An OASIS Energy Market Information Exchange Technical Committee White Paper

Transactional Energy Market Information Exchange (TeMIX)

An Information Model for Energy Transactions in the Smart Grid

By Edward G. Cazalet, PhD
On behalf of the OASIS Energy Market Information Exchange Technical Committee

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The OASIS eMIX Technical Committee works to define standards for exchanging energy characteristics, availability, and schedules to support the free and effective exchange of information. Better communication of actionable energy prices will help enable and expand efficient markets that satisfy the growing demand for lower-carbon, lower-energy buildings, net zero-energy systems, and supply-demand integration that take advantage of dynamic pricing. Businesses, homes, electric vehicles and the power grid will benefit from automated and timely communication of energy price, characteristics, quantities, and related information.

This white paper was produced and approved by the OASIS Energy Market Information Exchange Technical Committee as a Committee Draft. It has not been reviewed and/or approved by the OASIS membership at-large.

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1. Introduction

Transactional energy relies on clear, clean signals that can be easily understood. Because most energy transactions are small, they must be automatable to achieve full participation. Anything that muddies the economic signals is a barrier to transactional energy.

The purpose of the OASIS Energy Market Information Exchange (eMIX) Technical Committee is to define information models for exchanging prices and product definitions in energy markets.

The purpose of this White Paper is to use the eMIX information models to define information models to support Transactional Energy. These transactions are a subset of all possible energy transaction types that are selected to enable unambiguous human and automated transactions of energy. We label this information model as the Transactional Energy Market Information Exchange (TeMIX) model.

Transactional Energy is based on the clear and frequent communication of offers and transactions among buyers and sellers. Buyers and sellers may be generators, loads, or storage with metered delivery, or traders with no actual delivery and metering. A seller can be a load that is selling back from a contracted position. A buyer can be a generator that is buying back from a contracted position.

A core attribute of Transactional Energy is that a sequence of energy transactions for a delivery of a quantity of an energy product in a time interval at a location results in a position. This position may then be modified by additional buy and sell transactions.

Transactional Energy needs no hierarchy. A party can transact with any other party, or with intermediaries as desired. Transactional Energy can simplify business for all parties including generators, Independent System Operators (ISOs) and Regional Transmission Operators (RTOs). Transactional Energy is the current model for most wholesale energy forward and futures transactions.

Transactional Energy offers an opportunity for the coordination of retail and wholesale energy consumers and producers including variable energy resources such as wind and solar. Coordination is by large numbers of frequent small transactions executed automatically by smart agents. The communications systems, interval metering and smart devices being installed for the Smart Grid will need Transactional Energy to implement high volume and high speed, unambiguous transactions.

1 For an overview of how Transactional Energy can support the big vision for the smart grid see the comments submitted by Edward Cazalet to the Federal Energy Regulatory Commission on Integration of Variable Energy Resource (VERS) http://www.cazalet.com/images/Comments_to_FERC_on_VERS_-_Cazalet.pdf


A. Transactional Energy Markets

Transactional Energy requires no information exchange other than information on offers for energy transactions and the agreements on transactions. This information exchange is shown by the two-way arrows in Figure 1. The exchanges are priced offers and transactions. Such offers and transactions are for past current and forward intervals of time. Describing the information models for this information exchange is a principal focus of this White Paper.

The information exchange in Figure 1 is the same for large generators, distributed energy resources (DER), variable energy resources such as wind or solar, commercial and industrial customers, homes, electric vehicles, microgrids, energy traders, brokers, exchanges, aggregators, or system operators. Transactions can occur between parties in retail and wholesale markets and between parties in different wholesale markets. Transactional Energy equalizes the opportunity for every technology and every participant on the grid including participants within a microgrid.

Naturally the transactions must account for the transmission and distribution limits and losses and other physical constraints on the grid.

There are many market processes that may be used to exchange offers and reach agreements on transactions using the Transactional Energy model. Different parts of the energy market may employ different market processes. However, the purpose of this White Paper is to focus on the information

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5 For example, a priced offer could be a vector of hourly price-quantity offers to sell for the next 24 hours. Transactions can be contracted forward of delivery or after delivery. Any party can make offers or respond to offers.
models in support of Transactional Energy no matter what market processes are employed, competitive or cost of service, assuming that the transactions comply with the information models described herein.

Transactional Energy is essentially the current transaction model for forward wholesale energy transactions. TeMIX facilitates the extension of this wholesale transactional model to (1) retail markets and (2) transactions on smaller time intervals close to delivery. These close-to-delivery transactions are for spot market or balancing transactions. The transactional energy concepts are similar to concepts used in continuously traded bid/ask markets such as commodity and stock exchanges, and bilateral transactions.

B. The Core Transaction Types

The Transactional Energy Information Model (TeMIX) restricts the types of transactions in the model to only two core types:

1. **An obligation energy transaction**
   - An obligation transaction in the TeMIX model is an obligation by the buyer to purchase and the seller to deliver energy over a given interval of time (measured in hours or fractions of an hour) at a specific rate of delivery (kWh/hr or kW, for example). The rate of delivery of energy is also called power. The rate of delivery is constant over the entire interval. The energy delivered under the transaction in kWh is the rate (kW) times the number of hours (hrs)\(^6\).

2. **An option for an obligation energy transaction**
   - A TeMIX option transaction is a put (option to sell) or a call (option to buy) by one of the parties to the transaction. Once the option is exercised it becomes a TeMIX obligation transaction (as defined in 1). An option transaction is "price insurance" or a capacity, ancillary service or demand response\(^7\) contract.

All TeMIX offers and transactions are specified as to delivery location, time interval, price and rate of delivery.

With these two transaction types and interval meters we can support a wide range of retail and wholesale transactions where the contract positions and obligations of all participants are well defined and outcomes and payments are unambiguous.

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\(^6\) Specifying a transaction as a rate of delivery is more useful and simpler than specifying the amount of energy delivery over an interval because standard intervals such as a day, month and year have variable durations. For example, a 1 kW (kW/kWh) contract for a 24-hour day will provide 24 kWh. For a short, daylight savings day of 23 hours, 23 kWh would be delivered. For a long daylight day, 25 kWh would be delivered. If we had specified the energy to be delivered for a day as 24 kWh, then the rate of delivery would be 1.04347 kW for the 23-hour day, 1.0 kW for the 24-hour day, and 0.96 kW for the 25-hour day, which is confusing. Differences in days per month and days per leap year are other examples where specifying the rate of delivery (power level) is easier than specifying the total amount energy delivered.

