

The Smart Grid in 2010

Canada Institute at The Woodrow Wilson Center

David Leeds, Smart Grid Analyst, GTM Research

March 18th, 2010

Agenda

- The Smart Grid Overview
 - Smart Grid Characteristics
 - Market Drivers & Challenges
 - **Market Segments & Taxonomy**
- Smart Grid Deployment Timeline & Data

----- (additional topics)-----

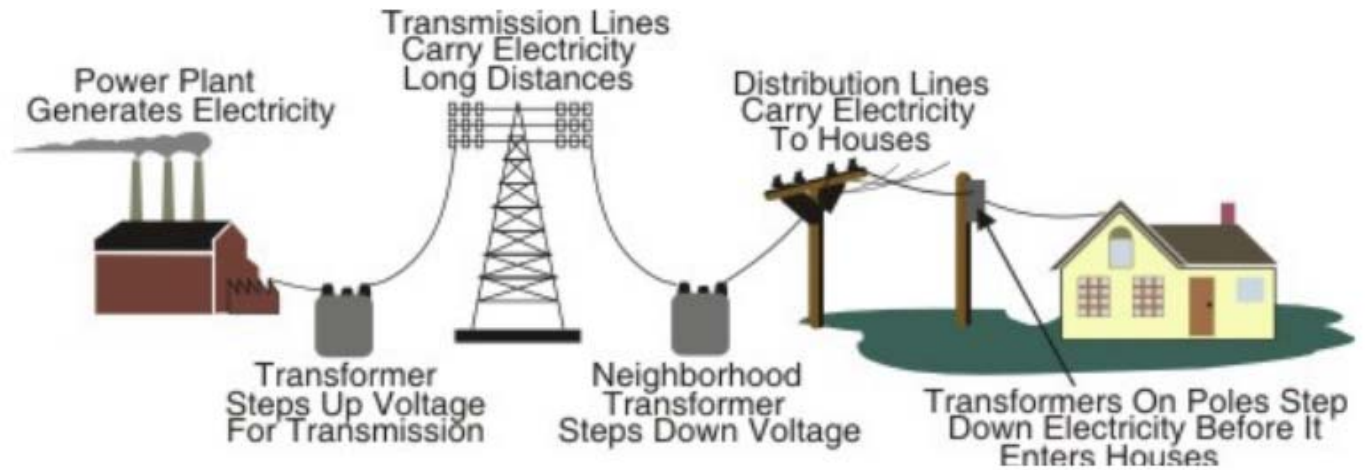
- Home Area Networks
- Future Trends and Opportunities



Visualizing The Smart Grid

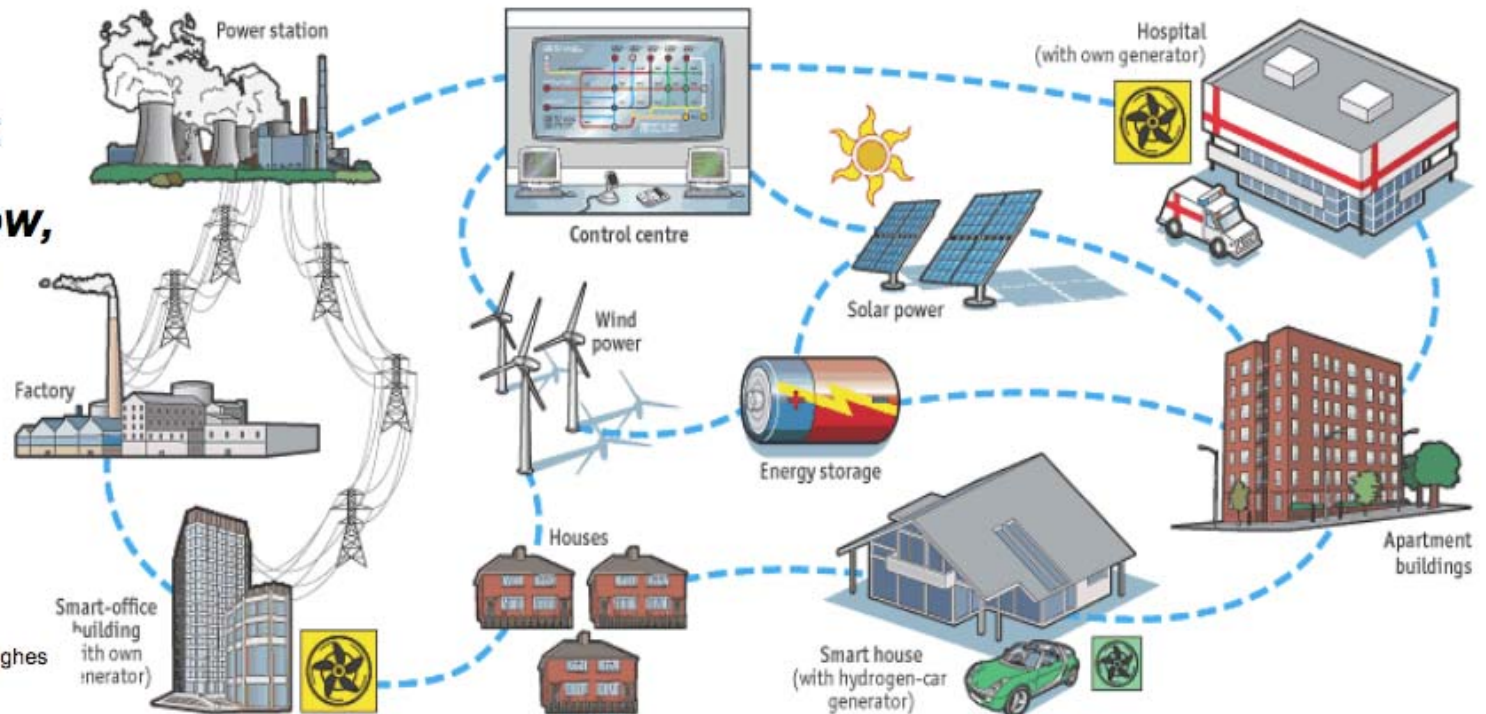
Before Smart Grid:

***One-way power flow,
simple interactions***



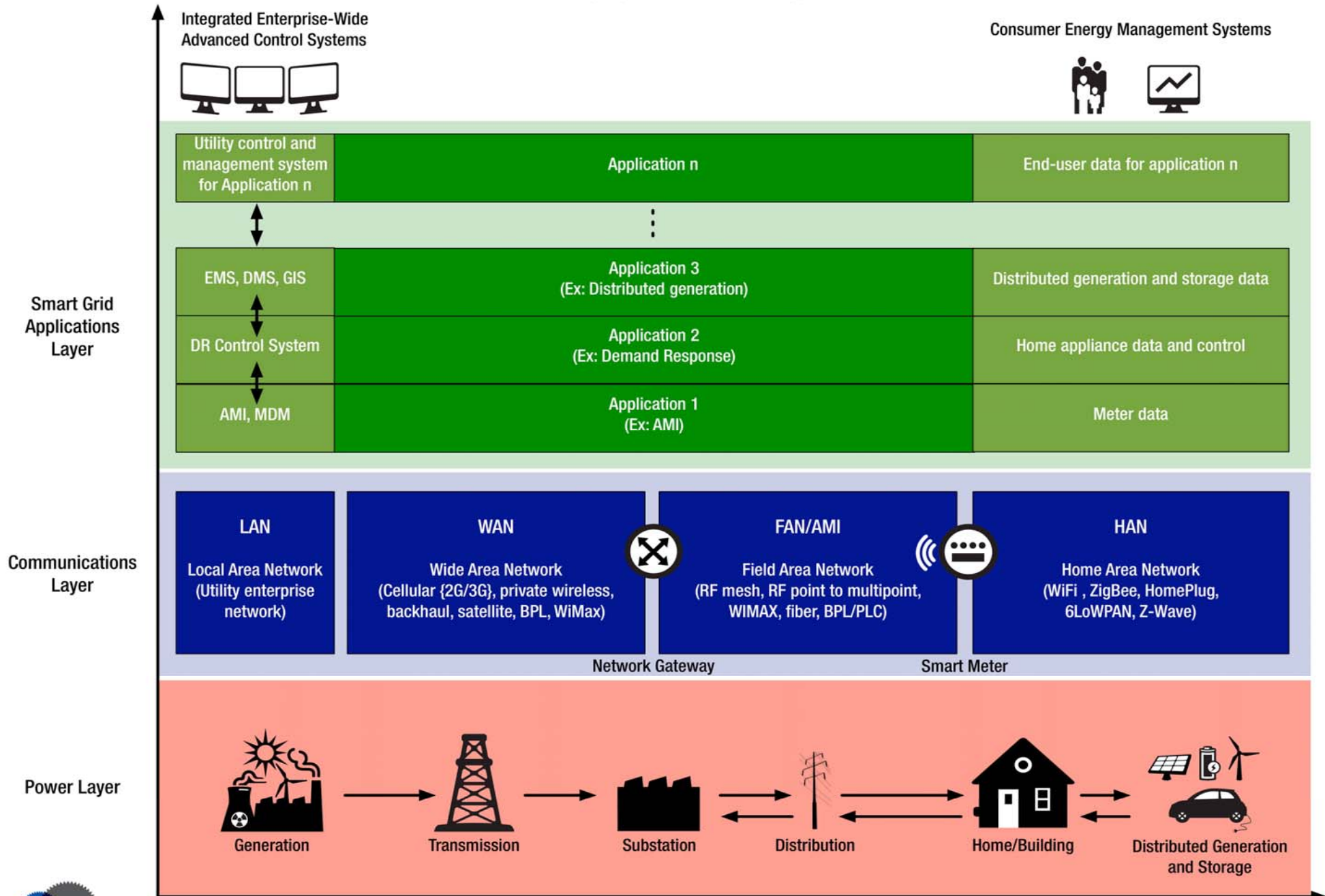
After Smart Grid:

