

**TO:** NAESB Wholesale Electric Quadrant (WEQ) Members, Retail Electric Quadrant (REQ) Members, Smart Grid Standards Task Force Participants and Interested Industry Participants [naesb@naesb.org](mailto:naesb@naesb.org)

**FROM:** Edward Cazalet (ed@cazalet.com)  
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**RE:** Request for Informal Comments on DR/DER Framework Document and Use Cases and Request for Informal Comments on Common Price Communication Model (PAP 3) - Use Cases -

Comments due **October 11, 2009**

**DATE:** October 11, 2009

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These comments address both the Framework for Integrated DR and DER Models and the Common Price Communication Model (PAP 3) Use Cases.

The use cases both provides very helpful information on the context for developing DR/DER control and pricing standards.

It is understood that there will be a transition from today's tariff and industry structures to pricing structures that will be enabled by the two-way communication and interval metering systems being deployed. Both pricing structures must be considered by the standards.

The new Smart Grid communication and metering technology will enable dynamic forward pricing that can be flexibly applied. Such pricing is a primary objective of the Smart Grid. Outlining what this may look like is an essential step in Smart Grid standards development.

Attached is a memo I recently prepared for the OASIS Energy Interoperation Technical Committee. The memo provides high level use cases based on the NIST Framework and Roadmap, and preliminary, price, product and messaging specifications for a very powerful and generalized implementation of dynamic pricing. It is only a draft and it has not be reviewed by the Technical Committee. The attached document is also available at <http://www.oasis-open.org/committees/download.php/34622/Retail%20Dynamic%20Price%2C%20Product%20and%20Messaging%20Specification%20DRAFT-2%20-%20Cazalet.pdf>

Dynamic pricing as described in the attached memo offers the opportunity to support customer self management of loads in response to prices that convey the needs of the grid for reliability and economic dispatch. It avoids the use of "programs" described in the Framework each designed to apply a particular version of DR. The proposed dynamic pricing is intended to operate 24/7 to support peak load reduction, management of ramping, integration of variable wind and solar generation, charging of electric vehicles and operation of DER including storage.

Edward G.-Cazalet

Comments to NAESB on DR/DER Framework Document and Use Cases

2009-10-11

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The dynamic pricing concepts suggested in the attached memo can apply to all four distinct types of retail service outlined in the Framework:

- Fully vertically integrated regulated distribution and energy where the Distribution Company owns the generation, supplies firm requirements to all its customers, and provides regulated distribution service.
- Vertically integrated regulated distribution and energy, but competitive supply permitted where, although the Distribution Company owns generation, third-party suppliers are permitted to supply customers within the Distribution Company's service territory. The Distribution Company provides regulated distribution service. Obviously, this is a very rare situation.
- Divested generation and regulated distribution with no competitive supply where the Distribution Company has divested its generation, but purchases all the energy to provide full requirements to its customers while still providing regulated distribution service.
- Divested generation and fully open competitive supply where the Distribution Company has divested its generation, permits third-party suppliers to supply energy to customers, purchases energy and provides Provider of Last Resort service, and provides regulated distribution service.

Dynamic pricing as described in the attached memo also applies to all customer classes. The pricing can combine tariff based cost of service prices with fully dynamic prices. We do not specify how the a Retail Service provider, regulated or competitive, would determine prices. Where wholesale markets are available we allow for the Retail Service Provider to determine how to access the wholesale markets. Thus it should work with any ISO/RTO market as it evolves.

Day-ahead, hour-ahead and real-time prices are all special cases of the attached dynamic pricing concept. Hence pricing standards based on this proposal might apply to many US and other markets.

A key element of the attached proposal is to avoid forecasted or estimated baselines for demand response. Such baselines are difficult to implement and subject to abuse.

This proposal is different than the Framework so I hope many of you will take the time to study the proposal. The generality of the proposal may not be evident to all at first. And with this generality comes a form of simplicity in specification, implementation and use. There is much more to be done to build out the use cases and price, product and messaging specifications. I look forward to your feedback.

# 1 Retail Dynamic Price, Product and 2 Messaging Specification (DRAFT -2)

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3 Draft Memo to OASIS Energy Interoperation TC by Ed Cazalet (original Sept 10,  
4 2009, updated October 11, 2009)

5 *During the September 2nd 2009, OASIS Energy Interoperation Technical Committee meeting, I was asked*  
6 *to describe (at a high level) the so called "Pure Price" approach to Demand Response (DR) and*  
7 *management of Distributed Energy Resources (DER) . I do not care for the Pure Price label, but the idea*  
8 *is to describe the use of dynamic retail prices as an alternative or complement to direct control Demand*  
9 *Response. Comments, corrections, and contributions to this draft are welcome.*

## 10 **1. Introduction**

11 FERC has stated that is not intending to require the use of dynamic prices in retail rates, but that it is  
12 encouraging utilities and states that choose this option to develop standard price terminology and  
13 methods for communicating price information. FERC also encouraged the further development of  
14 key standards that would enhance interoperability and communications between system operators,  
15 demand resources, and the systems that support them. This document is toward that end.

16 The NIST Smart Grid Taskforce Meeting held on August 10, 2009 provided some guidance for  
17 Retail Dynamic Prices in its Priority Action Plan 09 (PAP09) . The PAP09 plan focuses on Demand  
18 Response and Distributed Energy Resource Signal Semantics The PAP09 document on signaling  
19 defines a need for a framework and common terminology for:

- 20 • Price communication,
- 21 • Grid safety or integrity signals,
- 22 • DER support, and
- 23 • Other signals and/or an extensibility mechanism.

