Reduction of greenhouse gas emissions resulting from decreased losses in the conductors of an electrical installation

J.A. Lobão [a], T. Devezas [b], J.P.S. Catalão [b,c,d,]*

[a] *Polytechnic Institute of Guarda, Av. Dr. Francisco Sá Carneiro 50, 6300-559 Guarda, Portugal*
[b] *University of Beira Interior, R. Fonte do Lameiro, 6201-001 Covilha, Portugal*
[c] *INESC-ID, R. Alves Redol, 9, 1000-029 Lisbon, Portugal*
[d] *IST, Technical University of Lisbon, Av. Rovisco Pais, 1, 1049-001 Lisbon, Portugal*

Abstract

The activities of the electricity sector in production and consumption have implications in almost all environmental problems of today. The main environmental impacts occur during the production of electricity, mainly due to the emission of air pollutants, which is directly linked to climate change that has been observed over time. Ambitious climate change mitigation requires significant changes in many economic sectors, in particular in the production and consumption of energy. Considering that the primary energy consumption has increased, doubling since the 1970s, and in particular the consumption of electricity has had a sharper increase, nearly quadrupling in the same period, all measures that can mitigate environmental impacts on both the supply and demand sides of electricity are of interest. This paper introduces a new software application that analyses efficient investment in street lighting and industrial and domestic electrical equipment, accounting for the reduction of losses in the conductors of electrical installations, which is usually neglected. It also determines the reduction of CO_2 emitted into the atmosphere, which contributes to the reduction of emissions of greenhouse gases from a country or particular product.

Keywords: CO_2 emission, energy efficiency, electricity consumption, electricity production, cable losses

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1. Introduction

The greenhouse effect is the action that controls and maintains a constant temperature of the earth. This control is regulated by the amount of certain types of scattered gases – carbon dioxide, methane, and nitrogen oxides, among others – known as greenhouse gases (GHGs). When the concentration of these gases in the atmosphere increases considerably, it also increases the average infrared radiation that is retained in the atmosphere, causing various climatic changes, among them, very worryingly, the global warming confirmed by the scientific community.

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* Corresponding author at: University of Beira Interior, R. Fonte do Lameiro, 6201-001 Covilha, Portugal. Tel.: +351 275 329914; fax: +351 275 329972.
E-mail address: catalao@ubi.pt (J.P.S. Catalão).

The use of electrical energy, from production to consumption, during transportation and distribution has implications for almost every major environmental problem nowadays, especially regarding the emission of GHGs into the atmosphere. The electricity sector is responsible for a large portion of GHG emissions, which occur directly in the act of generating electricity, especially from fossil fuels in thermoelectric plants and indirectly in the extraction, transportation, and processing of fuels and raw materials used in the plants' production of electricity from thermoelectric or renewable energy.

If, on the one hand, the production of electricity releases GHGs into the atmosphere, contributing to climate change, and, on the other hand, climate change influences the production of electricity in particular, the use and planning of new power generation plants should be based on the implications of these changes.

In this complex relation and interconnection of influences, various studies have been developed. The influence of climate change on energy production has been the subject of study of various sources, in particular renewable energy sources, which are more vulnerable due to its dependence on weather and climate. For instance, impact of climate change in general on wind power [1], on the water used in nuclear power plants [2] and on the production of hydroelectricity [3], or in specific regions such as the analysis of the vulnerability of wind power to climate change in Brazil [4].

A review of the vulnerability of the energy sector to climate change, in terms of its various aspects, from production, transportation, distribution, and use to energy demand, is presented in [5].

If the long-term concerns regarding the vulnerability of the energy sector to climate change cannot and should not be ignored in the present, the influence of the electric sector on the present climate change also cannot be ignored, because the power sector is responsible for a significant part of GHG emissions. In this context it is important to quantify greenhouse gas emissions by developing electricity technology and influencing the decision making of economic and political agents that allow the effective reduction of GHG emissions into the atmosphere.

Quantification is difficult and not always coincident; it depends on the methods of calculation and encompassed components. If only the gas in the central production is counted, the value found is very different from what it might be if we include indirect influences upstream and downstream in order to make an assessment of the lifecycle. It may reach 25% for fossil fuel technologies and 90% for renewable energy technologies [6]. Various studies and methods were analysed to quantify the direct and/or indirect emissions of GHGs due to the production technology used for coal plants, natural gas, nuclear, biomass, photovoltaics, compiled and explained to the various technologies of electricity and its life cycle in the case of Greece [6-10].

Environmental component uncertainties are very high due to the complexity of the web of relations between natural systems and the various methods of energy production that constitute the electrical systems of a country or geographical region. Various methods can be used in the calculation of GHGs concerning electrical system gases, taking into account the production of electricity or its consumption, resulting in different values [11,12]. Knowing that consumption does not always coincide with the production in the respective country, we have to consider the losses, imports, and exports.

The quantification of emissions is important, as well as the limitation of emissions of GHGs by international laws and protocols, leading to emission reduction, is increasingly relevant and is the object of study.

The electricity sector differs significantly from many other energy sectors, since electricity cannot be stored as such and therefore it is consumed at about the same time as it is produced. The control and reduction of CO_2 emissions involves:

- Reduction of emissions at source through more efficient conversion of fossil fuels (China, for example, the world's largest consumer of coal for electricity generation, could use about 20% less coal if its plants were as efficient as the average in Japan);
- Increasing the use of renewable fuels or decarbonisation of fuels;
- Measures to manage demand and production, environmentally and economically efficient dispatch [13,14], and impacts of distributed generation on the operational characteristics of networks [15];
- Reduction of power consumption in terms of distribution structures and transport at the level of efficient use, such as dimensioning the section of cables to reduce energy consumption and optimizing operating distribution systems [16–18];
- Reduction of distribution losses by reducing reactive power optimization with capacitors placed in the distribution lines [19–21], layout optimization for radial distribution [22], use of superconducting power transmission [23,24], and development of efficient and sustainable electrical equipment, in particular industrial induction motors [25–27], which are responsible for a large share of electricity consumption, as well as efficient lamps [28–32] for industrial and domestic use.

