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Power system protection and automation reference

Enhanced power delivery reliability through network automation



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Savon Voima Verkkö Oy implements ABB's zone concept

Savon Voima Verkkö Oy is a wholly-owned subsidiary of Savon Voima Oyj. By the end of 2010 Savon Voima's power distribution system had some 110 000 user locations and some 2 600 customers were connected to the district heating system. Within the investment framework for enhancing the reliability of the power delivery Savon Voima has systematically increased the level of automation in its power system. Protection zones according to ABB's zone concept have been introduced into the network and the substation protection equipment has been renewed using IEC 61850 compliant 630 series feeder management IEDs of the Relion® product family. The connection to ABB's MicroSCADA Pro and DMS 600 system has been secured using COM600 substation automation devices.

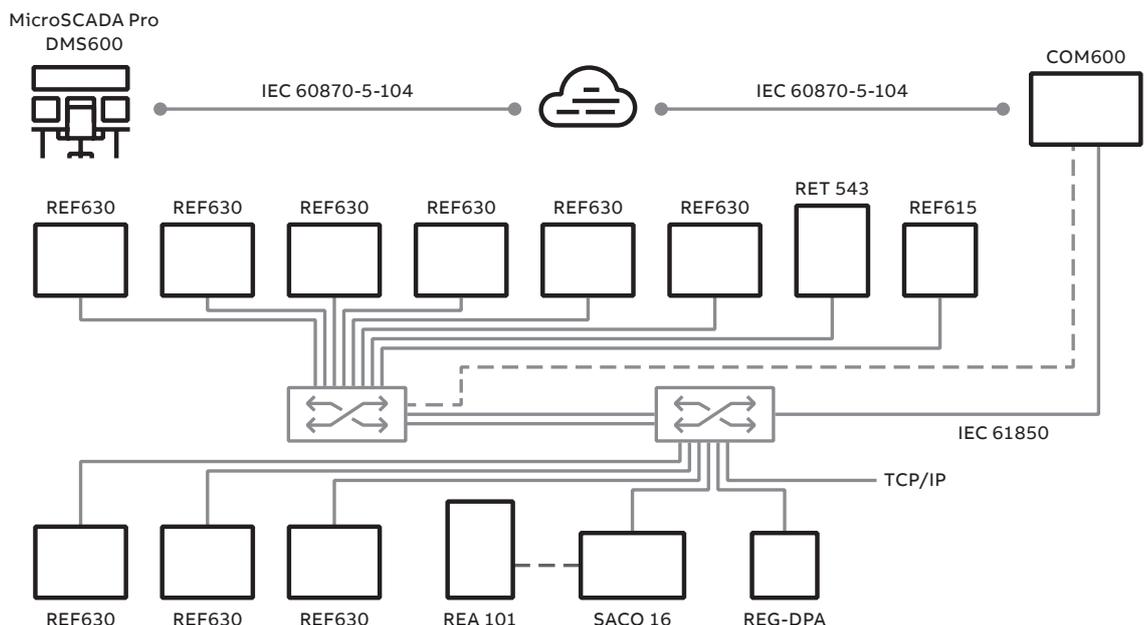
The power distribution system of Savon Voima covers an area of 40 000 square kilometer, roughly the size of Denmark, with a total line