24 The OASIS Energy Interoperation Technical Committee (TC) Charter<sup>1</sup> states:

25 "The TC will develop a data model and communication model to enable collaborative and  
26 transactive use of energy. Web services definitions, service definitions consistent with the OASIS  
27 SOA Reference Model, and XML vocabularies will be developed for interoperable and standard  
28 exchange of:

- 29 • Dynamic price signals

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<sup>1</sup> <http://www.oasis-open.org/committees/energyinterop/charter.php>

- 30           • Reliability signals
- 31           • Emergency signals
- 32           • Communication of market participation information such as bids
- 33           • Load predictability and generation information

34 In this memo we do not specify how to determine dynamic prices. Rather the focus is to describe the  
 35 messages for price quotes, offers and bids and the resulting transactions at the interfaces between the  
 36 customers and the grid. We also do not address in any detail how smart devices and controllers  
 37 would use the price signals. The transport and security for the messages also are not addressed here  
 38 as these standards are being developed elsewhere.

## 39           **2. Description**

40 Fully dynamic prices entail both real-time and forward prices and transactions for delivery or supply  
 41 of energy. Energy is delivered to and from Retail Customers and devices including Electric Vehicles,  
 42 and Distributed Energy Resources (DERs) such as solar, storage and small generators. Prices and  
 43 transactions may be for hourly intervals or perhaps 5-min intervals and can also include long term  
 44 forward transactions.

45 Retail Dynamic Prices are typically viewed as an element of Demand Response but there are  
 46 significant differences. Retail Dynamic Prices encourage continuous changes in electricity  
 47 consumption and Distributed Energy Resources (DER) supply in response to dynamically changing  
 48 prices of energy. In contrast, Demand Response Programs typically result in a temporary change in  
 49 peak electricity consumption in response to market or reliability conditions directed by a grid  
 50 operator. The focus on continuous 24/7 response in addition to the traditional focus of Demand  
 51 Response Programs on peak demand is especially necessary with increasing penetration of variable  
 52 renewables such as solar and wind. 24/7 response is also needed to support the growth of storage,  
 53 other distributed generation and electric vehicles that are difficult or impossible to dispatch using the  
 54 traditional central dispatch methods of utilities and ISO/RTOs

55 A fundamental flaw in most Demand Response Programs is that the baseline from which curtailment  
 56 are measured is only a forecast or estimate of what would have been consumed without the demand  
 57 response signal. Such forecast baselines invite gaming and are next to impossible to apply in a 24/7  
 58 baseline estimation needed for variable renewables integration.

59 Cost of service retail prices may be time varying but are not fully dynamic. With non dynamic  
 60 prices, there is a justification for Demand Response Programs to curtail demand at peak load times.  
 61 Retail Dynamic Prices will directly and efficiently coordinate load and generation on the grid.  
 62 Forward Dynamic Prices provide stability in the cost of electricity desired by many Customers  
 63 through long term transactions. With Dynamic Prices, the need for conventional Demand Response  
 64 Programs is mitigated and perhaps eliminated. Clearly as the market transitions, cost of service  
 65 prices, Dynamic Prices and Demand Response Programs may coexist.

66 Retail Dynamic Prices can be real-time dynamic prices or both real-time and forward dynamic prices.  
 67 Forward dynamic prices provide Customers and DER generators with the opportunity and lead time  
 68 to plan their energy consumption and production ahead of delivery and thereby improve efficiency.

69 Real-time dynamic prices provide the economic signals to dynamically balance supply and demand.  
70 We will develop high level retail dynamic price use cases, requirements and message standards so  
71 that dynamic prices to guide implementation at any level of detail desired or needed.

72 In summary, Retail Dynamic Prices have the potential to:

- 73 • Engage the consumer by allowing market participation and consumption/billing choices;
- 74 • Rapidly respond to wind and solar output changes on the distribution and transmission grid to  
75 maintain system reliability and support large amounts of variable renewable generation.
- 76 • Reduce carbon and other emissions.
- 77 • Control peak power conditions and limit or remove brownout/blackout instances;
- 78 • Flatten consumption curves and shift consumption times;
- 79 • Respond to temporary or continuing grid anomalies;
- 80 • Produce new markets for aggregators, micro-grid operators, distributed generation, vendors,  
81 smart device, smart appliances, smart meters and consumers;
- 82 • Reduce generation, transmission, distribution and customer costs and investments.
- 83 • Reduce the complexity and improve the performance of retail load management in  
84 comparison to the complexity and inefficiency of fixed retail tariffs combined with multiple  
85 Demand Response Program.

