GridWise™: A Public/Private Partnership for Transforming the Energy System

Bringing Energy into the Information Age

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June 2003
Issues & Uncertainties Surround Today’s Energy Infrastructure

System designed for linear power and financial flows; limits penetration of new, alternative technologies.

Massive, fixed assets sized for peak demands result in high mortgages & low asset utilizations.

$450B investment needed by 2020 to meet load growth with business-as-usual solutions.

Vulnerable to natural or man-made disruptions.

Volatile prices create economic uncertainty and boom-bust construction cycles.

Consumers are passive participants.

Controls, planning & operations disconnect at enterprise boundaries.
The Transformed Energy Infrastructure

- Real-time info, e-business, & market efficiencies minimize need for inventory & infrastructure, maximize productivity & asset utilization
- Loads & resources collaborate as a distributed, integrated system 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

markets provide opportunity and incentive for collaboration

Disrupts linear power & monetary flow network

1. Utility Restructuring & Planning & Operations
2. Competitive Distributed Generation
3. Ubiquitous Communications
4. Advanced Information Technology

Open door for other distributed resources

Agent-based technologies, controls & operations; diagnostics & prognostics

Security & privacy

Cross-enterprise links
Today's Energy System
Operation & Planning Processes

- **Generation**
  - Generation Control (governors, exciters, stabilizers)

- **Transmission**
  - Transmission Control (protection, voltage)
  - Transmission Markets
  - Congestion Management

- **Distribution**
  - Distribution Control (protection, voltage)
  - Distribution Operations & Maintenance

- **Customer**
  - Supervisory Control
  - Time-of-day Billing

- **Meter**
  - Monthly Billing

- **Appliances, Equipment**
  - Retrofits, Upgrades, Growth
  - Power Purchasing

- **Power Markets**
  - Market Reconciliation

- **Plant Construction**
  - Plant Engineering

- **Economics**
  - Power Engineering

- **Both**
  - Consider Combination of Engineering & Economic/Markets

Expanded Scope of Benefits, Issues
New Markets & Technologies
Span System Levels, Time Scales

- Grid-Friendly Appliances
- Ancillary Service Value of Distributed Resources
- Transaction-Based Process Controls
- Transactive Control-Based Dispatch & Congestion Management
- Just-in-Time Capacity Expansion Markets
- DC/Flexbus
- T&D Capacity Value of Distributed Generation
“Just-in-Time” Dynamic Operations
Loads, DG, Storage, Power & T&D Contracts
with Utility or Aggregator

Load Following: local spot-market

Load Shaping: mid-price, short-term, take-or-leave contract

Base Load: low, fixed-price, long-term energy contract
Role of Diversity
Location & Time

2 Households

Load per Customer [kW]

Time of Day

0 5 10 15 20

0 2 4 6 8 10 12

Advanced Communications and Control Program
Accumulating the Value Chain Accelerates Penetration of Distributed Resources

- **Central generation**
  - Avoided infrastructure

- **Transmission**
  - Avoided infrastructure
  - Congestion relief
  - VAR support
  - Spinning reserve
  - Non-spinning reserve

- **Distribution**
  - Avoided infrastructure
  - Voltage support
  - Power quality

- **Customer**
  - Lower electric costs
  - Waste heat utilization
  - Power quality
  - Backup power

\(~3\)-yr payback

Rate-of-Return

Penetration
Downward Communication of Availabilities, Prices, Forecasts, Capacity Expansion Plans

- Generator Marketplace
- Transmission Marketplace
- Distribution Marketplace
- Customer Meters
- Appliances/Equipment

- Power prices, contracts, availability
- Status, availability, ancillary service prices
- T&D prices, capacity, availability, forecast, status
- Cost, capacity, availability, forecast
Upward Communication of Current & Expected Loads, Status, Operation & Construction Plans

Generator Marketplace

Transmission Marketplace

Distribution Marketplace

Customer Meters

Appliances/Equipment

contract, $, load, forecast, $\Delta$load/$\Delta$ $

$, aggregated loads, forecast, $\Delta$load/$\Delta$ $

$, load, forecast, $\Delta$load/$\Delta$ $

demand, need ($), status

ancillary services required, $
Grid-Friendly Appliance Passive Control Chip
Grid-Friendly™ Appliances (GFAs) Help Keep the Lights On

Grid-Friendly Appliances Sense Frequency Excursions & Control Appliances to Act as Spinning Reserve Loads and Reserves on a Typical U.S. Peak Day

With GFA: Frequency Excursion Arrests at 59.950 Hz within 0.7 sec.

