Outline

• Company Overview
• Basic Concepts
• Con Edison System Losses
• Programs providing Loss Reduction
• Next Steps
Company Overview

Service Territory
- Customers: 3,200,000
- Population: 9,100,000
- Area: 604 mi²
- Peak Demand: 13,141 MW
- Con Ed Load Density: 21.8 MW/mi²
- NY State Load Density: 0.7 MW/mi²

System Voltages
- Transmission: 345kV, 500kV, 230 kV, 138kV, 69kV
- Primary Distribution: 33kV, 27kV, 13kV, 4kV
- Secondary Distribution: 120/208V, 265/460V
Company Overview

- Con Edison Service Territory represents **1.3%** of NY State Area
- Con Ed Service Territory represented **34.9%** of NY State 2007 Electricity Usage
- Con Edison expects to deliver **40.7%** of NY State 2008 peak demand
Electric System Efficiency

**Generation**
- Large Gas Turbine: 31%
- Fossil Fuel: 33%
- Combined Cycle: 45%
- ERRP: 68%
- Average Efficiency: 33%

**Transmission & Distribution**
- Transmission: 98.8%
- Distribution: 96.5%
- Average Efficiency: 93%

**Customers**
- Incandescent Lighting: 8-12%
- Room Air Conditioners: 15-30%
- Commercial Refrigeration: 55%
- Commercial HVAC: 65%
- Average Efficiency: 15-45%
Electricity Flow 2007 (Quadrillion BTU)
Annual Energy Review 2007

Source: Department of Energy, Energy Information Administration
Transmission & Distribution Losses

Cable & Wire

- Copper Losses ($I^2R$) (Load)
- Dielectric Losses (No Load)
- Corona Losses (No Load)

Cable Losses as Percent of Load
750 kcmil Copper Conductor

- Load Losses
- No-Load Losses, PILC Insulation
- No-Load Losses, EPR Insulation
Transmission & Distribution Losses

Transformers

- Copper Losses (Load)
- Core Losses (No Load)
Transmission & Distribution Losses

Reactive Power Losses

- Reactive Power (VAR)
- Power Factor = Real Power/Apparent Power
- Power Factor Decreases with Increased Reactive Load
- Low Power Factor Increases Losses
Con Edison System Design

Generating Station
(electricity generated at 13.8 to 22.0 kV)

Transmission Substation

Area Substation
(voltage stepped down to distribution voltage)

Transformers
(voltage stepped down to 480, 208, or 120 V)

60 Network Systems
Supply 86% of System Demand

Overhead System
Supplies 14% of System Demand

Connection To Others
Transmission & Distribution Losses

Con Edison

- 1.2% Transmission Losses
- 3.6% Distribution Losses
- 2.2% Other Losses
Average Seasonal Energy Usage Vs. Losses

2007

Winter Energy Usage | Winter Losses | Summer Energy Usage | Summer Losses
------ | -------------- | ------------------- | ---------------
9.73% | 4.41% | 9.73% |
Energy Efficiency Programs Reduce Losses

• 1971: *Save-A-Watt* program – 200 MW reduction


• 2004-08: Targeted DSM Program ~ 200 MW under contract

• Proposed 500 MW reduction for 2015
Energy Efficiency Programs Reduce Losses

Peak Shaving Programs

• Installed Capacity Programs (ICAP)

• Emergency Demand Response Program

• Day-Ahead Demand Reduction Program (DADRP)

• Distribution Load Relief Program (DLRP)
Transmission Losses Reduction

- Transmission Line Design
  - Larger Conductors
  - Low Corona Hardware
  - Low Reactance Phasing Arrangement
  - High Voltages
- Power Transformer Design Loss Guidelines
- Voltage Profile
  - Capacitor Banks
  - Transformer Tap Changers
Transmission Losses Reduction

• Balanced Power Flow
  – 21 Phase Angle Regulators
• Seasonal Bypassing of Series Reactor
• Load Flow Studies
Transmission Losses Reduction

Energy Control Center
Distribution Losses Reduction

- Low Loss Transformers & Cables
- Distribution Capacitor Installation
- Paper Insulated Lead Cable (PILC) Cable replacement
- Overhead wire replacement
- Advanced Remote Monitoring System
- Clean Distributed Generation

Replace Approximately 1600 Transformers a Year
Distribution Losses Reduction
Theft of Service Prevention

• Comprehensive Program
• Sources of Leads
  – Employee Incentive Programs
  – Theft Hotline
  – Special Exercises
• Machine Learning Tools
  – Neural Networks
  – Customer Billing System Citations
  – Historical Usage Trending
  – Load Factor Review
• Benchmarking
Transmission & Distribution Losses Reduction