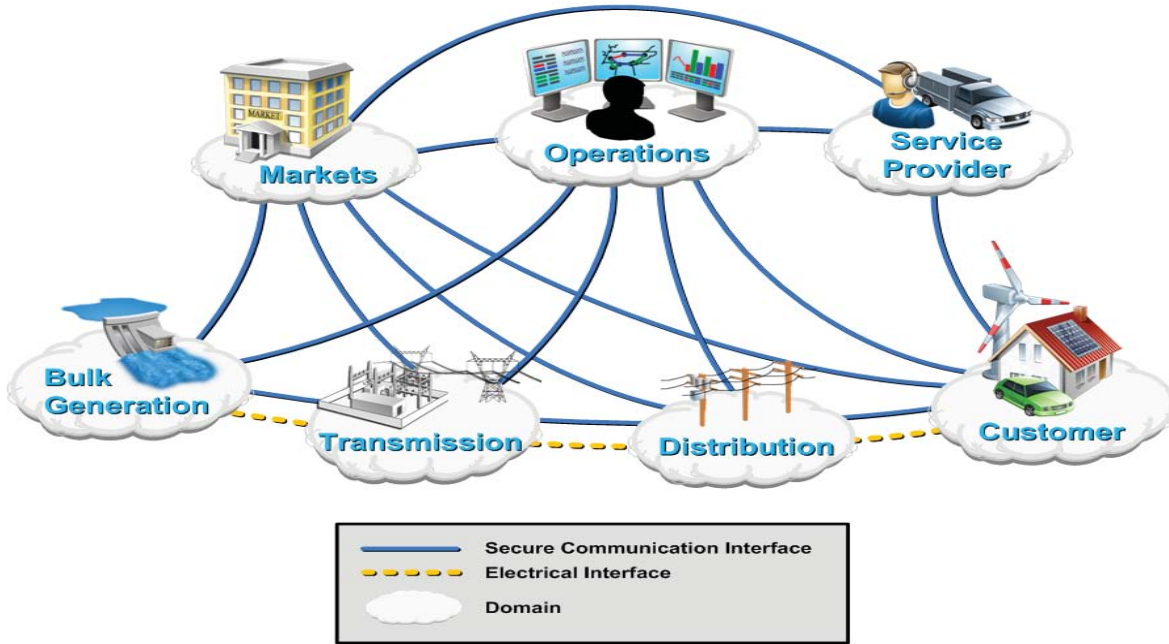
### 86 **3. Domains**

87 We will use the Domains defined in the August 10, 2009 Report to NIST on the Smart Grid  
88 Interoperability Standards.<sup>2</sup> The Domains in the Smart Grid Conceptual model are defined as  
89 follows:

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<sup>2</sup> [http://www.nist.gov/smartgrid/Report%20to%20NIST1August10%20\(2\).pdf](http://www.nist.gov/smartgrid/Report%20to%20NIST1August10%20(2).pdf)

# Conceptual Model



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Domains in the Smart Grid Conceptual Model	Actors in the Domain
Customers	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: home, commercial/building, and industrial.
Markets	The operators and participants in electricity markets
Service Providers	The organizations providing services to electrical customers and utilities
Operations	The managers of the movement of electricity
Bulk Generation	The generators of electricity in bulk quantities. May also store energy for later distribution.
Transmission	The carriers of bulk electricity over long distances. May also store and generate electricity.
Distribution	The distributors of electricity to and from customers. May also store and generate electricity.

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## 4. Dynamic Price Actors and Domains

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The Actors providing and using Retail Dynamic Prices in each Domain are described in the following table:

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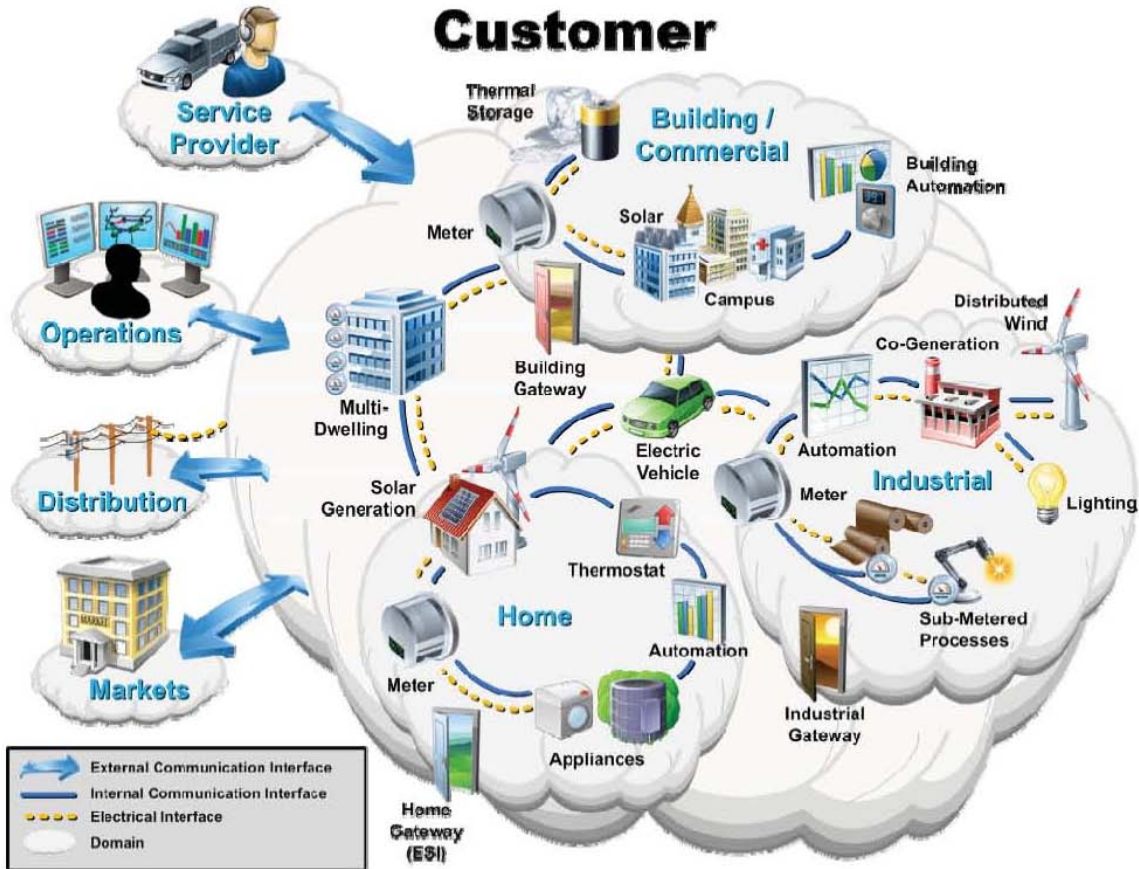
95

