

*Bringing the Electric System
into the Information Age: The
Evolution of Policy,
Technology, and Markets*

Modernizing the Grid Midwest Regional Summit
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QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

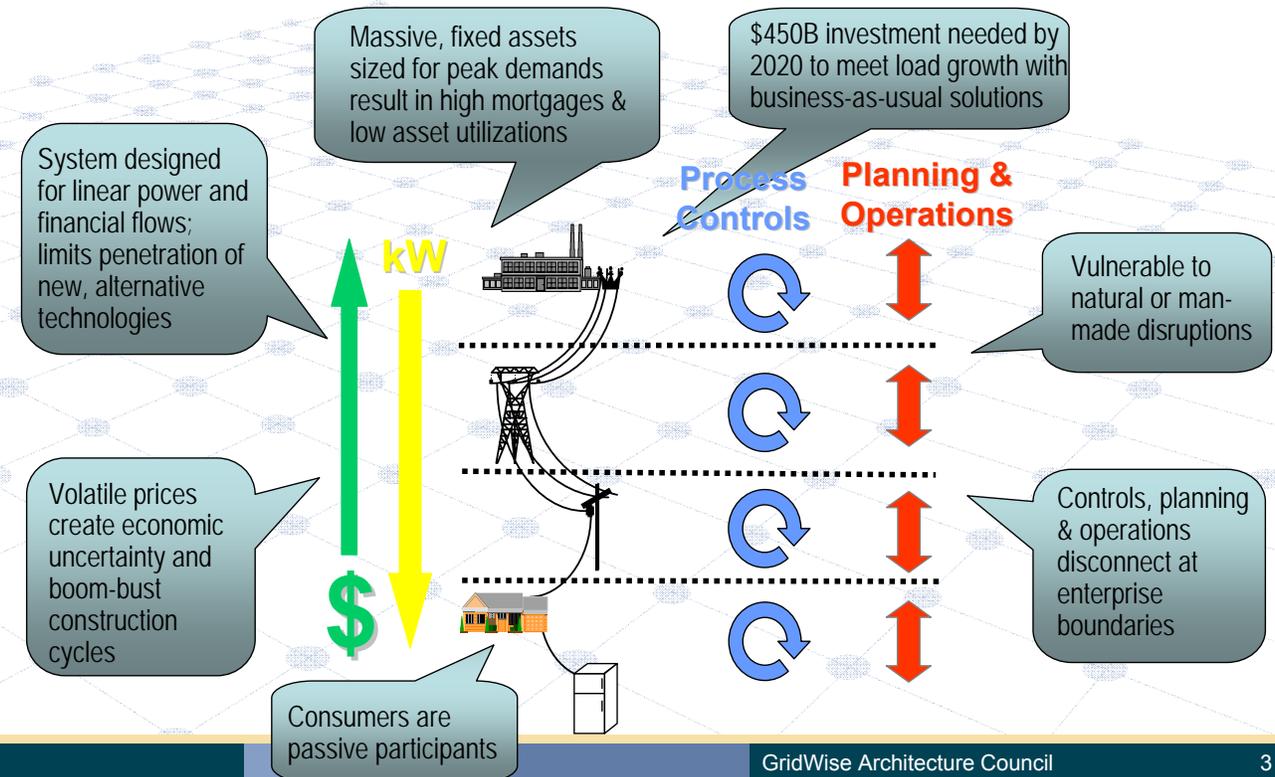


● Outline

- The impetus for integrated technology, economic, policy transformation in the electric power industry
- The role of engaged, empowered consumers
- GridWise

Issues & Uncertainties Surround

Today's Energy Infrastructure



Transforming the Energy Infrastructure

Competitive Distributed Generation

disrupts linear power & monetary flow network

markets or incentives expressing time- and location-dependent value of electricity provides incentive for collaboration

opens door for other distributed resources provides the means of taking advantage of opportunities expressed

