike prices and the penalty for non-performance are part of the option agreement.

Because it is useful to have a short-hand to refer to these services, they are enumerated in the Power Option Type enumeration which is incorporated into the Power Product Types.
The enumerated Power Option Types are: Spinning Reserve, Non Spinning Reserve, Operating Reserve, Black Start Recovery, and Reactive Power. The enumerated list is extensible as described in Appendix B.1: *“Extensibility in Enumerated Values”*. Because the exact definitions vary from market to market, and will continue to vary over time, EMIX does not define these terms. All definitions and performance requirements SHALL be expressed through the Terms.

15 EMIX Warrants

The information model in this section is described in EMIX-WARRANTS.XSD

Warrants are specific assertions about the extrinsic characteristics of EMIX Products that may affect market pricing. Warrants are in effect Product Artifacts as defined in EMIX. Warrants are extensions of the Product Descriptions type that are applied the Intervals in a Schedule. 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.

Some Warrants may be applicable only in certain jurisdictions. For example, in 2011 energy warranted as renewable in the Pacific Northwest can include hydropower. Energy markets in California exclude hydropower from their definition of renewable power. Credits or mandates for renewable energy in California are not met by Products warranted as renewable in the Pacific Northwest.

Some Warrants may be separable from the underlying energy. For example, a Warrant that energy is generated by a source that is certified as "green" by an authority, may be issued a "green certificate". In some markets, such a certificate can be traded separately. The detailed specification of Warrants is not part of version 1.0 of this specification.

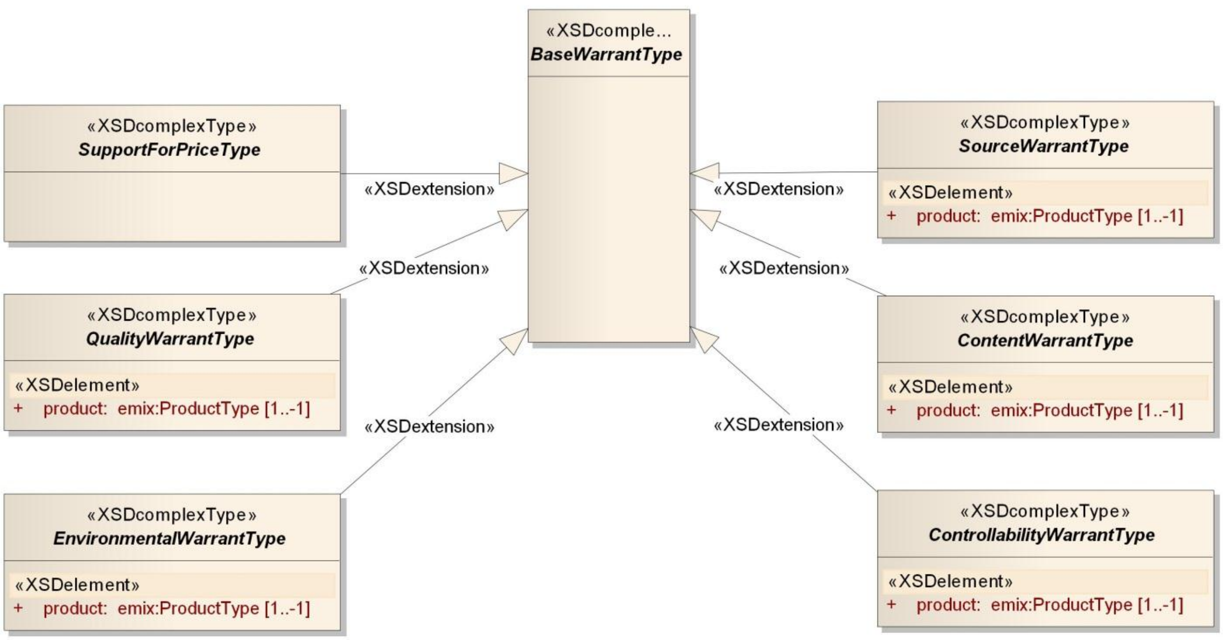

Figure 15-1: UML Summary of Warrants

15.1 Warrants Described

Warrant Types are abstract types defined in this specification for extension and definition elsewhere. Conforming information exchanges can include schema types derived from these types.