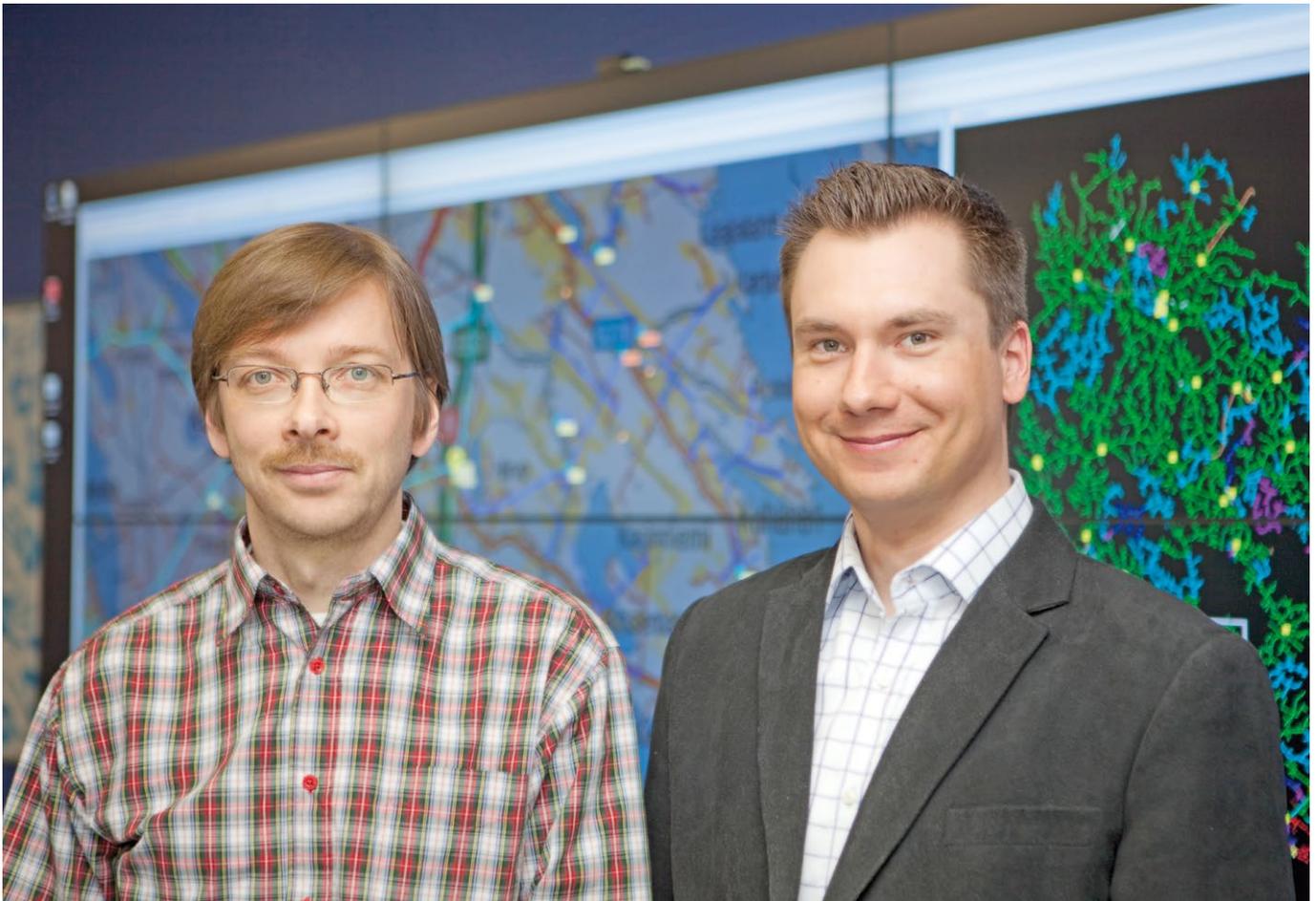
length of 25 000 km. The medium voltage network is mainly composed of overhead line feeders, which count for some 10 % of the entire overhead line network in Finland. The Savon Voima's network comprises thirty-five 110/20 kV and three 45/20 kV substations. Distribution management is extensively used in the power system of Savon Voima. The entire substation base of the power system is connected to the MicroSCADA Pro and DMS 600 system. Furthermore, protection zones have been added to the network by installing remote controlled reclosers on lengthy feeders. Adding automation is a fast and cost-effective way of enhancing the reliability of supply of the power system.

