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Optimization of power system structure and operation

Economical solutions for high quality power supply

At a glance

The implementation of quality regulation requires the joint consideration of economical aspects and system reliability during planning and operation of distribution grids.
Siemens Power Technologies International (Siemens PTI) provides methods for determining the economically optimum quality of supply. Therefore detailed reliability calculations are combined with modeling and analysis of operational organizations of utilities in the software PSS®SINCAL to answer central questions of quality regulation:

- How to cost-effectively reach or maintain a pre-defined level of quality?
- Which is the optimal composition of staff organization (OPEX) and of system assets (CAPEX) to reach this goal?

The challenge

Investments in power systems or the adjustment of operating structures have direct impact on annual operation costs and quality of supply. Changes of quality of supply have a direct impact on the profit of system operators depending on the regulatory framework schemes. The correlations between quality of supply and operational and system-related measures are often very complex, so that an efficiency of measures can only erived by analytic evaluations.

Our solution

Siemens PTI has developed a model which allows an integrated calculation of the correlations between assets, system operation and quality of supply to assess the costs for system-related and operational activities (Figure 1). The comprehensive reliability calculation determines the complex effects of failures and necessary remedial actions on customers based on failure models of electrical equipment.

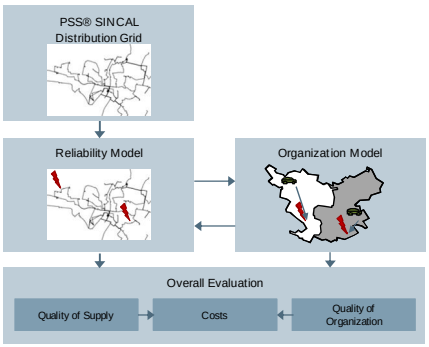

Figure 1: Overview of the model

The organizational model incorporates all resources and the organizational structure of the utility including number of employees during working time and on-call service, their qualification and responsibilities. Furthermore, the operational decision-making process is simulated. Thus, not only the influence of restructuring of the power system, but also the impact of changes in number and location of employees on the quality of supply can be investigated.

Application example

In a distribution network (20 kV, 350 km cable, 50 km of overhead lines, 4 transformer substations), 80,000 customers are supplied via open ring structures. The remedial actions are performed by twelve employees in three service zones and three employees during on-call service hours (Figure 2)

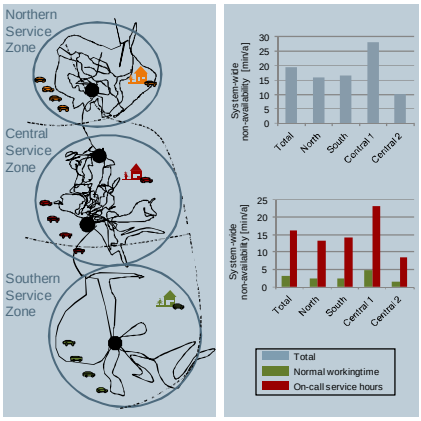

Figure 2: Investigated power system area

In the initial design of the power system and its operation, customers are facing different quality levels, depending on the substation they are connected to:

- The structures of the medium-voltage systems differ significantly with respect to length, equipment types, switching options, etc.
- The specific employee density (employee per components) varies in the service zones.
- The transport infrastructure and thus the travelling times of the employees differ in each service zone.

Adjustment of power system structure and operation

In order to influence the quality of supply in a long term perspective, three measures are examined:

- Replacement of overhead lines by cables
- Implementation of remotely controlled switches at suitable locations in the power system
- Improvement of the power system structure (reduction of central stations and cables)

Besides these long-term adjustments in the system structure, changes in operating structure are considered:

- Aggregation of operating areas
- Adjustment of the number of available employees during on-call service hours (nights and weekend)

Figure 3 shows the impact on the reliability of supply of the related measures in connection with the adjustment of the operating structure.

The results allow a detailed analysis and quantification of the individual measures in terms of their impact on the quality of supply:

- The aggregation of service zones leads to marginal changes of non-availability.
- The variation of the number of employees during normal working time has no significant effect on the reliability of supply, as planned activities generally bind more employees than failure events and thus are decisive for the number of employees during normal working time.
- The reduction of the number of employees during on-call service hours has significant influence on the reliability of supply.
- Remotely controlled switches and cabling of overhead lines prove to be effective in reducing the non-availability.
- The streamlining of the system structure increases the non-availability of supply. This can be compensated by changes in the organizational structure.

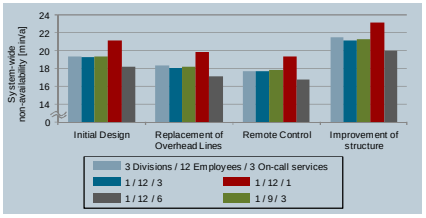

Figure 3: Non-availability of variants of the power system and organization

Duration until arrival on site

Using the duration until arrival on failure site, the quality of the power system organization is quantified. As the operator is in charge of the safe operation of the power system, the quality of the organization has to be included in management decisions. As an example, Figure 4 shows that in particular the number of employees during on-call service hours determines the share of failure sites which can be reached by an employee within 45 minutes.

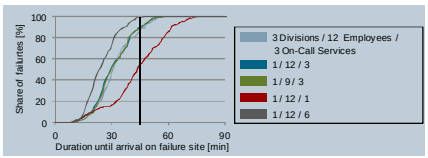

Figure 4: Duration until arrival on site in initial power system design

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Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

For more information, please contact
power-technologies.energy@siemens.com