MONTE CARLO SIMULATION USED FOR THE ELECTRICITY SUPPLIER SELECTION

Martina Kuncova[(a)], Jana Seknickova[(b)]

[(a),(b)]University of Economics, Prague (Czech Republic), Faculty of Informatics and Statistics, Dpt. Of Econometrics

[(a)]martina.kuncova@vse.cz, [(b)]jana.seknickova@vse.cz

ABSTRACT

One of the very important commodities that affect our life is electricity. The costs related to the electricity consumption are significant and so each subject (e.g. household or company) has to consider carefully which electricity supplier is the most suitable with respect to the minimal costs. The electricity price is influenced by the region where the subject chooses the suppliers, by the amount of the electricity consumption and by the electricity prices given by the regulatory office. The transformation of the electricity market in the Czech Republic has led to the increasing number of suppliers offering this commodity to households and companies. The aim of this paper is to select such a supplier that minimizes total costs of the electricity for given household and given tariff rate. As a tool we use Monte Carlo simulation for the electricity consumption.

Keywords: Monte Carlo Simulation, electricity consumption, suppliers' selection

1. INTRODUCTION

Electricity belongs to the commodities that are essential for our lives and also for the economic development. The expansion of modern technologies and the increase of the electronic equipment usage to ease the work, to relax, to study, etc. causes the non-decreasing demand for electricity (Fig. 1).

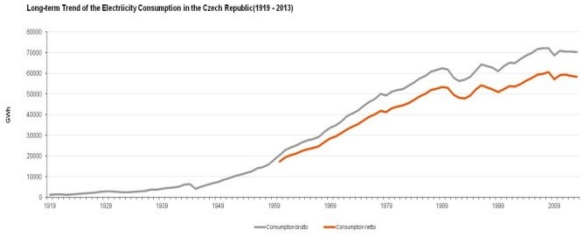

Figure 1: Long-term Trend of the Electricity Consumption in the Czech Republic. Source: CEZ (2015)

The transformation of the electricity market in the Czech Republic started in 2002 when the companies could choose its electricity supplier. For the households it started to be possible since 2006. After this process each household and company can choose the supplier of the electricity. This liberalization has led to the increasing number of suppliers entering the electricity market. Except of the suppliers, there are other subjects on this market in the Czech Republic: distributors, Energy Regulatory Office (ERU) and operator of the market (OTE) (www.eru.cz). The Czech Republic is divided into three network parts operated by three distributors (Fig. 2): PRE, CEZ, E.ON.

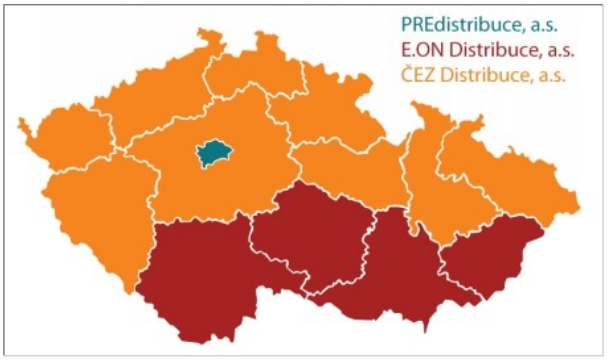

Figure 2: Distributors' regions in the Czech Republic (Source: www.penize.cz)

Each household cannot choose the distributor but only the supplier that sells the electricity. The tariff rate for each household is given according to the supplier's conditions. The complete list of the suppliers and their tariffs and prices is changing every year. The selection of the supplier depends on the contract conditions but mainly on the prices. With respect to all these facts it is a hard task to find the best supplier. Various techniques and methods can be used to model the situation on the market (Ventosa et al. 2005; Seknickova, Kuncova 2014). In this paper we use the simulation of the electricity consumption of one household (tariff rate D25d) to compare the final prices for all suppliers and their products in all regions in 2015 and we compare it with the results from the previous research (Kuncova, Seknickova 2014).

2. CZECH ELEKTRICITY MARKET

The electricity market in the Czech Republic was specific till 2002 when the transformation process oriented at the fully liberalization has started and so all the households and companies can choose its supplier. As it was mentioned above, there are other also other subjects on the electricity market, especially distributors, the Energy Regulatory Office (ERU) and the Operator of the market (OTE). OTE predicates the

whole market consumption and analyses the differences, ERU regulates the prices of the transfer and distribution of the electricity. The high number of the suppliers and their products on the retail market (Fig. 3) embarrasses the position of the households. According to this situation it is hard to follow the rules and the price changes on the market and so it is hard to choose the best (cheapest) product.