Flexible technological solutions

At the new Pellesmäki substation REF630 feeder management IEDs have been installed in ABB's Unigear switchgear. On the substation level an IEC 61850 substation automation bus

The IEC 61850 substation automation bus solution and its connection to the ABB's MicroSCADA Pro and DMS 600 of the Pellesmäki substation.





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Matti Pirskanen and
Sami Viiliäinen of Savon
Voima Verkko Oy.

has been implemented. Besides the feeder management IEDs, a SACO alarmsystem, the COM600 substation automation device, all by ABB, and a Petersen-coil regulator by A. Eberle GmbH & Co. KG have been connected to the bus. The implementation of the IEC 61850 standard on the substation level enables a smooth interconnection of substation devices from different suppliers. "One of the strengths of the standard is that it is not a proprietary standard of a particular device manufacturer. The entire transfer of information at the Pellesmäki substation is routed through the IEC 61850 bus. In industrial automation data transfer buses have been used for years. It is exciting that the development in network companies also is heading in the same direction. The IEC 61850 standard is an important milestone in this ongoing development," **Matti Pirskanen**, substation engineer at Savon Voima, states. Savon Voima's network currently comprises six substations based on the IEC 61850 standard and in the future all new and retrofit substations will be designed according to the standard.

ABB's 630 series feeder management IEDs are freely configurable devices that can be flexibly configured to suite the intended application. "The freely configurable feeder terminals, on

their part, support our company's long-term investment program. The configurability enables us to not just adapt to the network's current state, but also to future changes in the power system," Matti Pirskanen states. "We know right now that the network will incorporate wind power in the near future, that isolated overhead lines will become common and that the degree of cabling of the power system will increase. In the realization of the Pellesmäki project one aim was also to allow for these foreseeable changes," Pirskanen continues. In the planning phase, for instance, the REF630 feeder management IED configurations were prepared for directional overcurrent protection, phase discontinuity protection and intermittent earth-fault protection.

Total control of the whole network

All of Savon Voima's substations and remote controlled reclosers are connected to ABB's MicroSCADA Pro and DMS 600. "Our network is geographically widespread. Securing high delivery reliability in this type of a network calls for an extensive implementation of automation. The DMS 600 distribution management system provides immediate information about the current state of the network.

Among other things, we use DMS 600 for fault location tasks and relevant reporting. Without automation the interruption times caused by fault instances would be too long,” Matti Pirskanen describes. In the future, Savon Voima plans to also use data collected from remotely readable meters at the customer’s premises for fault location. ”The solution offered by ABB, where MicroSCADA Pro and DMS 600 are integrated into one package, is an excellent solution for us. I see it as an advantage that these systems come from one and the same supplier. The systems cooperate seamlessly also after updates have been performed to just one of the systems,” Matti Pirskanen summarizes.

The use of automation and a reliable data transfer network go hand in hand. Savon Voima relies on its own data transfer network. The network is a so-called radio link network with ring topology. The data transfer between the substations and the SCADA/DMS uses the IEC 60870-5-104 protocol. ”The most important feature of the data transfer network is its availability. Therefore we have invested in redundant solutions and an adequate data transfer capacity. Despite the high capacity it is not a realistic option to transfer all data from the substation level to the MicroSCADA Pro and DMS 600. On the substation level we use COM600 station automation devices. Through this solution we can flexibly pick those network data collected by the protection relay system that are essential from the SCADA/DMS point of view, such as e.g. network fault location calculations from the REF630 feeder management IED,” Matti Pirskanen describes.

Improving delivery reliability through automation

The main principle of the zone concept is to confine the impact of a network fault to as limited an area as possible. A fault in the distribution network often interrupts distribution along the entire feeder and to all the consumers connected to it. Integrating protection and reclosing functions deeper into the network directs reclosing functions and interruptions selectively to the problematic parts of the network. Thus distribution interruptions on other sections of the network are avoided. To do this, the feeder is divided into sections, also known as zones. Savon Voima is among the first network companies in Finland to systematically implement the zone concept on a large scale.

