Eliminating Obstacles and Delivering the Benefits of the Smart Grid: IBM's Optimized Energy Value Chain

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Hot Button Issues In Energy and Power

Climate change
- Renewable energy
- Energy efficiency
- Low emission generation
- Transportation

Grid utilization and reliability
- New contract and pricing policies
- Performance penalties
- Increased maintenance expense
- Increased T&D investment

Market restructuring
- Gas/electric market convergence
- Market design and bid optimization
- Resource adequacy
- Price spikes and gaming

Enterprise IT
- From better information to better decisions
- Empowering business users
- Data collection lags data management

Smart Grid
Optimization Problems in the Energy and Power Industries

Classic Applications

- Generation/Resource Planning
- Unit Commitment/ Economic Dispatch
- Hydro/Thermal Scheduling
- Optimal Power Flow/ Security Constrained Dispatch

Novel Applications

- Contract and Risk Management
- Power Market Simulation
- Distributed Generation Planning
- Demand Response
## How Optimization Addresses Hot Button Issues

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<tr>
<th></th>
<th>Climate Change</th>
<th>Grid Utilization and Reliability</th>
<th>Market Restructuring, Enterprise IT</th>
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<tr>
<td><strong>Generation/Resource Planning</strong></td>
<td>Optimal generation mix including renewables, demand-side programs</td>
<td>Better transmission utilization</td>
<td>More coordinated planning</td>
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<td>Lower data preparation effort</td>
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<tr>
<td><strong>Unit Commitment/Economic Dispatch</strong></td>
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<td>Quicker, more flexible response</td>
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<td><strong>Better compliance with emissions regulations</strong></td>
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Framework for Advanced Optimization Applications in Power

The Classic Applications
- Demand Response
- Distributed Generation

Novel Applications
- Unit Commitment

Operations
- System Operator
- Market Participant

Planning
- Demand Response
- Distributed Generation

Bulk Power
- Unit Commitment
A holistic approach to managing the portfolio of solutions within the utility

The Optimized Energy Value Chain
The Smart Grid suggests a more complex energy “eco-system”.....
…with more options available to the utility to “optimize” grid performance given the right near real-time intelligence

- Reliability
- Stability
- Supply
- Load Shaping
- Energy Efficiency
- Consumer (Behavior)
- Social
- Political
- Regulatory
- Environmental
- Financial
- Shareholder Value
- Workforce
- Security

- Business Models
- Consumer Behavior
- Regulatory Behavior
- Markets
- Integrity
- Partnership Models
- Outside Influencers
The Energy Value Chain Ecosystems

- Bulk Generation
- Transmission
- Distribution
- ISO/Coordinators
- Consumption (Residential, Commercial, Industrial)
- Aggregators
- Retailers
- Governments/Regulators *
- Outside Influencers (i.e. Google, Automotive Industry)

* Not a real-time impact but can influence behavior of the value chain
Why a Holistic Approach

- Optimizing the individual domains is only the first step

- Many domains, operating at peak efficiency would actually negate or prohibit other domains from reaching their goals or sub-optimizing the system as a whole

- The maximum value of the enterprise should be the goal
Why is this a Challenge

- The goals of an enterprise are constantly being challenged because the business drivers are always in flux.
- Both internal and external pressures dictate the current set of business drivers and prioritization.
- The system must be flexible and adaptable to change its business drivers in near real-time.
- Business drivers may need to be set aside, dismissed or even discovered rapidly.
- By their very nature, most silos of the enterprise are designed to optimize their domains, and may be counter to the enterprise goals.
What is IBM’s Solution? - OEVC

- It’s a collection of solutions to analyze and optimize the operations of a utility or collection of utilities.

- It’s a master conductor that will optimize across the entire energy domain to give the most value for a given set of business drivers.
  - Dynamically managed and tailored
  - A set of ‘trade offs’ that will be constantly monitored and adjusted during an operational period.

- The means to measure and report on the effectiveness of the enterprise in real-time across multiple operational and business domains.

- It’s the SMART in Smart Grid.
Progress Energy – Optimized Energy Value Chain

The Optimized Energy Value Chain (OEVC) will build a green Smart Grid virtual power plant through conservation, efficiency and advanced load shaping technologies. By the end of 2012 the OEVC will enable nearly 1000MW of peak load reduction, growing to over 1600 MW by the end of 2015, and producing a present value of fuel savings of $127M over 10 years.

