



**HAL**  
open science

## Investment efficiency assessment on the electric grid by group of control

K. Guillaume, B. Lacombe, P. Sevault, B. Lacroix, Jean-Louis Dirion, O.  
Faivre

► **To cite this version:**

K. Guillaume, B. Lacombe, P. Sevault, B. Lacroix, Jean-Louis Dirion, et al.. Investment efficiency assessment on the electric grid by group of control. CIREN 2023-27th International Conference on Electricity Distribution, Jun 2023, Rome, Italy. pp.406-408, 10.1049/icp.2023.0330 . hal-04229143

**HAL Id: hal-04229143**

**<https://imt-mines-albi.hal.science/hal-04229143v1>**

Submitted on 1 Dec 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Copyright

# INVESTMENT EFFICIENCY ASSESSMENT ON THE ELECTRIC GRID BY GROUP OF CONTROL

Kevin GUILAUME  
Enedis – France  
[kevin.guillaume@enedis.fr](mailto:kevin.guillaume@enedis.fr)

Bertrand LACOMBE  
Enedis – France  
[bertrand.lacombe@enedis.fr](mailto:bertrand.lacombe@enedis.fr)

Pierre SEVAULT  
Enedis - France  
[pierre.sevault@enedis.fr](mailto:pierre.sevault@enedis.fr)

Bastien LACROIX  
Enedis – France  
[bastien.lacroix@enedis.fr](mailto:bastien.lacroix@enedis.fr)

Jean-Louis DIRION  
IMT Mines Albi - France  
[dirion@mines-albi.fr](mailto:dirion@mines-albi.fr)

Odilon FAIVRE  
Enedis - France  
[odilon.favre@enedis.fr](mailto:odilon.favre@enedis.fr)

## ABSTRACT

*The French DSO Enedis spends several hundred million euros every year to maintain and renew its existing network.*

*The investments are made according some policies. One of these policies, called Refurbishment, consists in renovating some segment lines of the overhead medium voltage power network.*

*The choices of the segment lines are made by some experts according mainly to the past outages.*

*To be sure that the choice has been appropriate, we would like to know if the investment is efficient or not. To develop an investment efficiency assessment, we have to compare the number of outages after treatment in a group of refurbished segment lines with a group of un-refurbished segment lines all other things being equal.*

*The method proposed in this paper consist of defining appropriate weights for the un-refurbished segment lines group to make it statistically comparable to the refurbished segment lines group.*

*To define the appropriate weights, we use a method called calibration estimator well known in survey sampling theory [1].*

*When we apply the appropriate weights to the un-refurbished segment lines group, we obtain a control group that can be compared to the refurbished segment lines group.*

*By counting the difference of the outages after treatment between the refurbished segment lines group and the control group, we can estimate the performance of the investment.*

*Using the statistical test “Exact Test of Fisher” [2], we can prove that the difference of outages is significant.*

## INTRODUCTION

With a network of 1.4 million km, Enedis, main DSO in France, spends several hundred million euros every year to maintain and renew its existing network in order to maintain power supply quality.

Business Units follow different policies depending on the type of asset considered. One of these policies, called Refurbishment, consists of renovating some segment lines of the overhead medium voltage power network.

A segment line is the smallest part of the grid with the same features (material, age, size of the cables...).

Some experts carry out surveys to choose the segment lines on which we expect to maximize the improvement of electricity supply continuity by analysing, for example, past outages. When the choices are made, the intervention staff performs the renovation on the grid.

To be sure that the choice has been appropriate, we would like to know if **the investment is efficient or not**. Furthermore, Enedis uses the information about the efficiency of the investments made in the dialog with the public stakeholders who own the managed network.

Developing an investment efficiency assessment is difficult, as we have to **compare the number of outages after treatment in a group of refurbished segment lines with a group of un-refurbished segment lines all other things being equal. Groups have to be comparable on a spatial and a temporal aspect.**

First, let's look at the method used to define appropriate weights for the un-refurbished segment lines group. The method, called **calibration estimator**, is widely used in survey sampling theory to reweight the sample and make it representative of the population studied.

Then, we will see how to use a **statistical test** to compare the weighted un-refurbished segment lines group, called control group with the refurbished segment lines.

# CALIBRATION ESTIMATOR

## Theory and vocabulary

The principle can be summarized in the next picture [Figure 1] where we reweight the un-refurbished segment lines group among two variables called control variables (VarA and VarB) in order to have the same margin (total weighted or frequency weighted of VarA and VarB) between the refurbished segment lines group, i.e. target group and the un-refurbished weighted segment lines group, i.e. control group.

