SMART MICROGRIDS:
Re-visioning Smart Grid and Smart City Development in India

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TUTORIAL 2: “LEADING TRANSITION TO A SMART CITY” – 9TH MARCH 2017
Smart Microgrid Business Development
Within an “Integrated Smart Grid”:
Transforming our Power System and Communities

• Iterative Pathway for Market Development: Interconnection, Integration and Intelligent Interconnectivity

• Combining Smart Grid, Microgrid-Managed Distributed Resources, and Sustainable Community Energy Systems for Intelligent Energy Management

• **Smart Grid:** Manage and optimize energy, information, transaction flows and utility operations across supply and demand, transmission and distribution, and consumer end use programs and activities; Two-way communications and power flow, distributed sensors, automation and supervisory control systems

• **Smart Microgrid:** Aggregate, manage and optimize combinations of distributed resources using smart technologies; balance demand against supply in real time to maintain stable service within defined boundary with islanding capability; evolve scalable systems and distributed networked electricity systems

• **Smart Cities and Communities:** Integrated community energy systems for efficient and sustainable energy and resource development and use (NREL EIS)
PATHWAY: Technical, Business and Regulatory

- Iterative Pathway From **Interconnection** to **Integration** to **Intelligent Interconnectivity** within **Integrated Smart Grid** (from physical interconnection to Energy Internet/IoT for Energy sharing): Moving back and forth along technology development and commercialization continuum to change the dominant utility business model to spur value creation, measurement and compensation, evolving “interoperability” (technical, informational, organizational) within entire power value chain.

BNL: Roadmap to evolving dynamic microgrid. Sandia Advanced Microgrid Report
• India’s “Smart Grid Vision and Roadmap” interfaces integrally with India’s “Smart City Mission and Guidelines;”
• “Smart Grid” is the Anchor for “Smart City” development, merging electrical and digital infrastructures to enable:
  ➢ Integrated Planning of City Infrastructure and the Built Environment;
  ➢ Optimizing Energy Use through Intelligent Energy Management;
  ➢ Providing a Platform for “Infrastructure as a Service” (See, R.R. Mehta, CEO, Reliance Energy, “Role of Smart Grid in Smart City,” ISGW 2105);
• Smart City Mission Statement seeks smart energy management solutions (smart metering; renewable sources of energy; efficient and green buildings, water and waste management, urban mobility, etc.);
• Smart Grid Vision and Roadmap markedly shifts from India’s traditional, highly centralized and bulk supply-push electricity sector strategy to set significant distributed resource targets and support customer/demand driven strategies;
• Harmonizing the two blueprints could “leapfrog” legacy strategies to enable smarter solutions and increasingly cost-effective performance for customers, electric grid operators and businesses.
Smart Grid “Building Blocks” for Smart City Development

- Lay “Building Blocks” to tap into the Smart Grid Potential, enable (1) Two-way power, information, and transactional flows; customers to benefit from dynamic pricing and distributed energy; and (2) Visibility, predictability, integration, forecasting and event control to generation, delivery and end use to integrate intermittent Renewable Energy and Distributed Energy Resources, reduce peak demand and outages, increase system efficiencies and asset utilization, manage/optimizing DER, deploy intelligent energy management:

- Develop “Smart” or “Advanced” Microgrids to facilitate the convergence of energy supply and end user sectors within community development, using intelligent energy management;

- Develop a “3.0” or “Integrated Grid” to expand and modernize the grid, in which smart microgrids maximize consumer, grid and societal benefits of DER/RE;

- Build Standards for Interconnectivity and Interoperability between Smart Microgrids and Utility Distribution Systems to shape interactions to support: Diversifying electric resources; Designing infrastructure that optimizes management of energy requirements (heating, cooling and power); and Controlling and managing local reliability and protecting critical infrastructure;

- Develop Smart Microgrid and Networked Microgrid Systems to shape integrated community energy systems, managing and optimizing energy use across community end user sectors.
India’s Smart Grid Vision and Roadmap