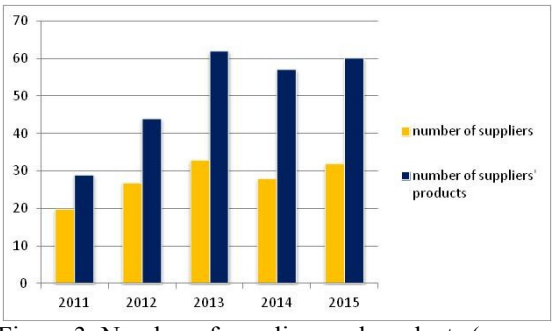

Figure 3: Number of suppliers and products (source: www.eru.cz)

The product selection is influenced mainly by the electricity take-off amount and by the prices for the electricity consumption. The final price is given by more factors such as consumption, fixed fees or taxes. Generally the price can be divided into two components. The first one is the controlled charge for services related to the electricity transport from the generator to the final customer. This charge is annually given by Energy Regulatory Office (ERU, 2015). It covers:

- monthly lease for the circuit breaker,
- price per megawatt hour (MWh) in high tariff (HT),
- price per megawatt hour in low tariff (LT),
- price per system services,
- price for the support of the renewable energy purchase,
- charges for the electricity market operator,
- electricity ecological tax (28,30 CZK per 1 MWh).

The second part of the total price is given by the electricity supplier. It covers:

- fixed monthly fee for the selected product,
- price per megawatt hour (MWh) in high tariff (HT),
- price per megawatt hour in low tariff (LT).

The final price is increased by VAT that was 20% till 2012 and 21% from 2013.

3. DATA AND METHODS

3.1. Data for the Analysis

According to the previous analysis (Kuncova, Seknickova 2014) we compare the offered products for the tariff rate D25d. This tariff rate is given to household when the electricity is used also for the accumulative heating and hot water heating for lower and middle yearly offtake with operative management of the validity period of the low tariff for 8 hours. It is so-called dual tariff rate as it covers 2 periods (high tariff, low tariff) during the day. The ranges for the electricity consumption were taken from the real data with the electricity consumption about 10 MWh anually, 45% energy in high tariff and 55% in low tariff and with the circuit breaker from 3x20A to 3x25A. According to the ERU calculator (2015) we use data for 60 products (offered by 32 suppliers) in all three distribution areas. All data display prices for year 2015. When we compare the average prices in 3 distribution areas (Fig. 4) we see that since 2012 they are decreasing but similar for all regions.

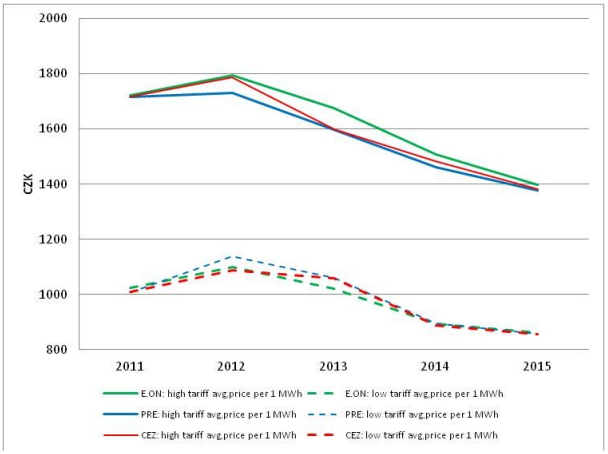

Figure 4: Suppliers' average prices for 3 regions

On the other hand when we compare the prices given by the distributor and ERU (Table 1), we see that the CEZ region is the most expensive one.