Power Factor

- Average Load Power Factor is 0.9
- Power Quality Nodes at Area Substations
- 20% Copper Losses caused by the Power Factor of our Customer's equipment
  - 0.64% of Total Losses
- Current Tariffs address standby and buyback customers with induction generation
  - Cogeneration Specifications require correction to 0.9 PF
  - 31 cents/KVAR per month
Transmission & Distribution Losses Reduction

Next Steps – Transmission Design

- Superconducting cable
- High Temperature Superconducting Fault Current Controllers
- Flexible AC Transmission System (FACTS)
- High Voltage Direct Current (HVDC)
Transmission & Distribution Losses Reduction

Next Steps - Distribution System Automation

• Expansion & Integration of Automated Metering Infrastructure (AMI)
• Network Secondary Modeling & Monitoring
Transmission & Distribution Losses Reduction
Next Steps

• EPRI National Green Circuits Initiative
  – Optimal VAR Reduction
  – Voltage Control
• Smart Grid Initiatives
• Comprehensive Study Planned
Conclusions

• Investments that cost effectively reduce losses should be pursued

• Increasing asset utilization to control capital costs often conflicts with effort to increase efficiency

• Need to be cautious about adding capital investment solely to reduce losses

• Infrastructure investments are reducing losses
Con Edison
Transmission & Distribution Losses
Technical Conference
July 17, 2008
Orange & Rockland
Transmission and Distribution Losses
Technical Conference

July 17, 2008
Company Overview

Orange and Rockland
Rockland Electric Company
Pike County Light & Power

Sullivan
Pike
Sussex
Orange
Passaic
Bergen
Rockland
# Company Overview

## Company Data

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<thead>
<tr>
<th></th>
<th>Electric</th>
<th>Gas</th>
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<tbody>
<tr>
<td>Number of Employees</td>
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<td>1,062</td>
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## Customer Data

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<thead>
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<th>Electric</th>
<th>Gas</th>
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<tbody>
<tr>
<td>Total Customers Served</td>
<td>298,322</td>
<td>127,371</td>
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<tr>
<td>New York</td>
<td>221,451</td>
<td>126,199</td>
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<tr>
<td>New Jersey</td>
<td>72,274</td>
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<tr>
<td>Pennsylvania</td>
<td>4,607</td>
<td>1,172</td>
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## System Data

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Miles of Overhead Electric Distribution Lines</td>
<td>3,643</td>
</tr>
<tr>
<td>Miles of Underground Distribution Lines</td>
<td>1,569</td>
</tr>
<tr>
<td>Miles of Electric Transmission Lines</td>
<td>593</td>
</tr>
<tr>
<td>Miles of Gas Pipeline</td>
<td>1,886</td>
</tr>
<tr>
<td>All-time Record Peak Demand for Electricity (8/2/06)</td>
<td>1,617 Megawatts</td>
</tr>
<tr>
<td>All-time Net Firm Sendout Record for Gas (1/15/04)</td>
<td>206,168 Dekatherms</td>
</tr>
</tbody>
</table>

*All data is as of the end of 2007, except where noted otherwise.*
System Statistics

- 1350 Square Miles

- Internal Transmission
  - Voltages - 138kV, 69kV, 35kV

- Substations
  - 56 Area Distribution Stations

- Distribution
  - 242 Distribution Circuits
    - Predominantly 13.2kV – 85%
    - Others - 2.4kV Delta, 4.8kV Delta, 4.16kV, 34.5kV
    - 70,000 Transformers
## ORU Load/Customer Density Summary

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>LOAD DENSITY (MW/Sq. Mi.)</th>
<th>Cust. Density (Cust./Sq. Mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern</td>
<td>5.0098</td>
<td>809.25</td>
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<tr>
<td>Central</td>
<td>0.5510</td>
<td>164.16</td>
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<tr>
<td>Western</td>
<td>0.5381</td>
<td>119.56</td>
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<tr>
<td>Total</td>
<td>1.4044</td>
<td>269.34</td>
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</tbody>
</table>
Orange and Rockland
Annual System Losses

- Total System Losses 5.0%
  - Internal Transmission 1.6%
  - Radial Distribution 3.4%
  - Unaccounted For Negligible
System Loss Determination

