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ELECTRICITY SUPPLIER SELECTION BY A HOUSEHOLD IN THE CZECH REPUBLIC IN 2017 AND 2018 – MONTE CARLO SIMULATION APPROACH

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ABSTRACT

The situation on the electricity retail market in the Czech Republic is not clear because of the number of suppliers and its products. Although the information about the prices for the electricity consumption for households is available on the web and each household can change the supplier nearly with no extra effort and cost, households are still often not familiar with the individual price items of the products. In this article the analysis of the Czech electricity market from the distribution rate D25d point of view is made for the years 2017-2018 when the household annual consumption is simulated via Monte Carlo simulation model. The aim of this paper is to select such a supplier and product that minimizes the total costs of the electricity for a household for the selected distribution rate and compare it with the results from the previous years.

Keywords: Electricity consumption, distribution rate D25d, Monte Carlo simulation, cost minimization

1. INTRODUCTION

Electricity is nowadays a commodity that is essential for nearly all activities we are used to doing. As still new and new electricity-based equipment arises we might expect the rise of electricity consumption. But on the other hand, there is the necessity of renewable resource usage and the decrease in the electricity consumption of the new machines. That is why the final trend in the consumption is not so clear.

Electricity is used in all sectors of the economy. Usually, the biggest part of the electricity is consumed by industry followed by services or households, energy transfer, transport, etc. The development of the consumption in European Union countries in the years 1990-2016 is shown in Figure 1 – the highest line is industry followed by services and residential sector (households). The structure of the consumption in 2016 in the Czech Republic is seen in Figure 2. The situation is similar: the highest share of electricity consumption is associated with the industry (30%) followed by households (26%).

Based on the data from Eurostat (2019) we see in Figure 3 that nearly in the half of the European Union countries the electricity consumption by households was higher in 2016 compared to 2006, but in the other half, we see the decrease of the electricity consumption.

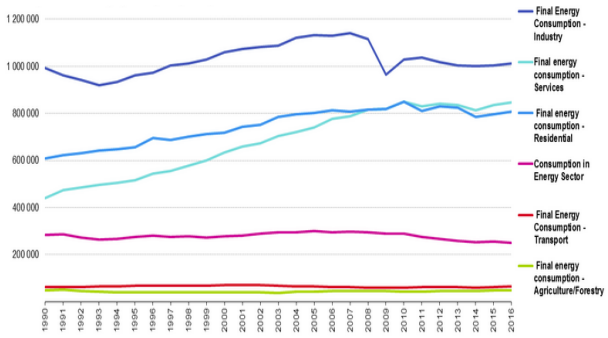

Figure 1: Consumption of electricity by sector in EU 28. Source: Eurostat (2019a)

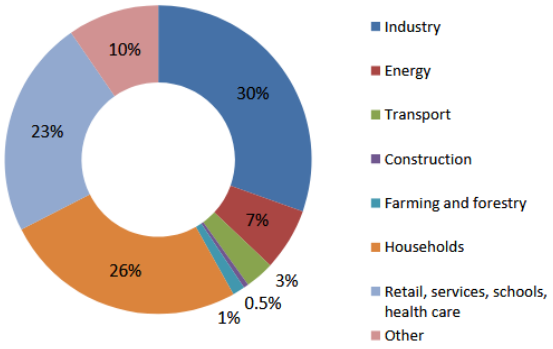

Figure 2: National economy sectors' shares of total electricity consumption in the Czech Republic. Source: ERU (2016)

The highest increase we see in Romania (20.7%), the highest decrease was in Belgium (about 17%, so the rate in 2016 was 83% compared to 2006). In the Czech Republic, we see the small decrease (1.7%) that is close to the EU average (decrease about 0.7%). As Karanfil and Li (2015) explain, the electricity-growth nexus is highly sensitive to regional differences, countries' income levels, urbanization rates and supply risks. The increase of the consumption of households might be caused by the development of ICT and the growing number of various machines and other electrical devices, the decrease by the lower demand of new

appliances for the electricity consumption. For any household it is probably the most used commodity although it does not belong to the common consumer goods - it is invisible, untouchable and it is used only via other equipment.