Table 1: Prices of distributors

year	distrib. region	circuit-breaker monthly fee	Distrib. HT price per 1 MWh	Distrib. LT price per 1 MWh	Distrib. Other services price per 1 MWh
2011	E.ON	105	1846.39	27.63	530.15
	PRE	98	1582.83	19.90	
	CEZ	120	1978.50	32.85	
2012	E.ON	98	1667.65	27.63	569.97
	PRE	98	1553.79	19.90	
	CEZ	120	1972.84	32.89	
2013	E.ON	98	1697.42	30.08	722.75
	PRE	105	1650.04	25.49	
	CEZ	120	1991.98	37.36	
2014	E.ON	90	1592.04	30.59	621.8
	PRE	98	1563.66	24.45	
	CEZ	105	1731.93	36.38	
2015	E.ON	95	1518.43	29.99	607.21
	PRE	102	1508.54	24.37	
	CEZ	110	1727.62	36.94	

3.2. Monte Carlo Simulation

To find the best product we can use various methods and techniques. One of them (that we also have used for

the previous comparison – Kuncova, Seknickova 2014) is Monte Carlo simulation. Simulation models can be applied in situation when some variables of the model are uncertain. Simulation itself is a technique for imitation of some real situations, processes or activities that already exist in reality or that are in preparation – just to create a computer model (Banks 1998). Simulation models do not provide the solution of the problem but they show what can happen. They are used to study the system and see how it works, to find where the problems come from, to compare more model variants and to select the most suitable one, to show the eventual real effects of alternative conditions and courses of action, etc. (Dlouhý et al. 2011). Monte Carlo simulation repeats a lot of random experiments to find out the possible outcomes. This is typical situation for various decision-making processes in finance (Razgaitis 2003), banking (Kuncova, Lizalova 2012) and also in energetics to generate the whole demand for the distributed units (Hegazy et al. 2003) or to generate the annual electricity consumption (Kuncova, Seknickova 2014). The process of simulation involves a lot of experiments when random number generator and the transformation of the random numbers into random variables from the selected distribution must be used. The spreadsheet add-in package Crystal Ball is designed specifically for Monte Carlo simulation in MS Excel and it has been used also in this article.

For the calculations we use the same model as in (Kuncova, Seknickova 2014). The ranges for the electricity consumption in each month were set (at about 900 kWh per month on average), the high tariff is used in 45% from the whole consumption. Our simulated consumption has been generated for each month from the normal distribution with 20% of the average taken as the standard deviation. In all Monte Carlo simulations 1000 experiments have been tried to randomly select consumption for each month and afterwards the annual costs are calculated. The formula for the annual cost calculation for each supplier's product is following:

$$COST_{ij} = (1 + VAT) \cdot \left[12 \cdot \left(mf_{ij} + mf_j\right) + 0.45 \cdot gc \cdot \left(ph_{ij} + ph_j\right) + 0.55 \cdot gc \cdot \left(pl_{ij} + pl_j\right) + gc \cdot (os + t)\right]$$

where

i … product, i =1, …, 60,
j … distributor, j = 1, …, 3,
VAT … value added tax (VAT = 0.21 in 2015),
mf … fix monthly fee,
gc … yearly generated consumption in MWh,
ph … price in high tariff per 1 MWh,
pl … price in low tariff per 1 MWh,
os … price for other services per 1 MWh,
t … electricity tax per 1 MWh (t = 28.3 CZK).

4. RESULTS

The comparison of suppliers is based on the 1000 simulation experiments created in the Crystal Ball software. We have found out that the difference among the distributors regions exists. The cheapest region is the area of the distributor PRE (Table 2). The order of the suppliers and their products in 2015 according to the average annual prices is nearly the same in all regions. On the first place there are 2 suppliers (that offer only one product each): CARBOUNION KOMODITY or ST Energy. The differences of the annual costs of the supplier CARBOUNION KOMODITY in all regions can be seen in Figure 5. The most expensive is the supplier Global Energy with its two products (Table 2). The difference between the lowest and highest annual average price is about 5400-5600 CZK which is about 20% of the average annual costs.

Table 2: Order in 2015 for all distributors and the average annual price

distr. area / order	E.ON	avg. annual price CZK	PRE	avg. annual price CZK	CEZ	avg. annual price CZK
1	CARB. KOMOD	28961	ST Energy	28850	ST Energy	30262
2	ST Energy	29040	CARB. KOMOD	28944	CARB. KOMOD	30390
3	Nano En.Trade	29063	Nano En.Trade	29062	Nano En.Trade	30474
4	Europe Easy Energy Com.aku	29385	Fonergy Premium	29179	Fonergy Premium	30591
5	Fonergy Premium	29462	Europe Easy Energy Com.aku	29231	Europe Easy Energy Com.aku	30643
58	E.ON elekt.	32927	E.ON elekt.	32925	E.ON elekt.	34342
59	Global Energy fix 2015 G aku	33241	Global Energy fix 2015 G aku	33075	Global Energy fix 2015 G aku	34503
60	Global Energy G aku	34564	Global Energy G aku	34339	Global Energy G aku	35693