• Total System Inputs
  – Generation, Bulk Power Taps

• MINUS

• Total Metered Output
  – Revenue Meters, Fixed Use

(Calculated on a monthly basis)
Electric Loss Theory

• Causes
  – Conductor Resistance
  – Transformer Iron Cores

• Magnitude
  – Resistance Losses $I^2 \times R$
  – Transformer Core – Approximately Constant
Theoretical Loss Mitigation

- **Resistance Losses**
  - Reduce $I$ (current) or $R$ (resistance)
    - Lower resistance conductors
    - Lower current
      - Generation should be close to load
      - Optimize conductors and loadings economically
      - Increase voltage
      - Reduce reactive power flow
        - Capacitors, SVC’s, Local VAR Generation

- **Core Losses**
  - Larger (weighty) Cores
  - Amorphous Core Material
O&R System Reactive Power

• On Peak Requirement 1000 MVars
  – System power factor – 0.85
  – Internal Substation MVars 178 MVars
  – Distribution System MVars 392 MVars
    • Switched capacitors for voltage support
    • Average circuit pf on peak – 0.957

• Off Peak is not optimized
Annualized Capacitor Costs

• Substation Capacitors
  – $4,500/MVar

• Distribution Capacitors
  – $2,000/MVar
35 MVA 69/13 kV Transformer Losses

- At 100% Load
  - Total Hourly Loss – 215 KWH
    - Core Losses – 15 kW
    - Winding Losses – 200 kW
- At 30% Load
  - Total Hourly Loss – 33 KWH
    - Core Losses – 15 kW
    - Winding Losses – 18 kW
Distribution Primary Conductor Loss

• 477 Al Conductor – Mainline Conductor
  – At 100% Load – 212 kW/mile
  – At 30% Load – 19 kW/mile

• 3/0 ACSR Conductor – Branch
  Conductor
  – At 100% Load – 172 kW/mile
  – At 30% Load – 15 kW/mile
Sample 13 kV Distribution Circuit Loss

- 3.5 Miles of Mainline Conductor
- 24.5 Miles of Branch Conductor
- 2,000 Customers
- Planned Peak Loading 500 amperes
  - Total Circuit Loss at Peak 434 kW
  - Total Circuit Loss at 30% 97 kW
Distribution Transformer Losses

• Typical 25 KVA Transformer
  – At 130% Loading
    • Core Losses 51 watts
    • Winding Losses 781 watts
  – At 100% Loading
    • Core Losses 51 watts
    • Winding Losses 462 watts
  – At 30% Loading
    • Core Losses 51 watts
    • Winding Losses 41 watts
O&R Loss Minimization Initiatives

• Bulk System Dependency Minimization
  – Lovett Generation (-180 MVar)
  – Substation Switched Capacitor Banks
    • 178 MVar installed now
    • 190 MVar to be installed in next 5 years
  – No Dynamic MVars planned
O&R Loss Minimization Initiatives

- Internal Transmission and Substations
  - Substation Capacitor Banks
  - New Larger Transmission Conductors
  - New Transmission and Distribution Substations
  - Loss Minimized Transformers
  - Lower Planned Transformer Peak Loadings
  - Balanced Loading and >0.95 pf at Substations on Peak
O&R Loss Minimization Initiatives

- Distribution System
  - Reconductoring Primary and Secondary Wires
  - Converting to Higher Voltages
  - Lowering Planned Circuit Peaks
    - New Substations and Circuits
  - Load Phase ID Program and Phase Balance at Peak
  - Purchase Lower Loss Transformers
    - 2010 DOE Standards
      - Typical 25 KVA Transformer Loss Reduction of 54 watts @ 100%
      - Improved Field Capacitor Control
Smart Grid Opportunities

• Dynamic Monitoring and Control
  – HVAC Energy Management System Analogy

• Dynamic Theoretical System Modeling
  – Distribution Engineering Workstation
  – Asset Data and Visualization Tool

• More Communications to Field Devices and Meters
Loss Minimization Cautions

• Transformer Loss Reduction
  – Susceptibility to ferro-resonance
  – Higher through-fault currents
    • Life reduction
  – Higher inrush currents
    • Susceptibility of momentary interruptions

• Greater Installed MVars
  – Voltage Excursions
  – Protection Mis-operation
Conclusions

• Investments that cost effectively reduce losses should be pursued.
• Loss minimization at peak is a primary focus.
• Transformer core losses are minimal but embedded in the system for their life.
• Planning and design can be economically optimized, with more weighting given to losses.
• Routine infrastructure upgrades and new equipment are reducing losses.
• Smart Grid can provide the capability to dynamically optimize system operation, including losses.
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