Technology for the SMART GRID

Transmission and Distribution Automation Solutions
Agenda for Presentation

• Axceleon Smart Grid Mission & Opportunities
• Axceleon Overview
• Customer Sample
• Smart Grid Domains
• Opportunities for CloudFuzion in Smart Grid Domains
• CloudFuzion Solutions for Smart Grid Domains
• Axceleon Products
  – EnFuzion®3D
  – CloudFuzion®
• CloudFuzion Applications & How it works?
• CloudFuzion & PSLF
• Power Studies in the Cloud
• Summary
Axceleon Mission: To help the Smart Grid run more efficiently and reliably

*Challenges faced by the Smart Grid*
- Transmission automation technologies well known but financially challenged, **near real time analytics needed**
- Distribution technologies not well understood also financially challenged, **near real time analytics needed**

**Opportunities for CloudFuzion Technology**
- Enable the smart grid to better use the available capacity of its infrastructure by flattening load profiles
- Provide Smart-grid technologies to address transmission congestion issues through demand response and controllable load
- Enable better Smart-grid control systems and tools targeted at responding to imbalances and reducing outage events

*Courtesy of PNNL*
Axceleon builds software to accelerate time to results for high performance computing (HPC) applications on HPC clusters, Private and Public Clouds.

Headquartered in Southern California.

Research partners with Universities around the globe, focused on bringing HPC research to market.

Deployed in 27 countries, 11 Fortune 100 companies among its customers.

Hardware Partner Deployments: IBM, HP, Dell, Oracle, SGI and BOXX.


System integrators in the US, Japan, China, Asean and Europe that focus on clustering within the various vertical markets, Power/Energy, 3D, HPC etc.
SMART GRID Domains

- Markets
- Operations
- Service Provider
- Bulk Generation
- Transmission
- Distribution
- Customer

- Secure Communication Interface
- Electrical Interface
- Domain
Smart Grid Domains

• **Bulk Generation**
  • Electricity generation from other forms of energy, chemical combustion to nuclear fission, flowing water, wind, solar radiation and geothermal heat

• **Transmission**
  • Bulk transfer of electrical power from generation sources to distribution

• **Distribution**
  • Distributes Electricity to and from the End Customer

• **Customer**
  • The Customer domain is electrically connected to the Distribution domain

• **Operations**
  • Manages the distribution of electricity to and from the End Customer

• **Markets**
  • Pricing or balance supply and demand within the power system

• **Service Provider**
  • Organizations providing services to electrical customers and utilities
**CloudFuzion Enabled Smart Grid Solutions**

**Objective:** To build software that accelerates, integrates applications used for analysis, optimization & data mining required to coordinate, operate and manage Transmission, Distribution & Markets Domains

- **Transmission:** Near Real-Time results from Electrical Transmission Analysis applications for Operations/Planning
  - Simulating, Analyzing, and Optimizing Power Systems
  - Stochastic forecasting of renewables, Wind/Solar, EVs, etc.
  - Demand Response Analysis
  - Data Mining to drive the operational shift to Smart Grid functionality

- **Distribution:** Integrating workflows from disparate Applications for improved Power System Modelling & Management
  - Power System Analysis and Visualization
  - System modeling, Optimization of Power Dispatches
  - Outage and Restoration Management

- **Markets:** Analysis of Big Data associated with Smart Grid Markets Analyses especially Locational Margin Pricing
Recent IEEE Meeting on the Smart Grid

• Modeling and analysis of demand response programs and energy resources is a key next step in smart grid integration, according to an IEEE panel of energy and utility professionals at the IEEE Innovation Smart Grid (ISG) conference in Washington, DC. reported in January 2012

• Oak Ridge National Laboratory (ORNL) is working with the U.S. Department of Energy to develop mathematical modeling and analysis tools to accelerate performance and grid resilience, as well as to predict how the smart grid may respond to certain events

• Tom King, a power grid expert with ORNL, said the goal is to create a "look-ahead" simulator to aid in creating more efficient demand response programs and understanding where the grid is the most strained

• It’s all about Accelerating Analytics = CloudFuzion
- Transmission: Transfer of power from generation to distribution
- Challenges: Balancing generation with load across network & maintaining reliability
Transmission Domain:

- Bulk transfer of electrical power from generation sources to distribution

- Connected to the Bulk Generation and Distribution domains

- Transmission network is typically operated by Regional Transmission Operator or Independent System Operator (RTO/ISO)

