ASSET MANAGEMENT OF GIS EQUIPMENT IN THE CONTEXT OF THE RENEWAL OF EUROPEAN MV GRID INFRASTRUCTURES

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ABSTRACT

The present distribution system is primarily built for the distribution of electrical power in one direction. It is not able to cope with the incoming power coming from renewable sources. Then, in the near future its architecture will have to be adapted to be ready to collect power from millions of decentralized renewable sources and to achieve optimization of the distribution network. In such a context, GIS technology offers particular advantages.
In this paper, after summarizing the present situation in the EU, the boundary conditions leading to the chosen switchgear design for the new MV distribution switchgear are explained. The safe, compact and effective solution in the network for the connection and protection of power transformers and cables is presented. Finally, the potential of GIS for modernization of the network by increasing the flexibility and the capacity of the distribution is demonstrated.

INTRODUCTION

Medium Voltage networks are facing challenging times!
This is especially true in Europe or in North America, where many aged equipment must be replaced at this time of increasing demand for high Energy Efficiency and increased amount of Renewable Energy Generation.
The European Union, in line with worldwide political agreements emphasizing attention to minimize environmental impacts of human activities, has fixed ambitious environmental targets regarding both its energy and its environment policies. Those are so called 20/20/20 targets – 20% cut in emissions, 20% improvement in energy efficiency and 20% increase in renewable by 2020.

In the field of Electricity Distribution, these ambitious objectives appear to be, in fact, achievable. Many technologies have been identified to be helpful to match the goal and some of them are made available from the industrial point of view.

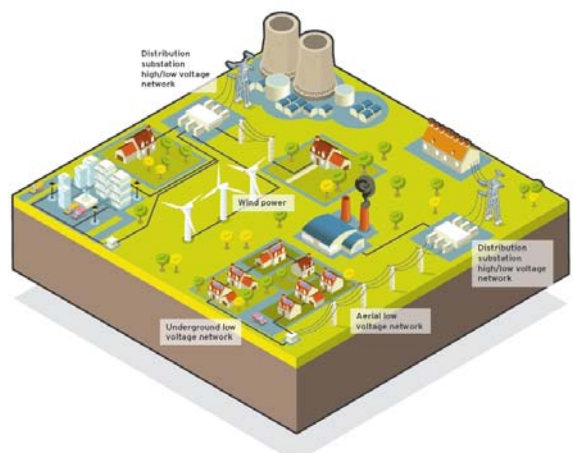


Figure 1: Typical layout for Future Electricity Networks

In the near future the architecture will have to be adapted to be ready to collect power from millions of decentralized renewable sources and to achieve optimization of the distribution network (Figure 1). This will require a very strong contribution of the Electricity T&D Equipment Industry as well as the EU support for improving generation, transmission and distribution of electricity [1].