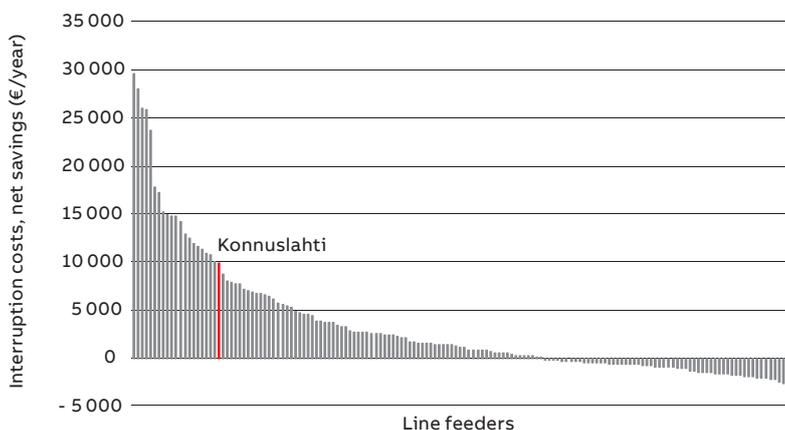
”By inserting reclosers the size of the protection zones of the network can be reduced and the effects of the disturbances limited to affect just a smaller group of customers. In practice this means a reduction in the number of interruptions and the interruption times experienced by the customers,” **Sami Viiliäinen**, development engineer at Savon Voima, explains.

For the implementation of the zone concept throughout the distribution network of Savon Voima the insertion points for recloser stations investigated feeder by feeder for the whole network. In this so-called potential study the insertion of one or two reclosers was found to be commercially justifiable in about one third of the some 300 feeders of the utility.

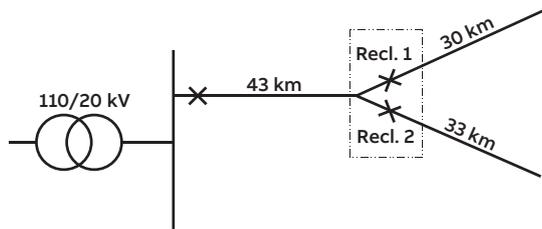
”By forming a more accurate technical reliability model for individual line feeders the most profitable location points for reclosers and the effects obtained by reclosers can be analyzed more accurately than with more simple potential calculations. In the planning process, however, the total effects of the solutions must be noticed also on the rest of the examined network. By means of the overall zone concept thinking, for instance, the power quality key figures are improved and the number of faults is reduced and the interruption times are shortened on the zones formed on the line feeder,” Sami Viiliäinen discloses.

In the Konnuslahti pilot object, ABB’s remote controlled recloser station was inserted on a 106 km long feeder having a total mean load of 700 kW. In the supply direction the insertion point splits the feeder into zones. The insertion

The potential profitability of reclosers as per line feeder.



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Location of the
Konnuolahti recloser
station on the
line feeder.



point was further chosen in such a way that 65% of the mean power of the feeder was located upstream of the station and thus out of reach of faults arising on the feeder section downstream of the recloser station. The mean powers of the line sections downstream of the reclosers amount to about 18% and about 17% of the mean power of the feeder.

The addition of recloser station in the pilot object has a substantial impact on the quality of the power distribution as experienced by the customer. In the planning phase the reduction of interruptions upstream of the recloser station was as high as 60% and on both line sections downstream of the station about 30% each, based on the reliability calculation models that were used. The improvement expected to be reached over the whole line feeder in energy weighted interruption figures was about 50% and even about 20 % in fault interruption times.

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The impact of the pilot
object on the energy
weighted key figures,
interruption costs (CIC)
and the economical
profitability of the
investment.

Parameter	Impact
Interruption time ^{*)}	- 20%
Number of interruptions ^{*)}	- 50%
Interruption costs (CIC) ^{**)}	- 34%
Life-cycle total costs	- 13%

^{*)} The interruption time and number of interruptions are energy weighted key figures of the power quality.