In order to reduce the energy consumption in a domestic or industrial installation, the efficiency of real loads and all losses in the cables of the installation should be thoroughly studied to improve the energy efficiency. Indeed, energy efficiency and reduction of consumption in electrical installations and equipment represent an important line of research, as the decrease in consumption affects the entire energy system and the reduction of greenhouse gases occurs along the entire production chain.

Hence, this paper provides consumers and managers with a new software application that allows them to compare options and choose the best investment in the acquisition and installation of electrical equipment, aiming for both efficiency and sustainability. Three research aspects are connected in an original way: the influence of equipment and the losses caused by it in the installation, the associated economic analysis, and the reduction of GHGs. Previously published works mainly studied the contribution of the reduction of greenhouse gases from the production side. In this paper, the study is focused on the user side, including the reduction of energy losses in an electrical installation as well as the reduction of the greenhouse gas emissions associated in the analysis and choice of efficient electrical equipment.

This paper is structured as follows, Section 2 presents the problem formulation, Section 3 explains the economic evaluation, Section 4 illustrates the new software application, Section 5 provides the simulation results, and, finally, concluding remarks are given in Section 6.

2. Problem Formulation

Considering climate change and the limitation of emissions of GHGs at the international level, the control of emissions of air pollutants (mainly SO_2, NO_x, particulates and, more recently, CO_2) has been one of the key aspects for the electric sector. CO_2 emissions responsible for the greenhouse effect from electrical systems cannot be eliminated but can be controlled and reduced. Multiple methods can be used and have been studied in all phases of electrical systems.

The reduction of energy consumption in its various forms is a direct method of reducing the emissions of GHGs, with effects in all phases of the operation of electrical systems. A contribution that is often forgotten is the reduction of losses in electrical installations associated with the use of efficient equipment. To quantify the contribution of the reduction of losses to the reduction of GHGs, the emissions of the final product (gCO_2/kWh) are quantified.

Hence, in this paper we examine how to determine the emissions in gCO_2/kWh of a country or region, present the development steps and calculation of losses in the electrical installations' cables (industrial, domestic, and public lighting), and quantify the reduction of CO_2 emissions into the atmosphere related to the reduction of losses in the conductors of an electrical installation, which is usually neglected.

Various types of power plants using different fuels with different carbonic intensities contribute to the production of electricity in an electrical system of a country. As each type of plant has a different CO_2 intensity we can determine the intensity in the production of electricity by Equation (1):

$$CO_2 Intensity = \frac{\sum(C_i I_i)}{\sum(P_i)} \tag{1}$$

in which:

CO_2 is the intensity of CO_2 in gCO_2/kWh

i is the fuel source 1, ..., n, which contributes to the production

C_i is the CO_2 emission factor of each fuel source

I_i is the fuel input by source

P_i is the production of energy by source

Special attention should be given to the contribution of combined heat and power (CHP), since the emission of gases should be allocated for the production of both products. Various methods can be adopted [11,12] and can positively or negatively influence the final outcome in countries with many cogeneration plants.

One method is to assign a relative weighting to the production of each product, ranging from 0 to 100%, allocated to each of the components. Equation (2) can be used for considering equally heat and power:

$$CO_2 Intensity = \frac{\sum(C_i I_i)}{\sum(P_i + H_i)} \tag{2}$$

National annual CO_2 emissions for the production of electricity by each country with the influence of various power plants can be calculated by Equation 3, as reported in [12]:

$$\begin{aligned} E_{elpro} = E_{ep} + E_{CHP} \times \left(\frac{A \times el_{CHP}}{A \times el_{CHP} + (1-A) \times h_{CHP}}\right) \\ + E_{own} \times \frac{el_{tot}}{el_{tot} + h_{tot}} + E_{autoel} \\ + E_{autoCHP} \times \frac{A \times el_{autoCHP}}{A \times el_{autoCHP} + (1-A) \times h_{autoCHP}} \end{aligned} \tag{3}$$

in which:

E_{elpro} = annual CO_2 emissions allocated to total electricity production

E_{ep} = annual CO_2 emissions from the main electricity plants (excluding CHP plants and own use)

E_{CHP} = annual CO_2 emissions from the main CHP plants

A = weighting factor for allocating CO_2 emissions between electricity and heat

el_{CHP} = annual electricity output from the main CHP plants

h_{CHP} = annual heat output from the main CHP plants

E_{own} = annual CO_2 emissions from own use of electricity, CHP, and heat plants

el_{tot} = annual total electricity output from electricity, CHP, and heat plants

h_{tot} = annual total heat output from electricity, CHP, and heat plants

E_{autoel} = annual CO_2 emissions from auto producer electricity plants (excluding CHP plants and own use)

$E_{autoCHP}$ = annual CO_2 emissions from auto producer CHP plants

$el_{auto\ CHP}$ = annual electricity output from auto producer CHP plants

$h_{autoCHP}$ = annual heat output from auto producer CHP plants

Currently, energy systems are economically operated globally, so the import and export of energy is normal between countries.

We analyze and include these data, and are thus able to analyze the CO_2 emissions relating to the production and not consumption, better reflecting the activity of the country. This analysis is performed in [12] by the following equation (4):

$$el_{pat} = el_{cons} - el_{imp} + el_{exp} \tag{4}$$

in which:

el_{pat} = annual electrical energy produced and transferred to final consumption points within a country

el_{cons} = annual total final electricity consumption

el_{imp} = annual electricity imports

el_{exp} = annual electricity exports

The annual national production-based CO_2 emission intensity of electricity ($gCO_2/kWhe$) was calculated using Equation (5):

$$I_{pb} = \frac{E_{elprod}}{el_{pat}} \quad (5)$$

A more detailed analysis of the influence of different variables that can affect the calculation of emissions of GHGs and their outcomes for several OECD countries can be found at [12].

