Distributed Generation & the Smart Electric Grid of the Future

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Moving the Energy Industry into this new Rapid Response future is possible ...

But it had better be a SMART Grid!

From Hoffert, et al, Science 298, 2002

Buckminster Fuller's Global Electrical Grid
High current cables (superconductors, or quantum conductors) with which to rewire the electrical transmission grid, and enable continental, and even worldwide electrical energy transport.

From: Rick Smalley
Energy & Nanotechnology Conference
Rice University
May 3, 2003
Innervation =

Digital Convergence

Distributed Business
+ Adaptive Learning
+ Simulation
+ Micro Real Options
+ Lean Workflows
+ Peer-2-Peer

Source: Larry Smarr
www.jacobsschool.ucsd.edu/~lsmarr/talks
“Plenty of Room at The Bottom”
* Richard Feynman describing nanotechnology opportunity

- Silicon embeds Adaptive Stochastic Control at every level of the Electric Grid -- saving TerraWatts through better efficiency and safety
- Innervation allows the Smart Grid of the Future

Dust Inc. Smart Chips
Nano CPU
Long Range RFID System
Superconducting Nano Wires

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Mobilizing the Sciences and Public Policy to Build a Prosperous and Sustainable Future
Innervation of the Smart Electric Grid
Linkage between Future Electric Grid & Innervation

Electric Power Efficiencies and Security
Internet & Cyber-security
Ubiquitous, low cost electronics
Innervation to the Last Mile
Decision Support & Reinforcement Learning
Peer-to-Peer Computing Automatically for FREE
SCADA sensing EVERYWHERE
Micro to Nano Sensors, GPS, ISDN

Allows for:
Rapid, low-labor assembly of sophisticated infrastructure
Graceful accommodation of change over time:
  Reconfiguration (without experts)
  Upgrading of subcomponents (without disruption)
Efficient Energy Management & Production
Grid Friendly Controllers

- 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

Event: Grid Unit Trips with 710 MW
Frequency Excursion Arrested by GFC within 0.7 sec.

Frequency on Grid recovers 5.8 sec later

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Distributed Generation: Given enough ANTS, you can move a mountain!
How the Innervated Smart Grid Responds to Multiple Cascading Threats
A Problem Begins at Canadian - Maine Border
Causes Buffalo Surge - Spreads to All of Northeast
Power Shortage Spreads over whole East Coast
New York has particular Difficulty
Foundation is the Simulation Model of the Smart Grid
Smart Grid directs Remediation

Data Inputs
- AM/FM System
- Engineering data
- Customer Information
- Load Research Statistics
- Large Customer kW/kVAR
- SCADA/Switch Positions
- Outage Reports
- Landbase data

Planning
Visualization of Results
Design
Operations
Power Flow is Solved for Continuously by Smart Grid
Distribution Grid must be “Process mapped”

- Base map data
- Service territories
- The distribution network
- Customer locations
- Customer attributes
- Emergency generator locations
Smart Grid has Learned Responses to Thousands of Threat Combinations, some similar to this one
Event 2: Transformer Fire at Power Plant
Problem Spreads to Multiple, Cascading Local Events
Smart Grid leads Remedial Actions using Learning System

Green = Excess Generating Capacity to bring On Line
Orange = In Trouble
Red = Outages
Blue = OK

The Innervated Electric Grid
Smart Grid Recognizes Regional Problems and Coordinates Remediation

But entire Electric Grid must be Innervated for it to work
Summary:

• The SMART grid of the Future must be responsive to “Nano-Time” and “Innervated” to accommodate Distributed & Centralized Generation both

• Efficiency of such a “Lean Engineered” System will improve by 50%, if process control improvements seen in automotive, aerospace, military, pharmaceuticals, petrochemicals, convert to the Energy World

• This SMART Grid alone will save us 10 TerraWatts or more in reduced global demand

• And we must have it, or the Electric Grid will become uncontrollable and simply WILL NOT WORK!