International Journal of scientific Research & Engineering Technology (IJSET)
Vol.19pp. 42-51

Energy saving for a domestic load

Samir Arfa[*1], Mohsen Ben Ammar[*1], Mohamed Ali Zdiri[*1], Hsan Hadj Abdallah[*1]

[*1]CEM Laboratory1, ENIS (National Engineering School of Sfax), Tunisia

University of Sfax, Sfax Engineering School, BP 1173, 3038 Sfax, Tunisia

[1]arfa.samir@gmail.comhird.author@first-third.edu

Abstract—**This work is part of the drive to control the use of electrical energy, in order to guarantee the energy efficiency of all electrical equipment and appliances. The revolution in energy dependency and the emergence of artificial intelligence have made it essential to minimize the cost of human energy needs. The aim of this work is to show the importance of using energy-saving lamps such as LEDs compared with non-energy-saving lamps. The first part consists of presenting the method for estimating each domestic load profile for each subscriber of the Tunisian Electricity and Gas Company (STEG), then drawing up the load energy balance with the cost to be paid for the two seasons (winter and summer), after which an annual techno-economic study is presented for this subscriber. The second part of this study deals with the profitability of Led lamps over a five-year period, such as the energy saved through this method and the added value from a cost-to-earn point of view.**

Keywords—**Energy saving,estimation, online application, domestic load, Lamps for lighting, LED**

I. Introduction

After the different world oil crises during the last decades, saving energy is becoming a very important task in everyday life.In order to minimize the costs of energy use [1].In this context, we note that scientific research and artificial intelligence are increasingly interested in the energy saving sector, especially at the level of manufacturing, design of appliances and energy equipment.In addition, this sector is currently a priority in the research and sustainable development sector [2].The axis of energy saving can be very important for the users of energy in various forms, when it can contribute both to better balance their annual budget and reduce the energy consumption of equipment, while ensuring sustainable development.There are several optimized methods to use more and less energy without loss of comfort.These simple tricks are also increasingly profitable [3, 4].

Given the unlimited growth of energy costs and to help these subscribers identify the most energy-intensive electrical loads, STEG is creating an online application.This application allows the estimation of the total bi-monthly (two months) energy consumption and the consumption share of each load.This estimate helps and informs the customer to know the most energy consuming appliances in order to replace them with economic devices [5].The application consists of an interface to be filled with the different electrical loads used daily and their types (economic or not), such as the number of lamps, refrigerator, air conditioner/heater, television, washing machine, oven, etc. In order to make the estimate consumption close to reality, this application asks for the number of people living in the home and the square footage of that home.Once this information is provided, we obtain two detailed consumption balances for each electrical load for both winter and summer modes for this subscriber [6, 7].The estimate of the energy consumption balance is generated based on very old historical consumption as well as subscribers similar to this domestic load.In addition, this application also allows to determine the cost of the requested consumption [8].

This research work consists of selecting all the different household appliances used to determine the energy balance of this subscriber.This assessment will allow us to determine the daily energy consumption. The next step is to replace uneconomical lamps with LED lamps.Afterwards, an analysis is made in this energy consumption balance by replacing these lamps with energy saving lamps,we then show the reduction in energy consumption induced by energy saving bulbs, which also results in lower energy costs. The next two steps focus on presenting the method used to draw up the household load profile and estimate the energy balance for two types of lighting: conventional lamps and energy-saving lamps. The next stage is dedicated to the techno-economic study and profitability of LED lighting. The section before the conclusion is dedicated to analyzing and interpreting the

ISSN: 2356-5608

importance of LED lamps in terms of energy savings, lifetime and the difference in value between the purchase cost of LED lamps and that of non-economical lamps.

II. Energy saving procedures

Nowadays, there are several energy saving techniques. These processes offer the possibility to reduce the amount of energy consumed. Among these procedures: purchase of certified and economic equipment, turn off appliances after use, and use natural lighting, installation of photoelectric sensors so that the light turns off when there are no people, construction of homes and buildings with insulation, heat exchangers and programmable thermostats, etc. The use of low energy lamps. Use of energy saving cycles for dishwashing, air drying of dishes. As for the refrigerator, it consumes a considerable amount of energy, knowing that, a refrigerator of average volume needs an annual energy more than 300 kWh. For this reason, the rationalization of household appliances during use often allows to make remarkable savings. For the industry sector, the energy saving is realized with the help of an energy audit which allows the analysis and the in-depth diagnosis. Eventually, we have to seek other procedures to economize energy. This audit also allows for inventories that identify energy-consuming loads and evaluate the energy efficiency of the various equipment used.

The objective of this work is to emphasize the importance of the use of energy saving lamps. The lighting sector consumes a considerable amount of energy. The choice of the type of lamp is very important in terms of consumption and price, in order to save energy.

