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The characteristics of the production and processing of oil and natural gas in Croatia from 2000 to 2014

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Abstract

This research analyzes the characteristics of the production and processing of oil, condensates and natural gas in the Republic of Croatia starting from 2000, until the end of 2014. Amounts of balance sheet (exploitable) reserves of oil and condensates ranges from 9330,92 × 10^3 m^3 in 2005, to 13 471,08 × 10^3 m^3 in 2013, while extracted amounts are gradually declining from 1332,61 × 10^3 m^3 to 639,96 × 10^3 m^3. The ratio of extracted amounts and reserves is gradually declining, meaning that a slight increase in reserves does not affect the extracted amounts. Exploitable reserves of natural gas during the observed period fluctuate greatly. Being peaked in 2007, at 40,919.70 × 10^6 m^3, they reached a low in 2014, at 17,932.98 × 10^6 m^3. Unlike liquid hydrocarbons, the ratio of extracted and exploitable amounts is growing and peaked in 2014. Overall energy demands for oil in Croatia (shown as total consumption of crude oil) amounted to 3032,8 × 10^3 m^3 in 2013, while demands for natural gas amounted to 2809,90 × 10^6 m^3. It is interesting to note that the consumption of oil is rapidly declining, which is a favorable trend from the standpoint of reducing emissions of greenhouse gases. While needs are partly covered by domestic exploitation, the dependence on imports of oil and natural gas is still evident and ranges from 75% to 84% for oil and 28% to 46% for natural gas, without major changes to the trend. The amounts of processed hydrocarbons are declining gradually, especially motor gasoline and fuel oil, while diesel fuel amounts remain mostly the same. Further research as well as development of the exploitation of oil and natural gas is of paramount importance, especially by investing in cadre education and new technologies.

Key words

Oil, natural gas, reserves, extraction, processing, Croatia.

1. Introduction

An increase in consumption of all forms of energy imposes solving the question of securing its supply in the future, especially of oil and natural gas as a particularly essential source of energy as well as an industrial raw material. Despite an increase in consumption, it is evident that even today over half of the world's energy needs (59,4%) are satisfied by the consumption of oil (60%) and natural gas (40%), and should remain so in the foreseeable future in regards to their supply. We have recently been witnessing a rising reliance on natural gas in overall energy consumption. In this sense, the planned construction of pipelines to supply natural gas into Europe named „South Stream" and „Nabucco" (**Sučić et al., 2011**) is of particular interest.

Therefore, supplies are increasing, and the so-called Hubert's peak (a theory claiming that petroleum production tends to follow a bell-shaped curve, reaching a maximum and then declining) keeps shifting into the future while recognizing that fossil fuels accrue over millions of years and are expended relatively quickly. For example, in 1939, oil sufficiency was estimated for a period of up to only 13 years, while in 1959 oil supplies (proven and probable) were at 159 × 10^9 m^3 which was estimated as sufficient for the following few decades. By the latest available data (**BP, 2015**), oil reserves are sufficient for an additional 52 years of extraction, and natural gas for 54 more years.

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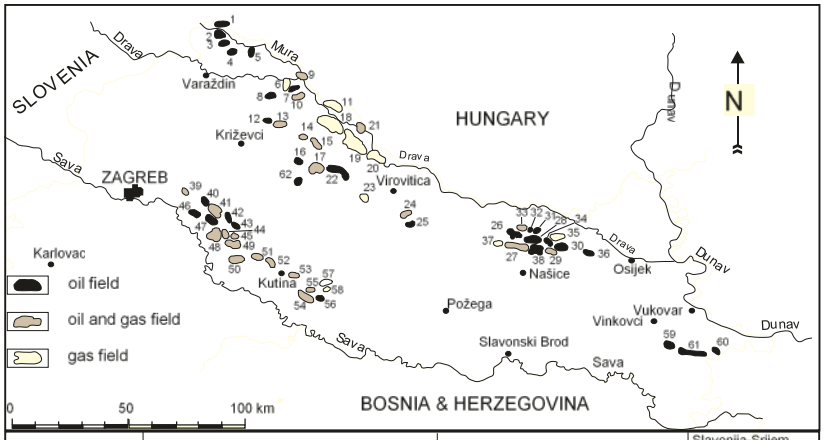
Therefore, oil and natural gas remain the main sources of energy in use until 2050, however in combination with coal, sun, sea, wave, sea flow as well as nuclear energy and others. While oil and gas exploitation still has an expiry date, it is important to ensure the rationality of their consumption and use.

The price of hydrocarbons is an important factor in their rational consumption. As hydrocarbon research becomes more complex and is undertaken in increasingly difficult conditions, its cost also rises. Oil and gas will therefore become more costly in the future although the price of crude oil has fallen drastically in the second half of 2015 to its lowest point in the last 12 years.

Croatia has a long and rich history of hydrocarbon exploitation **(Velić et al., 2010; Velić et. al., 2012).** The Croatian industry boasts with a tradition of 150 years and, while a drastic decrease of hydrocarbon supply can be presumed, due to its non-renewability, analysis of reserves and acquisitions has shown that reserves are regularly maintained, and are even increasing in volume. The eldest exploited field is Bujavica – the first natural gas field discovered in 1917 and active up until 1937. The first significant extraction of oil began in 1941 from the deposit of Gojlo field.



Mura depression	Drava depression		Sava depression		Slavonija-Srijem. depression
1. Mursko Središ će	10. Peteranec	25. Cabuna	39. Dugo Selo	51. Voloder	59. Privlaka
2. Zebanec	11. Gola-Ždala	26. Crnac	40. Lupoglav	52. Mramor-Brdo	60. Ilača
3. Selnica	12. Lepavina	27. Bokšić	41. Kloštar Ivanić	53. Gojlo	61. Đeletovci
4. Mihovljan	13. Jagnjedovac	28. Beničanci	42. Šume ćani	54. Lipovljani	
5. Peklenica	14. Mosti	29. Obod	43. Bunjani	55. Jamarica	
6. Veliki Otok	15. Čepel.-Hampovica	30. Ševkovica	44. Hrastilnica	56. Kozarica	
7. Kutnjak-Đelekovec	16. Letičani	31. Ku čanci-Kapelna	45. Vezišće	57. Janja Lipa	
8. Cvetkovec	17. Šandrovac	32. Krunoslavlje	46. Ježevo	58. Bujavica	
9. Legrad	18. Molve	33. Ladislavci	47. Ivani ć		
	19. Kalinovac	34. Obod-Lacić	48. Žutica		
	20. Stari Gradac	35. Sje če	49. Okoli		
	21. Ferdinandovac	36. Bizovac	50. Stružec		
	22. Bilogora	37. Obradovci			
	23. Gakovo	38. Kloko čevci			
	24. Pepelana	62. Galovac-Pavljani			

