OIL - STATE, TRENDS AND SUSTAINABLE DEVELOPMENT

Valeria Kovacheva-Ninova[1], Valentin Velev[2]

[1,2] University of Mining and Geology "St. Ivan Rilski", Sofia 1700, velev_mgu@abv.bg

ABSTRACT. The previous decades have been characterised by the intensive use of fluid (liquid and gaseous) energy sources in all spheres of economic life. The studied, summarised and analysed quantified information about global reserves and production-consumer dynamics of energy raw materials has shown that, without being leading as a natural resource compared to other energy sources, fluids are dominant as global consumption. Although their relative share has declined in the energy mix, their overall consumption is growing. It is driven by the development of technologies based on fluid fuels and the increase in proven reserves as a result of the huge investments in prospecting and exploration operations. In general, after the 1970s, oil consumption has doubled, and the consumption of natural gas has risen almost 9 times. This shows a sustained tendency for global development to be largely dependent on fluid hydrocarbon energy resources, particularly oil, which is contrary to the principles of sustainable development of the planet. The established trends are alarming and require real changes in global, regional and national policies in the energy sector and in particular the oil sector.

Key words: fluid energy resources, reserves, production, consumption, development.

ПЕТРОЛЪТ - СЪСТОЯНИЕ, ТЕНДЕНЦИИ И УСТОЙЧИВО РАЗВИТИЕ

Валерия Ковачева-Нинова[1], Валентин Велев[2]

[1,2] Минно-геоложки университет "Св. Иван Рилски", София 1700, velev_mgu@abv.bg

РЕЗЮМЕ. Предходните няколко десетилетия се характеризират с интензивното използване на флуидните (течни и газообразни) енергийни суровини във всички сфери на стопанския живот. Проучената, обобщена и анализирана количествена информация, относно световните запасите и производствено–потребителската динамика на енергийните суровини показва, че без да са водещи като природна даденост спрямо другите енергийни източници, флуидните са доминиращи като световно потребление. Независимо, че в енергийния микс техният относителен дял намалява, общото им потребление расте. То е продиктувано от развитието на технологиите, базирани на флуидните горива и на увеличаване на доказаните от тях запаси в резултат инвестирането на огромни средства в търсещи и проучвателни работи. Като обобщаващ резултат за периода след 1970 година потреблението на петрол се е удвоило, а на природния газ увеличението е почти 9 пъти. Това показва устойчива тенденция за екстензивна зависимост на глобалното развитие от флуидните въглеводородни енергийни суровини, в частност от петрола, което е в противоречие с принципите за устойчиво развитие на планетата. Установените тенденции будят безпокойство и са сигнал за необходими реални промени в световната, регионалните и националните политики в енергийния сектор и в частност на петролния.

Ключови думи: флуидни енергийни ресурси, запаси, производство, потребление, развитие.

Introduction

The rapid growth of the economy, the population growth and the improved quality of life worldwide have led to an increase in energy consumption that has grown 2.7 times in only forty-five years. Historical review [1,2] showed three stages in the development of global primary energy consumption and the contribution of fossil fuels (coal, oil and natural gas) to energy generation. *The first stage* is characterised by the introduction of coal around 1860 into global primary energy consumption. Shortly before World War I, coal accounted for 80% of global energy consumption. *The second stage* began after 1913 with the penetration of oil and natural gas into the world's primary energy consumption. In the mid-1960s, they already had a significant share of energy consumption, about 40% and 20%, respectively. *The third stage* began in the 1970s and continues today, where oil occupies a leading position in global primary energy consumption.

In the current structure of global primary energy consumption, besides the fossil hydrocarbon energy resources (oil, natural gas, coal), other types such as uranium, hydro-renewable (water, wind, solar, geothermal, biofuel) and products from anthropogenic activities (biomass, waste) are also included. Table 1 presents the primary energy consumption by types of energy sources in the period 1970-2016 [3].

