# Price Communication, Product Definition, and Service-Oriented Energy

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## Abstract

Clear communication of product and price is essential to any economic interaction.

Energy pricing varies according to regulatory regime and social policy across the country. The outcome of these various approaches can be summarized in all cases as a simple price. Clear standards for communicating that price are necessary for the development of national markets for systems and software that intelligently use and manage energy in homes, commercial buildings, and industrial sites.

A similar argument requires clear consistent descriptions of the product bought or sold in a particular market. Electricity product definitions include more than mere electrons, and include such characteristics as source, reliability, and regulatory burden. Energy products also include non-electricity products such as natural gas. Clear product definitions are critical to the development of products that dynamically differentiate between energy sources.

This paper discusses the requirements of clear price and product communications to and from energy markets. We discuss how such communications enable national markets in energy management systems even when there are no national markets in energy. We also discuss how such communications foster the adoption of service oriented architectures in integrating smart grids, and how these architectures will further the goals of smart grids.

## 1. INTRODUCTION

Interoperable price and product definition has been identified as a key cross-cutting issue for the Smart Grid [1] [2] in the NIST Smart Grid Interoperability Roadmap process.

Price is more than a number; for buyers and sellers to make informed economic decisions they need to know details such as quantity, units, location, and schedule. Some buyers and sellers would like to communicate additional characteristics of energy such as how it was generated, where it was generated, and carbon or emission characteristics.

While many examples in this paper reference electricity markets and characteristics, the intent is to address price communication in natural gas markets as well.

As dynamic pricing in various forms has advanced for industrial, commercial, and residential users, facility management equipment needs to understand price and product information.

| Market Design and Description |
| --- |

| *What* Is Communicated— Price, Characteristics |
| --- |

| *How* It's Communicated—Messages, Protocols |
| --- |

**Figure 1—Markets and Market Communication**

In Figure 1, the top bar is the market design and description; how the market operates. The middle bar is the information exchanged, including the price and characteristics of goods sold. The bottom bar is the protocols and messages that are used to exchange information.

In this paper we concentrate on the middle bar, the information that must be communicated for markets to function.

We take a broad view of markets, consumers and producers. Communication must work to, from, and within microgrids [3], and to and from aggregators as well as others participating in wholesale and retail markets which determine price.

Price is an *output* of markets or price setting (*pricing*) decisions. Tariffs and other contracts (we will use the term *contract* for both) can be viewed as functions with many inputs; the output is a current or future price. Price is also an

*input* to markets, e.g. demand-response bid prices in OpenADR [4].

Price is *actionable information*. Given the current price and some sense of history, or (if known) both current and future prices, facility management systems can make automated decisions on energy usage, timing of process and more. Earlier work on this subject was done by the authors and others in the NIST Building-to-Grid Working Group [5] [6] in the context of the GridWise Architecture Council GWAC Stack [7].

With thousands of utilities in the United States alone, equipment makers need a consistent way to receive and transmit price information so as to avoid having to install different software (or customize software) in every jurisdiction to communicate price.

By standardizing descriptions of the characteristics of energy, new markets are enabled, consumer choice is enhanced, and differential investment is better founded. And in the many places price is used as a surrogate for value we can use common and interoperable technology.

## 2. ENABLING MARKET INTERACTIONS

When I ask you go to the store for tomatoes, do you tell me that the price is "3"? That doesn't convey enough information. There are characteristics of tomatoes that are important to some purchasers—where did they come from? What are their qualities? What is the quantity or units? The condition?

Markets define different prices for tomatoes with specific identifiable characteristics. For example, organic tomatoes usually command a premium, as do ones in good condition, vine-ripened, and neither over- nor under-ripe.

### 2.1. Product Definition and Differentiation

Twenty years ago few people knew that there was a separate price and market for organic-raised tomatoes; if we had created a tomato price communication specification then, we would have needed to change or extend it.

The differentiation between the heirloom, organic, and conventional tomatoes you can see at your local grocery store has driven economic decisions by farmers on what tomato varieties to grow, how to tend them, and how to package and deliver them.

Tomatoes aren't energy. But with differentiation between classes of renewable energy and fossil fuel generated electricity, we already see price differences. A common vocabulary for communicating those product definitions and differences will enable new markets and investments.

Similarly, the tomato example reminds us that extensible information models are needed. What will the characteristics important to markets be in five years? Ten years?

Finally, differentiation in tomato markets has enabled new businesses and new business models. Not very long ago a farmer was making a lifestyle choice to use organic methods; today it's a business decision.

### 2.2. Efficient Allocation

Markets drive the efficient allocation of resources. Balancing of supply and demand on shorter and longer timeframes is critical to the efficient operation of energy systems, including both natural gas and electric markets.