Figure 1: Oil and gas fields in the Croatian part of the Pannonian Basin System (**Velić, 2007**)

Intense activities of research and oil and natural gas exploitation in Croatia have lasted for the last 70 years, and today on the territory of the Croatian part of the Panonnian Basin System (further in text – CPBS) (see **Figure 1**) hydrocarbons are being extracted from 33 oil fields, gas condensates from 9 gas-condensate fields and gas from 17 gas fields. Research of the Adriatic offshore has lasted over 40 years, and natural gas extraction has been conducted from 1999, from nine gas fields (see **Figure 2**).

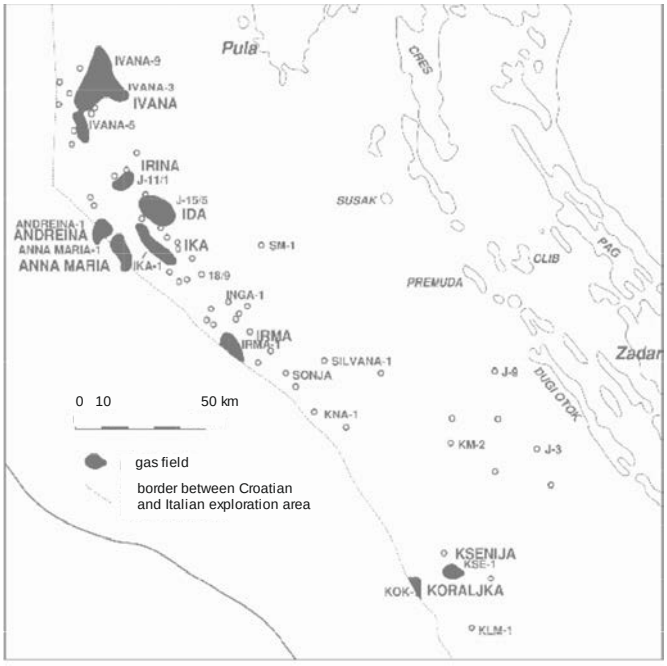


Figure 2: Gas field sites in the Adriatic offshore (**Velić, 2007**)

According to **Velić et al. (2010),** the sum of geological reserves equals 740 × 10^6 m^3 of oil equivalents. Initial oil reserves are estimated at 112 10^6 m^3, condensates are estimated at 10.74 × 10^6 m^3 and natural gas at 100.67 × 10^9 m^3 (see **Table 1**). The differential between estimated starting reserves and the total extracted sums yields remaining reserves, which are also shown in **Table 1** where the amounts of condensates are marked in brackets. The remaining oil reserves amount to 8.01 × 10^6 m^3 while natural gas reserves amount to 35.76 × 10^9 m^3. Based on the remaining reserves, **Dobrova et al. (2003)** have ranked Croatia third amongst the states of Middle and Eastern Europe in 2002, although according to more recent data the remaining reserves are estimated at lower values (**Velić et. al., 2010; Malvić et al., 2011**). At the end of this introduction, an additional remark: according to data relevance, in **Tables 8 to 9**, and on **Figures 8, 12, 14 to 22**, the data shown is up to the year 2013.

Table 1: Croatian recoverable reserves, cumulative production and remaining hydrocarbon reserves (**Malvić et al., 2011**)

Dobrova et al. (2003)						**Velić et al. (2010)**					
Recoverable reserves		*Cumulative production*		*Remaining reserves*		*Recoverable reserves*		*Cumulative production*		*Remaining reserves*	
Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas
141.18	**108.11**	**109.70**	**26.16**	**31.48**	**81.95**	**112.06** **(10.73)**	**100.67**	**104.45** **(6.93)**	**64.91**	**8.01** **(3.80)**	**35.76**
Oil in 10^6 m^3; Gas in 10^9 m^3											

2. Reserves of oil, condensates and natural gas

Exploitable (balance sheet, commercial or proven reserves) reserves of oil, condensates and natural gas observed in the period from 2000 to 2014 in the Republic of Croatia are shown in **Tables 2 to 4** and **Figures 3 to 5 respectively.** In **Table 3** and on **Figure 3** oil and condensates are shown separately. The assessed quantities of oil, condensates and natural gas in a deposit that can be profitably exploited are classified as proven reserves.

Proven reserves of oil and condensates have been generally decreasing until 2004, when they were estimated at $9348{,}71 \times 10^3$ m^3, which amounts to 80% of their value in 2000. Since 2006, reserves are increasing, especially in 2013, when they amounted to $13\,471{,}08 \times 10^3$ m^3. By comparing reserves separately for oil and condensates a disproportion is visible; namely oil reserves are growing while condensate reserves have fallen from $3468{,}82 \times 10^3$ m^3 in 2000, to only $1435{,}47 \times 10^3$ m^3 in 2014, a variation of 40%.

Tables 2 and 5: Proven reserves and produced volumes of oil and condensate, imported volumes and total consumption of crude oil in Croatia from 2000 to 2014

	Table 2			**Table 5**		
	According to the Annual report of mineral ores reserves, source: Ministry of Economy, Croatia			According to the Energy report 2003-2011 (Eurostat), Croatia; data labelled with a * Energy in Croatia, 2012-2013, Ministry of Economy (***3**)		
Year	**Proven reserves of oil and condensate** [10^3 m^3]	**Produced volumes of oil and condensate** [10^3 m^3]		**Imported volumes of crude oil** [10^3 m^3]	**Total consumption of crude oil** [10^3 m^3]	
	A	**B**	**B/A**	**C**	**D**	**C/D**
2000	11,477.34	1,332.61	0.116	-	-	-
2001	10,564.45	1,262.16	0.119	-	-	-
2002	10,152.69	1,217.40	0.120	-	-	-
2003	10,356.13	1,152.48	0.111	3,814.20	5,096.60	0.75
2004	9,348.71	1,085.37	0.116	4,250.90	5,324.20	0.80
2005	9,330.92	1,005.19	0.108	4,049.50	5,113.50	0.79
2006	9,689.11	977.49	0.101	3,847.30	4,856.30	0.79
2007	11,719.10	930.10	0.079	4,251.60	5,177.00	0.82
2008	11,472.48	867.87	0.076	3,517.40	4,508.30	0.78
2009	10,823.58	807.45	0.075	4,119.00	4,919.20	0.84
2010	10,481.58	743.93	0.071	3,598.00	4,362.00	0.82
2011	11,554.00	697.50	0.060	2,894.70	3,444.20	0.84
2012	11,531.60	659.32	0.057	2,325.00*	3,108.30*	0.75
2013	13,471.08	636.78	0.047	2,461.80*	3,032.80*	0.81
2014	12,597.80	639.96	0.051	-	-	-