***Two-way power flow,
multi-stakeholder
interactions***

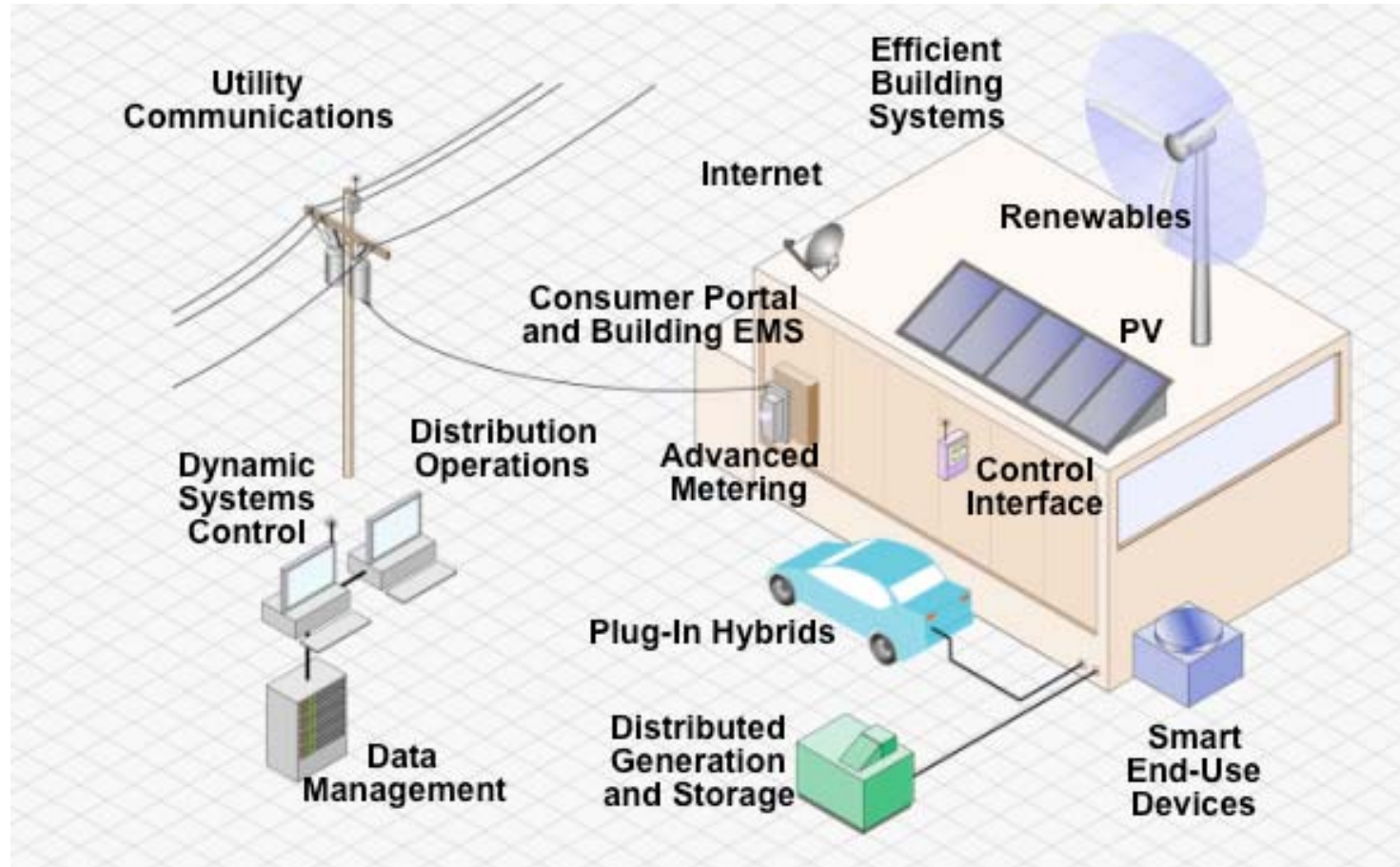


Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

"End-to-End" Smart Grid (High-Level Taxonomy)



Example of a Smart Home



Characteristics of the Smart Grid

- **Self-healing** – prevents disturbances like the Northeast Blackout 2003
- **Increased Efficiency/Optimization** – deep integration of grid intel w/ asset mgmt software
- **Distributed Generation & Storage** – accommodating distributed generation, storage and future tech
- **Empowering consumers** – robust, well integrated computer-managed wholesale markets (example - selling power back to the Grid)
- **Resilient** - tolerant of attack
- **21st Century Power Quality** – free of sags, spikes, disturbances, interruptions (increasingly important for digital/electronics)
- **Enabling**- new opportunities (applications, technologies, services) and markets capitalizing on **plug-and-play** innovation
- **Greener** – can not ship and control green power without a smart grid. Renewable Energy will remain “niche” without Smart Grid
- **Maintaining affordability** to all citizens (according to DOE energy prices are forecasted to rise 50% over the next 7 years)