• Alternative Supply
• Energy Storage
• Grid-Side Efficiency
• Condition Based Mngnt.
• Tailored Demand Response
• Wholesale Demand Response
• Customer Segmentation
• Dynamic Adaptability
• Holistic Analytics-Driven
• System Wide Optimization
OEVC is a solution element of SAFE

This is an optimizer/orchestrator approach, not a monolithic control center
- Through goals, metrics, targets
- Each system responsible for its domain

System orchestrates contingencies
- Pre-configured, ever changing rule sets

Real-time optimization of independent systems
- Based on sensing, analytics, modeling, history

Unification is through a services model
- Common business goals and exposed service models
- Disparate architectures are allowed
A Simple Demonstration

- Relieve a Transmission Nodal Limitation with Voltage Reduction, Demand Actions and Peaking

In this scenario the utility will relieve a congestion problem within a node of the transmission system using distribution capabilities of voltage reduction and peaking generation. The utility will determine the amount of energy that can be reduced that will affect the node from each participating substation. The substation contributions can come from either voltage reduction, demand actions and/or peaking capabilities.
Optimized Energy Value Chain – Example Demo

- Relieve a Transmission Nodal Limitation with Voltage Reduction, Demand Actions and Peaking

- Determine the amount of energy that can be reduced that will affect the node from each participating substation

- Legend
  - No load shaping
  - Voltage reduction
  - Voltage and demand
  - Peakers: size proportional to output
Example Scenario – Restrict Load at Transmission Node

Megawatt Reduction Required

- Total Demand (MW)
- Target Load (MW)

Time

00:00 01:30 03:00 04:30 06:00 07:30 09:00 10:30 12:00 13:30 15:00 16:30 18:00 19:30 21:00 22:30

Megawatts

900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900
Scenario – Physical View

Constrained Node

Transmission 1 (resistance 1)

Transmission 2 (resistance 2)

Substation 1

Peaker 1

Substation 2

Feeder 1 (voltage 1)

Feeder 2 (voltage 2)

Demand 1

Demand 2

Demand 3

Demand 4

Feeder 3 (voltage 3)

Feeder 4 (voltage 4)
Demonstration
Scenario – Systems View

- Data Warehouse
- Historical Load
- Customer Information
- Constraints/Contracts
- GIS
- Power Network Models
- Spatial Analysis
- Demand Management System
- Demand Reduction
- OEVC Engine
- System Wide Process and Optimization
- DMS
- Distribution Model
- Powerflow Modeling
- Voltage Reduction
- EMS
- Transmission Model
- Powerflow Modeling
- Generation Management
- Peaker Management
The following are examples of key IBM intellectual property leveraged to enable the OEVC solutions

- **Methodologies**
  - SG Maturity Model
  - SG Technology Roadmap Methodology
  - SG Disruptive Technologies
  - Impact of Future Technologies Methodologies
  - Service Oriented Modeling and Architecture for Energy (SOMA-E)

- **Frameworks and Models**
  - IBM Solutions Architecture Framework for Energy (SAFE)
  - IBM Common Information Model (CIM)

- **Software**
  - Cognos Now
  - Web sphere Business Integrator and Process Manager
  - ILog Optimization (ODM/OPL)
  - Web sphere Info Sphere streams
  - IBM Info sphere Data stage
  - IBM Rational Software Delivery Platform for Energy
  - Telelogic for Energy
  - IBM Tivoli and Net cool
  - IBM Maximo

- **Numerous Business Partners**
  - EMS, DMS, OMS, FMS, GIS, Power Flow Modeling, Load Control, Renewable Management, Demand Management, PHEV Management, Storage Management
Potential Roll-Out Considerations

- Start simple and build
  - Business process modeling
  - Data architecture modeling and integration
  - Dashboading/Visualization
  - Analytics and Modeling, Contingencies
  - Process control
  - About three to six interdependent rules systems based on a single common goal or characteristic – i.e. asset protection

- Can be implemented in phases
  - Through an iterative approach doing one LOB process at a time based on customer priorities/capabilities
  - Governance and a cross organizational approach are key
ILOG Overview – Better Decisions Faster