^{**)} Reducing CIC-costs (customer interruption costs) means that the delivery reliability improves correspondingly.

The zone concept is also a cost-efficient solution for enhancing the delivery reliability of rural power distribution networks. In the pilot network of Savon Voima the calculated 34% saving in interruption costs can be obtained with 13% lower life-cycle costs than in the initial state. "The practical experience of the recloser station set up a few years ago has been positive. This encourages us to continue on the chosen path. Today there is an installed base of some 20 remote controlled pole-mounted reclosers and five recloser stations. In the coming years some 60 pole-mounted reclosers will probably be installed and another 20 recloser stations," Sami Viiliäinen anticipates.

One of the foreseeable zone concept investments will be for the new Pellesmäki substation. All along the 106 km Pellesmäki feeder standardized ABB recloser station will be located. The functionality of the station comprises protection and control, also including e.g. auto-reclose functions. The station is provided with two remote controlled reclosers and an arc fault resistant switchgear system with integrated isolation and earthing devices.

The insertion point of the recloser station has been chosen such that the fault prone line length downstream of the recloser station will be considerably reduced. In the new situation 23% of the total mean power of about 813 kW of the feeder falls upstream of the recloser station and 27% or 50% falls on the feeder zones downstream of the reclosers. Of significance for the selection of the location point is that now faults are produced on a just 66 km long section (26 km + 40 km) downstream of the recloser instead of on a length of 106 km in the beginning. The calculated payback period of the investment is about four years.