Actors	Domain	Description
Retail Service Provider (also known as a Load Serving Entity or a Utility)	Markets	Sets retail prices or price quotes, and clears retail bids and offers, balances retail transactions with wholesale transactions in wholesale markets, and schedules power transactions with the grid operators. A Retail Service Provider may be either a regulated cost of service provider such as a vertically integrated utility or a competitive, direct access retail service provider. Multiple Retail Service Providers may provide services to a single Customer or Device where local regulations permit.
Dynamic Price (DP) Service Provider	Service Providers	A Dynamic Price Service Provider may provide dynamic price services to Retail Service Providers. They may also serve as a DP Administrator supporting Registration Processes and Registration Data Base.
Retail Market	Markets	The set of Retail Service Providers and others who support retail transactions.
Wholesale Market	Markets	Clears wholesale bids and offers and schedules among Bulk Generators and Retail Service Providers. Schedules wholesale transactions for delivery over the transmission Grid. Wholesale market participants include ISOs, RTOs, exchanges, brokers, marketers, generators, transmission operators and Retail Service Providers.
Meter	Customers	Unless otherwise qualified, a device used in measuring watts, vars, var-hours, volt-amperes, or volt-ampere-hours. Called a Smart Meter when part of an advanced metering infrastructure (AMI). Today, typically located at the customer facility and owned by the distributor or retail provider. Meters associated with specific devices such as Electric Vehicles meters and other sub meters are considered.
Device, HAN Device, Electric Vehicle, or Smart Appliance	Customers	Devices that can react to remote management, whether to price, grid integrity, or other energy management signaling. May be controlled by a Facility Energy Management System (EMS), a Facility Gateway, though a Smart Meter (serving as a Facility Gateway), or other means such as direct communication of price or other information. Communication to the device might be via a Home-Area Network or other means; we use the terms interchangeably.
Facility EMS, Energy Services Interface (ESI) /Gateway	Customers	A logical or physical device typically located at the customer facility and used as a communication gateway. The EMS may or may provide the Gateway function. The Energy Services Interface (ESI) permits applications such as remote load control, monitoring and control of distributed generation, in-home display of customer usage, reading of

Actors	Domain	Description
		non-energy meters, and integration with building management systems. The ESI may provide auditing/logging functions that record transactions to and from Home Area Networking Devices.
Display	Customers	An In-Home Display (for Homes) or facilities console for other customers (e.g. commercial buildings, industrial facilities, or vehicles) shows information related to energy management.
Distributed Energy Resource (including Storage)	Customers	Distributed Generation, often called Distributed Energy Resources (DER), includes small-scale generation or storage of whatever form. This is in contrast to centralized or bulk generation and/or storage of electricity. A DER energy resource may be behind a Customer Meter along with Customer Loads or be separately connected to the distribution system and have a dedicated meter.
Distribution Operations	Operations	Controls the distribution of electricity to and from customers and to and from the transmission grid.
Transmission Operations	Operations	Controls transmission of energy.

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97 For specifying retail dynamic prices we primarily refer to the Customers, Markets, Service Providers  
 98 and Operations Domains. The Customers Domain and its interfaces to the other Domains is  
 99 illustrated in the following diagram:



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## 5. Use Cases

102 This section describes an initial set of architecturally significant use cases for Retail Dynamic Prices.  
 103 The use cases are similar to or extensions of use cases identified in the NIST August 10, 2009  
 104 Framework report. More detailed Customer use cases are explored for example in  
 105 ZigBee+HomePlug Joint Working Group Smart Energy Profile Marketing Requirements Document  
 106 (MRD).<sup>3</sup> The focus here is on identifying the uses of dynamic prices rather than the specifics for  
 107 each type of device and the in-building and device controllers and networks.

108

109 Five high level use cases are described. Cases A through D describe customers with increasing  
 110 interest and automation to respond to dynamic prices. The last case extends dynamic pricing to  
 111 include distribution congestion and loss pricing.

112

- 113 A. Customer Changes their Usage in Response to Dynamic Prices
- 114 B. Customer Uses Smart Appliances and Devices or Energy Management System
- 115 (EMS) in Response to Retail Dynamic Prices

<sup>3</sup> <http://www.oasis-open.org/apps/org/workgroup/energyinterop/download.php/33261/Smart%20Energy%20Profile%202.0%20Marketing%20Requirements%20Document.pdf>

- 116 C. Retail Dynamic Prices with Ancillary Services
- 117 D. Retail Service Provider Quotes Dynamic Forward Prices and Transacts Energy with
- 118 Customers
- 119 E. Distribution Operator Provides Dynamic Distribution Prices and Loss Factors to
- 120 Retail Service Providers

121 **A. Customer Changes their Usage in Response to Dynamic Prices**

122 Customer awareness of energy scarcity and customer attention to energy use, each maintained by  
 123 economic signals, are key benefits of the smart grid. The most expensive use of the grid is to cover  
 124 short term shortages in energy supply. Today such shortages are caused as buildings respond to  
 125 weather or as the grid responds to unplanned outages. Tomorrow, as we rely more on intermittent  
 126 energy sources such as sun and wind, they will occur more frequently.