- Sophisticated Optimization Technology Solves Hard Business Problems
  - IBM ILOG Optimization helps businesses maximize resource efficiency
    • by helping companies make Choices
    • to reach Targets
    • while observing Limits
    • driven by analyzing Data
  - Using powerful, robust, scalable, and diversified optimization technology and services
    • Optimization has most value when there are many choices with complex relationships that force trade-offs

- Benefits of Optimization
  - Calculable ROIs, with paybacks within months, even weeks
    • Capital expense avoidance or deferral
    • Operating expense reductions
    • Total revenue, revenue mix, and margin improvements
  - Improved customer satisfaction
    • Better and more personalized customer service
  - Improved employee satisfaction
    • Focus on critical complexities, not repetitive routine
    • More productivity without more work
    • More flexibility to accommodate individual preferences
How Optimization Works

Two kinds of decisions:
- Continuous – How much to generate? How much to invest?
- Discrete – Which units to commit? Which plants to build?
CIM – Key Focus Areas around RSA

1. **UIM** - Core CIM modeling and transformation capability in RSA;
2. **Application Integration** - BPM/SOA-driven application integration;
3. **Customer Warehouse and Hub** - UML as a starting point for Logical Data Models
4. **IBM E&U Warehouse and Hub** - MDM plug-ins for RSA create domain-specific services and data models.
SAFE: CIM as the core of a **Unified Information Model**

**Unified Information Model**
- Represents a UML-based, system-level view of the information architecture;
- Incorporates the following Smart Grid standards: distribution management systems (IEC 61968), electricity transmission (IEC 61970) and substation automation (IEC 61850)
- Focus: Architecture and Design

### RSA Requirements

<table>
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<tr>
<th>Requirement</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Model Content</td>
<td>The current IEC models are built and maintained in a competitor product. Users would need a validated set of IEC models for the 61968, 61970 and 61850 standards within RSA (7.5+). The models are represented as UML class diagrams.</td>
</tr>
<tr>
<td>2. Model Profile</td>
<td>There are no requirements to create a UML Profile for the model.</td>
</tr>
<tr>
<td>3. Model-to-Model Transforms</td>
<td>M2M transforms would be required to support 3 scenarios: application integration, logical data representations and E&amp;U Data Warehouse and Operations Hub.</td>
</tr>
<tr>
<td>5. Packaging</td>
<td>The models and transforms should be packaged as a plug-in to RSA 7.5+. A specific project structure can be selected by the user within the modeling perspective that provides access to CIM models, model messages and transforms. Content for user enablement (examples, user help) would also need to be developed.</td>
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### Complementary Offerings

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<tr>
<td>2. Clear Case</td>
<td>Model management repository and schemas.</td>
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<tr>
<td>3. Requisite Pro</td>
<td>Requirements management traceability</td>
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2 Application Interoperability Model

**Rational Software Architect**
- Defines, manages canonical model in platform-independent (UML) design
- Defines mappings between data, services (application) and process
- Generates SOA-based implementation (BPEL, SCDL, WSDL, XSD)

**Web sphere Integration Developer**
- Implements SOA artifacts across Web sphere platform
- Defines common (meta-messaging) model in version-less schema
- Business Object Mapper enables impact analysis and change management of common model

### RSA Requirements
No additional requirements

### WID Requirements

| Canonical Model | The ability to proactively identify data changes and to weigh the business impact of those changes. Implementing an automated method to identify change and, even more importantly, implementing an automated means for identifying the impact of data changes across all systems can significantly reduce integration and maintenance costs. Coming in WID 7.x |
| Impact Analysis | A common model that provides broader meaning to the data exchanged between applications. Enables developers to map an interface and define data integrity rules once. Coming in WID 7.x |
Customer-built Operational Hub and Warehouse

Rational Software Architect
- Core System entities based on IEC 61968/61970 and 61850
- Enables enrichment of CIM models
- Focus: Conceptual Design

Info sphere Data Architect
- Project Information / Data Architecture represents specific instantiation of data models and standards
- Logical and physical description of data based on UML Information models
- Provides starting points to Master Data Management, Analytics/BI

RSA Requirements
No additional requirements

IDA Requirements
No additional requirements
IBM E&U Operational Hub and Warehouse

Rational Software Architect
- Uses IEC and EPRI Inteligrid models (UML) as design inputs
- MIH Workbench generates implementation of hub and warehouse

Info sphere MIH Workbench
- RSA Plug-in
- Logical and physical descriptions of data and business services based on UML models
- Enables customized to Master Data Management, Analytics/BI implementations specific to industry

RSA Requirements
No additional requirements

MIH Workbench Requirements
No additional requirements
OEVC Details
What does an OEVC Look Like?