* in 1,000 tons

Table 3: Proven reserves and produced volumes of oil and condensate in Croatia from 2000 to 2014

	Proven reserves of oil and condensate [10^3 m^3]		**Produced volumes of oil and condensate** [10^3 m^3]	
Year	Oil	Condensate	Oil	Condensate
2000	8,008.52	3,468.82	1,003.87	328.74
2001	7,040.30	3,524.15	934.35	327.81
2002	6,935.47	3,217.22	906.95	310.45
2003	7,435.20	2,920.93	853.00	299.48
2004	6,707.18	2,641.53	802.62	282.75
2005	6,152.09	3,178.83	745.59	259.60
2006	6,736.64	2,952.47	728.65	248.84
2007	8,949.30	2,769.80	702.19	227.91
2008	8,917.39	2,555.09	653.15	214.72
2009	8,454.81	2,368.77	619.65	187.80
2010	8,460.94	2,020.64	563.11	180.82
2011	9,199.24	2,354.76	528.45	169.05
2012	9,295.68	2,235.92	511.68	147.64
2013	11,370.71	2,100.37	499.51	137.27
2014	11,162.33	1,435.47	518.27	121.69

Regarding natural gas (see **Table 4** and **Figure 5)**, significant oscillations are visible. Reserves were at a peak in 2007 (40 919.70 × 10^6 m^3) and have been decreasing steadily – to 17,932.98 × 10^6 m^3. The grounds had a smaller investment in research while CPBS is considered to be well explored, and most deposits depleted. There are diverging standpoints on the matter, stated for instance in the work of **Velić (2007).** According to some research conducted for CPBS, 2 to 4 times more oil was generated than determined in existing deposits (**Malvić et al., 2011**). Even though the values might be overrated, a significant amount of hydrocarbon reserves can be obtained by increasing deposit utilization and discovering new ones. In this sense, it is relevant to quote the standpoint of **Velić et al. (2012)**, pointing to the fact that significant deposits can be expected in rocks underlying the Neogene deposits (under the EL-border "Tg", e.g. "PT", in the top of the Paleozoic magmatites and metamorphites and Mesozoic sedimentary rocks), at the edges of depressions or on rises in the paleorelief, as well as in stratigraphic traps inside Miocene deposits whereas they consist of diverse lithofacies from distinctly diverse sedimentary environments.

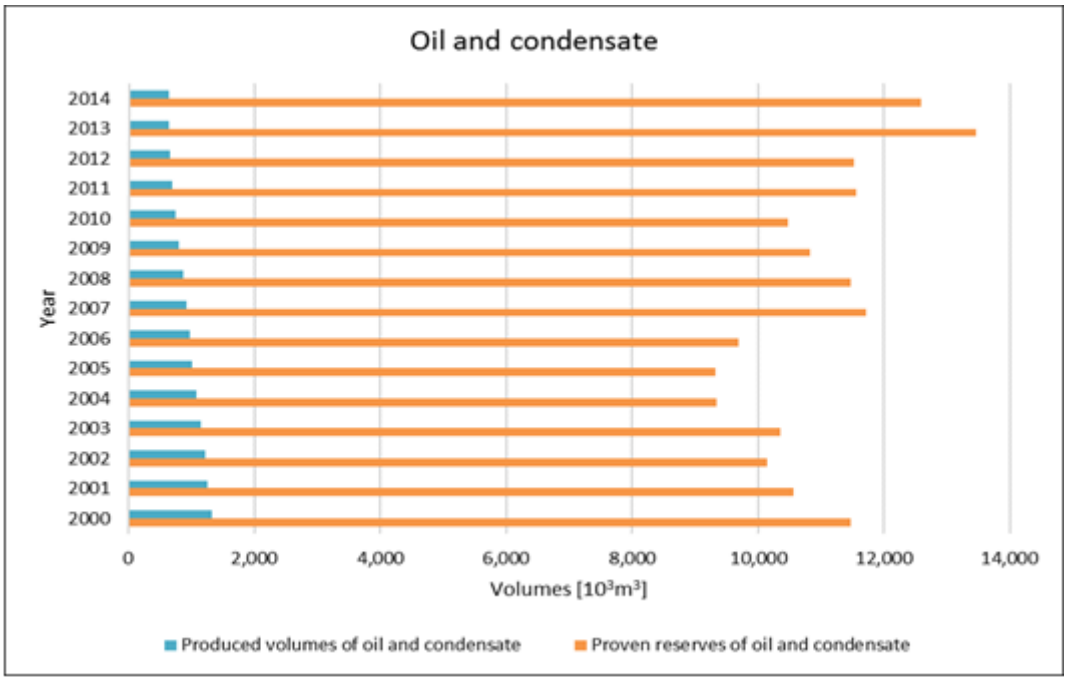


Figure 3: Proven reserves and produced volumes of oil and condensate in Croatia from 2000 to 2014