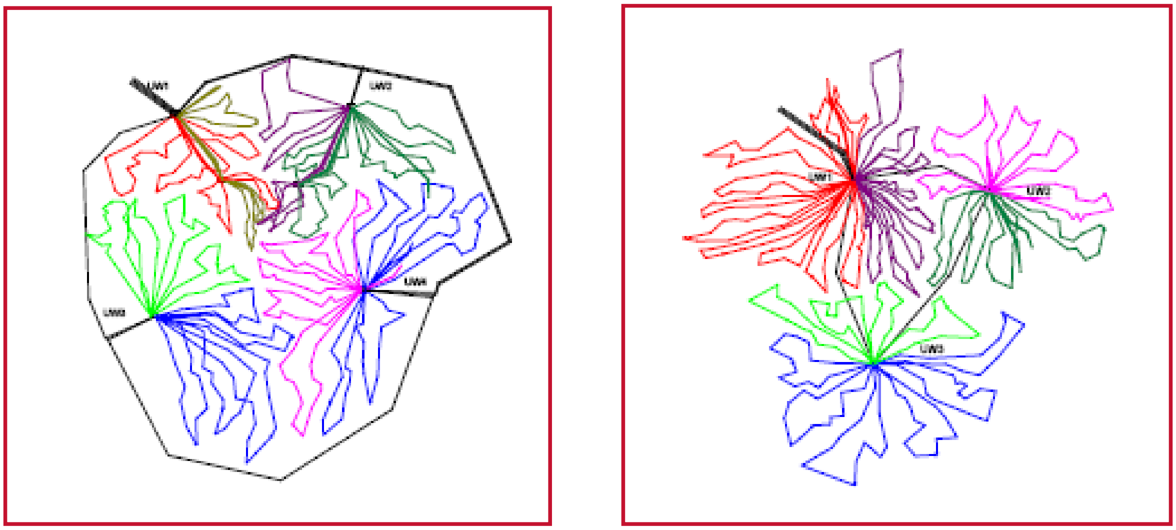
ENVIRONMENTAL ASSESMENT OF THE GIS TECHNOLOGY FOR POWER DISTRIBUTION

The future of such distribution networks can only be envisaged positively if the global environmental impacts appeared to be reduced: compared to the actual configuration, and if the technologies available also prove to be beneficial to the environment.

That is actually the case with GIS technologies. These have been deeply investigated through Life Cycle Assessments (LCA's) [2].
Network topology using conventional AIS technology has been compared to the one using GIS Technology regarding the Impact on the Global Warming in rural or urban networks (Figure 2). It appeared clearly that the Global Warming impact of AIS is higher than for GIS.

Even more important, the impact coming from switchgear is less than 10% of the total Global Warming impact of the full network. Indeed, the Global Warming impact is mostly due, to the energy losses within the network.

Finally, for GIS equipment, the contribution of SF_6 emissions to the GWP is only 1.4 % (urban) and 1.6 % (rural) of the full Global Warming impact of the Network.



(a) (b)

Figure 2: Typical 20 kV distribution network, a) with SF_6-free AIS technology, b) with SF_6-GIS Technology
Thick lines stand for 110 kV overhead lines (a) or underground cables (b), thin lines for 20kVunderground cables

SF_6 HANDLING IN MV GIS MANUFACTURING

As a matter of fact, state of the art gas handling and monitoring systems are introduced in MV switchgear manufacturer's factories, and these procedures and equipments are continuously improved together with modern GIS switchboard designs.
For example, in Areva T&D's medium voltage factory in Regensburg (Germany), three different manufacturing areas, and a separate storage area, are defined in the workshop [3].

A SF_6 dedicated shop is operational next to the workshops. The 600 kg SF_6 tanks are located in this shop and connected with copper distribution pipes going in the shop through the walls. From the storage area, the distribution of the SF_6 is done via 600 m copper pipes (at 3 to 5 bars of pressure) running in the shops. The SF_6 pipeline system includes one main stop valve and 12 stop valves on the counters and 3 additional stop valves for service are part of the SF_6 pipeline.

Figure 3: SF_6 filling Station and Tightness test tank

More over, the tightness of all pipe installations is checked before and after periods with no use of SF_6 (during long weekends or holidays), and the tightness of the pipe system is in the maintenance plan. A SF_6 detector is running (threshold value: > 2% SF_6). The tanks of liquefied SF_6 are weighted at the beginning, and then when they are empty (down to 20 mb). A storage tank filled at 20 bars of SF_6 gas is used before the distribution, and a SF_6 counter is placed between this storage tank and the SF_6 distribution departure.
Some SF_6 concentration measurements were done in the shops. The level was found to be lower than 10 pptv. The monitoring of the SF_6 pipeline system is continuous, and the transmitter limiting value has a threshold value of 0.011 kg of SF_6 gas per second.
Control of tightness is performed via a monitoring system during weekends (once per week). Maintenance and inspection are performed 4 times per year (Figure 3).
As mentioned in the CIGRE article on tightness test states some methods which are in relation with the standard IEC 60068-2-17 [4].
Standards require a leakage test and no method is prescribed. Some losses occur when the switchgear is filled and tested, the primary source of SF_6 gas releases are leaks from aging SF_6 gas-insulated switchgear. The permissible leakage rates depend on the kind of switchgear: sealed pressure systems mainly for medium voltage equipment are in the order of 0.1 % depending on the expected operation life.

UP TO DATE MV SF_6-GIS TECHNOLOGY

A typical example of an up to date SF_6-GIS technology is the well-known medium voltage SF_6 type FBX ring main unit.
Designed in AREVA T&D's Macôn Factory, FBX (Figure 4) is a secondary distribution SF_6 insulated switchboard. It is, available in compact version or expandable version. With these options it fits the needs up to 24 kV. It is insensitive to the environment and maintenance free. The role of the FBX is to transmit and distribute electricity for applications such as distribution public networks, industrial facilities, the fields of wind turbines.
This type of switchgear is manufactured at the volume of 4,000 three-phase units per year. The tanks are welded by a subcontractor, and then finished at the factory. There is a weight varying from 1 to 2 kg (2.2 to 4.4 lbs) of SF_6 in them according to the type of circuit.

