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Hydro-Atmospheric Modeling Of Losses by Crown Effect on the Bukavu-Bujumbura High-Voltage Line of the SocieteNationaleD'electricite (SNEL-RDC).

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Abstract:
Our problem was to find which model would best suit between the least square model and Lagrange's quadratic model.
According to the review of the literature related to this topic, Lagrange's quadratic model would be the best fit. This was taken as a hypothesis from our article.
To carry out this hydro-atmospheric modeling, we used hydro-atmospheric data of the turbined flow D of the RUZIZI River and the RRBUK precipitation of BUKAVU and RRBUJ of BUJUMBURA which constitute our independent variables in the models and the data of the losses by effect. Crown from 1990 until 2017 was the dependent variable of the models.
We therefore generated 12 equations which correspond to the 12 months by the least square model of the form: $P_{Ci}=aRR_{1i}+bRR_{2i}+cD_i+k+\varepsilon_i$ *where a, b and c are coefficients to be determined as well as the constant k. ε represents the error on the model in MWh.*
We also generated 12 equations which correspond to 12 months by the least square model of the form: $P_{Ci}=aRR_{1i}^2+bRR_{2i}^2+cD_i^2+dRR_{1i}+eRR_{2i}+fD_i+k+\varepsilon_i$ *where a, b, c, d, e, f are coefficients to be determined as well as the constant k. ε represents the error on the model in MWh.*
The equation plots showed us that the least square model was closer to the in situ data than the Lagrange quadratic model.
To validate the model, we then placed the in situ flow and precipitation data for 2018 in the different equations generated by the two models.
Finally, we noted on our graph that the line of the least square model practically rhymes with the line of the in situ data while that of the quadratic model of Lagrange is completely shifted compared to that of the least square model.
Thus we have drawn as a conclusion that the least square model is better suited for this modeling than the quadratic model of Lagrange. So our hypothesis is rejected.
Keywords: *lesser square model, quadratic Lagrange model.*

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I. Introduction

01. Problem

Electric current is a useful product because it contributes to the development of countries. This is why it is necessary to carry out research on the problems of its operation and even its transport and to propose possible solutions. It is produced to be marketed as electrical energy which must be well controlled. Electrical energy can indeed be secured by limiting losses in high voltage overhead lines.

Speaking of SNEL's BUKAVU-BUJUMBURA interconnected high voltage network, we asked ourselves a question:

Between the least square model and the quadratic model of Lagrange which is best suited to carry out the hydro-atmospheric modeling of the losses by Corona effect on the high-voltage line BUKAVU-BUJUMBURA of SNEL?

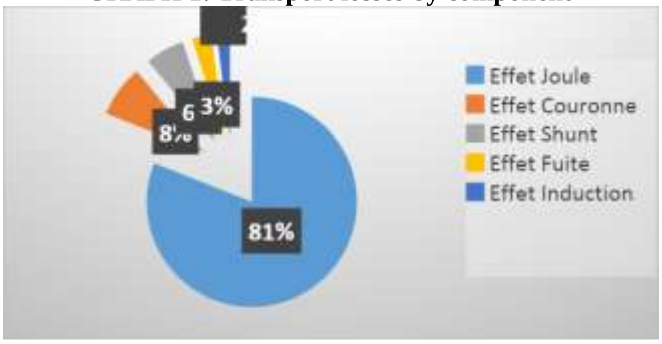
02. Hypothesis

As part of this study we formulated the following hypothesis:

The model which would be best suited to carry out the hydro-atmospheric modeling of the losses by Corona effect on the BUKAVU-BUJUMBURA high-voltage line of SNEL is the quadratic model of Lagrange because in the article entitled "Shared energy" RSEIPC of January 2007 the author modeled the technical losses

on the electrical distribution network by the quadratic method of Lagrange of the form: $P_T=aP^2+bP+c$ where P_T represents the technical losses on the network and P represents the power injected into the electrical distribution network.
The Corona effect is the second largest source of electrical energy transmission losses on a high-voltage line after the Joule effect as shown in the graph below.

GRAPH 1: Transport losses by component



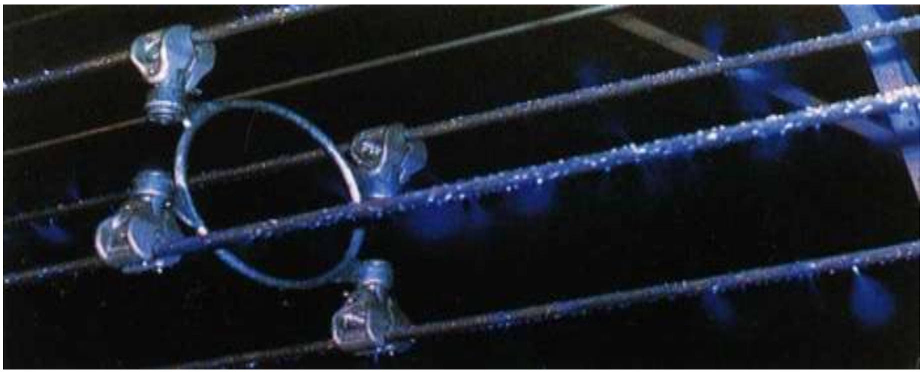
Source: [Anonymous, 2000, p 9].

Very close to the wires, the electric field is very intense, causing in the air nearby a multitude of small electric shocks accompanied by a crackle. This very local phenomenon occurs a few centimeters from the wires.

The crown effect is amplified by precipitation (snow, rain, drizzle).