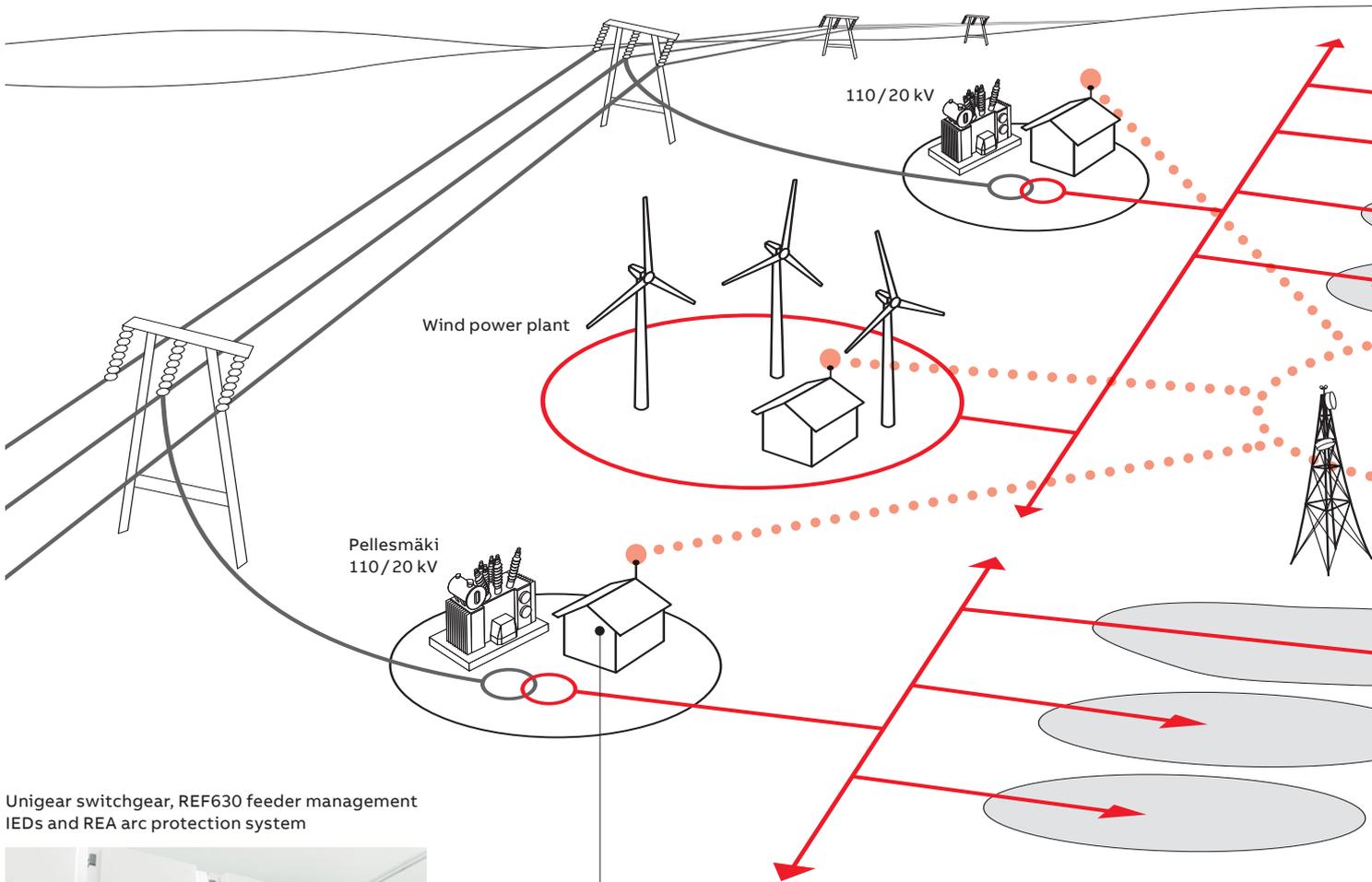
Our goal is zero fatal accidents

The goal for the power system maintenance and construction functions of Savon Voima is zero severe accidents. "Personal safety and security have always been put in focus. Already in the 1990's we took a decision that all new substations would be equipped with arc fault protection. We also carried out an updating project of our substations, during which we installed arc protection systems also in all old substations. In the Pellesmäki substation we installed ABB's REA arc fault protection system," Matti Pirskanen reveals. Electrical safety and safety at work aspects are emphasized even more nowadays, as maintenance jobs and construction work to a large extent have been outsourced. The number of actors in the power system field is constantly growing. "As a network owner we must be able to assure safety at work and power system security under all situations. Besides instructions and guidance it is important that risks caused by human errors also are taken into consideration in the protection system of the substation. We have been spared from serious consequences because of the extremely fast operation of the arc protection system," Matti Pirskanen summarizes.

Network automation solution

Embedding the communication solutions deep in the network structure and including all the central equipment into ABB's MircoSCADA Pro and DMS 600 enable the effective use of the entire network. Disturbance situations can be resolved effectively with the help of accurate fault locating and DMS functions. In case of a fault, the reclosers with versatile protection

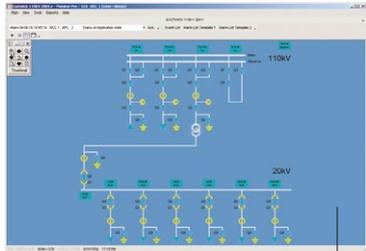
capability automatically perform fast, zone-discriminative fault disconnection. In case of major disturbance, the zone division significantly facilitates the use of the network. The operative actions can be performed in a safe way, and the use of earthing switches ensures secure and reliable earthing in all network situations.



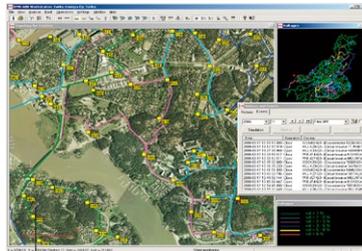
Unigear switchgear, REF630 feeder management IEDs and REA arc protection system