- Developing a **“Smart Grid”** for secure, adaptive, sustainable and digitally enabled **“ecosystem”** by 2027;

- **Smart Grid** – Electrical grid with automation, distributed sensors, communication and information technology (ICT), and supervisory control systems that provides two-way power and information flows, monitors power flows from points of generation to consumption and controls power flow or curtails load to match supply in real time;

- **Roadmap** shifts from current highly, centralized, target-driven, supply-push electricity sector strategy to combine decentralized energy elements and re-orient to a customer/demand-driven approach using smart technologies;

- **Smart Technologies** can bring visibility, predictability, flexibility and event control to generation, delivery and end use to integrate intermittent renewables, reduce peak demand and outages, increase system efficiencies, manage and optimize distributed resources; new focus on intelligent energy management to close the supply gap.

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Larisa Dobriansky, General MicroGrids
The Smart Grid Vision and Roadmap contain significant **microgrid targets**:

- Develop microgrids, storage options, virtual power plants, solar PV to grid and building to grid technologies to manage peak demand, optimally use installed capacity and eliminate load shedding and black-outs;
- Develop microgrids in 1,000 villages, industrial parks, commercial hubs by 2017, 10,000 by 2022, and 20,000 by 2027;
- **India’s Model Smart Grid Regulations** define a smart “microgrid” as an intelligent electricity distribution system that interconnects loads, distributed energy resources and storage within clearly defined electrical boundaries to act as a single controllable entity with respect to the main (electric) grid; A microgrid uses information, communications and control technologies to operate the system’s distributed supply and demand resources in a controlled and coordinated way, either while connected to the main grid or while islanded; A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.
Implementing the Vision and Roadmap

- **National Smart Grid Mission** – NSGM brings together all stakeholders to implement the policies and programs of the Roadmap;

- **NSGM Functions**: (1) Build national support across ministries and from States; (2) Develop detailed blueprint for Utility programs and projects in each State, estimating costs and budgetary support; (3) Coordinate with States, Utilities and other stakeholders rollout of Smart Grid Pilots and monitor implementation; (4) Coordinate development of standards and sustainable business models;

- **NSGM** implements the Roadmap to spur new operating grid parameters; empower new market players; and galvanize new regulatory structures;

- **NSGM** effectuates the Roadmap’s vision to expand electricity value chain boundaries through decentralized energy elements/distributed energy technologies; new third parties and prosumers in the electricity market; and regulatory innovations to change the current paradigm and the utility business model to achieve India’s policy objectives.
“Dynamic” Smart Microgrids

• U.S. Department of Energy (USDOE) and its National Laboratories envision “advanced” or “smart” microgrids as a “third element” of a Smart Grid, together with macrogrid operations and grid-load interaction;

• “Smart Microgrid” functionalities could help transform Electricity Value Chain, upstream and downstream; Contribute to interoperability, Firming Distributing Resources and Integrating DER into the Grid, Market and Communities;

• An Advanced Microgrid is an Intelligent Electricity Delivery Network that interconnects loads, DER and storage within defined electrical boundaries that acts as a single controllable entity with respect to the macrogrid; can island, connect and disconnect from the grid to enable it to operate in grid-connected or island modes;

• Overall intelligent and efficient load and resource management is achieved by using specialized hardware and software to integrate, control and optimize multiple demand and supply assets within microgrid systems;

• Advanced microgrids contain the essential elements of the macrogrid: Ability to Balance electrical demand with sources; Schedule the dispatch of resources; and Preserve grid reliability.
Advanced Microgrid Features include:

• Sensing, communications and control technologies used to generate, manage, distribute and use electricity more intelligently and effectively;

• Electricity supplied by diverse range of DER (natural gas, solar PV, micro-hydro plants, wind turbines, biomass, bio-gas, etc.);

• Distributed resources treated as an integrated and autonomous system; Microgrid configuration localized to customer, community or region;

• Intelligent load and energy resource management; Balancing loads with renewables’ variable generation; Efficiency and demand response capabilities;

