# URANIUM PRICES IN THE NUCLEAR ENERGY CONTEXT

**Covaci Brîndușa*, Paraschiv Roxana****

*Romanian Academy, 13 Septembrie St. 13, Bucureşti, Romania, e-mail: covacibrindusa@gmail.com

***Abstract***

*Article provides a brief analysis of the global nuclear energy market, highlighting the importance of the uranium market in the development of global energy production. In the first part, the authors present the evolution of global supply and demand for energy, highlighting the importance of nuclear energy. Article continues to analyze price development on nuclear energy and uranium and focuses on the most important effects of nuclear energy as a whole. It also shows the importance of the global situation of nuclear reactors and uranium demand through the further development of nuclear energy trade. It analyzes the main aspects of production, consumption, export and import related nuclear power industry. Finally, the article provides forecasting guidelines for the nuclear energy market development. The article is based primarily on exploratory research and statistical computing.*

**Key words:** nuclear energy, uranium, indicators of the nuclear industry, world economy and nuclear energy

## INTRODUCTION

The importance of energy sources is given mainly by their share in the total world supply and demand. The main types of energy considered in the analysis of this paper are: renewable energy, hydropower, nuclear power, energy produced by processing coal, electricity production through gas and energy from petroleum.

## RESULTS AND DISCUSSION

During 1965-2035, shares of energy sources constantly changes its supply structure, as follows (BP, 2016, p. 14):

- importance of reducing oil - from 42% to 30% and coal - from 38% to 25%;
- increased share of natural gas - from 17% to 25% and renewables - from 0% to 9%;
- keeping constant the weights from hydropower and nuclear energy around the values of 7% and 6% respectively.

As seen in the following figure, world energy demand will dramatically change in 2014-2035 period comparatively with 1994-2014 period.

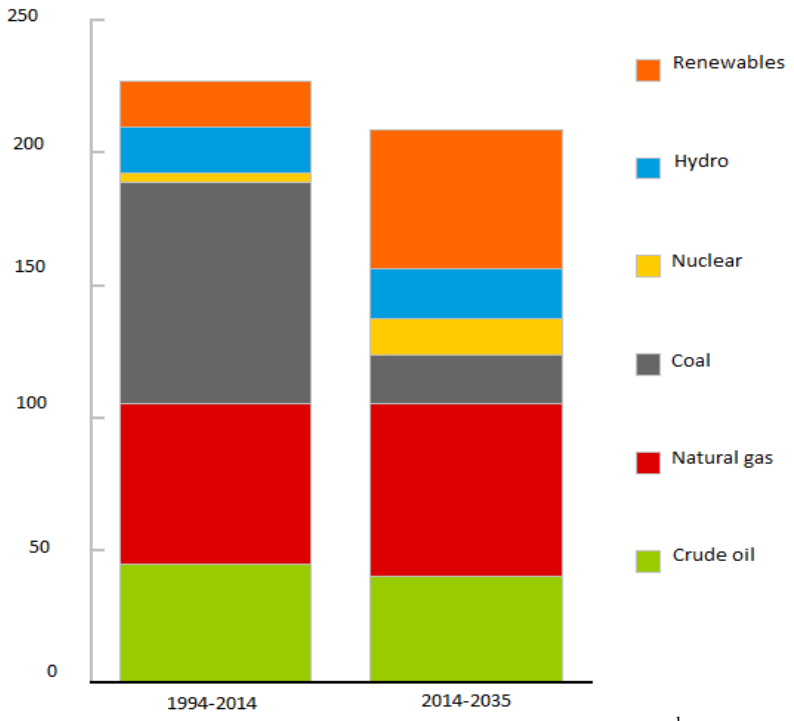


Fig. 1. World energy demand in 1994 – 2035 period (mtoe[1]/year)
Source: British Petroleum – BP (2016), Energy Outlook 2035, p.14

Supply trends are similar with energy demand, differing only in total size weights. As can be seen in the chart above, in the period 2014-2035 compared with 1994-2014, renewables, nuclear power and natural gas will increase in interest, while the others - hydropower, coal and crude oil - will decrease in interest. The most significant reduction in total annual demand of energy has the energy resulting from the processing of coal, while significant increases are given to renewables and nuclear.