127 Customers may increase their awareness of energy scarcity using dynamic price information  
 128 provided by In Home Display Devices (IHD) or other means and can display past, current and  
 129 projected consumption as well as past current and forward energy prices.

130 Customers without in-home display devices who are generally aware of current prices and the effect  
 131 of their usage decisions on their bill also may be able to benefit from dynamic prices.

132 Customers without automated smart devices will typically want simpler dynamic price protocols and  
 133 transactions.

134 In this case, Customers on a dynamic price service are likely to select, be offered, or have as a default  
 135 a baseline amount of energy that can vary by time of day and season. A Retail Service Provider may  
 136 provide, either a cost of service rate or a competitive rate for the baseline service. Any amounts  
 137 above the baseline would be measured by the Customer meter, perhaps hourly, and billed at a real-  
 138 time price. Any amounts below the baseline amount would be paid to the Customer at a real-time  
 139 price.

140 The customer baseline will provide some cost certainty to the Customer on his bill. The real-time  
 141 price applied to all customers will allow the customer to profit when able to reduce usage below the  
 142 baseline, but will pass on the high cost from the system when the grid is under stress. Customers  
 143 may learn over time to shift usage from high cost periods to low cost periods and reduce their overall  
 144 bill for electricity.

145 **B. Customer Uses Smart Appliances and Devices or Energy Management**  
 146 **System (EMS) in Response to Retail Dynamic Prices**

147 The Smart Grid allows customers to become actively involved in changing their energy consumption  
 148 habits by connecting their personal Smart Appliances and Devices to the utility grid either directly or  
 149 through an Energy Management System(EMS). Smart appliances and devices have their own  
 150 domain requirements, in particular safety requirements, and must manage their own behaviors in  
 151 response to coordinating and economic signals. Communication is through the Facility Energy  
 152 Services Interface (ESI) or the metering system. And, smart devices may also communicate directly  
 153 with the Retail Market Domain.

154 For example, a building with air conditioning can decide to pre cool in the morning and buy power at  
 155 lower dynamic prices and sell back power in the afternoon at higher forward dynamic prices, thereby  
 156 reducing costs. If the building has active thermal storage (for example, ice) the building will have  
 157 even more flexibility to shift consumption to reduce costs. Electric water heating, electric space

158 heating, refrigeration and some industrial process all have thermal inertia that enables dynamic  
 159 management of usage in response to dynamic prices. With more renewables, the dynamic prices will  
 160 be more volatile and the management of thermal storage using dynamic prices to accommodate  
 161 renewables variability will be very helpful.

162 This case includes Electric Vehicles whether charged at home, work or at a charging station. When  
 163 the current dynamic price is lower than forward dynamic prices for later in the day, it will generally  
 164 be less costly to charge at the lower price. At night when there may be excess generation on the grid  
 165 the price could be very low or negative. When the current dynamic price is high it may be possible  
 166 to defer charging. The customers driving plans and habits, the efficiency of charging at different rates  
 167 of charge, the cost of gasoline for a hybrid electric vehicle will all be factors in addition to the  
 168 dynamic power prices that will determine when and how fast to charge the vehicle batteries. And as  
 169 dynamic prices respond to grid conditions continuously, the charging plan can be modified  
 170 automatically. For example if too many Electric Vehicles attempt to charge at the same time, the  
 171 dynamic prices may increase, and some vehicles will automatically decide to charge at a later time.

172 This case includes Distributed Energy Resources (DER). A Customer may have on-site solar PV,  
 173 fuel cell, combined heat and power, storage or other generation behind his meter. Dynamic prices  
 174 will enable intelligent controllers for each device to determine when to generate, when not to  
 175 generate and when to store electricity. For example, if the solar PV panels on the house feed more  
 176 power back into the distribution grid than the house consumes or can store at that time and if the  
 177 dynamic price to the house is negative, the solar PV panels may be turned off. When battery storage  
 178 is available, battery controller can decide when to store and when to discharge. And a properly  
 179 configured the Electric Vehicle may also be able to deliver power back to the building or the grid  
 180 when dynamic prices are very high.

181 The availability of intelligent devices to automatically respond to dynamic prices will allow the use  
 182 of more frequent updating of prices and more dynamic price products to better respond both to  
 183 Customer preferences and provide customer cost reduction while better interfacing with the grid.

184 Rather than having smart devices attempt to forecast real-time prices, forward dynamic price quotes  
 185 provide opportunities to buy sell power forward of the real-time delivery interval and know that the  
 186 transaction will benefit both the Customer and the overall grid. And the response of load to forward  
 187 signals will enhance grid reliability and allow central station generation to be operated at a steady  
 188 rate with less cycling and startup and shutdown which increases costs and GHG emissions.

### 189 **C. Retail Dynamic Prices with Ancillary Services**

190 In addition to responding to Dynamic Energy Prices, the Retail Customer or a Distributed Energy  
 191 Resources with Smart Devices may be able to provide ancillary services such as frequency regulation  
 192 or spinning reserve capacity that can be called on by the grid operation under certain grid  
 193 emergencies. The Retail Service Provider combines retail schedules for ancillary services into an  
 194 aggregate schedule into the wholesale market operations scheduling system. The Retail Service  
 195 Provider transmits any ancillary services dispatches from the Grid Operator to the Retail Customer  
 196 and uses data from the Customer Meter to determine compliance and any deviations from schedules  
 197 and operations dispatches.