Table 15-1: Warrant Types

Warrant Type	Descriptions
Product Quality	Assertion of quality. Examples include: If during an offer, can be a promise of quality. If during verification, can be actual measurements. If during an indication of interest, might be a minimum standard.

Warrant Type	Descriptions
Environmental Warrant	Quantifies the environmental burden created during the generation of the electric power.
Content Warrant	The proportion of the product defined that is from non-fossil fuel sources, including but not limited to “hydroelectric”, “nuclear”, “solar”, and “wind”.
Source Warrant	The product source. In aggregate may be the same as a Content Warrant.
Controllability Warrant	Assertion that a Resource referenced on the face of the envelope can be controlled and/or operated by or to some standard.

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16 Power Quality

The information model in this section is described in POWER-QUALITY.XSD.

Higher quality power can obtain a market premium. A buyer willing to accept lower quality power may be able to obtain it at lower expense. Power qualities must be measurable, discrete, and allow buyers and sellers to make choices. They must also be auditable and measurable by a specific defined protocol, so performance can be compared to promise.

16.1 Power Quality Warrant

There are numerous protocols for determining power quantity, and often more than one name for the same quality. Assertions about Power Quality must be qualified with what protocol is being used, and must be able to specify the period or periods to which they refer.

The Power Quality Warrant is similar to the EMIX Base. As an extension to the EMIX Base, it holds a schedule, which can be populated with Quality Assertions. A Quality Assertion is a collection of Quality Statements that apply for an Interval.

Table 16-1: Elements of the Power Quality Warrant

Product Element	Description
Quality Warrant	See Table 15-1: Warrant Types
Power Quality Type	An enumerated string that about the origins of the Warrant. Defined enumerations are Guaranteed, Measured, Projected, Average.
Measurement Protocol	A string containing an identification of the standard or other protocol used to measure power quality.
Schedule	Sequence populated by a Power Quality Description.
Side	Buy or Sell, as defined in *Table 3-5: Simple Semantic Elements of EMIX.*

The Schedule is populated by Quality Measures. A Quality Measure is a collection of Power Quality Indicators. The Power Quality indicators MUST be recorded as per the requirements and definitions in the Measurement Protocol. The defined Power Quality indicators are in Table 16-3: Power Quality Indicators.

The terminology for characteristics is largely that of **[IEC61000-4-30]** and the generally similar **[Caramia]**. Table 16-2 defines strings for Measurement Protocol in Table 15-3; others may be added by prefixing “x-“ as described in Appendix B *“Extensibility in EMIX”*.

