RENEWABLE ENERGY & ITS IMPLEMENTATION WITH MICROGRID

Presented By
Prof. Dr. S.M Ali
Director(Membership)
Institute of Engineers, India(IEI)
Kolkata
&
Ritesh Dash
PG Scholar
School of Electrical Engineering
KIIT University
Bhubaneswar
Contents

- Introduction
- Indian energy scenario
- Environmental impacts
- Renewable sources in India
- Microgrid
- Reintegration
- Challenges
- IEEE standard
- Mitigation
- Solar Policy
• Expanding access to energy means including 2.4 billion people: 1.4 billion that still has no access to electricity (87% of whom live in the rural areas) and 1 billion that only has access to unreliable electricity networks. We need smart and practical approaches because energy, as a driver of development, plays a central role in both fighting poverty and addressing climate change.

Rebeca Grynspan, UNDP Associate Administrator and Under Secretary General, Bloomberg New Energy Summit, 7 April 2011
In India, since a decade ago depletion of the conventional energy sources had begun. Load demand was on increasing trend due to rapid increase in industrialization and population. This has forced researchers to look forward for other sources of energy. Sustainable Renewable Energy has been found as the future green energy solution.

A worldwide research on deployment of microgrid with the utilization of distributed energy resources is going on. In context to India microgrid seems to be future energy solution for economic development.

80% villages are powering for only 8 to 10 hours per day without quality due to forced load shedding. Yet 20% villages are surviving without electricity, being having tremendous potential for renewable energy.
ENERGY CONSUMPTION

Per Capita Energy Consumption (kgoe)

- India: 530
- World: 1770

Per Capita Electricity Consumption (KWh)

- India: 704
- World: 2500

Energy Demand (Mtoe)

- 2003-2004: 572
- 2016-17: 879
- 2026-27: 1484

Demand Deficit

- Peak Demand: 15%
- Average Demand: 9%

Source: CEA
WHY MICROGRID

LCOE for DG in Commercial Applications

- 50 kW Microturbine
- 1 MW Industrial Turbine
- 400 kW PureCell
- 200 kW SOFC

Price of Natural Gas ($/MMBTU)

$0.25

$0.20

$0.15

$0.10

$0.05

$0

$2 $4 $6 $8 $10 $12 $14 $16

Resiliency

Remote Power Systems
Microgrid is a contained network of energy generation sources and energy storage that are connected to the loads that consume the electricity. The generation can be from renewable sources, thus reducing the need to produce energy from fossil fuels.

Microgrid simply an integration of distributed energy sources generation into distribution operation and planning. Microgrid comprise a network of small scale distributed energy resources (DERs) like fuel cells, micro turbines, PV arrays and wind turbine etc. and energy storage devices.
In Indian context a microgrid can have several possible applications as to transform the current unreliable power supply to a reliable one needing suitable technologies in each case.

- A village or a cluster of villages
- University campuses/Institutions, R and D centers
- Hospitals
- Island communities
- Large Industrial complexes
- Small townships
Renewable Energy Integration focuses on incorporating renewable energy, distributed generation, energy storage, thermally activated technologies, and demand response into the electric distribution and transmission system.

The goal of Renewable energy integration is to advance system design, planning, and operation of the electric grid to:

- Reduce carbon emissions and emissions of other air pollutants through increased use of renewable energy and other clean distributed generation.
- Increase asset use through integration of distributed systems and customer loads to reduce peak load and thus lower the costs of electricity.
- Support achievement of renewable portfolio standards for renewable energy and energy efficiency. Enhance reliability, security, and resiliency from microgrid applications in critical infrastructure protection and highly constrained areas of the electric grid.
- Support reductions in oil use by enabling plug-in electric vehicle (PHEV) operations with the grid.
MICROGRID…… ELEMENTS TO CONSIDER

Microgrid – a distributed resource (DR) island system

**Characteristics:**
- Has Distributed Resources and load
- Ability to disconnect and parallel with distribution system
- Intentional and planned islanding

**Technical:**
- Proper control of voltage/ frequency/power quality
- Protection schemes and modifications
- Changes in power-flow magnitude and direction
- Steady state and transient conditions
- Reserve margins, load shedding, demand response, and cold load pickup