Station automation device COM600



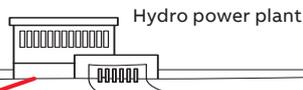
MicroSCADA Pro



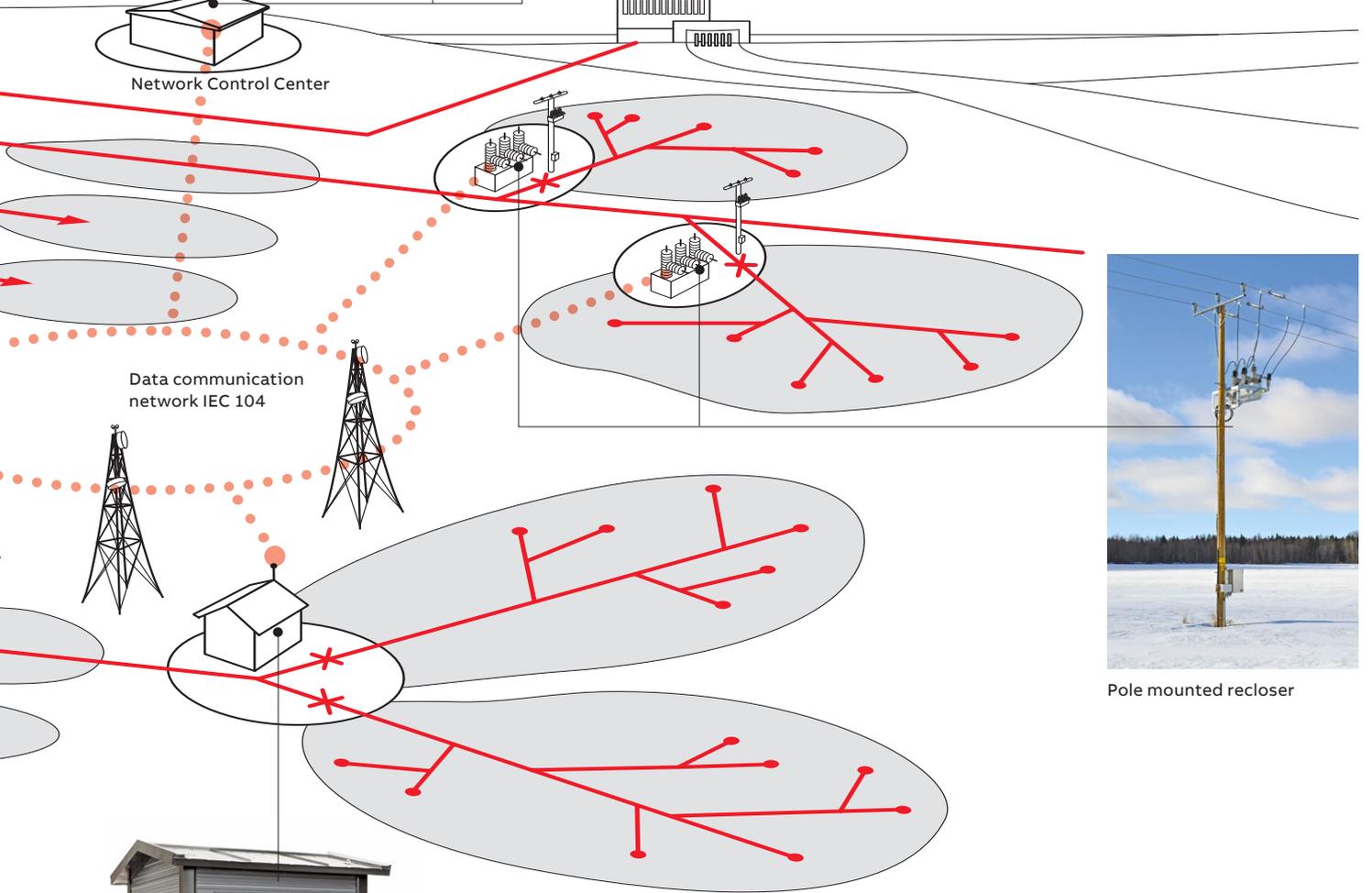
Distribution Management System
DMS 600



Network Control Center



Hydro power plant



Pole mounted recloser



Recloser station



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