III. Lamps for lighting

The lighting sector is made up of an important diversity of lamps used. These bulbs depend on the quality of light, wattage rating and lifespan of each lamp. In fact, there are several types of lamps such as incandescent lamps, halogen lamps, discharge lamps and LED lamps (Light-emitting diode lamps are types of lighting lamps based on light-emitting diodes.) nowadays. This diversity allows the choice to favor energy saving lamps over other types of lamps. For the purpose of saving energy and money.

For some decades, incandescent lighting lamps are the most used. However, the appearance of new technologies (LED) are becoming the most demanded. Because this type of lamp can achieve the same light output with less energy consumption and a longer life.

The life span of lighting lamps varies from one technology to another,because the life of a lamp is measured in terms of the number of hours it is on. For example, Incandescent bulbs, can last from 1,000 to 1,200 hours. LED lamps, on the other hand, have a lifespan ranging from 30,000 to 100,000 hours. These lamps have a better performance than other types of lamps. The following table gives a general idea of the types of lamps with their lifetime and the energy efficiency of each technology.

TABLE I Type of lighting lamps with life time

Lamps	form of lamp	Efficiency (lm/watt)	Life time of the lamp (hour)
incandescence		[10-20]	[1000-2000]
halogen		[15-20]	[2000-3000]
fluorescent		[40-70]	[6000-15000]
LED		[40-135]	[30 000-150 000]

IV. Materials and used Method

The interface of this method allows to estimate the consumption of each electrical load as well as the total energy consumption of the household load. This estimate depends on the equipment used with the mode of use. In addition, the method also presents the cost and the amount of consumption of each subscriber. Therefore, the subscriber should select and enter all necessary data of the most used loads [9].

The first step in this method is to create an account in the subscriber's name with the reference number of the energy meter. This account will be identified by a username and a password of the user.

The procedure of the estimation is described by the following figure [10, 12]:

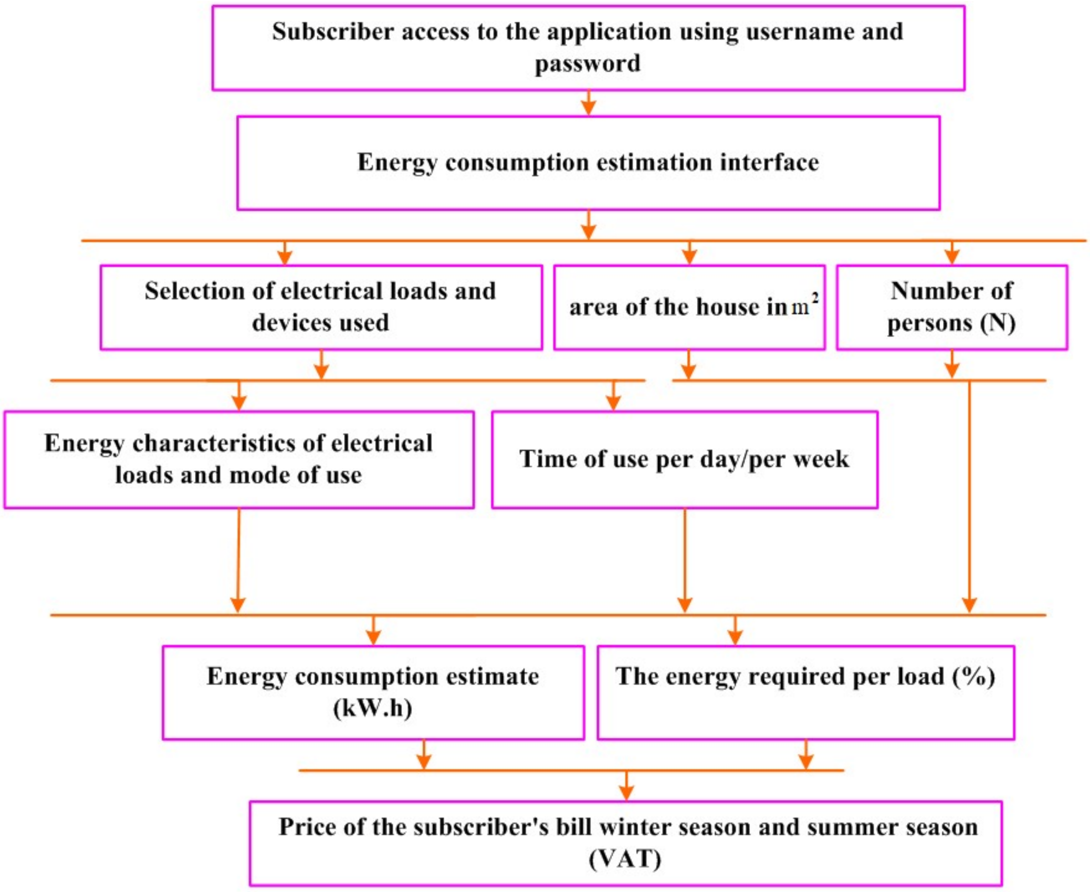


Fig. 1. Descriptive diagram of the load profile creation method

The equipment used for this subscriber is presented in the table below:

TABLE III ELECTRICAL LOADS USED

Electric load	Rate electric power (W)	Loads number
Lighting lamp	[100-200]	8
Refrigerator	[700-1700]	1
Air conditioner / Heater	[800-1800]	1
TV	[10-450]	1
Washing machine	[50-800]	1
Iron	[70-100]	1
Kitchen (Oven, dishwasher...)	[50-4500]	1
Desktop computer / Multimedia	[5-500]	1
Other equipment's*	[50-1000]	1

Other equipment's*: Low power electrical equipment.

V. ESTIMATED BALANCE OF ENERGY CONSUMPTION

Due to its geographical location and the climatic characteristics of the Mediterranean countries, the climate of Tunisia consists of two seasons: a winter season (cold) and the other summer (hot). Taking into account these characteristics, the Tunisian company of electricity and gas classifies the energy consumption of each subscriber in two modes winter mode and summer mode. For this, the estimate of the annual consumption of electricity of the subscriber is divided into an estimate for the winter season and the other for the summer season.

Thanks to the use of new technologies in the lighting sector, energy saving lamps offer the same light output with a remarkable reduction in the amount of energy used [10, 11 and 13]. We allow to realize energy saving. In this paragraph, we will discover together the impact of the use of the economic lamps in comparison with the incandescent ones at the level of the energy consumption.

1) Estimated winter consumption

This paragraph is devoted to the presentation of the estimated bimonthly winter energy consumption with the cost to be paid. The results are shown in tabular form:

TABLE IIIII ESTIMATED ENERGY CONSUMPTION IN WINTER MODE

(NO ECONOMICAL LAMPS)

Electricity use in winter mode	Average usage (kW.h)	%
Lighting	118,096	17,8
Refrigerator	95,4	14,4
TV	41,48	6,2
Washing machine	14,4	2 ,2
Heating	96,075	14,5
Ironing machine	4,8	0,7
Cooking	219,6	33
Micro-computer	47,58	7,2
Other equipment’s	27,068	4,1
Total	664,499	
Amount of 1	139,317 (TD)	

TABLE IV ESTIMATED ENERGY CONSUMPTION WINTER MODE

(ECONOMICAL LAMPS)

Electricity use in winter mode	Average usage (kW.h)	%
Lighting	39,04	6,7
Refrigerator	95,4	16,4
TV	41,48	7,1
Washing machine	14,4	2 ,5
Heating	96,075	16,5
Ironing machine	4,8	0,8
Cooking	219,6	37,8
Micro-computer	47,58	8,2
Other equipment’s	23,115	4
Total	581,49	
Amount of 1	112,872 (TD)	

TABLE V ESTIMATED GAS CONSUMPTION FOR WINTER SEASON ECONOMICAL AND NO ECONOMICAL MODE

Natural gas use	Average usage (m^3)	%
Water heating	15,36	29,6
Cooking	36,6	70,4
Total	51,96 (m^3)	
Amount of 2	12,003 (TD)	

TABLE VI PRICE OF ENERGY CONSUMPTION IN WINTER MODE (NO-ECONOMICAL LAMPS) IN TD

Invoice details (TD)	
Total= Amount 1+ Amount 2	151,319
Flat fee	12,8
ERTT	4,258
Taxes	22,392
Total	190, 769

TABLE VII PRICE OF ENERGY CONSUMPTION IN WINTER MODE (ECONOMICAL LAMPS) IN TD

Invoice details (TD)	
Total= Amount 1+ Amount 2	124,875
Flat fee	12,8
ERTT	3,926
Taxes	19,008
Total	160,609

1) Estimated summer consumption

The estimated energy consumption for the summer season with non-economy and economy lamps, as well as the cost to be paid, are given in the following tables:

TABLE VIII ESTIMATED ENERGY CONSUMPTION SUMMER MODE (NO ECONOMICAL LAMPS)

Electricity use in summer mode	Average usage (kW.h)	%
Lighting	118,096	13,9
Refrigerator	148,4	17,4
TV	41,48	4,9
Washing machine	14,4	1 ,7
Air conditioner	227,676	26,7
Ironing machine	4,8	0,6
Cooking	219,6	25,8
Micro-computer	47,58	5,6
Other equipment’s	29,718	3,5
Total	851,75	
Amount of 1	204,106 (TD)	

TABLE IX ESTIMATED ENERGY CONSUMPTION SUMMER MODE (ECONOMICAL LAMPS)