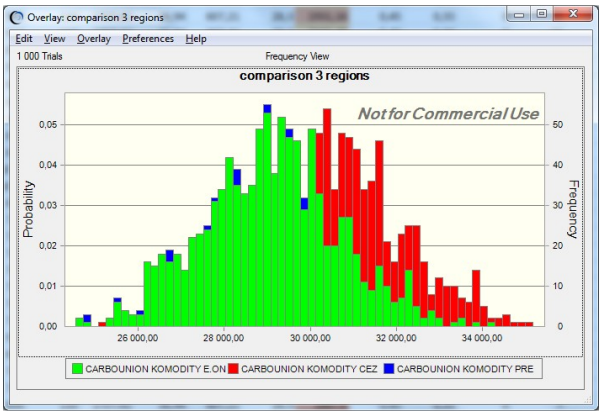

Figure 5: Histograms for the annual costs for the supplier CARBOUNION KOMODITY

As all the annual average costs oscillate around 30000 CZK, we have dealt with the probabilities that the annual costs will be lower than 30000 CZK. For the best products this probability is around 74-76% (region PRE, ST Energy; region E.ON CARBOUNION KOMODITY – Fig. 6), but only around 44% in CEZ area (Fig. 7). The worst products have this probability close to zero (Fig. 8) so there is very small chance to have the household annual electricity consumption costs lower than 30000 CZK (for D25d tariff rate with the selected circuit breaker, consumption around 9-10 MWh annually with 45% consumption in high tariff).

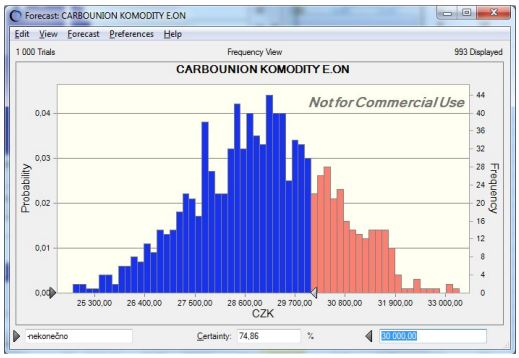

Figure 6: The probability of the annual costs lower than 30000 CZK – region E.ON, CARBOUNION KOMODITY

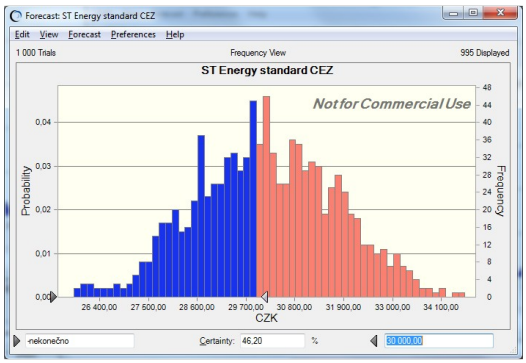

Figure 7: The probability of the annual costs lower than 30000 CZK – region CEZ, ST Energy

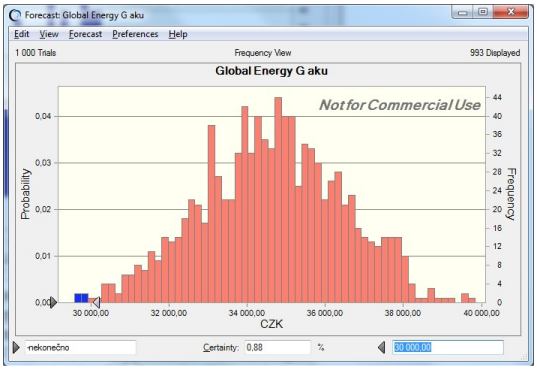

Figure 8: The probability of the annual costs lower than 30000 CZK – region E.ON, Global Energy G aku

When we compare the histograms of the best and worse products we can see the difference between the annual costs (Fig. 10).