The data show that the contribution of oil to the generation of primary energy for the period has increased 2 times. At the same time, its share in the energy mix of primary energy has decreased from 46% to 33% [5]. There is a start of a new period of reallocation of energy sources in the primary energy mix, with an increase of the share of natural gas and a decrease of coal's share. Oil consumption will continue to increase, and by 2040 growth will be around 0.5-0.6% per year according to the estimations [3]. The hybrid and electric transport machines will increasingly affect the demand for petroleum derivatives. Oil will be mainly sought for the production of lubricants, bitumen and as a raw material for the petrochemical industry.

The current state of the global oil sector and in particular of individual regions and countries, as with other fossil-based hydrocarbon sources (coal and natural gas) [2], is characterised by other contradictory features:

Table 1.

Global Consumption of Primary Energy Sources 1970-2016

Year/Energy sources	1970		1980		1990		2000		2010		2016		2020**	
	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%
Oil	2253	45.9	2986	45.0	3153	38.7	3580	38.1	4021	33.0	4418	33.3	4564	32.0
Coal	1483	30.2	1813	27.3	2246	27.6	2385	25.4	3636	29.9	3732	28.1	3697	25.9
Natural gas	890	18.1	1291	19.4	1767	21.7	2182	23.2	2874	23.6	3204	24.1	3534	24.7
Hydro-	266	5.4	385	5.8	487	6.0	601	6.4	779	6.4	910	6.8	1015	7.1
Nuclear- (uranium)	18	0.4	161	2.4	453	5.6	584	6.3	626	5.2	592	4.5	674	4.7
Renewables*	2	0.0	7	0.1	35	0.4	59	0.6	234	1.9	420	3.2	794	5.6
Total	4912	100	6642	100	8141	100	9391	100	12170	100	13276	100	14278	100

*Renewables: wind, solar, geothermal, biomass, biofuel

** Estimates of BP, 2018

- ✓ uneven distribution of oil reserves in the various regions of the world;
- ✓ uneven production and consumption of petroleum energy raw materials in the different regions of the world;
- ✓ disproportion between the volumes of proven oil reserves worldwide and their share in the global energy production and consumption.

The current stage, the peculiarities in the development of the petroleum sector and its still high importance for the energy sector, require presenting and analysing the state of reserves, production and consumption of oil and its role in the global energy sector as a whole and in particular in individual regions, in the context of the Concept for sustainable development [6,7].

World oil reserves

The proven world reserves of fossil hydrocarbon energy sources are presented in Figure 1 [4,5] for 1995-1996, 2005-2006 and 2015-2016. Quantitative data show that oil reserves are significantly smaller than coal reserves and larger than those of natural gas.

The quantitative distribution of world oil reserves and the distribution of reserves by regions over the three ten-year periods from 1987 to 2016 are presented in Figure 2. The data show that the distribution of oil reserves by region is rather uneven over the period. For the thirty year period, there is a steady upward trend in world oil reserves. The increase in global oil reserves is 1.9 times, and the increase in the different regions is as follows: for North America 2.2 times, for South and Central America 4.8 times, for Europe and Eurasia 2.1 times, for the Middle East 1.4 times, for Africa 2.2 times and for Asia-Pacific 1.2 times.

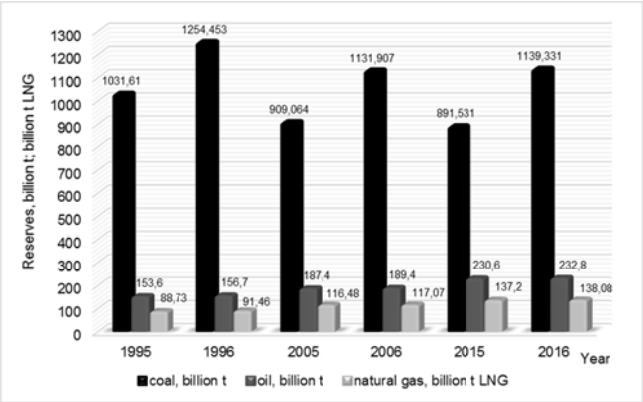

Fig.1. Proven World Reserves of Primary Hydrocarbon Energy Sources (1995-1996, 2005-2006, 2015-2016), billion t.