\(^7\) Demand Response is conventionally an agreement by a customer to curtail load below a baseline amount that was predicted to be consumed\(^7\). In Transactional Energy with interval metering and forward contracting, the baseline is contracted and demand response is an option contract with a specified curtailment amount, option premium price and a strike price. For an excellent description of how demand response is better enabled with contracted baselines see "When It Comes to Demand Response, Is FERC Its Own Worst Enemy?" by James Bushnell, Benjamin F. Hobbs and Frank A. Wolak. [http://www.ucei.berkeley.edu/PDF/csemwp191.pdf](http://www.ucei.berkeley.edu/PDF/csemwp191.pdf)
Transactional Energy will need to co-exist with other energy market models and processes. For example, spot markets operated by ISOs and RTOs do not fully comply with the Transactional Energy model. However, intermediaries can offer retail and wholesale Transactional Energy services while also participating in an ISO/RTO dispatch market model that may have different information requirements and interactions.

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[^1]: Independent System Operator (ISO) or Regional Transmission Operator (RTO) spot markets accept day-head forward and real-time priced offers and enter into transitions with participating parties. Each party's positions are unambiguous as in the Transactional Energy model. However, the information required of the participating parties such as generator and storage providers includes information on priced offers at all levels of operation (offer curve), start-up costs, no load costs, up and down ramp rate curves, no operation zones, stored energy levels, storage efficiency in order to dispatch these devices. Such information is complex and device specific. The ISOs/RTOs use optimization (auction) software to dispatch the system while accounting for transmission constraints and losses.

Transactional Energy relies on self-dispatch of generation and storage using only priced offers to or from the parties. By using frequent small offers a Transactional Energy markets continuously work to improve the self dispatch of generation and price-responsive loads as variable energy resource generation and loads are continuously changing.

ISOs and RTOs can move closer to the Transactional Energy model, by promoting self-dispatch and providing more frequent auctions between day-ahead and real-time delivery, accepting only single-part priced offer of a limited size.
2. The Transactional Energy Market Information (TeMIX) Model

A. Actors in the TeMIX Information Model

The actors in this information model include any entity, metered device or market that is a Party to a prospective or actual energy transaction. Each actor can take on either of the following two roles:

1. Buyer
2. Seller

For example, a Buyer or a Seller can be a retail customer, a metered intelligent device owned by a retail customer, a retail aggregator, a wholesale supplier, a metered intelligent device (such as an electric vehicle or a generator) owned by a retail or wholesale supplier, a retail or wholesale market or exchange, a broker or a marketer. Any Party can be a Buyer or a Seller relative to their current contracted position for energy in a delivery interval. A Party can be represented by a human or automated agent in carrying out transactions.

B. Point-of-Delivery (Location)

The point-of-delivery is typically a customer meter or a generator meter. Additionally, transactions have a point-of-delivery at intermediate electrical points or trading hubs where there is no net delivery of energy and no metering. The costs and losses for transmission and distribution must factor into the energy deliveries and prices of transactions at the retail and wholesale points-of-delivery.

C. Control Interface

For transactions terminating at a metered Point-of-Delivery, TeMIX assumes nothing about how devices on the other side of the meter are controlled. The control interface may be an Energy Services Interface or a Facility Interface. The only information provided to the interface is priced offers to buy or sell energy and the only information required from the interface is information on forward transactions and metered deliveries. The intelligence to control devices in response to priced offers, to make offers, and to engage in transactions with other parties either resides at the control interface or is remotely activated at the control interface.

D. Delivery Intervals

Delivery intervals are defined as an interval of time with a start time and end time. For example a delivery interval might be one or more consecutive calendar years, calendar months, days, hours, 5-minute

^9 Devices behind an Energy Services Interface with a common meter are not considered to be a Party in this definition. A Party may control such devices and may or may not use priced offers as a basis for device control.

^10 Energy Services Interface / Facility Interface are described in a paper by David Holmberg, "Facility Interface to the Smart Grid" [http://www.gridwiseac.org/pdfs/forum_papers09/holmberg.pdf].

^11 Priced Offers can be made by either party at the Interface.
E. Rate of Delivery

An energy transaction in this model has near-constant delivery over an interval$^{12,13}$. A contract to deliver 1 kWh/hr (1 kW) over a 24-hour day is a contract for 1 kWh in each of the 24 hours (sub intervals) of the day (a total of 24 kWh) and 1/12 kWh in each 5-minute subintervals of the day. A short daylight savings day of 23 hours delivers 23 kWh. However, in every subinterval of the day the rate of delivery (power) is the same, until modified by a possible transaction on a subinterval of a day.

By assembling a set of transactions a party can shape the total energy as desired. For each interval the sum of the rate of delivery for all transactions for a party (sell transactions are netted against buy transactions) is called the Party's position for the interval. Note that a position for a Party could include transactions with several parties$^{14}$. And a position in a 5-minute interval will include positions in hourly or monthly intervals, for example.

What is essential to the TeMIX model is that the rate-of-delivery be known at any instant in time and that the buyer is obligated to buy and the seller is obligated to sell at that rate of delivery. If the rate of delivery is not known at any time it is not be possible to know a Party's position at that time and the basis and incentives for further transactions will be ambiguous.

Transactions with arbitrary, but fixed rates of delivery over an interval are consistent with the TeMIX model. However, this introduces an element of complexity that is unnecessary, as complex transactions can be built up with a series of constant rate transactions over subintervals of longer intervals.

F. Balancing Transactions

Some parties are able to transact on short intervals of time and therefore are able to participate in balancing supply and demand on short intervals. Other parties may choose to not accurately balance supply and demand and depend on others for balancing energy.

After a delivery interval passes then the delivery obligation must be settled. If delivery occurs to a meter, then the imbalance energy for the interval is the Party's rate of delivery position multiplied by the length of

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$^{12}$ The requirement for constant rate of delivery excludes full requirements contracts used for utility retail sales. However, with the advent of interval metering and need for 24/7 price-responsive load and smart devices it is essential that the baseline for transactions be contracted and not estimated.

$^{13}$ An exception to the constant rate of delivery allows for variations in the rate of delivery within the metered delivery interval. For example, if the metered delivery interval is one hour, 5-minute meter readings would not be relevant. Likewise if the metered delivery interval is 5-minutes then variations on 4 second intervals would not be measured.