## D. Retail Service Provider Quotes Dynamic Forward Prices and Transacts Energy with Customers

198  
199  
200 Customers want to know the prices of products before they buy. It is beyond the scope of this  
201 specification to specify how Retail Service Providers would determine the price levels to quote to  
202 Customers. However it is useful to provide a high level description as to how Retail Service  
203 Providers might operate so that we can specify the message protocols for dynamic prices and  
204 transactions.

205 A Retail Service Provider typically assembles a portfolio of transactions by purchasing and selling  
206 power products in wholesale markets to support the sale and purchase of power products in retail  
207 markets. Wholesale markets involve generators, system operator markets, brokers, exchanges, and  
208 marketers. A Retail Service Provider will also pay for the costs and losses to schedule, transmit and  
209 distribute the power products to Customers so that the price to customers is an actionable price  
210 covering all costs. Retail Service Providers, whether cost of service or competitive, do this today.

211 Where permitted and facilitated by State regulatory policies, multiple Retail Service Providers may  
212 compete to serve a given customer. With the Smart Devices and the message protocols specified  
213 here it will be possible to purchase power in a given interval from one Retail Service Provider and in  
214 another interval from a different Retail Service Provider. And at a later time, the Customer may  
215 purchase additional power in the same intervals from a third Retail Service Provider, or sell back to  
216 that Retail Service Provider.

217 Dynamic Price Retail Service Providers will provide dynamic price quotes forward of each Delivery  
218 Interval. For example, at 8 am today, for the 2 pm to 3 pm delivery hour tomorrow, the Retail  
219 Service Provider may quote a price for the Customer to buy (ask price) and a price for the Customer  
220 to sell (bid price) for amounts of power to be delivered during the 2 pm to 3 pm hour tomorrow. The  
221 ask price typically will be slightly higher than the bid price. As conditions on the wholesale market  
222 and the grid change and as Customers respond to price quotes, a Retail Service Provider may  
223 increase or decrease its price quotes to better reflect current supply and demand. Different Retail  
224 Service Providers may make different price quotes and the Customer's Smart Devices can choose the  
225 best prices for transactions. Many frequent quotes for small amounts of energy with automated  
226 response will support grid and market stability and reduce risks to both Customers and Retail Service  
227 Providers.

228 Retail Service providers will post forward price quotes for a set of delivery intervals over the next  
229 day or so. This will provide a forward price curve for smart devices (especially those with storage  
230 and thermal inertia) to plan their operation and contract for the power required.

231 Retail Service Providers will also quote longer term prices for power products days, weeks, months,  
232 and perhaps years ahead of delivery. Customers may purchase these products to lock in their power  
233 cost but still be open to later transactions to buy more or sell back based on dynamic prices closer to  
234 delivery.

235 A special case of forward priced service is customer baseline service based on cost of service prices.  
236 In this case a cost of service Retail Service Provider offers a baseline amount of power in each hour  
237 of the day. The amount may vary by hour of the day and season. The price of this baseline amount  
238 would be cost based. However, the customer would be obligated to pay for this baseline amount, but  
239 could sell back to Retail Service Providers or buy more from Retail Service Providers at dynamic  
240 prices quoted by these providers.

241 After the delivery interval, Retail Service Providers will also quote prices for real-time energy  
 242 measured by interval meters. Customers will pay or be paid by Retail Service Providers in excess of  
 243 their forward purchases from all Retail Service Providers. Customer may be able to chose the best  
 244 price quotes for settling real-time actual energy deliveries.

245 Customers may also have the option to quote prices to Retail Service Providers. However, it can be  
 246 difficult for Customers to know what price to offer, especially when the price offered depends on the  
 247 prices received in other intervals for energy that may have been shifted in time using storage, thermal  
 248 intertie or changes in process operations or other customer activities.

#### 249 **E. Distribution Operator Provides Dynamic Distribution Prices and Loss** 250 **Factors to Retail Service Providers**

251 Retail Service Providers will typically quote bundled prices that include distribution costs and losses.  
 252 Alternatively, Retail Customers could buy at wholesale locations and separately pay for distribution  
 253 services, but the bundled pricing is likely to be more convenient for Customers.

254 Today Distribution Operators charge cost of service prices and average loss factors for distribution  
 255 services. However, the distribution grid may face increased loads from simultaneous charging of  
 256 Electric Vehicles and other loads. It also may face two way flows from distributed generation  
 257 including solar PV. The need may arise to use congestion pricing and marginal loss factors on the  
 258 distribution grid in the same way that the transmission grid uses congestion pricing and marginal  
 259 losses in jurisdictions with wholesale locational pricing.

260 Distribution marginal losses on heavily loaded distribution feeders and equipment can be much  
 261 higher than losses at low loads. Dynamic Retail Prices that incorporate dynamic distribution  
 262 marginal losses will provide the correct economic signals to Retail Customers to reduce, increase or  
 263 shift load when they can.

264 A dynamic distribution price on a distribution feeder, for example would signal to Customers on the  
 265 feeder that the feeder is full. In the case where the feeder is full because of the simultaneous  
 266 charging of several electric vehicles, a higher dynamic congestion price will induce some customers  
 267 to curtail charging while other customers who see value in charging now can continue. The  
 268 congestion price will be paid to those who curtail charging by those who continue to charge.

269 How the congestion prices and marginal losses would be determined is beyond the scope of this  
 270 document.

### 271 **6. Retail Dynamic Price Products**

272 Retail Dynamic Prices apply to specific products delivered to Customers. Typically Customers will  
 273 want to receive quotes for bundled products that include distribution costs, distribution losses and  
 274 perhaps other costs. However, Customers in some cases might directly pay for some of the  
 275 components of the bundled prices in order to directly access products at other Locations, for  
 276 example. We do not address unbundled prices, products and transactions at this time.