**Operational:**
- Safety – Lockout/tag-out
- Protection coordination
- Load to generation matching
- Load (phase) imbalance
- Microgrid communications, monitoring and dispatch (mini EDC)
- Ongoing maintenance

**Economic:**
- Microgrid and non-microgrid customer impacts
- Balancing of cost vs. reliability
- Lifespan of installed system
India Power Generation Mix

- Coal: 52%
- Gas: 11%
- Diesel: 1%
- Hydro: 24%
- Nuclear: 3%
- Renewable: 9%
- Small Hydro: 1%
- Biomass: 1%
- Others: 0%
- Wind: 7%

Renewable Power Generation Mix – India (2022)

- Solar: 29%
- Wind: 53%
- Bio Power: 10%
- Small Hydro: 8%

Opportunities

Wind Power:
- To be added

Solar Power:
- Technologies to reduce cost of generation.
- Developing effective storage capacity, especially for monsoon season.
- Developing domestic manufacturing capability to reduce costs and to meet the targets specified under National Solar Mission.

Small Hydro:
- Product development to reduce cost and improve reliability and other performance parameters of equipment.
Following are the various typical issues in RE integration:

- Data and forecasting
- Scheduling flexibility and incentives
- Day-ahead market participation and reliability commitments
- Balancing authority coordination
- Reserve products and ancillary services
- Capacity markets
- Real-time adjustments
CHALLENGES WITH INTEGRATING RE SOURCES INTO ELECTRICAL POWER SYSTEMS

- Most RE resources is location specific. Therefore, renewable-generated electricity may need to be transported over considerable distances.
- Certain RE sources lack the flexibility needed to deal with certain aspects of power system operation, in particular balancing supply and demand. Overall balancing will become more difficult to achieve as partially dispatch able RE penetrations increase.
- Depending on local system penetration, network faults can trigger the loss of significant amounts of generation if the renewable generation resources are concentrated in a particular section of the power system and connection requirements have not properly accounted for this risk.
• At high penetration levels the need for frequency response will increase unless supplementary controls are added. Many of the renewable technologies do not lend themselves easily to such service provision.

• In addition, RE interfaced through power electronics may displace synchronous generators, thereby reducing the overall system inertia and making frequency control more difficult.

• There is the additional challenge of managing the transition from the predominant generation mixes of today to sustainable sources required for the low carbon power systems of the future.

• Major changes will be required to the generation plant mix, the electrical power systems infrastructure and operational procedures if such a transition is to be made. Specifically, major investments will be needed and will need to be undertaken in such a way, and far enough in advance, so as to not jeopardize the reliability and security of electricity supply.
MITIGATING MEASURES IN RE INTEGRATION

• Flexible generation, Ancillary Services, Reserves etc. For supply-balancing.
• Demand Side management, Demand Response and Storage for load balancing.
• Strong Grid interconnections.
• Forecasting of Renewable generation & Forecasting of Demand.
• Establishment of Renewable Energy Management Centres (REMC) equipped with advanced forecasting tools along with reliable communication infrastructure.
• Deployment of Synchrophasor technology i.e. Phasor Measurement Unit (PMUs)/Wide Area Monitoring System (WAMS) on pooling stations and interconnection with centralized control centre through Fiber Optic Communication for real time information, monitoring and control.
• Institutional arrangements with defined roles & responsibilities of various agencies/generation developers.
• Technical Standard Requirements (Grid code, Connectivity standards, Real time monitoring etc.)
• Policy advocacy for development of power-balance market and pricing mechanism.
# Solar Policy Landscape

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1,100 MW</td>
<td>4,000 MW</td>
<td>20,000 MW</td>
</tr>
</tbody>
</table>

### Phase 1

<table>
<thead>
<tr>
<th>Category</th>
<th>Size of Project</th>
<th>Status of Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 MW, Small scale Projects</td>
<td>0.1 to 2 MW grid connected</td>
<td>Projects have already been shortlisted</td>
</tr>
</tbody>
</table>

### Phase 2

<table>
<thead>
<tr>
<th>Category</th>
<th>Size of Project</th>
<th>Status of Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 MW Off-grid and decentralized applications</td>
<td>Up to 100 kW</td>
<td>Applications open from center.</td>
</tr>
</tbody>
</table>