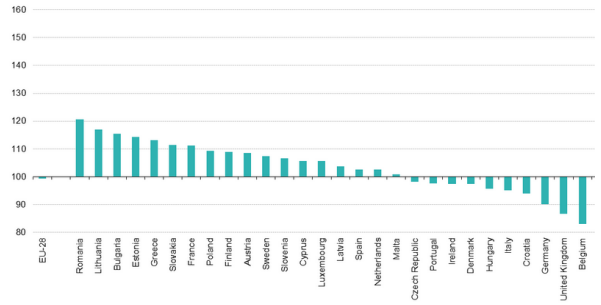

Figure 3: Electricity consumption by households in 2016 compared to 2006 in EU28. Source: Eurostat (2019b)

The liberalization process which started in Europe in the period 2003-2009 initiated the possibility to choose the electricity supplier by households (Newbery, 2013). Each household cannot choose the distributor but only the supplier that sells the electricity. The complete list of the suppliers and their products and prices is changing every year and sometimes it is hard to follow the rules nor the conditions for the households to understand the situation and to choose the appropriate product. The selection of the product depends on the contract conditions given by the distributor but mainly on the prices set by distributors and suppliers. Various techniques and methods can be used to model the situation on the market – multi-criteria analysis, simulation modelling, optimization (Ventosa et al. 2005; Kuncova 2015). In this paper the simulation of the electricity consumption of one household (tariff rate D25d) via Monte Carlo model is applied on the data from the years 2017 and 2018 for all suppliers and distributors in the Czech Republic. Afterwards, the comparison with the previous research (Kuncova, Seknickova 2014; Kuncova, Seknickova 2015; Kuncova 2015; Kuncova 2016) is added.

2. CZECH ELECTRICITY MARKET

The development of the energy sector in the Czech Republic after the Velvet revolution in 1989 started with the restructuring of the centrally run energy system and its division into a number of smaller entities with one state-owned (Vlcek, Cernoch 2013). Afterwards, the privatization of the key energy companies followed. Based on the EU demands, the liberalization of the Czech electricity market started in 2002, later from 2006 also the households could choose its electricity and gas supplier – but as the situation was hardly understandable for a household, the higher number of suppliers' switches has started around the year 2010 (Vlcek, Cernoch 2013) – see Figure 5.

Except suppliers, there are other subjects on the electricity market, especially 3 distributors (PRE, CEZ, E.ON), 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 (Figure 4) embarrasses the position of the households. Based on the ERU (2019) data, it is evident that only 9 companies (including 3 distributors that also serves as suppliers) have been on the market offering D25d rates products since 2011.

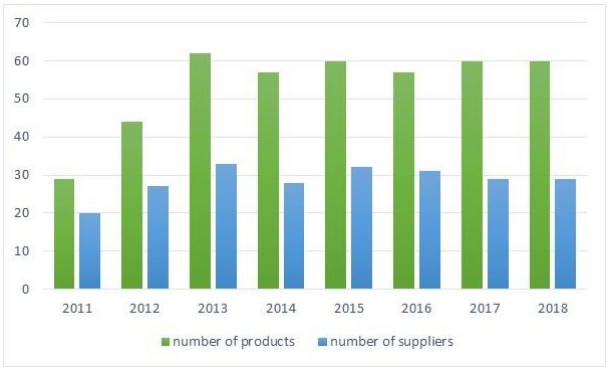

Figure 4: Number of suppliers and its products. Source: ERU (2019)

As the ERU offers the online calculator (ERU, 2019) and the conditions of the supplier switch are more and more explained in media, the number of supplier changes increased, mainly last year (Figure 5). The reason might be connected with the increase of electricity consumption prices – the development of the average prices for high and low tariff rates in each distribution region for the selected distribution rate D25d are shown on Figure 6. 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 the so-called dual tariff rate as it has 2 periods (high tariff, low tariff) during the day (ERU, 2019).