• Integrate storage, load shifting and prioritization; base plus variable generation with smart grid;

• Self-healing (detect, analyze, respond and restore itself in case of disruptions), self-configuring, plug and play

Advanced microgrid will interact with the grid and other microgrids. (SANDIA: Advanced Microgrid Report, 2014)
Smart Grid/Smart Microgrid Drivers

- **Energy Surety and Resiliency**: Increase grid reliability and resiliency; assure available supply to meet energy requirements; harden critical infrastructure;

- **Economic Competitive Advantage**: Defer/avoid utility T&D investment; where DG is near grid parity, microgrids can optimize capacity and add value; least cost regional planning as an alternative to transmission siting challenges;

- **Manage Peak Load Demand**: Manage distributed resources to provide power during peak load periods and to shape load curves;

- **Environmental and Efficiency Goals**: Lower environmental emissions; transition to greater reliance on renewable resources; Use fuel resources efficiently; Improve local control and increase self-reliance; Increase efficiencies using waste heat;

- **Sustainable Economic Development**: Increase sustainable economic development and job growth

- **USDOE Microgrid Targets** (Outages/Resiliency, Peak Demand Reduction, Greenhouse Gas Emissions Reduction, Increase Efficiencies); **US/State Mandates and Targets**
Uncertainties, Barriers and Risks

• **Technical:** Moving beyond niche market/customized applications to the market mainstream; Developing a track record; Standardizing a Technology and Business Framework to govern development of different types of microgrids;

• **Economic:** Establishing a business case for advanced microgrid applications; Monetizing value streams and developing bankable projects; Increasing market access; Improving economics of microgrid development related to utility interconnection and other fees and charges;

• **Policy and Regulatory:** Combining decentralized elements within a centralized paradigm; Moving from meeting peak capacity to load profiling; and from measuring megawatts to measuring value creation; Defining microgrids as legal entities; Addressing “utility” triggers and utility franchises; Re-delineating monopoly vs. competitive domains; Building customer acceptance and engagement;

• **Institutional:** Centralized Paradigm Institutional Structure; Lack of Technology Requirements, Infrastructure and Interoperability; Incompatible Market and Pricing Structures; Lack of Cost-Effectiveness and Valuation Methods.
Grid 3.0 Vision: “Integrated Grid”

- **Smart Grid technologies could fundamentally alter the current electricity system configuration** to achieve new policy mandates, respond to rapidly changing market conditions and to meet new consumer expectations, interests and needs;

- **New Operating Parameters, Players and Structures: Expanded Electricity Value Chain Parameters** (Integration of new resources and technologies; decentralized elements/distributed energy technologies); **New Market Players** (Prosumers and Third Parties in electricity market); and **New Regulatory Structures** (Changing the Utility Business Model to achieve Policy Objectives, while maintaining reliability, safety and affordability);

- **Interactive, Flexible and Innovative Grid**: Highly flexible, configurable and interactive networks of utility, customer and third-party applications; market data, price signals and transactions; “System of Systems” operations for DER integration and load-side management; All electricity resources treated as primary resources;

- **“Integrated Grid”:** Take fully into account and value DER in Utility Planning, Investments, Operations and Trading; Grid Design to increase the independence, flexibility and intelligence for optimization of energy use and management within local energy networks (building, community and distribution systems levels) and to integrate local energy resources (supply and demand assets) into the Smart Grid.
New Distribution System Operator (“DSO”) Functions to actively respond to dynamically changing market conditions and manage customer-side resources; Transmission system-like functions to manage distribution planning, investments and operations:

Maintaining reliable distribution system operation with two-way, multi-point, reversible power flows with increasing volume and diversity of distributed resources (voltage monitoring, telemetry and real-time control);

Integrating and balancing distributed resources and load to shape load profile and peak demand and to enable multi-function DER to provide services to bulk power system; Reducing need for transmission and generation investments in bulk system flexibility, ramping and reliability; Developing local energy markets;