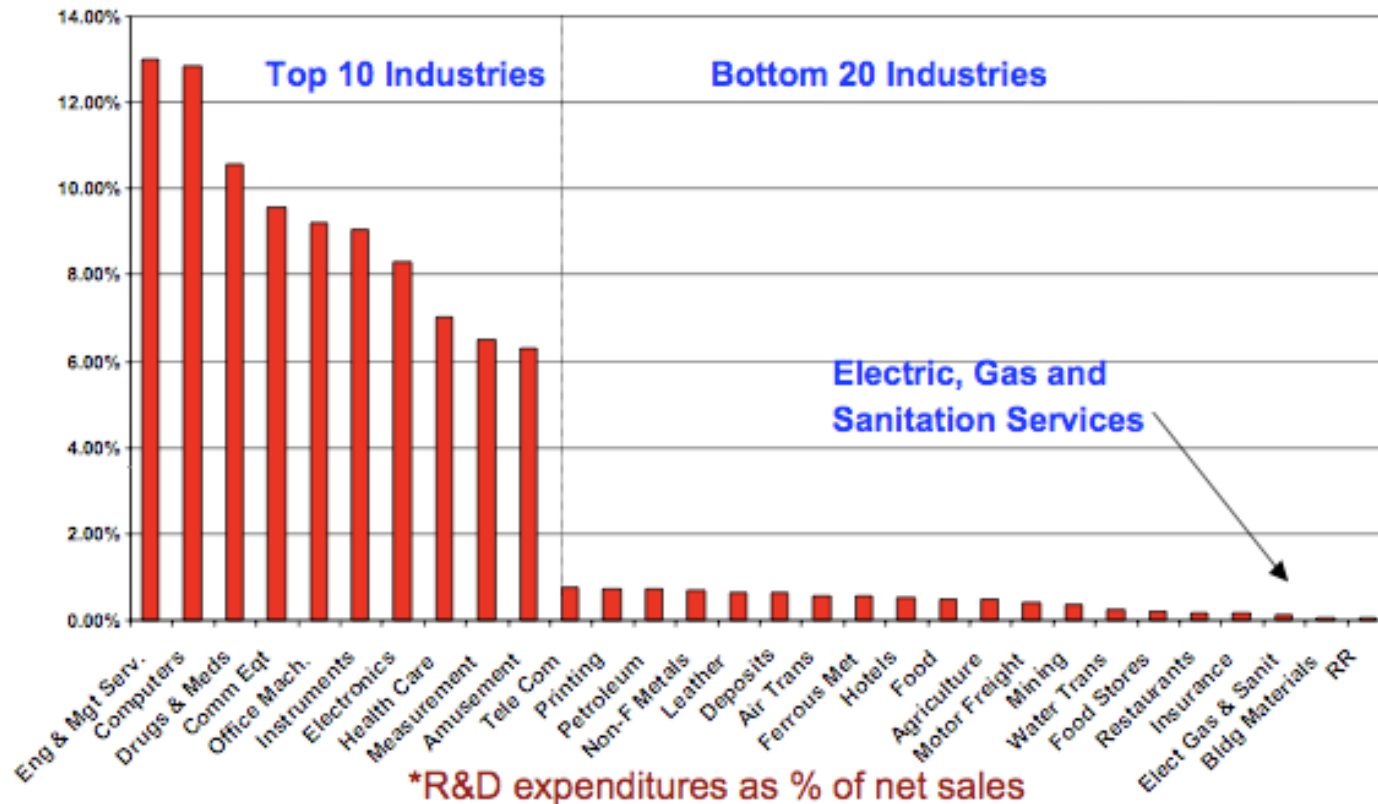
Smart Grid Market Drivers

- Growing Energy Demand
- Energy Independence and Security
- GHG Reduction
- Economic Growth
- Policy and Regulation
- Technology Advancement
- Increased Efficiency through Grid Optimization
- Advanced Consumer Services
- Infrastructure Reliability and Security
- 21st Century Power Quality