Electricity use in summer mode	Average usage (kW.h)	%
Lighting	30,04	5,1
Refrigerator	148,4	19,3
TV	41,48	5,4
Washing machine	14,4	1 ,9
Air conditioner	227,676	29,6
Ironing machine	4,8	0,6
Cooking	219,6	28,6
Micro-computer	47,58	6,2
Other equipment’s	25,765	3,4
Total	768,741	
Amount of 1	175,385 (TD)	

TABLE X ESTIMATED GAS CONSUMPTION FOR THE SUMMER SEASON (ECONOMY AND NO-ECONOMY LAMPS)

Natural Gas Use	Average usage (m^3)	%
Water heating	7,68	17,3
Cooking	36,6	82,7
Total	44,28 (m^3)	
Amount of 2	10,229 (TD)	

ISSN: 2356-5608

TABLE XI PRICE OF ENERGY CONSUMPTION IN SUMMER MODE (NO-ECONOMICAL LAMPS) IN TD

Invoice details (TD)	
Total= Amount 1+ Amount 2	214,334
Flat fee	12,8
ERTT	5,007
Taxes	30,356
Total	262, 497

TABLE XII PRICE OF ENERGY CONSUMPTION IN SUMMER MODE (ECONOMICAL LAMPS) IN TD

Invoice details (TD)	
Total= Amount 1+ Amount 2	185,613
Flat fee	12,8
ERTT	4,675
Taxes	26,676
Total	229, 764

Referring to the estimated values indicated in the previous tables, the average daily consumption is determined by the following relationship:

$$ADC = \frac{\text{Total}}{\mathbf{60}} \tag{1}$$

TABLE XIII DAILY CONSUMPTION OF THIS DOMESTIC LOAD

Domestic Load	Bimonthly econsumption in kWh	Cost of billing in TD	Daily consumption in kWh
Winter mode (no-economy lamps)	664.499	190.769	11.0749
Summer mode (no-economy lamps)	851.750	262.497	14.1928
Winter mode (energy-saving lamps)	581.490	160.609	9.6915
Summer mode (energy-saving lamps)	768.741	229.764	12.81

VI. TECHNO-ECONOMIC STUDY

The techno-economic study involves calculating energy consumption and the cost of the customer's annual bill. In the context of saving energy by using energy-saving lamps, the aim of this section is to calculate the energy saved and the cost to be gained, and to show the importance of using these lamps.

1) Annual energy balance in economic and no-economic modes

Using the estimate obtained for winter and summer mode, we determine the annual energy consumption required with billing. The following table shows these values:

TABLE XIV YEARLY ENERGY BALANCE

Type of lamp	Consumption mode	Enregy kWh	N	Totale energy en kW.h	Annual consumption kWh	Cost (TD)	Annual cost (TD)
No-economic lamps	Winter	664,499	x 3	1993,497	4 548,747	572,307	1 359,798
	Summer	851,75	x3	2555,25		787,491	
Economic lamps	Winter	581,49	x 3	1744,47	4 050,693	481,827	1171,119
	Summer	768,741	x 3	2306,223		689,292	
Energy economic per year (kWh)					498,054		
Annual cost saved (TD)					188,679		

The value of annual energy saved is obtained using the following expression:

$$ESL = ELNEL - EEEL \tag{2}$$

$$ESL = \mathbf{498,054}\,\text{kW.h}$$

The annual cost saved is calculated from the equation below:

$$CEH = CCHN - CCHE \tag{3}$$

$$CEH = \mathbf{188,679}\,\text{TD}$$

In order to obtain realistic results, the techno-economic study is based on a 12-month load profile.LEDs reduce consumption by less than 10% per year.

ISSN: 2356-5608

2) *Techno economic study of consumption and cost*

A study of the cost-effectiveness and efficiency of energy-saving lamps for both lighting load and total load is illustrated in the following table.

TABLE XV PROFITABILITY STUDY

Type of lamps	**N**	**Unit price TD [14]**	**Number of hours per year**	**Lifetime in hours [15]**	**Annual cost TD**	**Costs over 5 years TD**	**Cost saved during 5 ans TD**
Incandescence (100W)	8	2,5	1095	1000 à 1200 h	1379,79	6898,99	983,395
LED (13W)		7,5		30 000 à 100 000 h	1231,119	4684,46	

N: lamp number used.

The rate of savings over the five-year period is identified by the following formula:

$$TEH(\%) = \frac{CEH}{CCHN} \quad (4)$$

$$TEH(\%) = \mathbf{14,25\%}$$

Using the above table, we can see that over a period of 5 years (the lifetime of the LED), the subscriber will earn an amount in excess of 983,395 thousand DT on his budget, taking into account the price of the LED lamps.The economic profitability of using these lamps depends essentially on the amount of energy they save compared with no-economical lamps. This value will be accumulated over five years, which translates into a considerable reduction in the cost of the electricity bill. The cost of energy requirements will be reduced by 14, 25 %. The reduction in consumption will be even greater if we look for ways to save money on other household appliances. These include the use of energy-guzzling appliances with a high energy (efficiency) class.

