Supply-Following Loads: A Berkeley Perspective

Randy H. Katz
University of California, Berkeley

100% Renewable Energy Workshop

1 August 2011
Energy “Spaghetti” Chart

http://www.eia.doe.gov
2008 data
Sources and Loads

Dispatchable Sources

Non-Dispatchable Sources

Oblivious Loads

Aware Loads
Supply- versus Load-Following

Load Duration Curve

- Most expensive, least efficient energy
- Latency involved in bringing capacity on line

Demand Response:
Incentivize reduced loads during times of peak demand

Demand Side Management:
Shift demand to reduce peak loads, e.g., *Supply-following Loads*
1. Degree of Freedom: On-demand + scheduled workloads

2. Principle: Power proportionality from non-power proportional components

3. Sustainability: Maximize use of renewable sources
Supply-side Challenge: Wind

- High variability of wind energy is an impediment to its large-scale penetration in traditional Grid/Load architectures.
Load-side Challenge: Power Proportionality

- Scheduling agility: workload awareness and resource allocation
- Wikipedia interactive workload + HPC batch workload
Server Efficiencies

Server Class Machines (similar figure for netbook/embedded class nodes)

Energy–efficiency and Response Times of a Nehalem Node

- Better
- Operating Range
- Response Time

Joules/Response

Requests/sec

Measured
Effectively Scaling Work Capacity and Power
Requests degraded
Response rate maintained
Energy and cost reduced

Wikipedia workload
Run Immediately, Grid-Oblivious
54% Grid, 46% Wind

Greedy, Grid-Aware
30%, 70% Wind
Aware Co-operative Grid

Power Proportional Cluster as a Model System applied to the Smart Grid—now distributed

• Availability
• Pricing
• Planning

• Forecasting
• Tracking
• Market

• Observe-Analyze-Act:
  • Deep instrumentation
  • Waste elimination
  • Efficient Operation
  • Shifting, Scheduling, Adaptation
Smart Buildings

Cory Hall

Soda Hall

SDH
Smart Buildings

Observe – Analyze – Act
Summary

• Awareness of Load and Supply
  – Load-Following: match load with managed supply
  – Demand Response: reduce load to meet supply
  – Supply-Following: schedule work to exploit knowledge of available supply—essential for non-dispatchable sources like wind and solar

• Key idea: make information actionable
  – Observe-Analyze-Act
  – Information overlay on cluster, machine room, building-scale “grids”
  – Interface sensors, facilities, clusters, and buildings to information buses at a variety of scales
Conclusions

• Smart Clusters, Smart Buildings, Smart Grids
  – Use less energy
    • Right provisioning for expected + reserve vs. peak
  – Use the energy you need:
    • Power proportionality
  – Use better energy
    • Integrate renewables
Thank You!