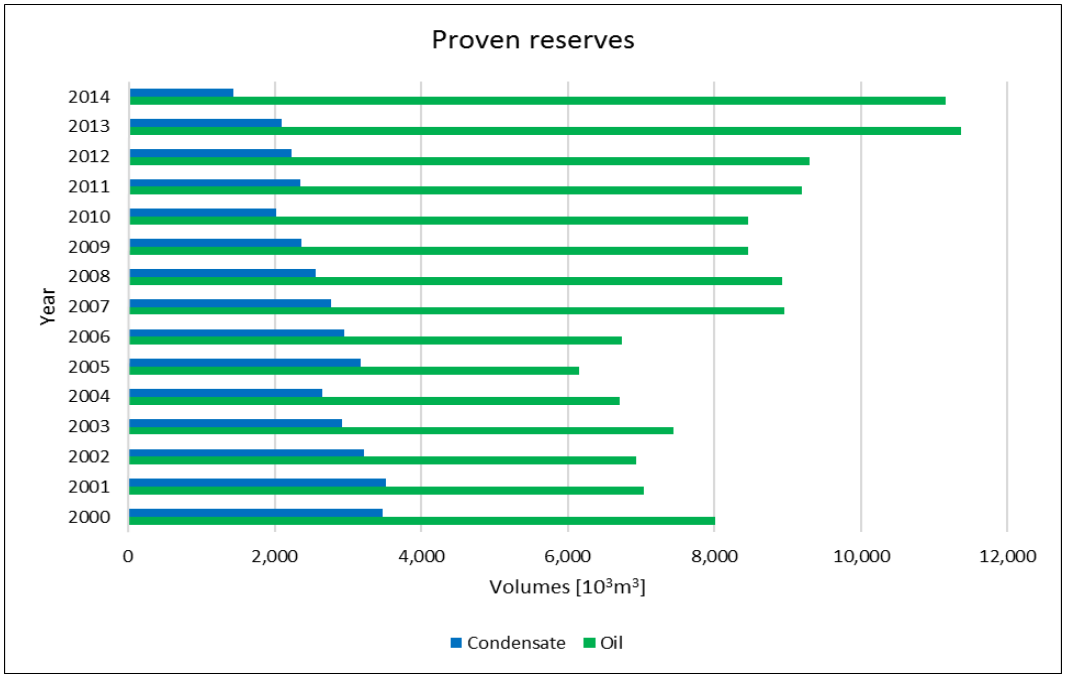


Figure 4: Proven reserves in Croatia from 2000 to 2014 shown separately for oil and condensate

Tables 4 and 6: Proven reserves and produced volumes of natural gas and imported volumes and total consumption of natural gas in Croatia from 2000 to 2014

	Table 4			**Table 6**		
	According to the Annual report of mineral ores reserves, source: Ministry of Economy, Croatia			According to the Energy report 2003.-2011. (Eurostat), Croatia; and data labelled with a * Energy in Croatia, 2012.-2013. Ministry of Economy (***3***)		
Year	**Proven reserves of natural gas** $[10^6\,m^3]$	**Produced volumes of natural gas** $[10^6\,m^3]$		**Imported volumes of natural gas** $[10^6\,m^3]$	**Total consumption of natural gas** $[10^6\,m^3]$	
	A	**B**	**B/A**	**C**	**D**	**C/D**
2000	29,204.51	1,888.35	0.065	-	-	-
2001	33,203.17	2,851.87	0.086	-	-	-
2002	35,906.14	2,880.48	0.080	-	-	-
2003	28,150.91	2,278.40	0.081	827.40	2,095.80	0.39
2004	26,574.65	2,352.25	0.089	855.60	2,443.80	0.35
2005	30,358.60	2,432.42	0.080	921.00	2,363.10	0.39
2006	30,110.54	2,863.70	0.095	914.80	2,337.00	0.39
2007	40,919.70	3,001.04	0.073	856.80	2,685.30	0.32
2008	36,436.12	2,847.18	0.078	996.30	2,602.80	0.38
2009	34,500.20	2,819.07	0.082	848.00	2,403.30	0.35
2010	31,163.58	2,833.22	0.091	868.60	2,632.30	0.33
2011	23,959.91	2,571.46	0.107	711.50	2,570.20	0.28
2012	24,315.39	2,086.38	0.086	1,357.70*	2,971.70*	0.46
2013	21,368.61	1,963.32	0.092	1,270.40*	2,809.90*	0.45
2014	17,932.98	1,824.03	0.102	-	-	-

In Croatia, oil is recovered by primary, secondary and tertiary methods. The recovery ratio for some of the largest Croatian fields can be as low as 16% (Žutica), however it is significantly higher in most other fields like 31% in Kloštar, 39% in Stružec, and as high as 51% in the Beničanci.

The most common secondary method is water injection, however alternative solutions are explored such as carbon dioxide (CO_2) flooding whereby carbon dioxide is injected into an oil reservoir in order to increase output when extracting oil. Tests were conducted in INA's laboratories for fourteen fields (**Goričnik & Domitrović, 2003; Novak et al., 2013 a, b**), results were also analyzed by the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb (**Vulin, 2010; Novak, 2015**). It is opportune to mention some opinions here on unconventional deposits of hydrocarbons and the methods of their evaluation, which is certainly relevant in reserve planning and acquisition (**Rusan, 2014**).

Quantities of acquired hydrocarbons sorted as oil and condensate (liquid hydrocarbons) and natural gas are shown in **Tables 2, 3 and 4** and on **Figures 3, 5 and 6**. It is evident that acquired quantities of oil and condensates are declining from an observed peak of $1332{,}61 \times 10^3\,m^3$ to only $639{,}96 \times 10^3\,m^3$ in 2014 (see **Table 2** and **Figure 3**). Certain

oscillations are the result of a field's development on oil fields, which contributed to the increase of oil extraction in 2014 by 3,7% in relation to 2013.

Quantities of natural gas oscillate readily (see **Table 4** and **Figure 5**). According to **Table 7,** it can be noticed that, at the beginning of the observed period, the leading role in the extraction of natural gas was held by the quantity from the CPBS deposit (relation 7:1). A reversal is noticed in 2009 and 2010, where a slightly larger quantity of extracted gas came from the Adriatic offshore, and at the very end of the observed period – in 2013, the relation stands at 1:1 (see **Figure 7**). A natural drop in natural gas extraction in 2014 from 6,4% in relation to 2013 is the consequence of the suspension of drilling activity in the Ika Field, the restoration project on the Anamaria field and on the contracted area „North Adriatic“ as well as an increase in share of water in the contracted area „Aiza Laura“.