Table 16-2: Named Power Quality Protocols

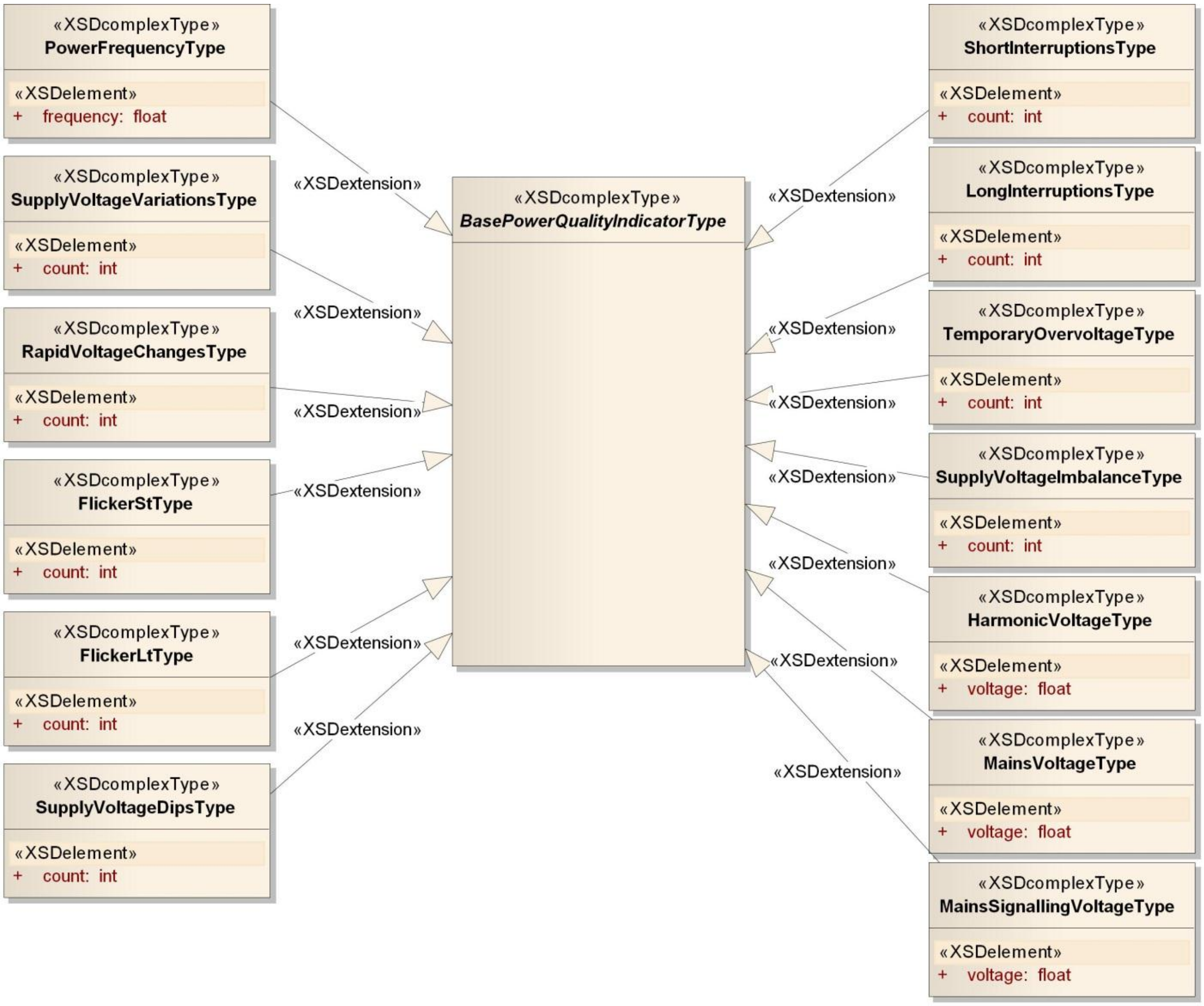
Protocol	Reference
EN 50160	As described in **[EN50160]**
IEEE 1519-2008	As described in **[IEEE1519]**
IEC 61000+2003	A described in **[IEC61000-4-30]**

The power quality indicators are described in Table 16-3. Other Quality Indicators can be defined by deriving from the base Quality Indicator type.

Table 16-3: Power Quality Indicators

Name	Description
Measurement Protocol	A string containing an identification of the standard or other protocol used to measure power quality.
Power Frequency	A floating point number describing the measured Power Frequency. Note: users who wish to describe how the frequency varies over time will need to derive their own measure from the base Power Quality type.
Supply Voltage Variations	An unsigned integer count of Supply Voltage Variations during the period.
Rapid Voltage Changes	An unsigned integer count of Rapid Voltage Change events during the period.
Flicker ST	An unsigned integer count of Flicker Short Term events during the period.
Flicker LT	An unsigned integer count of Flicker Long Term events during the period.
Supply Voltage Dips	An unsigned integer count of Supply Voltage Dip events (called Sags in some protocols) during the period.
Short Interruptions	An unsigned integer count of Short Interruption events during the period.
Long Interruptions	An unsigned integer count of Long Interruption events during the period.
Temp Overvoltage	An unsigned integer count of Temporary Overvoltage events during the period.
Supply Voltage Imbalance	An unsigned integer count of Supply Voltage Imbalance events during the period. Not meaningful for DC.
Harmonic Voltage	A floating point number for the Harmonic Voltage during the period. For DC, distortion is with respect to a signal of zero (0) Hz.
Mains Voltage	A floating point number indicating Mains Voltage.
Mains Signaling Voltage	A floating point number indicating Mains Signaling Voltage, relating generally to power line communications systems.