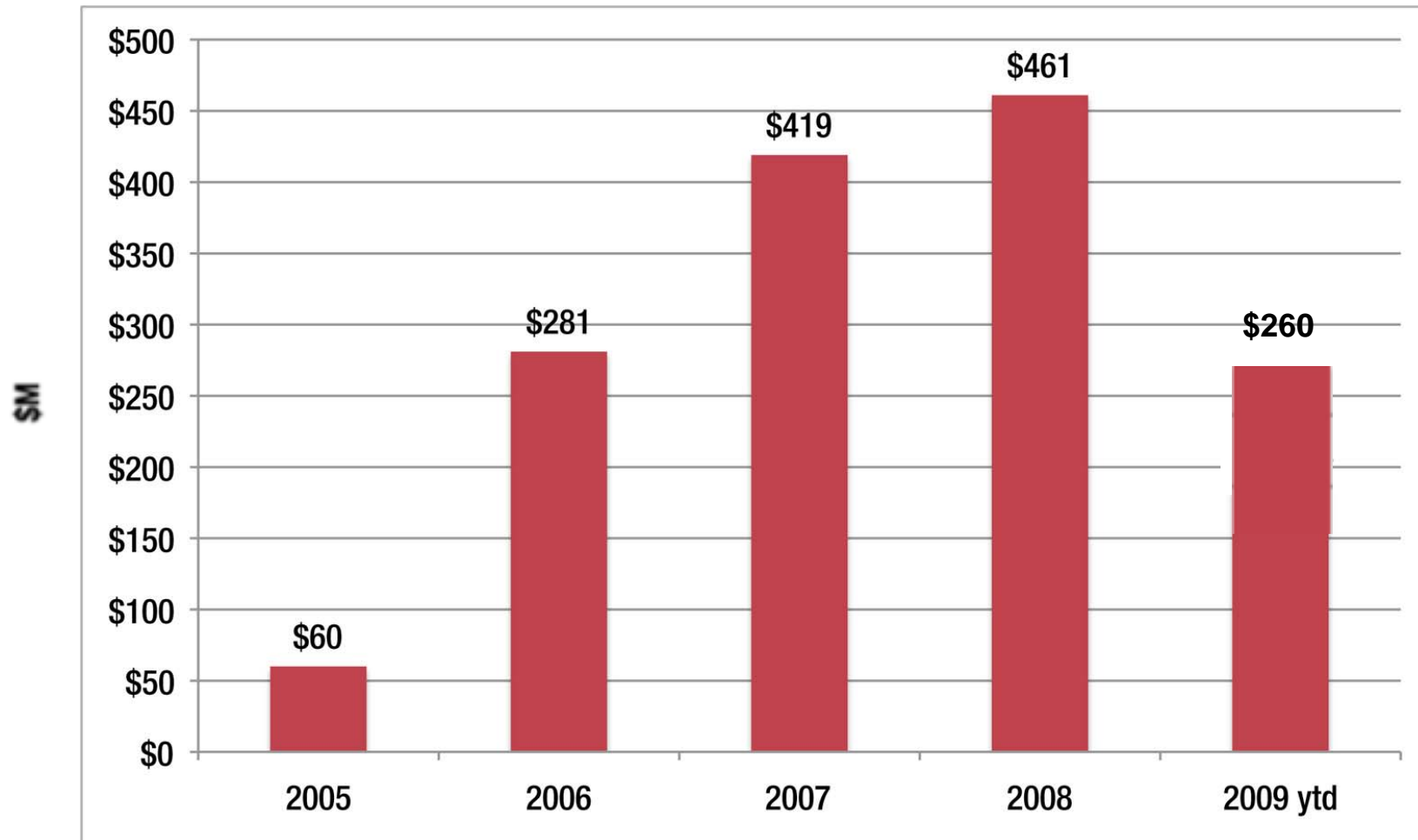
Opportunities are Tremendous

Context: R&D Expenditures*



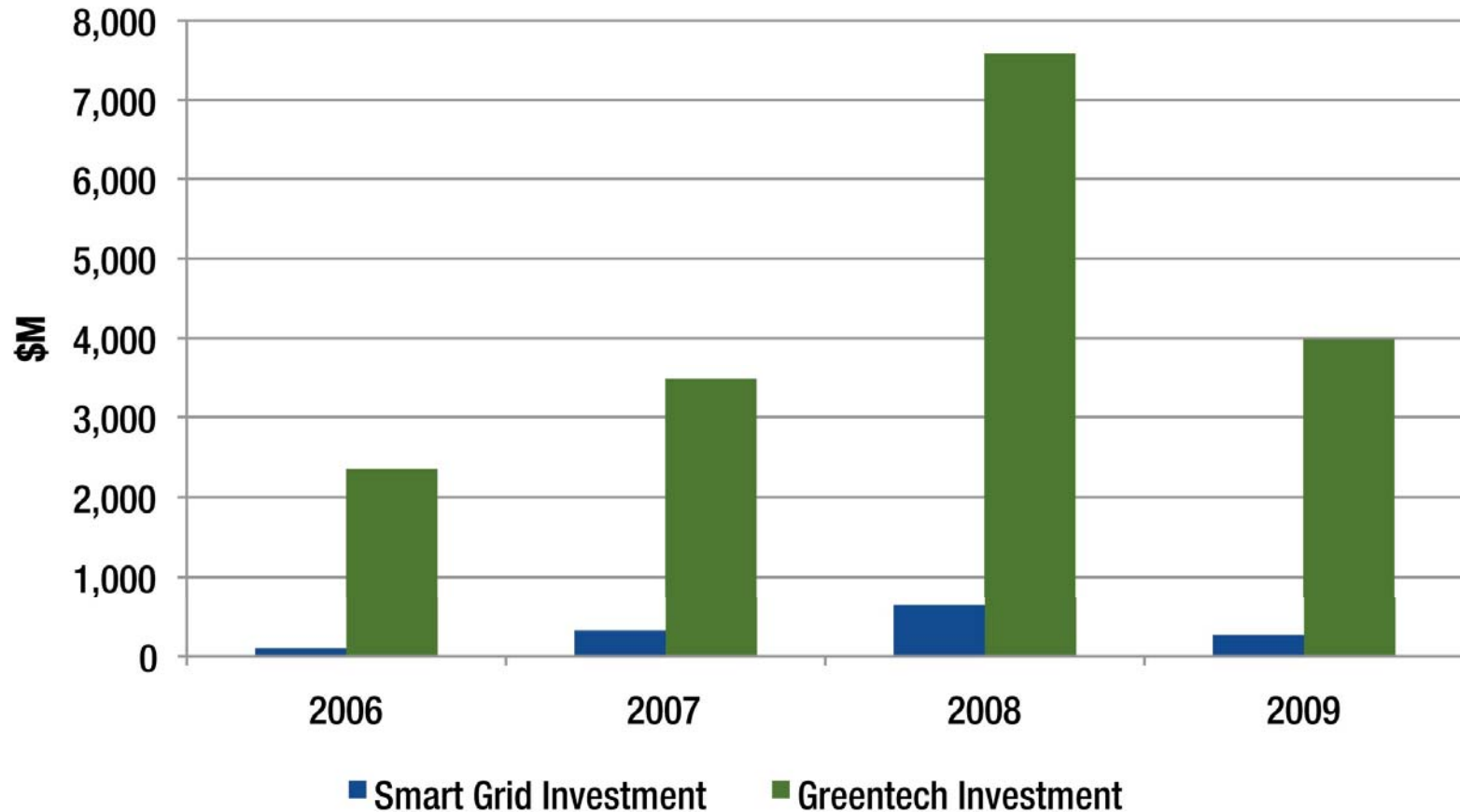
Source: University of Minnesota

Smart Grid: VC's Latest Greentech Darling



Over-Hyped? Or Under Funded?

Smart Grid & Greentech VC Investment 2006-2009



Smart Grid ARRA Stimulus Funds

- \$3.4 billion in federal government matching grants awarded (plus the matching investments of \$4.7 billion)= **\$8.1 billion direct investment in Smart Grid**
- 18 million Smart Meters will be purchased/installed as a result of ARRA (13% of nation)
- 1 million in-home devices
- 200,000 Advanced transformers (needed for PHEVs)
- 850 Transmission Centers (virtually the whole network)
- 700 Substations upgraded (5% of the nation)



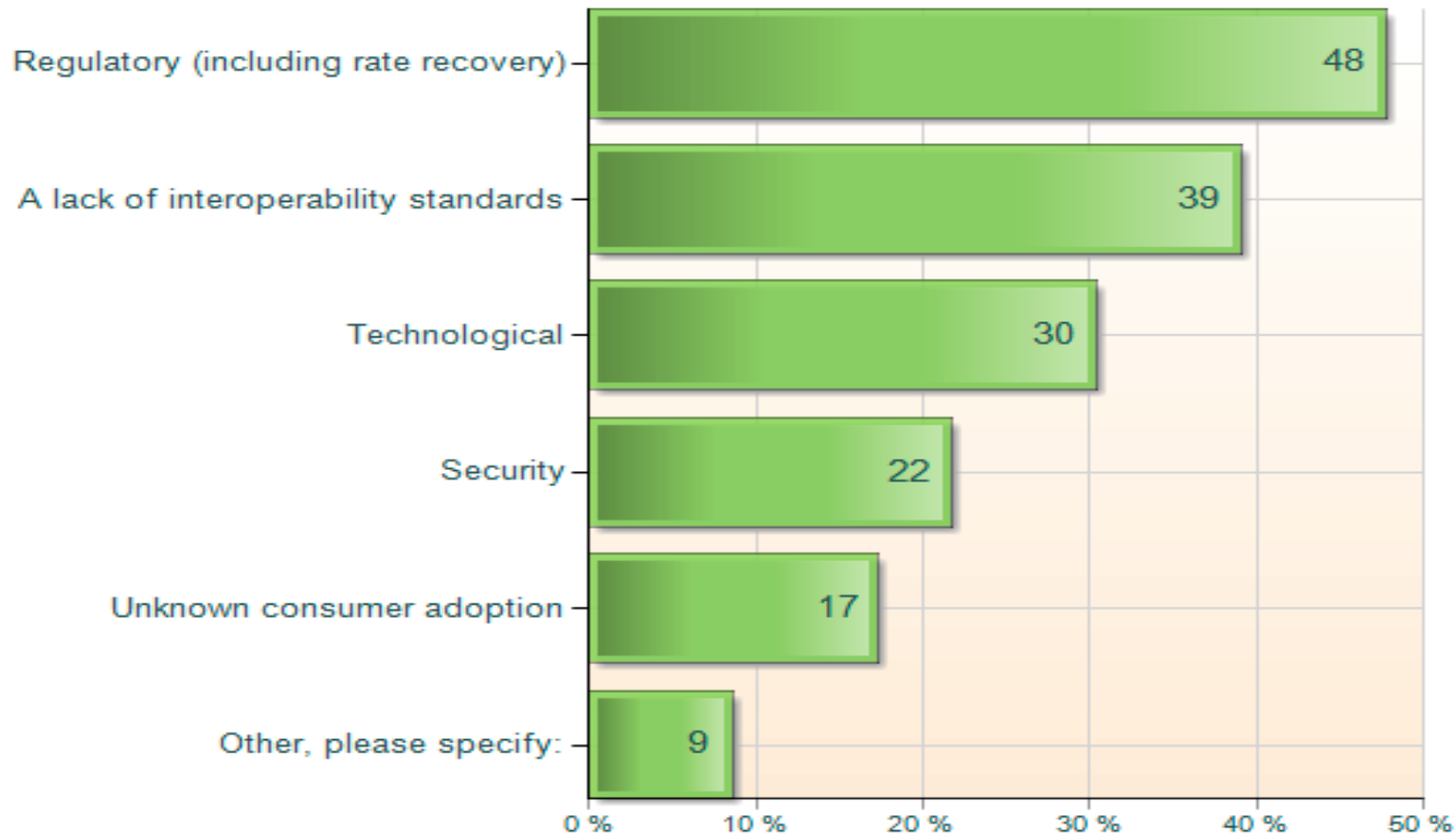
Primary Smart Grid Challenges

- Interoperability Standards
- Future-Proofing Utility Systems Architecture
- Policy & Regulation – Dynamic Pricing
- Re-Defining Utility Business Models and Incentives
- The Integration of Large Amounts of Renewable Energy
- Consumer Adoption of Smart Grid Services



North American Utilities Survey

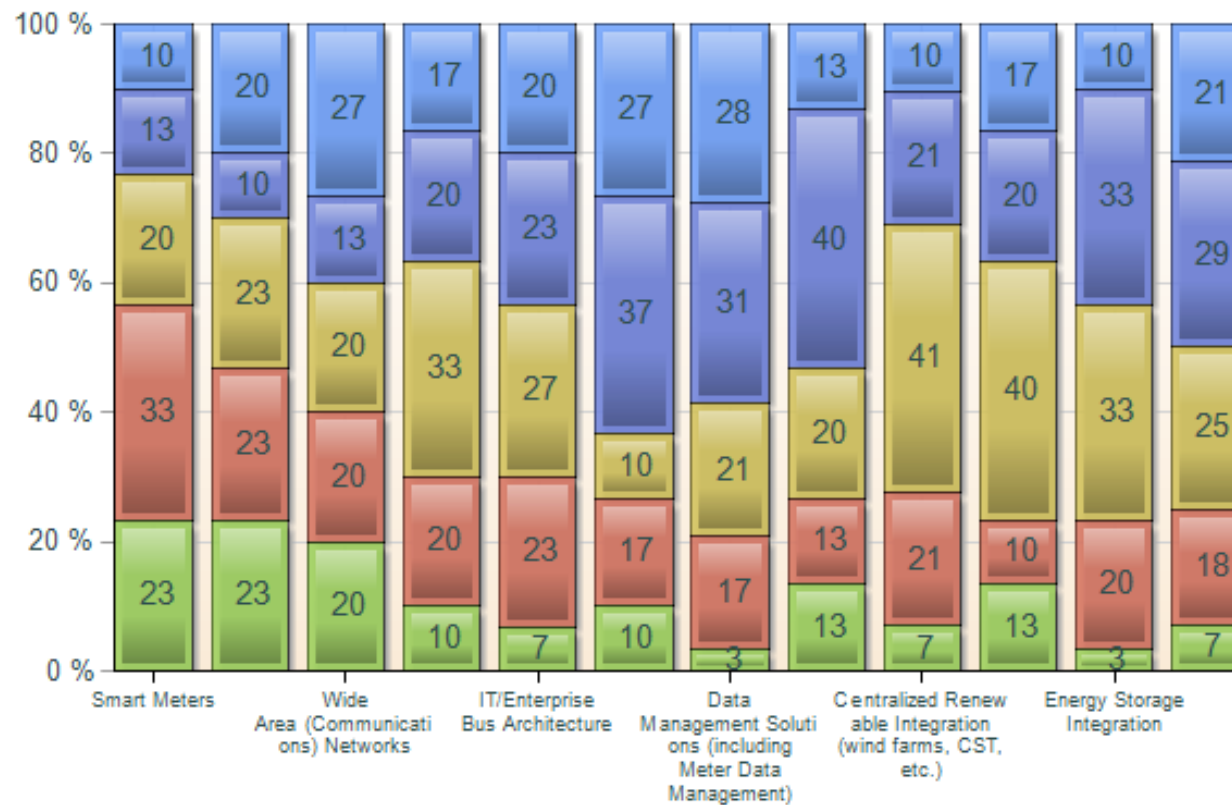
The primary challenge related to a successful Smart Grid deployment is:



Utility Areas of Concern

On a scale of 1 to 5 (with 1 = not concerned at all and 5 = highly concerned) how concerned are you with your company's ability to assess and deploy the following technologies and applications:

1 2 3 4 5



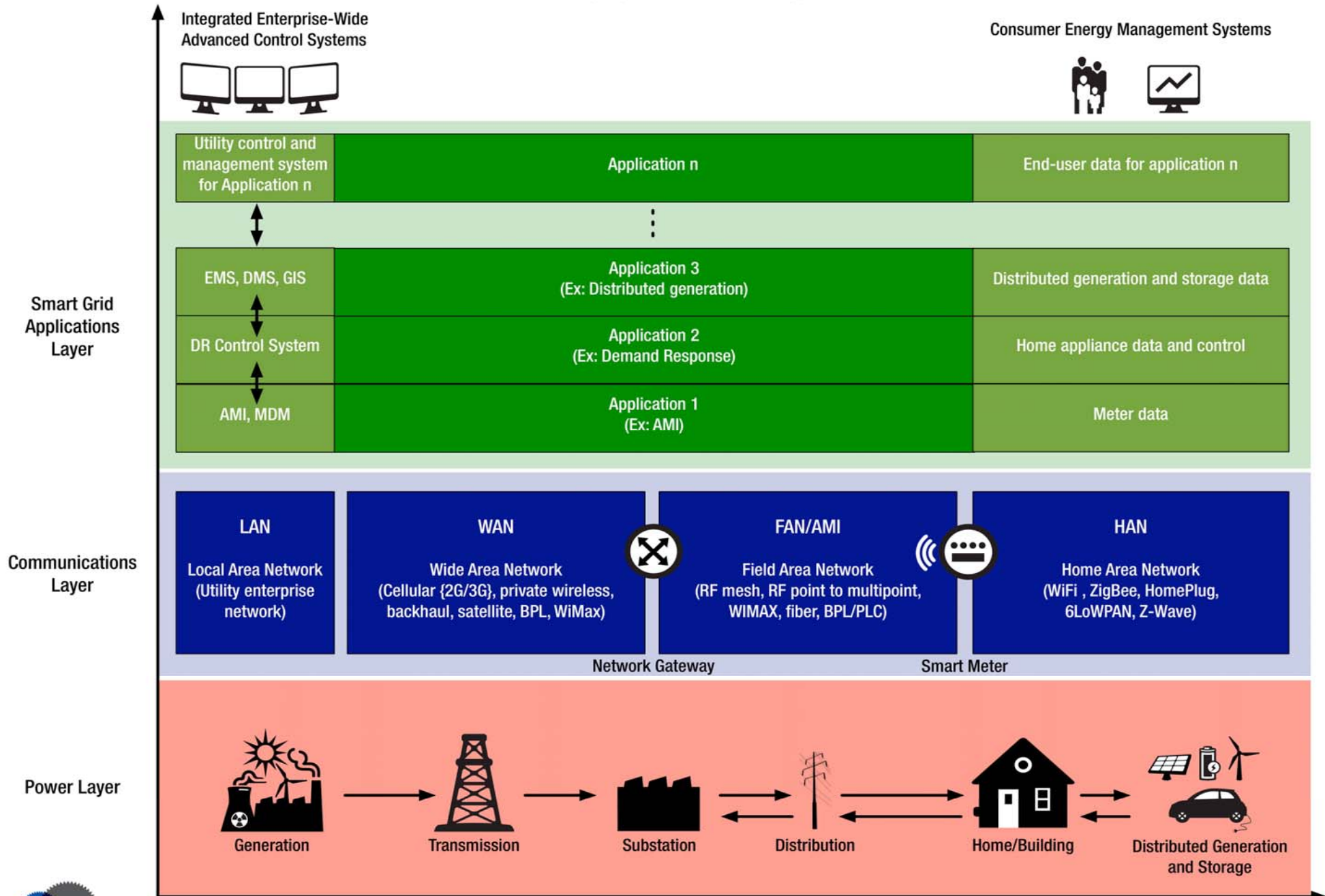
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Architecture and Market Segments

- The Smart Grid is Comprised of Three Layers (see next slide)
 - Physical Power Layer (transmission and distribution)
 - Data Transport and Control Layer (communications/control)
 - Applications Layer (applications and services)
- The Primary Smart Grid Market Segments and Applications Include
 - Advanced Metering Infrastructure (AMI)
 - Demand Response
 - Grid Optimization
 - Distributed Generation
 - Grid-Scale Storage
 - PHEVs and V2G
 - Advanced Utility Control Systems
 - Smart Homes/Networks



"End-to-End" Smart Grid (High-Level Taxonomy)



"End-to-End" Smart Grid (Detailed Taxonomy)

Integrated Enterprise-Wide
Advanced Control Systems



Consumer Energy Management Systems

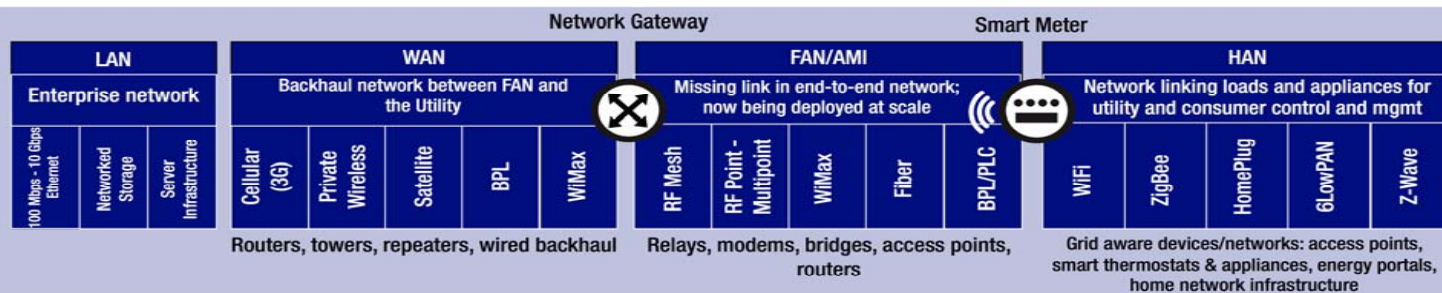


Future Apps & Services
Business and Customer Care
Smart Charging of PHEVs and V2G
Distributed Generation and Storage
Grid Optimization
Demand Response
AMI

eg: Energy trading systems, retailers/regulators	eg: Real time energy markets		eg: Bid/Ask Market Data necessary for buying/selling power
Integration of advanced and legacy systems into business processes	Application data flow to/from End-User Energy Management Systems		Home/Building Web-based "portals": online bill pay/prepay, historical energy data, comparison of energy use to peers/neighbors, TOU pricing info, carbon footprint data
Utility Control and Load Monitoring for PHEV applications	Application data flow for PHEVs		End-User Interface for PHEV Smart Charging and V2G
Visibility and control systems for distributed assets	Monitoring and Discharge of Distributed Assets		Simple Integration of Distributed Generation assets
EMS/DMS, OMS, GIS	Self-healing grid: Fault prediction, outage management, remote switching, minimal congestion, dynamic control of voltage, weather data integration, centralized capacitor bank control	Distribution and Substation automation, asset protection, advanced sensing, PQ management, automated feeder reconfiguration	Point of consumption voltage readings
Load Measurement and Control; Self Optimization of Supply and Demand	Advanced demand maintenance and demand response; Load forecasting and shifting		Precise and Adaptable control (granular data and visualization of appliance energy use)
AMI, MDM, CIS, Outage detection, Billing	Remote meter reading, remote disconnect/connect, tamper and theft detection, short internal readings, customer prepay, mobile workforce management		Real-time Customer access to meter data; meter sends "last gasp" signal in advance of fault/outage