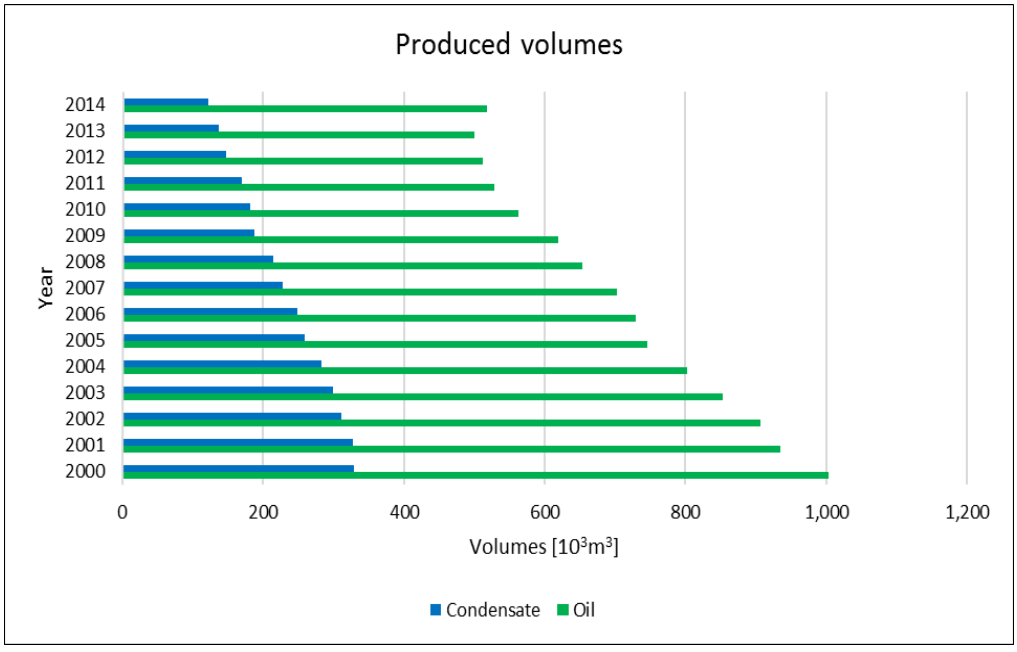


Figure 5: Produced volumes in Croatia from 2000 to 2014 shown separately for oil and condensate

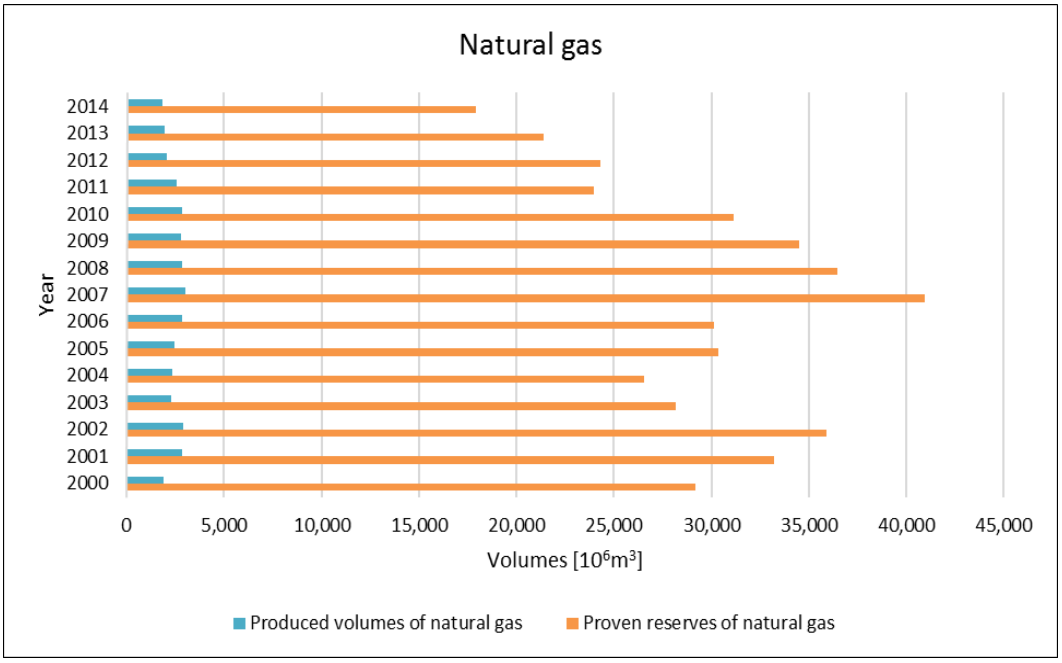


Figure 6: Proven reserves and produced volumes of natural gas in Croatia from 2000 to 2014

Table 7: Comparison of the produced volumes of natural gas from the CPBS and the Adriatic offshore

Production region	CPBS	Adriatic offshore	CPBS/Adriatic offshore ratio
Year	Volumes A [10^6 m^3]	Volumes B [10^6 m^3]	A/B
2000	1,654.15	234.19	7.06
2001	2,314.36	537.52	4.30
2002	2,199.17	681.31	3.23
2003	1,597.06	681.34	2.34
2004	1,678.01	712.55	2.35
2005	1,955.95	892.21	2.19
2006	1.747.38	1,386.16	1.26
2007	2,084.14	1,687.98	1.23
2008	1,930.95	1,601.35	1.20
2009	1,737.94	1,680.50	1.03
2010	1,577.08	1,803.82	0.87
2011	1,378.44	1,608.29	0.86
2012	1,145.20	1,227.86	0.93
2013	1,177.64	1,147.26	1.03

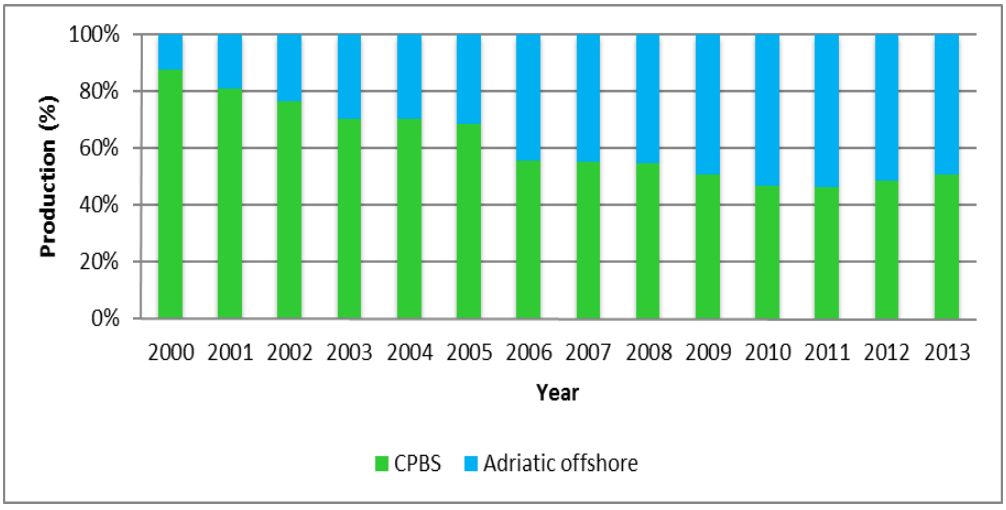


Figure 7: Ratio of natural gas recovered in Croatian part of the Pannonian Basin System and the Adriatic offshore from 2000 to 2013 (**Kišić, 2015**)