SF_6 is introduced via a permanent valve. The equipment is "Helium Tight" tested, and, in case of leak, the leakage point is detected with SF_6 leakage tests. Then the apparatus is filled with SF_6. The counter, placed next to the gas valve gives the mass (weight at sea level) of SF_6 included in the switchgear. Then this mass is indicated on the label affixed to the circuit breaker.

Figure 4: FBX Ring main Unit

FBX Life Cycle Assesment

In addition to specific attention paid to SF_6 handling during manufacture, and environmental design of the product, End of Life Considerations and Life Cycle Assessments are also run in order to qualify such switchgear.
Starting from manufacturing, over the whole service life of our products until their disposal we meet the legal regulations through the use of environment-compatible materials or through refraining from particular materials (e. g. heavy metal-content paint pigments, halogenated flame resistant substances in insulating materials for high-voltage systems) as well as through the establishment of an efficient environment management system certified according to Areva's Eco Audit Directive. The Material and Utilization Data Sheet at hand gives information on material types, quantities as well as disposal and utilization ways.
Results from Life Cycle Assessment, as shown in table 1 & 2, considering the whole life cycle of the equipment (figure 5), also demonstrate that such equipment has a very low impact to the environment.

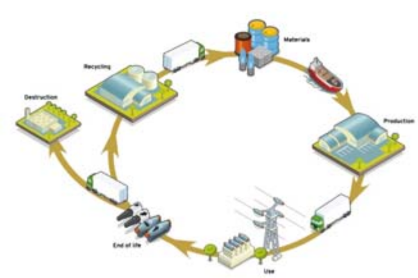


Figure 5: The Life Cycle Loop

Indicators	Unit	Total
Abiotic depletion	kg Sb eq	15,25
Acidification	kg SO2 eq	10,38
Eutrophication	kg PO4--- eq	1,34
Ozone depletion	kg CFC-11 eq	0,00018
Human toxicity	kg 1,4-DB eq	7234,41
Terrestrial ecotoxicity	kg 1,4-DB eq	31,98
GWP 100 a	kg CO2 eq	7310,75
Energy consumption	MJ eq	57380,87
Ionizing radiation	Bq C14 eq	293249,53
Hazardous waste	kg	0,62
Slags /Ashes	kg	65,16

Indicators	Manufacturing	Use	Distribution	End of Life	Fuse	Pakaging
Abiotic depletion	58,0%	8,6%	34,4%	-7,3%	6,3%	0,3%
Acidification	60,8%	12,3%	27,5%	-5,9%	5,3%	0,3%
Eutrophication	53,3%	6,2%	35,2%	-3,1%	6,0%	2,9%
Ozone depletion	32,8%	5,0%	58,8%	0,8%	1,7%	0,9%
Human toxicity	96,7%	2,7%	3,9%	-6,1%	3,1%	0,0%
Terrestrial ecotoxicity	38,5%	54,4%	7,0%	-2,6%	2,7%	0,0%
GWP 100 a	28,1%	65,4%	10,4%	-4,4%	0,9%	-0,3%
Energy consumption	34,6%	44,5%	22,7%	-3,0%	1,1%	0,2%
Ionizing radiation	11,9%	84,1%	5,2%	-1,4%	0,3%	0,1%
Hazardous waste	75,8%	1,2%	27,9%	-5,6%	0,3%	0,6%
Slags /Ashes	0,2%	0,1%	0,8%	89,2%	5,7%	0,1%

Table 1 & 2 : LCA results of FBX Ring Main Unit

CONCLUSION

Medium Voltage networks are facing great challenges-times, and many technologies have been identified to be helpful to match the 20/20/20 targets – 20% cut in emissions, 20% improvement in energy efficiency and 20% increase in renewable by 2020. In the field of MV switchgear, GIS technologies have been proven to be the best environmentally solution, when considering the full environmental impact of the network, as well as considering more detailed aspects such as End of Life handling.
More over, due to the compactness of such technology, it offers a large flexibility for a better integration of such equipment in windmills or underground installation, and no other technology can compete on such parameters.
So, GIS technology appears to be a very good option for modernization of the network by increasing the flexibility and the capacity of the distribution.

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