In this work, to quantify the influence of reducing losses in cables of electrical installations on reducing CO_2 emissions to the atmosphere, it is considered that the emission factor associated with the consumption of electricity in Portugal is equal to 0.47 $kgCO_{2e}/kWh$, in accordance with the Decree 63/2008.

2.1. Identification of Parameters

Three types of parameters are considered: physical, load, and operating parameters.

2.1.1. Physical Parameters

The physical parameters are subdivided into two cases according to the utilization installation under analysis.

a) Identification of physical parameters for industrial or domestic installation

- Distribution boxes (Q): The distribution boxes are numbered from 1 (initial distribution boxes) to the total number of distribution boxes for the installation.
- Connections between distribution boxes: The connection of the distribution boxes is saved in a matrix that identifies the connection paths. The number contained in the matrix [*k*,*i*] indicates the number of the respective output, where *k* indicates the distribution boxes that provide energy, and *i* indicates the distribution boxes that receive energy.

- Length and section of the output conductors in the distribution boxes: From the length and section, the resistance of the conductors is determined for all outputs.

b) Identification of physical parameters for an installation of public lighting

- Knot connection (KC)

The knot connections are numbered from 1 (initial knot connection) to the total number of knot connections for the installation.

- Connections between knot connections;

The connections of these knot connections are saved in a matrix that identifies the connection paths. The number contained in the matrix [k, i] indicates the number of the respective branch (B).

k: a knot connection which provides energy; i: a knot connection which receives energy; [k,i]: a branch in knot connection k. For example:

Matrix connection [1, 2]: = 2;

Knot connection (k) 1 provides power to knot connection (i) 2, the second branch.

- Length of branch conductors in knot connection;
- Section of branch conductors in knot connection;

From the length and section, the resistance of the conductors is determined for all branches.

The values are saved in a resistances matrix.

k: knot connection; i: branches; [k,i]: value of resistances

2.1.2 Load Parameters

The Load parameters correspond to:

- The power of the loads connected to the electrical installation
- The efficiency and power factor of the loads

- The daily load diagram

2.1.3 Operating Parameters

The operating parameters correspond to:

- The operating time of the electrical installation
- Number of days of operation per month (d)
- Number of months of operation per year (m)
- The price of electricity (λ)
- The price of CO_2/kWh (φ)
- Emission factor associated with the consumption of electricity (β).

2.2. Calculations

After the input of the parameters and load diagrams, the following calculations are made:

- Determination of the load diagram associated with the output distribution boxes or knot connection, adding the corresponding load diagrams;
- Determination of the currents in all conductors of the electrical installation;
- Difference in cable losses (ΔP) in the conductors (using Joule's Law) affected by the changed equipment;
- Profits from the variation of cable losses ($G1$), given by:

$$G1 = \sum_{j=1}^{n} \left[R[k,i](I[k,i]_1)^2 - R[k,i](I[k,i]_2)^2 \right]_j d\, m\, \lambda \qquad (6)$$

- Profits from the variation of power equipment ($G2$), given by:

$$G2 = \sum_{j=1}^{n} [(P1[k,i]_j - P2[k,i]_j)\ ] d\, m\, \lambda \qquad (7)$$

- Reduction of CO_2 emissions to the atmosphere from the variation of cable losses ($ECO_2 1$), given by:

$$\mathrm{ECO_2 1} = \sum_{j=1}^{n}\left[R[k,i](I[k,i]_1)^2 - R[k,i](I[k,i]_2)^2\right]_j d\,m\,\beta \tag{8}$$

- Reduction of CO_2 emissions to the atmosphere from the variation of power equipment ($ECO_2 2$), given by:

$$\mathrm{ECO_2 2} = \sum_{j=1}^{n}[(P1[k,i]_j - P2[k,i]_j)\ ]d\,m\,\beta \tag{9}$$

- Total reduction of CO_2 emissions to the atmosphere (ECO_2T), given by:

$$\mathrm{ECO_2 T} = \sum_{j=1}^{n}\left[R[k,i](I[k,i]_1)^2 - R[k,i](I[k,i]_2)^2\right]_j d\,m\,\beta + \sum_{j=1}^{n}[(P1[k,i]_j - P2[k,i]_j)\ ]d\,m\,\beta \tag{10}$$

- Profits from the variation in CO_2 for cable losses ($G1CO_2$), given by:

$$\mathrm{G1CO_2} = \sum_{j=1}^{n}\left[R[k,i](I[k,i]_1)^2 - R[k,i](I[k,i]_2)^2\right]_j d\,m\,\beta\varphi \tag{11}$$

- Profits from the variation in CO_2 for power equipment ($G2CO_2$), given by:

$$\mathrm{G2CO_2} = \sum_{j=1}^{n}[(P1[k,i]_j - P2[k,i]_j)\ ]d\,m\,\beta\varphi \tag{12}$$

- Total profits (T_p), given by:

$$\begin{aligned} T_p = {} & \sum_{j=1}^{n}\left[R[k,i](I[k,i]_1)^2 - R[k,i](I[k,i]_2)^2\right]_j d\,m\,\lambda + \sum_{j=1}^{n}[(P1[k,i]_j - P2[k,i]_j)\ ]d\,m\,\lambda \\ & + \sum_{j=1}^{n}\left[R[k,i](I[k,i]_1)^2 - R[k,i](I[k,i]_2)^2\right]_j d\,m\,\beta\varphi + \sum_{j=1}^{n}[(P1[k,i]_j - P2[k,i]_j)\ ]d\,m\,\beta\varphi \end{aligned} \tag{13}$$

3. Economic Evaluation

Economic analyses are conducted in accordance with the guidance during the rational selection of a solution to be taken during an investment decision and should be based on a number of comparisons and analyses. The methods can be grouped into static methods and dynamic methods.