- Contains distributed energy resources such as electrical storage and/or peaking generation units

- Responsibility to maintain stability on the electric grid by balancing generation (supply) with load (demand) across the transmission network
Transmission: CloudFuzion Solution Stack

• Accelerated execution of simulations and power analysis algorithms such as DSA applications used in electrical network and power grid management and modeling, can be 1000+ times

• Ability to run many hundreds of simulations and analyses in parallel solutions, delivering near real-time results with no sacrifice in accuracy

• Hardware acceleration, applying additional processing power, through core management and clusters of machines

Benefits

Automated Workflows quickly developed and easily customized
Removes the need for burdensome Manual “Job processing”
Integrated PSLF/SSTOOLS/PSSE/MUST/Tara output(s) with other on-premise applications and home grown tools
Delivers more studies faster to support optimizing the operational agility, responsiveness & reliability requirements for Smart Grid
Target > Distribution Domain

- Distribution: Distributes power to and from the End Customer
- Challenges: Load is complicated, want off asap, then brought back in timed sequences to optimize load profile. Managing self-supporting “micro-grids”
Distribution Domain:

- Distributes Electricity to and from the End Customer
- Connects Smart Meters and all Intelligent field devices
- Management & Control via two-way communications
- Connects to Energy Storage facilities and alternative Distributed energy resources capable of generating power
- Distribution Networks built with much interconnection, extensive monitoring and control devices
- Can break into self-supporting "micro-grids" when a problem occurs and customers may not even be aware of it
**Distribution: CloudFuzion Solution Stack**

- Accelerated execution of simulations and power analysis algorithms to model “micro-grids”, distributed generation etc.
- Application parallelization, dividing applications to execute independent tasks concurrently
- Hardware acceleration, applying additional processing power, through core management and clusters of machines

**Benefits**

Benefits Power / Electrical network management that require fast, accurate decision-making in order to optimize the electrical Distribution network, maximize market potential and manage associated safety and reliability risks

Provides robust information needed now for better operational decisions

Provides the data needed to optimize the operating state to realize value in system through increased revenue and longevity of investment in the Distribution domain
Markets: Balance supply and demand within the power system

Challenges: Managing the market needs from generation, transmission & distribution to achieve the lowest economic cost balanced for all parties
Markets Domain:

- Pricing or balance supply and demand within the power system
- Interfaces between Markets domain and domains containing Generation are most critical
- Efficient matching of production with consumption relies on markets
- Distributed energy resources (DERs) participate in markets to some extent today
- DERs will participate to a greater extent as the smart grid becomes more interactive
Markets: CloudFuzion Solution Stack

• Accelerated execution of LMP (Locational Margin Pricing) type studies delivering near real-time results

• Application parallelization, dividing applications to execute independent tasks concurrently

• Enables the integration of various Market type study applications so results and data flow easily between these different applications

Benefits

• Better/Faster LMP data allows more efficient use of the transmission system when congestion occurs on the bulk power grid

• Better/Faster Markets data improves the efficiency of the wholesale electricity market by ensuring that the cost of congestion is reflected in electricity prices and ensures that the least-cost supply of electricity is delivered while respecting the physical limitation of the entire grid
Workflow Management

Applications on the Cloud

Mission critical, 100% redundant stable easy to use workload management, cluster control software

Applications Driven Workflows for Cloud Computing. Cloud launch, management and cloud cluster controls designed in
Applications for CloudFuzion

**Typical Applications**

- Power Flow
- Transfer Limits
- N-1 / N-2 Studies
- Contingency Analysis
- Transient Stability
- LMP Applications
- Accelerate Excel
- Operations Usage
- Dynamic Stability

**Applications**

- Power Flow
- Limit Equations
- N-2 Studies
- Data Mining
- LMP

**Input Data**

Input data can be on local machine or on a server and moved as needed during initialization.

**Interim Data**

Interim data storage is on nodes.

**Results**

Results are stored on local machine or server and available for future runs.

