PowerFactory Applications

Applications for Distribution Systems
Distribution System Analysis

- **Project Scope**
  - Network Planning, i.e.
    - Voltage plan studies (distributed generation)
    - Network optimization
    - Power restoration strategies
    - Connection requests
  - Integrated analysis of MV and LV networks
  - Replacement of former software PRAO

- **Number of PowerFactory Users**
  - 8 regions with 15 regional planning offices
  - > 300 users (network planning)

- **Network Statistics**
  - ~ 2200 MV grids
  - ~ 25,000 MV feeder
  - ~ 845,000 LV grids (secondary ss)
  - MV grid: ~ 592,000 km
  - LV grid: ~ 664,000 km
  - Grid serves 32 Mio. customers
Solution Architecture for National Process

**Solution is highly parallelized**
Smart Grid Application

LV Grid Analysis
• Constraint detection (overloaded transformers, excessive voltage drops,...)
• On-demand investigations

Daily Process
• Import of daily load/generation characteristics from smart meters
• Import of real temperature and construction of missing characteristics using temperature
• Execution of 3-phase load-flow sweep over the considered day
• Capturing of extreme conditions and export of corresponding snapshots to result database
• Computation / update of average conditions and storage in the result database
• Export of daily cases for on-demand analysis
Analysis Functions
Distribution Network Tools

Optimal Power Restoration

- Conduct optimal restoration analysis for a single element (no failure data required)
- Report recovery scheme (various stages)
- Tracing functionality
Power restoration in distribution networks incorporates *Tie Open Point Optimization* methods to achieve an utmost level of resupply.
Reliability Analysis

- Incorporates **Optimal Power Restoration** for most accurate simulation of resupply strategies

- Support of both *balanced* and *unbalanced* network representations (reliability & tie open point optimization)

- Feeder constraints
  - Maximum allowed voltage drop/rise (global or feeder-wise)
  - Particularly important in network with high portions of distributed generation, where bidirectional power flows may occur

- Load states and load distribution states
Reliability Analysis – Contribution to Indices

• Contribution of individual contingencies to the system reliability indexes (SAIFI, SADI, ENS, EIC…)

• Example: contribution to Expected Interruption Costs (EIC) based on one part of the network
Backbone Calculation

- **Backbone:** Electrical path between two meshed feeders, separated by a tie open point
- Various strategies to determine backbones
**Power Restoration** traverses various phases ("Sectionalizing"):  
- Stage 1: Remote Controlled Switches  
- Stage 2: Switching of breakers with Shc Indicators  
- Stage 3: Manual Switching of all breakers

Where should Remote Controlled Switches be located to have most effective Power Restoration?
Optimal Remote Control Switch (RCS) Placement

- Optimizes RCS locations within feeders to minimize Energy Not Served (ENS), Expected Interruption Costs (EIC) or balance ENS

Calculation results of optimal RCS placement

<table>
<thead>
<tr>
<th>Feeder:</th>
<th>Feeder 1, Feeder 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backbone:</td>
<td>1</td>
</tr>
<tr>
<td>Number of new RCS per backbone:</td>
<td>1</td>
</tr>
<tr>
<td>Expected ENS:</td>
<td>1,240 MWh/a</td>
</tr>
<tr>
<td>Optimal RCS:</td>
<td>Switch2</td>
</tr>
<tr>
<td>Existing (calculation-relevant) RCS:</td>
<td>None</td>
</tr>
</tbody>
</table>
Optimal Remote Control Switch (RCS) Placement

- **Optimizes RCS locations** within feeders to minimize

  Energy Not Supplied (ENS), Expected Interruption Costs (EIC), or balance ENS

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<td>Existing RCS on backbones:</td>
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</tbody>
</table>

- FD_26
- FD_26_FD_35
- 2
- 8,264 MWh/a

- SW_0595
- SW_1156
- None
Distribution Network Tools

Voltage Profile Optimization

- Consider two worst-case scenarios simultaneously (bidirectional power flows):
  - High load & low distributed generation
  - Low load & high distributed generation

- Optimization of distribution transformer tap positions

- Allows for a combined study of MV and LV networks
Cable Sizing

- **Cable Reinforcement**
  - Support of unbalanced networks
  - Constraints: loading, voltage per terminal and along feeder
  - When applied to a network without types, PF will automatically assign types from the library, with consideration of loading/voltage drops
  - Report on short-circuit loading of lines/cables

- **Automatic Cable Sizing**
  - Cable sizing optimization based on international standard:
    - IEC 60364-5-52
    - BS 7671
    - NF C15-100, C13-200
Techno-Economical Analysis

- Economic assessment of network reinforcement strategies (expansion stages) under consideration of:
  - Cost of electrical losses
  - Economic impact on the failure rates (reliability)
  - Costs for the expansion:
    - Investment costs, additional costs per year
    - Commercial equipment value: original value, scrap value, expected life span
    - User-defined costs
- Output: Net Present Value (NPV) of the expansion strategy over the selected period
Protection

- Short-Circuit trace
  - Based on complete short-circuit method
  - Accounts for the effect of switching actions on the fault current

- Tabular relay settings reports

- Reach settings for distance relays in Primary or Secondary ohms