0037, "DEALING WITH HIGH IMPACT, LOW PROBABILITY (HILP) EVENTS SUCH AS ATTACKS, NATURAL DISASTERS, IN ASSET MANAGEMENT?

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ABSTRACT

Electricity is a key element in any French person's life. Power interruptions have become less frequent and are less and less acceptable to customers. It has even become unthinkable that power interruptions exceed a few hours or affect a large number of customers.
Thus, after each "major interruption", most often due to storms, the media use powerful images to demand that ERDF does its best to make sure that it does not happen again.

These large-scale events occur in two different situations:
- *during climatic events that affect mainly rural zones.*
- *when an HV/MV primary substation feeding a dense urban area is lost.*

In order to deal with these issues and to meet the demands of society, ERDF has implemented two sets of measures:

The ***Climate Risk Mitigation Plan****, designed to minimise the effects of floods, heat-waves and above all wind or snow storms.*

The plan for the ***security of primary substations supplying big towns and cities*** *set up to avoid power failures and, if one should occur, to minimise its consequences by facilitating recovery for customers.*

To fulfil its public service missions, ERDF has decided to take appropriate measures to minimise these events. For the climate risk plan, the performance expected is stated in the public service contract signed by ERDF and the State.

The rest of this document sets out these two plans, the first one requiring very significant resources.

THE CLIMATE RISK MITIGATION PLAN

Commitments to be fulfilled

Under the terms of a public service contract, ERDF is required to take measures enabling it to resupply 90% of customers affected by an interruption during a climatic event within five days. This commitment runs until 2015 and concerns storms, floods and heat-waves.

The majority of resources implemented concern storms since, to reach the objective, no less than 70,000km of MV overhead lines, i.e. 20% of all ERDF's overhead MV networks, have to be replaced by underground cables.

However, we will start by setting out the two other plans which are much less costly.

The flood risk

Structures concerned

During episodes of flooding, supply to customers is dependent, in the following order, on primary substations, MV substations, networks' operating equipment and, to a lesser degree, LV networks. We will give special attention to the first three of these structures.
During floods, power interruptions concern:
- Flooded customers: They are located in flood areas (supplied by flooded MV substations)
- Interrupted customers: They are not located in flood plains but their supply depends on flooded structures (flooded MV substations located on the same MV feeder).

Identification

Mapping of floodable zones is diverse and sometimes accounts for several different flood scenarios. The inventory has been carried out on the main scenario used by the local authorities, who are responsible for this plan in France. The structures (primary substations, MV substations and networks' operating equipment) located in flood plains have been identified by studying these maps. Additional electrical studies have also been used to identify MV substations and networks' operating equipment subject to power interruptions.

Reducing sensitivity

For primary substations, this means flood-proofing sensitive elements (installing pumps, raising or moving equipment, etc.)

For flooded MV substations and networks' operating equipment, the solution is to replace the MV switches, if it has not already been done, with switches that enable continued electric supply in the event of flooding. As a last resort, it may be envisaged to move or raise the MV substation.

For MV substations subject to a power interruption, the solution lies in the structure of the MV network; this must minimise the number of power interruptions during periods of flooding.

Structures to be considered include arteries between two primary substations, which can be:

- parallel to rising water levels so that the substations located in areas not subject to flooding are protected;
- or perpendicular, so that substations located close to the flooded area can be switched off to protect the substations that are not flooded.

Heat-wave risk

Structures concerned

Structures concerned by this risk are the MV underground networks. Two distinct phenomena occur during summer periods.

- Failure of cables during hot weather: the underground temperature gradually rises and does not easily dissipate the heat produced by the cable.
- Failure of joints during very hot weather: transitions joints have a high tendency to fail during these periods.

Reducing sensitivity

The first of these two issues can occur very frequently, but the second less often. ERDF has set up two solutions to deal with them:

For summer periods:

In general, networks are sized for the winter period, when the maximum of the cable capacities is authorised. To limit the heat-wave risk, it has been decided to size the networks for the summer as well.

In general, this is not a problem since:

- summer power is 20% of the winter power
- the summer permissible current value of the cables corresponds to 70-80% of the winter value.