### Phase 3

<table>
<thead>
<tr>
<th>Category</th>
<th>Size of Project</th>
<th>Status of Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 MW Grid Connected Solar Photovoltaic technology</td>
<td>5 MW +/- 5%</td>
<td>FY 2010-11 50 MW</td>
</tr>
<tr>
<td>500 MW Grid connected Solar Thermal Projects</td>
<td>5 MW +/- 5%</td>
<td>FY 2010-11 500 MW</td>
</tr>
<tr>
<td>500 MW Grid Connected Solar Photovoltaic technology</td>
<td>5 MW +/- 5%</td>
<td>FY 2011-13 350 MW</td>
</tr>
</tbody>
</table>
There are several standards specifying various aspects grid interconnection of a local power generation source. Arguably the most important one is IEEE 1547.

IEEE 1547 has several parts:

- Main body
- IEEE Standard 1547.5 has not been issued, yet. Its intended scope is to address issues when interconnecting electric power sources of more than 10 MVA to the power grid.
- IEEE Standard 1547.6 “IEEE Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks.”
- IEEE Standard 1547.8 has not been issued, yet. Its intended scope is to provide supplemental support for implementation methods for expanded use of the previous standards, for example when addressing issues with high penetration of residential PV systems.
MICROGRIDS are...

Multiple distributed resources controlled as a single entity with respect to the grid

But they can be more than that...

A fundamental shift in the way that the electric grid is built, operated, and financed.

A Threat or Opportunity to utilities depending upon how the transition occurs
## MICROGRIDS CAN HELP OR HURT TODAY’s UTILITY

<table>
<thead>
<tr>
<th>Value/Opportunity</th>
<th>Cost/Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Absorb renewable intermittency at the source</td>
<td>• Revenue reduction (demand and kWh)</td>
</tr>
<tr>
<td>• Avoided cost benefit</td>
<td>• Negative power system impacts</td>
</tr>
<tr>
<td>• Low-cost ancillary services</td>
<td>• Utility customer disintermediation</td>
</tr>
<tr>
<td>• Demand response</td>
<td>• Higher cost if we passively manage DG on the grid (DERMS)</td>
</tr>
<tr>
<td>• More resilient grid</td>
<td></td>
</tr>
<tr>
<td>• New value-add service from utility (growth opportunity)</td>
<td></td>
</tr>
</tbody>
</table>
GOALS OF THE DISTRIBUTED RESOURCES BUSINESS MODEL

Objectives

- Ensure designs and operations are grid-friendly
  - Influence the design, location, and operation of microgrids to maximize operational value and minimize operational cost to the grid.

- Provide incentive to cooperate
  - Provide the ability (information) and incentive ($) for customers to design and operate distributed generation in a way that benefits the grid.
  - Compensate distributed generation operators in a way that truly reflects the benefits and costs to the grid.

- New value-add growth opportunity
  - Create growth opportunities to provide value-add services to microgrid owners and operators.
  - Opportunity to own distributed assets.

Desired outcome

- First, do no harm
- Benefit both parties
- New Services
How can a microgrid benefit an individual customer and the grid?

- **Provide resiliency to a critical facility**
  - Fire station will be able to operate during periods of prolong grid outages.

- **Utilize utility-owned, utility sited assets**
  - All equipment is owned and operated by Duke Energy. No alterations behind the customer meter.

- **Demonstrate ancillary and grid stability services:**
  - Frequency regulation
  - Circuit voltage support (VAR dispatch)
  - Demand response through islanding
  - Mitigating solar intermittency at the source
Imagine being transported 10 years into the future. You are moving into a new home and call for utility service. You are surprised at the choices that are available:

- Distributed renewable generation;
- Net zero energy construction;
- Community solar;
- Electric vehicles that allow owners to charge vehicles and sell storage services to the grid based on prices that optimize their financial investments;
- Green commodity services that are available from the utility or third parties;
- After meter services that automate demand in response to prices and/or emission levels associated with electricity use while allowing remote control of devices through the internet; and,
- Customized combinations of the forgoing as well as other services.
- Microgrid solutions to improve power quality, reliability, or reduce costs

Utilities and regulators have realized that all customers are different and empowered them in a way that lowered emissions and was fair to all customers.