Achieving functional control of DER for real-time balancing and flexibility and services such as reactive power and frequency control to local and bulk grid; modelling and forecasting load and DER growth;

Defining/Managing Transmission/Distribution Interface to reliably and optimally operate whole power system;

Addressing Changing Characteristics of New Resources (onsite RE, DG, CHP, DSM, ES, EV, DR, EE) and Changing Nature of Customers (Prosumers; Increasing Demand Elasticity) (See, Erickson of CPUC on Distributed Grid)
• Advanced Microgrids are potentially tools for utilities and communities to address system complexities of managing wide and dynamic sets of distributed and intermittent resources and control points;

• **A Smart Microgrid is built upon Smart Grid:** Smart technologies can connect microgrid cells to “nest” within distributed networked electricity systems that, in turn, are connected to the bulk power system; Networked microgrids would allow sharing of generation, controllable load and storage capabilities over wider areas for optimal energy and risk management;

• **Advanced Microgrids cluster compatible loads and DER units within an integrated autonomous system,** providing smart distribution through fast-control, avoiding problems of standalone and randomly dispersed DER;

• **Smart Microgrids provide C/E Distributed Systems Control:** Taking a “System of Systems” approach, Advanced Microgrids could provide C/E power quality, availability, reliability/resiliency and “heterogeneous” benefits, managing and optimizing distributed and intermittent resources.
NETWORKED MICROGRID CELLS
Microgrid “grid connection” means both interconnection physically and integration with the Smart Grid—each with unique challenges and opportunities.

Open standards for DERs within the microgrid to be integrated with the smart electric grid domains—transmission, distribution, and customer network.
Smart Microgrids in Sustainable Community Energy Systems
Integrating Advanced Energy Systems into Community Planning and Development

• **Smart Energy Planning:** Combine with Smart Growth Design, Smart Grid/Microgrid in land use development and growth management processes to balance energy supply and demand, diversify energy resources, increase resiliency, amplify sustainability, facilitating orderly, capital efficient and environmentally sound application of distributed energy resources;

• **Integrated Energy Systems:** Integrate and optimize clean and efficient energy technologies within development projects to accelerate the combined use of renewable energy and advanced end-use and smart grid enabling technologies within the community’s built-environment and infrastructure;

• **Smart Microgrids:** Advance resource integration (thermal and electric, water, waste, transport, buildings, etc.), efficiencies and optimal energy use/investment in communities

• **Microgrid Value Streams:** Economic, Reliability/Resiliency and Power Quality, Environmental and Security and Safety
Mutually Enhancing: Energy Assurance and Sustainability Planning with Smart Microgrids

- **From design to development and delivery**, through operation, repair and maintenance to replacement, interrelate planning using smart microgrids to develop more sustainable and resilient communities and critical infrastructure networks; (US: CUNY for NYC and NYS, Baltimore, Silicon Valley, San Diego, Pecan Street Project, Metropolitan Washington Council of Governments)

- **Build energy surety and resiliency as bedrock for sustainability; Harness sustainability** to mitigate impacts, diversify supplies, harden critical infrastructure, increase resiliency, stabilize energy costs and reduce reliance on fossil fuels;

- **Smart Microgrids as Integrative Agents** in Planning/Development for New Infrastructure and Built-Environment: (Integrate new clean energy portfolios (RE, biofuel, energy efficiency, CHP, etc.) and new applications (EV, Energy Storage, DR, HEMS, etc.) into EAP and Emergency Preparedness Plans; Integrate tactical and strategic EAP methods, mechanisms and solutions into Sustainable Energy Systems Plans (DC, CT, NY, MD)

- **Minimize impacts and costs;** Reduce risks, uncertainties and vulnerabilities; Develop fuller potential, maximize outcomes and capture co-benefits
Smart Microgrids: Transforming Power System and Community Energy Infrastructure

- **Smart Microgrid Infrastructure as a Service Platform:** Taking a “Resource-Efficient Systems Approach,” smart microgrids could manage and optimize local energy across end use sectors (Power, Transportation, Water, Waste, Buildings, etc.), leveraging data sets that span diverse facilities, systems and purposes to interrelate/link and optimize energy-using functions of diverse infrastructure systems and the built environment of communities;

