COSTSAVING AND RELIABILITY IMPROVEMENT BY USING INNOVATIVE TECHNIQUE FOR REFURBISHMENT OF A SUBSTATION

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Summary
The deregulation of the Electricity Market and decreased profit for power companies has made it more essential to reduce the investment costs for refurbishment, service and maintenance. Studies of different substation configurations have shown that innovative solutions with a reduced number of apparatuses and new type of equipment will give a significant improvement of the availability compared with conventional solutions. The enormously increased availability of modern Circuit Breakers has enabled the elimination of Disconnectors. By using Disconnecting Circuit Breakers (DCB) the single line diagram is simplified and the amount and types of apparatuses are decreased.

In addition use of Disconnecting Circuit Breakers leads to a reduction of the total number of HV apparatuses in the substation with associated reduction of space requirements. The innovative configuration with three disconnecting circuit breakers was selected for refurbishment of a 132/33 kV substation in Kolsva, in the middle of Sweden.

![Diagram](image)

One of these innovations is the Disconnecting Circuit Breaker. It is essentially a normal SF₆ circuit breaker, which has been modified to also fulfill disconnector requirements. Such requirements are

- The dielectric withstand requirements of a disconnector must be fulfilled over the entire life cycle
- The disconnecting circuit breaker must be possible to interlock electrically and mechanically

Each breaker is equipped with an On-Line Monitoring equipment, OLM. By this equipment the breaker condition is continuously monitored giving support for a reliability centred maintenance for optimisation of maintenance resources.

By using innovative solutions at refurbishment of substations, several advantages can be achieved.

The two principal design parameters have been:
- Reduction of unplanned maintenance
- Minimal impact on the ambient

The result of the modernisation of the substation was:
- The investment cost was reduced
- The expected maintenance work is reduced to half
- The expected availability is higher
- The substation area was reduced by 50 %.

Keywords
Substation – Reduction of costs – Reliability – Refurbishment – Compact switching equipment
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Summary

As a result of availability studies comparing a traditional substation configuration with conventional equipment and an innovative solution with disconnecting circuit breakers the latter was found drastically better with regard to power flow.

The use of Disconnecting Circuit Breakers also leads to a reduction of the total number of HV apparatuses in the substation with associated reduction of space requirements and costs.

Keywords

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1. INTRODUCTION

The deregulation of the Electricity Market and decreased profit for power companies has made it more essential to reduce the investment costs for refurbishment, service and maintenance. Studies of different substation configurations have shown that innovative solutions with a reduced number of apparatuses and new type of equipment will give a significant improvement of the availability compared with conventional solutions. The enormously increased availability of modern Circuit Breakers has enabled the elimination of Disconnectors. By using Disconnecting Circuit Breakers (DCB) the single line diagram is simplified and the amount and types of apparatuses are decreased.

To optimize the repair and maintenance on line monitoring is used. Analysis can then continuously be made and the possible work most economically planned.

2. SUBSTATION BEFORE REFURBISHMENT

In Kolsva about 150 km from Stockholm, in the middle of Sweden a well known ironwork was situated. In mid of the 50th Kolsva Ironwork built a new 132/33 kV substation for feeding power to the ironwork, the community and the surrounding countryside. The 132 kV switchgear had a H-configuration with two overhead lines and two transformers. There were four circuit breakers and totally seven disconnectors. The busbar was made of stranded conductors. Some of the existing H.V. apparatuses are more than fifty years old and spares were sometimes impossible to find.

Also the control and protection equipment was antiquated and a replacement was needed.

![Fig.1 - Previous configuration of 132 kV switchgear in Kolsva](image)

The 33 kV switchgear was of the same age as the 132 kV switchgear. Incidents had occured and it was no longer considered as personnel safe.

Due to the bad condition of the substation and as an increase in load was foreseen a complete refurbishment of Kolsva substation was decided.

3. RELIABILITY IMPROVEMENT

The availability of a substation is strongly dependent on the configuration and the substation components. In order to select the most efficient configuration for a substation, an availability study has been conducted [1]. The availability study was focused on the effects of scheduled maintenance and sustained failures of HV equipment. Comparisons were made between traditional substation configurations with conventional equipment, and innovative solutions with switchgear modules and disconnecting circuit breakers.

