Contribution to the Analysis and Improvement of a Billing System

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Abstract -The excess of power consumption has consequences for production companies, which are always trying to switch between production and consumption, as well as those customers who want to minimize the cost of electricity consumption. This problem of power consumption is the objective of this paper. For this purpose, we have compared two methods of calculating the tariffs of the STEG (Tunisian Company of Electricity and Gas) to the tariffs of the EDF (Electricity of France) for a better improvement of the billing system.

Key-Words - power consumption, consumption of buildings, billing system.

1 Introduction

Today, significant innovation in all areas and the large number of electronic devices implies an increase in the use of electricity while conventional resources are being depleted [1-6]. Controlling energy consumption and minimizing the cost of eclectic consumption are the most important axes in ensuring an easy life for the human being.

According to many researchers, the building is responsible for more than a third of energy consumption (38% on average, ranging between 27% and 65% in the Southern and Eastern Mediterranean countries for energy, and between 21% and 51% for electricity) and should be multiplied by more than 1.5 by 2030 [7-15].

In Tunisia, for example, unit consumption rose from 0.3 toe per (ton of oil equivalent) per household in 1990 to almost 0.4 toe per household in 2006. In fact, the large share is reserved for heating and cooling which has been increased from 20.4% in 1989 to 25.7% in 2004 [16-20].

In this paper, an example of home appliance consumption for a winter day is presented. Then an improvement of the billing system is proposed by a comparison of calculation methods. Finally, a validation of the results found is presented.

2 Consumption of domestic appliances

Energy consumption has dramatically increased in buildings over the past decade due to population growth; more time spent indoors, increased demand for building functions and indoor environmental quality, and global climate change.

Electricity and natural gas are the most common energy sources used in commercial buildings. Most individual commercial buildings have their own heating and cooling systems. However, there are district energy systems that supply heating and cooling to groups of commercial buildings.

In fact, building energy efficiency can provide key solutions to energy shortages, carbon emissions and their serious threat to our living environment.

To achieve a good energy efficiency that adds the smart word to the power grid to become a smart grid, an efficient building design must be considered and a performance study of the equipment must be performed [21-29].

In this section, the consumption of household appliances during a typical winter day is analyzed [30-34]. Simulations on Matlab / Simulink are carried out to have the total consumption of the devices in 24h (Figure 1). The total charge demand exceeds the available power profile at different times of the day. It is clear that the peak of consumption is about 5.5 kW between 20h and 21h and 3.8 kW at 13h due to the activation of most devices in the same period.

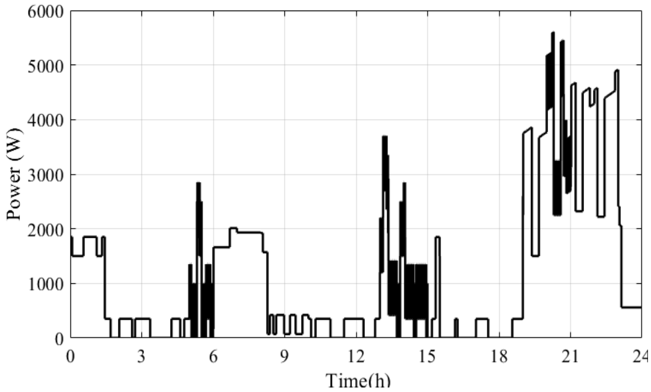

Figure 1: Total consumption of domestic appliances in 24h.

3 Improving a billing system

In this part, we compared the cost of a Tunisian electricity bill according to two different methods (case of the EDF in France and the case of the STEG in Tunisia).

3.1 First French case of EDF

The first French case of the EDF which follows the tariffs at hourly positions: off-peak hours and full hours, gives to its customers the opportunity to choose a time interval where the price of electricity is lower than the price of the other hours not chosen.

The energy cost model is calculated by Equation 1. The parameters Tstart and Tend are respectively the start time and the end time of the off-peak hours. Cph is the cost of peak hours in the interval [Tstart, Tend], Cfh is the cost of off-peak hours outside the interval [Tstart, Tend].

$$Cost = C_{ph}\int_{T_{start}}^{T_{end}} P(t)dt + C_{fh}\int_{0}^{T_{start}} P(t)dt + C_{fh}\int_{T_{end}}^{T_{h}} P(t)dt$$

(1)

Where: Th= 24.