1167 ## 16.2 UML Summary of Power Quality Indicators



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1169 *Figure 16-1: UML Summary of Power Quality Indicators*

17 Conformance and Rules for EMIX and Referencing Specifications

This section specifies conformance related to the semantic model of EMIX. EMIX is heavily dependent upon **[WS-Calendar]**, and repeatedly incorporates **[WS-Calendar]**-based information models.

EMIX Artifacts can be exchanged at any of several stages of a transaction. Necessarily, a tender must be able to accept an incomplete information model while a call for execution must fully define the performance expected. Specifications referencing EMIX SHALL define conformance rules by transaction type and market context.

EMIX conformance necessarily occurs in two stages. EMIX uses **[WS-Calendar]** to communicate similar Intervals that occur over time, each containing an EMIX Artifact. Portions of that Artifact may be expressed within the Lineage of the sequence. Applications MUST apply **[WS-Calendar]** Inheritance and then EMIX Inheritance to Compose the information exchange for each Interval. Only after Composition, can the EMIX Artifact within each Interval of the Sequence be evaluated for conformance and completeness.

17.1 EMIX Conformance with [WS-Calendar]

EMIX Base are EMIX Products and Resources instantiated through the schedule model of **[WS-Calendar]**. As such, EMIX Base SHALL follow **[WS-Calendar]** Conformance rules. These rules include the following conformance types:

- Conformance to the ***inheritance rules*** in **[WS-Calendar]**, including the direction of inheritance
- ***Specific attributes*** for each type that MUST or MUST NOT be inherited.
- ***Conformance rules*** that Referencing Specifications MUST follow
- Description of ***Covarying attributes*** with respect to the Reference Specification
- ***Semantic Conformance*** for the information within the Artifacts exchanged.

EMIX Products and Resources also extend the Inheritance patterns of **[WS-Calendar]** to include the EMIX information model. We address each of these in the following sections.

17.1.1 Inheritance in EMIX Base

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

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

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

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

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

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

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

17.1.2 Specific Attribute Inheritance within EMIX Envelopes

This section refers to EMIX Products, agreements, and Resources as Artifacts. In general, an Artifact of a particular type blocks inheritance of a complete Artifact of that type down the lineage.

The root node of parent and the child must match for blended inheritance to occur, that is, the roots must be of the same type. The exception is if there are no roots in the child's Artifact, then the root and all its branches are inherited by the child.

If matching roots for the model are found in both the parent and in the child, then each tree should be navigated to determine blended inheritance. The child's artifact may be mostly unpopulated. Within any branch in the child, the first node that is populated blocks all further inheritance on that branch. All nodes deeper into the Artifact than that populated node are determined by the child. When a branch is inherited from the child, it blocks the inheritance of any deeper nodes within that branch.

Specific artifacts may declare rules that break this inheritance pattern. As of now, the exceptions are:

- There are no exceptions.

Inheritance creates a virtual artifact at each level of processing. That virtual Artifact is the basis for inheritance for any child Artifact.

In EMIX the following attributes MUST NOT be inherited

- UID (Gluons and Intervals)
- Temporal Relationships

Some elements of EMIX are may be **covariant**, meaning that they change together. Such elements are treated as a single element for inheritance, they either are inherited together or the child keeps its current values intact. This becomes important if one or more of a covariant set have default values. In that case, if any are present, then inheritance should deem they are all present, albeit some perhaps in their default values.

17.2 Time Zone Specification

The time zone MUST be explicitly expressed in any conforming EMIX Artifact.

This may be accomplished in two ways:

- The time, date, or date and time MUST be specified using **[ISO8601]** utc-time (also called *zulu time*)
- The **[WS-Calendar]** Time Zone Identifier, TZID, MUST be in the Lineage of the artifact, as extended by the Standard Terms. See 17.3 below.