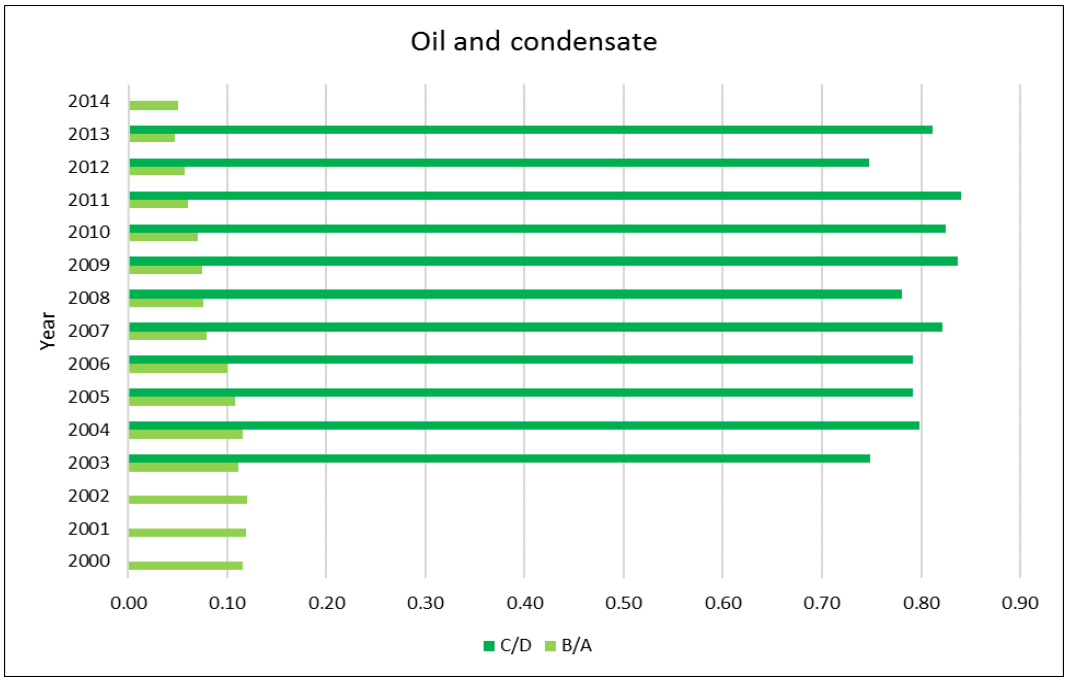


Figure 8: Volume ratio of proven reserves and produced volumes of oil and condensate (B/A) and ratio of imported volumes and total consumption of crude oil (C/D) in Croatia from 2000 to 2014 (B/A and C/D from **table 2**)

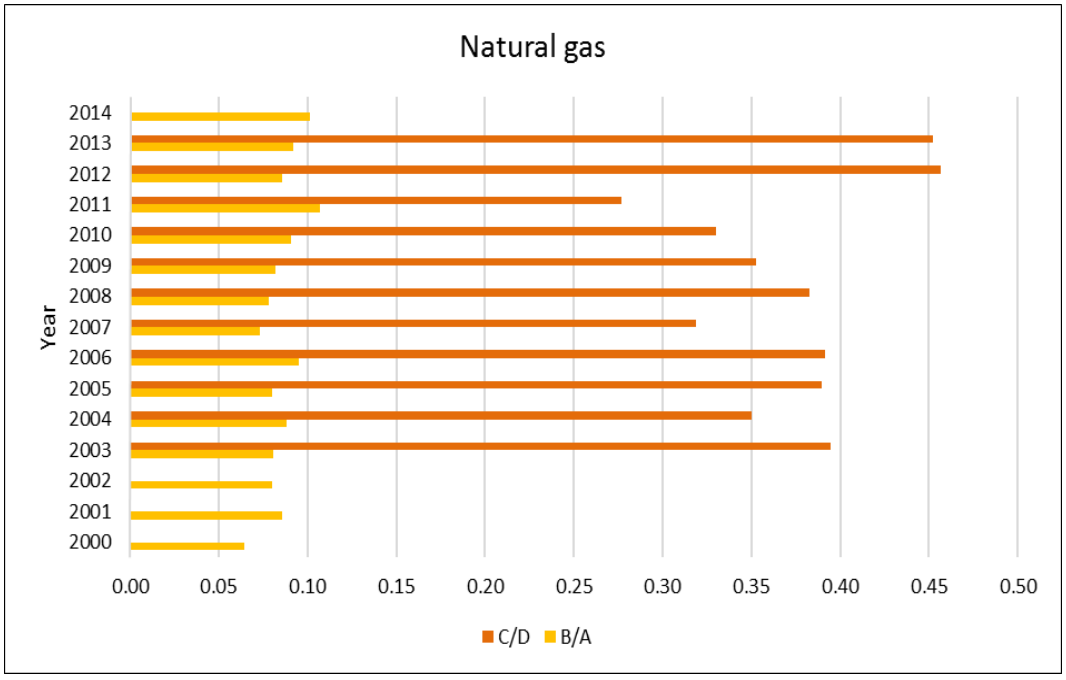


Figure 9: Volume ratio of proven reserves and produced volumes (B/A) and ratio of imported volumes and total consumption of natural gas (C/D) in Croatia from 2000 to 2014 (B/A and C/D from **table 4**)

In contemplating reserves and extraction, data on the ratio of total reserves and extraction is relevant, also by observed years (**Tables 2 and 4, Figures 9 and 10**). In general the ratio „extraction: proven reserves“ for liquid hydrocarbons is gradually declining from 0,12 (2002.) to 0,051 in 2014, in other words, at the beginning of the observed period around

10% of the reserves were being extracted compared to 5% at the end of the period. It is unclear why oil and condensate extraction is declining yet reserves are regenerating.