$^{14}$ If a party has a position of 2 kW for a delivery hour, this implies a position of 2 kW in each 5-minute subinterval of the hour. If a transaction, in one 5-minute subinterval sells 1 kW then the position in that 5-minute interval will be 1 kW and 2 kW in the other 5-minute intervals of the hour.
the delivery interval in hours less the meter reading for the interval. The intervals will be at the resolution of the meter readings used imbalance energy, such as an hour, 15-minutes, 5-minutes, or 4-seconds.\textsuperscript{15}

A pure trading party will typically net out its position before delivery. If there remains an imbalance then the imbalance will need to be settled as in the case of a metered delivery.

Each party's imbalance amount must be provided or absorbed. Overall there can be no imbalance at the system level as the power consumed plus losses must equal power generated. However, some parties will not participate fully in forward transactions and others may intentionally end with a positive or negative balance.

Intermediary parties such as system operators (but not limited to system operators) with access to grid level or microgrid metering and forecasting may engage in transactions to provide the net imbalance energy for the grids. After the delivery interval passes, parties with a deficit or a surplus position must offset their imbalance with ex-post transactions.

### G. Reliability

In today's electric energy markets, one party, the system operator, has the responsibility for service reliability. To that end the system operator enters into various transactions and options with generators and loads to provide balancing services as described above in Section F.

In the future smart grid with smart meters, micro grids and open markets the choice of service reliability levels will be a customer choice and balancing services will be provided by multiple parties, but with a level of regulatory oversight. TeMIX supports both reliability models.

### H. Collateral Requirements

All transactions in the TeMIX model are obligations to perform and pay. An obligation transaction obligates the buyer to take delivery of the energy and pay the contracted price. It also obligates the seller to deliver the energy at the contracted price. If either party fails to perform, the aggrieved party has the right to enter into a transaction to reverse the remainder of the deliveries under the transaction and charge or pay the defaulting party for the difference. The defaulting party obviously has similar rights to enter into an offsetting transaction with any party prior to default. Because of the possibility of default by either party to a transaction, collateral must be posted by both parties to a transaction. Collateral in support of transactions is a critical element of the TeMIX model.

Collateral management is a complex subject that deserves its own information model and is beyond the scope of this White Paper. The exposure of one party to another depends on the total portfolio of all transactions between the parties and with third parties. Collateral management is likely to require regulatory oversight to prevent meltdowns of markets. Clearing exchanges can reduce the costs of collateral management by netting; requiring a collateral amount to be associated with every transaction is inefficient.

\textsuperscript{15} The imbalance energy (kWh) is calculated as the metered energy less the (kWh) position (rate of delivery) (kW) times the delivery interval duration (hours). The imbalance rate of delivery (kW) is the imbalance energy (kWh) divided by the delivery interval duration (hours). Typically the delivery interval will be a fraction of an hour. The imbalance energy can be a buy or sell transaction.
I. Ancillary Service Products

TeMIX, smart devices, interval metering and two-way communications combine to facilitate the balancing of electricity supply and demand without energy-related ancillary service products such as regulation, spinning and non-spinning reserves as described in Section F (see also Section 4.A.b).

Other ancillary services such as voltage control are not transacted as energy. Voltage control is required both at a system level and a local level. System voltage is controlled throughout the transmission system using transformer taps, voltage regulators and reactive-power-control devices such as capacitors, reactors, static-var compensators, PV and storage inverters and generators. At some locations, it may be more economical for the utility to purchase reactive support from a customer or generator than it is for the transmission operator to directly supply reactive support. Transactions to provide or absorb reactive power (VARs) are a transaction of a different product type in the TeMIX Model. However, such transactions are beyond this scope of this White Paper but provided in the eMIX information model.

J. Reliability Signals

A reliability signal is a term that is not well-defined. In the context of Transactional Energy, priced offers and options are the primary means to manage reliability. Under extreme emergency conditions, some devices, customers, circuits and areas may be disconnected from the grid to protect the grid. Additionally, public appeals to conserve in times of system stress and prohibitions on use of electricity for such purposes as decorative lighting may be employed.

Communication of reliability signals is outside the scope of TeMIX. However, the use of such reliability actions instead of priced offers and transactions may slow the response and reduce the incentives to parties to quickly and automatically respond to emergencies. Reliability signals may increase the social and economic costs of emergencies over the costs if priced offers are used to manage emergencies. This higher social cost occurs because some parties will bear extremely high costs of reliability signals that can be reduced if other parties are able to respond at a lower cost.

A high priced offer to every customer in an area to sell back to a generator that has failed or to a transmission operator that has lost a critical system element can be communicated and responded to automatically about as fast as customers and circuits can be disconnected. The inconvenience and cost to customers for short-term reduction in air conditioning, refrigeration, heating, pumping and light dimming resulting from priced offers should be much less than broad curtailments. And those customers who did not respond for whatever reason will continue to get service and share in paying those who did respond.

K. Environmental Commodities

The eMIX information model provides for transactions of environmental commodities (carbon credits and renewable energy certificates). Environmental commodities can be transacted as a bundle with energy. Another way is to transact the energy and the environmental commodities as separate transactions.

The TeMIX model allows for the bundled case. However, it is important to distinguish positions in bundled energy transactions with different ratios of environmental commodities. A customer can buy a green bundle and a brown bundle at different prices, but in managing his position in these two bundles he could not mix them. This adds to the complexity of bundled transactions that we do not address in this White Paper.

The TeMIX model can be applied to transactions in environmental commodities, where a customer buys a standard electric energy product and then also buys one or more certificates for environmental commodities. However, modeling of environmental commodity offers and transactions is beyond the scope of this particular White Paper.
3. TeMIX Information Models

The information models described herein are based on the eMIX information model\textsuperscript{16}.

The Four information models defined for the Transactional Energy Model (TeMIX) are as follows:

1. **Energy Transaction**: A transaction between a buyer and a seller obligating both parties to deliver energy at a constant rate over the delivery interval.

2. **Energy Offer**: An offer of an Energy Transaction as in 1.

3. **Energy Option Transaction**: A put or a call option for an Energy Transaction as in 1.

4. **Energy Option Offer**: An offer for an Energy Option Transaction as in 3.

A. Process to Reach Agreements to Transactions

In this White Paper we abstract the energy business model to focus on the information model for exchange of information for energy transactions. Hence, it is beyond the scope of this document to address how buyers and sellers reach agreements on transactions or how a regulated utility or any party would compute its offer prices.