The roughness on the conductors are natural discontinuities conducive to increasing the electric field. In humid weather, the water droplets present on the conductors considerably increase the roughness, which favors the ionization of the air. This phenomenon is mainly observed in conductors subjected to very high voltages. [Anonymous, 2000, p 4]

CROWN EFFECT ON A HIGH VOLTAGE LINE



SOURCE: [Anonymous, 1998]

The corona losses depend on the tension of the lines and the amount of precipitation. The study of corona losses is approached by taking into account the characteristics of transmission lines (circuit length and route per voltage level), the frequency of precipitation and experimental data adapted to operating conditions. [Anonymous, 2000, p 8]

The Corona effect is a difficult phenomenon to quantify. The criterion often used consists in checking that the surface field remains well below 18kVeff / cm. This "EMAX" field is calculated by the following relation:

$$E_{MAX}=\frac{V_{eff}}{r\ln\frac{2H_{MIN}\ .EPH}{r\sqrt{4H_{MIN}^2+EPH^2}}}\ \square\ \text{kVeff/cm}\square\ .$$

EPH represents the phase separation and H_{MIN} the minimum distance between a conductor and the ground. . □ Anonymous, pp 17 and 18 □

03. Objective

The objective is to perform hydro-atmospheric modeling of corona losses on the BUKAVU-BUJUMBURA high voltage line of SNEL

04. Choice and interest of the study

The choice and interest of this research is prompted by the desire to seek solutions to the problems of corona losses on the BUKAVU-BUJUMBURA high voltage line of SNEL.

05. Subject delimitation

We conducted this study over a period from January 1990 to December 2017 excluding the year 1996 when the area was infested by wars.

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We conducted this study over a period from January 1990 to December 2017 excluding the year 1996 when the area was infested by wars.

II. Methodology

We started by taking the energies produced monthly at the RUZIZI I Plant. And then we took the energies received monthly at the REGIDESO of BUJUMBURA and finally we took the difference between the source and received energies to have the overall monthly electrical energy losses on the BUKAVU-BUJUMBURA high-voltage line of SNEL.

The overall losses were obtained by measurement while the corona losses were obtained analytically.

As we saw in the intro chart, Joule losses represent 8% of overall losses. In this article we will model the corona losses as a function of hydro-atmospheric variables given that this BUKAVU-BUJUMBURA high voltage line from SNEL is subject to climatic hazards.

The hydro-atmospheric variables we are talking about here are: turbine flow and precipitation.

Turbine flow being a hydraulic variable is found as an independent variable in the modeling of corona losses. This can be explained by the following mathematical proof:

$dW = Pdt$

$\Leftrightarrow dW = pdV$

We also know that: $P=\frac{dW}{dt}$

$\Leftrightarrow P=\frac{pdV}{dt}$

$\Leftrightarrow P=\frac{FdV}{Sdt}$

$\Leftrightarrow P=\frac{F}{S}D$

$\Leftrightarrow P=p*D$

Where $p=p_0+\rho gz+\frac{1}{2}\rho v^2$.

Hence $P=(p_0+\rho gz+\frac{1}{2}\rho v^2)*D$

With P: Nominal power of the alternator

D: Turbine flow

P_0: Atmospheric pressure

ρ: Density of water

g: Acceleration of gravity

z: Height difference

v = Rω, R: Radius of the turbine and ω: Angular speed

W: Electric energy

t: time

p: Pressure

V: Volume of water.

F: Water force

S: Pallet surface

From the last relation found we can say that the power of the turbine is a function of the flow, the electrical energy is a function of the power of the turbine, the losses by Joule effect depend on the electrical energy therefore the losses by effect Crown depend on turbine flow.

Referring to the introduction, Corona losses depend on flow and precipitation.

II.1. Least-squared modeling of corona losses on SNEL's BUKAVU-BUJUMBURA high-voltage line.

The losses by Corona effect PC depend on the turbined flow D of the RUZIZI River, the RR_1 precipitation of the BUKAVU region and the RR_2 precipitation of the BUJUMBURA region.
Indeed: $P_{Ci}=aRR_{1i}+bRR_{2i}+cD_i+k+\varepsilon_i$ where a, b and c are coefficients to be determined as well as the constant k. ε represents the error on the model in MWh.

$\varepsilon_i = P_{Ci}-aRR_{1i}-bRR_{2i}-cD_i-k$

$\Leftrightarrow \varepsilon_i^2 = (P_{Ci}-aRR_{1i}-bRR_{2i}-cD_i-k)^2$

$\Leftrightarrow \Psi = (P_{Ci}-aRR_{1i}-bRR_{2i}-cD_i-k)^2$

With $\Psi=\varepsilon_i^2$ is the variance

As a result we will have:

$$\frac{\partial\Psi}{\partial a}=\frac{\partial\Psi}{\partial b}=\frac{\partial\Psi}{\partial c}=\frac{\partial\Psi}{\partial k}=0$$

Finally we will have a system of 4 equations with 4 unknowns to solve to have the coefficients a in MWh⁄mm, b in MWh⁄mm and c in MWhsm3as well as the constant k in MWh.

$a\sum_{i=1}^{27} RR_{1i}^2+b\sum_{i=1}^{27} RR_{1i}RR_{2i}+c\sum_{i=1}^{27} RR_{1i}D_i+k\sum_{i=1}^{27} RR_{1i} = \sum_{i=1}^{27} RR_{1i}P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}RR_{2i}+b\sum_{i=1}^{27} RR_{2i}^2+c\sum_{i=1}^{27} RR_{2i}D_i+ k\sum_{i=1}^{27} RR_{2i}=\sum_{i=1}^{27} RR_{2i}P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}D_i+b\sum_{i=1}^{27} RR_{2i}D_i+c\sum_{i=1}^{27} D_i^2+k\sum_{i=1}^{27} D_i=\sum_{i=1}^{27} D_i P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}+b\sum_{i=1}^{27} RR_{2i}+c\sum_{i=1}^{27} D_i+kn=\sum_{i=1}^{27} P_{Ci}$

II.2. Modeling by the quadratic method of Lagrange of the losses by Corona effect on the high-voltage line BUKAVU-BUJUMBURA of SNEL

The losses by Corona effect P_C depend on the turbined flow D of the RUZIZI River, the RR_1 precipitation of the BUKAVU region and the RR_2 precipitation of the BUJUMBURA region.
Indeed: $P_{Ci}=aRR_{1i}^2+bRR_{2i}^2+cD_i^2+dRR_{1i}+eRR_{2i}+fD_i+k+\varepsilon_i$ where a, b, c, d, e, f are coefficients to be determined as well as the constant k. ε represents the error on the model in MWh.