Advanced Information Technology

controls and diagnostics & security & private market monitoring

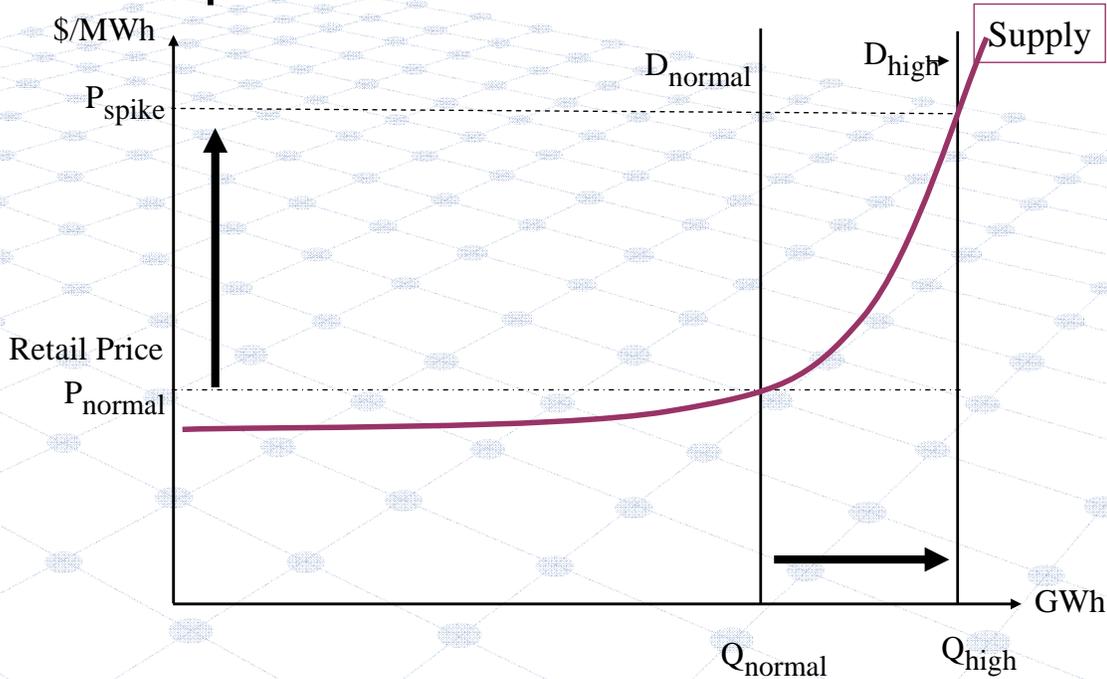
Utility Restructuring

expressive linkages opportunities across enterprise boundaries

Ubiquitous Communications

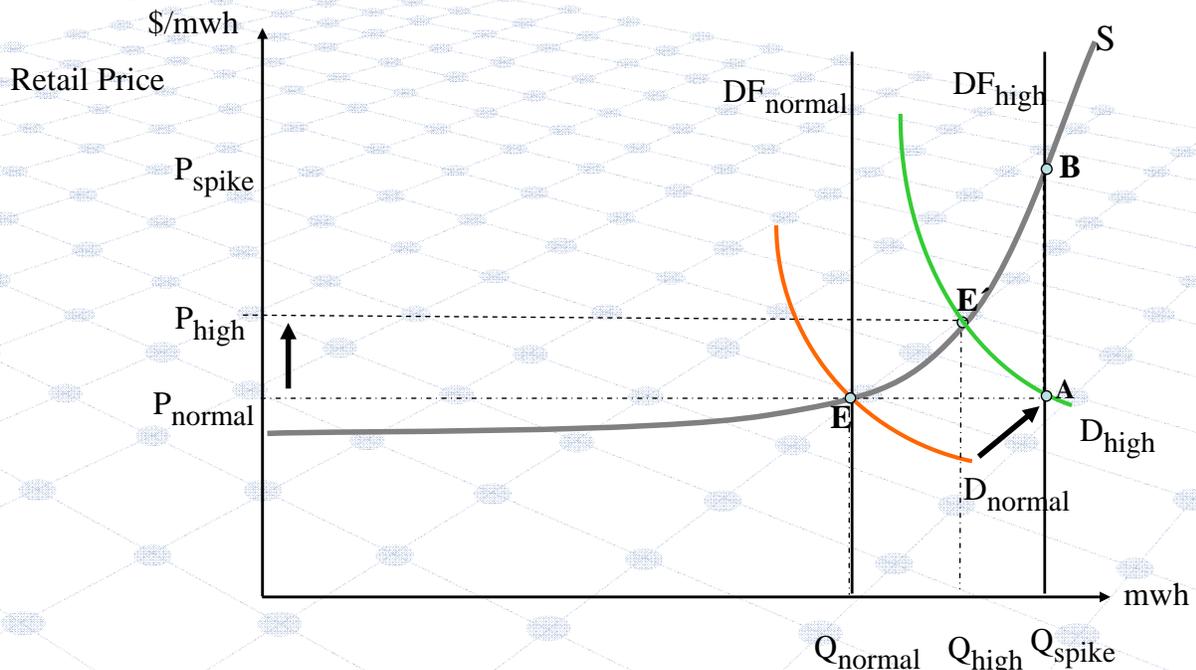
- Real-time info, e-business, & market efficiencies minimize need for inventory & infrastructure, maximize productivity & asset utilization
- Loads & resources collaborate as a "society" with self-organizing & self-optimizing properties of free, fair markets
- Stability, security, crisis management capabilities enhanced
- Rapid, seamless penetration of DG, storage, & load management
- Efficiency & renewables competitive