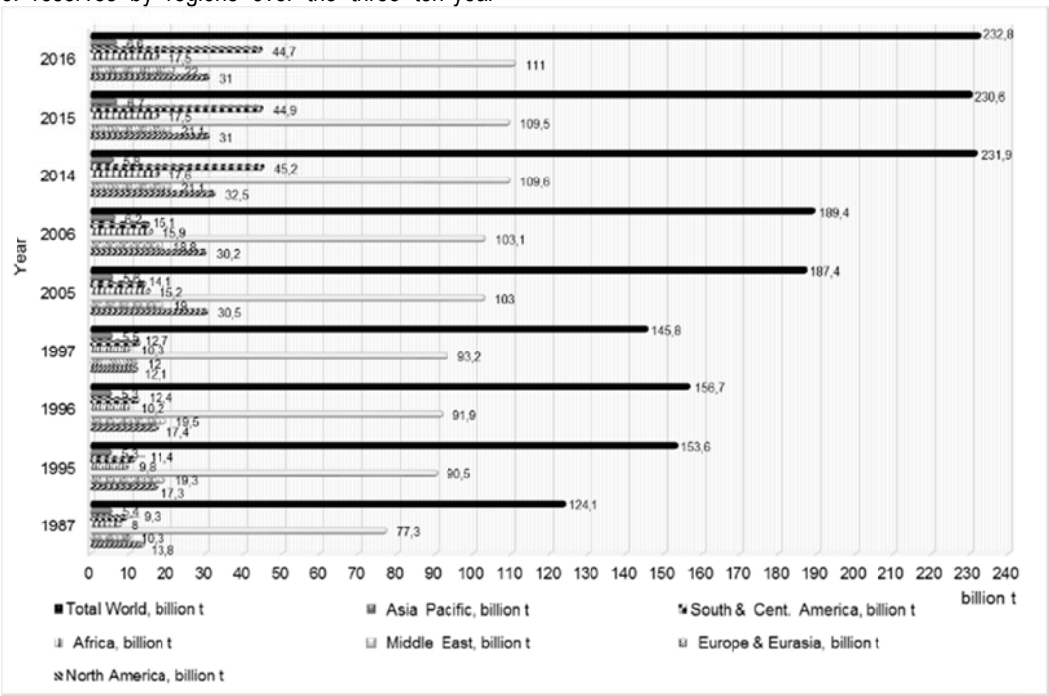

Fig.2. Proven World and Regional Oil Reserves for the period 1987 - 2016, billion t.

By sustaining oil production in the regions concerned at 2016 levels, the reserves will ensure the consumption in North America for 35 years, South and Central America for 116 years, Europe and Eurasia for 26 years, the Middle East for 74 years, Africa for 47 years and Asia-Pacific for 17 years.

In 2016, 80.3% of global oil reserves were concentrated in the following regions: the Middle East (47.7%), South and Central America (19.2%) and North America (13.4%). The other 19.7% of global reserves were distributed in Europe and Eurasia (9.4%), Africa (7.5%) and Asia-Pacific (2.8%). For the same year, 85% of the world's oil reserves were distributed in 10 countries - Venezuela (17.6%), Saudi Arabia (15.6%), Canada (10.0%), Iran (9.3%), Iraq (9.0%), Russian Federation (6.4%), Kuwait (5.9%), UAE (5.7%), the United States (2.8%) and Libya (2.8%).