$\varepsilon_i=P_{Ci}-aRR_{1i}^2-bRR_{2i}^2-cD_i^2-dRR_{1i}-eRR_{2i}-fD_i-k \Leftrightarrow \varepsilon_i^2= (P_{Ci}-aRR_{1i}^2-bRR_{2i}^2-cD_i^2-dRR_{1i}-eRR_{2i}-fD_i-k)^2 \Leftrightarrow \Psi= (P_{Ci}-aRR_{1i}^2-bRR_{2i}^2-cD_i^2-dRR_{1i}-eRR_{2i}-fD_i-k)^2$

With $\Psi=\varepsilon_i^2$ is the variance

As a result we will have:

$$\frac{\partial\Psi}{\partial a}=\frac{\partial\Psi}{\partial b}=\frac{\partial\Psi}{\partial c}=\frac{\partial\Psi}{\partial d}=\frac{\partial\Psi}{\partial e}=\frac{\partial\Psi}{\partial f}=\frac{\partial\Psi}{\partial k}=0$$

Finally we will have a system of 7 equations with 7 unknowns to solve to have the coefficients a in MWh⁄mm², b in MWh⁄mm², c in MWhs²m6, d in MWh⁄mm, e in MWh⁄mm, f in MWhsm3 as well as the constant k in MWh.

$a\sum_{i=1}^{27} RR_{1i}^4+b\sum_{i=1}^{27} RR_{1i}^2RR_{2i}^2+c\sum_{i=1}^{27} RR_{1i}^2 D_i^2+d\sum_{i=1}^{27} RR_{1i}^3+e\sum_{i=1}^{27} RR_{1i}^2RR_{2i}+f\sum_{i=1}^{27} RR_{1i}^2 D_i+k\sum_{i=1}^{27} RR_{1i}^2= \sum_{i=1}^{27} RR_{1i}^2P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}^2RR_{2i}^2+b\sum_{i=1}^{27} RR_{2i}^4+c\sum_{i=1}^{27} RR_{2i}^2 D_i^2+d\sum_{i=1}^{27} RR_{2i}^2RR_{1i}+e\sum_{i=1}^{27} RR_{2i}^3+f\sum_{i=1}^{27} RR_2^2 D_i+k\sum_{i=1}^{27} RR_{2i}^2= \sum_{i=1}^{27} RR_{2i}^2P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}^2 D_i^2+b\sum_{i=1}^{27} RR_{2i}^2 D_i^2+c\sum_{i=1}^{27} D_i^4+d\sum_{i=1}^{27} RR_{1i} D_i^2+e\sum_{i=1}^{27} RR_{2i} D_i^2+f\sum_{i=1}^{27} D_i^3+k\sum_{i=1}^{27} D_i^2=\sum_{i=1}^{27} D_i^2 P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}^3+b\sum_{i=1}^{27} RR_{2i}^2RR_{1i}+c\sum_{i=1}^{27} RR_{1i} D_i^2+d\sum_{i=1}^{27} RR_{1i}^2+e\sum_{i=1}^{27} RR_{1i}RR_{2i}+f\sum_{i=1}^{27} RR_{1i} D_i+k\sum_{i=1}^{27} RR_{1i}= \sum_{i=1}^{27} RR_{1i}P_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}^2RR_{2i}+b\sum_{i=1}^{27} RR_{2i}^3+c\sum_{i=1}^{27} RR_{2i} D_i^2+d\sum_{i=1}^{27} RR_{1i}RR_{2i}+e\sum_{i=1}^{27} RR_{2i}^2+f\sum_{i=1}^{27} RR_{2i} D_i+k\sum_{i=1}^{27} RR_{2i}= \sum_{i=1}^{27} RR_{2i}P_{Ci}$

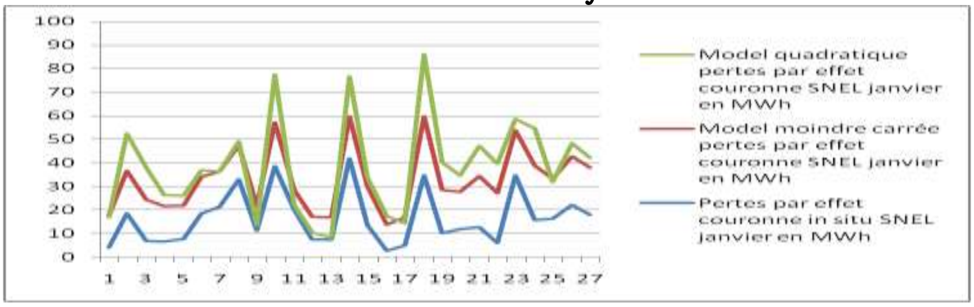
$a\sum_{i=1}^{27} RR_{1i}^2 D_i+b\sum_{i=1}^{27} R_{2i}^2 D_i+c\sum_{i=1}^{27} D_i^3+d\sum_{i=1}^{27} RR_{1i} D_i+e\sum_{i=1}^{27} RR_{2i} D_i+f\sum_{i=1}^{27} D_i^2+k\sum_{i=1}^{27} D_i=\sum_{i=1}^{27} D_iP_{Ci}$

$a\sum_{i=1}^{27} RR_{1i}^2+b\sum_{i=1}^{27} RR_{2i}^2+c\sum_{i=1}^{27} D_i^2+d\sum_{i=1}^{27} RR_{1i}+e\sum_{i=1}^{27} RR_{2i}+f\sum_{i=1}^{27} D_i+kn=\sum_{i=1}^{27} P_{Ci}$

III. Presentation And Discution Of The Results

The following results are presented by month over a period going from 1990 until 2017. Unfortunately the year 1996 was not taken into account because it did not have availability of data for most of the months due to the war that was rampant in the region at that time. This is why the number of years of study is 27 instead of 28