The transaction process could be bilateral negotiation, quotes and acceptance, auctions, bid/ask continuous markets, or a retail regulated tariff or dynamic price offer. Typically, a sequence of one or more Energy Offers by either party leads to an Energy Transaction between the two parties. As mentioned earlier, Transactional Energy is ideally based on buyers and sellers offering and executing many frequent, small transactions.

To illustrate, a retail customer might make monthly transactions for his average peak and off-peak daily usage followed by hourly buy and sell transactions to shape the power to the customer's needs. Finally, real-time transactions would account for the difference between the accumulated forward position and the meter reading in each metered interval.

Generators will strive to maximize profits and manage risk of the transactions they agree to. Generators may offer long-term agreements of months or years and shorter term transactions based on hourly offers close to delivery to buy or sell. Shorter term transactions (less than an hour) will typically be automated.

A vector of priced offers on future delivery intervals defines a forward price curve for buyers and sellers. As time passes the future intervals become present intervals and then delivered intervals. A forward price curve simplifies generator unit commitment and operation decisions as well as storage and customer management decisions such as air conditioner operation and electric vehicle charging.

\textsuperscript{16} OASIS Energy Market Information Exchange Technical Committee Working Draft \url{http://www.oasis-open.org/committees/download.php/37060/emix-1%200-spec-wd-04.pdf}
In addition to Energy Transactions parties may buy or sell “insurance” against very high or very low prices using Energy Option Transactions. An Energy Option Transaction, such as a call option, is an option that may be exercised by the buyer at a specified strike price up to a specified quantity (rate of delivery over an interval).

The buyer of a call option could be interested in protecting against extremely high prices in the event of a shortage. A seller of a call option could be interested in giving up a small chance of a very high price sale for two payments: (1) a guaranteed payment for the premium and (2) an energy payment at the strike price that only is exercised in the event of high prices.

Energy Option Transactions are similar to capacity and ancillary services products. Also, an Energy Option can be a demand response contract with a contracted baseline. A contracted baseline means is not necessary to estimate what the consumption would have been without the demand response transaction.

An Energy Option Offer by either party is an offer to enter into an Energy Option Transaction. When an Energy Option Transaction is exercised an Energy Transaction is created.

B. The Four Information Models

The information models described below are expressed in extended form. Nothing is assumed concerning the units, currency, location and identity of the buyer and seller. A reduced, vector version of the information model is illustrated in Section C.

The four information models for TeMIX are described in Tables 1 to 4 as follows:
### Table 1: Energy Transaction Information Model

<table>
<thead>
<tr>
<th>Energy Transaction Element</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Extended Price</td>
<td>The total cost of the transaction over the Delivery Interval at the Rate of Delivery. The Extended Price is the Price times the Rate of Delivery times the duration of the Interval.</td>
</tr>
<tr>
<td>2 Rate of Delivery</td>
<td>The constant rate of delivery over the Delivery Interval. The seller is obligated to deliver at this rate and the buyer is obligated to take at this rate. The amount of energy to be delivered is the Rate of Delivery times the duration of the Interval.</td>
</tr>
<tr>
<td>3 Delivery Interval</td>
<td>The interval of time during which the energy, was, is, or will be available for physical delivery. An Interval is designated by a Start Time and an End Time. The duration of the Interval is the End-Time - Start-Time.</td>
</tr>
<tr>
<td>4 Buyer</td>
<td>The Party buying the energy.</td>
</tr>
<tr>
<td>5 Seller</td>
<td>The Party selling the energy.</td>
</tr>
<tr>
<td>6 Transaction Execution Time</td>
<td>Date-Time the transaction was executed.</td>
</tr>
<tr>
<td>7 Location</td>
<td>The geospatial location for delivery of the energy (Point of Delivery).</td>
</tr>
<tr>
<td>8 Meter ID</td>
<td>If delivery is at a meter, an identifier designating the meter.</td>
</tr>
<tr>
<td>9 Currency</td>
<td>Code for the currency used.</td>
</tr>
<tr>
<td>10 Units</td>
<td>The units of measure for the energy.</td>
</tr>
</tbody>
</table>

### Table 2: Energy Offer Information Model

<table>
<thead>
<tr>
<th>Energy Offer Element</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Price</td>
<td>The offered price of a single unit of energy. If offered into a market this is a limit order price (the highest buy price or the lowest sell price offered).</td>
</tr>
<tr>
<td>2 Rate of Delivery</td>
<td>The constant rate of delivery over the Delivery Interval. The seller is obligated to deliver at this rate and the buyer is obligated to take at this rate over the Delivery Interval. The amount of energy to be delivered is the Rate of Delivery times the duration of the Interval.</td>
</tr>
<tr>
<td>3 Delivery Interval</td>
<td>The interval of time during which the energy, was, is, or will be available for physical delivery. An Interval is designated by a Start Time and an End Time. The duration of the Interval is the End-Time - Start-Time.</td>
</tr>
<tr>
<td>4 Buy/Sell Flag</td>
<td>Boolean variable designating the offer as (1) an offer by the Offering Party to buy energy from the Counter Party, or (2) an offer by the Offering Party to sell energy to the Counter Party.</td>
</tr>
<tr>
<td>5 Offering Party</td>
<td>The Party offering the energy</td>
</tr>
<tr>
<td>6 Counter Party</td>
<td>The Party(s) receiving the offer of energy.</td>
</tr>
<tr>
<td>7 Offer Availability Interval</td>
<td>The time interval that the offer is available for a transaction designated by a Start Time and an End Time.</td>
</tr>
<tr>
<td>8 Location</td>
<td>The geospatial location for the delivery of the energy.</td>
</tr>
<tr>
<td>9 Meter ID</td>
<td>If delivery is at a meter, an identifier designating the meter.</td>
</tr>
<tr>
<td>10 Currency</td>
<td>Code for the currency used.</td>
</tr>
<tr>
<td>11 Units</td>
<td>The units of measure for the energy.</td>
</tr>
</tbody>
</table>

---

17 This specification relies on eMIX standards and other (OASIS) standards for security, authentication of offers and parties, time and intervals, locations, meter ID, currency and units. Product definition of environmental commodities is also considered by eMIX.
### Table 3: Energy Option Transaction Information Model

