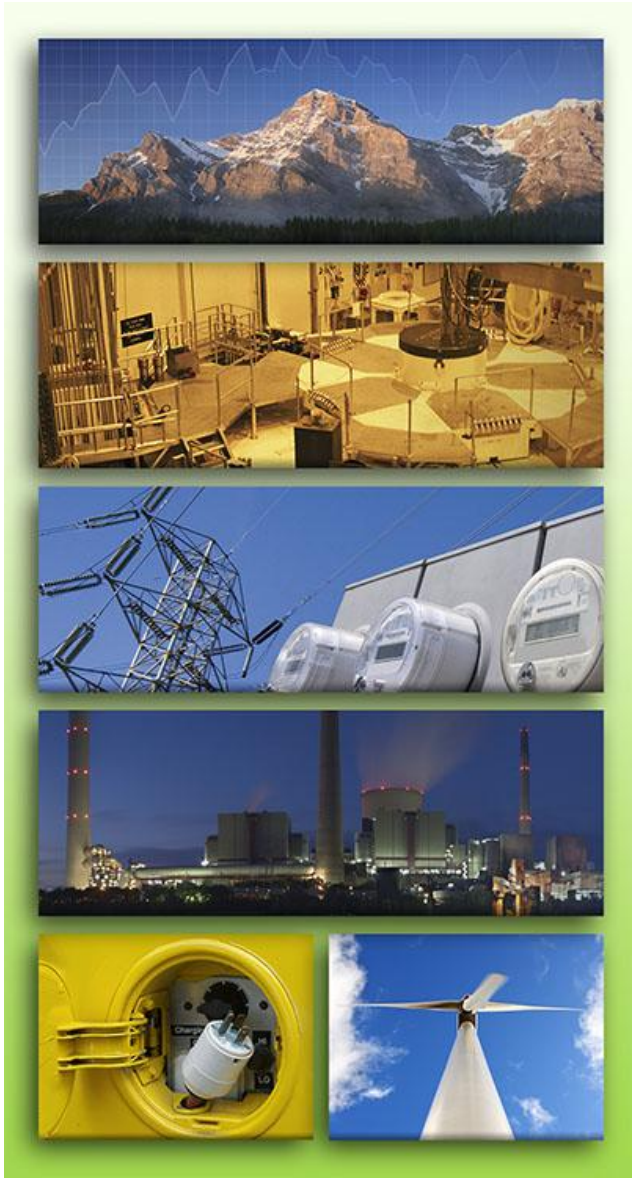

Some High-Level Smart Grid Requirements

IEEE 802.11 Interim
Los Angeles, Jan 19, 2010

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Selected utility Smart Grid requirements

Not exhaustive – to illustrate a range of requirements.

- **Advanced Metering Infrastructure (AMI)**
- **Distributed Energy Resources (DER) Integration**
- **SCADA and Distribution Automation (DA)**
- **Advanced DA ("Self-Healing Circuits")**
- **Wide-Area Situational Awareness (WASA)**

Advanced Metering Infrastructure

- **Links to/from fixed Smart Meters (SMs)**
  - One SM per Utility Service Point = customer premise
  - Can be numerous in sub/urban grid (>5K per sq mi)
- **Traffic characteristics (per SM)**
  - Typically low BW (256 Kbps UL&DL), low latency (1–10 sec E2E)
  - Can burst to higher BW (0.5-1+ Mbps), faster rate (100-500 msec E2E)
- **Applications**
  - Metering: revenue, supply & demand (intervals)
  - Monitoring: voltage/current, VAR, outage, tamper
  - Manage device configuration, health, etc.
  - Interface to HAN (DR, PH/EV Charging)
- **Main requirements**
  - Security
  - Reliability, robustness
  - Scalability, aggregate performance

Large-scale DER Integration

- **Exchanges between DERs (PV arrays, Micro-Wind, Small-scale Storage, PH/EVs) and other SG devices and central applications**
  - Monitor delivered active/reactive power, fluctuations, stability
  - Monitor inverter performance (i.e. voltage, frequency)
  - Monitor EV charging impact on distribution system
  - Detect aging/degradation, failure; manage islanding and reconnection
- **Example motivation: passive anti-islanding protection**
  - IEEE 1547-2003 requires 2 sec shut-off (DGs <= 500kW)
  - >10 of DGs in parallel => anti-islanding algorithms too slow
  - Drives case for a comms-based transfer trip implementation
- **Main requirements**
  - Similar to AMI
  - Potentially higher performance, i.e. for intentional islanding
    - To maintain power quality (voltage and frequency within range)
    - To co-ordinate distribution system and DG reclosing and restoration

SCADA and Distribution Automation

- **Communications between utility control center and**
  - SCADA devices (largely based in substations)
  - DA devices (situated on distribution feeders)
- **Applications**
  - Operations (grid monitoring, analysis, simulation, configuration, protection, maintenance, …)
  - Capacity planning, load modeling and forecasting
  - Asset management, work management
- **Main requirements**
  - Security (!!!)
  - Scalability, manageability
  - Support for legacy protocols (tunneling, translation, termination)
  - Integration of legacy devices into multi-device schemes

Advanced DA

- **Pushing DA into fully autonomous behavior**
- **"Self-healing circuits"**
  - i.e. aggressive sectionalization for improved reliability
  - i.e. fine-grained power/voltage/frequency stabilization
- **Some applications/devices operate at "sub-cycle" speeds**
  - Static VAR Compenstors (SVC), Dynamic Voltage Restoration (DVR), D-STATCOM (Distributed Static Compensator)
  - Currently closed-loop sensor-controller architectures
  - Could such functionality be distributed? benefit from comms-based open-loop control?

Wide-Area Situational Analysis

- **Communications between Phasor Measurement Units (PMUs), Phasor Data Concentrators (PDCs), and central mointoring/control platforms**
- **Applications: grid (voltage, frequency, phase) stabilization, predictive modeling**
- **Driving high-bandwidth, low-latency requirements for WAN/MAN**
- **Requirement: very accurate (~1 usec) time source**
  - Currently using GPS clocks
  - Could benefit from distributed SW implementation (IEEE 1544, NTP, PTP)
- **Current efforts: NASPINet, multiple ARRA projects**