GRAPH 2: Month of January 1990-2017

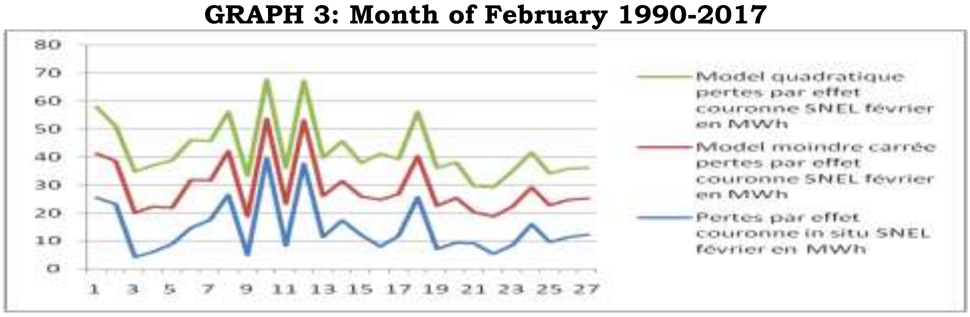


SOURCE: EXCEL software

$P_{C\ NEL}=-0.059*RR_{BUK}-0.001*RR_{BUJ}+0.288*D-0.049$ (Least square model)

$P_{C\ NEL}=0.001*RR_{BUK}^2-0.0002*RR_{BUJ}^2+0.033*D^2-0.5*RR_{BUK}+0.075*RR_{BUJ}-5.906*D+312.246$ (Quadratic model)

GRAPH 3: Month of February 1990-2017

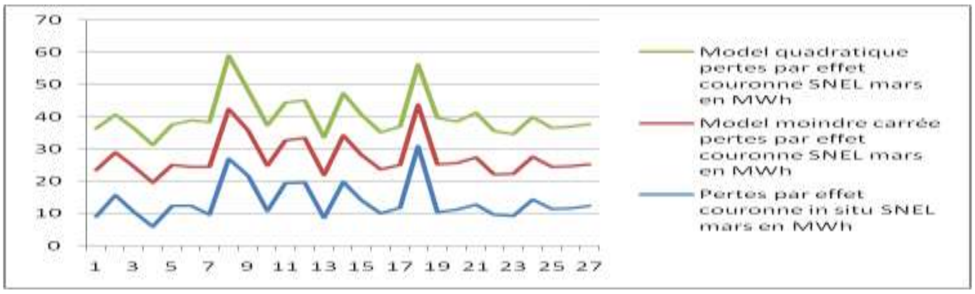


SOURCE: EXCEL software

$P_{C\ NEL}=-0.007*RR_{BUK}+0.0269*RR_{BUJ}-0.11*D+22.53$ (Smaller square model)

$P_{C\ NEL}=-5.324*10^{-5}*RR_{BUK}^2-0.0007*RR_{BUJ}^2+0.008*D^2-0.024*RR_{BUK}+0.118*RR_{BUJ}-1.552*D+88.524$ (Quadratic model)

GRAPH 4: Month of March 1990-2017

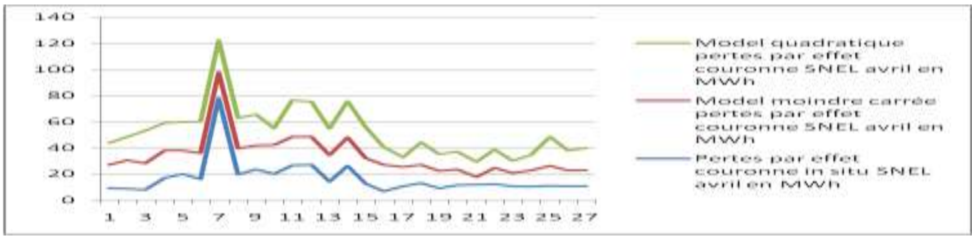


SOURCE: EXCEL software

$P_{C\ NEL}=-0.0002*RR_{BUK}+0.017*RR_{BUJ}-7.493*10^{-5}*D+11.774$ (Smaller square model)

$P_{C\ NEL}=-1.853*10^{-6}*RR_{BUK}^2-0.0004*RR_{BUJ}^2+0.0001*D^2+1.143*10^{-6}*RR_{BUK}-0.084*RR_{BUJ}+0.001*D+15.457$ (Quadratic model)

GRAPH 5: Month of April 1990-2017

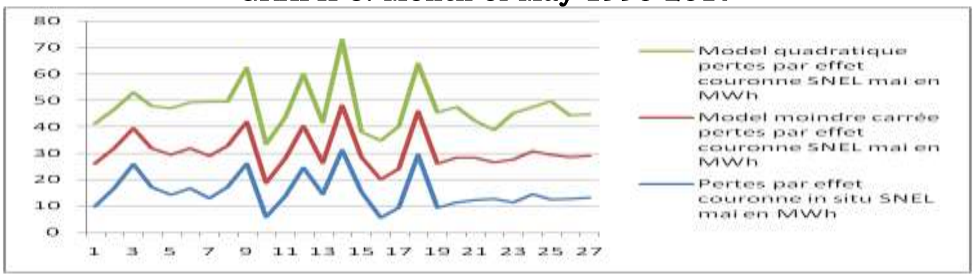


SOURCE: EXCEL software

$P_{C\ NEL}$=-0.022*RR_{BUK}+0.045*RR_{BUJ}-0.216*D+42.488 (Smaller square model)

$P_{C\ NEL}$=0.0001*RR^2_{BUK} -0.005*RR^2_{BUJ} -0.018*D^2-0.048*RR_{BUK}+0.904*RR_{BUJ}+2.968*D-133.528(Quadratic model)

GRAPH 6: Month of May 1990-2017

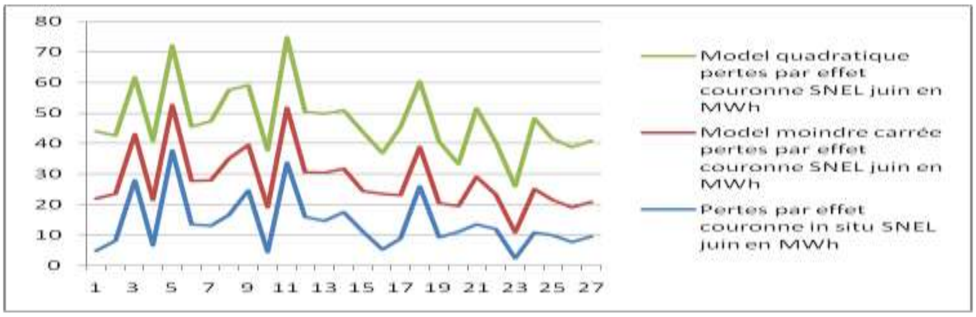


SOURCE: EXCEL software

$P_{C\ NEL}$=-0.025*RR_{BUK}+3.919*10^{-5}*RR_{BUJ}+0.044*D+13.696 (Smaller square model)