<table>
<thead>
<tr>
<th>Energy Option Element</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extended Price: The total cost of the energy option transaction (the option premium).</td>
</tr>
<tr>
<td>2</td>
<td>Strike Price: The price to be paid for a single unit of energy upon exercising the option up to the Rate of Delivery.</td>
</tr>
<tr>
<td>3</td>
<td>Rate of Delivery: The constant rate of delivery over the Delivery Interval.</td>
</tr>
<tr>
<td>4</td>
<td>Delivery Interval: The interval of time during which the energy, was, is, or will be available for physical delivery. An Interval is designated by a Start Time and an End Time. The duration of the Interval is the End-Time - Start-Time.</td>
</tr>
<tr>
<td>5</td>
<td>Exercise Party: The Party with the right to exercise the option.</td>
</tr>
<tr>
<td>6</td>
<td>Counter Party: The Party subject to the option.</td>
</tr>
<tr>
<td>7</td>
<td>Put/Call Flag: Boolean variable designating the option as a Put (an option to sell by the Buying Party) or a Call (an option to buy by the Buying Party).</td>
</tr>
<tr>
<td>8</td>
<td>Transaction Execution Time: Date-Time the option offer transaction was executed.</td>
</tr>
<tr>
<td>9</td>
<td>Exercise Interval: The time interval the option is available to be exercised as designated by a Start-Time and an End-Time.</td>
</tr>
<tr>
<td>10</td>
<td>Location: The geospatial location for the energy delivery.</td>
</tr>
<tr>
<td>11</td>
<td>Meter ID: If delivery is at a meter, an identifier designating the meter.</td>
</tr>
<tr>
<td>12</td>
<td>Currency: Code for the currency used.</td>
</tr>
<tr>
<td>13</td>
<td>Units: The units of measure for the energy.</td>
</tr>
</tbody>
</table>

### Table 4: Energy Option Offer Information Model

<table>
<thead>
<tr>
<th>Energy Option Offer Element</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Option Price: The offered price of an option on a single unit of energy (option premium per unit of Rate of Delivery).</td>
</tr>
<tr>
<td>2</td>
<td>Strike Price: The price to be paid for a single unit of energy for exercising the option.</td>
</tr>
<tr>
<td>3</td>
<td>Rate of Delivery: The constant rate of delivery over the Delivery Interval.</td>
</tr>
<tr>
<td>4</td>
<td>Delivery Interval: The interval of time during which the energy, was, is, or will be available for physical delivery. An Interval is designated by a Start Time and an End Time. The duration of the Interval is the End-Time - Start-Time.</td>
</tr>
<tr>
<td>5</td>
<td>Offering Party: The Party offering the energy option.</td>
</tr>
<tr>
<td>6</td>
<td>Counter Party: The Party(s) receiving the offer of the energy option.</td>
</tr>
<tr>
<td>7</td>
<td>Exercise Party: The Party that would hold the right to exercise the option.</td>
</tr>
<tr>
<td>8</td>
<td>Put/Call Flag: Boolean variable designating the option as a put (sell option by the Exercise Party) or a call option (buy by the Exercise Party).</td>
</tr>
<tr>
<td>9</td>
<td>Offer Availability Schedule: The time interval that the option offer is available for a transaction.</td>
</tr>
<tr>
<td>10</td>
<td>Exercise Interval: The time interval the option is available to be exercised designated by Start-Time and an End-Time.</td>
</tr>
<tr>
<td>11</td>
<td>Location: The geospatial location for the energy.</td>
</tr>
<tr>
<td>12</td>
<td>Meter ID: If delivery is at a meter, an identifier designating the meter.</td>
</tr>
<tr>
<td>13</td>
<td>Currency: Code for the currency used.</td>
</tr>
<tr>
<td>14</td>
<td>Units: The units of measure for the energy.</td>
</tr>
</tbody>
</table>
C. Vector Information Models

The four information models above are expressed in scalar, extensive form. Table 5 below illustrates the vector, compact form of the Energy Offer Information Model. Additionally, given the context of an offer, the elements in grey may be inferred rather than transmitted in each message. The reduction in message size is evident.

Table 5: Vector Energy Offer Information Model

<table>
<thead>
<tr>
<th>Energy Offer Element</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Price Vector</td>
<td>The offered price of a single unit of energy. If offered into a market this is a limit order price (the highest buy price or the lowest sell price offered).</td>
</tr>
<tr>
<td>2 Rate of Delivery Vector</td>
<td>The constant rate of delivery over each interval in the Delivery Interval Vector. The seller is obligated to deliver at this rate and the buyer is obligated to take at this rate over each Delivery Interval. The amount of energy to be delivered in each interval is the Rate of Delivery for each interval times the duration of each interval.</td>
</tr>
<tr>
<td>3 Delivery Interval Vector</td>
<td>The vector of intervals of time during which the energy was, is, or will be available for physical delivery. Each interval in the vector is designated by a Start Time and an End Time. The duration of each Interval is the End-Time - Start-Time.</td>
</tr>
<tr>
<td>4 Buy/Sell Flag</td>
<td>Boolean variable designating the offer as (1) an offer by the Offering Party to buy energy from the Counter Party, or (2) an offer by the Offering Party to sell energy to the Counter Party.</td>
</tr>
<tr>
<td>5 Offering Party</td>
<td>The Party offering the energy.</td>
</tr>
<tr>
<td>6 Counter Party</td>
<td>The Party(s) receiving the offer of energy.</td>
</tr>
<tr>
<td>7 Offer Availability Interval</td>
<td>The time interval that the offer is available for a transaction designated by a Start Time and an End Time.</td>
</tr>
<tr>
<td>8 Location</td>
<td>The geospatial location for the delivery of the energy.</td>
</tr>
<tr>
<td>9 Meter ID</td>
<td>If delivery is at a meter, an identifier designating the meter.</td>
</tr>
<tr>
<td>10 Currency</td>
<td>Code for the currency used.</td>
</tr>
<tr>
<td>11 Units</td>
<td>The units of measure for the energy.</td>
</tr>
</tbody>
</table>

The vector offer assumes that all of the offers in the vector have the same buy/sell flag, offering party, etc. Thus a vector of sell offers would be distinct from a vector of sell offers. Alternatively a vector of both buy and sell offers for each interval in the vector could be defined.

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18 The OASIS Web Services Calendar Technical Committee is developing standards for communication of schedule and interval. The vector information model described here should adopt those standards when they become available. Useful vectors in TeMIX include all intervals for the next hour, day, month or year, for example. Vectors could cover contiguous intervals or could be repeating sets of hours such as weekdays, weekends and holidays, or peak hours and off-peak hours of such days.
4. TeMIX Application Examples

This section illustrates the application of the TeMIX model to electricity transactions. The examples focus on the information exchange and not the processes for price calculation, negotiation, or market clearing. The examples address only the direct costs associated with energy transactions.

