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

Distributed Generation Technologies

Technology	Size	Efficiency	Cost
Micro Turbine	25-100 kW	25-30%	$350 / kW
Fuel Cell	20-2,000 kW	30-45%	$2,000 / kW
Micro Turbine + Fuel Cell	100-2,000 kW	60-70%	
Battery	10-500 kWh	70-80%	$500 / kWh
Fly-wheel	2-100 kWh	70-80%	

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 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?