Only some "atypical" feeders hold our attention. This plan is therefore very limited.

A significant renewal plan for old MV networks is underway and should improve the "robustness" of the MV networks during summer periods.

For periods of very hot weather:

Temporary configurations are set up to reduce the intensity transiting via networks that include joints at risk. We can decide to limit power by up to 40% in the most critical cases (old networks with a high number of transition joints).

The storm risk


The networks concerned

First, supply of the primary substations is guaranteed by RTE, the entity responsible for transmission networks in France. After, networks that are in the greatest need of being secured are the MV networks. The underground network is reliable during storms and the French network does not include an extensive pre-assembled network; thus ERDF decides to bury the bare overhead MV lines.

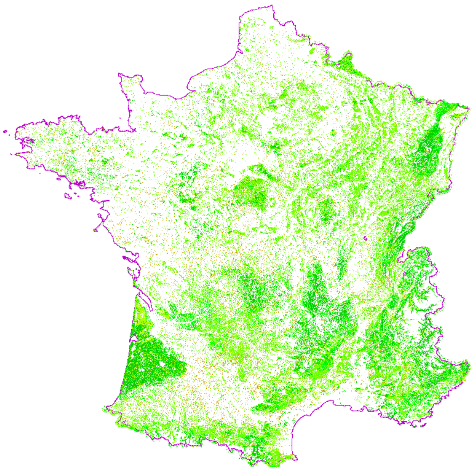
The definition of risk

A MV overhead network is considered at risk if it complies with at least one of the following conditions:

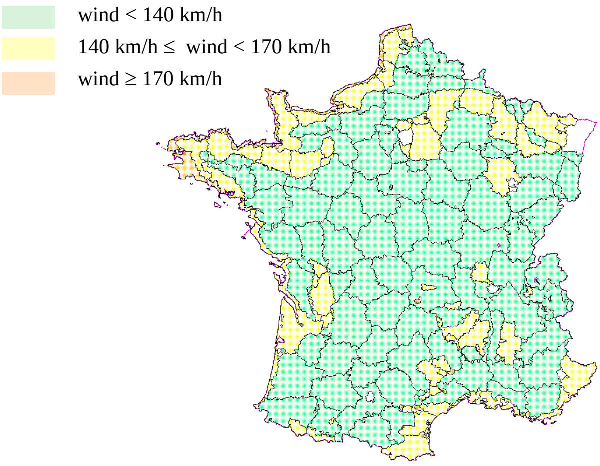
- **Wood** risk: Trees located nearby
- **Wind** risk: the line has not been designed to resist the wind speeds recorded during the most recent storms
- **Snow and frost** risk: the line has not been designed to resist the weight of snow or frost recorded during severe winters.
- **Thin cross-section** risk: The conductors are too thin to resist episodes of wind or snow, even where these are not particularly severe.

Identification

Wood risk: A survey of the structures concerned was carried out using the forests identified in the Corine Land Cover database.



Wind risk: The vicennal risk has been selected to reduce network sensitivity. A study carried out across the whole of France using data from Météo France has been used to determine these risks. Three wind classes have been defined to link this risk with construction methods:

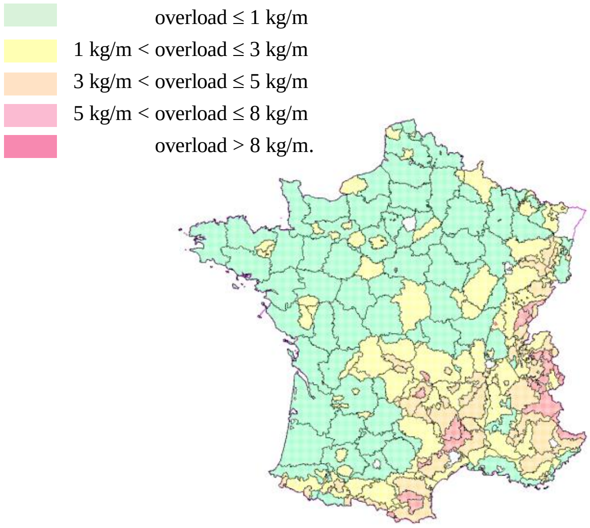


The resistance of all types of overhead MV networks to these three categories of wind must be determined.
The parameters selected to classify MV networks are:

- the fitting technique (rigid or suspended)
- the metal and the cross-section
- the year of fitting (standards have become stricter over the years)

This information (wind and resistance to wind) is crossed in order to identify the networks at risk.