- **Smart Microgrids** could contribute to **Critical Infrastructure Protection and Security; Quality Power Provision; Local Communications Networking; Data Quality, Measurement and Management for Optimization Control**;

- **Smart Microgrids** could interconnect community users with Energy-Using Infrastructure through new layers of intelligence/ICT;

- **Advanced Microgrids** could contribute to developing **Transactive Distributed Energy Networks within a 3.0 Grid**;

- **Advanced Microgrids**, as locally-based smart distribution architecture, could leverage private investment to help utilities, customers and communities achieve higher levels of electricity/energy performance, while protecting key community facilities/functions during grid outages and energy disruptions.
• **Holistic, Dynamic and Systemic:** Integrated, Intelligent Energy Systems Capabilities and Solutions for Resilient and Sustainable Eco-Systems and Critical Infrastructure Networks; Game-Changing Pilots (ARRA, State, local)

• **Systems Approach in Planning:** Understand impacts of embedded energy costs and operational energy needs of infrastructure systems and urbanization; Assess costs/benefits of EA and SE Planning; Understand and quantify C/B of alternative technologies, practices and development scenarios; Develop cost-effective decision support tools and methods for community/regional-based energy systems planning;

• **Disciplines for Assessing, Managing and Optimizing Community Resources for Cost-Effective Outcomes:** Incorporate energy supply and demand infrastructure analyses of alternative energy and resource development options into housing, land-use, water supply and wastewater, transportation, waste recycling and reuse and other municipal processes; strategically site and permit DER, cluster compatible uses of infrastructure, buildings and public works, build local and regional energy networks
CA: Borrego Springs

- **Micro Grid Yard**
  - Generators
  - Advanced Energy
    - Substation Energy Storage (SES)
      - One 500 kW/1500 kWh battery at Borrego Sub
    - Community Energy Storage (CES)
      - Three 25 kW/50 kWh units on circuit 170
    - Home Energy Storage (HES)
      - Six 4 kW/8 kWh units
GE Grid Solutions – Re-thinking Urban Community Development

**CITY RESILIENCE**

**PUBLIC SAFETY**
- Infrastructure Reliability
  1. More Unplanned Electric Outages
     1. Hurricane Irene
     2. Super Storm Sandy
     3. ...
  2. Security Threats

**CITY JOBS**

**ECONOMY**
- Technology Innovation
  1. Information Communication Technology (ICT)
     1. Internet Of Things (IoT)
     2. Information Networks
  2. Smart Grids & City Microgrids
     1. Energy Asset Management
     2. Automation & Optimization
     3. Less Energy Supply at Affordable Price
  3. Smart Traffic & Parking Systems

**CITY GREEN GOALS**
- Climate Change
  - Emergence of Distributed Energy Resources DER Assets
    1. Renewables
    2. Storage
    3. Demand Response
    4. Energy Efficiency
    5. Electric Vehicle

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Worldwide -> 50 billions of devices & DER assets expected to be connected by 2020 !
The US national economy Impact - Last 3 year outages impacted billions of dollars !!
The Navy Yard – A Community Microgrid / Mini City
Microgrid / Mini City Energy Master Plan

Business as Usual – 100% Utility Fed
• All PECO supply
• No On-site generation (DG)
• No proactive EE or DR effort
Utility Demand - 82 MW

On-Site DG
Grid Programs:
• Natural gas DG
  ➢ 6 MW Peak Reduction
  ➢ 3 MW CHP (data center)
• 1 MW Solar PV
• 600 KW Fuel Cell
Utility Demand - 72 MW

SG Infrastructure / Priority Repairs / Demand Response & Energy Efficiency
Customer programs:
• 20% EE goal by 2022
• Navy DOD mandates
• B-T-M Demand Reduction
Utility Demand - 60 MW