3.1. Static Methods

Static methods are applied for the assessment of the efficiency during the initial stage when the economic justification of an investment is examined. One of the most popular methods involves the payback period.

Payback time (SPBT) refers to a method that enables one to determine the overall period necessary for the expenditure to be repaid and is expressed as the length of time needed before the initial investment is recouped.

$$SPBT = \frac{N_i}{O_i} \tag{14}$$

where:

N_i – initial investment,

O_i – mean annual savings resulting from an investment.

3.2. Dynamic Methods

Dynamic methods result in the verification of the credibility of the calculations due to the application of a discount account, accounting for the change in value of money over time and the total cash flow associated with an investment.

The following methods have found the most extensive application: Net Present/Actual Value (VAL), Internal Rate of Return (IRR), and Payback Period, (PP).

In this work, VAL or PP is used, and is computed from the sum of the annual cash-flows for a given annual interest rate.

The interest rate is indicated by the investor according to the desired profitability.

$$VAL = \sum_{k=0}^{n} \frac{T_p - D_k - I_k}{(1+a)^k} + \frac{V}{(1+a)^n} \tag{15}$$

with:

T_p – Total profit

D – Operation cost

I – New investment

n – Years of useful life

V – Residual value of the old equipment

The PP for the investment can be calculated using the following equation:

$$PP = ln\frac{100\ W_{el}C_e}{100\ W_{el}C_e - iC_{inv}} \div ln\frac{100 + a}{100} \tag{16}$$

with:

W_{el} – Electricity savings

Ce – Electricity cost

$W_{el}Ce$ – Net profit

C_{inv} – New investment

a – Annual interest rate

4. Software Application

The software is structured using matrices and vectors that allow the characterization of the electrical installations and respective loads. Figure 1 provides a flowchart of the new software application. The load diagram and parameters of the installation are entered via the keyboard, or data acquisition may be carried out automatically. After the installation has been characterized (physical parameters, load parameters, operating parameters), updating the data in all sections, it starts with the distribution boxes (knot connection for street lighting) that do not feed other distribution boxes (knot connection for street lighting).

The load diagram associated to the output distribution boxes is determined by adding the corresponding load diagrams. For example: output "1" in "Q2" is the sum of output diagrams in "Q3", as shown in Figure 2. The algorithm follows the flowchart in Figure 1 with the calculations identified by the equation numbers.

5. Case Study

5.1. Simulation Results for an Installation of Street Lighting

Figure 3 shows the scheme of a real installation of street lighting with the respective parameters. Figure 4 presents the results of the new software application comparing the results of an initial situation with luminaires of 166 W with the case of using bi-power ballasts of 116 W with an investment of 39 € [30] or bi-power ballasts of 129W with an investment of 30€ in Street D of Figure 3 as the load diagrams in Figure 5. These results are illustrative of the capabilities of the software application developed (VAL, PP, reduction of CO_2 emissions, cable losses, best investment). The software allows the analysis of multiple possibilities, allowing the user to choose a specific individual point of light and to replace the existing technology on a street or in a selected group of streets. This example searches the path of conductors, determining the reduction of losses and reduction of GHGs.

5.2. Simulation Results for an Industrial Installation

Figure 6 shows the scheme of a real industrial installation with the respective parameters. Figure 7 presents the results of the new software application for the scheme shown in Figure 6.

The results compare an initial situation of a normal pump with two more efficient pumps (Op1 and Op2), shown in Figure 6, working 10 hours a day. Considering the operation over a year and large-scale electrical installations, the new software application developed represents a valuable tool for assessing different alternatives, indicating the most efficient and sustainable ones.

Additionally, the electrical installation shown in Figure 8 was assembled in the lab, where the replacement of an spotlight of 240W for a 30W spotlight LED has been studied, in position B [2,1], with all other lamps of 100 W. Figure 9 shows the simulation results during one year of operation and with a price of 0.10 €/kWh, and working 11h per day. Measurements were performed at the beginning and end of the cables identified in the bold in Fig. 7. With a 240 W spotlight, 10 W losses in cable B[1,1] and B[2,1] were obtained. With the 30 W LED spotlight (option 1), 5.83 W losses in cable B[1,1] and B[2,1] were obtained.

From the experimental results, it was observed that the initial losses were equal to 10 W, corresponding to 18.87 kCO_2, while the losses for option 1 were equal to 5.83 W, corresponding to 11.00 kCO_2. Thus, the reduction of CO_2 is equal to 7.87 kCO_2 (≈41%), validating the simulation results of 7.87 kCO_2 corresponding to the reduction of losses in the cables.

Analysing the results we can see that the choice of more efficient equipment, in addition to reducing energy bills, which is economically important, allows a reduction of CO_2 emissions resulting from decreased losses in the conductors of the electrical installation.

6. Conclusions

As noted in this study, the activities of the electricity sector have implications for almost every major environmental problem of today. The main environmental impacts occur during the production of electricity, mostly due to the emission of air pollutants. Various measures can be taken to minimize the environmental impacts of electricity, since the measures orientate the choice of fuels and forms of management and production to reduce consumption. This work presented and accounted for a measure usually forgotten: losses in conductors of electrical installations for domestic or industrial use, as a new contribution to earlier studies. The losses in electrical installations can make a considerable difference in the economic evaluation supporting the investment decision. The results presented confirm that the VAL is superior when the losses are included. The accounting for losses and reduction of GHGs associated with the application of new software applications in real situations is extremely important. It is possible to quantify the contributions of GHGs, which could reduce 40% in the component of the losses in the cables, managing electrical systems and making decisions in real time, considering the whole lifecycles of their components, in order to preserve the environment and minimize the environmental impacts generated. The sum of all contributions will provide great help in reducing overall GHG emissions.