Snow and frost risk: The procedure is identical to that used for wind risk. However, five overloading risks have been defined.



Thin cross-section risk: Bare overhead networks with the thinnest cross-sections have been highly subject to failure daily and also during the climatic events. Lessons learned from past events have helped to limit this risk for the following cross-sections:

- Copper > 20mm²
- Aluminium alloy < 34mm²

Recognized risk: Certain overhead MV networks are much more subject to failure during climatic events. These are networks subject to at least one of the following risks:

- wood risk
- thin cross-section risk
- wind risk with a differential of 2, i.e. networks built to resist winds < 140kph (class 1) and where there is a risk of winds exceeding 170kph (class 3).
- snow or frost risk with a differential of two or more (ditto wind risk but with five snow or frost classes)

Result: The method provides a rapid diagnosis over the whole of ERDF's territory which includes no less than 350,000km of bare overhead lines.

Work to be carried out:

The main activity included in the plan is to bury:

- the most sensitive networks: those where the risk has been recognized
- the networks which are the most significant for serving customers: "backbone" MV lines

Networks that show both of these characteristics represent 20% of all MV bare overhead lines.

Unfortunately, the networks to be dealt with are neither the oldest and nor those failing most often on a daily basis.

If the policy is to be as profitable for assets and quality, investment decisions will integrate the following rules:

- planning work so as to wait for networks to be paid off
- choosing network structures which improve SAIDI
- authorising the coverage of work to be extended to treat at the same time the low reliability network at proximity.

Alongside this investment plan, maintenance operations are also planned for certain MV overhead network types:

- lines threatened by several trees: localized tree cutting
- thin cross-section lines: improvement of conductor configuration

Prioritisation and Monitoring progress of the plan

In order to monitor progress of this action plan, a risk criterion has been defined and calculated for each section of the MV networks. It is defined as follows:

$$\mathbf{R} = \Sigma(\lambda_i * L_i) * P_{eq}$$

λ_i weighting of the risk (wood =1, wind= 0.75, ….)
L_i length of risk
i = 1 to 4 for each of the risks:
wood, wind, snow-frost and thin cross-section
P_{eq} = power downstream of the section

This criterion may be applied for groups of sections as, for example,

an MV feeder: $R_{feeder} = \Sigma\ R_{feeder\ section}$

a territory: $R_{territory} = \Sigma\ R_{territory\ section}$

ERDF uses this criterion to communicate outside of the company on progress with its action plan.

An effectiveness criterion E has been defined, using this risk criterion, to grade projects:

$$E = R_{project} / \text{Cost of the project}$$

SECURITY OF PRIMARY SUBSTATIONS SUPPLYING LARGE TOWNS AND CITIES

To avoid loss of supply for a large number of customers, ERDF has implemented a policy to secure primary substations supplying large towns and cities. Security is ensured by implementing two actions plans designed to:

- minimise the risk of total loss of these primary substations by improving their reliability
- limit the consequences of the total loss of these substations by securing them via the MV network

Improving reliability:

The reliability action plan covers all actions within the substation and actions concerning its HV supply-feeding; the aim is to prevent the total loss of the primary substation.

It mainly concerns the following improvements:

- simplification and protection of MV grids,
- containment of main MV switchboards
- elimination of MV common failure modes (cable tunnel, shared paths).

A detailed list of the risk situations to be avoided has been drawn up. Visits have been made to all urban primary substations to identify them and plan for their elimination in the medium term.

Improving security:

The loss of substations is still possible and, as such, provision for very rapid recovery for the most sensitive customers has been defined. In the worst case scenario, the networks hosting these customers represent 40% of the urban substation’s power.

For its urban primary substations, ERDF has decided to implement a plan whereby the MV networks will recover 40% of the substations’ power. The network structures to be implemented in urban zones are set up with this aim, with artery networks recommended between primary substations.