- Business processes and supporting IT infrastructure to unify and optimize the energy ecosystem from generation to consumption.
  - Business modeling and process integration
  - Best of breed solutions across the value chain
  - Integration framework
  - Best practices
  - Optimization analytics and process orchestration

- A Framework for a Uber-Business Process Optimizer
  - Coordinates all related business processes
  - Dynamically responds to rapidly changing business metrics
  - Builds and executes enterprise wide contingency plans
  - Utilizes advanced modeling, analytics and process control
  - Discovers new, unknown business models and defines new metrics and relationships
Sensing / Metering and Data Acquisition
Real World Aware Data Processing
Spatiotemporal Patterns, (Contingencies)

Outside Influencers
Information Broker
Data Collection and Distribution

Business Process Optimization Engine
Business Processes
Historical Data, Analytics & Deep Computing
Business Insights

Events
Actions

Events
Actions
Energy Value Chain Optimization is all about prioritizing and coordinating options into a enterprise based balanced solution, in near real-time

- The models are evaluated within two domains
  - Financial Impacts
  - Resource Requirements and Availability Impacts
- A total quantitative score is aggregated to determine the most optimal solution
Scenario - Rules/Constraints

- The utility will need to use some combination of the three techniques to reduce the projected demand on the system for the period identified.
- The limitations are that the utility can derive a limited amount of power from each feeder using voltage reduction.
- The distance from the node to each substation will effect the amount of real power that effects the node – for example the farther the load is to the node the greater the impact at the node will be.
- Load reduction will represent 5% of the total load of the participating feeder.
- Load reduction techniques cannot make up the entire balance of the demand during the duration and the utility will be limited to where and how often (once for example) they may exercise the reduction for each feeder.
- For this scenario we will assume that the utility pays (credits) each customer that participates in a demand action. For this demonstration it will be calculated by a ratio of the feeder load value.
- Peaking may be used but there is associated fuel and maintenance cost calculated per megawatt.
- The total amount of throughput (total transfer capacity) at a node on the transmission network is established for the scenario.
- The planned demand on the node is established in the pre-demonstration scenario and is determined to exceed the capacity of the node. This delta from the first statement is the differential amount of load to be made up.
- The scenario will be based on 15 minutes intervals.
- The duration of the event will be determined based on the load target. The system must calculate the load shaping capabilities dynamically across the target timeframes.
- No demand action can last more than one period (15 minutes).
- Demand actions are limited to the number of events per scenario and have adjustable costs.
- If you use demand action on a feeder at the same time as voltage reduction the amount of voltage reduction will be lessened by 50%.
- There is no costs for voltage reduction to the utility.
- Demand actions need to be spread out spatially.
IBM ILOG Optimization Can Help Your Business Run More Efficiently

3 Ways to Use IBM ILOG Products and Services

- Build an optimization application yourself
  - If you have the OR experts, IBM ILOG technology will make their development faster and more reliable

- Use a packaged solution for your business
  - IBM and its ISV partners have configurable applications for many kinds of business issues
    - Resource planning, unit commitment, hydro-thermal scheduling, …

- Let IBM help you build it
  - IBM Professional Services can provide the expertise to build custom applications that meet your business requirements
The Value of IBM ILOG Optimization Technology

- Better decisions
  Get better performance for lower cost
  True optimization finds non-obvious solutions that maximize your value or minimize your costs while observing the many, complex requirements and limitations of modern power system operations
  Optimization produces quantifiable benefits on your bottom line

- Faster decisions
  Automating decision processes increases the speed of your responses in today’s accelerating markets and allows your operators and planners to focus on critical complexities rather than on routine issues

- Faster, lower cost development and maintenance
  Using the high-level modeling tools in IBM ILOG’s OPL-CPLEX Development System enables your engineers to code and validate your model with less time and effort than traditional programming languages, and by increasing the transparency of your model, makes maintaining and upgrading your system easier and more reliable

- Turn information into action
  IBM ILOG optimization technology leverages the investment you are making in enterprise information technology
Questions & Answers

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