VII. RESULTS AND MEANING

The energy balance of the domestic load for the two seasons is obtained is given by the following figure:

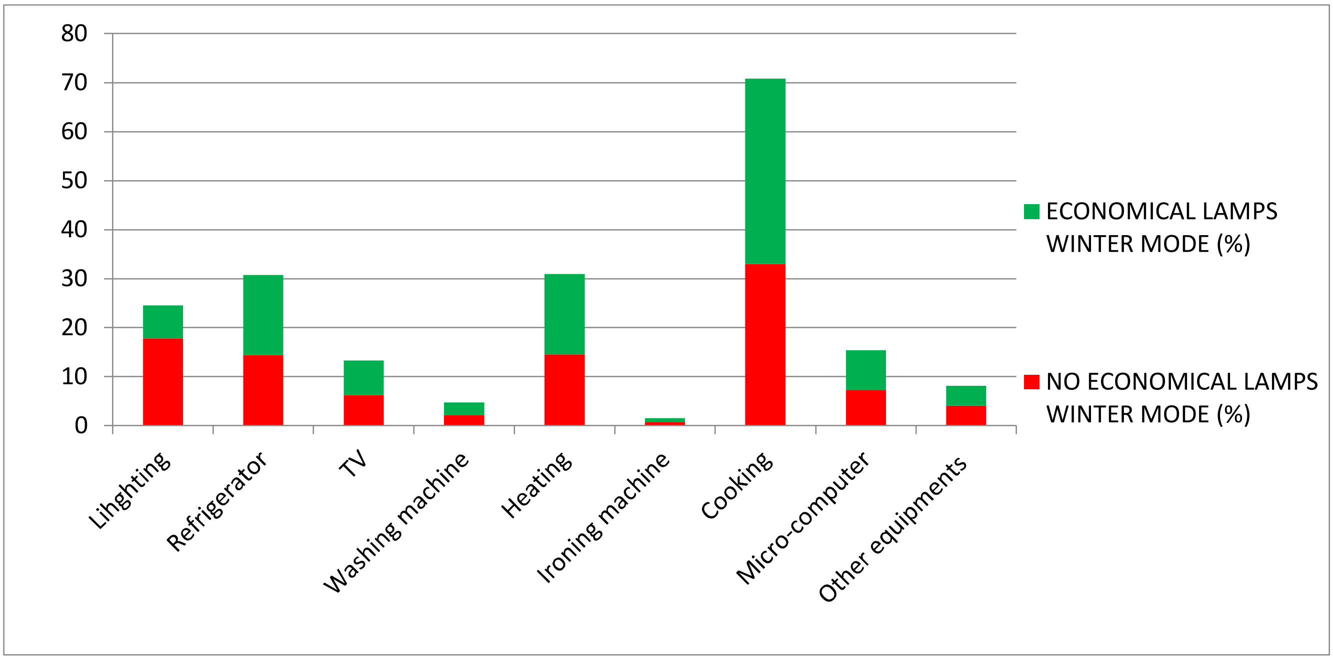


Fig. 2. Detailed energy balance in with and without economical lamps winter

ISSN: 2356-5608

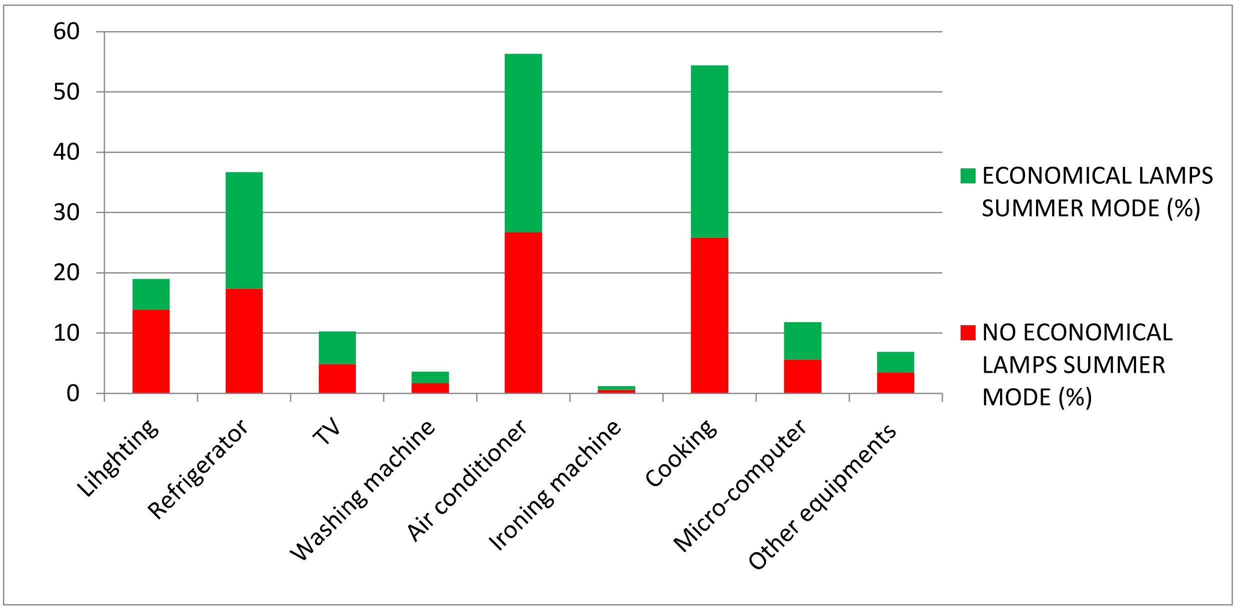


Fig. 3. Detailed energy balance in with and without economical lamps winter

The use of energy-saving lamps (LED) in both modes (winter and summer) reduces energy consumption from 118.096 kWh to 38.04 kWh. Otherwise, the energy saving rate thanks to the use of LEDs for the lighting load is 66.94%. This reduction will be reflected directly in billing costs. This is the main objective for every customer.