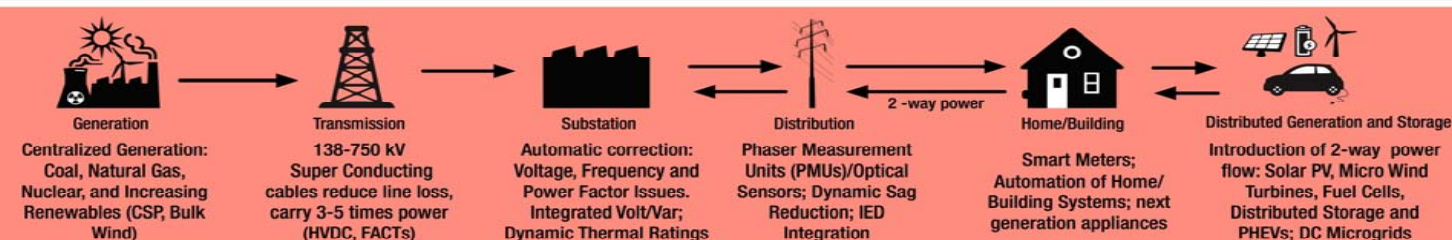
Communications Layer

Integrated Cyber Security



Power Layer

Security: Asset Monitoring
and Protection



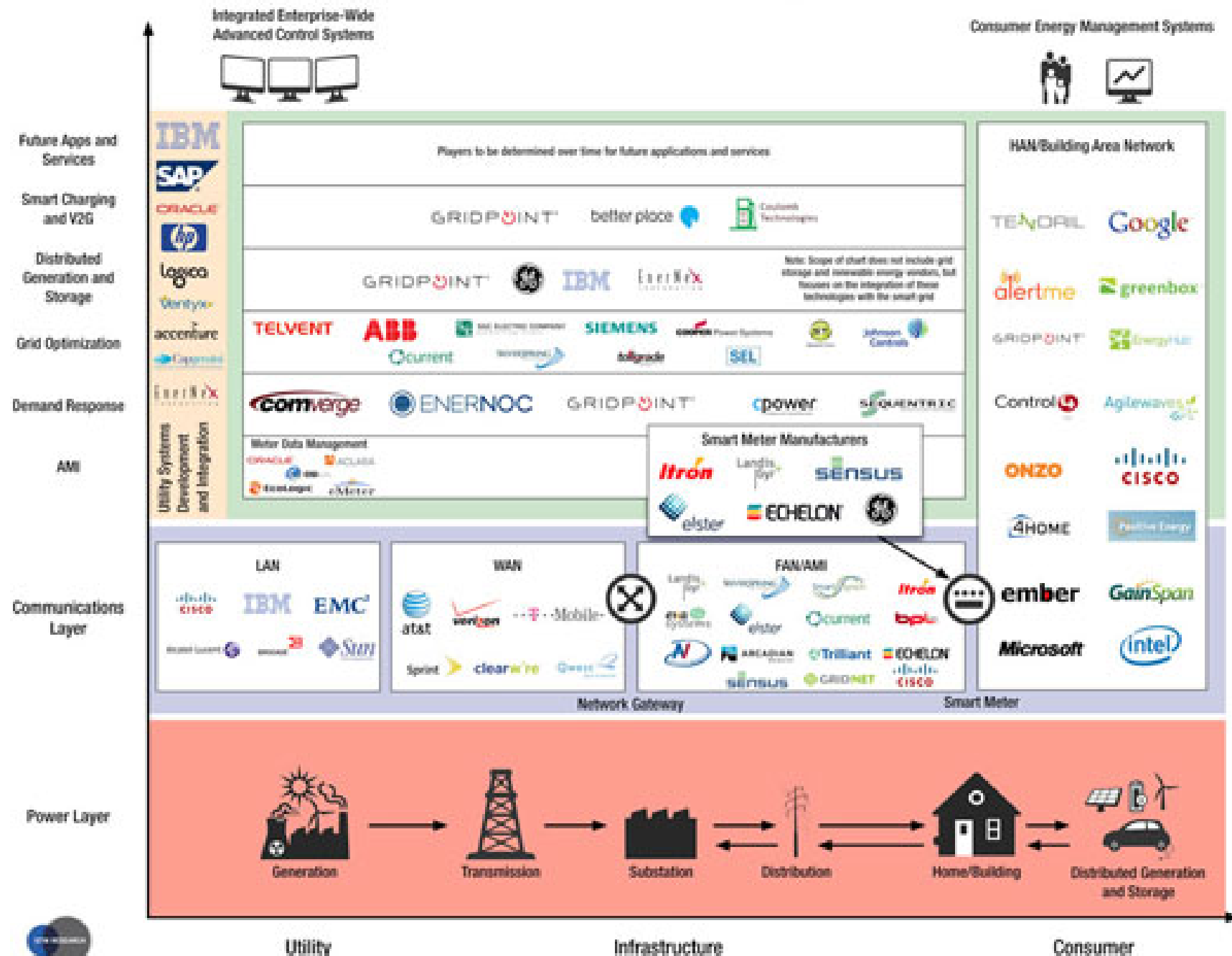
Utility

Infrastructure

Consumer

"End-to-End" Smart Grid

Leading Players by Market Segment



A Timeline for Smart Grid Applications

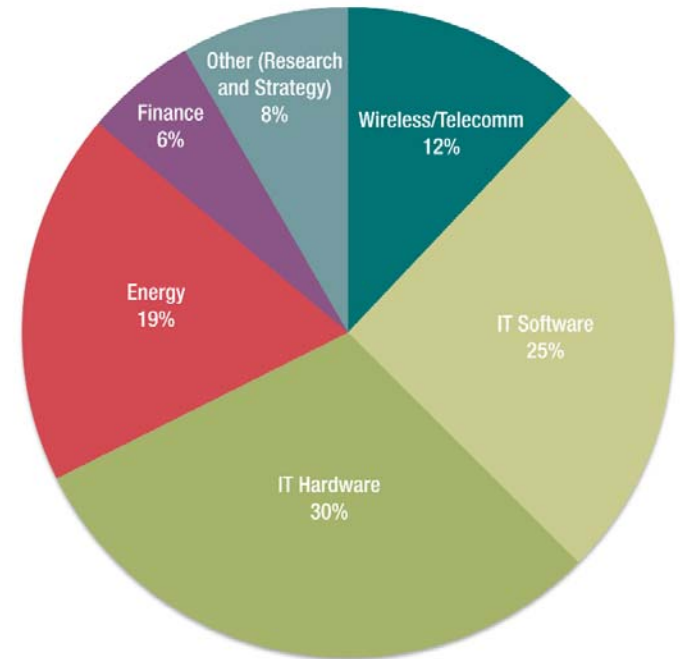
APPLICATION/MARKET SEGMENT	2010	2015	2020
AMI	The first large-scale deployments underway	Substantial and growing market penetration and network Infrastructure build-out	Significant and wide-ranging Implementation
Demand Response	Limited reach (mainly commercial and industrial customers)	Substantial market penetration for residential, commercial and Industrial	Commonplace with a wide variety of end-user service programs
Grid Optimization	A handful of utilities beginning distribution/substation automation projects	Sensor technology embedded on the distribution network; automation becoming routine	Dynamic Sensing everywhere; Grid becomes an Intelligent Utility Network
Distributed Generation Integration	Nascent	Maturing, but still a small % of power generation	Approaching Mainstream More substantial presence;
Energy Storage	A few pilots among progressive utilities	Expected technology advancements and increased Distributed Generation penetration will boost storage's role	Vital role in supporting Distributed Generation
PHEV	N/A	Smart Charging	V2G (vehicle-to-grid)
Consumer Energy Management Systems	Successful pilots continue to highlight consumer demand	Gaining traction as “set-it-and-forget” technologies make energy management simple to use and cost-effective	Routine, Web-based