Unresponsive Demand Leads to Price Spikes



Source: Based on a graph from Steven Braithwait, Christensen Assoc.

Demand Response Damps Price Spikes



Source: Based on a graph from Steven Braithwait, Christensen Assoc.

Implementing Demand Response

- Programs
 - Retail
 - Wholesale, reliability: ISO
- Market-based pricing: retail contracts with customers
- Types of contracts
 - Fixed price
 - Time of Use (TOU)
 - Critical Peak Pricing (CPP)
 - Real-Time Pricing (RTP)
 - Fixed bill (DLC)

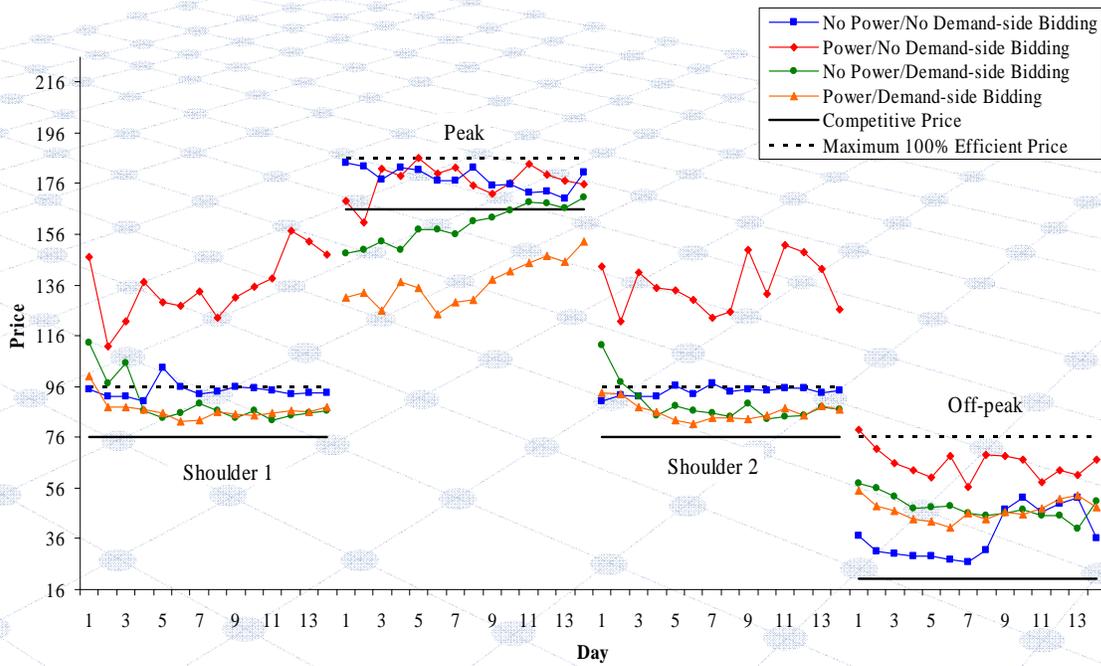
○ Important Policy Questions

- Will customers shift or reduce demand when they see time-varying price signals?
- What is the price elasticity of demand?
- Does elasticity vary by contract, climate, and customer characteristics?
- Will customers accept dynamic pricing?
- With enabling technology and grid-friendly appliances, to what extent will customers automate their response?