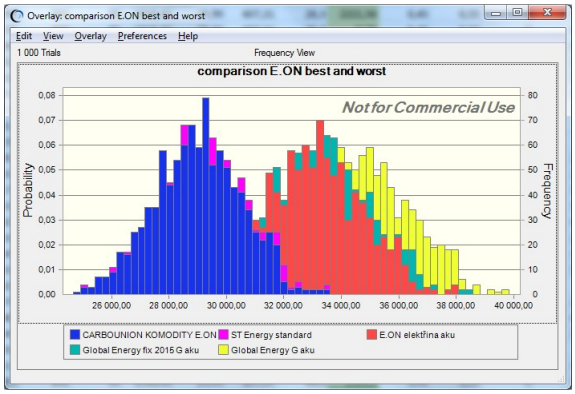

Figure 10: Comparison of the best and worst products – region E.ON

5. CONCLUSION

The situation on the electricity retail market in the Czech Republic is not clear because of the number of suppliers and its products. The formula of the annual cost calculation of the electricity consumption contains a lot of factors and so it is hard for the household to compare the costs and to choose the cheapest product. For all products the cheapest distributor is PRE. Monte Carlo simulation of the electricity consumption can be used as a good tool to compare the prices of the products as it covers the variability in the electricity consumption. Our analysis has showed that there are the big differences in annual cost for the electricity consumption and all suppliers in CEZ region have higher prices than in other regions. The selection of the cheapest product can save about 20% of the annual electricity consumption costs on average. The next research will be aimed at the optimization models minimizing the annual costs when looking for the limits of the annual consumption for each supplier and also at the comparison of other tariff rates.

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REFERENCES

Banks, J. 1998. Handbook of Simulation. John Willey & Sons, USA, 1998.

Dlouhy, M., Fabry, J., Kuncova, M. and Hladik, T. 2011. Simulace ekonomických procesů. 2. ed. Computer Press, Brno, 2011.

ERU - Energy Regulatory Office (2015). Price calculator [online], available at: http://kalkulator.eru.cz/VstupniUdaje.aspx [cit. 2015-05-05]

Hegazy, Y.G., Salama, M.M.A. and Chickhani, A.Y.: Adequacy assessment of distributed generation systems using Monte Carlo Simulation. Power Systems - IEEE Transactions 18/1 (2003), 48-52.

Kuncova, M., Lizalova, L. 2012. Monte Carlo simulation – the bank account selection in the Czech Republic according to the bank charges. In: Proceedings of the International Conference on Modeling and Applied Simulation. Wien, 2012, 153-161.

Kuncova, M., Seknickova, J. 2014. Analysis of the efficiency of the electricity supplier selection depending upon the price changes. In: Mathematical Methods in Economics (MME2014) [CD]. Olomouc, 10.09.2014 – 12.09.2014. Olomouc : Palacký University in Olomouc, 2014, s. 542–547. ISBN 978-80-244-4208-2. CD ISBN 978-80-244-4209-9.

Razgaitis, R. 2003. Dealmaking Using Real Options and Monte Carlo Analysis. John Willey & Sons, New Jersey, 2003.

Ventosa, M., Baíllo, Á., Ramos, A. and Rivier, M. 2005: Electricity Markets modeling trends, Energy Policy 33, 897–913.

AUTHORS BIOGRAPHY

Martina Kuncova: She has got her degree at the University of Economics Prague, at the branch of study Econometrics and Operational Research (1999). In 2009 she has finished her doctoral study at the University of West Bohemia in Pilsen (Economics and Management). Since the year 2000 she has been working at the Department of Econometrics, University of Economics Prague, since 2007 also at the Department of Economic Studies of the College of Polytechnics Jihlava. She is a member of the Czech Society of Operational Research, she participates in the solving of the grants of the Grant Agency of the Czech Republic, she is the coauthor of three books and the author of many scientific papers and contributions at conferences. She is interested in the usage of the operational research, simulation methods and methods of multi-criteria decision in reality.

Jana Seknickova: She graduated at Faculty of Mathematics and Physics, Charles University in Prague (Probability, Mathematical Statistic and Econometrics) in 2001 and received her PhD degree at the University of Economics in Prague, Department of Econometrics (Operational Research and Econometrics) in 2008. The main part of her professional interests consists in optimization, multiple criteria decision making and in software support for optimization in general. Now she is working as a senior lecturer at the Department of Econometrics, Faculty of Informatics and Statistics, University of Economics in Prague and also at the Department of Software Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague. She is a member of the Czech Society of Operational Research, she participates in the solving of the grants of the Grant Agency of the Czech Republic, Internal Grant Agency etc. She is the author or coauthor of many scientific papers and contributions at conferences and coauthor of several books focused mainly on optimization, multicriteria decision making and econometric analysis.