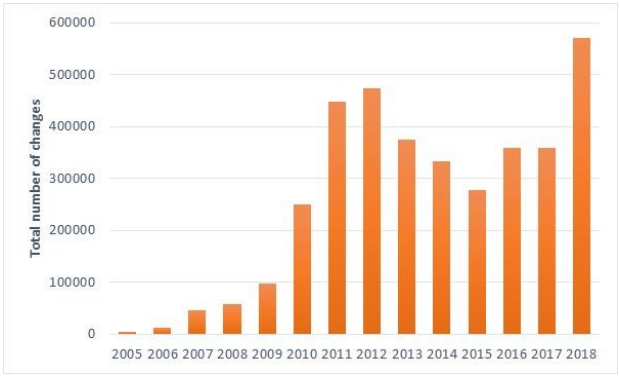

Figure 5: Number of changes of electricity suppliers in the Czech Republic. Source: OTE (2019)

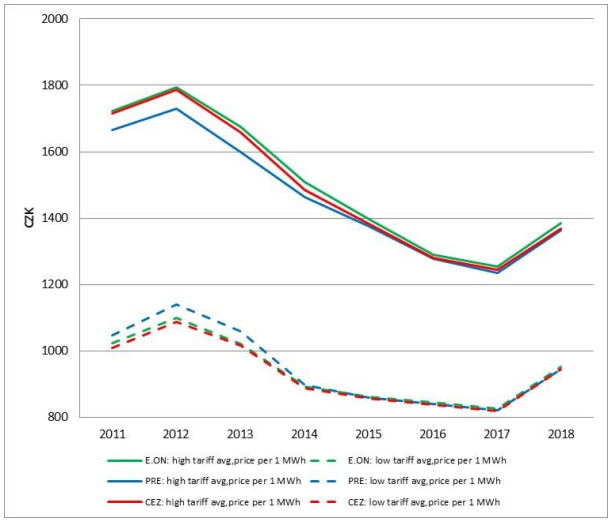

Figure 6: The development of the average prices in high and low tariffs per 1MWh for D25d rate in 3 distribution regions. Source: ERU (2019), own calculations

The final costs for the electricity consumption of the household are influenced by consumption, fixed fees or taxes. Generally, the prices are divided into two components. The first one is the controlled charge for services related to electricity transport from the generator to the final customer. This charge is annually given by ERU (2019). 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 is 21% from 2013.

3. DATA AND METHODS

3.1. Data for the Analysis

Several previous analyses were aimed at the comparison of the products offered for the households in the distribution rate D25d: Kuncova, Seknickova (2014) where multi-criteria evaluation methods were used; in Kuncova, Seknickova (2015) the Monte Carlo simulation was applied on the data from the year 2015; in Kuncova (2015) the multi-criteria comparison, Monte Carlo simulation and the linear optimization model were used and the results of the product choice compared; in Kuncova (2016) the changes in period 2011-2016 were described and analyzed. To be able to compare the results from the years 2017 and 2018 with the previous ones the same assumptions are used in this article.

The ranges for the electricity consumption were taken from the real data and real household with the electricity consumption about 10 MWh annually, 45% energy in high tariff and 55% in low tariff and with the circuit breaker from 3x20A to 3x25A.

Data for the 60 products offered by 29 companies for the years 2017 and 2018 were taken to find the best product for each year with the lowest electricity consumption cost. As there are differences in prices in the distribution regions, all 3 regions were analyzed separately. The distributors' prices and the average prices of the suppliers are in Table 1 and Table 2. As it was mentioned above, the prices raised in 2018 compared to 2017 but the increase was not equal in all distribution regions. The most expensive (for the households) is still the CEZ region (north part of the Czech Republic) which is visible from Figure 6. In this region the highest increase of the average suppliers' monthly fee in 2018 compared with 2017 is visible – about 34%, while in other two regions it was about 12% (PRE region) or 13% (E.ON region).