$P_{C\ NEL}$=0.0004*RR^2_{BUK} -0.0003*RR^2_{BUJ} -0.0002*D^2-0.129*RR_{BUK}-3.9*10^{-6}*RR_{BUJ}+0.305*D-13.706(Quadratic model)

GRAPH 7: Month of June 1990-2017

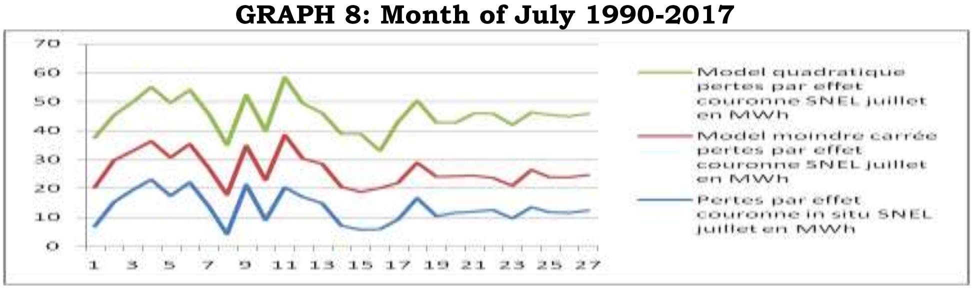


SOURCE: EXCEL software

$P_{C\ NEL}$=-0.028*R_{BUK}+0.211*R_{BUJ}-0.192*D+28.665 (Smaller square model)

$P_{C\ NEL}$=0.0003*R^2_{BUK} -0.002*R^2_{BUJ} -0.011*D^2-0.071*R_{BUK}+0.276*R_{BUJ}+1.826*D-54.944(Quadratic model)

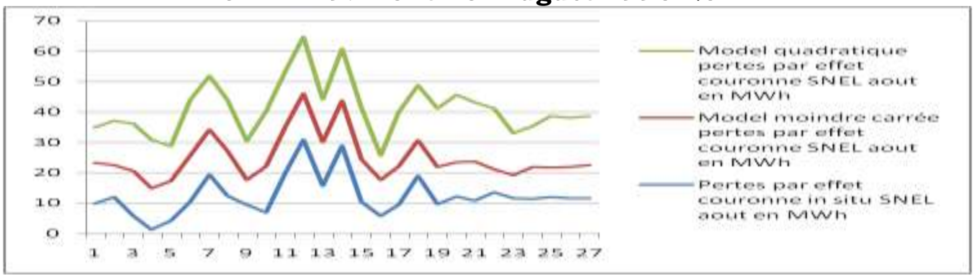
GRAPH 8: Month of July 1990-2017



SOURCE: EXCEL software

$P_{C\ NEL}=-0.064*RR_{BUK}+0.032*RR_{BUJ}-0.051*D+16.873$ (Smaller square model)
$P_{C\ NEL}=0.004*RR_{BUK}^2+0.012*RR_{BUJ}^2-0.004*D^2-0.251*RR_{BUK}-0.251*RR_{BUJ}+0.817*D-19.085$ (Quadratic model)

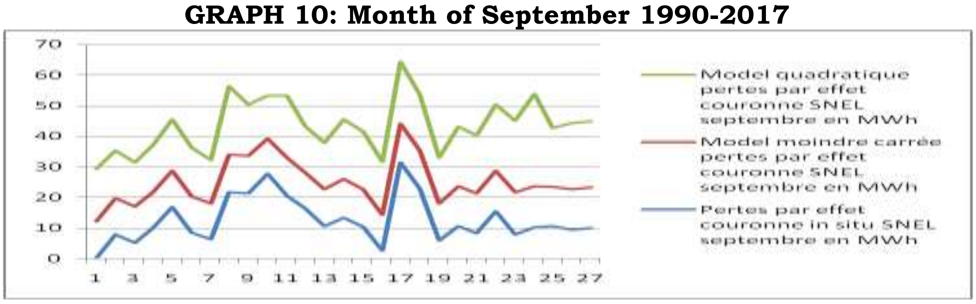
GRAPH 9: Month of August 1990-2017



SOURCE: EXCEL software

$P_{C\ NEL}=-0.02*RR_{BUK}-0.114*RR_{BUJ}-0.106*D+22.608$ (Smaller square model)
$P_{C\ NEL}=8.229*10^{-5}*RR_{BUK}^2+0.023*RR_{BUJ}^2-0.007*D^2-0.034*RR_{BUK}-0.753*RR_{BUJ}+1.338*D-40.708$ (Quadratic model)

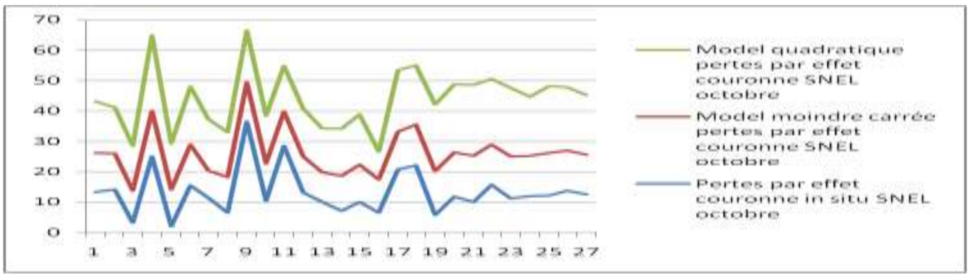
GRAPH 10: Month of September 1990-2017



SOURCE: EXCEL software

$P_{C\ NEL}=-0.004*RR_{BUK}-0.009*RR_{BUJ}-0.027*D+9.57$ (Smaller square model)
$P_{C\ NEL}=-0.0001*RR_{BUK}^2+3.002*10^{-5}*RR_{BUJ}^2-0.001*D^2+0.031*RR_{BUK}-0.01*RR_{BUJ}+0.235*D+1.129$ (Quadratic model)