Recent Research

- Rassenti, Smith, Wilson PNAS (2003)
 - Experimental investigation of demand response and market power
 - 16% of load on interruptible contracts completely mitigated generator exercise of market power
- Caves, Eakin, Faruqui (2000)
 - Midwest price spikes 1998-99
 - Consequence of disconnection between wholesale and retail markets
- Borenstein, Jaske, Rosenfeld (2002)
- GAO (2004)
- Kiesling (2006)

Demand Response Smoothes Prices and Controls Market Power



Source: Rassenti, Smith, and Wilson, PNAS 2003

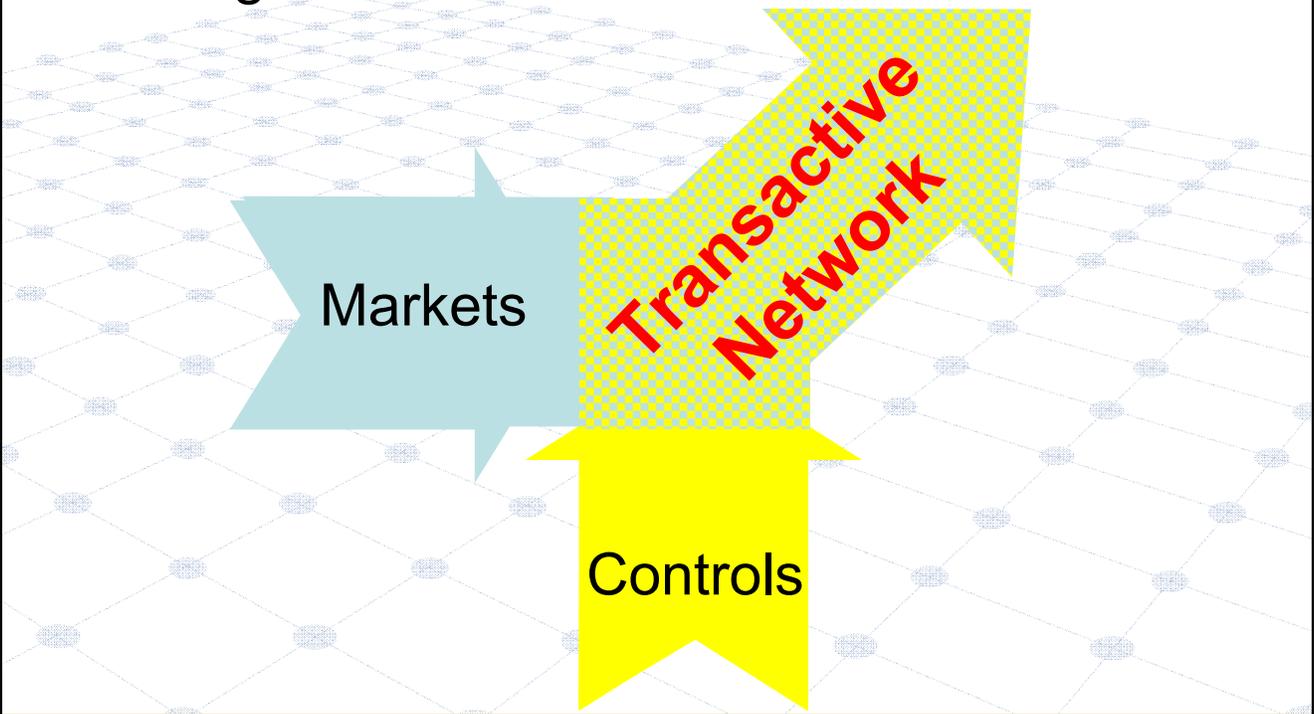
• ComEd/CNT ESPP

- 1100+ residential participants in Northern IL
 - Demographically diverse
 - Single family and multi unit
 - Range of household incomes
- Interval meter
- Simple 24 hr advance communication rule
- Over 3 years, average price elasticity approx 7%, marginal (immediate hour) 20%
- Small customers do respond to dynamic pricing!