Defining characteristics of goods bought and sold drives markets in those characteristics. Today, renewable energy (overly restrictively defined as solar and wind) commands a premium. By determining a market clearing price for products, we increase supply or reduce demand through markets.

### 2.3. Automatic Adaptation

For efficiency suppliers and customers need price information, and need to adapt automatically to that price information. Market participants must be able to understand prices and product definition, that is, the price and the description of what is bought and sold. And this must be done automatically. Early work in demand response was (and in some cases still is) manual—a telephone call, a paging message. One key advance of OpenADR (Open Automated Demand Response) [4] was the enabling of effective automation.

### 2.4. Extensible

As the power grid evolves, and energy technology evolves, we need mechanisms that anticipate new sources of energy, and allow of additional characteristics of interest to be used. Fashions and perceived needs change over time—what characteristics will differentiate products in five years or in ten?

### 2.5. Broader Markets

The engineering of price-sensitive equipment, building, industrial, and residential automation and energy systems, as well as distributed energy resources for storage or generation is made simpler with a key piece of information, price and product definition, exchanged in a consistent standardized way. Equipment manufacturers don't want to build or customize equipment for different market or price domains. A consistent exchange if information reduces the cost of each implementation and installation.

Improved and simplified exchange of price and product information enables consumer investments in generation and storage, and enables greater energy efficiency. Energy profiles adapted to the need can be created on a common

interoperable base—light-weight profiles for managed energy, extensible profiles for operation of buildings and microgrids, and high speed profiles for market trading and compound transaction.

Product differentiation enables markets to create products that customers want and will pay for.

## 2.6. Standard Information Exchanges
By standardizing the format for information exchanged the Smart Grid can take advantage of electronic commerce (eCommerce) approaches and mature standards. Informational building blocks including, but not limited to, price, schedule, and usage information enable a dynamic and generative environment to improve the efficiency and stability of the grid.

## 3. ENERGY MARKET INFORMATION
Common price and product definition for energy enables greater efficiency, better adaptation to business and owner needs, and larger markets for equipment manufacturers. In this section we look at details of price and product definition and architectural issues about the information exchanges.

## 3.1. Who Communicates
Price is the most important cross-cutting issue for the Smart Grid [1] [2]. Actors in nearly all of the domains of the Smart Grid (See Figure 2) either participate in markets, react to market information, or have a hand at communicating price information.
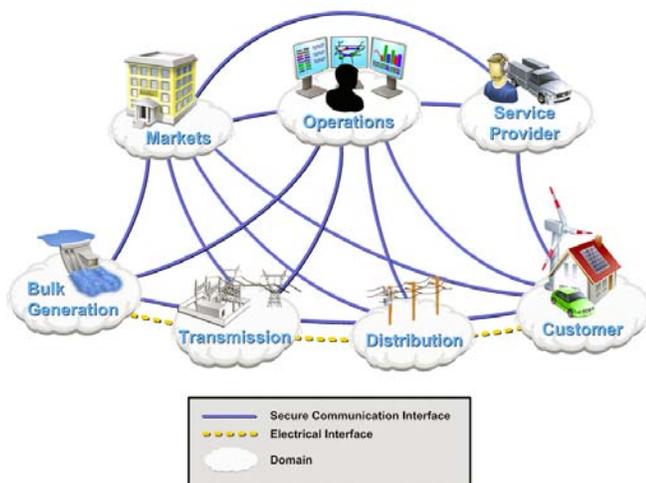


Figure 2—Conceptual Model of the Smart Grid [1]

These actors include markets themselves, supplier, customers, equipment that controls energy and reacts to, distributes, or provides control information. Some of these actors are building automation systems (BAS), industrial automation systems (IAS), home automation systems (HAS), energy management systems (EMS) or energy services interfaces (ESI).

Moreover, a microgrid [3] has aspects of the domains within it, and communicates to other domains where it participates as a customer or net supplier of energy.

## 3.2. Actionable Information
We define *actionable information* to be information that an automated system can act on—what's the current price? Is it high? Low? What will it be tomorrow? The antonym of actionable information is all around us. What was the price last year? What contracts are in place for energy usage and for tenants? Longer term trends or history may be useful, but is less likely to affect a present action[1].

For example, wholesale markets have a variety of services that clear only after some days or weeks. To use a purchased block of energy on a wholesale market, transmission rights may be needed (and are not part of the purchase transaction). To the extent that the nature and extent of these additional costs is not known (or not reliably projected) wholesale prices in the North America are therefore less actionable than (say) retail prices which include all factors. But a market trader, knowing the market context (see Figure 1) is presumably aware of the type and nature of the additional costs.