GRAPH 11: Month of October 1990-2017



SOURCE: EXCEL software

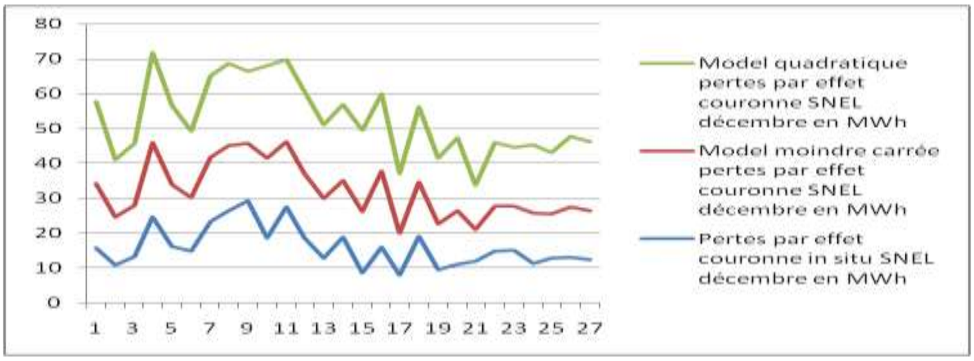
$P_{C\ NEL}=-0.024*RR_{BUK}-0.005*RR_{BUJ}+0.088*D+9.341$ (Least square model)
$P_{C\ NEL}=0.0004*RR_{BUK}^2+3.*10^{-6}*RR_{BUJ}^2-0.003*D^2-0.155*RR_{BUK}-0.0003*RR_{BUJ}+0.777*D-11.961$ (Quadratic model)

GRAPH 12: Month of November 1990-2017

SOURCE: EXCEL software

$P_{C\ NEL}$=0.006*RR_{BUK}-0.047*RR_{BUJ}-0.217*D+35.936 (Smaller square model)
$P_{C\ NEL}$=-0.0002*RR^2_{BUK} +0.0001*RR^2_{BUJ} +0.001*D^2+0.084*RR_{BUK}-0.103*RR_{BUJ}-0.502*D+59.109 (Quadratic model)

GRAPH 13: Month of December 1990-2017



SOURCE: EXCEL software

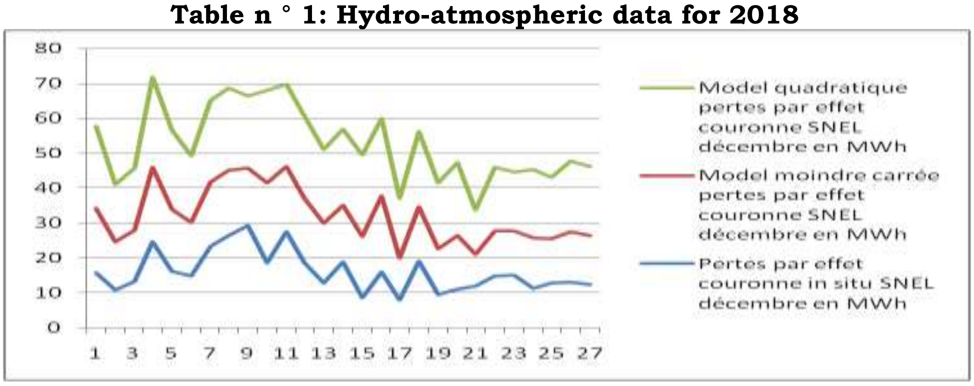
$P_{C\ NEL}$=0.047*RR_{BUK}+0.0007*RR_{BUJ}-0.325*D+37.282 (Smaller square model)
$P_{C\ NEL}$=-0.0002*RR^2_{BUK} +5.868*10^{-5}*RR^2_{BUJ} -0.011*D^2+0.123*RR_{BUK}-0.011*RR_{BUJ}+1.713*D-57.816 (Quadratic model)

By observing all twelve graphs, we find that the least squared model is better than the quadratic Lagrange model.
The curve of the least squared model is closer to that of the in situ data over the 27 years while that of the quadratic Lagrange model, although following the same course, moves further away from it.

IV. Discussion Of The Results

In this point we will seek to validate the model which would be most suitable for modeling losses by Corona effect on the BUKAVU-BUJUMBURA high-voltage line of SNEL. Here we will have to replace the hydro-atmospheric data of 2018 in our equations and thus have the data modeled 2018 for the corona losses.

Table n ° 1: Hydro-atmospheric data for 2018



Month	Flow 2018 in m3/s	$_{RRBUK}$ 2018 en mm	$_{RRBUJ}$ 2018 en mm
JAN	100.1	138.1	65
FEB	97.55	152.7	128
MAR	97.62	169	116
APR	101.99	81.1	109
MAY	94.55	38.4	51
JUNE	94.96	24.7	20
JULY	95.34	0	0
AUG	89.17	0	2
SEP	90.56	144.4	60
OCT	93.27	159.4	40
NOV	90.38	169	83
DEC	93.92	145	133

Source: RUZIZI I SUD-KIVU power station

Table n ° 2: Overall losses and losses by ring effect 2018 in MWh

Month	ES NEL 2018	ER NEL 2018	P_{GOBALE} NEL 2018	$P_{Couronne}$NEL 2018
JAN	3126	2853	273	21.84
FEB	2617	2442	175	14
MAR	2615	2451	164	13.12
APR	3262	3089	173	13.84
MAY	3424	3250	174	13.92
JUNE	3009	2842	167	13.36
JULY	3506	3343	163	13.04
AUG	3555	3377	178	14.24
SEP	2680	2539	141	11.28
OCT	2404	2249	155	12.4
NOV	2814	2604	210	16.8
DEC	3144	2955	189	15.12

Source: RUZIZI I plant monthly technical report (RTM) IV.1. 2018 MODELED LOSSES BY CROWN EFFECT PER MINUS SQUARE

