MARCH 2017

Reliability Management Services
Substation Risk Assessment & LifeStretch™
Peter Lokang, Regional Business Development Manager
Reliability Management Services

Agenda

- Background
- Reliability Management
  - Substation Risk Assessment
  - Substation LifeStretch™
- Case study
- Summary & Conclusion
Reliability Management Services

Background

<table>
<thead>
<tr>
<th>Typical economical lifespan of major HV electrical equipment</th>
<th></th>
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<tbody>
<tr>
<td>Substation establishment</td>
<td>50-60 years</td>
</tr>
<tr>
<td>Power transformers</td>
<td>45-50 years</td>
</tr>
<tr>
<td>Capacitors</td>
<td>40 years</td>
</tr>
<tr>
<td>Circuit breakers</td>
<td>45 years</td>
</tr>
<tr>
<td>Instrument transformers</td>
<td>45 years</td>
</tr>
<tr>
<td>Control &amp; Protection systems</td>
<td>15-30 years</td>
</tr>
<tr>
<td>SCADA systems</td>
<td>15 years</td>
</tr>
<tr>
<td>Telecommunication</td>
<td>10-12.5 years</td>
</tr>
<tr>
<td>Transmission lines</td>
<td>45-60 years</td>
</tr>
<tr>
<td>Transmission cables</td>
<td>40-45 years</td>
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Source: Sinclair Knight Merz (SKM)

**Economical lifespan**: Period over which an asset (machine, property, computer system etc.) is expected to be usable, with normal repairs and maintenance, for the purpose it was acquired, rented or leased for – usually less than the asset’s physical lifetime.

**Q. What are the three most pressing challenges for your utility?**

- Old Infrastructure: 48%
- Current Regulatory Model: 32%
- Aging Workforce: 31%

The greatest challenges that utilities face

*Credit: Utility Dive*
Deferred maintenance is a global phenomenon. Life goes on, but expected lifetime is not likely to be reached...
Reliability Management Services

Asset Management is a balance act where different factors need to be considered:

- Initial investment
- Substation Lifecycle cost
- Cost of power interruption
- Operation and Maintenance cost
- New expected lifetime
- Health and Safety aspects
- Functional specification
- Remote monitoring features
- ... 
- Substation risk profile
- Expected mean time between failures
- Expected mean time to repair
- Unplanned outages duration
- Unplanned outages frequency
- Substation availability
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Substation Risk Assessment

Overview

Substation assessment is essentially a risk assessment of substations based on component condition evaluation and importance analysis.

Substation assessment is a visual inspection only, and does not require equipment outage.

Objective is to provide owner a decision base for planning future investments.

The result is presented in a technical report, outlining the following:

- Current situation
- Identified risks and related consequences
- Recommended actions, e.g. diagnostics, maintenance, upgrading, replacement, etc.
- List of priorities, based on calculated risks
Substation Risk Assessment

The process in RISE (Reliability Improvement through Substation Enhancement)

Substation RISE

Services projects

To develop a valuable technical solution, choose a project you want to edit or create a new project.

The steps that you will have to follow to develop the technical solution varies according to the type of project. Click on the type of project to see the development steps.

Assessment Maintenance agreement LifeStretch Operation and Maintenance

- PROJECT DEFINITION
  - Select customer
  - Define installation
  - Create project

- RISK EVALUATION
  - Condition and importance evaluation
  - Risk evaluation

- MAINTENANCE EVALUATION
  - Maintenance strategy

- RELIABILITY ANALYSIS
  - Technical and economic analysis
  - Reliability of current installation
  - Evaluation of potential alternatives
  - Selecting the optimal solution
  - LifeStretch conclusions

- TECHNICAL REPORT
  - Photos annex
  - Report settings

- GENERATE REPORT
  - Create report
Substation Risk Assessment

Modeling of the current Substation

Confirm installation diagram (Step 2 of 2)

Please build up the single line diagram and component designation for the new installation.
Substation Risk Assessment

Risk evaluation in RISE

During the site visit:

- Conduct visual inspection of each component
- Interview the client about:
  - Maintenance practices
  - Reliability issues
  - Historic events
  - Availability of spares
  - Impact of equipment outage
- Complete condition assessment of each component using the tablet software
# Substation Risk Assessment

<table>
<thead>
<tr>
<th><strong>Visual Inspection</strong></th>
<th><strong>Risk Calculation</strong></th>
<th><strong>Technical Report</strong></th>
<th><strong>Result</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tablet app for data collection and condition assessment</td>
<td>Risk calculation based on condition assessment and reliability analysis</td>
<td>Automated report generator</td>
<td>Specific conclusion</td>
</tr>
</tbody>
</table>

- **Guided process to perform assessment**
- **Data collection based on tablet app:**
  - Condition assessment based on ABB Assessment criteria
  - Components importance calculated according its contribution to outages rate
  - Risk calculation based on public reliability libraries

- **Risk analysis**

- **Report Generation**
  - Value protection via report content management
  - Report auto generated

- **Report**
  - Risk assessment result
  - Recommended actions prioritized
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Substation LifeStretch™

LifeStretch™ - trademarked product of ABB

Custom tool with proprietary algorithms developed to support ABB’s systematic approach to economically improving substation reliability

LifeStretch™ utilizes information gathered during Substation Assessment to provide structured customer support to select optimal substation life extension solution

Reliability Model for Existing Substation Based On:

**ABB developed algorithm** for adjusting equipment reliability data
- Utilize reliability data from open sources (CIGRE, IEEE, CEA, and local data if available from customer)

**Create reliability model** for existing substation as basis for evaluation
- Rank substation components using the following criteria:
  1. Contribution to overall reliability
  2. Contribution to reliability of specific feeders/loads
  3. Economic impact of lost revenues
Substation LifeStretch™

As preparatory measure, the scope must be clearly defined and relevant information received.