A more complete simulation, the energy tariff chosen is the following: Cph = 75DT / KWh in the time interval [Tstart = 23h, Tend = 7h] and Cfh = 162 DT / KWh.

In this case and according to the consumption figure (fig.1) for one day, we calculated the consumption (C) over one month for the two time intervals:

- From 23h to 7h in the morning, the cost is calculated on 75 millimes;
- From 7h to 23h, the price of KW / h is calculated on 162 millimes.

3.1 Second Tunisian case of STEG

The second Tunisian case of STEG follows the pricing on the monthly consumption per slice presented by the algorithm of Figure 2. The first slice ≤ 200 KWh called social slice where the selling price (75 to 162 millimes) is lower than cost price of KWh produced by STEG (286 millimes). Indeed, this tranche is subsidized by the state and represents more than 70% of STEG subscribers, about 2700000 onto 3800000 subscribers.

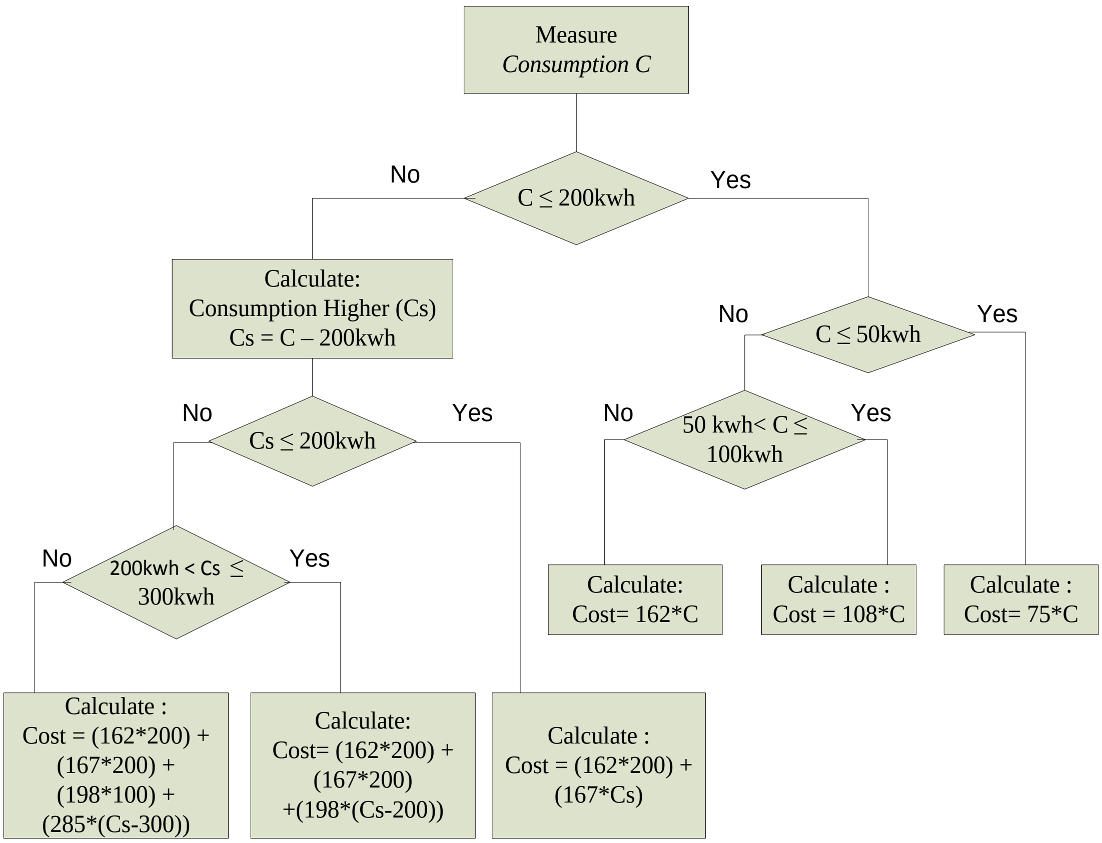

Figure 2 : Algorithm of Tunisian electricity cost calculation

With: C: Consumption; Cs: Consumption higher than 200 kWh.