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

17.3 Inheritance from Standard Terms

If an Artifact exists within the context of Standard Terms, the artifact inherits from the Standard Terms. Elements that can be inherited from Standard Terms include Product Type, TZID, Currency, and Measurement Units.

Inheritance MUST be determined in the manner of Section 17.1.1. Rules I1, I2, and I3, that is, that the attribute definition be determined by going to the nearest Gluon in the Lineage containing that attribute, with the addition that if no such Gluon is present then the search continues in the associated Standard Terms.

17.4 Specific Rules for Optimizing Inheritance

1. If the Designated 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.
2. If the Designated 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.
3. If the Designated 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.

A. Acknowledgements

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Bill Stocker, ISI/RTO Council (IRC)
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Jake Thompson, EnerNOC
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Leighton Wolffe, Individual
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B. Extensibility and EMIX

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

B.1 Extensibility in Enumerated values

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

In emix.xsd, the extensibility pattern is:

```
<xs:simpleType name="EMIXExtensionType">
   <xs:annotation>
          <xs:documentation>Pattern used for extending string enumeration,
where allowed</xs:documentation>
   </xs:annotation>
   <xs:restriction base="xs:string">
          <xs:pattern value="x-\S.*"/>
   </xs:restriction>
</xs:simpleType>
```

An example of non-extensible enumerated types is:

```
<xs:simpleType name="PowerOptionTypeEnumeratedType">
   <xs:annotation>
          <xs:documentation>Power Reserve Options</xs:documentation>
   </xs:annotation>
   <xs:restriction base="xs:string">
          <xs:enumeration value="SpinningReserve"/>
          <xs:enumeration value="NonSpinningReserve"/>
          <xs:enumeration value="OperatingReserve"/>
          <xs:enumeration value="DemandResponse"/>
   </xs:restriction>
</xs:simpleType>
```

The enumerations used in the specification follow this pattern:.

```
   <xs:element name="powerOptionType" type="power:PowerOptionTypeType"/>
   <xs:simpleType name="PowerOptionTypeType">
          <xs:union memberTypes="power:PowerOptionTypeEnumeratedType
emix:EmixExtensionType"/>
   </xs:simpleType>
```

This pattern has been followed throughout EMIX, allowing any string beginning “x-“ to be a legal extension enumeration for EMIX enumerated strings.

Some extensible enumerated types assume they will be used for extension. For example, the means of measurements for power quality enumerate specific testing protocols. As of this writing, there are only two testing protocols in the specification.

```
   <xs:simpleType name="MeasurementProtocolEnumeratedType">
          <xs:restriction base="xs:string">
                 <xs:enumeration value="EN 50160"/>
                 <xs:enumeration value="IEEE 1549-2009"/>
          </xs:restriction>
```

```
   </xs:simpleType>
```

It is anticipated that other protocols will be used. In this case the suffix "EnumeratedType"is used to allow for the possibility of other Measurement Protocols that are not enumerated. Actual compliance, though, is based upon the type:

```
   <xs:simpleType name="MeasurementProtocolType">
          <xs:union memberTypes="power:MeasurementProtocolEnumeratedType
emix:EMIXExtensionType"/>
   </xs:simpleType>
```

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

EMIX defines extensibility for the following values:

- [Quality] Measurement Protocol
- Contract Type
- Option Type
- Power Option Type
- Resource Type

B.2 Extension of Structured Information Collective Items

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

EMIX uses abstract classes for many information exchanges. For example, trading partners could agree on the exchange of larger or smaller lists of quality measures. Many measures of power quality are defined in power-quality.xsd. Quality consists of an array of elements that are derived from the abstract base quality element.

```
<xs:complexType name="PowerQualityType">
   <xs:annotation>
          <xs:documentation>Power Quality consists of a number of measures,
based on contract, negotiation, and local regulation. Extend Power Quality to
incorporate new elements by creating additional elements based on
PowerQualityBaseType</xs:documentation>
   </xs:annotation>
   <xs:sequence>
   <xs:element name="measurementProtocol"
type="power:MeasurementProtocolType"/>
          <xs:element name="constraints" type="power:ArrayOfPowerQualities"/>
   </xs:sequence>
</xs:complexType>
```