Without GFA: Frequency Drops to 59.886 Hz within 5.8 sec.

Four Corners Unit 5 Tripped with 710 MW on May 8, 2002 At 13:38 PDT

Industrial
28%

Residential (GFA)
20%

Commercial
29%

Operating reserves
13%

Resident (non-GFA)
10%

GFA potential exceeds US operating reserve requirements!
Grid-Friendly™ Appliances (GFAs) Help Keep the Lights On

Millions of GFAs

Grid-Friendly Appliance Controller

eliminate need for 100s of new power plants,

saving tens of billions of dollars over 20 years.

Grid-friendly appliances…
…rapid, automatic response to grid crises
…platform for active communication & control
…pre-heat/pre-cool to coast through peaks
…utilize & value thermal storage
…increase reliability & security
…unnoticeable by consumer
…mass customization/marketing

“…given enough ants, you can move a mountain!…”
impromptu reaction from a utility power engineer
Traditional Control — Satisfies Absolute Demand Regardless of Cost or Grid Conditions

Com-mercial Bldg.

Zone 1 Zone 2

Cooling Demand: On Off

Cost of Cooling

Temperature (°F)

74

72

Zone 1 Zone 2

setpoint control range

start-up demand energy

1 Stage 2 Stages

$20/hr $10/hr $0/hr

200 kW 100 kW 0 kW

14
Transaction-Based Control — Relative Need Expressed as Willingness to Pay; Control System Minimizes Cost

Zone 1

Zone 2

Stage 1 $5/hr
Stage 2 $18/hr

Cooling Need pay up to:

$4/hr
$8/hr

Temperature (°F)

74
72

Cost of Cooling

Need for Cooling

Setpoint

Control range

Stage 1 $5/hr
Stage 2 $18/hr

$10/hr
$5/hr
$0/hr

72 °F
74 °F

$20/hr
$10/hr
$0/hr

0 kW
100 kW
200 kW

transactive

traditional
Transaction Control for Congestion Management

7. 8 hrs later, Path A restored, price returns to normal level.
GridWise Markets and Controls Merge to Form a Transactive Network
DC / Flexbus Increases End-User Electrical Efficiency

Efficiency from grid to server electronics is often 42% or lower. Wasted electricity goes to heat, which causes additional air conditioning loads and even lower overall efficiency.
The Value of Just-In-Time Capacity: Timely and Smaller Increments Mitigate Price Volatility & Boom-Bust Cycle

Price ($/MW)

Demand

Supply

DER Price

Just-in-time

load growth

capacity expansion

load growth

Quantity (MW)
Benefits Exceed $80B (20-yr PV)

- Actively managing peak demand defers construction: ~$50B
- Better utilization of existing generation: ~$2.5B
- Actively grid managing reduces outage costs: ~$5B
- Advanced controls & diagnostics increase customer efficiency: ~$10B
- Grid-friendly appliances & equipment supply required spinning reserve capacity: ~$0.5B
- Reducing risk premium by just-in-time capacity markets lowers bond rates 1%: ~$10B

Benefits Exceed $80B (20-yr PV)
Information: the Virtual Energy Infrastructure

GridWise™ Principle 1:

\[ MC^2 \equiv e \]

Markets + Communications + Control

\[ \equiv \]

energy infrastructure

GridWise™ Principle 2:

\[ \$ \text{bits} \ll \$ \text{iron} \]

Investing in a 21st Century Electric System
Industry is Already Mobilizing

- Wide variety blue-chip & high-tech startup corporations embrace the vision
  - GridWise™ Alliance Board
    - Sempra Energy Solutions
    - PJM Interconnection, LLC
    - Alstom Esca Corporation
    - IBM Global Energy & Utilities Industry
    - The Rockport Group
    - CEO Coalition

- **Federal role** is to make the vision broader, more integrated, occur sooner, and ensure public benefit
Long Range Program

- Architecture and Standards
- Simulation and Analysis
- Technology and Applications
- Test-beds and Demonstrations
- Stakeholder and Institutional Adoption

Architecture Established
Stds. Available
Simulation & Analysis Tools,
Applications Suite Available
Regulatory Institutional & Markets Framework
Architecture & Performance Proven
Utility, Vendor, Regulator, Customer Acceptance
Technology & Applications – Strategy

Energy Industry
- Generation & DG
- ISOs, DISCOs, PMAs
- ESCOs
- Equip./Appliances
- Controls
- T&D Equipment
- Labs & Universities

initial core applications
- strategic, public-interest apps.

number & sophistication of applications

IP frenzy!

public sector

private sector

time