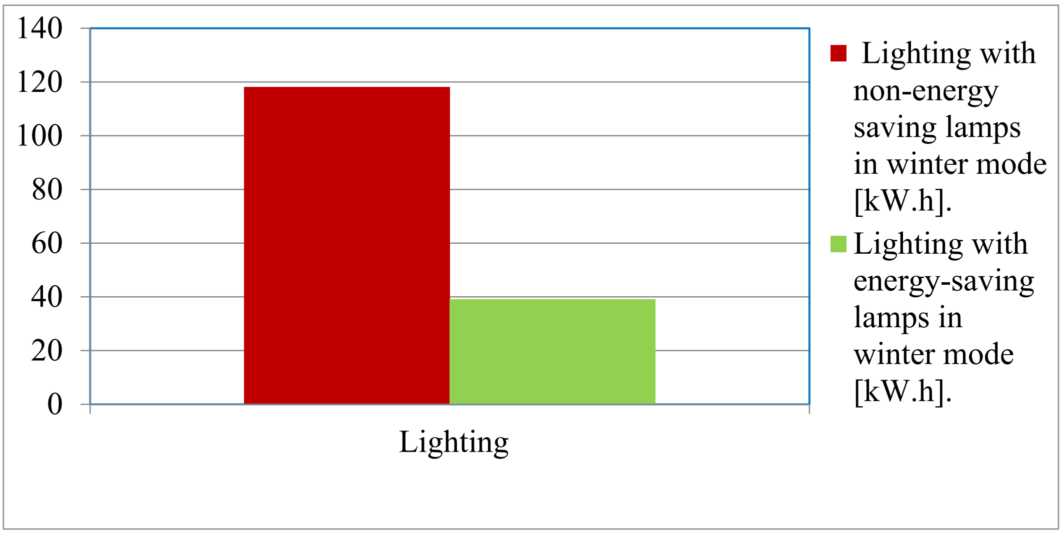


Fig. 4. Lighting load consumption winter mode

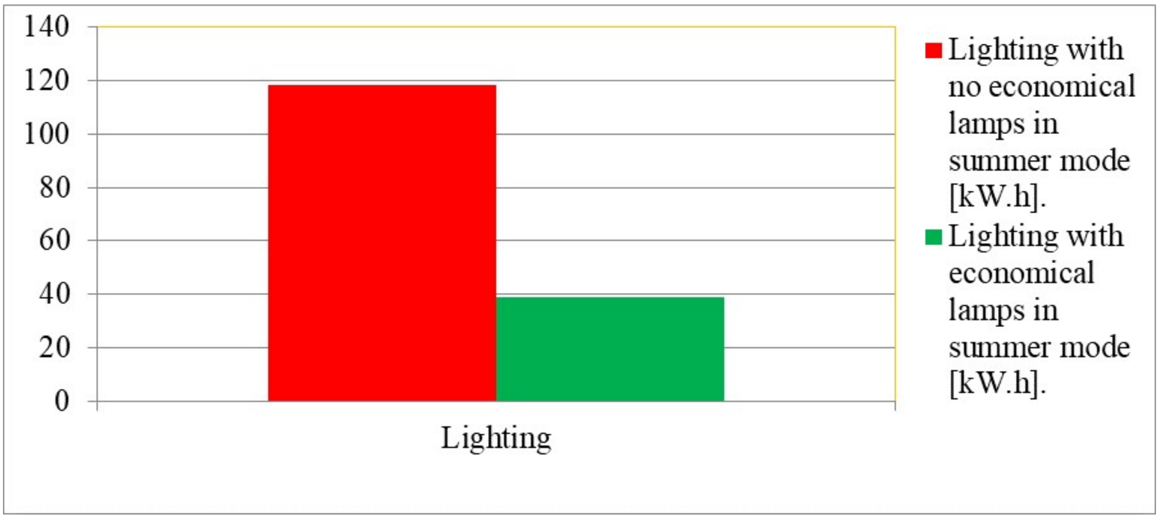


Fig. 5. Lighting load consumption summer mode

The use of energy-saving lamps minimizes consumption by 2 kWh per day. We can say that we can minimize our energy needs for all other equipment, such as household appliances, which consume a lot of energy.

With high-definition LED lamps, lighting energy savings of up to 90% can be achieved.In fact, for the same wattage, an LED consumes ten times less energy than a conventional lamp.Using this technology also saves money in terms of lifetime. LED lamps can last up to a decade. From a cost point of view, the price of LEDs is higher than that of conventional LEDs, but generally speaking, the price ratio is no more than double at worst.

VIII. Conclusion

With the help of this study, the subscriber can take advantage of the reduction in energy required for lighting loads through the use of energy-saving lamps and artificial intelligence. Since this subscriber can achieve a savings rate in excess of 66.94% for the lighting application alone. This reduces the cost of electricity billing by up to 20%.

It's true that scientific and technological development is helping to save energy. But it's not enough if people don't use electrical appliances correctly and to the required standards. It's important to take a serious part in mastering energy-saving processes and the energy efficiency of household appliances. On the other hand, energy-saving awareness is the simplest method and the most important task in optimizing the use of electrical energy. It's also worth noting that proper management of the use of different sources of natural and renewable energy contributes to sustainable development, the main objective of the economic and energy challenges facing the world today.

