Systems Loss Reduction

TechAdvantage, March 6, 2014
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Outline

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> Loss Reduction Techniques
> Impact of Smart Grid Technologies on Losses
> Management Guidelines
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Introduction

> The largest electric consumer is the electric grid itself, consuming 6-8% of energy generated.  
  *source: Energy Information Administration*

> T&D losses are costing the U.S. approximately $9 billion each year.

> Losses are inherent to the grid operations but there is room for improvement in most cases.
Introduction

> Average distribution co-op losses are 5-6%

> Co-ops that borrow through Rural Utilities Service (RUS) and National Rural Utilities Cooperative Finance Corporation (CFC) are required to report their losses to NRECA.

> Roughly 97% of distribution co-ops report their losses
Understanding Total System Losses

> Non-technical losses can result from problems with meter reading and related accounting or energy theft.

> Technical losses are associated with the loss of energy due to energization of equipment (fixed losses) and current flowing through electrical devices (variable losses).

> Fixed losses are defined as energy required by the system to energize equipment and keep the system ready, even when no load is being serviced.

> Variable losses are the losses that are incurred as load is added to the system and changed in proportion to the load.
Understanding Total System Losses

**Metering vs. Analytical Calculations**

- Installing energy meters may be costly.
- Coincident measurements are required.
- Accuracy is important.
- Power system modeling software is generally used for analytical calculations.
- Modeling errors are introduced.

**Calculating Peak Losses vs. Annual Energy Losses**

- Analysis using distribution system models typically evaluates peak load scenario.
- However, losses are present in the system throughout the year. Majority of losses happen off-peak.
Understanding Total System Losses

Load and Loss Factors

> Factors that represent the relationship between peak losses and average losses

Calculating Losses by Distribution System Components

> Substation transformer losses
> Distribution primary line losses
> Capacitor and voltage regulator losses
> Distribution transformer losses
> Equipment and meter losses
> Service and secondary losses
Loss Reduction Techniques

- Voltage optimization
- Power factor correction
- Increasing primary conductor size
- Adding a (parallel) feeder
- Upsizing conductors or reconfiguring secondary network
- Changing out a distribution transformer
- Using amorphous core transformers
- Voltage conversion
- Updating substation auxiliary equipment
- Adding substation transformers
- Upgrading metering technology
- Updating street lighting technology
Loss Reduction Techniques
Voltage Optimization

Voltage Optimization (VO) is the concept of tuning the circuit to achieve a flattened voltage profile before implementing CVR in order to produce greater savings than CVR alone.
Loss Reduction Techniques

Voltage Optimization

> Leidos performed Voltage Optimization studies for Northwest Energy Efficiency Alliance’s (NEEA) Distribution Efficiency Initiative

> Studied seven utilities that included 21 substations and 70 distribution feeders.

> Total energy savings was estimated at 1.3 percent and 19,837 MWh/year

> 11.3% of the savings were from system loss reductions and 88.7% from end-use customer load.
Loss Reduction Techniques
Power Factor Correction

> Certain customer inductive loads, distribution lines, and transformers require reactive power to be supplied by the electric grid.

> Addition of reactive power (VAR) increases the total line current, which contributes to additional losses in the system.
Loss Reduction Techniques
Load Balancing and Multi-Phasing

> Phase balancing is balancing phase currents along three-phase circuits.

> Balancing phase loads at the substation does not guarantee phase balance along the feeder path.

> On a typical distribution feeder, loads were allocated as balanced and then re-allocated as unbalanced in 5% increments, and line losses were determined.

> Percentage of line losses increases as percentage of phase imbalance increases.
Loss Reduction Techniques
Voltage Conversion

> For a given amount of apparent power, doubling the voltage would reduce the current by half and reduce the line loss to 25% of original.

> Upgrading the primary voltage of the distribution feeder involves upgrading the distribution equipment, which can be cost intensive.
Loss Reduction Techniques
Adding Substation Transformers or Substations

> Balances load between the transformers at existing substations or at a new substation location

> Requires comprehensive cost/benefit studies

> San Isabel Electric Association (SIEA), headquartered in Pueblo West, Colorado planned for a new substation in the middle of suburban Pueblo West service area.

  > Due to excessive loading and long feeder lines, SIEA used to experience heavy line losses in this area.

  > SIEA engineers simulated the distribution system losses before and after the substation addition

  > SIEA found out that line losses in this area were reduced by 50% with the new installations.

  > Cost-benefit analysis showed that the new substation would pay for itself within 10 years by considering the line loss savings alone.
Additional Loss Reduction Techniques

> Increasing primary conductor size
> Adding a (parallel) feeder
> Upsizing conductors or reconfiguring secondary network
> Changing out a distribution transformer
> Using amorphous core transformers
> Updating substation auxiliary equipment
> Upgrading metering technology
> Updating street lighting technology
Impact of Smart Grid Technologies on Losses

- **Advanced Metering Infrastructure**: Data improves loss analysis and CVR effectiveness.
- **Volt/VAR Control via Distribution Management System**: Optimizes set points for local Volt/VAR controllers (LTC, regulator, cap banks).
- **Distribution Automation**: Provides monitoring and control to optimize system configuration.
- **Distributed Generation**: Distributed generation in close proximity to a load center reduces line losses.
- **Energy Storage Systems**: Shifts load to reduce peak and associated losses.
- **Demand Management**: Reduces peak load and energy and associated losses.
Management Guidelines

> Develop a loss reduction plan
> Empower your staff with the tools and training they need
> Quantify and locate your losses
> Evaluate technological loss reduction techniques
> Consider time-of-use rates or demand response to re-shape load curves
> De-energize unloaded transformers
> Study your load growth carefully when sizing new transformers
> Keep an eye on reactive power flows
Management Guidelines (Cont’d)

> Periodically evaluate your planning and design standards
> Include losses in bid evaluations
> Consider loss savings in your capital expenditure plans
> Manage your transformer inventory

> Establish programs to calibrate meters periodically
> Leverage data that is being collected
> Evaluate economics of losses
> Embrace smart grid technologies
Case Study
Fort Loudoun Electric Cooperative (FLEC)

> Funded a study analyzing effects of voltage optimization on distribution system in order to lower peak demand and conserve energy

> A series of incremental solutions were evaluated in the following stepped approach:

  > Phase Balancing – phase-change selections based on loss savings

  > VAR Management – correct power factor between 99% and 100%; only use current inventory of FLEC capacitors

  > Voltage Regulator Management – identify key locations for voltage monitoring and use voltage regulators to help boost voltage in sensitive areas

  > Voltage Optimization – reduce voltage in regulation zones, including LTCs and voltage regulators, while maintaining a voltage on the primary distribution system above 117 Volts, on a 120-Volt base
Case Study  
Fort Loudoun Electric Cooperative (FLEC)

The FLEC voltage optimization study shows that they can reduce peak demand by 2.4% which equates to $244,000 in demand savings per year.

The study also shows that while total energy consumed decreases, line losses may increase as a result of voltage reduction events.