Table 1: Prices for each distribution area

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
2017	E.ON	113	1607.38	72.22	593.84
	PRE	116	1503.96	70.58	
	CEZ	120	1624.71	64.01	
2018	E.ON	119	1687.78	77.28	594.03
	PRE	123	1590.53	75.52	
	CEZ	127	1719.17	71.669	

Table 2: Average prices of the suppliers for each distribution area

year	distrib. region	Suppliers monthly fee avg,	high tariff avg,price per 1 MWh	low tariff avg,price per 1 MWh
2017	E.ON	43.838	1253.853	826.139
	PRE	46.824	1234.639	820.437
	CEZ	44.990	1244.705	818.420
2018	E.ON	49.646	1384.163	951.274
	PRE	52.630	1363.746	945.424
	CEZ	60.446	1369.246	945.424

3.2. Monte Carlo Simulation

Simulation models can be applied in a situation when some variables of the model are uncertain. The simulation itself is a technique for imitation of some real situations, processes or activities that already exist or that are in preparation – just to create a computer model (Banks 1998). Monte Carlo simulation (or technique) is closed to statistics as it is a repeated

process of random sampling from the selected probability distributions that represent the real-life processes (Turban, Meredith 1994). This method is based on running many times and for each sample random variates are generated on each input variable (Thomopoulos, 2013). Based on the existed information the type of probability distribution (that corresponds with the expectations about the values of the variable) must be selected. The most typical and frequent distribution types are normal, triangular, uniform (discrete uniform), Poisson, lognormal and exponential ones. Mathematical specification of these variables and the calculations derived from them might be complicated (especially when a non-trivial distribution is chosen). But via the simulation Monte Carlo and via MS Excel and its add-ins (for example Crystal Ball or @RISK) it is possible to analyze the problem and find a recommendation for each specified situation.

Crystal Ball is one of the MS Excel add-in applications for the Monte Carlo simulation models. "Oracle Crystal Ball solutions begin with Oracle Crystal Ball, the base package for predictive modeling, Monte Carlo simulation and forecasting. Oracle Crystal Ball Enterprise Performance Management builds on that set of tools by adding the power of Oracle Crystal Ball to your Oracle Enterprise Performance Management (EPM) and Oracle Business Intelligence (BI) applications" (www.oracle.com). The advantage of this software is the usage of Excel tables. It is possible to use models created before but change the distribution for random inputs generation. Then usually 1000 trials are run and afterwards the programme gives all statistics (and histogram) of the selected decision cell. Figure 7 shows all the possible statistical distributions that can be chosen.

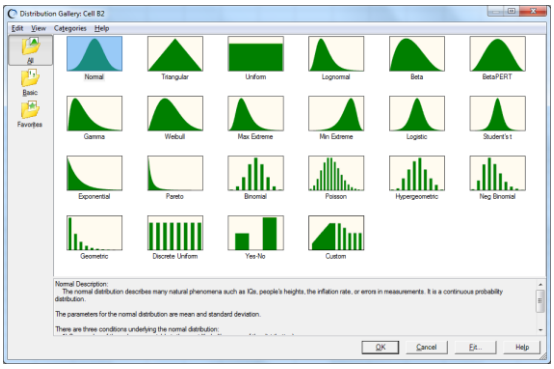

Figure 7: Crystal Ball – Distribution Gallery (www.oracle.com)

Monte Carlo simulation is associated with the systems affected by randomness when several different scenarios are randomly generated to obtain the probability description of the selected results (Brandimarte, 2014). The method repeats a lot of random experiments to find out the possible outcomes. This is a 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).

To find the best product the online ERU calculator (2019) can be used – the only problem is to set the annual electricity consumption. But as the consumption is not fixed for more years, the Monte Carlo simulation could be another possibility to find the best product minimizing the annual electricity consumption costs for the given household.