With natural gas, the situation is different. Moving towards 2014, increasingly larger amounts are extracted in relation to reserves, from 6,5% at the beginning to 10% in 2014. One speculative conclusion is that perhaps oil is being preserved for the future, while natural gas as a cheaper energy-generating product is being increasingly exploited. The answer could also lie in INA's business policy.

4. Consumption and import of oil and natural gas in Croatia

The Republic of Croatia meets its hydrocarbon needs only partially by internal oil and gas extraction, meaning a larger share falls on import. During the observed period, from 2000 to 2014, the total quantity of imported crude oil amounted to 50, 360 × 10^3 tons. Croatian needs for crude oil decreased by 40%, observing from 2003. Specifically, from 5096,60 $10^3 m^3$ total consumption has dropped to 3032,80 × 10^3 m^3 by 2013. Furthermore, from 2000 to 2014, quantities of imported oil have irregularly, but gradually decreased (see **Table 5**). The ratio of internal production to import however is relatively stable through the years and stands at 2:8 (see **Figures 10 and 11**). However, it can be noted that the imported quantity was significantly lower in the last three years (2325,00 × 10^3 m^3) in relation to the largest ever imported quantity (4251,60 × 10^3 m^3 in 2004 and 2007). Thereby the quantity of oil produced locally has a regular trend of decline. Total consumption of natural gas is steadily growing and has stood at 2810 × 10^6 m^3 in 2013. To satisfy local needs, 1300 × 10^6 m^3 is being imported, amounting to 40% of Croatian consumption (see **Table 6**, **Figures 9**, **12** and **13).**

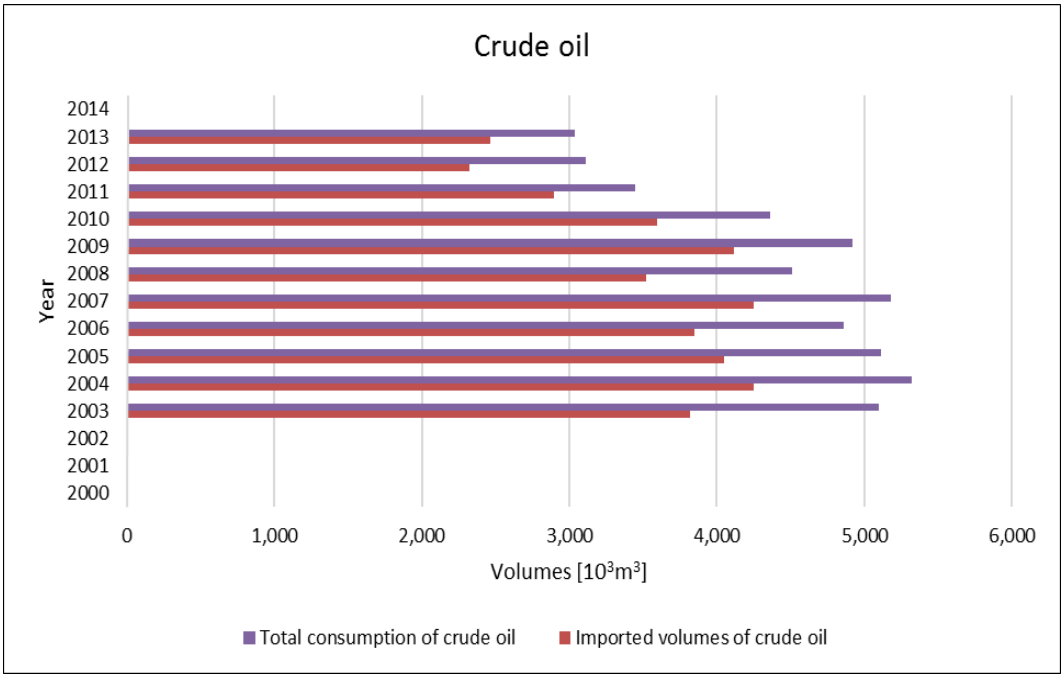


Figure 10: Total consumption and imported volumes of crude oil in Croatia from 2000 to 2014

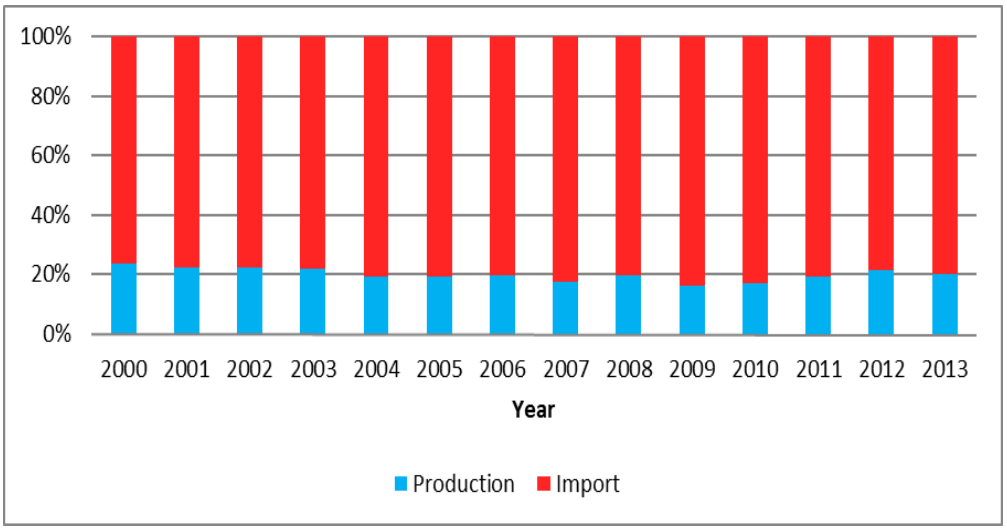


Figure 11: Ratio of domestic production and imported volumes of oil in Croatia from 2000 to 2013 (**Kišić, 2015**)