Optimized Scenario & Business Plan

Cumulative Usage decrease – over 61,000 MWh

GE Solutions

Grid Capacity Upgrades
$35M

Stand Alone Energy Projects
$25M

Smart Grid & Operation Infrastructure
$35M
The Navy Yard – A Community Microgrid / Mini City
System Integration Architecture GE Solutions

Bldg. 101 – Microgrid Network Operation Center

Supervisory Microgrid Controller
- Forecasting & Planning Operation
- Market Interface Operation
- Customer Resource Operation
- DCR Asset Operation

e-terra Integration Platform
- Enterprise Data & Interface Management
- Smart Substation & Microgrid Control for Interface

SS602 - Navy Yard Microgrid #2
- Substation Microgrid Controller
- FUEL CELL AMERESCO 6 MW DG
- Building Energy Management
- 750kV Community Solar
- Substation 2000 kW
- Energy storage

SS864 - GridSTAR Navy Yard Microgrid #1
- Substation Microgrid Controller
- GridSTAR Microgrid
- Feeder Microgrid Controller
- Asset - Market
- Smart Graphics
- Control Room

PSCO Dist. Substation
PSCO Trans. Substation

Distribution Control Room
Transmission Control Room
“Policy Eco-System” to Capture DER Benefits and Microgrid Systems Value:

- **Interoperability and Integration/Standardize DER Use Throughout Electricity Value Chain:** Technical “Smart Grid” Design; Information Access and Valuation Methods; and New Rules, Institutional and Business Structures;

- **DESIGN: Smart Architectural Design** to advance interoperability and integration “end to end”; evolve highly flexible, configurable and interactive networks; establish a 3.0 Grid Operating System to address digital age requirements and integration of RE/DER (automated, controlled/coordinated, widely distributed energy delivery networks);

- **RESOURCE VALUATION:** Measure consistently full range of DER benefits and Smart Microgrid System Value; Integrate DER into Utility Planning, Procurement and Investment Decision-making processes; Optimize mix of centralized and distributed resources;

- **NEW REGULATORY COMPACT:** Change incentives of traditional ratemaking, cost of recovery, rate design to make utility decision-making focused on achieving the most cost-effective solutions; shape new Utility Business and Service Delivery Models;

- **CONSISTENT DEFINITION OF MICROGRIDS:** So “System” Value can be taken into account in utility and community planning, investment decision-making and operations.
Reforming Traditional Regulatory Paradigm

Changes to **Traditional Paradigm** need to support a **distributed grid** in which advanced microgrids serve as **integrative agents**: 

- **Address traditional assumptions:** (i) There is little role for customers to play in addressing system needs; and (ii) Centralized generation and bulk transmission invariably yield cost-effective results;  
- **Reform traditional economic regulation** to achieve more efficient allocation between capital and operating expenses and to incent continuous improvement;  
- **Develop a results-based model**, like UK’s RIIO, to shift regulatory focus from the reasonableness of historically incurred costs to pursuit of long-term customer value;  
- **Provide dynamic price signals and rate design that reflects the value** of grid service to customers with and without DER and the value of DER to the grid; Rate structures should reflect value based on timing, location, flexibility, predictability and controllability of the resource.
Lay a foundation in Model Smart Grid Regulations to:

(3) **Expand power system** to include **cost-effective decentralized elements** and to take a "**system of systems**" approach to achieve Roadmap objectives;

(4) **Value and take fully into account** the benefits, attributes and costs of advanced microgrids, distributed resources and energy efficiency;

(5) **Define microgrids consistently**; incorporate India’s policy objectives;

(6) **Develop new cost-benefit analytical frameworks, standards and protocols, performance metrics and M&V methods** to assess microgrids, DER and to value interoperability and integration;

(7) **Develop performance and out-put based cost recovery criteria, tariff structures and incentives** for utilities to shape new business and service delivery models;

(8) **Develop more robust interstate and intrastate power markets** at both the wholesale and retail levels;

(9) **Shift to a customer-driven, “dispersed” smart grid**;