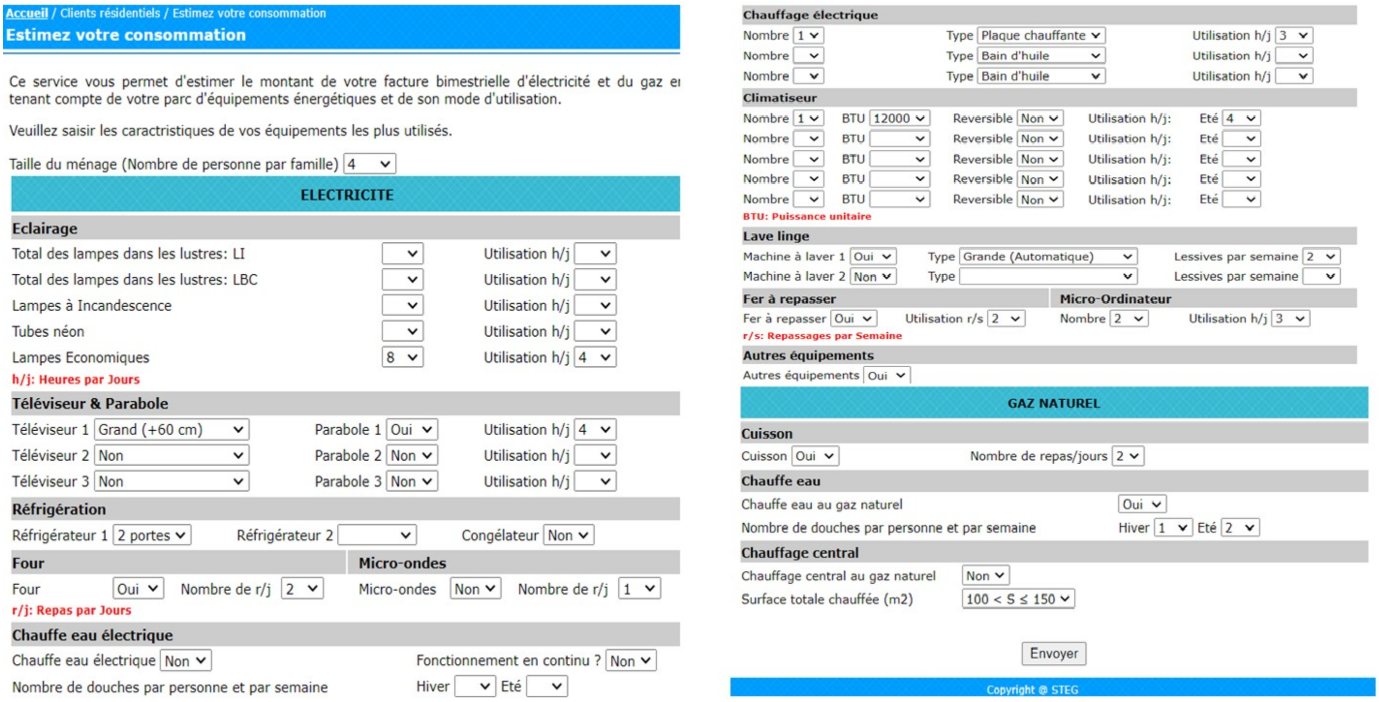
APPENDIX

TABLE XVI Meaning of the abbreviations used

Symbol	Designation	Symbol	Designation
TCEG (STEG)	Tunisian Company of Electricity and Gas	TD	Tunisian Dinar
ATI (TVA)	All Taxes Included	ADC	Average Daily Consumption (kWh)
kW.h	Kilo watt-hour	CEH	Cost saved during 5 ans TD
ELNEL	Annual consumption with no-economic lamps (kWh)	TEH	Rate of return over five years
EEEL	Annual consumption with economic lamps (kWh)	CCHN	Costs over 5 years TD with incandescence lamps
ESL	Energy economic per year (kWh)	CCHE	Annual cost with economic lamps (TD)
CEH	Annual cost saved with (TD)	N	Number of lamps used
CCHN	Annual cost with no- economic lamps (TD)	LED	Lighting emitting diode
TV	Television	ERTT	Etablissement Radiodiffusion Television Tunisienne

ISSN: 2356-5608

THE ELECTRIC CHARGE INTERFACE



REFERENCES

[1] Ç. Ahmet. "Energy consumption and energy saving potential in clothing industry". *Energy*, 159: 74-85, 2018.

[2] B. Catherine, "Energy consumption and energy saving measures in poultry". *Energy Environ. Eng*, , 5.2: 29-36, 2017

[3] J. Zhu, D. Li. "Current Situation of Energy Consumption and Energy Saving Analysis of Large Public Building". *Procedia Engineering*, 121, 1208–1214. 2015.

[4] K. Ghaib, and F.Z. Ben-Fares, "A design methodology of stand-alone photovoltaic power systems for rural electrification", *Energy Conversion and Management*, 148, pp. 1127–1141, 2017.

[5] Tunisian Company of Electricity and Gas (Société Tunisienne de l'Electricité et du Gaz). STEG Tunisie.

[6] A. Soares, A. Gomes, and C. H. Antunes. "Domestic Load Characterization for Demand-Responsive Energy Management Systems". *IEEE International Symposium on Sustainable Systems and Technology (ISSST).* 2012