Looking Forward: The Soft Grid

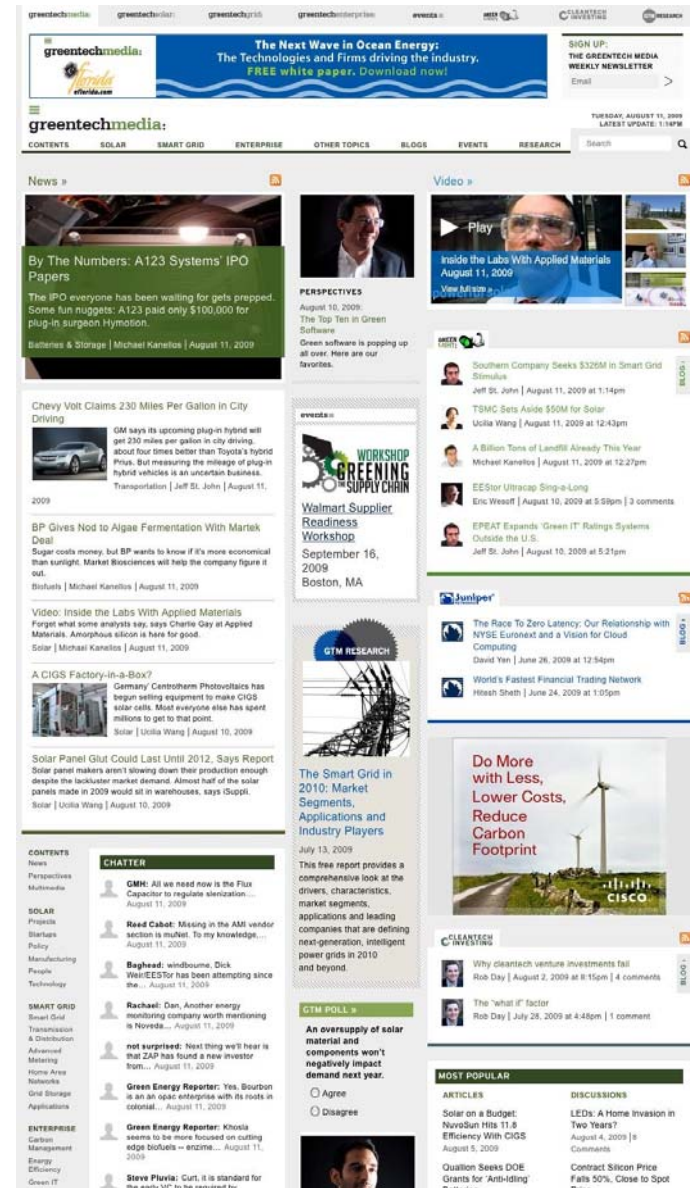
- Intelligent infrastructure is the critical bedrock of the smart grid
 - Required before advanced applications and services can move forward
- Smart meter and AMI networking deployments are well underway
- Opportunities for new entrants exist at the software/applications layers of the smart grid taxonomy
 - Advanced communications protocol software
 - User Interface software (EMS, etc.)
 - Data management and analytics
 - Application-specific software platforms

Prior Industry Experience of Smart Grid Management Professionals



About Greentech Media / GTM Research

- Web-based publisher of information on the future technology trends for renewable energy generation, distribution and consumption
- Founded February 2007; \$4.5M Venture Funding
- 18 Employees: Boston, New York, San Francisco, Munich
- Readership of 175,000+ Global Renewable Energy Professionals
- NOT: Green Gadgets, Green Lifestyle, Environmentalists



RESEARCH

Thank You!

Q&A

AMI (Advanced Metering Infrastructure)

- A System that collects, measures and analyzes energy usage by enabling data to be sent over a two-way communications network connecting smart meters and a utility's control systems
- Primary AMI Components
 - Smart Meter
 - Communications Network
- Example Applications
 - Remote meter reading for billing
 - Remote connect/disconnect
 - Outage detection and management
 - Tamper/theft detection
 - Short interval energy readings
 - Distributed generation monitoring and management



Demand Response

- Utilities incentivize electricity customers to reduce their consumption at critical, “peak” times, on demand
- A smart grid infrastructure enables significant reach for demand response services
- Expected to be the first smart grid application to capture a critical mass of market penetration
- Cheaper, faster, cleaner and more reliable than adding a peaking power plant
- “Virtual Peak Power” from third-party load aggregators
- The Future of DR: in the hands of utilities or load aggregators?



Grid Optimization (Distribution Automation)

- A wide array of potential advances that will give utilities and grid operators digital control over the power delivery network
- Encompasses improvements in three main areas
 - System Reliability
 - Operational Efficiency (example: line losses)
 - Asset Utilization and Protection
- Enabled largely by the addition of new sensor and communications technology
- Significant reductions in distribution losses from optimal power factor performance and system balancing
- Improved Power Quality



Integrating Renewable Energy & Storage

- Challenges
 - Intermittent Power Sources (storage requirements)
 - Distributed Power Sources (distributed vs. centralized architecture)
 - Transmission and Distribution of Centralized Renewable Power to End-Users
- Smart meters and AMI networks, with their ability to measure and communicate energy consumption (and output) are critical for distributed generation
- Communications systems required for sending price signals and commands
- Utility-Scale Storage Solutions in Demand



PHEVs and V2G

- The growth of the PHEV market drives critical smart grid applications such as smart charging and V2G
- Market Phases
 - Phase I: Smart Charging (0-5 years)
 - Phase II: V2G (5-10 years)
- Challenges (& Opportunities)
 - Mass adoption of grid-connected PHEVs causing accidental peaks or system interruptions
 - Load profile over time not well understood, smart charging and ‘power shaping’ required
 - How to best leverage a potentially large-scale source of distributed generation (V2G)



Advanced Utility Control Systems

- Mission-critical systems, applications and back-end technology infrastructure necessary to support a utility's monitoring, control and optimization of the grid
- Advanced Utility Control Systems primarily include:
 - Energy Management Systems (EMS)
 - Supervisory Control and Data Acquisition Systems (SCADA)
 - Distribution Management Systems (DMS)
 - Other advanced applications, such as Meter Data Management (MDM), Geographic Information Systems (GIS), etc.
- A move from silo'd to integrated systems
- Opportunities for application-specific vendors
- Opportunities for back-end systems integrators and consultants



Energy-Aware Home Area Networks

- Two Primary Product/Market Sub-Segments
 - Home Communications Network
 - Home Energy Management System
- Competing Network Technologies
 - ZigBee, WiFi, HomePlug, Z-Wave, 6LowPAN
- Wide-Arrange of Energy Management Systems
 - Feature sets, web portals, dedicated displays, etc.
- The future of the energy home gateway?
- Consumer awareness/engagement challenges
- Great for discussions of what's possible but this market segment is in early stages