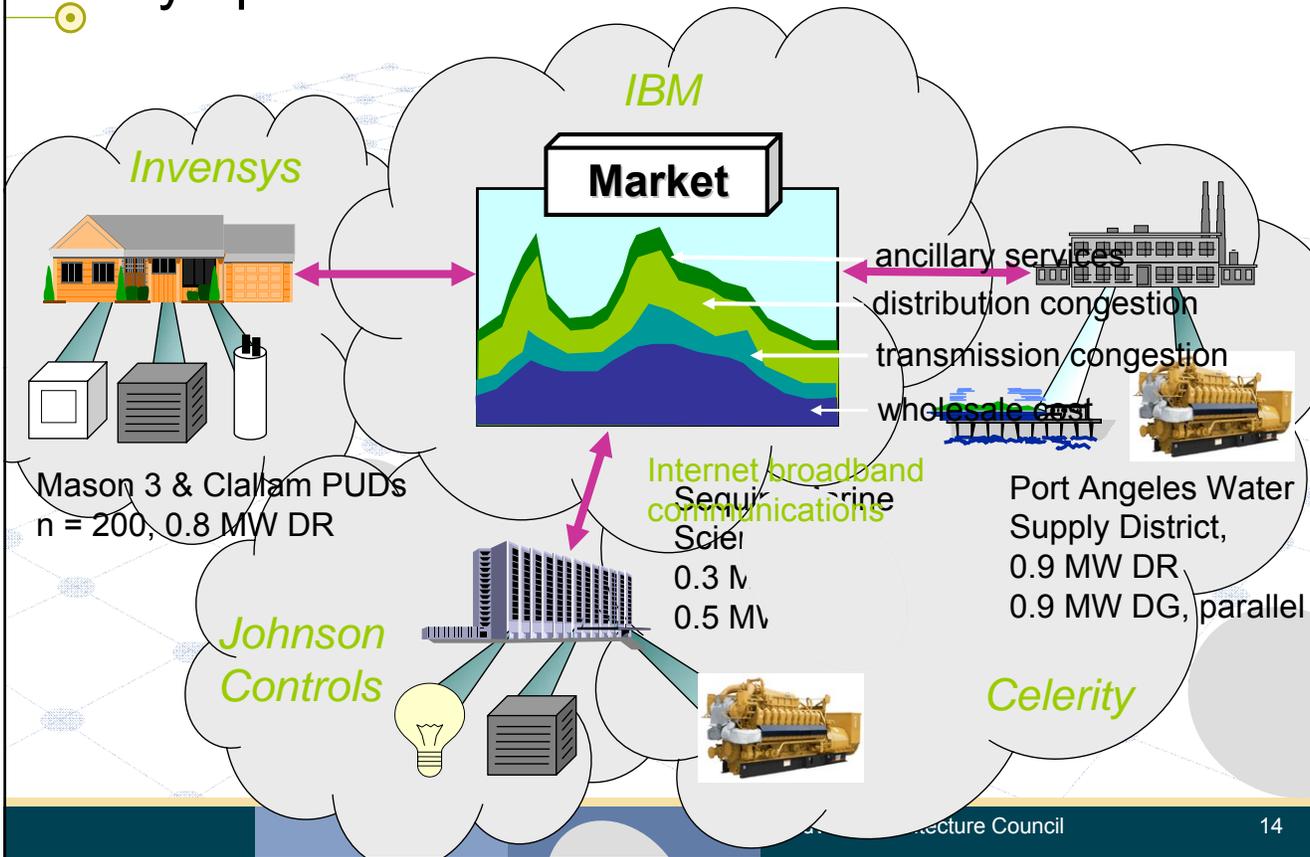
Summary: Benefits of Demand Response

- Demand for electricity
 - Is downward sloping
 - Has varying elasticity across customers
 - Has varying elasticity across the day => electricity service can be sold as a differentiated product
- Provides system/network reliability by prioritizing use in peak hours
 - Current policy: shut down entire substations
- Integrates wholesale and retail markets
 - Correct generation investment signals
 - Correct transmission investment signals
- Conservation/reduced resource use