(10) **Align Federal and State Smart Grid programs** and pilot planning, development and implementation.
Consider changes that are being evaluated in the U.S. and other countries such as the following:

- **Transmission Planning** that treats DER and microgrids as cost-effective resources;
- **Utility mapping** to site DER and microgrids where the most value can be obtained;
- **Develop distribution resources plans** to delineate optimal DER portfolios to achieve policy objectives and address consumer needs;
- **Reform the role of utility distribution companies** into Distribution System Operators responsible for distribution network operation;
- **Build retail markets** designed and operated to value system-based investments and operation protocols that can drive distribution utility innovation and efficiency;
- **Assure fairness and equity** to all customers; obviate disproportionate burdens on customers who cannot afford or unable to install DER.
Microgrid Regulatory Issues and Impact Areas

- Implement dynamic pricing
- Refine Interconnection policies, System Siting and Permitting
- Consumer Engagement, Rights, Protections
- Performance Metrics: Reliability and Resiliency
- Cybersecurity
- Market Access: Wholesale, Retail, Transmission and Distribution
- Microgrid Ownership and Asset Management
- Types of Microgrids and “Utility Regulation” Triggers and Franchise Rights, Exemptions
- Utility Cost of Service, Tariff Structures, Rate Design; Incentives to Align Utility interests with achieving new policy objectives, while assuring reliability, affordability and safety of service
- Coordinate microgrid policies with other policies (DG, EV, ES, DSM, etc.)
- Consistent regulatory policies across utility service areas

Sandia Report, 2014
Evolving Smart Microgrid Business Models

• Reducing Regulatory Uncertainty, Barriers and Risks

• Defining Microgrids, Delineating a Regulatory Framework for Scaling and Replication, Designing and Implementing Demonstrations

• Addressing Different Types of Microgrids and Changing Functionalities:
  • Market Segments: Industrial, Commercial and Residential/Campus/Institutional;
  • Single Customer or Multi-Customer; Contiguous Properties or Non-Contiguous Properties;
  • Utility-Owned and Managed; Privately Owned and Managed; Hybrid Ownership and Management Models; Cooperative and Micro-Municipalization Structures;
  • “Energy Improvement Districts” or “Eco-Districts”; DER Development Zones; “Community Microgrids;”
  • Managing High Penetration of Variable Renewable Energy; Increasing Resiliency and “Hardening” Critical Infrastructure; Locally-based, Large MW “Power Refineries;” Smart Microgrids for Smart Cities; Distributed Networked Electricity Systems with “Nested” Microgrid Cells

• Assessing and Monetizing Value Streams Upstream and Downstream

• Evaluating Levels of Regulation, “Utility” triggers; “Sale for Resale” triggers; Structuring Exemptions, Incentive Schemes and Financing Models

• Shaping Regulatory Frameworks for New Energy Delivery Infrastructure within Communities to maximize energy value and benefits and minimize incremental costs; From design to development and delivery, through operation, repair and replacement, interface Community Energy Assurance and Sustainability Planning with Utility Planning, using advanced microgrids
Smart Communities in Japan

KYOTO
- Energy Management System
- Eco-House
- EV Battery charge system
- Introduce EV Bus

KITAKYUSHU
- Real Time Management by Smart Meter
- Energy Management System
- HEMS, BEMS

YOKOHAMA
- Energy Management System
- Eco-House
- EV Battery charge system

TOYOTA
- Energy Management System
- Eco-House
- EV Battery charge system
- Deployment of EV, V2H, V2G

*METI: Ministry of Economy, Trade and Industry in Japan
Kyoto

- Development of EMS
  → Energy Management Center
  HEMS: Eco-House
  BEMS: Shopping Mall
  EV: EV Management Center, ITS, V2H and H2V
- Introduction of Renewable Energy
  → PV and Local Battery
- Lifestyle Innovation
  → Eco-House
• **Smart Microgrid Intelligent Energy Management Maximizes “Value”:** Smart Microgrid “Systems” maximize DER benefits, minimize costs; “Systems” management and optimization distinguishable from Third-Party aggregation and Virtual Power Plants;