[7] D. H. Muhsen, H. T.Haider, Y. M. Al Nidawi, & T. Khatib, "Domestic load management based on integration of MODE and AHP-TOPSIS decision making methods". *Sustainable Cities and Society*, 50, 101651, 2019.

[8] C. Bucher, G. Andersson. "Generation of Domestic Load Profiles an Adaptive Top Down Approach". *Proceedings of PMAPS. Istanbul*, Turkey, June 10-14, 2012.

[9] S. Arfa, M. Ben Ammar, M. Al Zidir &Hsan Hadj Abdallah. "Daily energy management system for a house powered by renewable energy", *Proceedings of Engineering & Technology, 4ème Congrès International sur les Energies Renouvelables et le Développement Durable,* Vol. 69, pp .40-47. 2022.

[10] A. K. Aliyu, A. Bukar, L. Ringim, J. G., & A. Musa. "An approach to energy saving and cost of energy reduction using an improved efficient technology". *Open Journal of Energy Efficiency*, 4(04), 61. 2015.

[11] M. W. Akram, M. F. Mohd Zublie, M. Hasanuzzaman, & N. A. Rahim. "Global Prospects, Advance Technologies and Policies of Energy-Saving and Sustainable Building Systems" *A Review. Sustainability, 14*(3), 1316. 2022

[12] M. F. Zublie, M. Hasanuzzaman, & N. A. Rahim. "Feasibility Analysis of Solar Power Generation System for Office Building in Academic Institution". *In IOP Conference Series: Materials Science and Engineering (Vol. 1127, No.* 1, p. 012039). March 2021.

[13] R. Saidur, M. Hasanuzzaman, & N. A. Rahim. Energy use, energy savings and environmental analysis of industrial boilers and compressors". International Journal of Thermal & Environmental Engineering, 1(1), 29-36, 2010.

[14] https://luminaire.tn/product-category/ampoules-led/ visited on 02-06-2023 at 09:30

[15] https://www.silamp.fr/focus-sur-la-duree-de-vie-des-ampoules-led-c1200x61794/ visited on 28 05-2023 at 23h00