The distribution of oil reserves in the countries of the regions concerned is also very uneven. For 2016, oil reserves in the regions concerned were distributed in the following countries as follows:

- for North America - 75.4% in Canada, 21.1% in the United States and 3.5% in Mexico,
- for South and Central America - in Venezuela 91.8%, Brazil 3.8%, Ecuador 2.4% and Argentina 0.7%;
- for Europe and Eurasia – in the Russian Federation 67.8%, Kazakhstan 18.6%, Norway 4.7% and Azerbaijan 4.3%;
- for the Middle East - in Saudi Arabia 32.8%, Iran 19.5%, Iraq 18.8%, Kuwait 12.5%, UAE 12.0% and Qatar 3.1%;
- for Africa - in Libya 37.8%, Nigeria 29.0%, Algeria 9.5%, Angola 9.1%, Egypt 2.7%, South Sudan 2.7%, Gabon 1.6%, R Congo 1.2%, Chad 1.2% and Sudan 1.2%;
- for Asia-Pacific - in China 53.1%, India 9.7%, Vietnam 9.1%, Australia 8.3%, Malaysia 7.4%, and Indonesia 6.8%.

World production and consumption of oil

Figure 3 presents quantitative data on the world production and consumption of primary energy sources in the period 1997-2016. After overcoming the price shock in the 1970s, until 2003, oil had a leading role in the production and consumption of primary energy raw materials, followed by coal and natural gas. From 2003 to 2016, coal production and consumption outpaced that of oil and natural gas. For the period under review, there is a steady trend towards increasing world production and consumption of primary energy raw materials. Oil production and consumption has increased 1.3 times, and coal and natural gas - 1.6 times.

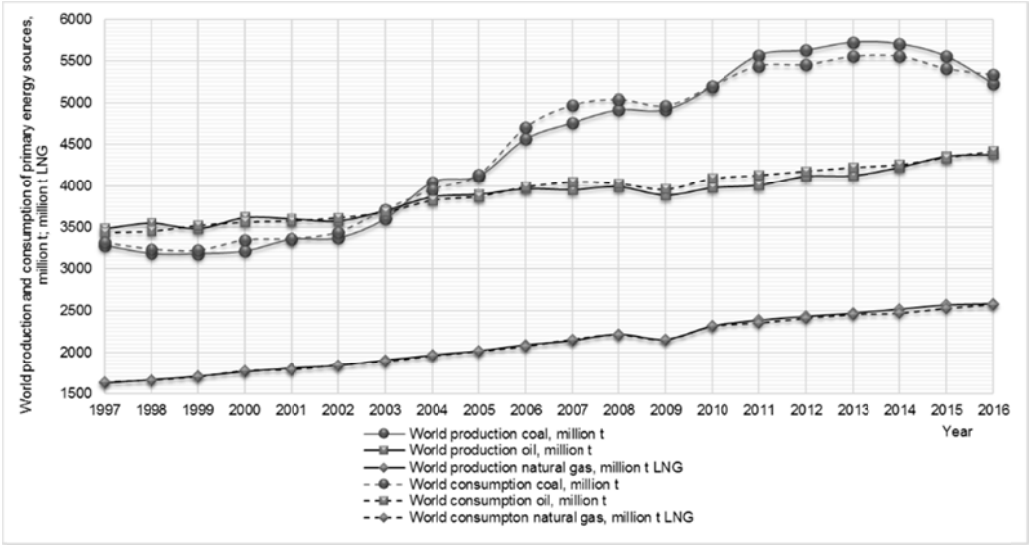

Fig.3. World Production and Consumption of Primary Energy Sources, 1997-2016

Comparative quantitative data on regional production and consumption of oil between 1997 and 2016 are given in Table 2. The share of regional production and consumption of oil in the world is also presented.

Table 2. *Regional Production and Consumption of Oil for 1997 and 2016*

Region	Production				Consumption			
	1997		2016		1997		2016	
	Million t	%	Million t	%	Million t	%	Million t	%
North America	670.4	**19.26**	882.6	**20.14**	1012.3	**29.49**	1046.9	**23.69**
S. & Cent. America	329.1	**9.46**	384.5	**8.77**	220	**6.41**	326.2	**7.38**
Europe & Eurasia	688.6	**19.79**	860.6	**19.64**	936.4	**27.27**	884.6	**20.02**
Middle East	1050.7	**30.19**	1496.9	**34.16**	211.7	**6.17**	417.8	**9.46**
Africa	370.3	**10.64**	374.8	**8.55**	108.9	**3.17**	185.4	**4.2**
Asia Pacific	370.8	**10.66**	383	**8.74**	943.9	**27.49**	1557.3	**35.25**
Total	3479.9	100	4382.4	100	3433.2	100	4418.2	100