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Bundled Retail Product	Product Type (Units)	Description
Bundled Retail Access Charge	Access (kW per month)	Access of a Retail Customer to the Grid to pay for certain (fixed) distribution and transmission services.
Bundled Retail System Energy	Energy (kWh)	Energy delivered to the Customer Meter from the Grid Systems after accounting for all distribution and transmission losses. Grid System Energy may be required to meet Renewable Portfolio and Clean Air Standards and pay Environmental Taxes or Purchase Environmental Credits with such costs included in prices.
Bundled Source Specific Energy	Energy (kWh)	Energy delivered to the Customer Meter from a specific Generation Source ( such as a wind or solar farm, or from set of sources such as only renewable sources) after accounting for all distribution and transmission losses.
Environmental Credits	kWh	Customers may purchase or sell Renewable Energy Certificates (RECs) or Carbon Credits or the Credits could be bundled with Energy Products
Bundled Retail Capacity	Capacity (kW per month)	In some jurisdictions Customers may be required to purchase capacity to assure reliable delivery of energy.
Bundled Retail Ancillary Services	(kW per hour)	Customers may sell Ancillary Services and stand ready to respond to grid operator dispatch messages.
Bundled Retail Product Puts, Calls and other Options	Underlying Bundled Product	Options including puts and calls on energy may be useful to some Customers and Retail Service Providers. For example a Call Option, exercisable by a Retail Service Provider to a Customer could be used reduce load at critical peak times similar to curtailments in a Demand Response Programs.

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## 7. Time Intervals

279 Retail Dynamic Prices are specified for defined intervals of time. The intervals are each defined by a  
 280 Begin Date and Time and an End Date and Time. The Date and Time calendar values will need to be  
 281 coordinated across time zones and daylight savings time shifts.

282 Typical time intervals that may be used for dynamic prices and transactions are as follows:

Interval	Description
5 Minute	Potentially divisible. 10 and 15 minute intervals are also common.
Hour	Divisible into 12 5 minute intervals.
Day	Divisible into 24 hours or (23 or 25) hours for daylight time shifts

Interval	Description
Month	Divisible into the 28,29,30 or 31 days of a month.
Year	Divisible into the 12 months of a year.

283

284 Products may be priced and transacted simultaneously for a set of hours. The follow Interval Sets are  
 285 representative.

Interval Set	Description
Peak Hours	Typically a set of week-day hours and Saturday hours during the daylight hours except on certain Holidays
Off Peak Hours	Typically a set of nighttime hours not designed as peak hours and all day Sunday and on Holidays/
Load Shape	An amount of a product in each hour over a period such as a Day, Month or a Year.
Customer Base Line	An amount of energy in each hour allocated to a Customer under a cost of service contract. The amount may vary each hour and season and be indexed to the weather. However, the amount should be independent of Customer use and the Customer may enter into forward or delivery interval (real-time) transactions to buy more or sell surplus as needed. Ideally, Customer Base Lines are contracted and not estimated based on previous customer consumption.

286

## 8. Delivery Interval

287 The Delivery Interval is the shortest time interval defined for transactions. The energy delivered  
 288 during this Delivery Interval is measured by the Meter. Typically the Delivery Interval is an hour or  
 289 5 minutes or perhaps 10 or 15 minutes. Given current and future technology the delivery interval  
 290 could be less than 5 minutes.

291 If there are no forward purchases then the energy delivered during this interval is provided by one or  
 292 more Retail Service Provider designated by the Customer or the Regulator as a Real-time Provider..

293 If there are forward purchases, the meter reading for the Delivery Interval is compared to the total  
 294 energy purchased forward of the Delivery Interval. The difference (positive or negative) is provided  
 295 by one or more of the Retail Service Providers authorized by the Customer or the Regulator as a  
 296 Real-time Provider.

## 297 **9. Sequencing of Customer Purchases and the Final Contracted** 298 **Position for Each Interval**

299 The final contracted position in each Delivery Interval is the sum of all forward transactions applying  
300 to that interval. For example, the final contracted position for a given 5-minute interval may be  
301 determined by

- 302 1) a Customer Base Line amount based on a cost of service tariff,
- 303 2) plus a forward purchase made a month- ahead,
- 304 3) less a forward sale made day-ahead,
- 305 4) plus a forward purchase made a hour-ahead of delivery,
- 306 5) less a 5-minute sale made just before delivery.

307 All of these transactions could be done automatically based on dynamically changing prices and amounts  
308 quoted by the Retail Service Providers with decisions based on customer needs and customer preference.  
309 The prices and amounts quoted may change with overall demand and higher costs of incremental  
310 generation, or because of sudden changes in wind or solar generation or transmission and distribution  
311 congestion and outages. Reliability and grid integrity signals can be communicated through these price  
312 signals as well. Communication of non-price reliability signals when needed is a separate discussion not  
313 addressed here.

314 When the actual meter reading becomes available the Customer pays or is paid at a real-time price for the  
315 difference between his final position and the actual reading. The cost to the Customer in each Delivery  
316 Interval is the simple sum of the price of each transaction times the amount transacted (sales by the  
317 Customer are considered as negative Customer purchases).

318 Of course, this sequence can be done at any level of detail. For example a customer might have a zero  
319 Base Line and pay real-time prices for all of his usage with no forward purchases. Or a customer might  
320 have a Base Line amount that has been augmented to better shape his purchases to his needs followed by  
321 the settlement of real-time differences at real-time prices.