Older types of contracts that include demand charges create more complexity, and more challenges for automated control.

A final example can be found in the variety of proposed treatments of carbon release. A transaction that carries an unknown or unpredictable credit or tax months or years after use makes energy management far riskier than a transaction that includes credits or taxes at the source or use point. The latter encourages action; the former increases risk and decreases responsiveness to what it seeks to limit.

## 3.3. Contracts or Tariffs
The complexity and size of energy tariffs and other contracts is confounding. Some tariffs describe market design; others define products—this is why we use the word *contract* rather than tariffs when we discuss price.

Contracts set terms and conditions on the buying and selling of energy, and are subject to all the complexities that the human mind can imagine.

Contracts (including tariffs) can be very complex; we are not proposing an interoperable, computer-understandable version of contracts. Effective and automated response to price and product definition requires actionable information, hence our focus on the results of contract calculations rather than the details.

An actionable price is computed as a function of the relevant contracts and other inputs; then the outcome (a current or future price for a product) is transmitted.

### 3.4. Price and Product Definition

What exactly are these characteristics that we've called price and product definition? In this section we'll describe some of the more obvious ones, as well as the need for extensibility.

*Price*, a number, typically with a decimal fraction

*Currency*, because it matters if it is U.S. or Canadian dollars, Euros, or another currency.

*Units* of measure for the energy bought or sold (e.g. a 50 Megawatt-Hour forward contract)

*Quantity*, the number of the units

*Schedule*, the time interval in which the energy is to be used or provided

*Location*, the geographic location at which the energy will be available (or delivered)

*Source*, the manner in which the energy was generated

*Carbon or emission characteristics*, for those wishing to manage carbon or emissions.[2]

*More definitions*, an extensible set of definitions for the characteristics we don't know or haven't discovered yet. This is the energy analog of organic tomato characteristics twenty years ago.

### 3.5. Technology that Enables

We've already shown how consistent information exchange can simplify technology deployment and enable new markets and investments. In this section we'll take a closer look at how more effective technology deployments and product creation are enabled.

There are thousands of utilities in the United States alone. There are roughly thirty wholesale markets in North America. As microgrids are more broadly deployed, there are likely to be markets and actionable price information in each microgrid—potentially for many thousands more.

An equipment manufacturer creating a controller that will react to price, say in an appliance, needs consistency in price communication over a large market to recoup development costs. A single standard for accepting and interpreting price communication creates a single market. Each manufacturer can seek competitive advantage within that market in how they respond to price and product communications. If each manufacturer is forced to support thousands of products, e.g. with plug-ins or firmware, that

market will not develop. We need a single approach to communicating price to enable price-responsive devices.

In the same way, a common means of communicating price and product definition creates better markets for facilities management or energy management system for buildings and industrial facilities. The cost of a custom installation is today a significant source of market friction, both for initial installation and for changing systems.

In homes, the cost of custom integration looms still larger as a component of the smaller systems involved. The number of homes to participate is far larger. For residential management systems, the requirement to control unit costs through larger markets is critical. The common communication of price can create markets that span entire countries, continents, or the entire world.

By applying the same market information inside your microgrid, condominium development or office park, the same technology can work with only the source changing.

This benefits manufacturers and consumers as well as those looking for broad deployment of energy-saving technologies.

### 4. SERVICE ORIENTATION

A number of technical contributions have been made to what Considine calls the "service oriented grid."[8] He points out the role that interoperable price and product definition play in building a service oriented grid, and that adheres to critical architectural principles for integrating across the system of systems that is the Smart Grid [9][10].

Service orientation requires not only the definition of services at the top level, but the information models for the services to use [11]. The interoperable price and product definition (price information) is essential to exchanging price signals for Demand-Response [12], market clearing prices, and more.

Shallow integration [9] can be achieved more readily by not communicating details of markets or market operations; price communication addresses this need by communicating the result of market actions.

Finally, the extensibility we have observed is a critical part of flexible, shallow bindings. As the notion of a price and a product evolve, existing software can use the newer versions without updates except to take advantage of new features. And with careful design, new characteristics can be presented and acted on by today's software.

### 5. COLLABORATIVE ENERGY

The Smart Grid will rely on better collaboration—collaboration between producer and consumer, between generator and load, keeping in mind that distributed energy resources (generation and storage) turn some conventional

models around. We call this approach *Collaborative Energy* [13], and call some participants *Smart Loads* [14].

The benefits of collaboration include more efficient use of all energy resources, and engagement of energy use patterns in support of business and personal objectives.