4 Validation of the results

According to Table I, the cost of a consumption of 135.75KW / h / month is 12,870 DT for the first case and 21,990 DT for the second case.

In the critical case, if the calculation will be for example in four months, the result given by applying the first case is 51.480 DT and applying the second case is 97.870 DT instead of 87.960 DT. This is how we can notice a very big difference of calculation.

TABLE I. Comparison of the invoicing system

	EDF	STEG	Difference Price
Consumption Price / 1 month	12.870 DT	21.990 DT	9.120 DT
Consumption Price / 4 months	51.480 DT	97.870 DT	46.390 DT

According to the results found in Table I, the first case which offers an interval division between peak and off-peak hours has very beneficial consequences, such as encouraging customers to use high-consumption devices during off-peak hours. . This solution allowed to the STEG to not think about the creation of new power stations but to think about the reduction of consumption peaks and to diversify them over time. Thus this solution reduces the cost of electricity consumption, which is the goal of all consumers.

In this part, we present the contributions expected to STEG from the Smart Grid project such as the combination of a new method of calculation of the electricity price according to intervals in order to have a balanced market and an optimization of the consumption by the smoothing of the load curve according to the choice of customers.

5 Conclusion

The cause of the sharp increase in consumption is due to the strong demand for housing resulting from a large demographic increase, to the increase in population and to the use of energy-intensive appliances (heating, air conditioning, etc.). It is for this reason that the complements made of the two methods of calculation of the STEG tariffs in Tunisia with the EDF tariffs in France and the result which declares a significant difference of price is an obligation to satisfy the two actors of the field.

The change of the method offers to the STEG, a balanced market by optimizing consumption with smoothing the load curve according to the choice of customers.

References :

[1] X. Frang, Smart-grid-the new ans improved power grid : a survey, *IEEE communications surveys and tutorials*, Vol.14, N°.4, fouth quarter, 2012.

[2] R. Glaa, M.N Lakhoua, L. El Amraoui, Modelling of renewable energy production based on systemic analysis method, *International Journal of Applied Systemic Studies*, Inderscience, Vol.8, N°4, 2018.

[3] R. Glaa, M.N. Lakhoua, L. El Amraoui, Analysis and System Modeling of a Smart Grid: Case Study of the Operations Domain, *GECS'2017*, Hammemet, 23-25 March 2017.

[4] H.L. Thibault, H. Andaloussi, L'éfficacité énergitique dans le batiment en Méditerranée, *Futuribles*, N°376, 2011.

[5] S. Adil, W. Arthur, A.Hanya, Simplified modeling of a PV panel by using PSIM and its comparison with laboratory test results, Global Humanitarian Technology Conference, 2015.

[6] H. Wertani, J. Ben Salem, M.N. Lakhoua, Analysis and supervision of a smart grid system with a systemic tool, The Electricity Journal, vol. 33, pp. 1-8, 2020.

[7] R. Glaa, N. Jeddi, M.N. Lakhoua, L. El Amraoui, Application of system modeling and simulation of the photovoltaic production, *Advances in Science and Technology Research*, *Journal*, Vol.11, Issue 3, 2017.

[8] Rapport Annuel de la STEG, Société Tunisienne de l'Electricité et du Gaz, 2018.

[9] M.N. Lakhoua, W. Naouali, A . Chakroun, System Analysis of a Hybrid Renewable Energy System, *International Journal of Electrical and Computer Engineering* (*IJECE*), Vol. 4, N°3, 2014, pp 343-350.

[10] M.N. Lakhoua, R. Glaa, M. Ben Hamouda, L. El Amraoui, Contributions to the Analysis and the

Supervision of a Thermal Power Plant, *International Journal of Advanced Computer Science and Applications*, Vol.7, N°1, 2016.

[11] Association Méditerranéenne des Agences Nationeles de Maitrise de l'Energie, L'efficacité energitique dans les pays du Sud et de l'Est de la Mediterranée.

[12] D. Saheb-Koussa, M.BEL Hamel, Production d'électricité sans interruption moyennant un système hybride (éolien – photovoltaïque – diesel), *Revue des Energies Renouvelables*, 2007.

[13] R. Glaa, M.N. Lakhoua, L. El Amraoui, Application of System Modeling of the Renewable Energy Production, *ICRAES'2016*, Hammamet, Dec. 22, 2016 Tunisia.