For the calculations we use the same model as in Kuncova, Seknickova (2014; 2015). The ranges for the electricity consumption in each month were set as values from the normal distribution with the standard deviation equal to 20% of the average and the average (at about 900 kWh per month – Table 3) was taken from the real data of the household.

Table 3: Parameters of the normal distribution used in the simulation model

Month	Mean (kWh)	St.deviation (kWh)
January	933	186.6
February	973	194.6
March	900	180
April	819	163.8
May	771	154.2
June	730	146
July	689	137.8
August	665	133
September	730	146
October	795	159
November	835	167
December	892	178.4

The consumption has been generated for each month from the normal distribution with 45% in the higher tariff rate. In all Monte Carlo simulations, 1000 experiments have been tried using MS add-in application Crystal Ball 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 (ERU, 2019):

$$COST_{ij} = (1 + VAT) \cdot \begin{bmatrix} 12 \cdot (mf_{ij} + mf_j + ot) + \\ 0.45 \cdot gc \cdot (ph_{ij} + ph_j) + \\ 0.55 \cdot gc \cdot (pl_{ij} + pl_j) + \\ gc \cdot (os + t) \end{bmatrix} \quad (1)$$

where
i … product, i =1, …, 60,
j … distributor, j = 1, …, 3,
VAT … value added tax (VAT = 0.21 in 2017 and 2018),
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,
ot … price for other services per 1 month,
os … price for other services per 1 MWh,
t … electricity tax per 1 MWh (t = 28.3 CZK).

The only difference in the formula (1) in the comparison with the year 2015 is in the *ot* part which is now calculated for 1 month while in 2015 it was a part of *os*.

4. RESULTS

The comparison of suppliers is based on the 1000 simulation made in the MS Excel add-in application Crystal Ball. The results of the years 2017 (Table 4) and 2018 (Table 5) are completely different not only in the average annual costs but also from the suppliers' point of view. The best and worst products (out of 60 for PRE and CEZ, and 59 for E.ON distribution area) are the same for all regions in the given year, but the average annual electricity consumption costs are different. The cheapest region when the same product is selected seems to be PRE in 2017 and E.ON in 2018. The CEZ region is the most expensive one.

The best (cheapest) products in 2018 are about 5-7% (based on the region) more expensive than the winners in 2017 (Figure 8). The difference between the cheapest and the most expensive products in 2017 are about 17.5-23.5%, in 2018 about 25.5-28%, so in 2018 there is not only a price increase but also a widening of the gap between the cheapest and the most expensive product is visible.

The difference in average costs does not necessarily mean that the product will always be more expensive - but even the histograms (Figure 9, Figure 10) show quite a significant difference in the resulting costs.

When we compare the lowest average annual cost in 2017 and the highest annual cost in 2018, the difference is about 36%.

Table 4: Order in 2017 for all distributors and the average annual costs

distr. area / order	Product	E.ON avg. annual cost CZK	PRE avg. annual cost CZK	CEZ avg. annual cost CZK
1	CARBOUNION BOHEMIA,spol.s.r.o. , STANDARD	28742.32	27704.17	28770.51
2	CARBOUNION BOHEMIA,spol.s.r.o. , STANDARD 12	28742.32	27704.17	28770.51
3	Nano Energies Trade s.r.o., Dobrý skutek	28778.59	27733.56	28805.33
4	Fonergy, PREMIUM Aku 8	28983.79	27929.08	29008.5
5	Amper Market, HOME_AKU	29042.79	27994.20	29068.79
57	LAMA energy, STANDARD Akumulace 8 region PRE	32799.81	32421.80	32674.85
58 (56)	ČEZ Prodej, Elektřina na dobu neurčitou	32094.76	32430.87	32783.20
59 (58)	E. ON. Energie, Elektřina/Aku	33221.91	33591.60	33931.83
60 (59)	E. ON. Energie, Elektřina TrendAku_prosinec	33796.54	34182.91	34517.13