Markets and market prices (and the description of goods bought and sold) drive efficient allocation of resources. By enabling market-based interactions, we facilitate markets and efficient resource use.

By factoring out the complexities of price computation (*pricing*) and turning instead to price communication (*price and product definition*) developers and integrators can learn and code once; an interoperable price can be used for Demand-Response signals and bidding [4], usage information [15], market transaction information or indices, distribution of retail price information, so-called "prices to devices," and more.

Taking advantage of the cross-cutting nature of price in the Smart Grid enables new products and more effective deployment of existing products by allowing the players in the Smart Grid to collaborate.

## 6. STANDARD ENERGY MARKET INFORMATION EXCHANGE

To satisfy these requirements in an enterprise-to-enterprise (or if you prefer, Business-to-Business) world, a group of experts have created the OASIS Energy Market Information Exchange Technical Committee, or *EMIX* [16].

We think of this work as a *micro-standard*, one that exists to be composed with and included in information exchanges for other standards. Schedule and schedule semantics [17] [18] will be used in a similar way, as part of payloads for messages and as information exchanged. A third example is the OASIS UnitsML (units-of measure markup language) work in progress [19].

The charter for the EMIX TC addresses many of the issues we have discussed in this paper. The TC started work in October 2009, and expects to produce draft specifications in early 2010.

As with all OASIS Technical Committee work, the intermediate drafts, minutes, and email communication among the group is archived and is publicly visible on the web as soon as it is created.

Other projects are anticipated to use the EMIX specifications as they progress, including the OASIS Energy Interoperation Technical Committee [12] which is focusing on interoperation for Demand-Response and Distributed Energy Resources (see also NIST Priority Action Plan 9 [20]).

And in keeping with the compositional approach for cross-cutting Smart Grid standards, EMIX anticipates using the output of the OASIS WS-Calendar Technical Committee [18] as that work progresses; the WS-Calendar work will standardize semantics for common schedule information (see also NIST Priority Action Plan 4 [17]) by building on the recently updated IETF iCalendar specification [21] which itself is the common information model for schedule and calendar maintenance.[3]

## 7. CONCLUSIONS

Consistent and interoperable communication of energy price and product definition enables markets, new business investment, and energy efficiency through collaboration.

The OASIS Energy Market Information Exchange Technical Committee [16] is working in collaboration with others to define exactly that interoperable communication of energy price and product definition.

This cross-cutting need was anticipated by the GridWise Architecture Council in its Interoperability Framework; price represents business context and shared meaning of content in the GridWise Architecture Council Stack [7].

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**Biography**

*William Cox* is a leader in commercial and open source software definition, specification, design, and development.

He is active in the NIST Smart Grid interoperability efforts, including the Domain Expert Working Groups. He contributed to the NIST conceptual model, architectural guidelines, and the interim roadmap and framework documents.

Bill is co-chair of the OASIS Energy Interoperation and Energy Market Information Exchange Technical Committees, and an elected member of the OASIS Technical Advisory Board, where he advises the Board and membership of the leading XML and Web services standards organization in the world.

Bill has developed enterprise product architectures for Bell Labs, Unix System Labs, Novell, and BEA, and has done related standards work in OASIS, ebXML, the Java Community Process, Object Management Group, and the IEEE, typically working the boundaries between technology and business requirements.

He earned a Ph.D. and M.S. in Computer Sciences from the University of Wisconsin-Madison.

*Toby Considine* is a recognized thought leader in applying IT to energy, physical security, and emergency response. He is a frequent conference speaker and provides advice to companies and consortia on new business models and integration strategies.

Toby has been integrating building systems and business processes for longer than he cares to confess. He has supported and managed interfaces to and between buildings, cogeneration plants, substations, chilled water plants, and steam and electrical distribution. This work led to Toby's focus on standards-based enterprise interaction with the engineered systems in buildings.

Toby has been chair of the OASIS oBIX Technical Committee. oBIX is an unencumbered web service designed to interface between building systems and e-business. He is an elected member of the OASIS Technical Advisory Board. He is active on the NIST Smart Grid Domain Experts Groups and works to promote applying information technology to buildings with groups such as buildingSmart and FIATECH.

Before coming to the university, Mr. Considine developed enterprise systems for technology companies, apparel companies, manufacturing plants, architectural firms, and media companies old and new. Before that, Toby worked in pharmaceutical research following undergraduate work in developmental neuropharmacology at UNC.

**End Notes**

[1] Recent or historic price history can guide our present and future actions by enabling prediction of future price.

[2] We focus on actionable information. This suggests that if carbon characteristics are used they should not be in a form that is indeterminate or may take months or years to close.