322 For this discussion we have defined the Customer Base Line as contracted amount that the Customer must  
323 pay for. Any unused amounts of the Base Line would be sold back to a Retail Service Provider at prices  
324 that may be higher or lower than the price implied in the Base Line amount.

325 Typical tariff Base Line amounts and offers today are actually Call Options on Energy exercisable by the  
326 Customer. The Customer is able to take any amount at the offered price. When block rates are offered  
327 the price may increase then the purchases over a defined interval exceeds a given level. Because such  
328 options cost more to the Retail Service Provider to deliver, the offered prices are likely to be higher than  
329 for a contracted purchase of a fixed amount in the same interval. Such call options are provided for in  
330 this design. A problem with such call options arises when the Customer can sell back to Retail Service  
331 Providers at real-time prices that are higher. Then the Customer will have every incentive to take the full  
332 call option amount and make a profit at the expense of the Retail Service Providers. Estimated Base

333 Lines are an attempt to mitigate this behavior, but are difficult to do correctly without abuse, especially  
 334 when 24/7 dynamic pricing is employed for renewables integration.

## 335 **10. Dynamic Price Messages**

336 This section provides a high level outline of the inter Domain messages for electronic  
 337 communication of retail dynamic prices and transactions over the interfaces among the customers  
 338 and the actors in the other Domains identified above. The purpose of this description is to outline the  
 339 types and contents of the messages leaving detailed specification for later.

340 The focus here is on the Application Layer messages. Message transport and security are beyond the  
 341 scope of this document. Details of the application level messages are also beyond the scope of this  
 342 document and clearly much more software engineering is required to design the messaging protocol  
 343 or adapt other messaging protocols from the energy or financial industries.

Message	Sender	Receiver	Description
Distribution Operator Registration	Distribution Operator	Common Registration Data Base	Identifies Distribution Operator including necessary descriptive information.
Delivery Location Registration	System Admin.	Common Registration Data Base	Identifies locations where power is delivered on the distribution grid typically where several Customers are connected and associates Locations with a Distribution Operator.
Interval Registration	System Admin.	Common Registration Data Base	Standard intervals such as 5 min, 10 min, and hourly intervals used for quotes, orders, transactions and scheduling with distribution and transmission operators.
Retail Service Provider Registration.	Retail Service Provider	Common Registration Data Base	Identifies Retail Service Provider including necessary descriptive information
Customer Registration	Customer	Common Registration Data Base	Identifies Customer including necessary descriptive information.
Meter Registration	Meter Installer	Common Registration Data Base	Identifies Meter including necessary descriptive information and associates Meter with a Customer and a Delivery Location (unless the Meter is mobile)
Smart Device Registration (incl. DER and Storage)	Customer	Common Registration Data Base	Identifies Device including necessary descriptive information and associated Device with a Meter
Product Registration	System Admin	Common Registration Data Base	Defines standard products for transactions among Customers and Retail Service Providers

Message	Sender	Receiver	Description
Price Quote	Retail Service Provider	Customer or Device	Both an ask(sale to Customer) and a bid(buy from Customer) price and quantity. The quote is for a specific product delivered to the Customer Location or a Device such as a Vehicle at a given Location during a specific future Interval. The quantity is the maximum amount the Customer can transact at the price at this time. There will be an expiration time on the quote. Quotes for multiple Products and multiple Delivery Intervals could be assembled in a single Price Quote message. This specification allows for a different bid and ask price although the two prices could be the same.
Quote Transaction Report	Customer	Retail Service Provider	Confirms acceptance of all or portions of currently available Price Quotes.
New Customer Order	Customer or Device	Retail Service Provider	A Customer offer to buy or sell a quantity of a Product for an Interval at the Customer or Device Delivery Location. Several Orders can be combined into a single message. Conditions such as filling all Orders or None could be specified. There will be an expiration time on the Order.
Order Transaction Report	Retail Service Provider	Customer or Device	Confirms acceptance of all or portions of currently available Customer Orders.
Meter Reading	Meter	Retail Service Provider	Net Energy Deliveries during Delivery Intervals
Customer Position Report	Retail Service Provider	Customer or Device	Customer Cumulative Position in each Product for Each Delivery Interval with this Retail Service Provider.
Customer Bill Report	Retail Service Provider	Customer or Device	Customer Cumulative Cost incurred for each Product in each Delivery Interval with this Retail Service Provider. Includes Access, Capacity and other charges.
Customer Payment/Credit Report	Retail Service Provider	Customer or Device	Bill Amounts Due and Payments Made, Credit Balance in the case of Pre Payment or Credit Allowance.
Retail Service Provider Schedule Report	Retail Service Provider	Distribution and Transmission Operators	Total Amount of Product across all Customers in an Delivery Interval scheduled by the Retail Service Provider to, distribution and transmission providers.
Distribution Operator Report	Distribution Operator	Retail Service Provider	Information on Distribution system outages, loss factors and congestion.

Message	Sender	Receiver	Description
Other Messages			Not described are messages to support transactions with Wholesale Markets and among Retail Service Providers.

344

345 In addition to the fully dynamic forward pricing described herein, within the above pricing structures  
 346 many kinds of dynamic pricing also can be implemented including Time-of-Use (TOU), critical peak  
 347 pricing (CPP), Day-Ahead Market Price (DAMP), Market Clearance Price for Energy(MCPE), Peak-  
 348 time Rebate (PTR), Variable Peak Pricing (VPP). and Real-time Pricing (RTP).