Table 5: Order in 2018 for all distributors and the average annual costs

distr. area / order	Product	E.ON avg. annual cost CZK	PRE avg. annual cost CZK	CEZ avg. annual cost CZK
1	Eneka s.r.o., Jednička	29791.17	29842.49	30268.39
2	Europe Easy Energy, eDOMÁCNOST	29939.88	29999.12	30420.60
3	Eneka s.r.o., STANDARD	29991.84	30047.04	30470.78
4	BOHEMIA ENERGY entity s.r.o., Benefit Plus	30230.28	30289.52	30711.00
5	X Energie, PREMIUM	30230.28	30289.52	30711.00
57 (56)	CARBOUNION BOHEMIA,spol.s.r.o. , STANDARD 24	38133.93	36780.26	38109.91
58 (57)	E. ON. Energie, Komplet Elektřina 36	38180.19	36827.18	38156.37
59 (58)	CARBOUNION BOHEMIA,spol.s.r.o. , STANDARD 12	38804.26	37433.77	38775.11
60 (59)	CARBOUNION BOHEMIA,spol.s.r.o. , STANDARD	39043.67	37667.17	39012.69

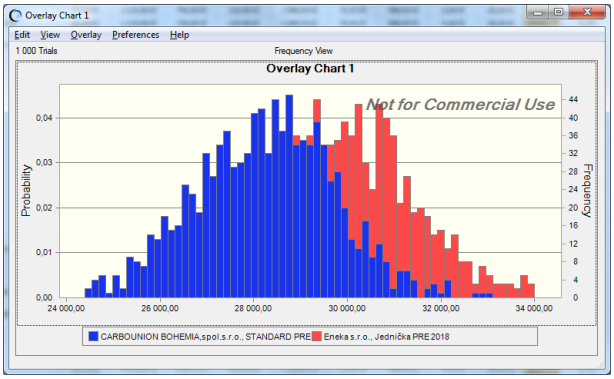

Figure 8: Histograms for the annual costs for the best products in 2017 and 2018

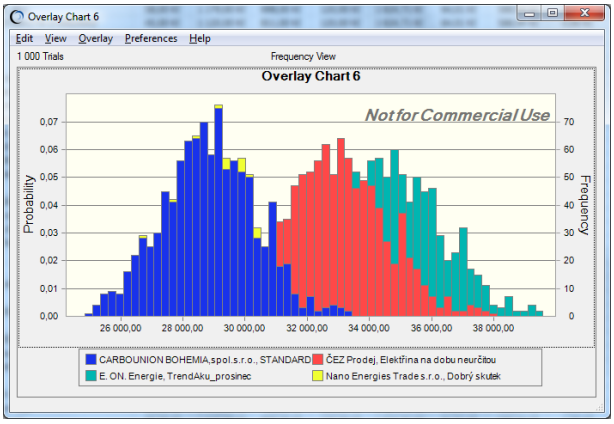

Figure 9: Histograms for the annual costs for the best and worst products in 2017

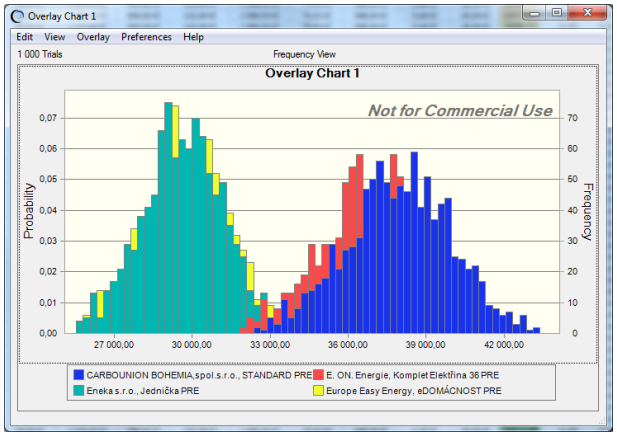

Figure 10: Histograms for the annual costs for the best and worst products in 2018

