The Future of Distribution Systems in the Deregulated Environment:
Opportunities and Challenges

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Presentation Outline

- Historical Perspective
- Current Dilemma
- Emerging Future: Driving forces
- Creative Responses to Changing Culture
- Crystal Ball Predictions for Future
Historical Perspective

- Most Attention on Bulk Systems
- Capital Intensive
- Benign Neglect
- Poor Planning
- Inefficient Operation
- No Respect for Cost
Current Dilemma

- Deregulation or Re-regulation is a Fact
- Electricity is Expensive
- Global Demand Increasing
- National Economic Growth
- Population Growth
- Better Awareness of Public
- Higher Expectations from Customers
Emerging Future

- Driving Forces
  - Market Needs
  - Regulatory Agencies
  - Technological Issues
Emerging Future - Markets

Markets: Keyword is - Need

- Diverse needs of Markets
  - Large Industrial Customers
  - Residential Customers
  - Generation and Transmission Companies
  - Distribution Companies
Market Needs

- **Large Industrial Customers Need**
  - Highly Reliable Power Supply
  - High Power Quality
  - Controllability of:
    - Frequency (For Variable-speed drives)
    - Wave Shape (As in Rectifiers/Inverters)

- **Residential Customers Want**
  - Low-Cost Energy
Market Needs

- **Generation and Transmission Companies Need:**
  - **Local Support**
    - Peak Load, Stand-by Reserve
    - Ancillary Services
      - Power Quality
      - Reliability
      - Reactive Power
  - **Distribution Companies Need:**
    - **Reduced O&M Costs**
      - Improved Reliability
      - System-wide SCADA
      - Performance Based Rate Making
Emerging Future - Regulation

Regulators: Keyword is - Ensure

- Obligation to Protect Interests of
  - People
    - Safety of personnel and equipment
  - Small and Large Businesses
    - Fair-play
  - Environment
    - Clean/Green Technologies

- Federal Energy Regulatory Commission
- Public Utility Commissions (State)
Regulatory Issues

- Uncoordinated proliferation of distributed generation equipment can lead to serious safety problems.

- Typically, development of market and engineering infrastructure precedes "regulation".
  - Use experiences from other countries.
Regulatory Challenges

- Develop procedures for installation and operation of distributed resources

- Develop measures and calculation methods for assessing reliability and power quality of new distribution technologies
Emerging Future - Technology

- Technology: Keyword is - Facilitate

- Technological Break-throughs
  - Power Generation
  - Optimization Techniques for Resource Utilization
  - Communication Technologies
  - Power Electronic Devices
Technological Solutions

Distributed Generation
- Micro Turbines
- Fuel Cells

High Power Electronics
- Controllers for Drives
- Power Supplies
- Power Quality Modulators

Communication and Information
- Micro-sensors
- Metering Technology

Economics of Reliability
- Reliability Centered Maintenance Techniques
Distributed Generation

- **EPRI Estimate**
  - 25% of the new generation facilities by the year *2010* Distributed would be Distributed resources

- **Distributed Generation Technologies**
  - Micro turbine
  - Fuel Cell
  - Battery
  - Flywheel
## Distributed Generation Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Size</th>
<th>Efficiency</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro Turbine</td>
<td>25-100 kW</td>
<td>25-30%</td>
<td>$350 / kW</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>20-2,000 kW</td>
<td>30-45%</td>
<td>$2,000 / kW</td>
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<tr>
<td>Micro Turbine + Fuel Cell</td>
<td>100-2,000 kW</td>
<td>60-70%</td>
<td></td>
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<tr>
<td>Battery</td>
<td>10-500 kWh</td>
<td>70-80%</td>
<td>$500 / kWh</td>
</tr>
<tr>
<td>Fly-wheel</td>
<td>2-100 kWh</td>
<td>70-80%</td>
<td></td>
</tr>
</tbody>
</table>
Problem Areas

- **Speed of response**
  - Most systems are sluggish
  - Need back-up storage devices

- **Control and dispatch** a large number of distributed generators

- **Protection coordination**
  - Fault location
  - Isolation
  - Restoration coordination
Resource Utilization

Economics of Reliability

* Budgeting for preventive maintenance is mostly by heuristics*

* Optimization principles must be used right from planning stage*

* Optimum planning requires knowledge of*
  - fault cause models,
  - utility and customer cost of outages, and
  - cost of maintenance
Resource Utilization

- **Problem of aging equipment:** Need-
  - Accurate models for failure mechanisms
  - Realistic estimates of cost of outages

- **A program very much in use is:**
  - RCM and Condition Monitoring for substation transformers

- **Need to develop similar techniques for other distribution system equipment**
  - Example: Monitor exposure of:
    - overhead lines to trees
    - insulators to pollution
Resource Allocation

- **Economics of Reliability**
  - Performance based rate making (PBR)
    - Customer pays less for power that is expected to be “a little less reliable”!
    - “A little less reliable” ≠ Unreliable!!
    - Helps the utility to **focus planning-resources** on the more “critical” customers
Communication Technologies

- Advanced *micro-sensors* for *distribution system* SCADA

- Benefits include
  - Enhanced *fault-location* and isolation
  - *Condition-monitoring* of field equipment
  - *Real-time* customer loads

- *Cost* is still a concern
Power Electronics Solutions

- **Power Electronic (PE) Devices**
  - Large number of PE controllers installed on customer premises
    - Variable speed drives
    - Phase-angle regulators in fans
    - Rectifiers and inverters
Problem Areas

- Seen from line side, most PE devices are highly non-linear loads

- They generate a wide variety of:
  - Power Quality (PQ) harmonics
  - Voltage sag
  - Flicker problems

- What is the impact of PQ on performance of:
  - Distribution protection equipment?
  - Distribution SCADA systems?
Concluding Remarks

Creative and innovative ways to organize DISCO’s role to bundle the service that best fits the customer needs:

- Radical cultural change
- Flexibility

Customer satisfaction:

- Rate based price structure vs. Power quality and reliability based pricing

Distributed generation
Concluding Remarks

- **Innovation is the key**
  - There is always a **use** and a **need** for an **innovative product**

- **Regulators should** **preserve** the **incentive for innovators** of technology
Concluding Remarks

- Tremendous engineering innovation is currently involved in shaping the future.

- There are a wide variety of market players facilitating this development.

- Independent regulatory effort is needed for a smooth and coordinated transition into the future.
Concluding Remarks

- We are faced with a significant number of open questions.

- With all these changes distribution systems have become a fertile ground for:
  - Innovators
  - Investors
  - Investigators
Crystal Ball Predictions for Future

- Systems will become More Complex
- Optimum Planning & Operation is Imminent for Efficiency Improvement
- Adopt New Technologies
- Adapt to Changing Culture
- Why Sinusoidal Systems?
- Totally Independent Customer Owned Systems?
- Why Distribution be Radial?