The Middle East, North America and Europe and Eurasia have a leading role in oil production, accounting for 69.2% in 1997, and 74% of world oil production in 2016. For all regions, there is an increase in oil production in 2016 compared to 1997, which is 1.4 times for the Middle East, 1.3 times for North America, 1.2 for South and Central America, for Europe and Eurasia 1.2 times, for Africa 1.01 times and for Asia-Pacific 1.03 times. The leading region for oil consumption for 1997 was North America, followed by Asia-Pacific, and Europe and Eurasia, with the three regions accounting for 84.5% of world oil consumption. Data for 2016 show that there is a redistribution in oil consumption, with Asia-Pacific being the region with the highest consumption, followed by North America and Europe and Eurasiia. The three regions for the same year account for 79% of the world's oil consumption. For the twenty-year period, oil consumption has grown in most regions: the Middle East 2 times, Asia-Pacific 1.7 times, South and Central America 1.5 times, Africa 1.3 times and North America 1.03 times. In Europe and Eurasia, oil consumption has dropped 1.06 times.

Regional production and consumption of oil for the period from 1997 to 2016 is presented in Figure 4.

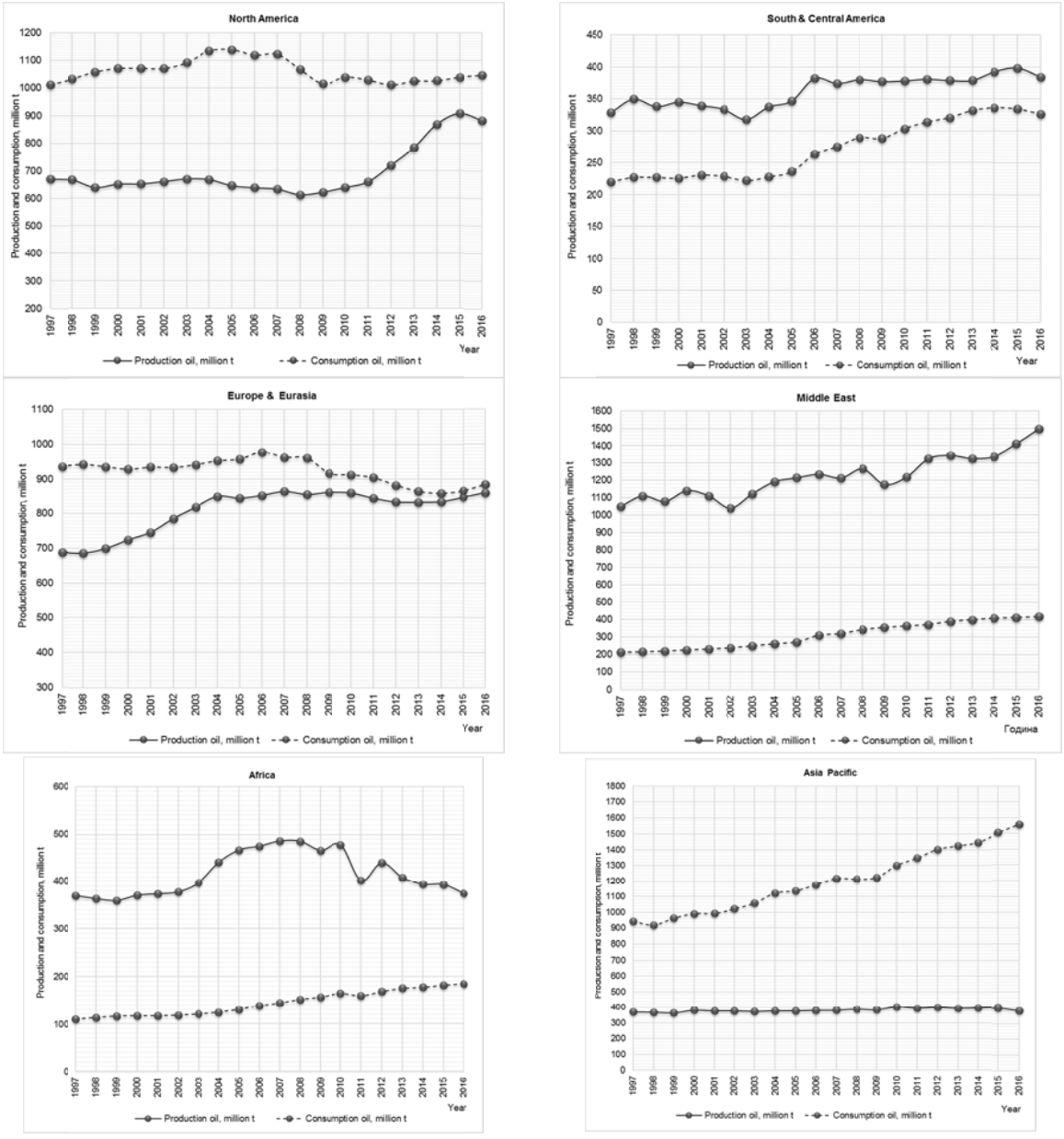

Fig.4. Production and Consumption of Oil by Region, 1997-2016

In ***North America***, from 1997 to 2013, coal is the leader in the production of primary energy raw materials, followed by oil and natural gas production. After 2014, there is redistribution in the production of primary raw materials – the oil production is in the lead, followed by natural gas and, finally, coal. The region occupies the 2nd place in world production and consumption of oil for 2016, respectively with a share of 20.1% and 23.7%. In the consumption of primary energy raw materials, oil has a leading role throughout the period presented. In North America, for the period, the United States occupies a leading position in both the production and consumption of primary energy raw materials. In 2016, oil production in the region was distributed in the following way: 61.5% in the USA, 24.7% in Canada and 13.8% in Mexico, and

