Wind farm switching and protection of medium voltage transformers in air insulated technology for substation applications

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Introduction

The worldwide demand for renewable energy is growing constantly, with wind power as one of the fastest growing sectors. To meet the current and future needs of network operators, manufacturers and designers of wind power systems need to be able to call on both advanced technologies and in-depth knowledge. The wind onshore sector, even being one of the most efficient source of renewable technologies, must focus on continuous cost optimisation process. This we can see either in turbine manufacturers behaviours and in all other installation components including medium voltage components. The demand is going towards more and more bigger turbine power and efficiency that definitely means higher step up transformers cooperating with turbine generators. Additional accent is placed on service and maintaining wind farms in long term perspective since the most common demand for installation life time is at least 20 years.

Objectives

Major global power and distribution manufacturers provide alternative solutions starting from compact substations, breakers and switch-fuse combinations. These solutions are based on gas insulation technology mostly and vacuum interrupting chambers.

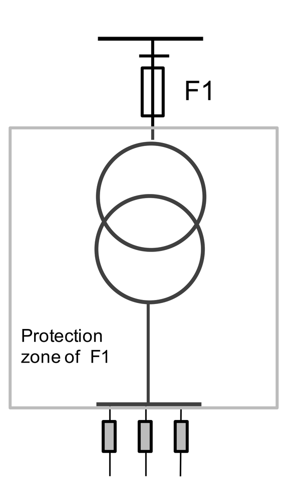
The methodology of wind farm transformer protection has not been changed since years and can be provided either by combination of breaker and protection units or by switch-fuse combination, that historically is far more preferable solution due to lower cost. And the cost aspect for wind farm installation is becoming more and more noticeable by investors and contractors.

So, why not to use switch-fuse combination for cost optimization? We may look at this from two points of view: realization and design. There is quite big freedom for contracting companies to realize design concept that presents mostly main configuration functionality. Therefore the selection of equipment capable to fulfil project requirements are in the hands of company awarded for this scope of wind farm project. Therefore switch-fuse combination may be easily implemented as cost-efficient solution. However switch-fuse technology used to have one important limiting factor for renewables applications – typical solution has been limited for transformers up to 1600 kVA, whereas average size of installed turbines exceeds 2 000 kVA for onshore installations. So, without t changing performance of switch-fuse combination the application is limited by turbine size. This limit has been broken through in the way that the application has been developed for windfarm projects to maximize cost effectiveness and safety. The solution itself is called NALFWind™ and it is air insulated switch-fuse combination designed for up to 36 kV rated voltages. Technically the design news are related to innovative breaking chamber suitable for high value of transfer current and fast acting current limiting fuses. The combination of these two gave excellent results capable to extend switch-fuse combination application up to 3000 kVA wind transformers located outside wind towers. There is additional advantage of presented solution that is related to fast acting fuses performance since these fuse type can protect transformer from low voltage side faults without necessity to install LV fuses. This protection model, commonly known as § 17 model (fuse with cut off time within 0,1 seconds "Sverigesäkring") has been commonly used by utilities in Sweden since years. The protection concept is presented below;

Methods

Protection zone concept and Sku calculation based on 12 kV 40A ABB fast acting CEF-S and standard CEF fuses

§ 17 model with fast acting fuses

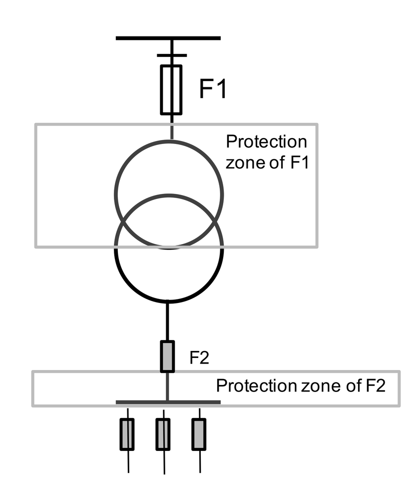


Calculation		
I 0,1s =IK3	299	A
Uh	10,5	kV
Strf	630	kVA
Uk	6	%
Flj	0,7	
Skr	7,768248	MVA
Sktrf	10,5	MVA
Sku	29,85871	MVA

The calculated Sku value: $S_{ku} = \frac{S_{ktrf}}{\left(\frac{S_{ktrf}}{S_{kr}} - 1\right)}$

- required short-circuit power on primary side for cut off within 0,1 sec - is significantly lower for § 17 protection model and related to this CEF-S fast acting current limiting fuse.

Standard arrangement with standard fuses



Calculation		
I 0,1s =IK3	330	A
Uh	10,5	kV
Strf	630	kVA
Uk	6	%
Flj	0,7	
Skr	8,573651	MVA
Sktrf	10,5	MVA
Sku	46,73263	MVA

An complement to Swedish regulation the power sector has stipulated a guideline to reduce consequences for accidentally arcing at improper operation/work on low voltage busbar/switchgear.

By extending the protection zone for the high voltage fuse to included the low voltage busbar/switchgear and require a breaking time less then 0,1 seconds, the injury level can be reduced for the accident-prone staff.

This put high demand on fuses, especially at it's current steepness. Lack of steepness will otherwise rapidly increase the demand of high short circuit power in the grid. High level of short circuit power means greater sizing of power line etc.

Conclusions

Market applications are based on available technologies that sometimes create application standards due to lack of competitive alternatives. However the technology development is the process that never ends and may surprise us providing new safe and also very cost effective solutions for the wind industry, that has not been previously possible in this type of switching portfolio. It looks to be not easy task since turbines are bigger and installation cost efficiency is expected to go down. Therefore it is good that global manufacturers take this challenge. The NALFWind™ is good example of such a technology development that definitely is very interesting option for 3 MW installations.

References

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5. § 17 model and calculation examples (fuse with cut off time within 0,1 seconds "Sverigesäkring"), *e.on Sweden*