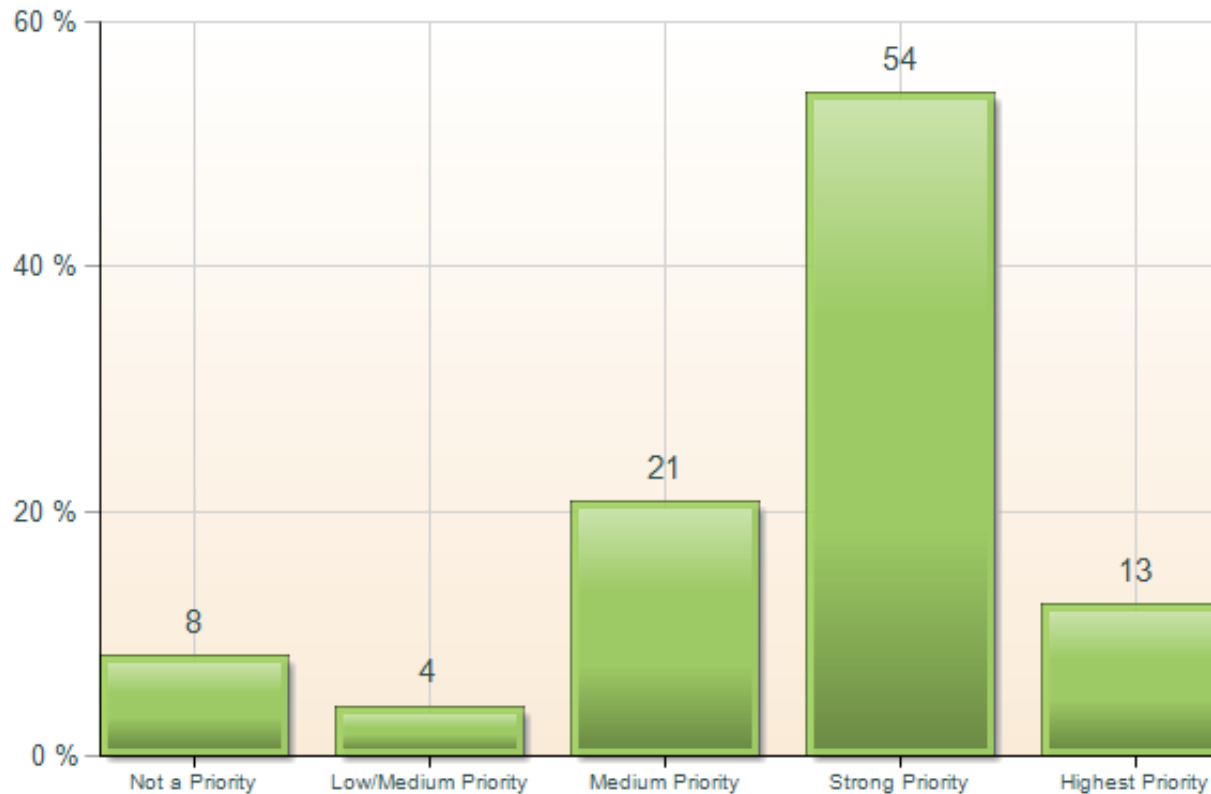
Tying Smart Grids to Energy-Aware HANs

- Utilities sell electricity but have little data about how individuals consume it
- Consumers use products & services but have little concept of electricity consumption
- Products & services use electricity but have little concept of how or when to conserve



Utility Prioritization of Smart Grid

On a scale of 1 to 5 (with 1 = lowest priority and 5 = highest priority) how important are Smart Grid Projects relative to your overall business plan over the next 5-year period?



Example HAN Energy Web Portal

Demo Home

San Bruno, CA

brad@greenbox-inc.com : my homes : my account : log out



[Messages](#) [Community](#) [Environment](#) [Marketplace](#)

Solar
\$50

Heating/Cooling
\$47

Water
\$2.34

Total Cost
\$69

Weather
77°F

Electricity
\$63

Natural Gas
\$54

Year Month **Week** Yesterday Today

Heating and Cooling

Auto Heat Cool Off

90°
80°
76°F
70°
60°

76.0°F Cool
70.0°F Heat

Auto Fan On Savings **Balanced** Comfort

Thermostat Schedule



Utility HAN Goals

- General Conservation
 - Minimize customer energy & carbon footprint
- Demand Management
 - Cost Reduction
 - Grid Reliability & Stability Increase
 - Demand Generation Avoidance
- Build an Energy Information Services Business
- PHEV(s), Distributed Generation
- TOU Pricing



Consumer HAN Goals

- Consumption Awareness & Understanding
- Consumption Behavior Modification
- Utility Program Participation
- Smart, Adaptive Appliances
- Integrate Storage and Distributed Power Generation
- Sell Power to Grid
- Many More Yet To Be Determined

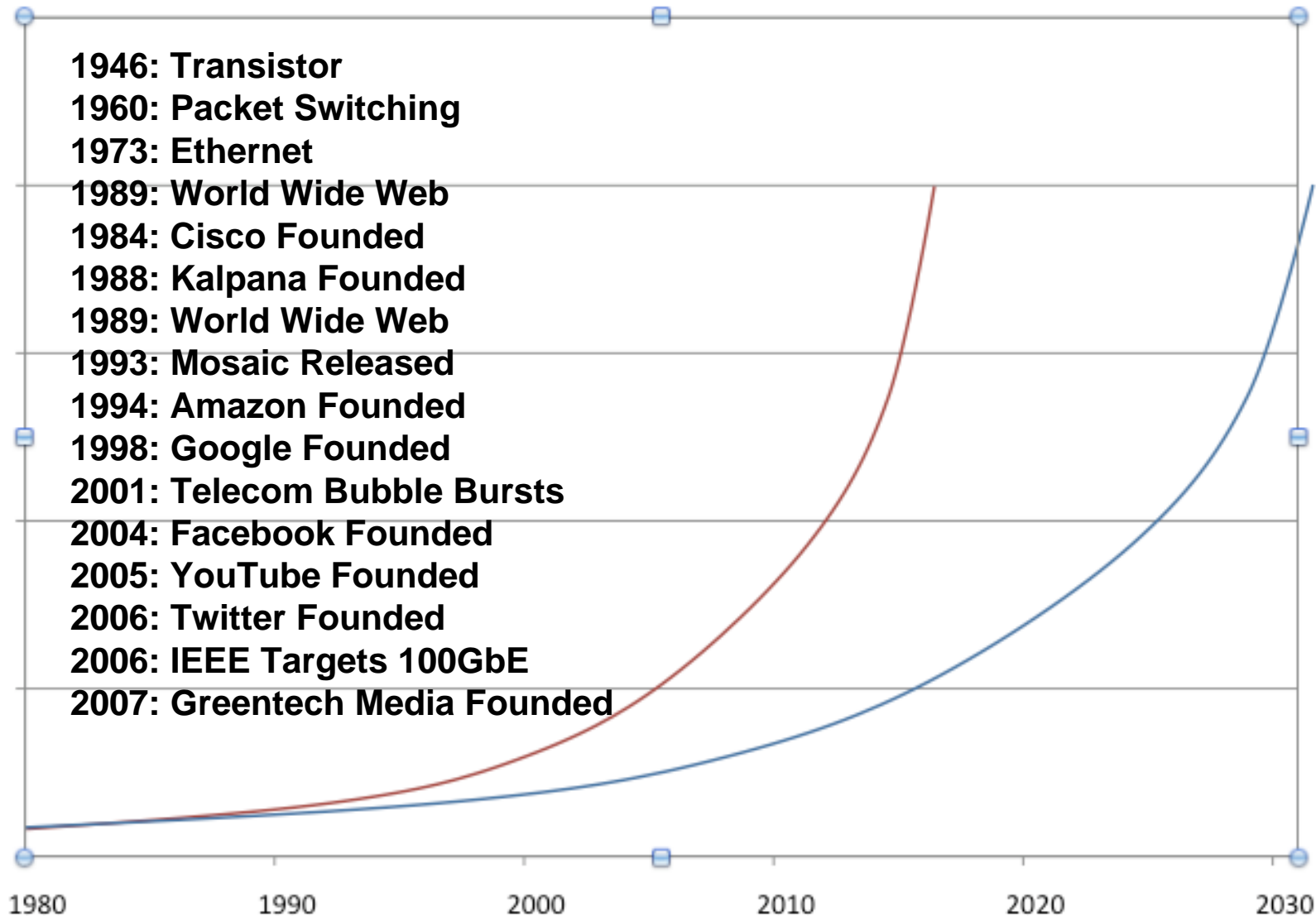


New Opportunities

- **“Most exciting time to work in the Electric Industry in 25+ years”** – Director of Smart Grid, San Diego Gas & Electric
- 1. Hundreds of Emerging Smart Grid Start-Ups
 - Jobs: Engineers, Programmers, Technical Strategy, Finance, Sales/Marketing needed
 - More Entrepreneurial by nature : Developing and Bringing New Products and Services to Market
- 2. Utilities
 - New Problems and Challenges require new skill sets
 - Many new job titles: CIO, CTO, VP of Engineering & Technical Services, Director of Smart Grid, Director AMI, Director of HAN Devices and Integration, Technical Strategist, AMI Program Manager, Engineer: Smart Grid
- 3. Adjacent Industries
 - Telecom, Software, & Defense



History Will Repeat Itself



RESEARCH

What is 'Greentech' (aka Cleantech)?

GENERATION

Renewable Energy

Biofuels

'Clean' Fossil Fuels

Nuclear (?)

DISTRIBUTION

Networked Grids

Power Optimization

Energy Management

Software Control

CONSUMPTION

Energy Efficiency

Carbon Management

Green Buildings

Green IT

The electric power sector is the largest sector in terms of energy-related carbon dioxide emissions.