consumption - 82.4% in the USA, 9.6% in Canada and 7.9% in Mexico. For the same year, the USA occupies the 3rd place with a share of the world oil production of 12.4% and the 1st place in oil consumption with 19.5 %. In ***South and Central America*** for the period both in the production and consumption of primary energy raw materials, the first place is occupied by oil, followed by natural gas and coal. In 2016, with a share of 8.8% of world oil production, 95.6% of its production in the region is divided between five countries - Brazil 35.5%, Venezuela 32.3%, Colombia 12.7% Ecuador 7.6% and Argentina 7.5%. For 2016 Brazil holds the 10th place in world oil production with 3.1%. With 7.4% of world oil consumption, the consumption in the region is mainly spread across eight countries, with Brazil in the lead (42.5%), followed by Argentina (9.8%), Venezuela (8.8%), Chile (5.5%), Colombia (4.9%), Peru (3.5%), Ecuador (3.4%) and Trinidad and Tobago (0.7%). In ***Europe and Eurasia*** for the period presented, the consumption of primary energy raw materials outpaces their production. In both production and consumption, oil has the leading role, followed by natural gas and coal. In 2016, Europe and Eurasia ranked third in global oil production and consumption with a share of 19.6% and 20.0%, respectively. 96.7% of oil production in the region is distributed in the following countries: 64.4% in the Russian Federation, 10.5% in Norway, 9.2% in Kazakhstan, 5.5% in the United Kingdom, 4.8% in Azerbaijan, 1.5% in Turkmenistan and 0.8% in Denmark. In terms of world oil production, the Russian Federation occupies 2nd place with 12.6%, while consumption is 6th with 3.3%. 86% of the oil consumption in the region are distributed as follows: 16.7% Russian Federation, 12.8% Germany, 8.6% France, 8.3% United Kingdom, 7.1% Spain, 6.6% Turkey, 4.5% Netherlands, 3.6% Belgium, 3.1% Poland, 1.7% Greece, 1.7% Sweden, 1.5% Kazakhstan, 1.4% Austria, 1.3% Portugal, 1.2% Norway and 1.1% Switzerland. *The **Middle East***, for the period, ranks 1st in world oil production. For 1997, the region has a share of 30.2% of world oil production, which in 2016 has grown to 34.2%. For 2016, oil production is 3.6 times larger than consumption. For 2016, 99.2% of regional oil production is distributed in the following countries: Saudi Arabia 39.1%, Iraq 14.6%, Iran 14.5%, UAE 12.2%, Kuwait 10.2% , Qatar 5.3% and Oman 3.3%. In terms of world oil production, Saudi Arabia ranks 1st with a 13.4% share, followed by Iraq ranked 4th with a 5.0% share, Iran 6th with a share of 4.9 %, UAE 8th with a share of 4.2% and Kuwait 9th with a share of 3.5%. For the same year, 81.6% of regional oil consumption is allocated to Saudi Arabia with 40.2%, Iran 20.1%, UAE 10.4%, Kuwait 5.3%, Qatar 2.8%, and Israel 2, 8%. In ***Africa*** for the period, the production of primary energy raw materials is significantly higher than their consumption. For example, for 2016, oil production is twice as much as its consumption, coal 1.6 times, and natural gas 1.5 times. Leading role in the