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Figure 1 Flowchart of the new software application.

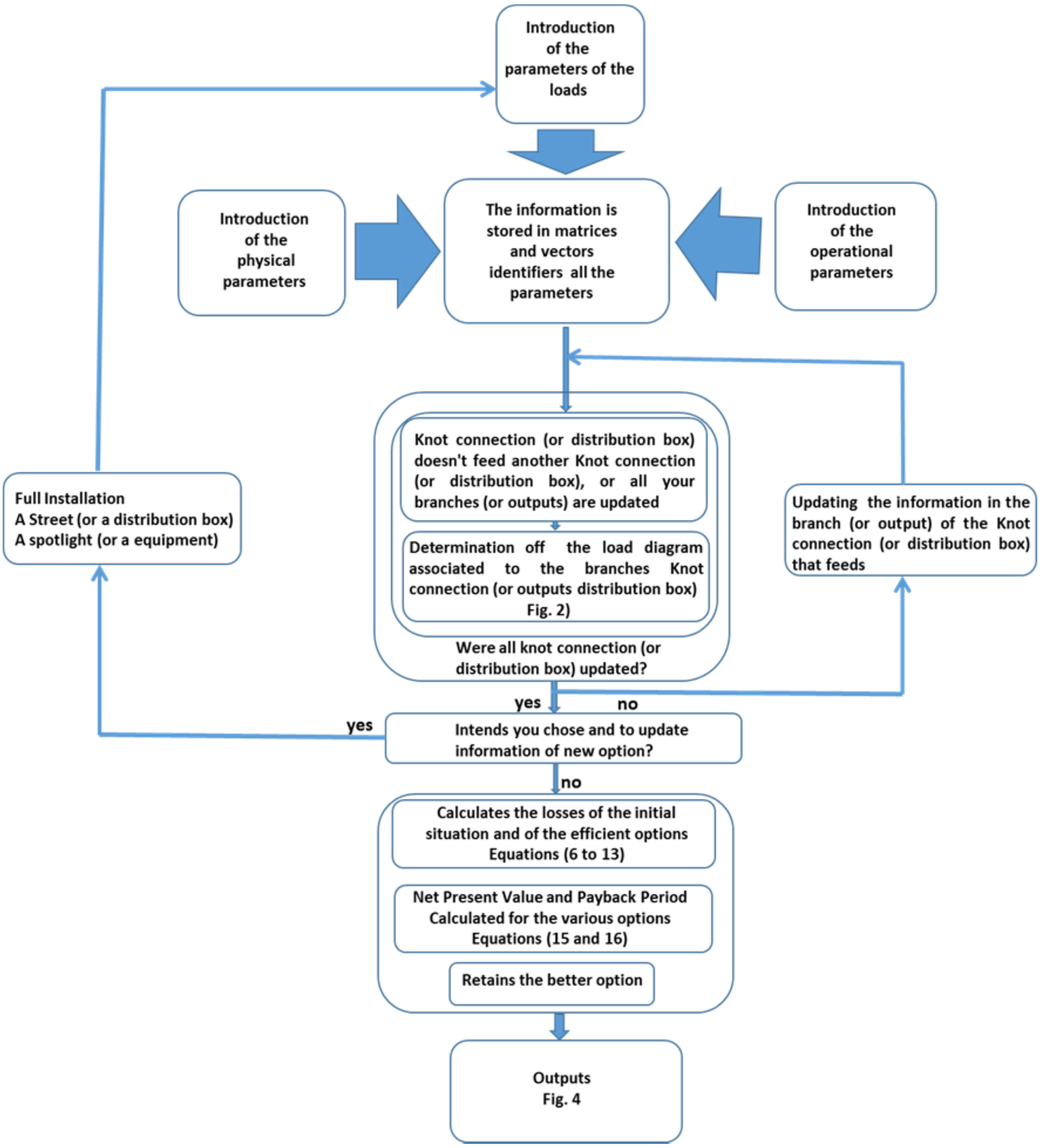
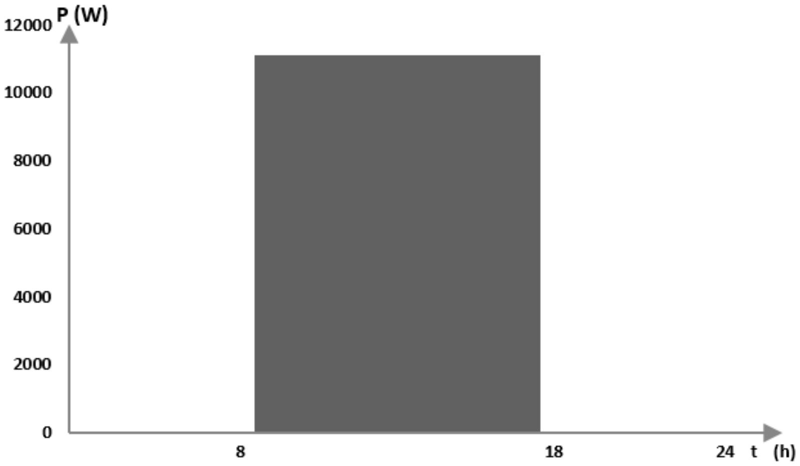
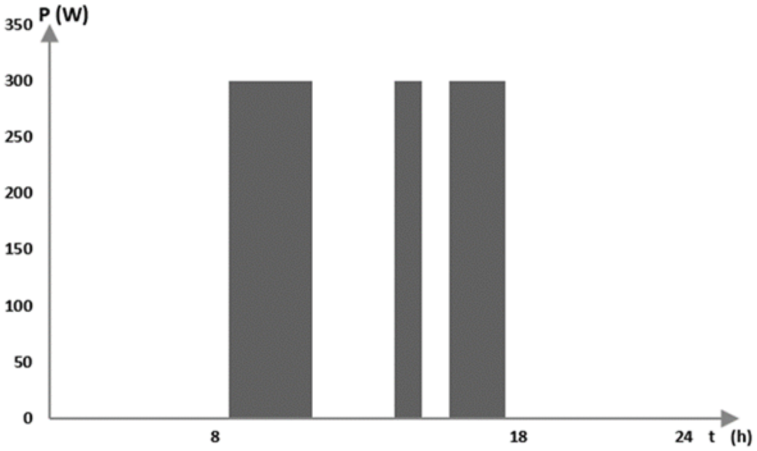


Figure 2. Example for updating the data.

