Power Management in the Smart Grid

Gregory T. Smedley, Ph.D.
Taotao Jin, Ph.D.
Tong Chen, M.Sc.

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Power Management, Cell Phones to the Grid

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The Grid
Big
Passive
Dynamically Stressed
Dynamic Sources & Loads ?

Problem:
Dynamic Voltage & Frequency

Micro-Grid ?
Problem: Cascading Outages

San Diego - 09/2011

San Diego - 09/2011

Got Power?

Eastern USA - 08/2003

Est. Loss ~ $80B / year (USA)
The Smart Grid
Distributed
Semi-Active
Central Control

Enabler: Datacom / Telecom
Sensors, Loads, Sources with Central Control

Grid

Loads
Sources
Loads
Sources
Loads
Sources
Loads
Sources
Loads
Sources
Loads
Sources

Problems:
“big brother”
\[ c = 3 \times 10^8 \text{ m/s} \]

Actuators?
Smart Grid Challenge

“One of the most daunting challenges facing utilities is the surge of data that will result as we modernize [the grid] .... managing thousands of times more data than you do today.”

Jesse Berst (Smart Grid News, Jan 2010)
How can we simplify?

Add Grid “Reflexes”

- "Reflexes" Mitigate Dynamics
- Autonomous => Reduces Data/Com burden
Future Grid
Distributed
Active
Autonomous

Enabler: Power Electronics
Grid Solutions

Increase Operating Margin
- More/Bigger Wires
- Eliminate Pollution

Active Control
- Voltage
- Peak Load

Reactive Power
Harmonics
Wire
Power Electronic “Reflexes”

- Eliminate Pollution
- Control Voltage
- Control Peak Load

Active Power Filtering
Dynamic VAR Compensation
Peak Load Regulation

Scalable: kW to MW
Active Power Filtering

Eliminate Grid Pollution
Boost Capacity & Efficiency

* Grid Pollution Occupies ~20% of Grid Capacity
APF Test Data

OFF
PF=0.79

* Boost Grid Capacity (~20%) & Efficiency in Real Time

ON
PF>0.99

QuickTime™ and a decompressor are needed to see this picture.

* Boost Grid Capacity (~20%) & Efficiency in Real Time
Dynamic VAR Compensation

Stabilize Grid Voltage
Increase Renewables
Boost Grid Resilience

* Grid Instability limits Renewable Generation to 15%
DVC Field Data (240 kVAR)

- Real Time Setpoint Control
- Voltage support ~ V
- Distributed, Small, Fast, Precise “Reflexes”
- Low V ride-through
Peak Load Regulation
Reduce Peak Load
Stabilize Grid
Increase Renewables

* Peak Load forces Grid Over-Design
* Load Dynamics Destabilize Grid
PLR Field Data

OFF
Spiky peak power
* Stabilize Grid Load in Real Time

ON
Flat peak power
Autonomous Constellations

APF, DVC, PLR

Stabilize Grid
Reduce Central Control Burden
Increase: Renewables, Grid Capacity, Grid Efficiency

Enabler: Datacom / Telecom & Power Electronics
Thank you for your attention ... Questions ??

address: 12 Mauchly, Building P, Irvine, CA, 92618
phone: (949) 727-0107 x01
email: gsmedley@onecyclecontrol.com