A practitioner who wanted to add an additional quality type would need to develop a description and instantiation of that type based on the abstract base, similar to that used below. The implementation refers to the substitution group:

```
<xs:element name="supplyVoltageVariations"
type="power:SupplyVoltageVariationsType"
substitutionGroup="power:basePowerQualityMeasurement"/>
```

and the type extends the abstract base class BasePowerQualityMeaurementType:

```
<xs:complexType name="SupplyVoltageVariationsType" mixed="false">
   <xs:complexContent mixed="false">
```

```
        <xs:extension base="power:BasePowerQualityMeasurementType">
            <xs:sequence>
                <xs:element name="count" type="xs:int"/>
            </xs:sequence>
        </xs:extension>
    </xs:complexContent>
</xs:complexType>
```

The resulting schema, which references the approved EMIX schemas, but does not change them, can then be distributed to business partners to validate the resulting information exchanges. The core EMIX types, which are used throughout the specifications herein, can be extended this way, including:

- **EMIX Base Type**: iCalendar-derived object to host EMIX Product Descriptions
- **Product Description Type**: In EMIX, the Product Description is the basis for all Resources and Product Descriptions.
- **Item Base**: Abstract base class for units for EMIX Product delivery, measurement, and Warrants. Item does not include Quantity or Price, because a single product description or transaction may have multiple quantities or prices associated with a single item.
- **EMIX Interface**: Abstract base class for the interfaces for EMIX Product delivery, measurement, and/or pricing.

The following additional abstract types are among those designed with extension by practitioners in mind:

- **BasePowerQualityMeaurementType**: the basis for exchanging measurements of power quality
- **BaseTermType**: used to express Terms on the performance of equipment exposed to the market as Resources
- **BaseRequirementType**: used to express the market or business requirements of a trading partner.
- **BaseWarrantType**: the root for all Warrants delivered with the energy product.

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 envelope contents, perhaps as informational support for the intrinsic prices.

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

- Apparent Energy: the production or consumption of Apparent Power over time; unit: volt-ampere hours; abbreviation: VAh
- Apparent Power (S): mathematical product of root-mean-square voltage and root-mean-square current, vector sum of Real Power and Reactive Power, square root of sum of squares of Real Power and Reactive Power; unit: volt-ampere; abbreviation: VA
- Current: flow of electric charge, or rate of flow of electric charge; unit: ampere; abbreviation: A
- Energy: the production or consumption of Power over time.
- Power Factor: 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; abbreviation: p.f.
- Power Triangle: the mathematic relationship between the Apparent Power (S), the Real Power (P) and the Reactive Power (Q) where S = sqrt(P*P + Q*Q).
- Reactive Energy: the production or consumption of Reactive Power over time; unit: volt-ampere-reactive hours; abbreviations: VARh, VArh, VA-rh, varh
- 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; abbreviations: VAR, VAr, VA-r, var
- Real Energy: the production or consumption of Real Power over time; unit: Watt-hour; abbreviation: Wh
- Real Power (P): rate at which electricity is produced or consumed, mathematical product of Voltage and Current; unit: Watt; abbreviation: W
- Voltage: difference in electric potential between two points; unit: volt, abbreviation: V

Generically, the use of the term "Power" refers to "Real Power" and is expressed in Watts. Otherwise, one talks of Apparent Power in VA, or Reactive Power in VARs. Generically, the use of the term "Energy" refers to "Real Energy" and is expressed in Watt-hours. Otherwise, one talks of Apparent Energy in VArh, or Reactive Energy in VArh.

D. Mapping between NAESB PAP03 work and this specification

Under the **[NIST]**-led smart grid interoperability process, the North American Energy Standards Board (NAESB) provided a minimal scope and requirements for this specification, specifically in its work to address the Priority Action Plan 03 (PA03), Price and Product definition. This section maps the specific requirements from NAESB to the work in this specification.