2. a) Load diagram [3,1]



2. b) Load diagram [3,2] and load diagram [3,3]



2. c) Load diagram [2,1]

Load diagram [2,1] is the sum of load diagram [3,1], load diagram [3,2] and load diagram [3,3]

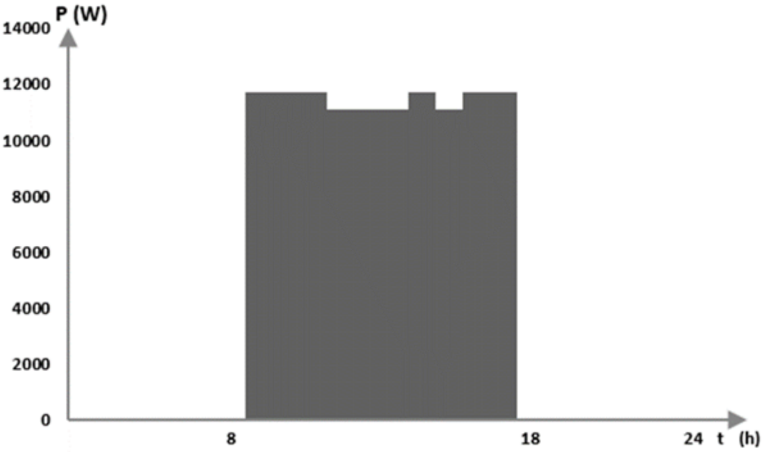


Figure 3. Scheme of real street lighting installation.

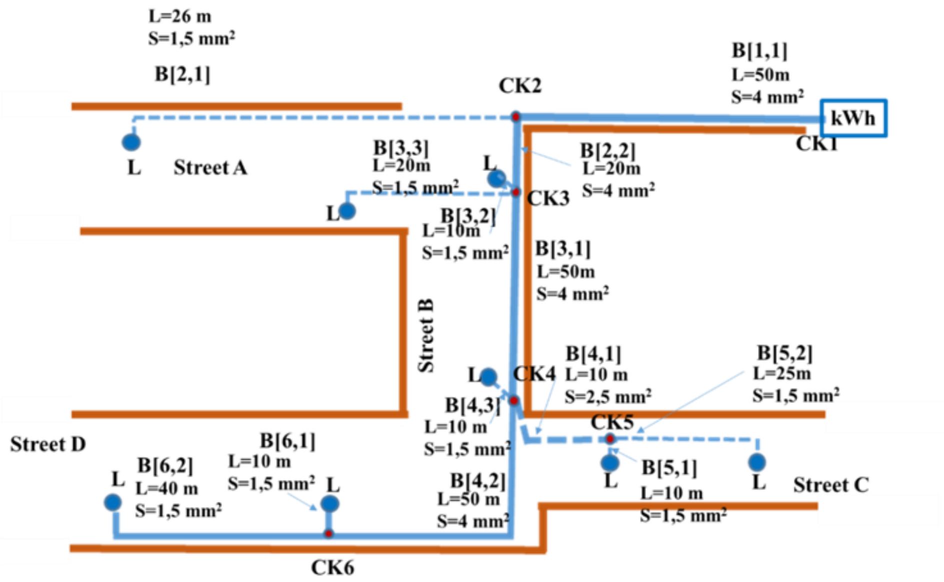
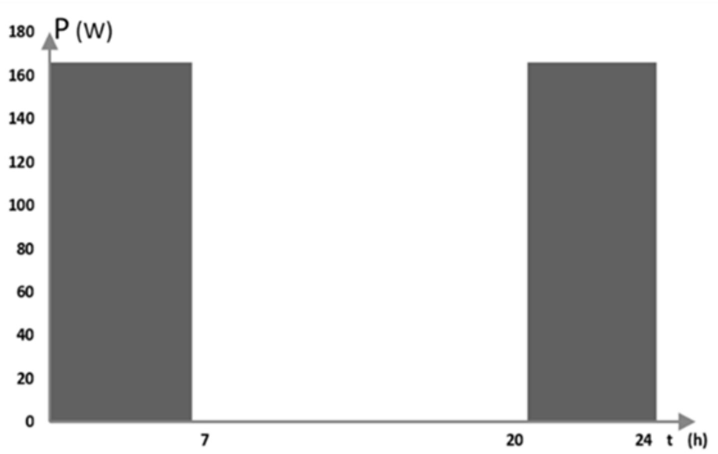


Figure 4. Results of the new software application.

