Energy Storage and its Control in the “Smart Grid”

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Overview

Popular Opinion: Renewable "Smart Grid" is 21st century Moon Mission

Renewable Intermittency > Big Problem > Big Solution > Storage and "Smart Grid"

Reality: Grid 1.1 not Grid 2.0

Real challenges beyond renewables, but economic and technical realities impede revolutionary solutions

Path Forward and Agenda

Path Forward: Pragmatic and Economic Solutions Compatible with Existing Controls

Agenda:

- Legacy Grid Controls
- Grid Control Challenges
- “Smart Grid” and Energy Storage: Opportunities and Challenges
- Path Forward:
  - Central Grid Control and Distributed Grid Support
  - Growing Role for Converters, Compensation and Storage
- Breaking Through: Call to Action

Legacy Controls and Power Electronics

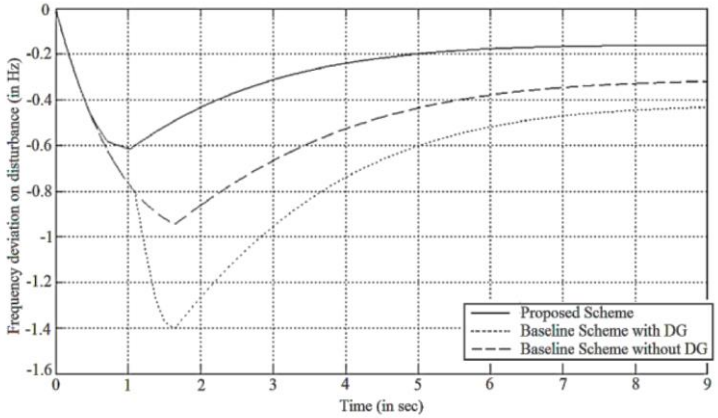
	Ubiquitous	Growing
Frequency Regulation	Rotating Inertia Generation Control AGC Advanced Excitation Control	Distributed Generation Energy Storage HVDC Faster Ramping Generation
Voltage Regulation & System Topology	Tap Changers, Regulators, Capacitors, Switchgear	SVC and FACTS Distributed Generation Energy Storage
System Protection	Fusing, Circuit Breakers, Arrestors, Grounding Teleprotection and Relaying	Faster Fault Clearing Fault Detection and Isolation Distribution Automation
Supervisory Control, Security and Telemetry	SCADA EMS/GMS State Estimation G&T Communications	SCADA DMS and DA Phasor Measurement Units Distribution Communications

Power Electronics and advanced controls will continue to drive advancement of electromechanical power system equipment & controls

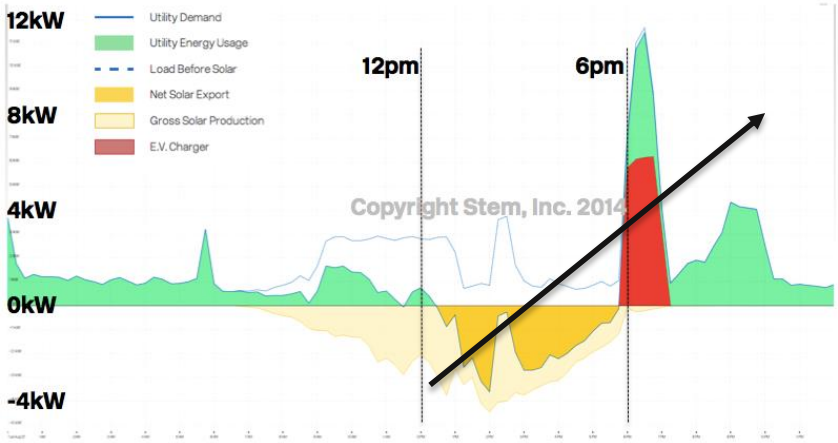
Grid Control Challenges

- Less “dispatchable” generation
- Less mechanical generation inertia
- Higher load volatility
- Aging T&D equipment
- Weather and adverse events
- Growing political and regulatory focus
- Noisier loads, yet more sensitive loads
- Inconsistent utility equipment
- Utility engineering demographics

Transient Response Example



Customer with PV and EV Charger



“Smart Grid” and Energy Storage: Opportunity

- Grid sized for peak demand, not average demand
- Lower costs for renewables, distributed generation and compensation equipment
- Advanced computing and communications has revolutionized all facets of life: logical extension for the Power System?

“Smart Grid” and Energy Storage: Realities

- “Smart Grid” too slow to countermeasure large signal disturbances
- Cybersecurity and integration complexity. High downside, low upside.
- Significant system protection & control impacts from unmanaged DG.
- Role of economic actors and equipment capital cost realities.
- Available physical locations, costs and application requirements limit bulk Energy Storage technologies

Market Roles and Central Grid Control

Clear Roles and Responsibilities – Market Consistencies:

- "Utility responsible for Voltage; Customer responsible for Current".
- Exporting energy means controls, scheduling and consequences.
- No top down control over demand. Promote dynamic pricing for demand response.

Utility and ISO Managed Equipment – Centralized – "Closed Loop" Control

- Consistent with current roles, systems and equipment
- Main responsibility: safety and synchronism
- Ultimate supervisory control - thousands of system points
- Electrical systems and projects: heavy SCADA integration.
- Generation dispatch control. No control over customer demand.

Distributed Grid Support

Cost Competitive - Distributed Resources

Customer Managed Equipment

"Open Loop" Control

- Electrical products and standards. No integration with utility SCADA.
- Promote non-exporting customer facilities. Distributed load shedding and DR.
- Observable price metrics, not control systems and signals.
- Compliance and verification by utility smart meters
- Distributed generation control: speed droop and leading power factor

Growing Role for Power Electronics Equipment

Utility and ISO Managed– Centralized – Closed Loop Control

- Generation Control and AGC
  - Bulk energy storage
  - HVDC
- Local Voltage Regulation Control and DMS Supervision
  - Lower cost FACTS and SVC
  - Power Electronics alternatives for switched distribution capacitors

Customer Managed – Distributed – Multiple-Application Equipment

- Renewable generation & distributed energy storage products
- Simple regulation and protection control schemes (non exporting)
- Fault protection and clearing
- Leading power factor
- Regulating resource: distributed load shedding and DR
- Active filtering and power quality
- Support microgrid and standby power

Breaking Through: Call to Action

Lower Power Electronics and Energy Storage Installed Costs

- Power conversion and compensation: $200 per KVA
- Power compensation: $75 per KVAR
- Storage/batteries: driven by EV technology and cost reduction
- Reduced design, engineering and construction project costs

Standards and Certifications

- IEEE 1547 and UL 1741
- Exporting versus non-exporting resources

Utility and Regulatory Activities

- Interconnection practices
- Customer tariff reform

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