production of primary energy raw materials has oil, followed by coal and natural gas. With a share of 8.6% of world oil production, its production in the region is mainly distributed in the following countries: Nigeria 26.4%, Angola 23.4%, Algeria 18.3%, Egypt 9.0%, Libya 5, 3%, Equatorial Guinea 3.5%, Republic of the Congo 3.2%, and Gabon 3.0%. With 4.2% of world oil consumption, the consumption in the region is mainly distributed in the following countries: Egypt 21.9%, South Africa 14.5% and Algeria 10.2%. ***Asia-Pacific*** account for 8.7% of world oil production. With a share of 4.6%, China ranks 7th in world oil production and 1st in the region with 52.1% of regional oil production. In regional oil production, Indonesia also has 11.2%, India 10.5%, Malaysia 8.5%, Thailand 4.6%, Vietnam 4.25%, Australia 4.1%. Oil consumption in the region is 4.1 times larger than its production. By oil consumption, the region ranks 1st in the world, accounting for 35.2% of world consumption. China is ranked 2nd in global oil consumption with a share of 13.1%, in the 3rd place is India with 4.8%, Japan - 4th place with 4.2% and the 8th place is for South Korea with 2.8%. 93% of regional oil consumption is distributed in the following countries: China 37.2%, India 13.7%, Japan 11.8%, South Korea 7.8%, Singapore 4.6%, Thailand 3.8% Australia 3.1%, Taiwan 3.0%, Malaysia 2.3%, Pakistan 1.8%, Vietnam 1.3%, Philippines 1.3%, and Hong Kong 1.2%.

Index of use of the world's oil reserves. World production and consumption of oil per capita

The data presented are undisputed evidence that during the period under review the global trends in oil production and consumption are steadily growing and there is about 30% growth. The increase is clearly inconsistent with the goals of resource saving and efficient use of natural resources as set out in the UN Secretary-General's Report [8] in 2014 and in the UN General Assembly Resolution [9] in 2015. Growth encompasses almost all mineral raw materials, and it is more than 80% over the last thirty years [10]. These tendencies have been formed and developed under the mutual influence of various factors - technological, economic, social, natural and others. The current state of the planet is most dependent on the growth of the world's population and the economic activity of some countries from the respective regions belonging to leading economic groups (China, India, Brazil, Russia, USA, etc.) which is measured by the produced GDP. These deepening processes from year to year are becoming more and more difficult to manage and are an indisputable argument that mankind, despite its vast technological advances, uses natural resources extensively. The problems were discussed at the Second World Resources Forum in Davos in 2011 [11] by EU Environment Commissioner Dr. Janek Potočnik, who said that "the world needs not economic growth but transformation of the economy" and "if we continue to use the available resources at the current rate, resources equivalent to two planets will be needed to sustain it."