[14] M. Ourahou, W. Ayrir, B. El Hassouni, A. Haddi, Review on smart grid control and reliability in presence of renewable energies: challanges ns prospects, 2018.

[15] M. Weedall, BPA Smart Grid Overview, *Energy and Communications*, Washington House Technology, January 22, 2000.

[16] H. Bellia, R .Yousef, M. Fatima, A detailed modeling of photovoltaic module using Matlab, *Journal of Astronomy and Geophysics*, 2014.

[17] P. Jangwoo, K. Hong-Geun, C. Yongyum, Changsum S. Simple modeling and simulation of photovoltaic panels using Matlab/Simulink, *Advanced Science and Technology Letters*, 73, 2014, 147-155.

[18] M. Ourahou, W. Ayrir, B. El Hassouni, A Haddi, Review on smart grid control and reliability in presence of renewable energies challanges ns prospects, 2018.

[19] H. Wertani, J. Ben Salem, M.N. Lakhoua, Analysis and supervision of a smart grid system with a systemic tool, *The Electricity Journal*, vol.33, Issue 6, July 2020.

[20] H. Wertani, J. Ben Salem, M.N. Lakhoua, Application of Bond Graph of Renewable Energy Sources in Smart Grids, *Journal of Electrical and Electronics Engineering*, vol.13, May 2020.

[21] H. Wertani, J. Ben Salem, M.N. Lakhoua, State of the art on modeling and optimization of Smart electricity networks, *European Conference on Electrical Engineering & Computer Science* (ELECS 2020, former EECS. Bern, Switzerland,December 21-23, 2020.

[22] M.F. Karoui, H. Aljouni., H. Wertani, M. Jemal, M.N. Lakhoua, Methodology of System Analysis and Monitoring of Wind Power Plant, *6th IEEE International Energy Conference (ENERGYCon)*, 28 Sept. - 1st Oct. 2020.

[23] H. Wertani, M.N. Lakhoua, Overview of Smart Grids Architecture and Design, *SmartNets2018*, Hammamet Tunisia, November 15-17, 2018.

[24] M. P. Fanti, A. M. Mangini, M. Roccotelli, A simulation and control model for building energy management, *Control Engineering Prectice* 72, pp192-205, 2018.

[25] A. Mirakhorli, B. Dong,Market and behavior driven predictive energy management for residential buildings, Elsevier, *Sustainable cities and society*, Nº38, pp. 723-735, 2018.

[26] M. Shad, A. Momeni, R. Errouissi, C.P. Diduch, M. E. Kaye, L. Chang, Identification and estimation for electric water heater in direct load control programs, *IEEE Transactions on smart grid*, Vol 8, Nº2, 2017.

[27] F. Issi, O. Kaplan, The determination of load profiles and power consumptions of home appliances, *Energies*, 2018.

[28] K. Thinzar Oo, T. Zaw Soe, Operation system of washing machine with fuzzy logic control system and construction of detergent box, International *Journal of science, engineering and technology research*, 2017.

[29] E. Pouresmaeil, J. M. Gonzalez, A. Canizares, K. Bhattacharya, Development of a smart residential load simulator for energy management in smart grid, *IEEE Transaction on power system*, 2018.

[30] G. Costanzo, P. Bacher, H. Madsen, Grey-box modeling for system identification of household refrigerators: a step toward smart appliances, 2013.

[31] P. Sossan, Grey-box modelling of a household refrigeration unit using time series data in application to demand side management, Sustainable Energy, *Grids and Networks*, 2016.

[32] A. Harmin, M. Merzouk, M. Boukar, M. Amar, Mathematical modeling of a box type solar cooker employing as asymetric compound parabolic concentrator, *Solar Energy*, N°86, pp 1673-1682, 2012.

[33] K. Le, Gestion optimale des consommations d'energie dans les batiments, these, Institut National Polytechnique de Grenoble-INPG French, 2008.

[34] S. Bissey, S. Jacques, J. Chaeles L. Bunetel, La logique floue au cœur d'un algorithme d'optimisation de la consommation d'energie electrique d'une habitation individuelle, *Conference des Jeunes Chercheurs en Genie Electrique (JCGE*), HAL Id: hal-01580300, 2017.