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June 17-20, 2002
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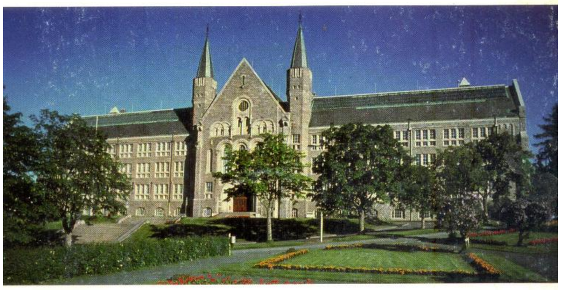

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Application of non parametric reliability distributions and tests for analizing MV energy distribution network's failures : *case of Niamey's 20 Mv network*

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An appropriate maintenance strategy, based on "theory of equipement renovation", is proposed. The ABC analysis allowed us to select the equipement with significant contribution in decresing departures' availability. The determination of failures and maintenance costs guided us in the choosing of preventive maintenance strategy. This choice is justified by the obtained results.

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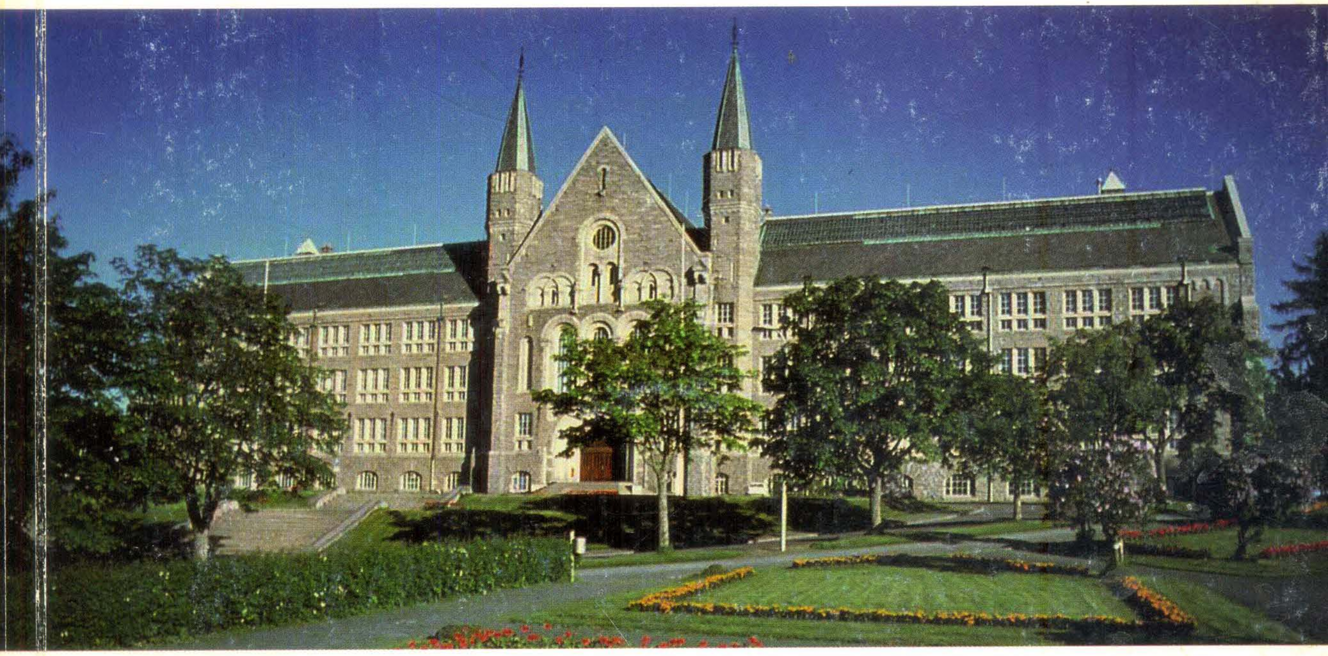

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Introduction

Nowadays, in the theory of electric and energetic systems' functioning, reliability notions occupied a wide domain and constituted a determinant factor. Particularly, more than 60% of failures collected on these systems appear on energy distribution networks. Therefore, we recommanded reliability analysis for energy distribution network. It detected failures which deteriorated the system and determinated the measures to take in view to improve the system's functioning.

This present work is included in FSE_2's aim (reliability of electric and energetic system). This aim consist to have care for studies about reliability of energy networks in specified conditions (lack of datas, ...).