Substation info.
- Single line diagram
- Equipment lists
- Manufacturer, type
- Year of installation
- Identification no.
- Failure & Service history

More accurate information at this stage will enable higher efficiency on site.
**Substation LifeStretchtm**

- **Substation risk analysis**
  - Requirements analysis
  - Substation Assessment

- **Definition of alternatives**
  - Design comparison criteria
  - Identify technical solutions

- **Reliability analysis**
  - Design reliability models
  - LifeStretcht result analysis

- **Conclusions**
  - Selecting the optimal solution
  - Action plan agreement

**Condition** is evaluated based on:
- Application and design
- Environment
- Number of operations and short circuits
- Operational experience
- Maintenance program
- Availability of spare parts and expertise
- Personal safety

**Importance** is calculated based on:
- Economical factors for the user
- Loading, connection, topology
- Equipment failure mode and effect analysis
- Reliability modelling of the substation (MTBF, MTTS, MTTR, ...)
- Data from Open Sources – CIGRE, IEEE, CEA

**Risk Matrix** is a combination of Equipment Condition and calculated Importance (FMEA)
Multi-objective tailored criteria to be modelled to fit specific needs.

The comparison criteria must be done prior to the identification of potential technical solutions.
Substation LifeStretch™

Description of Solution #1:
Replace components presenting poor condition to reduce MTBF.
Spare parts acquisition for critical HV CBs to impact MTTR

Description of Solution #2:
MV SS configuration change to increase redundancy and reduce criticality of MV components.

©ABB
Substation LifeStretch™

Current installation risk snapshot enables asset risk management. High risk components replaced to reduce risk and improve reliability. MV component importance reduced by adding redundancy into the system. Methodology provides collaborative approach to make the right investment choice.
Substation LifeStretch™

Tailored Benchmark criteria

- Total life cycle cost (LCC)
- Life cycle cost per year (LCC/year)
- Initial investment cost
- Operation and Maintenance cost
- Cost of power interruption
- LifeStretch project life
- Forced outage frequency (FOF)
- Maintenance outage frequency (MOF)
- Total outage frequency (TOF)
- Forced outage duration (FOD)
- Scheduled maintenance works duration (SMD)
- Total outage duration (TOD)
- LifeStretch footprint
- Forced mean time between failure ( Forced MTBF)
- Mean time between failure (MTBF)
- Total mean time between failure and maintenance
- Commissioning down time
- Health and safety
Substation LifeStretch™

Condition Assessment
ABB assessment criteria to evaluate the condition of the substation components

Importance calculation
Analysis of the impact of a component malfunction

Substation Risk Analysis
Recommended risk mitigation plan developed according the assessed substation risk

ABB technical recommendations
Prioritization of the recommended actions to optimize investments

Comparison on criteria
- Life cycle cost
- MTBF
- O&M Cost
- Initial investment
- Interruption cost

Technical solution #1

Technical solution #2

Technical solution #3

Selecting the optimal solution
Compare the solutions according a multi-objective criteria focused on your decision process.

Selecting the optimal solution based in a quantitative analysis of pros and cons of the alternatives
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Substation LifeStretch™

Case study

**Customer Needs**
Decision base for the future of an aged and worn-out substation having obsolete equipment – rehabilitation or scrap and build new

**ABB’s Response**
Risk assessment to define current status, identify risks and give recommendations of improvement actions, reliability calculation and Life Cycle Cost comparison of five alternative solutions resulted in:
- Major rehabilitation program, e.g. overhaul/retrofit of GIS,
- Overhaul of power transformers,
- Replacement of AIS components,
- Modernization of protection and control etc.

**Customer Values and Benefits**
- LifeStretch™ analysis proved rehabilitation program to be the totally most favorable solution
- Comprehensive technical screening of the entire substation
- Customer was given five possible solution and could the most optimal
- Sustainability and reduced CAPEX – Lifetime extension of substation through adequate and right on time maintenance actions

Customer: Ministry of Electricity, Iraq  
Substation: Babil 400/132/11kV S  
Year of construction: 1987 by ASEA
Substation LifeStretch™

Case study

Customer Needs
Decision base for the future demand and challenges to improve both the availability and Reliability of the power distribution system.

ABB’s Response
Risk assessment to define current status, identify risks and give recommendations of improvement actions, safety related and reliability study on the entire power system

Customer Values and Benefits
Comprehensive technical screening of the entire power system
Sustainability and reduced CAPEX – Lifetime extension of substation through adequate and right on time maintenance actions
Substation LifeStretch™

Case study

Component Risk Matrix

The risk of each component type is shown both in a risk matrix and a priority list in xl. The priority list can be used to filter each component type with the highest risk, condition or importance depending.
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Summary & Conclusions

Extending substation life based on:

- Evaluation of the current substation condition from equipment and system perspectives
- Proposing different solution for substation life extension
- Evaluating reliability for each of the proposed solutions
- Evaluating the cost related to each of the proposed solution
- Selecting an optimal customized solution depending of the specific customer requirements
- Make a decision based on reliability and related cost
Summary & Conclusions

Substation LifeStretch™ includes:

- Low cost investment with high value to asset owners
  - Offering clear options for planning and improvement
- Short turnaround time for service
  - Including data gathering, site visit, and meetings to finalize the reports
- Visual inspection of all substation equipment & key components
  - No equipment outages necessary
- Final report describing the optimal solution considered
  - Multiple criteria’s based on reliability and economical analysis

Comprehensive report provided including explanation of results achieved