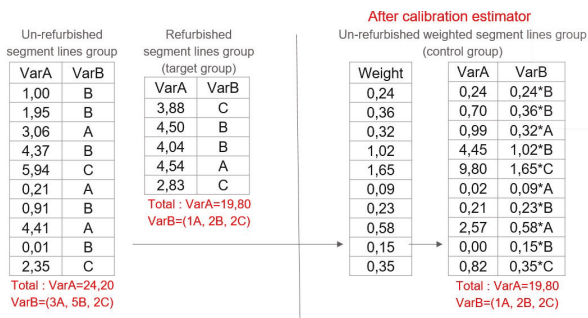


Figure 1: Calibration estimator principle

## Time and spatial aspects between the target and the control group

In order to count the outages among same size time periods, we would like to be sure to have comparable time intervals between the refurbished segment lines group and the weighted un-refurbished segment lines group before and after the refurbishment date.

As we don't have refurbishment date for the un-refurbished segment lines group, we will create a "fictive date" as it is shown in the below figure [Figure 2].

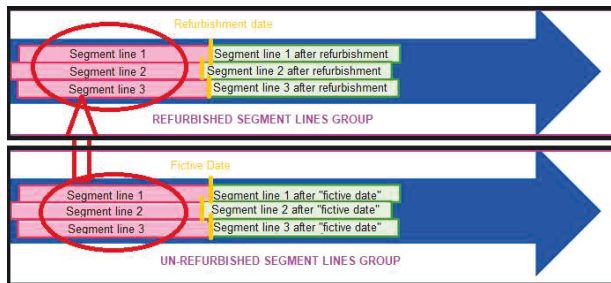


Figure 2: Fictive date

All the un-refurbished segment lines are grouped by age and given a fictive date which is the average of the refurbishment date for the same age refurbished lines.

To deal with time aspects, we consider the number of outages before refurbishment or fictive date as a control variable: in [Figure 2], it means we make sure that on the red time intervals we have the same outage rate for both lines groups.

To deal with spatial aspects, we will add the department (the region) in the control variables.

## Choices of control variables

Choosing appropriately control variables is essential to construct a control group representative of the target group.

In addition of the number of outages before refurbishment or fictive date and department, the technical experts of Enedis consider size, age and designation of the segment lines, structure and number of clients of the grid as control variables.

## RESULT AND STATISTICAL TEST

### Contingency table

When the control group is well defined, we can compare the target group and the control group through a contingency table [Figure 3].

	Segment lines untreated before calibration estimator	Segment lines untreated after calibration estimator MIRROR GROUP	Segment lines treated TARGET GROUP
Segment lines with outages	329	38	19
Segment lines without outages	60849	6123	6142
Total	61178	6161	6161

Figure 3: Example of result on a geographical subdivision of Enedis

In this contingency table, in order to assess the efficiency of the refurbishment on 6,161 segment lines, we used the calibration estimator to affect weights to the 61,178 un-refurbished segment lines. Thus, we obtain a control group of 6,161 segment lines comparables to the 6,161 refurbished segment lines.

We can see that we **have two time less outages** on the refurbished segment lines than on the un-refurbished segment lines, **all other things being equal considering the control variables.**

In the next section we will check if the result is statistically efficient.

## Exact Fisher test

To assess if the refurbishment is statistically efficient, we can compare the target group and the control group by doing statistical test like the Fisher test [2] widely used to test the link of two variables through a contingency table.

In the following screenshot [Figure 4], we can see the R output of the fisher test function:

```
Fisher's Exact Test for Count Data

data: matrice
p-value = 0.0161
alternative hypothesis: true odds ratio is not equal to 1
95 percent confidence interval:
 0.2711224 0.8875482
sample estimates:
odds ratio
0.4984833
```

**Figure 4 : Fisher's Exact test – R output**

As the pvalue of the test is less than 0.05, we can reject the hypothesis that the number of incidents and the groups (control and target) are independent, so, the refurbishment is statistically efficient.

The output of the R fisher test function also gives a confidence interval of the odds ratio that is the inverse of the ratio (0.5 for 2 in our case).

**We can conclude that the refurbishment is statistically efficient.**

## CONCLUSION

The algorithm proposed in this article is useful to prove the efficiency of our investments on the overhead medium voltage power network all other things being equal.

The efficiency is **statistically** proven. This is well appreciated by the public stakeholders in the region to whom Enedis reports regarding the investments made on the network.

We used it for one of ours policies but it can be used for others policies.

Our further actions will be to think about some declinations of this algorithm by cluster of segment lines to find the cluster which maximise the efficiency of our policy.

## MISCELLANEOUS

### Acknowledgments

Thanks to IMT Mines Albi School and particularly Jessy IDEZ, Gregory FOLTYN, Florentin ROUBY for having implemented the algorithm in R.

Thanks to Isabel GARCIA BURREL for his trust and support.

### REFERENCES

[1] Jean-Claude Deville and Carl-Erik Sarndal, 1992, Calibration Estimators in Survey Sampling, *Journal of the American Statistical Association*

[2] [https://en.wikipedia.org/wiki/Fisher%27s\\_exact\\_test](https://en.wikipedia.org/wiki/Fisher%27s_exact_test)