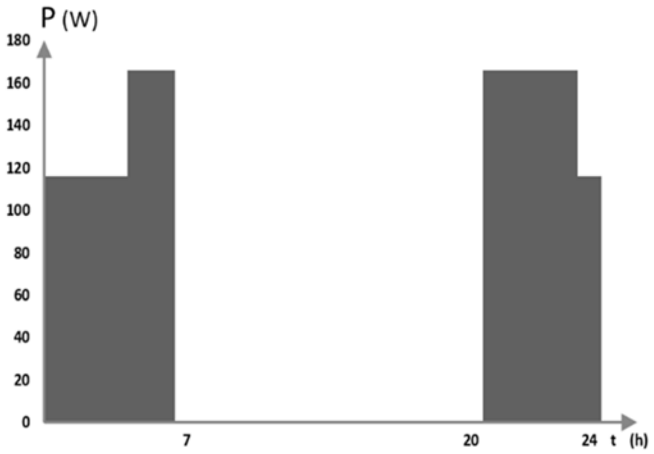
```
                CHOICE OF EFFICIENT LIGHTING


      TECHNOLOGY OF INITIAL LIGHTING:
Power loss in cables:12.956373Euro/Year


        WITH EFFICIENT Lamp1:
Power loss in cables:10.893794Euro/Year
VAL (present net value - WITHOUT LOSSES):37.975
VAL (present net value - WITH LOSSES)50.056


PP (Payback Period  - WITHOUT LOSSES):4.842357 Year
PP (Payback Period  - WITH LOSSES):4.305849 Year


        WITH EFFICIENT  Lamp2:
Power loss in cables:11.116205Euro/Year
VAL (present net value - WITHOUT LOSSES):26.688
VAL (present net value - WITH LOSSES)37.467

PP (Payback Period  - WITHOUT LOSSES):5.812168 Year
PP (Payback Period  - WITH LOSSES):4.359749 Year

      THE BEST INVESTMENT IS:

          Lamp:1

   WITH VAL(present net value):50.056


  THE BEST INVESTMENT DECREASE:102.754 kgCO2/Year
```

Figure 5. Load diagrams

5. a) Initial load diagram (all streets).



5. b) Load diagram using bi-power ballasts (Lamp 1 in the streets D).



5. c) Load diagram using bi-power ballasts (Lamp 2 in the streets D).

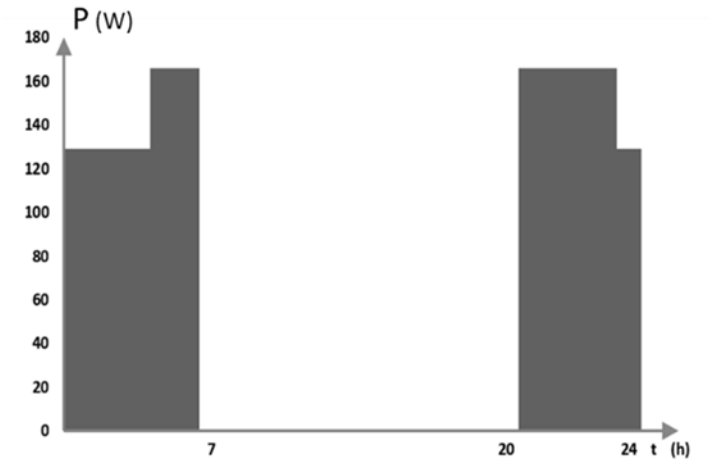


Figure 6. Scheme of real industrial installation.

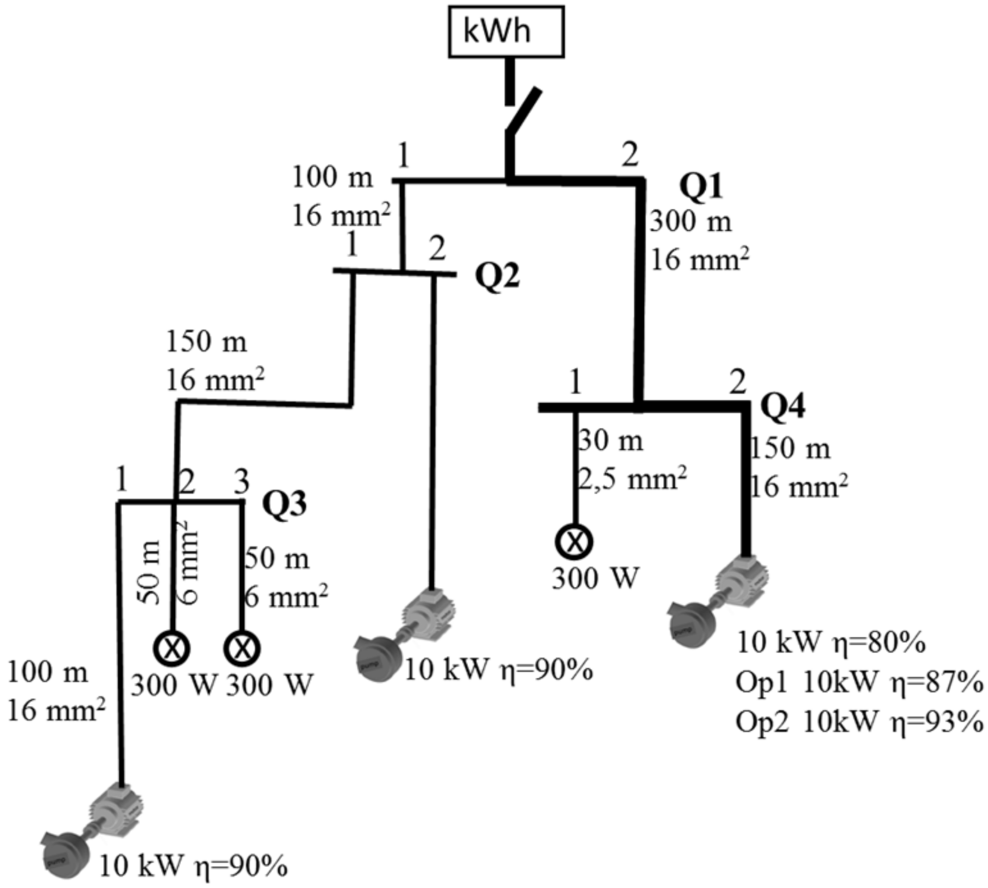


Figure 7. Results of the new software application for the installation of Figure 6.

```
                CHOICE OF EFFICIENT EQUIPMENT


     Initial situation:
Power loss in cables:617.510957Euro/Year


     WITH EFFICIENT option1:
Power loss in cables:582.494075Euro/Year
VAL (present net value - WITHOUT LOSSES):1295.966
VAL (present net value - WITH LOSSES)1501.071


     WITH EFFICIENT  option2:
Power loss in cables:558.523741Euro/Year
VAL (present net value - WITHOUT LOSSES):3108.200
VAL (present net value - WITH LOSSES)3453.706


 THE BEST INVESTMENT IS:

       option:2


 WITH VAL(present net value):3453.706



 THE BEST INVESTMENT DECREASE:3211.955 kgCO2/Year
```

Figure 8. Experimental scheme of street lighting installation.