Table E-1: Mapping between NAESB PAP03 and this work

Tariff Rate Type	Description
block rate	In POWER-CONTRACTS.XSD, addressed by the Block Power Full Requirements Contract.
critical peak price	Addressed by both Price Relative and Price Multiplier when applies to a business schedule.
demand rate	Demand charges can be applied to all Product types in EMIX.
day ahead market rate	Either TeMIX or a Block Power agreement applied to a day-ahead schedule addresses this need.
market clearing price for energy	TeMIX addresses this use case directly.
peak time rebate	Peak Time Rebates can be handled by TeMIX Transactions
real time price rate	Either TeMIX or a Block Power agreement applied to a day-ahead schedule addresses this need.
time of use rate	Either TeMIX or a Block Power agreement applied to a day-ahead schedule addresses this need. EMIX applied alongside any of the standard agreements can support variable peak pricing.
variable peak pricing	TeMIX applied alongside any of the standard products can support variable peak pricing.

1467 # E. 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	2010-11-14	Toby Considine Ed Cazalet Sean Crimmins	EMIX Sequence changed to EMIX Base. General tightening. Addition of Load and Power Offers, including 3-part bids for each.
CSD01	2010-11-15	Toby Considine	Minor changes as per comments
WD16	2011-01-15	Toby Considine	46 Minor issues from PR01 Adopted new WD format Moved namespaces into section 1 Adjusted duplicate table names Fixed section numbering anomalies
WD17	2011-02-08	Toby Considine	Issue Resolution. See Release Notes from Jira
WD18	2011-03-07	Toby Considine	Numerous Jira Issues, (see release notes), Significant Schema work: Resources as discussed, General EMIX constraints and requirements now in Core EMIX namespace, but isolated in requirements.xsd. Added schedule constraints as optional constraint
WD19	2011-03-17	Toby Considine	Tightened language, some egregious errors and references not found removed
WD20	2011-03022	Toby Considine	Simplified Tables, Added NAESB appendix, updated schemas in appendix
WD21	2011-0323	Toby Considine	Quick Pass for show-stoppers, Purged last 16 uses of EMIX Terms for EMIX Base,
WD22	2011-0329	Toby Considine	Minor edits and comments from Jira. Made explicit relations between Base, Product Description, Items, Interfaces, and all derived extensions
WD23	2011-0411	Toby Considine	Extensive review and re-write to consolidate changes as logged in Jira
WD24	2011-05-29	Anne Hendry	Reorganization, underbrush of PR02
WD25	2011-05-31	Toby Considine	Paul Knight comments, related
WD26	2011-06-01	Toby Considine	Most Aclara comments, Gerry Gray comments, Cox comments, others from Jira
WD27	2011-06-05	Anne Hendry Dave Holmberg Ed Cazalet	Tightened spec, formalized many definitions earlier, incorporated many suggestions for improving definitions, moved base class, non-normative ref to WS-Calendar to Section 2,

Revision	Date	Editor	Changes Made
		Toby Considine	Changes made up only though Section 5 (6 and 7 may require complete re-write)
WD28	2011-06-07	Toby Considine	Completed run though from WD27 Added Market Rules section
WD29	2011-06-14	Toby Considine	Jira issues from PR02 Added Plenty-O-UML Propagated Envelope language Removed top level TEMIX Base type Moved Temix toward Profile
WD30	2011-06-15	Toby Considine, Aaron Snyder	Too numerous to list here, almost 100% editorial.
WD31	2011-06019	Toby Considine	Many Editorial issues, Updates to Resource Introduction, TeMIX, Offer Curves
WD32	20110620	Toby Considine	Editorial final pass, esp Offer Segments
WD33	2011-06-21	Toby Considine	More editorial, moves some references to non-normative *Integral Only* in Product and Option
WD34	2011-06-22	Toby Considine	Mino changes (Josh Phillips in Jira) in intro material in sections 2, 4, 13