The annual electricity consumption average costs for the given household and its consumption oscillates around 30000 CZK (about 1130 EUR). The probability of the lowest annual cost (CARBOUNION BOHEMIA spol. s.r.o. STANDARD product) in 2017 is about 80% (Figure 11), but the same product in 2018 is the most expensive one and the probability that the average costs are lower than 30000 CZK goes to zero (Figure 12). The best product in 2018 (Eneka s.r.o. Jednička) has the probability of the cost lower than 30000 CZK about 58% (Figure 13).

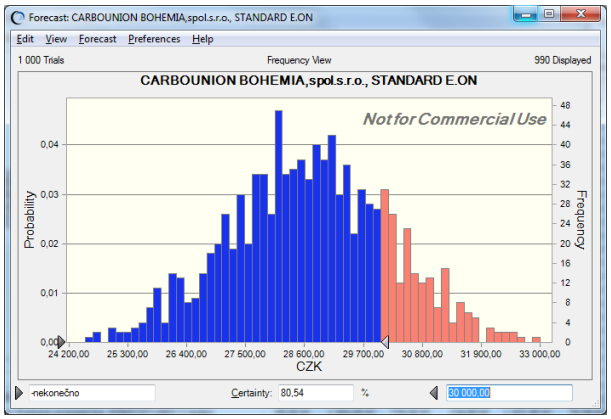

Figure 11: Histograms for the best product in 2017 and the probability of the costs lower than 30000 CZK

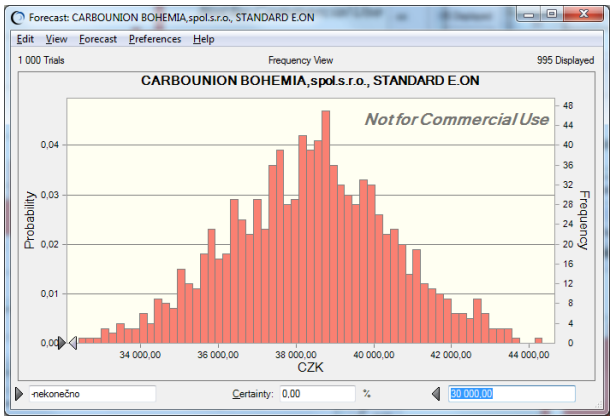

Figure 12: Histograms for the worst product in 2018 and the probability of the costs lower than 30000 CZK

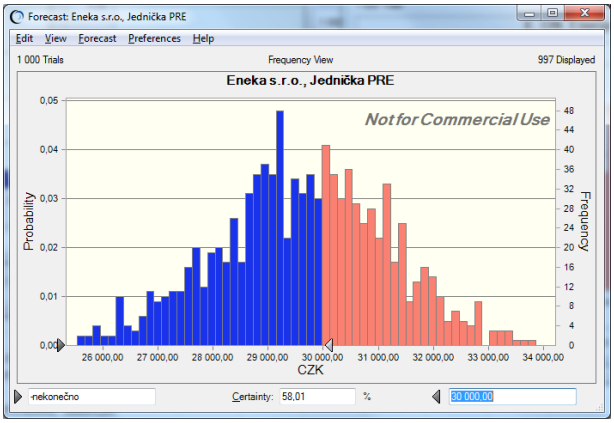

Figure 13: Histograms for the best product in 2018 and the probability of the costs lower than 30000 CZK

According to the results in 2017 and 2018, we see a big difference in the best (cheapest) products and also in the annual costs as well. When we use the data and results of our previous analysis (Kuncova 2015; Kuncova 2016; Kuncova, Seknickova 2015), the increase in annual costs is also evident (Figure 14) especially for the most expensive products which are on the same level as in the year 2013. On the other hand, the annual costs of the cheapest products are closed to the results from the year 2015. The differences between the cheapest and the most expensive products increased in 2018 compared with the previous years.