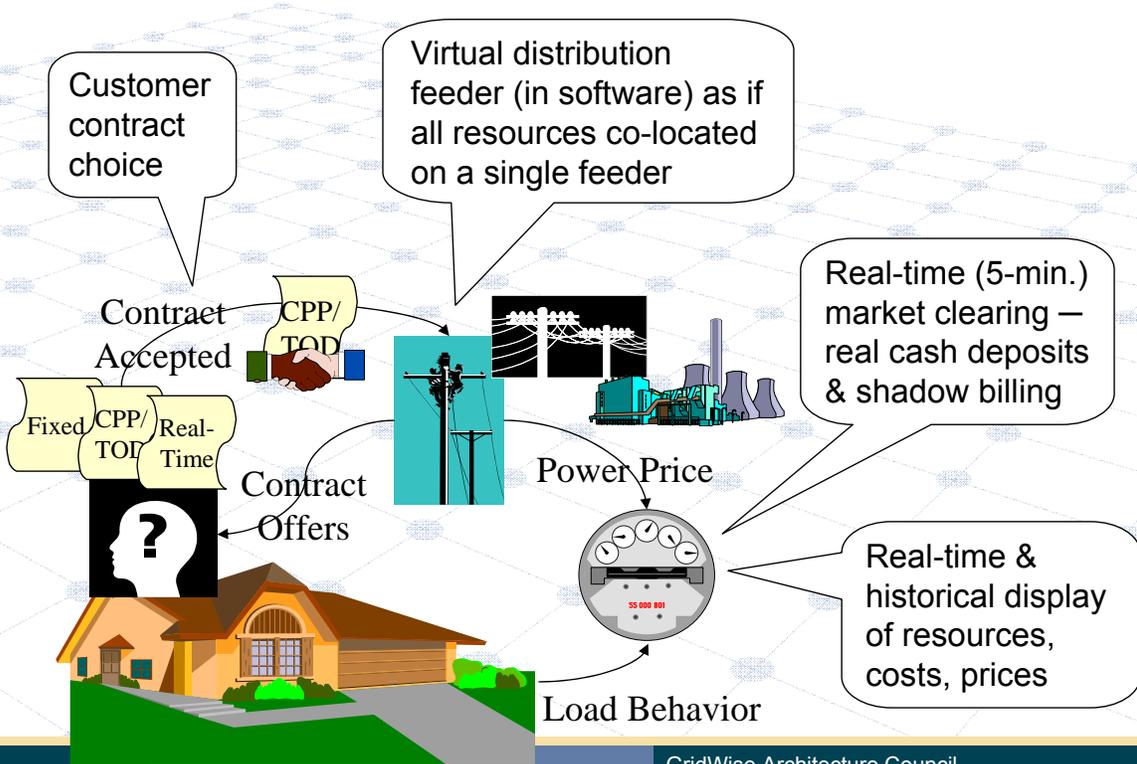
- Markets and Controls
Merge to Form a Transactive Network



Olympic Peninsula GridWise Demonstration



Testing Market-based Customer Incentives



Information: The Virtual Electric Infrastructure

FACT:

In the next 20 years, the U.S. will spend \$450B on electric infrastructure, just to meet load growth.



CHOICE:

Perpetuate a 20th Century solution

OR

Invest in a 21st Century system saving ratepayers \$80B while increasing reliability and flexibility.

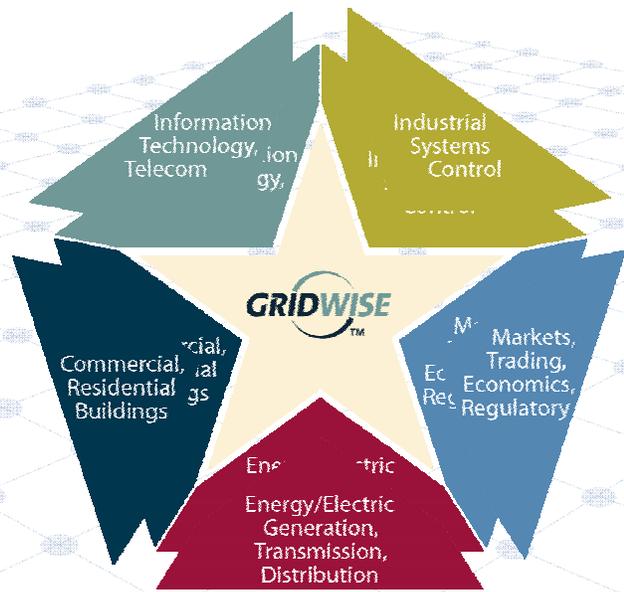


Revealing Values +
Communications +
Advanced Controls
≡ Electric infrastructure

The choice is
easy because...