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How Does EnFuzion Work

1. Users submit jobs
2. EnFuzion distributes, manages and executes jobs on worker machines until completion
3. EnFuzion stores results and cleans up the worker machines
4. Users retrieve results

The configuration below shows a typical multi-user environment

Types of Computers:
- Control Computer - one
- Worker Computers - many
- User Computers - many

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Cores Usage: Single-threaded Applications

Single-threaded applications on their own can only utilize one of the available logical processors on a system leaving the other idle.
CloudFuzion: Multiple Data Streams, One to each core

CloudFuzion manages multiple PSLF/PSS®E Program Studies among multiple execution cores to produce more results per unit of time.
CloudFuzion Expediting PSLF & PSS®E Execution

- CloudFuzion manages PSLF & PSS®E contingency cases transparently
- Run times are reduced proportionally to the number of processors and/or cores used
- Can be dedicated compute cluster or desktops
- CloudFuzion uses all cores in a multi-core computer
- Integrated with Commercial Applications
  - PSLF – GE
  - MARS – GE
  - Tara – PowerGem
  - Home Grown Power Flow Applications
  - PSS®E - Siemens
  - MUST - Siemens
  - ASSESS - RTE France
  - PowerGem

Desktop
Laptop
Remote Access

CloudFuzion
Server/Scheduler
Results
Analysis

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Potential PSLF & PSS®E in the Real Time Environment

- Direct interface to EMS for system snapshot
- Automatically perform (behind the scenes) analyses
- Results are customized using Python
CloudFuzion for the Smart Grid

The **Easy Button** for Applications Acceleration

- Applications, Applications, Applications - It’s all about accelerating Applications for use in the Smart Grid

- Automated, optimized workflow driven execution for Electrical Transmission Analysis applications

- Integrated workflows from disparate Applications for improved Power System Modelling & Management
  - Power System Analysis and Visualization
  - System modeling, Optimization of Power Dispatches
  - Outage and Restoration Management
  - Demand Response Analysis

- Easy Analysis of Big Data associated with Smart Grid Markets analyses especially Locational Margin Pricing
Opportunities for the Smart Grid & the Cloud

• **Access:**
  • Internet access becoming pervasive and a priority

• **Big Data:**
  • Fast encrypted transfer methods to move Big Data
  • Big Memory, high core count machines in the cloud
  • Rapid data processing in the cloud

• **Applications:**
  • All candidates for the cloud
  • SaaS for many Applications showing up

• **Security:**
  • Clouds are secure, safe, resilient, encrypted
  • Azure has ISO/IEC 27001:2005 certification and SAS 70 Type 1 and II attestations
CloudFuzion Cloud Power Studies Workflow & Management

1. One Click Cloud (Azure) HPC Cluster
2. No change in Power Engineer’s Workflow
3. Automatically Processed
4. Alerts, Updates & Management

- Intelligent Cloud Cluster Control
- Auto Expansion / Contraction of compute cloud resources
- Automated Smart Workflows
- Managed to SLA /QoS
- Lights Out Operation

- High speed transport to/from Cloud
- Contingency Analysis results returned as Built
- Option to download all at one time
- Status viewable via CF Web GUI
CloudFuzion Workflow & Cloud Cluster Data Movement

- Drag work to Drop Box / Web Portal
- Automatically Processed
- High speed Big Data Xfer to cloud
- Intelligent Cloud Cluster Control
- Auto Expansion / Contraction of compute cloud resources
- Automated Smart Workflows
- Managed to SLA /QoS
- Lights Out Operation

Power/Engineering

Big Data Input

Managed to defined Quality Metrics and standards
Monitors, Alerts and Actions

Output Reports Work Results

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Summary:

• Challenges faced by the Smart Grid
  – Transmission: Balancing generation with load across network and maintaining reliability
  – Distribution: Load is complicated, want off asap, then brought back in timed sequences to optimize load profile. Managing self-supporting “micro-grids”
  – Markets: Managing the market needs from generation, transmission & distribution to achieve the lowest economic cost balanced for all parties

• Opportunities for CloudFuzion in the following Smart Grid Domains
  – Transmission
  – Distribution
  – Markets

• How we can help
  – 100% Application focused – Enabling Applications for the Smart Grid & the cloud
  – Focused on User Workflows and integrating CloudFuzion directly with applications so End User launches computation jobs from within the Application, minimal thinking required
  – Workflow and cloud management can be manual, automated as part of Job, (start/stop n nodes), cost managed and budgeted
  – CloudFuzion team can help with Applications integration, deployment, cluster deployment on Microsoft Azure
  – The result: faster electrical network analysis and more effective operations management and optimized market opportunity to help the Smart Grid run more efficiently and reliably
Thank you
Please visit http://www.CloudFuzion.com

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Appendix
- Case Studies, EWEB & Powerlink
- Typical Power Study Workflow
Case Study: EWEB - Eugene Oregon USA.