January

$P_{C\ NEL}$=-0.059*RR_{BUK}-0.001*RR_{BUJ}+0.288*D-0.049
=-0.059*138.1-0.001*65+0.288*100.1-0.049
=20.566 MWh

Febrary

$P_{C\ NEL}$=-0.007*RR_{BUK}+0.0269*RR_{BUJ}-0.11*D+22.53
=-0.007*152.1+0.0269*128-0.11*97.55+22.53
=14.173 MWh

March

$P_{C\ NEL}$=-0.0002*RR_{BUK}+0.017*RR_{BUJ}-7.493*10^{-5}*D+11.774
=-0.0002*169+0.017*116-7.493*10^{-5}*97.62
=13.719 MWh

April

$P_{C\ NEL}$=-0.022*RR_{BUK}+0.045*RR_{BUJ}-0.216*D+42.488
=-0.022*81.1+0.045*109-0.216*101.99+42.488
=13.768 MWh

May

$P_{C\ NEL}$=-0.025*RR_{BUK}+3.919*10^{-5}*RR_{BUJ}+0.044*D+13.696
=-0.025*38.4+3.919*10^{-5}*51+0.044*94.55+13.696
=16.897 MWh

June

$P_{C\ NEL}$=-0.028*R_{BUK}+0.211*R_{BUJ}-0.192*D+28.665
=-0.028*24.7+0.211*20-0.192*94.96+28.665
=13.961 MWh

July

$P_{C\ NEL}$=-0.064*RR_{BUK}+0.032*RR_{BUJ}-0.051*D+16.873
=-0.064*0+0.032*0-0.051*95.34+16.873
=12.010 MWh

August

$P_{C\ NEL}$=-0.02*RR_{BUK}-0.114*RR_{BUJ}-0.106*D+22.608
=-0.02*0-0.114*2-0.106*89.17+22.608
=12.927 MWh

September

$P_{C\ NEL}$=-0.004*RR_{BUK}-0.009*RR_{BUJ}-0.027*D+9.57
=-0.004*144.4-0.009*60-0.027*90.56
=13.132 MWh

October

$P_{C\ NEL}$=-0.024*RR_{BUK}-0.005*RR_{BUJ}+0.088*D+9.341
=-0.024*159.4-0.005*40+0.088*93.27+9.341
=13.523 MWh

November

$P_{C\ NEL}$=0.006*RR_{BUK}-0.047*RR_{BUJ}-0.217*D+35.936
=0.006*169-0.047*83-0.217*90.38+35.936
=13.436 MWh

December

$P_{C\ NEL}$=0.047*RR_{BUK}+0.0007*RR_{BUJ}-0.325*D+37.282
=0.047*145+0.0007*133-0.325*93.92+37.282
=13.666 MWh

IV.2 LOSSES BY CROWN EFFECT MODEL 2018 BY THE LAGRANGE QUADRATIC METHOD

January

$P_{C\ NEL}$=0.001*RR^2_{BUK} -0.0002*RR^2_{BUJ} +0.033*D^2-0.5*RR_{BUK}+0.075*RR_{BUJ}-5.906*D+312.246 =0.001*(138.1)² -0.0002*(65)² +0.033*(100.1)²-0.5*(138.1)+0.075*(65)-5.906*(100.1)+312.246 =5.767 MWh

February

$P_{C\ NEL}$=-5.324*10^{-5}*RR^2_{BUK} -0.0007*RR^2_{BUJ} +0.008*D^2-0.024*RR_{BUK}+0.118*RR_{BUJ}-1.552*D+88.524 =-5.324*10^{-5}*(152.1)²-0.0007*(128)+0.008*(97.55)² -0.024*(152.1)+0.118*(128)-1.552*(97.55)+88.524=12.118 MWh

March

$P_{C\ NEL}$=-1.853*10^{-6}*RR^2_{BUK} -0.0004*RR^2_{BUJ} +0.0001*D^2+1.143*10^{-6}*RR_{BUK}-0.084*RR_{BUJ}+0.001*D+15.457 =-1.853*10^{-6}*(169)²-0.0004*(116)²+0.0001*(97.62)² +1.143*10^{-6}*(169)-0.084*(116)+0.001*(97.62)+15.457 =12.029 MWh

April

$P_{C\ NEL}$=0.0001*RR^2_{BUK} -0.005*RR^2_{BUJ} -0.018*D^2-0.048*RR_{BUK}+0.904*RR_{BUJ}+2.968*D-133.528=0.0001*(81.1)-0.005*(109)-0.018*(101.99)²-0.048*(81.1)+0.904*(109)+2.968*(101.99)-133.528 =17.838 MWh

May

$P_{C\ NEL}$=0.0004*RR^2_{BUK} -0.0003*RR^2_{BUJ} -0.0002*D^2-0.129*RR_{BUK}-3.9*10^{-6}*RR_{BUJ}+0.305*D-13.706 =0.0004*(38.4)² -0.0003*(51)²-0.0002*(94.55)²-0.129*(38.4)-3.9*10^{-6}*(51)+0.305*(94.55)-13.706 =19.520 MWh

June

$P_{C\ NEL}$=0.0003*R^2_{BUK} -0.002*R^2_{BUJ} -0.011*D^2-0.071*RR_{BUK}+0.276*RR_{BUJ}+1.826*D-54.944 =0.0003*(24.7)²-0.002*(20)²-0.011*(94.96)²-0.071*(24.7)+0.276*(20)+1.826*(94.96)-54.944=23.130 MWh

July

$P_{C\ NEL}$=0.004*RR^2_{BUK} +0.012*RR^2_{BUJ} -0.004*D^2-0.251*RR_{BUK}-0.251*RR_{BUJ}+0.817*D-19.085 =0.004*(0)²+0.012*(0)²-0.004*(95.34)²-0.251*(0)-0.251*(0) +0.817*(95.34) -19.085 =22.830 MWh

August

$P_{C\ NEL}=8.229*10^{-5}*RR_{BUK}^{2}+0.023*RR_{BUJ}^{2}-0.007*D^{2}-0.034*RR_{BUK}\ 0.753*RR_{BUJ}+1.338*D-40.708$ $=8.229*10^{-5}*(0)+0.023*(2)^{2}-0.007*(89.17)^{2}-0.034*(0)-0.753*(2)+1.338*(89.17)-40.708=21.528$ MWh