1. Niamey's 20 Mv distribution network

This system extracts energy through two posts. We named: Niamey III repartition's post and Goudel 66/ 20 Mv post of transformation. The network is constituted to 16 departures. Among them 7 are underground. Equipements are found on the departures with different functions:

- protection and isolation components (circuit - breakers,...)
- measure and command components
- power components (power's transforming)

The departures are affected by different kind of failures. Here, we restricted the study by analyzing permanent failures . There occasioned important indisponibility time to the damaged departures.

2. Statistics tests for non parametric reliability distribution:

Generally, it's not easy to detect the adequate distribution on the base of statistic datas: many distributions can be proposed to the same equipement . So, it's preferable to characterize life distribution by a qualitative property which express the "age" of the equipement (Aïssani and Saidi, 1997). This reason explained why we used the non parametric reliability distributions and tests.

A usual format for testing is:

$$H_0 : « \overline{F} = \exp(-\alpha x) » \text{ against } H_1 : « F \in C, \text{ not exponential} »,$$

Here, C is a class of non parametric distribution. It exists various statistic tests for the same class of non parametric distribution. In this case, we used the test Tn of Kochar and Dn of Koul. Their statistics are given respectively by (Kochar 1985, Koul 1977)

$$T_n = \frac{\tilde{T}_n}{\overline{X}} = \frac{\sum_{i=1}^{n} J(\frac{i}{n+1})X_{(i)}}{n\overline{X}}$$

where $J(u) = 2(1-u)[1-\log(1-u)]-1$ and $\overline{X}$ is the sample mean of $X_1, X_2, \ldots, X_n$.
The T_n test reject H_0 in favour of H_1 for large values of T_n. The critical values are given in (Kochar 1985)

$$D_n = \frac{1}{n^2} \min_{1 \le i \le j \le n} [nS_{ij} - (n-i)(n-j)] = \frac{1}{n^2} \min_{1 \le i \le j \le n} T_{ij}$$

with $S_{ij} = \sum_{k=1}^{n} I(X_{(k)} > X_{(i)} + X_{(j)})$ and $T_{ij} = [nS_{ij} - (n-i)(n-j)]$ pour $1 \le i \le j \le n$.

This test reject H_0 for small values of $n^2 D_n$. The critical values of D_n test are given in (Koul 1997).

3. Application of statistic tests for non parametric distribution on Niamey's 20 Mv network

We have to note that for computations, we appeal to the software named "FiaElectricité". We 'll present it in the following pages.

3.1 Modelisation

In view to simplify the model, we codify the different departures. Among the 16 departures, we considered only 13 for the study. Quite so, Koubya and Medina are departures which are created recently.

We assimilated X_i, the random variable denoting the lifetime of equipement i in reliability theory, to "the number of permanent failures collected each year on the departure i (i= 1,…,13)". The X_i's values are given in the table 3.1 (see document of the Nigerien Compagny ***Nigelec***).

At each X_i, we associated a distribution F_i (F_i characterized a qualitative property which expressed the "age" of the departure i). The fundamental problem consists to determinate the F_i (i = 1,…, 13). This reason explained our choice for non parametric tests.

Before determinating the F_i, we did a previsions study. We considered that the values of each X_i constituted a chronological series. By applying "exponential lissage" method, we obtained the results of the following table:

Table 3.2 : forecasts' values for 2001's year by departure

	1997	1998	1999	2000	Forecast 2001	Constant of Smoothing (α)
Departure 1	10	13	15	14	14	0,1
Departure 2	12	12	18	8	12	0,9
Departure 3	8	12	8	4	8	0,9
Departure 4	8	10	6	8	8	0,9
Departure 5	5	1	4	9	5	0,9
Departure 6	2	8	10	7	7	0,1
Departure 7	17	10	6	9	9	0,1
Departure 8	5	21	14	11	12	0,5
Departure 9	3	4	2	3	3	0,9
Departure 10	1	1	0	1	1	0,9
Departure 11	4	3	1	2	2	0,1
Departure 12	1	5	4	4	4	0,2
Departure 13	4	2	6	6	4	0,9

3.2 Determination of the F_i (i = 1,..., 13)

a) Test T_n of Kochar

This test is consistent, it application on Niamey's network gave the following results:

Table 3.3 : statistics' values and F_i's nature by departure

Departures	1	2	3	4	5	6	7	8	9	10	11	12	13
Val(T_n)	0,543	0,492	0,472	0,530	0,382	0,456	0,455	0,433	0,511	0,463	0,468	0,468	0,479
F_i	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp

It resulted to this test that all the F_i are exponential with a level $\alpha = 0.05$. In refering to the classification of non parametric reliability distributions, we proposed to do a test for NBU's property.

b) Test D_n of Koul

We can notify that the critical values for n = 4 exist (n is the size of the sample), and on the other hand D_n test is consistent. The applying of D_n test at 0.05's level gave the results of the following table

Table 3.4 : F_i (i = 1, ..., 13)'s nature for each departure

Departures	Nature	Dist $\alpha = 0{,}05$	Dist $\alpha = 0{,}10$	Source station
1	Air	F_1 is NBU	//	Station of Ny III
2	Air	F_2 is Exp	F_2 is NBU	//
3	Air	F_3 is Exp	F_3 is NBU	//
4	Air	F_4 is NBU	//	//
5	Air	F_5 is Exp	F_5 is Exp	Station 66/20KV
6	Air	F_6 is Exp	F_6 is Exp	//
7	Underground	F_7 is Exp	F_7 is Exp.	Station of Ny III
8	Underground	F_8 is Exp	F_8 is Exp	//
9	Underground	F_9 is NBU	//	//
10	Underground	F_{10} is Exp	F_{10} is NBU	//
11	Underground	F_{11} is Exp	F_{11} is Exp	Station 66/20KV
12	Underground	F_{12} is Exp	F_{12} is NBU	//
13	Air	F_{13} is Exp	F_{13} is NBU	//

These results expressed that among all the departures, only three (3) presented NBU distributions. There are F_1, F_4 and F_5.

On other hand we would propose to test NBUE alternative, but the small size of the sample didn't allow us. Then, we resumed the Dn test of Koul with an increasing risk. We considered α = 0.10. The results obtained are given in the table 3.4.

3.3 Interpretation of Results

It derived from the obtained results that only F_1, F_4, and F_9 are NBU's distribution. The other remained exponentials. However, NBU distribution placed in a prominent position the oldness of 1, 4 and 9's departures. Then, we affirmed that those departures are in reliability viewpoint,"old". For α = 0.10, in addition of 1, 4, 9, the departures 2, 3, 10, 12, and 13 are "old" too.

4. Optimization of different departures equipements maintenance

Here, we considered the departure 9. After the ABC analysis, for each considered equipement, we determinated the failure cost C_{d9} and the maintenance cost (Lyonnet 1993). There are respectivelly given by the following formulas:

$$Cd_9 = K_w(1+\theta)\,Pc_9\,Tc_9$$
$$Cp_9 = Cm_9 + Cmo_9$$

If $r_9 = \frac{Cd_9}{Cp_9} > 1$, this result justified our choice for a preventive maitenance policy.

At last, for optimizing the time of preventive replacement of equipements, we considered the preventive and corrective maintenance cost:

$$Gc_9 = \frac{Cp_9 + Cd_9}{MTBF} \;;$$
$$G_9(T) = \frac{Cp_9 + [1-\overline{F_9}(T)]Cd_9}{\int_0^T \overline{F_9}(t)dt}$$

with $G_9(T) < Gc_9$. The optimal time of replacement is the time which minimizing the cost $G_9(T)$. For its evaluation, we had to resolve the following equation: $\frac{dG_9(t)}{dt} = 0$. Then, we could confirme the decision relative to the test of Koul.

5. Presentation of "FiaElectricité" software:

This program is developped for previsions computations and determination of different distributions based on statistic datas collected from Niamey's 20 Mv distribution network.

"FiaElectricité" is been conceiving specifically to take into account the datas specificity. It is realized under Delphi 5 environment. "FiaElectricité" is constituted to 3 principal programs:

- computations of prevision. It gave α (lissage's constant corresponded) which minimize the chosen criteria and the corresponded previsions' values.
- the appurtenance of a distribution to IFRA alternative
- the appurtenance of a distribution to NBU alternative

Conclusion

It derived from this application that three departures presented NBU distribution at 0.05's level. This reason allowed us to assert that corresponding departures are "old" in reliability viewpoint: NBU property belongs to the oldness models. In other hand we recommanded an applying on a preventive maintenance strategy. For the justification of this decision, we proposed an application which based on the "theory of equipement renovation".

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Contents

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