First, we begin with an example of a mature application of TeMIX to energy and option transactions in open markets. Then we follow with a set of examples that apply to regulated markets.

A. Mature Transactional Energy Markets

a) Mature Transactional Energy Example

This mature example applies to open competitive wholesale and retail markets with many participants. The parties to the offers and transactions in this example are wholesale and retail parties. Transactions at retail will account for retail distribution and service costs in addition to wholesale costs. The example also applies to residential, commercial industrial and wholesale parties with loads, storage, electric vehicles, and generation.

A mature Transactional Energy market employs near continuous forward and real time energy-only transactions among all market participants. A mature market has wide deployment of interval metering, two-way communication, and automated smart price-responsive devices. The process of negotiation and exchange is highly dynamic and automated. Table 6 summarizes the transaction process without being specific to the means of negotiation.

Table 6: Dynamic Forward Energy Transactions with Ex-Post Balancing

<table>
<thead>
<tr>
<th></th>
<th>Forward Energy Offers:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parties make and counter parties receive vectors of forward buy and sell, priced offers, Table 5. The vectors of offers may be for each 5-minute interval for the remainder of the hour and the next hour, hourly for the rest of the day and the next day, and daily, monthly or yearly. Each offer has an availability interval that extends from the offer time for a short time or until it is withdrawn and replaced by refreshed offers, or the offer closes just before the start of delivery.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Forward Energy Planning:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Parties self-plan electric usage and supply, with automatic and/or manual response to the current forward priced offers and their own assessment and forecasts of power prices, needs, costs, weather, etc. A planned schedule of usage and supply is developed over a party’s chosen horizon. This plan may change as the offers and forecasts change.</td>
</tr>
</tbody>
</table>

The examples address only the direct costs associated with energy transactions. Additional costs that are independent of the amount of energy or the rate of delivery are not included here. It is important that all costs that do vary with energy or rate of delivery be reflected in the priced offers.

Where markets are not fully competitive, parties with market power may be subject to price mitigation and must offer requirements. However, markets with substantial forward transactions are less vulnerable to market power.

As described in Section b), regulation services are transacted on 4-second intervals. This example could be carried out at the 4-second interval for parties where technology is available and economics allow.
### Forward Energy Transactions:
Parties buy or sell all or some fraction of planned energy schedule over their planning horizon using a set of energy transactions. Transactions are the result of accepting offers received or making offers that are accepted by other Parties. Parties make a number of small transactions across many forward intervals to build towards their planned positions. Each energy transaction is entered at its rate of delivery at the agreed price. The extended price (cost) for each transaction is the rate of delivery times the duration of the interval times the price. As plans and offers change, transactions may add to or subtract from the customer's total rate of delivery in each interval.

### Energy Metering:
After delivery, the meter reports the energy delivered in each 5-minute interval. The balancing energy rate of delivery is equal to the meter reading (kWh) for the 5-minute interval times 12\(^{22}\)), less the net rate of delivery of all forward transactions\(^{23}\).

### Balancing Energy Transactions:
Parties including balancing market operators make and receive ex-post priced offers of balancing energy. Each party purchases or sells its balancing energy amount in one or more transactions. The extended price (cost) of each 5-minute balancing transaction is the 5-minute offer price times the 5-minute transaction rate of delivery divided by 12.

### Total Energy Costs and Revenues:
The total cost or revenue to each party is the sum of the extended prices (positive or negative) of all transactions by the party.

#### b) Mature Transactional Energy and Options Example
Reserve products (ancillary services), capacity products and demand response in the conventional sense may become obsolete with mature implementation of the smart grid vision and Transactional Energy. Parties will self select the amount of reliability and risk mitigation using call or put options for energy in addition to energy transactions as in Section a) above. Such options can be provided by both generators and loads.

In continuous, energy-only markets, higher prices quickly signal shortages and lower price quickly signal surpluses to all parties and devices on the grid. This provides all loads, generators and storage an opportunity and incentive to respond. Price caps and price floors\(^{24}\) in these markets need to be very wide to provide the necessary incentives for reliability and efficiency. Near continuous energy markets and energy options will allow all to self-manage their risks.

Fast and reliable response as a function of price will be provided by loads, storage, and distributed generation resources. Today's generators on automated generation control (AGC) receive signals about every 4 seconds. Energy transactions based on 4-second priced offers are practical and can enhance reliability. To see that this is practical, we only need to observe current financial markets where similar transactions in the billions are completed every day with round trip transaction times of micro seconds.

\(^{22}\) There are 12 5-minute intervals in an hour.

\(^{23}\) If parties are transacting forward on 5-minute intervals, the ex-post balancing transactions are likely negligible, but perhaps necessary to assure that the forward transactions are balanced.

\(^{24}\) Price caps and floors can be expected to continue in most mature energy markets to prevent extreme abuse in situations that may arise. However, price caps that are too low and price floors that are too high can mute the incentives of parties to self-manage risks though forward energy and option transactions. When the price cap is reached there may be a need for mandatory curtailment of service. In emergency situations prices above the normal price cap might be used for short intervals.
Each financial market transaction has a buyer, seller, price and a quantity, just like energy. Obviously, for the smaller parties, short interval pricing, transactions, control and billing will not be economic.

Loads desiring protection from higher prices can purchase forward energy contracts as in Section a), or call options from generators, other loads, or storage. The options can have a range of exercise prices, and notification lead times such that buyers can decide on the level of protection they want to buy.

Examples of call options are options at strike prices less than or equal to the price cap with exercise intervals ending 1-year, 1-month, 24-hours, 30-minutes, 10-minutes and 4 seconds before the delivery time. Such options mimic current capacity products and ancillary service products for regulation, spinning and non-spinning reserves.25

---

**Table 7 : Dynamic Forward Option and Energy Transactions with Ex-Post Balancing**

<table>
<thead>
<tr>
<th></th>
<th>Forward Energy Offers:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parties make and counter parties receive vectors of forward buy and sell, priced offers, Table 5. The vectors of offers may be for each 5-minute interval for the remainder of the hour and the next hour, hourly for the rest of the day and the next day, and then daily, monthly or yearly. Each offer has an availability interval that extends for a short time or until it is withdrawn and replaced by refreshed offers, or the offer closes just before the start of delivery.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Forward Option Offers:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parties also make and counter parties receive vectors of forward priced call options as in Table 4. The call options may be for exercise intervals with a notice of 1-year, 1-month, 24-hours, 30-minutes, 10-minutes and 4-seconds before exercise. The vectors of option offers may be, hourly for the rest of the day and the next day, and then daily, monthly or yearly. Each option offer has an availability interval that extends for a short time or until it is withdrawn and replaced by refreshed offers, or the offer closes just before the start of the exercise interval. The strike price of the call options is a strike price that is less than the price cap. The option premium price is based on offer and acceptance.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Forward Energy Planning:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Parties self-plan electric usage and supply, with automatic and/or manual response to the current forward priced offers and their own assessment and forecasts of power prices, needs, costs, weather, etc. A planned schedule of usage and supply is developed over a party’s chosen horizon. This plan may change as the offers and forecasts change.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Forward Option Planning:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parties plan how much to buy or sell how much to buy or sell as call option contracts27.</td>
</tr>
</tbody>
</table>