\$ bits << \$ iron

GridWise Architecture Council



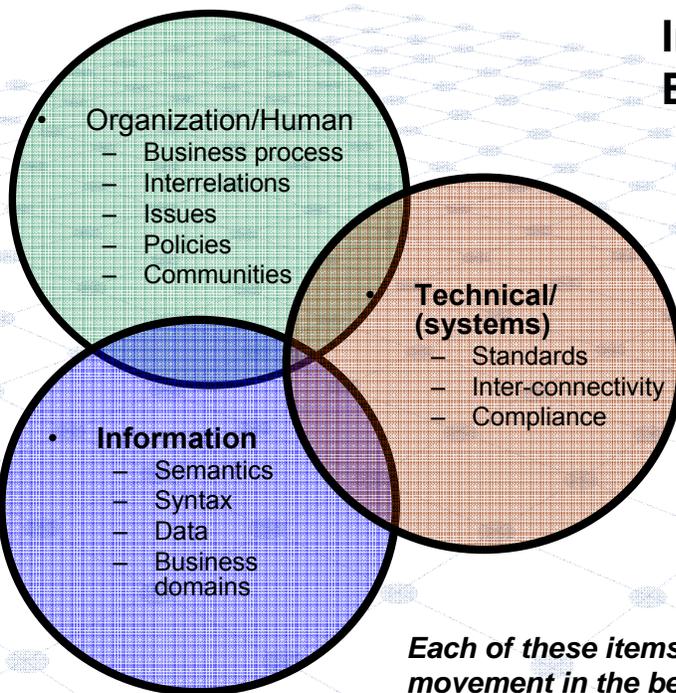
The Electricity Community

→ The future is in the linkage of sectors across the electricity chain.

- Who
 - Respected experts
 - Volunteers
 - Cross-sector organizations
 - What
 - Principles of interaction
 - Interoperability
- Developing**
Communicating
Guiding
- IBM
 - Cummins
 - Colorado State Univ.
 - Energy Control, Inc.
 - Interop
 - eMeter
 - Southern Calif. Edison
 - Bonneville Power Admin.
 - EnerNex
 - Emerson
 - Drummond Group
 - Infotility
 - Areva T&D



GWAC's Mission - Interoperability



Interoperable Software - Expected Grid Impact:

- Reduces integration cost
- Reduces cost to operate
- Reduces capital IT cost
- Reduces installation cost
- Reduces upgrade cost
- Better security management
- More choice in products
- More price points & features

Each of these items has a very significant percentage movement in the beneficial direction – up to 50%

• The Nutshell

- Objective
 - Principles and concepts to advance integration/interoperation
- Challenges
 - Electric system is too vast for one enterprise architecture or standard
 - New players from other industries with their own IT
 - Evolving heterogeneous, 24x7 system of technologies
- GridWise Architecture Council (GWAC)
 - Neutral, cross-sector, voluntary group of respected experts
- Plan of Attack
 - Develop a common agenda and frame the debate on interoperability
 - Reference framework, levels for interoperability agreement
 - Involve industry sectors and policy makers for buy-in/ownership
 - Identify and address priorities for advancement
 - Standards, regulatory issues, message communication, community forums

Take Away Points

- Interoperability is reducing costs in other industries
- GWAC is forming and maintaining a common vision on interoperability
 - Across community segments
 - Electric community will own and fund
 - 30 years
- Accomplishments:
 - Constitution Convention (100+ attendees)
 - Interviews (100+)
 - 27 key principles for a cost effective, efficient grid
 - High level of consensus on direction and key issues
 - Several related supporting activities in progress

Contact Information

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For more GridWise information please see,

GridWise Architecture Council: <http://www.gridwiseac.org>

DOE OEDER: <http://www.electricdistribution.ctc.com>

GridWise Alliance: <http://www.gridwise.org>

GridWise at PNNL: <http://gridwise.pnl.gov>