Numerous studies confirm that alternative energies are increasingly in importance, overall global supply and demand of energy. The ratio of supply and demand influences the costs associated with the production of various types of energy. Thus, "estimated costs of nuclear power production in 2016 stands at $ 119 / MWh - the lowest level in the category of alternative energies. Hierarchy costs for other types of renewable energy will be: wind - $ 149.3 / MWh, solar - $ 256 / MWh, photovoltaics - $ 396.1 / MWh. Initially nuclear energy was considered one of the most expensive alternative because many of the major reactors were under construction. Today, after many reactors were completed and put into use, nuclear energy presents high return in terms of costs ever lower. The cost of uranium ($U_3O_8$), the basic raw material for nuclear power generation, account for about 28% of the total cost of nuclear energy. Although the price of uranium

is currently in decline, it is expected that the trend will change in the next years. This scenario is possible in the planet's diminishing uranium, economic crises and geopolitical situation of the countries that account for over 30% of world uranium: Kazakhstan, Namibia, Nigeria and Uzbekistan." (Covaci, 2015, p. 221)

The scenario for 2030 foresees an increase in the price of nuclear energy. The trend is given by the reduction of nuclear generating capacity by North America (-72%) associated European OECD countries (70%) and Japan (48%). Price increases associated with these areas will be 28%, 23% and 24%. Closing some of the reactors in these countries will discourage demand amid rising prices. From experience to date, world energy cost increases rapidly when one of the important reactors is temporarily closed. By analogy one can deduce that the final closure of some nuclear reactors will increase the price increase for the entire energy industry. (Solveig et all, 2013)

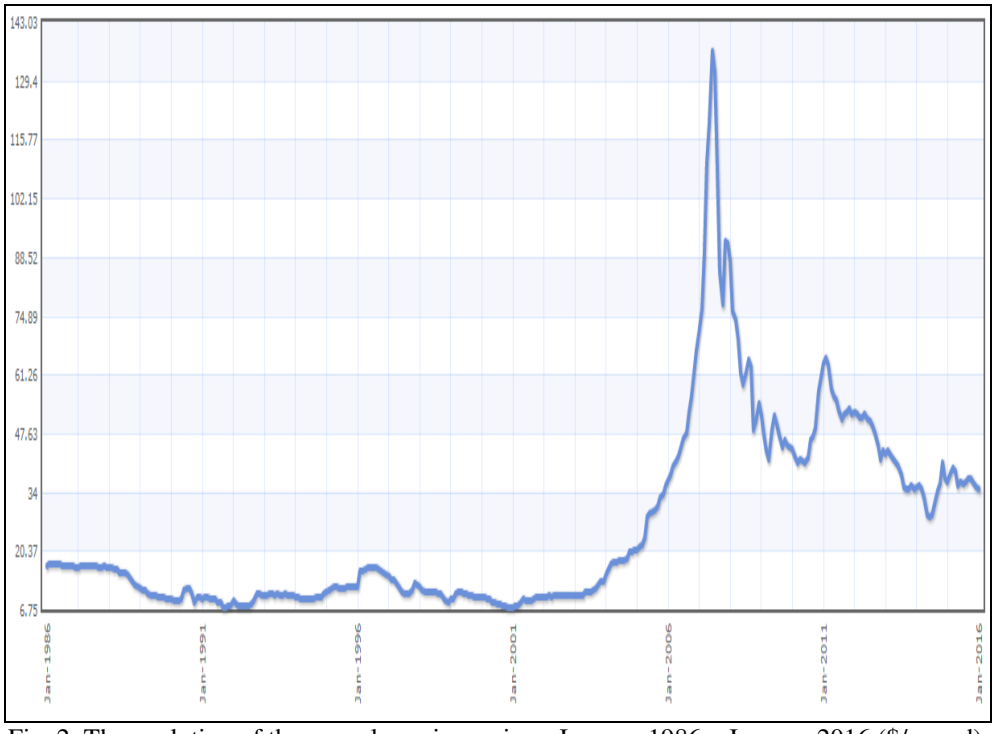


Fig. 2. The evolution of the annual uranium prices, January 1986 – January 2016 ($/pound)
Source: International Monetary Fund & Index Mundi, Uranium Monthly Price 1986-2016, http://www.indexmundi.com/commodities/?commodity=uranium&months=360
Delivering conditions: Spot, Nuexco Exchange

The ratio of global supply and demand of uranium significantly influence both, prices and uses of nuclear energy. In 2015, comparatively