September

$P_{C\ NEL}=-0.0001*RR_{BUK}^{2}+3.002*10^{-5}*RR_{BUJ}^{2}-0.001*D^{2}+0.031*RR_{BUK}-0.01*RR_{BUJ}+0.235*D+1.129$ $=-0.0001*(144.4)^{2}+3.002*10^{-5}*(60)^{2}-0.001*(90.38)^{2}+0.031*(144.4)-0.01*(60)+0.235*(90.38)+1.129=17.308$ MWh

October

$P_{C\ NEL}=0.0004*RR_{BUK}^{2}+3.*10^{-6}*RR_{BUJ}^{2}-0.003*D^{2}-0.155*RR_{BUK}-0.0003*RR_{BUJ}+0.777*D-11.961$ $=0.0004*(159.4)^{2}+3.*10^{-6}(40)^{2}-0.003*(93.27)^{2}-0.155*(159.4)-0.0003*(40)+0.777*(93.27)-11.961=19.856$ MWh

November

$P_{C\ NEL}=-0.0002*RR_{BUK}^{2}+0.0001*RR_{BUJ}^{2}+0.001*D^{2}+0.084*RR_{BUK}-0.103*RR_{BUJ}-0.502*D+59.109$ $=-0.0002*(169)^{2}+0.0001*(83)^{2}+0.001*(90.38)^{2}+0.084*(169)-0.103*(83)-0.502*(90.38)+59.109=5.562$ MWh

December

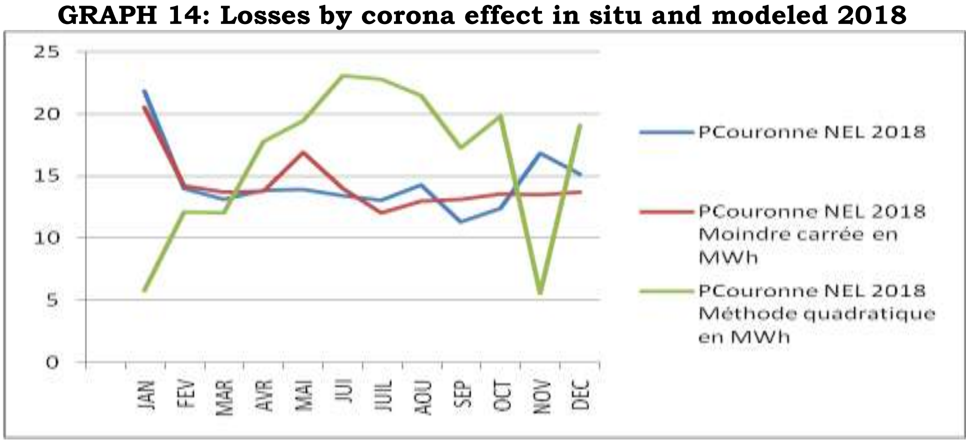
$P_{C\ NEL}=-0.0002*RR_{BUK}^{2}+5.868*10^{-5}*RR_{BUJ}^{2}-0.011*D^{2}+0.123*RR_{BUK}-0.011*RR_{BUJ}+1.713*D-57.816$ $=-0.0002*(145)^{2}+5.868*10^{-5}*(133)-0.011*(93.92)^{2}+0.123*(145)-0.011*(133)+1.713*(93.92)-57.816=19.089$ MWh

Table n°3: Losses by in situ corona effect and modeled 2018 in MWh

Month	Pcrown NEL 2018	Pcrown NEL 2018 Least square	Pcrown NEL 2018 Quadratic Method
JAN	21.84	20.566	5.767
FEB	14	14.173	12.118
MAR	13.12	13.719	12.029
APR	13.84	13.768	17.838
MAY	13.92	16.897	19.520
JUNE	13.36	13.961	23.130
JULY	13.04	12.010	22.830
AUG	14.24	12.927	21.528
SEP	11.28	13.132	17.308
OCT	12.4	13.523	19.856
NOV	16.8	13.436	5.562
DEC	15.12	13.666	19.089
TOTALS	172.96	171.778	196.575

Source: RTM Power Plant RUZIZI I and Modeling

GRAPH 14: Losses by corona effect in situ and modeled 2018



Source: EXCEL software

As we observed in the previous point, the least square model is best suited for the hydro-atmospheric modeling of the corona losses of the SNEL.

The graph presents a situation where the red line of the least square model is practically close to the blue line of the in situ data over the 27 years while the green line of the quadratic Lagrange model is completely offset by two others.

V. Conclusion

Here we are at the end of our article devoted to the modeling of losses by Corona effect in electrical energy on the BUKAVU-BUJUMBURA high-voltage line of SNEL. In the presentation point of the results the twelve graphs, clearly shows us that the least squared model is better than the quadratic model of Lagrange.

The curve of the least squared model is closer to that of the in situ data over the 27 years while that of the quadratic Lagrange model, although following the same trend, deviates further from it in the presentation of the results.

The graph presents a situation where the red line of the least squared model practically rhymes with the blue line of in situ data over the 27 years while the green line of the Lagrange quadratic model is completely shifted from two others in the discussion part of the results. .

Consequently our starting hypothesis is rejected because we find that to carry out a hydro-atmospheric modeling of the losses by Corona effect for our case, it is necessary to apply the model of least squares.

SUGGESTIONS

To keep the line in good condition we make the following suggestions:

To the governments of the DRC:

To become actively involved in finding solutions to the problems that SNEL is experiencing on the BUKAVU-BUJUMBURA high-voltage line;

Support SNEL's efforts to combat online Crown loss;

To seek both national and international partners to improve SNEL's work system on the BUKAVU-BUJUMBURA high-voltage line;

To create relationships with researchers to master the problem of line losses due to the Crown effect.

At SNEL:

To make regular descents on the ground for possible maintenance and especially to fight against pollution caused by vegetation around the line as well as insects;

Use thicker or bundled conductors;

Increase the distances between phase and phase / Earth;

To use non-symmetrical beams.

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