The above is also confirmed by the data presented in Fig. 5 about the change in Global Reserves Utilization Index (GRUI) for oil and the oil production and consumption per capita. It can be seen that for twenty years the world has been producing and consuming almost the same quantities of oil. There is a tendency for development of the oil energy sector at a rate commensurate with the growth rates of the population, i.e. every newborn is a prerequisite for increasing the profits of the companies in the "oil reserves - end needs" technology chain, but unfortunately this is being done through the involvement of new and new petroleum raw materials. These arguments, which provide indirect evidence that the world is on the path of declining energy supply with oil, are also confirmed by the GRUI analysis. The GRUI, as an indicator reflecting the rate of depletion, has adopted and maintains values according to which oil reserves can be judged critical [12]. Similar conclusions can be made in the analysis of the indicator of supply with petroleum energy raw materials. The data in Figure

6 show that, at current consumption rates and proven quantities, the world is reliably secured with oil for up to 5 decades.

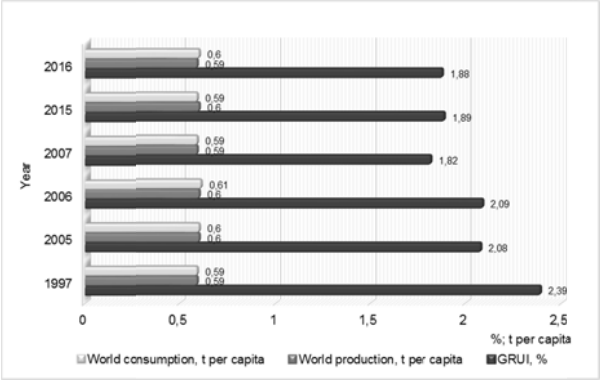

Fig.5. Global Reserves Utilization Index (GRUI), World Oil Production and Consumption per Capita, 1997-2016

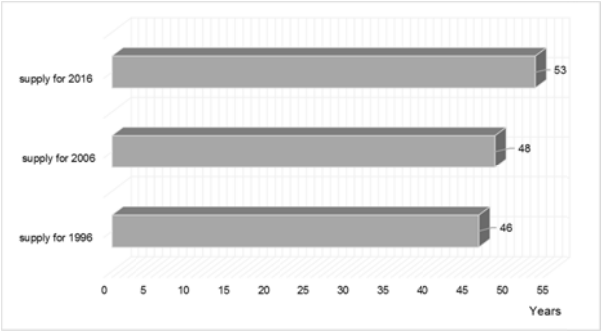

Fig.6. Global Supply with Petroleum Energy Raw Materials for 1996, 2006 and 2016

Conclusion

At the beginning of the third millennium, mankind has increased its strong energy dependence on petroleum raw materials and with a share of 33.3% they continue to have a leading place in the world primary energy consumption. The analysis of the processes over the previous decades has made it possible to outline an objective picture on the development and state of world oil reserves, production and consumption. Based on this, the following more important trends can be defined:

- There is a steady increase in world reserves, production and consumption of oil, which have almost doubled in three decades. Such a process is inherent in development of a *technogenic* type and is in contradiction with the requirements for increasing the efficiency of energy consumption as an important component of the green and the circular economy;
- There is an increasing disproportion between the amount of regional/country oil reserves and their share in regional/country production and consumption of oil;
- Over the past decades, the level of individual consumption (per capita) of oil has been maintained; i.e. the oil production and consumption is commensurate with the increase in the population. For the 1995 - 2016 period, the Earth's population has grown 1.3 times (30% growth as compared to 1995);
- Notwithstanding the exploration of new deposits, the tendency for decreasing the global oil supply is becoming more and more sustainable and deepening.

The outlined trends show that the world is currently governed by its *extensive* attitude to oil resources. Unfortunately, all reported data and trends point to emerging and deepening problems which have current and long-term manifestations. Their solution is a task of fundamental importance to the economic, social and environmental future of the world.

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