For voltage levels 72,5-170 kV the typical configuration for a small HV/MV substation is the H-configuration with two HV lines and two transformers. With conventional equipment, Vattenfall has traditionally used four circuit breakers and a disconnector for sectionalizing the busbar, see Fig.1. For a innovative solution, three circuit breakers are used for line

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[1]: Reference omitted for brevity.
switching and busbar sectionalizing. Combinations with switching modules and disconnecting circuit breakers have been compared with the conventional configuration.

The study has included calculation of unavailability due to scheduled maintenance and sustained failures of the HV components.

The study shows a less availability for the alternative with conventional equipment. Innovative solutions with switching modules or a combination of two disconnecting circuit breakers and one switching module for sectionalizing of the busbar, are drastically better with regard to power flow. By use of removable jumpers to permit access to the sectionalizing component without taken the whole substation out of service at maintenance or repair, reliability improvement can also be performed when the switching module is replaced by a disconnecting circuit breaker.

In addition use of disconnecting circuit breakers leads to a reduction of the total number of HV apparatuses in the substation with associated reduction of space requirements.

4. INNOVATIVE TECHNIQUE

In the beginning of the 90th a concept for a future substation was developed by Vattenfall. Many innovative solutions were suggested, such as compact substations, disconnecting circuit breakers, compact MV switchgears with arc-extinguisher and computerized control and protection with analytical redundancy [2]. The concept was in detail discussed with manufacturers and some of the ideas have later been realized. These are some of the innovative techniques used for refurbishment of the Kolsva 132/33 kV substation.

4.1 Disconnecting Circuit Breaker

The disconnecting circuit breaker is essentially a normal SF6 circuit breaker, which has been modified to also fulfill disconnector requirements. Such requirements are

- The dielectric withstand requirements of a disconnector must be fulfilled over the entire life cycle
- The disconnecting circuit breaker must be possible to interlock electrically and mechanically

The maintenance demand of normal open-air disconnectors is relatively high in cases with severe environmental conditions, and is then often concentrated to the contacts. In the disconnecting circuit breaker the contacts are enclosed, and maintenance of the combined unit is reduced to the same level as for a normal circuit breaker.

In order to minimize possible leakage currents across the open disconnector gap, the disconnecting circuit breaker is equipped with polymer insulators. It is, in this very installation combined with an external earthing switch, and optical current transformers, reducing the space requirement drastically and thus being cost effective.

![Fig. 2 – Disconnecting circuit breaker rated 145 kV, equipped with external earthing switch and optical current transformers.](image)

4.2 On line monitoring

Each breaker is equipped with an On-Line Monitoring equipment, OLM. By this equipment the breaker condition is continuously monitored giving support for a reliability centred maintenance for optimisation of maintenance resources. Every operation in the breaker history is stored and may be analyzed and treated with respect of prevailing environmental condition. Various features are included like travel, damping, stroke, SF6-density and more.

![Fig. 3 OLM; On Line Monitoring](image)

5. SUBSTATION AFTER REFURBISHMENT

To get the most reliable configuration the number and different types of equipment were reduced. The innovative configuration with three disconnecting circuit breakers was selected for refurbishment of the substation in Kolsva.
For normal maintenance on the transformer and at transformer fault, two disconnecting circuit breakers will be opened. The other transformer can then quickly be fed by the remaining overhead line in service. If a long period out of service is foreseen, the faulty transformer will be disconnected by jumpers and the H.V. network will then be restored.

The result of the modernisation of the substation was:
- The investment cost was reduced
- The expected maintenance work is reduced to half
- The expected availability is higher
- The substation area was reduced by 50%.

7. CONCLUSIONS

By forward-looking studies future improvements can be identified. Vattenfall started ten years ago a study to identify the requirements, from a power company point of view, for the futures substation. A lot of innovations were suggested of which some already now are realized to improve the substation design and lower the total cost for transmission and distribution. New WEB-based control systems are e.g. already in commercial use and will open new possibilities. Some other innovations are under development. Similar studies have then been performed in CIGRÉ and by other utilities.

By using innovative solutions at refurbishment of a 132/33 kV substation, lower costs has been achieved.

Studies has shown that the availability of substations mainly depends on the complexity of the configuration. A reduction of components highly influence the availability to the better. A configuration with three disconnecting circuit breakers instead of a conventional configuration with four circuit breakers and seven disconnectors will give a significant improvement of the availability.

In addition, use of disconnecting circuit breakers leads to a reduction of the total number of HV apparatus in the substation, with associated reduction of space requirements and reduce of costs for e.g. civil works.

8. REFERENCES