---

25 Spinning and non-spinning reserves are typically deployed only in the event of grid contingencies such as a sudden loss of generation or transmission. And then additional generation and load reduction is usually deployed to return the deployed reserves to reserve status. A call option with a strike price at or near the price cap would accomplish this function by exercising the option for various intervals only until high prices bring the system back into balance and not continuing to exercise options after that.

27 Large generators may want to buy put options to cover some of the start-up costs of generators. Wind generators may want to buy put options to project against low prices in high wind situations.
### Forward Energy Transactions

Parties buy or sell all or some fraction of planned energy schedule over their planning horizon using a set of energy transactions. Transactions are the result of accepting offers received or making offers that are accepted by other Parties. Parties make a number of small transactions across many forward intervals to build towards their planned positions. Each energy transaction is entered at its rate of delivery at the agreed price. The extended price (cost) for each transaction is the rate of delivery times the duration of the interval times the price. As plans and offers change, transactions may add to or subtract from the customer's total rate of delivery in each interval.

### Forward Option Transactions

Parties buy or sell all or some fraction of planned energy schedule over their planning horizon using a set of call option transactions. Transactions are the result of accepting option offers received or making offers that are accepted by other Parties. For example, a load party might buy 50% of planned energy on one year notice, 10% on 24 hour notice, 4% on 30 minute notice, 3% on 10 minute notice and 1% on 4 second notice. Generators or other loads would take the other side of these options. Parties make a number of small transactions across many forward intervals to build towards their planned energy and option positions. Each option transaction is entered at a rate of delivery at the option premium price. The extended price (cost) for each option transaction is the rate of delivery times the duration of the interval times the option premium price. As plans and offers change, transactions may add to or subtract from the customer's total call option rate of delivery in each interval.

### Option Exercise:

In situations where the prices of energy offers exceed the option strike price, the exercise party of a call option will exercise the option up to its rate of delivery to assure delivery of energy at the strike price. The cost of exercise is the strike price times the exercised rate of delivery times the duration of the delivery interval.

### Energy Metering:

After delivery, the meter reports energy delivered in each 4-second interval. The balancing energy rate of delivery is equal to the meter reading (kWh) for the 4 second interval times 900, less the net rate of delivery of all forward transactions including exercised option transactions.

### Balancing Energy Transactions:

Parties including balancing market operators make and receive ex-post priced offers of balancing energy. Each party purchases or sells its balancing energy amount in one or more transactions. The extended price (cost) of each 4-second transaction is the offer price times the transaction rate of delivery divided by 900.

### Total Energy and Option Costs and Revenues:

The total cost or revenue to each party is the sum of the extended prices (positive or negative) of all transactions by the party.

### B. Retail Real-Time Cost-of-Service Markets

The following retail real-time market examples are specific applications of TeMIX to regulated markets where a single Retail Service Provider (RSP) provides a real-time dynamic pricing tariff. The tariff offers are priced offers with no counter offers by the Customer as in mature Transactional Energy Markets.

---

28 A "demand response option" might be offered by a load to sell energy that the load has already purchased but at a strike price below or at the price cap. A "capacity option" would be an option to buy energy at a strike price below or at the price cap.

29 There are 900 4-second intervals in one hour.
There are many ways to implement hourly, 15-minute or 5-minute real-time pricing. The following examples are a Retail Service Provider (RSP) offering hourly real-time dynamically priced service.

The first retail real-time pricing (RTP) example described in Table 8 is a simple Ex-Ante hourly sale offer. Ex-Ante means that the offer is made before the delivery interval. In this first case the offer remains available until after the interval passes.

### Table 8: Hourly Ex-Ante Sell Offers

1. **Day-Ahead Hourly Offers:**
   - At 12 noon the day-head, a vector of ex-ante sell offers, Table 5, for each of the 24 hours of the next day are tendered to the retail customer by the RSP. The offer availability interval is from 12 noon the day before until the close of each delivery hour. The rate of delivery of the offer is limited only by the electrical limits on the service connection.

2. **Real-Time Usage:**
   - Customer self-manages electric usage with automatic and/or manual response to the ex-ante hourly priced offers.

3. **Metering and Costs:**
   - Meter reports energy delivered in each hour. An energy transaction, Table 1, is entered with the rate of delivery equal to the meter reading (kWh) for the hour. The extended price (cost) in each hour equals the ex-ante hourly offer price times the meter reading for the hour.

The RSP can set the price in Table 8 equal to the hourly clearing price in a wholesale day-ahead market plus a retail adder. The RSP is carrying two risks: (1) the amount that will be transacted is unknown and (2) the RSP’s cost of wholesale supply is unknown until delivery. The RSP can buy at the wholesale price by estimating the amount needed and bidding that amount into the Day Ahead hourly market. The retail customer knows the price in each hour of the next day, so the customer can easily manage his loads to minimize his costs with no price risk.

The second retail RTP example, Table 9, settles actual deliveries based on ex-post hourly priced offers. Customers rely on forecasts of the ex-post hourly prices. The risks are assumed by the retail customer and no price or quantity risks are borne by the RSP in procuring in the wholesale real-time markets.

### Table 9: Hourly Ex-Post Sell Offers

1. **Day-Ahead Customer Forecasts:**
   - Customer makes or receives frequently updated forecasts of 24 or more future hourly prices at various times before the interval. (Note that forecasted prices are not priced offers.)

2. **Real-Time Customer Usage:**
   - Customer self-manages electric usage, with automatic and/or manual response based on the forecast hourly priced offers.

3. **Real-Time Ex-Post Offers:**
   - After each hourly delivery interval passes, an hourly ex-post sell offer is tendered by the RSP. (Note that ex-post offer prices will vary from forecasted hourly prices).