The utility is a small load serving entity utilizing 30 plus 115kV circuits while running <100 MW of mixed generation. System is not complex but does parallel major 500kV and 230kV bulk grid facilities. Based on NERC definitions this company must comply with the applicable standards annually.

Based on discovery work, the study plan and scheme for EnFuzion were in a preliminary state such as to be easily manipulated into required run scheme. Previous year study time for man-machine were in the ~4 man-month period. This is suggestive ¼ to ½ FTE will be consumed annually for a redundant workload.

EnFuzion process integration reduced this work load from months to hours. EnFuzion managed the process phase to allow the engineer to focus back to the primary work function doing performance reviews-assessments and defining options for critical issues faced by the utility. No bulk data-entry phase was ensued nor was the machine management required. The merging of the process manager with the engineer function resulted in a 20 to 1 cost benefit.

Time spent was one man-week for annual setup, one process-day (13hours), and one man-week for review and documentation. 2 weeks versus 16+ weeks from the prior year.
Case Study: EWEB - Eugene Oregon USA.

Solution Description

EWEB is a load serving entity utilizing 30 plus 115kV circuits, running <100 MW of mixed generation. System also parallels a major 500kV and 230kV bulk grid facilities and must meet NERC standards. Previous year study time for man-machine were 4+ man months, ¼ to ½ FTE annually. Time spent was one man-week for annual setup, one process-day (13hours), and one man-week for review and reporting. 2 weeks versus 16+ from the prior year. The merging of the process manager with the engineer function resulted in a 20 to 1 cost benefit.

Value Proposition

For The Planning Engineer
- Automated run scheduling & management
- Reduces errors & labor intensive work
- Gets results faster, uses multiple machines
- Easy to setup and simple to use and reuse

For The IT Department;
- Secure, roll out is quick & easy
- Logging / Scalable / Fault Tolerance
- Optimizes all available IT assets
- Works with Homegrown & 3rd Party Apps.
- Resource Management capability

For The Power Company;
- Reduces Operational Costs
- Increases Reliability and Safety
- Increases Plant and Asset utilization
- Improves Profitability and Productivity
- Regulation Requirements met (NERC)

Solution Components

Software
- CloudFuzionPower
- GE PSLF software
- Operating Systems
- Windows 7 & Windows Server

Hardware
- Internal Intel based HP 8 core machines in HB Calif.

Services Provided
- On-Site Discovery and switch file and data development
- Data preparation for EnFuzion
- EnFuzion PSLF execution
- Reports generation and delivery

References / Experiences

- Powerlink – 30+ Planning engineers on EnFuzion since 2003
- EDF / RTE – French Utility has designed EnFuzion in Software used for Reliability & Security simulations & analysis, 2003
- Europe: UK National Grid, Scottish Power, Denmark, Belgium
- US Utilities: SPP, PJM, ISO-NE, FLP, Entegy, BPA, UI
- Others: Korea Power Exchange. FinnGrid TRC, RLC, PowerGem
- Universities: Edinburgh, Strathclyde, Manchester, Univ. of Iowa

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## Case Study: Powerlink - Queensland Australia.

### Solution Description

Australia’s eastern seaboard and supports multiple energy companies. EnFuzionPower is used to run all Planning and Operational studies for the company. Powerlink have fully integrated EnFuzion into their workflow and for all transmission studies. They use EnFuzion to accelerate their Excel spreadsheet work along with home grown apps. EnFuzion offers the ability to automate & accelerate complex power simulations, analysis & optimization of their T&D Network.

### Solution Components

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<th>Software</th>
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<tbody>
<tr>
<td>✔ EnFuzionPower</td>
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<tr>
<td>✔ Siemens PSS®E software</td>
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<td>✔ Home Grown &amp; Industry Apps.</td>
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<th>Operating Systems</th>
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<td>✔ Windows XP &amp; Windows Server</td>
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<th>Hardware</th>
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<td>✔ IBM HPC Cluster, 120 nodes</td>
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<th>Services</th>
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<tr>
<td>✔ Professional Services</td>
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<tr>
<td>✔ Training &amp; Support</td>
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<td>✔ Software updates</td>
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