



Distributed Generation Integration						
Transmission Enhancement Applications	v-	v	v-			
Distribution & Management		v-	v	v-		
Advanced Metering Infrastructure (AMI)			v	v	v	v
EV Charging Infrastructure			v	v	v	v
Customer-side Systems				v	v	v

Smart Grid Technologies [1, page 21]

Technology Areas	Hardware	Systems and Software
Wide Area Monitoring & Control	Phase measurement units (PMU) & other sensor equipment	SCADA (Supervisory Control and Data Acquisition), WAMS (Wide Area Monitoring Systems), WAAPCA (Wide-Area Adaptive Protection, Control & Automation), WASA (Wide-Area Situation Awareness)
Information & Communication Technology Integration	Communication equipment (Power line carrier, WIMAX, LTE, RF mesh network, cellular), routers, relays, switches, gateway, computers (servers)	Enterprise Resource Planning (ERP) software, Customer Information System (CIS)
Renewable & Distributed Generation Integration	Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology	<b>Energy management system (EMS)</b> , <b>distribution management system (DMS)</b> , SCADA, geographic Information system (GIS)
Transmission Enhancement Applications	Superconductors, FACTS, HVDC	Network stability analysis, automatic recovery systems
Distribution & Management	Automated re-closers, switches and capacitors, remote controlled distributed generation and storage, transformer sensors, wire and cable sensors	Geographic information system (GIS), <b>distribution management system (DMS)</b> , <b>outage management system (OMS)</b> , workforce management system (WMS)
Advanced Metering Infrastructure (AMI)	Smart meter, in-home displays, servers, relays	<b>Meter data management system (MDMS)</b>
EV Charging	Charging infrastructure, batteries,	Energy billing, smart-grid to-vehicle

Infrastructure	inverters	charging (G2V) and discharging vehicle-to-grid (V2G) methodologies
Customer-side Systems	Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostat	Energy dashboards, <b>energy management systems</b> , energy applications for smart phones and tablets

Maturity Levels & Development Trends of Smart Grid Technologies [1, page 22]

Technology Areas	Maturity Level	Development Trend
Wide Area Monitoring & Control	Developing	Fast
Information & Communication Technology Integration	Mature	Fast
Renewable & Distributed Generation Integration	Developing	Fast
Transmission Enhancement Applications	Mature	Moderate
Distribution & Management	Developing	Moderate
Advanced Metering Infrastructure (AMI)	Mature	Fast
EV Charging Infrastructure	Developing	Fast
Customer-side Systems	Developing	Fast

California ISO/EPRI Smart Grid Roadmap & Architecture [3]

- Key Smart Grid Drivers:
  - Energy supply from renewables
  - CO2 emission level rolled back to 1990 level by 2020
  - One million roof-top solar panels
  - Large investment in energy conservation & delivery
  - New Once-Through Cooling regulation affecting coastal plants 2012-2024
  - Large investments in smart grid (smart meters, storage, etc)
- Smart Grid Objectives (research, pilot, implement, integrate smart grid technologies)
  - Increase grid visibility, efficiency, and reliability
  - Enable diverse generation including utility-scale renewable resources, demand response, storage and smaller-scale solar PV technologies to fully participate in the wholesale market
  - Provide enhanced physical and cyber security
- The Expected Benefits
  - Ability to recognize grid problems sooner and resolve them
  - Efficiently use the transmission system to defer or displace costly transmission investments
  - Enable customers to react to grid conditions making them active participants in their energy use
  - Leverage conventional generation and emerging technologies when possible including distributed energy resources, demand response and energy storage, to address the challenges introduced by variable renewable resources

## References

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- [ 2 ] Free Publications, International Energy Agency, <http://www.iea.org/publications/>
- [ 3 ] Smart Grid Roadmap and Architecture, California ISO/EPRI, December 2010, [http://www.smartgrid.epri.com/doc/cal%20iso%20roadmap\\_public.pdf](http://www.smartgrid.epri.com/doc/cal%20iso%20roadmap_public.pdf)
- [ 4 ] NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 2.0, 227 pages, [http://www.nist.gov/smartgrid/upload/NIST\\_Framework\\_Release\\_2-0\\_corr.pdf](http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf)
- [ 5 ] NIST Smart Grid Interoperability Standards Update, July 25, 2011, [http://www.smartgrid.gov/sites/default/files/doc/files/National\\_Institute\\_Standards\\_Technology\\_NIST\\_Smart\\_Grid\\_Inte\\_201103.pdf](http://www.smartgrid.gov/sites/default/files/doc/files/National_Institute_Standards_Technology_NIST_Smart_Grid_Inte_201103.pdf)
- [ 6 ] NIST Smart Grid Advisory Committee (SGAC) Report, 2011, 70 pages, [http://www.smartgrid.gov/sites/default/files/doc/files/NIST\\_Smart\\_Grid\\_Advisory\\_Committee\\_SGAC\\_Report.pdf](http://www.smartgrid.gov/sites/default/files/doc/files/NIST_Smart_Grid_Advisory_Committee_SGAC_Report.pdf)

## Smart Grid Demos

- [ 1 ] EPRI (Electric Power Research Institute) Smart Grid Demo Projects (Youtube), <http://www.youtube.com/playlist?list=PLphKrncF69X0MxPf4aHDu1UJHNN8wGuq>
  - a. EDF Smart Grid Demo, 2012
  - b. PNM/EPRI Smart Grid Demo
  - c. KCP&L/EPRI Smart Grid Demo
  - d. Smart Grid Application – Southern Company’s Approach
- [ 2 ] Smart Grid Demos – Integration of Distributed Energy Resources, EPRI Smart Grid Resource Center, <http://smartgrid.epri.com/Demo.aspx>
  - a. Smart Grid Demonstration Five-Year Update, 28 pages, 08/10/2013
  - b. Smart Grid Demonstration Four-Year Update, 07/26/2012
  - c. Smart Grid Demonstration Three-Year Update, 07/21/2011
  - d. Smart Grid Demonstration Two-Year Update, 08/20/2010
- [ 3 ] Pacific Northwest Smart Grid Demo Project, <http://www.pnwsmartgrid.org/>
  - a. Transactive Control
  - b. Integrating Renewable Energy
  - c. Improving Reliability
  - d. Keeping the Cost Down
  - e. Empowering Consumers
- [ 4 ] The Pecan Street Project, Texas, <http://www.pecanstreet.org/projects/smart-grid-demonstration/>
- [ 5 ] Lower Valley Energy, <http://www.lvenergy.com/smart-grid-demo-project-moves-forward/>
- [ 6 ] Residential Smart Grid Solutions – Lutron, <http://www.lutron.com/en-US/Residential-Commercial-Solutions/Pages/Residential-Solutions/ResidentialSmartGridSolutions.aspx>