Benefits … Benefits …

For Loads, Producers and Transmission Providers:

- **Fair, fact-based pricing** through Locational Marginal Pricing
- **Clears the market at a consistently lower price**

For Market Operators:

- **Flexibility defining market-rules** and implementing an automated market participation process.
- **Solving congestion the Day-Ahead** inherently increases the Transmission Security, making the day-to-day operations easier.
- Producing an identical and predictable solution for a set of given resources and bids greatly **reduces the risk** of disputes between stakeholders and may **limit liabilities** of the Market Operator.
- Robust platform providing **highest level of system availability** through integration of market-leading hardware and software for relational databases, business rules and optimization engines, middleware and web technology.
- **Rapid delivery and deployment** of a Market Operator System made possible by combining mature, robust 3rd party software with the Siemens core expertise of producing best-in-class solutions for operating electric grids.
- An option to **verify anticipated lower market clearing prices** when using the Siemens technology through a short pilot study including comparison with legacy algorithms.
Market Operations -
Balancing the Interest of the Public and Market Participants

Operating an energy market requires balancing the complex interests of the public, market participants and the market operator.

Siemens helps market operators meet this challenge through its Spectrum Power Energy Market Management (EMM) system that incorporates the latest market clearing technology in a set of modular, high performance components and engines.

Public interests include reliability of the electric energy supply and the macroeconomic interest for the lowest market-clearing price for electric energy.

Market participants need to optimize investments, increase operational efficiency and have timely access to highly accurate information.

Market operators need to be highly efficient in running complex operations, flexible in adjusting market rules and proficient in coordinating grid security while providing highly available market operations.

Spectrum Power EMM meets these needs and more with a highly modular solution that lowers market prices, optimizes business processes and increases grid reliability for LMP-based centralized markets. The components of the Spectrum Power EMM are best deployed as an integrated solution; however, each can be individually applied to an existing market management system to preserve investments already made into legacy systems.

Alternatively, market operators can get the benefits of the key components by subscribing to Application Hosting Services provided by Siemens.

Scalable to Process Very Large Models
The hardware architecture is designed to meet the tough performance requirements for very large size of network models. During the security assessment phase of the Security Constraint Unit Commitment, it is necessary to perform complete studies for all 24 hours of the next day’s schedule to ensure that the system is within the n-1 contingency requirement. The security assessment can be independently performed on multiple applications servers for each study period. The number of servers required is purely a function of the size of the model.

Cutting Model Maintenance Cost
The Spectrum Power Information Model Manager (IMM) is a powerful desktop data modeling, data maintenance and data exchange tool specially designed for electric power applications, network management and market operations. It helps to reduce cost and improve model quality by providing graphical topology verification capability and extensive import and export facilities, compliant with the EPRI CIM standards. The XML-based import function enables the market operator to easily merge model information provided by market participants, transmission service providers and loads.

The IMM can automatically produce the graphic representation of the model which is used in the Market User Interface to display pricing down to the bus level.

Limiting the Risk of Exposure to Legal Claims
Saving the Market Data and documenting the Power System State for later review and to mitigate possible Market Participant claims is of utmost importance to the Market Operator. The Spectrum Power Historical Information System is a high performance data warehousing system designed for the scalability and availability requirements of market operators. The information can be easily retrieved using Web technology and imported in widely available office and professional analysis tools.

Meeting the Control Area Operations Requirements
Siemens can provide all Control Area control and monitoring functionality to meet the highest requirements of Transmission Operators and Generation providers. This functionality includes advanced Grid Control and Monitoring, Transmission Grid Security Applications for both real-time control and studies, Resource Scheduling support and real-time Unit Control.
The Market Operator and Market Participants interact through the Market Participant Interface, a set of secure, web-based User Interface and Web Services presented in a web portal. Market Participants perform all day-to-day transactions such as entering bids and bid extensions, and accessing current and historical Market Prices, Schedules, Load Forecasts and Settlement information. This is carried out through personalized views of the portal, which automates and optimizes all interactions with the market.

The highest transparency levels of the state of the market are achieved through the integration of notification and instant messaging capabilities and the presentation and availability of data. This is done within a secure, Public Key Infrastructure (PKI)-based environment.

User Interface

The Market Participant User Interface is a set of secure, web-based, dynamic pages that presents data and information in tabular and graphical forms including scalable displays for network information. It requires no software installation other than a standard web browser and standard Scalable Vector Graphics (SVG) viewer and Java® plug-ins. All pages that are generated are pure HTML and Javascript®, with the scalable displays in the SVG XML format. Dynamic data updates in these displays, as well as dynamic messaging, alarms and notifications are enabled by the use of a Java applet.