4. **Metering and Costs:**
   - Meter reports energy delivered in each hour. An energy transaction, Table 1, is entered with a rate of delivery equal to the meter reading (kWh) for the hour. Extended price (cost) in each hour equals the ex-post hourly price times the meter reading for the hour.
The third retail RTP example provides clear price information to the buyer without imposing major risks on either party. In this example, both ex-ante hourly and 5-minute offers are provided. The hourly transaction is a forward transaction to the 5-minute delivery interval transactions.

### Table 10: Hourly Ex-Ante Forward Sell Offers with Ex-Ante 5-Minute Buy/Sell Offers

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Day-Ahead Hourly Ex-Ante Offers:</strong> At 12 noon the day-head, a vector of ex-ante sell offers, Table 5, for each of the 24 hours of the next day are tendered by the Retail Service Provider (RSP). The offer availability interval is from 12 noon the day before until 1 pm the day before.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Day-Ahead Customer Planning:</strong> Customer plans electric usage, with automatic and/or manual response to ex-ante hourly priced offers. Planned electric usage is developed for the 24 hours of the next day.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Day-Ahead Energy Transactions:</strong> Customer purchases all or some fraction of planned energy for each of the 24 hours. An energy transaction, Table 1, is entered for each hour at the planned rate of delivery and at the ex-ante hourly offer price. The extended price (cost) is the rate of delivery times the ex-ante offer price.</td>
</tr>
<tr>
<td>4</td>
<td><strong>Real-Time Customer Usage:</strong> Customer self-manages electric usage, with automatic and/or manual response to forecasted 5-minute prices.</td>
</tr>
<tr>
<td>5</td>
<td><strong>Real-Time Ex-Post Offers:</strong> After each 5-minute delivery interval passes, 5-minute interval ex-post buy and sell offers are tendered by the RSP. (Note that ex-post offer prices will vary from forecasted 5-minute prices).</td>
</tr>
<tr>
<td>6</td>
<td><strong>Metering and Costs:</strong> Meter reports energy delivered in each 5-minute interval. A 5-minute energy transaction, Table 1, is entered equal to the meter reading for the 5-minute interval less the rate of delivery from the forward hourly transaction. The Extended price (cost) in each hour equals the ex-ante 5-minute offer price times the 5-minute transaction rate of delivery divided by 12.</td>
</tr>
<tr>
<td>7</td>
<td><strong>Total Customer Costs:</strong> The total cost for each hour is the hourly transaction extended price plus the sum of the 5-minute interval transaction extended prices.</td>
</tr>
</tbody>
</table>

### C. Retail Forward Baseline Transactions with RTP

Retail forward baselines provide a forward rate-of-delivery to retail customers in each delivery interval. Actual deliveries may be more or less than the forward baseline and deficit and surplus amounts are transacted using real-time buy and sell offers. Forward baselines allow the customer and the RSP to fix the cost of a baseline amount of energy, while retaining the opportunity for the customer to manage consumption based on real-time priced offers and respond to grid conditions as reflected in priced offers.

The first baseline example in Table 11 illustrates a cost-of-service baseline provided by an RSP. The second example in Table 12 illustrates a retail customer making forward transactions to build his own baseline.

Combining both examples will allow a retail customer to take a cost-of-service baseline and reshape it in a series of forward transactions to better match his needs. Each of the examples pair forward baseline transactions with different real-time transactions. The real-time transactions can take several different forms as illustrated in Section B.
### Table 11: Fixed Baseline with Hourly Ex-Ante Offers

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
</table>
| 1 | **Cost of Service Baseline Allocation:**
Customer accepts a cost-of-service fixed baseline transaction as in Table 1. The baseline amount will typically vary by time-of-day, day-of-week and season. The cost of the baseline transaction is a fixed amount per month. The monthly baseline cost can be a lower amount for low income groups.|
| 2 | **Day-Ahead Hourly Ex-Ante Offers:**
At 12 noon the day-head, a vector of ex-ante sell offers, Table 5, for each of the 24 hours of the next day are tendered by the Retail Service Provider (RSP). The offer availability interval is from 12 noon the day before until the close of each delivery hour. |
| 3 | **Real-Time Customer Usage:**
Customer self-manages electric usage, with automatic and/or manual response to ex-ante hourly priced offers. |
| 4 | **Metering:**
Meter reports energy delivered in each hour. An energy transaction, Table 1, is entered with a rate of delivery equal to the meter reading (kWh) for the hour. Extended price (cost) in each hour equals the ex-ante hourly offer price times the meter reading for the hour. |
| 5 | **Total Costs:**
The total cost per month is the monthly baseline cost plus the hourly transaction cost (positive or negative) over all hours in the month. |

### Table 12: Build-Your-Own Baseline with Forward Ex-Ante Offers and 5 Minute Ex-Post Offers

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
</table>
| 1 | **Build Customer Baseline:**
Customer receives vectors of forward buy and sell, priced offers as in Table 5. The vectors of offers may be for each 5-minute interval for the remainder of the hour and the next hour, hourly for the rest of the day and the next day, and then daily, monthly or yearly. Each offer has an availability interval that extends until it is withdrawn and replaced by refreshed offers, or the offer closes just before the start of delivery. |
| 2 | **Customer Forward Planning:**
Customer self-manages electric usage with automatic and/or manual response to the current ex-ante forward priced offers and forecasts of prices need and weather. A planned electric usage is developed over a customer chosen horizon. This plan may change as the offers and forecasts change. |
| 3 | **Customer Forward Transactions:**
Customer purchases all or some fraction of planned energy over his planning horizon using a set of energy transactions. Each energy transaction is entered at its rate of delivery and at the ex-ante offer price. The extended price (cost) for each transaction is the rate of delivery times the ex-ante offer price. As the offers change, transactions may add to or subtract from the customer's total rate of delivery in each interval. |
| 4 | **Real-Time Ex-Post Offers:**
After each 5-minute delivery interval passes, 5-minute interval ex-post buy and sell offers are tendered to the customer. |
| 5 | **Metering and Costs:**
Meter reports energy delivered in each 5-minute interval. A 5-minute energy transaction, Table 1, is entered with a rate of delivery equal to the meter reading (kWh) for the 5-minute interval times 12), less the total rate of delivery from all forward transactions. The Extended price (cost) of the 5-minute ex-ante transaction is the 5-minute offer price times the 5-minute transaction rate of delivery divided by 12. This extended 5-minute price may be negative or positive. |
| 6 | **Total Customer Costs:**
The total cost of energy to the customer is the sum of the extended prices (positive or negative) of all transactions. |