with 1986, uranium prices have increased by + 116.08% - from $ 37.50 / kg to $ 81.04 / kg. Compared, however, in 2014, uranium prices have only increased by + 9.77% - from $ 73.83 / kg to $ 81.04 / kg. On the whole review period, 1986 - 2016, average annual uranium quotations fluctuated in New York Stock Exchange, remarking periods of significant fluctuations in the total amount of + 95.62% - from $ 37.50 / kg to 73 36 $ / kg. For 2016, calculations for term prices - accumulated over the year, the authors predict a reduction in price of -9.46%, from $ 81.04 / kg to $ 73.36 / kg. The world price of uranium has recorded over the period 1986 - 2016, a clear trend of increase in the amount of 103.65% - from $ 37.47 / kg ($ 17.00 / pound) in 1986 to 76.32 $ / kg ($ 34.62 / pound) in 2016. As shown in Figure 2, the general economic growth in 2005 - 2008 marked by a rising uranium price significantly, in June 2007 representing the highest price point in the analyzed period, when the uranium price reached $ 300.31 / kg ($ 136.22 / pound). The lowest price of the period was reached in January 2001 when he came to deliver uranium worth $ 7.10 ($ 15.65 / kg). The midpoint of the period analyzed, reached in February 1996 - March 1996 show that the price of uranium was located around $ 34.72 / kg ($ 15.75 / pound). Between January 1986 - January 2005, the variation was relatively constant, with values fluctuated around the average of $ 41.39 / kg, representing a variation $ 7.80 / kg (+ 20.83%) - from 37 47 $ / kg ($ 17.00 / pound) in 1986 to $ 45.28 / kg ($ 20.54 / pound) in 2005. the year 2005 marked a major turning point in the overall prices for uranium that is the year the average price stood at $ 67.57 / kg, a level below which has not descended so far. The following minimum was reached in June 2014, when the uranium price dropped to the level of $ 62.23 / kg.[2]

*Table 1*

Uranium prices evolution in 1986 – 2016 ($/kg)

| Year | Uranium ($U_3O_8$) |
|---|---|
| 1986 | + 37,50 |
| 2014 | +73,83 |
| 2015 | + 81,04 |
| ±2015/2014%*) | +9,77% |
| ±2015/1986%*) | +116,08% |
| 2016 | + 73,36 |
| ±2016/2015%**) | -9,46% |
| ±2016/1986%**) | +95,62% |

Notes: *) Delivery condition for 1986-2015: Spot, Nuexco Exchange

**) Future prices on New York Mercantile Exchange (statistics realized by the authors)

Sources: Forecasting calculations realized by the authors, uranium spot prices - Index Mundi[3] and uranium future prices - CME Group[4];

Major fluctuations in the uranium prices during 1986 - 2016, the division interval into two periods and the inflection point gave the incident Fukushima (2011), shows how important the construction of nuclear reactors - approach mainly achieved in the first part range and keeping them safely - stabilized in the second step of the period, especially after 2011.

For February 2016 - February 2020 period, the derivatives market futures on the New York Mercantile Exchange, the price of uranium is projected to increase on average by 19.20% (from $ 32.87 / pound to $ 39.18 / pound). Specific 2016 moving averages by the end of November 2016 traded during 22.02.2016-26.02.2016, Structure have the following values[5]:

- Simple Moving Average[6] price of uranium is $ 73.33 / kg ($ 33.26 / pound), marking an increase of 0.28% from the previous trading 19.02.2016-25.02.2016, when the average mobile Simple was $ 73.12 / kg ($ 33.17 / pound).

- Weighted moving average[7] uranium price is $ 1124.42 / kg ($ 510.03 / pound), 0.29% more than during the previous trading when weighted moving average was $ 1,121.16 / kg ($ 508.55 / pound);

- Exponential moving average[8] with -1.23% decreased compared to the previous trading - at $ 64.85 / kg ($ 29.41 / pound) at $ 64.05 / kg ($ 29.05 / pound).

Meanings computations are multiple, indicating a growing and stable price for securities of uranium in the short term (approximately 30 days), a decrease of prices in the medium term (40 weeks) and an increase in relatively small long-term (four years). For investors, the effect on the price of uranium, trading rule is given by convergence / divergence[9] in price. During this period, investors in uranium (uranium related actions) are advised to enter purchase orders, as the signal line favors this approach. It is recommended, however, that the investments are completed quickly, whereas negative value means that the exponential moving average will start moving averages diverging price trend reversing itself little by little. Since the simple and exponential moving averages are currently positive, investors can quickly take purchasing decisions in the short term. In the long term, stock prices for uranium, they are advised to be cautious. According to the statistical calculations to the end of March 2016 and early April 2016, the investors may consider the operation of sell orders with assumption of a negative trend moving averages. Now, investment in these securities may be made simple moving averages and weighted positive signifying a high volatility of shares in uranium. For the next period, as the moving average will be reduced and then become negative, the volatility of the securities will decline. According to calculations, it is expected that the trend reversal - from positive to negative - will occur in early April 2016.