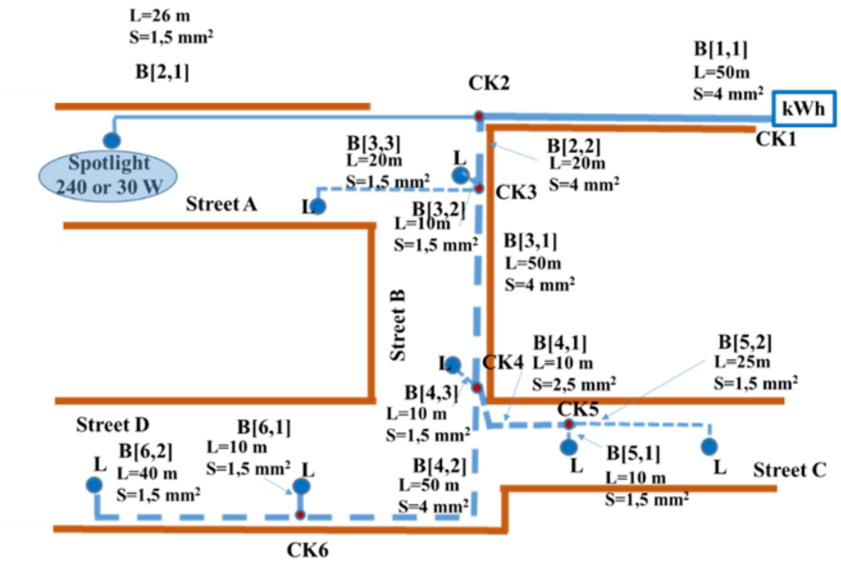
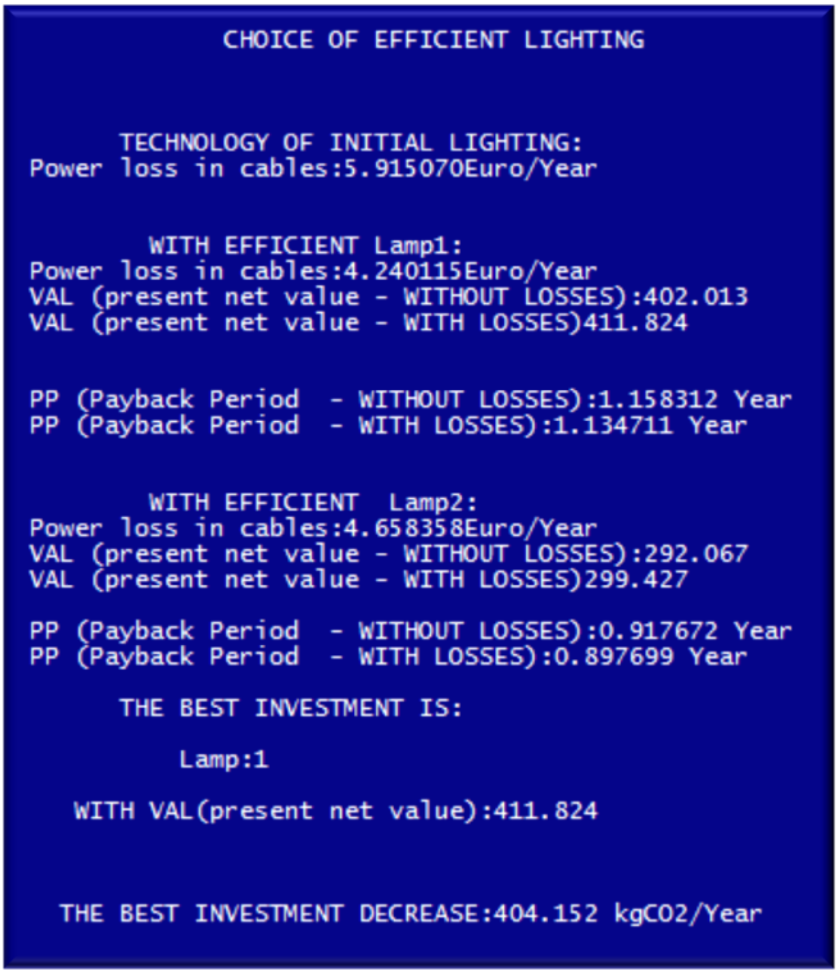


Figure 9. Results of the new software application for the installation of Figure 8.



```
              CHOICE OF EFFICIENT LIGHTING


      TECHNOLOGY OF INITIAL LIGHTING:
Power loss in cables:5.915070Euro/Year


        WITH EFFICIENT Lamp1:
Power loss in cables:4.240115Euro/Year
VAL (present net value - WITHOUT LOSSES):402.013
VAL (present net value - WITH LOSSES)411.824


PP (Payback Period  - WITHOUT LOSSES):1.158312 Year
PP (Payback Period  - WITH LOSSES):1.134711 Year


        WITH EFFICIENT  Lamp2:
Power loss in cables:4.658358Euro/Year
VAL (present net value - WITHOUT LOSSES):292.067
VAL (present net value - WITH LOSSES)299.427

PP (Payback Period  - WITHOUT LOSSES):0.917672 Year
PP (Payback Period  - WITH LOSSES):0.897699 Year

      THE BEST INVESTMENT IS:

          Lamp:1

   WITH VAL(present net value):411.824


  THE BEST INVESTMENT DECREASE:404.152 kgCO2/Year
```