Security

A modern, n-tier architecture is used for security with distinct web, application and database tiers. Use of either an existing corporate Public Key Infrastructure (PKI), B2B-enabled PKI or a separate market-dedicated PKI allows the utilization of digital certificates or biometric devices for authentication and authorization, ensuring non-repudiation for all transactions.

Adapt to Changing Market Rules

The Market Participant Interface incorporates a business rules engine component, which allows immediate validation of input data from the Market Participant. Data submissions from the Market Participant can be immediately verified for compliance to market rules, and feedback is provided instantly.

The Market Operator has the flexibility to rapidly adapt to regulatory changes and evolving market rules by using a visual development environment for creating, editing and testing business and market rules. New or modified rules can be deployed without requiring software changes or downtime.

Manage Workflow and Automate Processes

A workflow controller component manages the workflow between the Market Operator and Market Participants. From enforcing the market timeline to sequencing intervention that may be required of the Market Operator, the workflow controller orchestrates the processes that are required in the market, providing a combination of automated process logic, human workflow and robust exception management that weaves systems, people and organizations into an integral efficient process for successful completion of each transaction.

Web Services, defined using the Web Services Definition Language (WSDL) and published to a Universal Description, Discovery and Integration (UDDI) directory, allow for flexible automation of processes such as bid submission and modification, upload and download of data and other tasks. This helps that the day-to-day activities of trading and responding to the changing signals in an energy market are coordinated and efficient.

Optimizing Processes and Flexibility

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The Market Clearing Engine

The Market Clearing Engine is the core of Spectrum Power Energy Market Management and is based on the Security Constrained Unit Commitment (SCUC) software. For the first time ever, the Market Clearing Engine does not impose artificial limitations on the design of centralized electric energy markets. It is now possible to include all relevant production, load and network constraints when clearing the central spot market simultaneously for energy and ancillary services. This solution approach, known as co-optimization of energy and ancillary services, produces the lowest overall clearing prices while meeting all physical constraints and grid security objectives.

Superior Technology - Optimal Solution

The Siemens technology utilizes advanced Mixed Integer Programming (MIP) techniques combined with a Separable Quadratic Interior Point Method to obtain the optimal SCUC solution. The MIP-based SCUC represents the next step when compared to the traditional Lagrange Relaxation-based SCUC. The Siemens MIP-based SCUC implementation reaches superior technology - optimal solution consistently and independent of the operator.

Improving Reliability - Achieving the Lowest Prices

These breakthrough technologies enable market designs based on a full AC network model, allowing Market Operators to manage congestion well before it gets to real-time. This may be inherently more complex, but the Siemens technology is capable of managing that complexity and actually makes day-to-day interactions between Market Operators and Participants simpler and more transparent. The handling of a large number of transmission constraints is one of the most important aspects in achieving feasible schedules and avoiding the high cost of congestion management in real-time, when available resources may be scarce and expensive.

Ease of Day-to-Day Operations

One Engine for Multiple Markets – Achieving Flexibility

The Market Clearing Engine is designed for easy activation/de-activation of variables, various objective functions and constraints, enabling easy switching between the different runs such as a full Security Constrained Unit Commitment, a Reliability Commitment, a Security Constrained Dynamic Dispatch or a Security Constrained Economic Dispatch. This built-in flexibility enables the use of the same market-clearing engine in multiple market structures such as a Day-Ahead Market or a Real-Time Market.

The speed necessary to facilitate the flexibility of solving the different optimization problems using the same engine is achieved by applying Siemens’ Mixed Integer Programming technology and innovative computing platforms.

Solving the Complexity the Day-Ahead

Day-Ahead and Real-Time Market Process Flow

Comparison of Siemens’ Market Clearing Engine Capability with the Traditional Lagrange Based Methods

At the core of the Market Clearing for centralized markets is the Security Constrained Unit Commitment and Economic Dispatch, a complex optimization problem.

The chosen optimization algorithm must be able to produce a solution within minutes to support all coordination efforts necessary between market operators and participants. A traditional way to meet the time requirements has been to relax the optimization problem and not include all real-life parameters and constraints, risking real-time congestion and unpredictable market clearing prices.

One critical aspect of contemporaneous day-to-day interactions between Market Operators and Participants is the ability to adjust market clearance prices and avoid congestion. The Market Clearing Engine used by Siemens is capable of solving this problem consistently and independent of the operator, allowing market operators to manage congestion effectively and efficiently.

<table>
<thead>
<tr>
<th>Function</th>
<th>Siemens MIP</th>
<th>Traditional Lagrange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known distance from optimal solution</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Modeling of large number of coupling constraints</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ramp rate as function of unit loading</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Modeling of forbidden regions with crossing rules</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Heuristics or manual intervention required to achieve a feasible solution</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Optimal discrete relaxation of infeasible constraints</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Flexibility for adding new constraints and models</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>