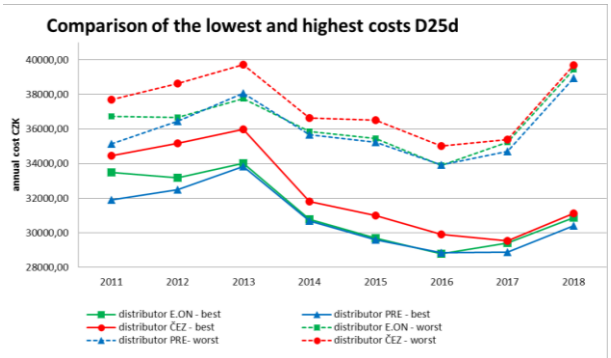

Figure 14: The time development of the highest and lowest annual cost of electricity savings

Table 5: The best products in the given years for E.ON

year	place	distributor E.ON
2014	1.	CARBOUNION KOMODITY
	2.	ELIMON eProdukt
	3.	Amper Market
2015	1.	CARBOUNION KOMODITY
	2.	ST Energy standard
	3.	Nano Energies Trade
2016	1.	ST Energy, Standard AKU 8
	2.	Amper Market, HOME_AKU
	3.	FOSFA, FEE e-TARIF
2017	1.	CARBOUNION BOHEMIA,spol.s.r.o., STANDARD
	2.	CARBOUNION BOHEMIA,spol.s.r.o., STANDARD 12
	3.	Nano Energies Trade s.r.o., Dobrý skutek
2018	1.	Eneka s.r.o., Jednička
	2.	Europe Easy Energy, eDOMÁCNOST
	3.	Eneka s.r.o., STANDARD

The differences are not only in the final annual costs but also in the best (cheapest) products. Table 5 shows the top 3 products in the five years in the E.ON distribution area. It is evident that nearly each year (except 2014 and 2015) the winner is different. Indeed, the differences between the annual costs may not be too large, but based on this analysis, it is advisable to analyze suppliers' costs and to use Monte Carlo simulation, which can show how much the annual cost of the selected products varies.

Many households still think that it is not necessary to change electricity suppliers and that due to the variable annual electricity consumption, the cheapest product cannot be estimated. However, Monte Carlo simulation is able to do this, and the results show that switching suppliers/products can save a considerable sum of money.

5. CONCLUSION

The situation on the electricity retail market in the Czech Republic is changing every year. All households can choose its supplier and the product based on their annual electricity consumption. The possibility of changing the supplier is also influenced by the setting up of a contract with the relevant supplier, where for a fixed contract length it is usually possible to switch to another supplier only at the price of the contractual penalty, which is quite high. As the annual electricity consumption is usually not fixed for each year, the Monte Carlo simulation model could be a good tool to use to be able to compare the products better. According to the results of this kind of simulation for the years 2017 and 2018 it is evident that the electricity prices were higher in 2018 and the increase in the annual electricity consumption costs in 2018 compared with 2017 could be higher than 25%. As the winning product of 2017 fell to the last place in 2018, it is evident that it is recommended to review annually the appropriateness of choosing a supplier and consider a possible change. Staying with the same supplier can increase the electricity consumption cost significantly.

The presented analysis was based on the real case study and related to the D25d tariff rate data. The conclusions are connected with this study and cannot be generalized for other tariff rates for which a similar analysis would be necessary. Equally, it can be expected that the savings in electricity supplier switching at low consumption levels will be different and probably lower. Again, it would be necessary to recalculate it. Anyway, with the knowledge of the products offered, it is always possible to use, for example, the Monte Carlo simulation to test for potential savings in different energy consumption situations.

Although this study is connected with the Czech conditions, the liberalization of the European electricity market is still work in progress (Boltz, 2013) and so similar analysis could be made for other countries with respect to their market conditions and rules.

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