*How did this happen?*
PUBLIC POLICY

- AB32 (state GHG emissions at 1990 levels by 2020)
- RPS (33% by 2020)
- CSI
- Net Energy Metering
- SB32 (Feed-in Tariffs)
- Low Carbon Fuel Standard
- SB17

What changes are required in the energy industry to make this transition achievable in the long term?
OPTIONS FOR UTILITY AND GRID

Customers and utilities have growing opportunities to leverage a number of behind the meter technologies:

• Distributed generation
  • Solar
  • Wind
  • Fuel Cells
• Energy storage
  • Reduced bills
  • Increase reliability
  • Provide capacity services
  • Energy arbitrage
• After-meter services
  • Demand automation
• Microgrid solutions
  • Power quality
  • Reliability
  • Cost effective alternative to grid expansion?
OPPORTUNITIES FOR UTILITY

- Support the integration of renewable resources
- Improve reliability and power quality
- Support emergency operations
- Ability to “ride through” outages
- Optimize energy usage
- Enable participation in new markets for demand response and ancillary services
Role of utilities

- How can utilities leverage microgrid technologies to improve reliability, power quality and/or to reduce costs?
  - Integration of renewable resources
  - Improved reliability and power quality
  - Support emergency operations
  - Ability to “ride through” outages
  - Optimize energy usage
  - Enable participation in new markets for demand response and ancillary services

- What utility rate design is necessary to promote technological innovation in distributed technologies, ranging from Distributed Generation to a full microgrid solution?
THE UTILITY OF THE FUTURE

• An I-Phone creates a platform for customization
  • Third parties develop apps that target services that customer’s value
  • Customers love the I-Phone because it allows them to customize their phone and their phone service

• The utility grid will do the same thing:
  • Some customers may want DG
  • Some may want an EV
  • Some may want distributed storage
  • Some may want to sell services to the grid
  • Some may want community solar
  • Others may want a green tariff from their utility, service from an ESP, or customary utility procurement service
MICROGRIDS – KEY BUSINESS QUESTIONS

- Will technologies continue to improve and will costs decline enough?
- What will be the pace of technological change and timing of market development?
- Can investor owned utilities earn a return on investing in “community power” systems?
- How should we think about breaking “the grid” into smaller operating segments? (to what extent a “grid of grids”?)
- Will microgrids be a good platform for deploying greater amounts of cleaner, generation in the future?
- Will utility customers choose to take advantage of emerging technologies?

In the long run, will customers be willing to pay for grid improvements and migration to a more interactive, cleaner operation based on microgrids?
MICROGRIDS – KEY TECHNICAL QUESTIONS

• What are the critical parameters and their range of values for reliable and cost effective microgrid operations?
  • Optimum scale – MVA?
  • Automated – trustworthy and cyber-secure
  • Optimum mix of generation, storage and load?
  • Low inertia generation – will power quality and stability be problematic?
  • Cleaner generation - distributed?
  • Can a 9 be added to overall reliability – even with greater adoption of distributed renewable generation and storage?

The electric utility industry has the core capabilities to contribute to microgrid technology development and deployment
• Need more analysis of system stability and integrity.
• Grid protection studies to be analysed.
• Grid technical standards should be cover technical feasibility as well as specific location of RE.
• Formation of number of small grids & making them strongly interconnected.
• Formation of Renewable Energy management Centres for proper R&D.
• Need of Fiber Optic Communication for real time information, monitoring and control.
• Analysis of the issue of supply unbalancing.
• Transformation of microgrid system today into the intelligent, robust energy delivery system in the future by providing significant reliability and security benefits.
• To investigate full scale development, field demonstration, experimental performance evaluation of frequency and voltage control method under various operation modes.
CONCLUSION

• The electricity sector in India had an installed capacity of 254.049 GW as of end September 2014. India became the world’s third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia.

• Still we require another 19% of global share to meet our daily need. So more focus must be given to the renewable sector to achieve this demand.
Together...Shaping the Future of Electricity