• **Smart Microgrids represent a “System of Systems,”** running from building to district to community to utility distribution service levels; Networks of microgrid cells nested into distributed systems and connected to the grid enable sharing of generation, controllable load and storage capabilities over wider areas for optimal energy and risk management;

• **Smart Microgrids and Networked Microgrids could serve as “sustainable platforms,”** enabling transition, innovation, retail market integration and transactive interaction: (1) Embrace diverse party collaboration; (2) Foster mutually beneficial relationships; (3) Promote customer utility and communications; (4) Enable rapid adaptation; Such platforms could support value-added “personalization” (heterogeneous services) through using cloud technologies and data analytics.
SHAPING CONSUMER BEHAVIOR AND “COST-REFLECTIVE” PRICING

- Advanced Microgrids and Networked Microgrids could help shape more rational, informed and efficient consumer behavior and decisionmaking;

- Smart Microgrids could offer risk management to reduce/minimize TE market risks for residential and small commercial customers that buy-into the systems;

- Smart Microgrids could help to promote the role of “real-time” markets in the evolution out of “cost-based” pricing to “market-based” pricing. Dynamic microgrids could help support the development of a “disaggregated” framework of “nodal” pricing, separating between decentralized energy decisions, based on local and time differentiated distribution network constraints. Within this framework, distribution system operators would provide disaggregated nodal pricing to promote optimal allocation of scarce network capacities; the framework would differentiate allocation problems at different network voltage levels, as well as differentiate different timing perspectives (Knieps, Disaggregated Nodal Pricing).
Microgrids Applied to Smart Cities

• Phase 1 (individual service level): Information and Communication Technologies (ICT) to improve individual city operations, such as real-time bus schedule

• Phase 2 (vertical service level): integrates related processes and services by smart technology, such as citizens offered information on transportation system’s real-time activity and emergencies, road conditions, road repairs, and detours

• Phase 3 (horizontal service level): no distinction between different service areas, with all parts now seamlessly integrated within an efficient smart city ecosystem
Electricity Supply Decentralization

City CCE and IDSO* Domain

Power Plants → HV Wires → LV Wires → Meter → On-site Renewables

*Independent Distribution System Operator
To capture synergies and co-benefits, coordinate and harmonize India’s Smart City and Smart Grid strategies; Develop mechanisms to coordinate relevant governmental activities and stakeholder participation;

To achieve the significant distributed resource objectives of India’s Smart City and Smart Grid blueprints, consider the need to develop a 3.0 Grid; and to design and implement demonstrations to test and quantify the cost-effectiveness of alternatives, such as microgrid systems, to traditional bulk power system investments;

To provide an economically viable opportunity for smart microgrid development, establish a consistent definition of microgrids; and valuation methods and cost-benefit analytical frameworks to quantify and monetize the value created by Smart Microgrid Energy Management Systems as distinctive from the value created by technology-specific applications;

Develop Open Source Architecture, Standards and Protocols, and Configurations to achieve interoperability, integration and flexibility and to spur competitive market opportunities;

Evaluate Utility regulatory reforms that are needed to change utility incentives and to align utility financial interests with the creation of long-term customer value.
Communities need to:

• Develop consistent and verifiable methods for assessing the benefits and costs of smart microgrid systems in their consideration of alternative technologies, practices and development scenarios;

• Develop cost-effective decision support tools and methods for integrated community energy systems planning and development;

• Evaluate and determine governance structures, financing mechanisms and procurement policies and procedures that take into account the net benefits of smart microgrid infrastructure to achieve smart city objectives and that can leverage private investment;

• Develop coordinated planning and development processes across organizational divisions to address the challenge that new smart grid and smart microgrid architecture will necessitate a certain level of openness to connect and integrate historically resource silos, while protecting end user privacy rights and mitigating cyber security risks.

Conclusions and Recommendations
• General MicroGrids: “Balancing Energy for a Smarter, Renewable-Driven Grid”

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“THANK YOU”