The trend recalibration can occur toward the end of the 40-week analysis, specifically in November 2016. The situation presented takes into account factors calculate the light of fuzzy logic - based on a portfolio of marketing, without taking into account the possible rumors and expectations. Cannot be incorporated into specific models or statistical calculations, rumors and expectations of stock trading can create special situations that lead to multiple and complex analysis. An incident like Fukushima can complete destructuring, short-term instruments market for uranium, and the effects can be quantified only after two to three years. In the papers, Fuzzy MCDA for remediation of a uranium taling, authors punctuate importance of multi-criteria analysis, including the moving averages for the stock market, in order to avoid problems related to the activity of nuclear reactors (Danyl, 2015). Although the area was conducted Zapadnoe Ukrainian scenarios in different cases including Chernobyl, the study can be replicated in order to avoid future nuclear disasters. Stock market influence the market's uranium and nuclear energy trade volume is given by the shareholder, who through joint efforts and sustained policy makers and scholars may consist of actors more responsible and involved.

Among the determinants of price development and production is uranium (mining) of uranium. In 2015, uranium production worldwide was in the fourth quarter, 225 tons of uranium (585.048 lbs U3O8), lower by 24% compared to the third quarter of the year and by 46% compared to the fourth semester of 2014. This level indicates the lowest production since 2002 until now. International Energy Agency (EIA) put 49% decrease in production in the first quarter of 2015, when production amounted to 442 tons of uranium (1.15 million pounds U3O8), to the fact that uranium prices, both spot as and associated futures market were low. EIA analyzes indicated a sharp drop in uranium production, 32% in 2015 compared to 2014 - 1881 tons of uranium (4,891,332 million pounds U3O8) 1271 tons of uranium (U3O8 3,303,977 pounds). Also, the United States recorded the lowest production in 2015 from 2005 to present. According to EIA, production of 2015 accounted for only 7% of anticipated demand of US nuclear reactors. (WNA, 2016)

**CONCLUSIONS**

Although uranium market presents a linear structure, it is expected that trade patterns will change in the future, especially amid increased supply. This perspective is reinforced by 2030 on expansion of new uranium mines. In light of the optimistic scenario of demand, uranium mines can reach up to 140 units. Baseline demand of around 110 uranium mines, being so close to the optimistic scenario and so far from pessimistic (about 58 mines), confirms that the number of mines will increase, and obtaining

nuclear power will become a decisive factor in the current energy market. (Uranium Markets, 2015)

**NOTES**

[1]1 mtoe (million tonnes of oil equivalent) = 11,63 TWh

[2]Authors calculus uranium spot - Index Mundi in accordance with International Monetary Fund (http://www.indexmundi.com/commodities/?commodity=uranium&months=60) and uranium future prices - CME Group (transaction from New York Mercantile Exchange in 22.02.2016 – 26.02.2016)
(www.cmegroup.com/trading/metals/other/uranium_quotes_settlements_futures.html#tradeDate=02/26/2016)

[3]IndexMundi according to International Monetary Fund
http://www.indexmundi.com/commodities/?commodity=uranium&months=60

[4]Transactions on New York Mercantile Exchange in 22.02.2016 – 26.02.2016:
www.cmegroup.com/trading/metals/other/uranium_quotes_settlements_futures.html#tradeDate=02/26/2016

[5]Average futures for February 2016 - February 2020, trading on the New York Mercantile Exchange in the period 02.22.2016 - 02.26.2016; the average value volume period is $ 36.20 / pound.

[6]Simple Moving Average (SMA) is defined as the total value divided by the number of terms terms. Authors calculations based on the formula

$$SMA = \frac{\sum_{i=1}^{n} pi}{n}$$

pi=closing prices, n=the number of time periods.
Source: Daniela Zapodeanu, Dorina Popa (2006), Mediile mobile în analiza tehnică a titlurilor cotate la bursă, Annales Universitatis Apulensis Series Oeconomica, Nr. 8 / 2006, volumul 2, Universitatea '1 Decembrie 1918 Alba Iulia':
http://www.oeconomica.uab.ro/upload/lucrari/820062/57.pdf

[7] Weighted moving average (WMA) attaches importance to increasingly higher prices with the approach of the current day. Authors calculations based on the formula

$$WMA = \frac{(P1x1) + (P2x2) + \cdots + (Pnxn)}{1 + 2 + \cdots + n}$$

Significations are similar with the SMA. Sursa: Idem [6]

[8] Exponential moving average (EMA) - this average is commonly used because it has the advantage of giving more importance to the current value and price. Authors calculations based on the formula EMA = [(P −SMA)×Exp]+ SMA; P – the current day price; SMA – simple moving average of the previous day; Exp – the exponent. Sursa: Idem[7]
http://www.oeconomica.uab.ro/upload/lucrari/820062/57.pdf

[9] Convergence is the fact that the trading price follows the same trend with moving averages; divergence means that the trading price follows a certain trend and moving average trading price follows the opposite trend.

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