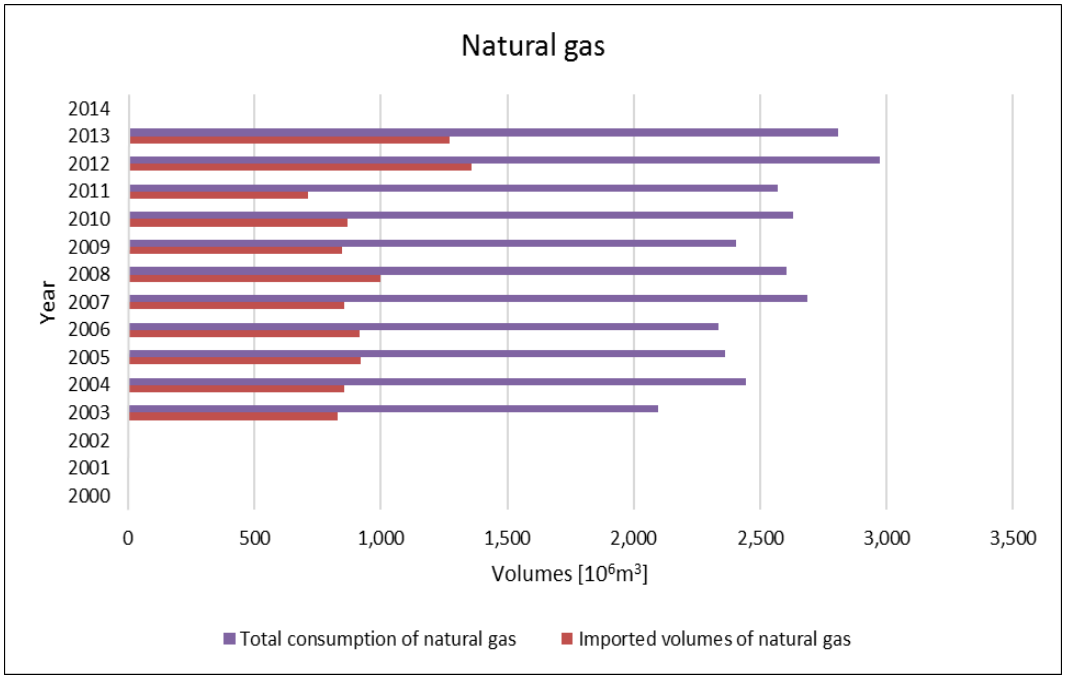


Figure 12: Total consumption and imported volumes of natural gas in Croatia from 2000 to 2014

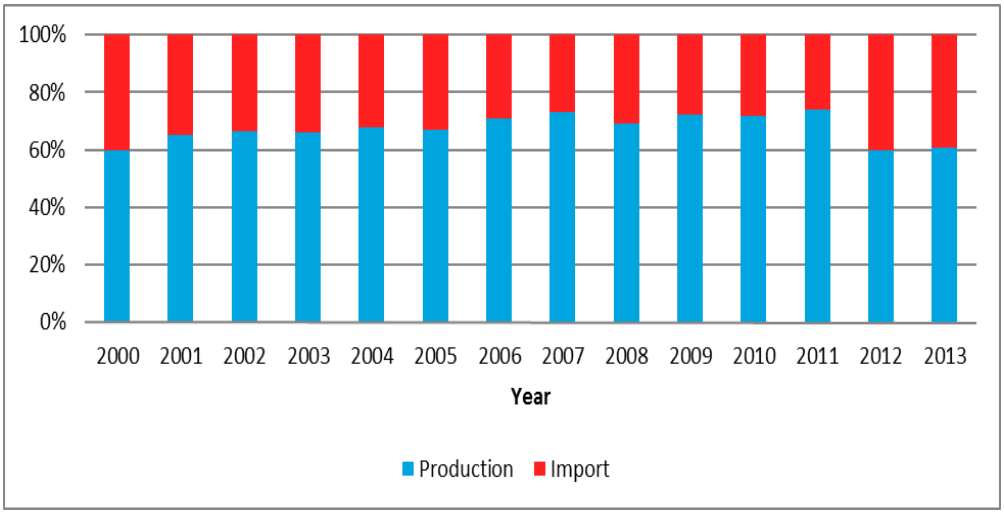


Figure 13: Ratio of domestic production and imported volumes of natural gas in Croatia from 2000 to 2013 (**Kišić, 2015**)

5. Processing

Since oil contains numerous types of hydrocarbons, which differ greatly in composition, vapor pressure and boiling point, oil cannot be directly used neither as an economical fuel, nor a chemical raw material. Usable oil products are gained only by processing. Oil is processed in refineries by separation, conversion and cleansing. Processes of separation are also called primary, and processes of conversion and cleansing secondary processes.

By its chemical composition, oil predominantly consists of hydrocarbons and, in a lesser part, of organic compounds with oxygen, nitrogen and sulfur, with traces of inorganic matter (e.g. metals in smaller quantities). The physicochemical properties of oil depend on its origin (chemical composition of oil).

According to **Sertić-Bionda (2006),** non-hydrocarbon components (sulfur, oxygen and nitrogen) are the properties highly influencing oil processing. The organic compounds sulfur, oxygen and nitrogen tend to concentrate in petroleum cuts with higher boiling points and thus irrespective of their initial content in crude oil significantly impede the processing of those fractions. The hydrocarbon-based part of oil mostly consists of paraffin, naphthene and aromatic organic compounds. Olefin and acetylene hydrocarbons are usually not present in crude oil.

Petroleum products are the products of the industrial processing of oil, in the first order products of atmospheric and vacuum fractional distillation that can be directly utilized as fuel or as a raw material for obtaining diverse organic compounds. The most important groups of petroleum products are petroleum gas, kerosene, motor gasoline, diesel fuel, rocket fuel, kerosene and petroleum for jet engines, fuel oil (light and heavy), lubricating oil, bitumen and petroleum coke, paraffin (wax) and olefin as well as aromatic hydrocarbons such as petrochemical raw materials, especially ethylene, propylene, benzene, toluene and xylene.

Refineries in Croatia have a long history and carry great importance in the economy. The processing of oil in Croatia takes part in refineries in Rijeka and Sisak and in the facility "Maziva" in Zagreb that are the property of INA, d.d. In **Table 9,** refinery products are listed. For the most part petroleum products that are created by oil processing come from imported crude oil. The quantity of crude oil entering refineries ranges from 5 million tons of oil at the beginning of the observed period (2000) to 3 million in 2013. Observing the available capacities of Croatian refineries (**Table 8**) it becomes evident that processing in the observed period was carried under much smaller capacity than was available. In total these refineries possess the capacity to process around 9 million tones yearly by atmospheric distillation. As stated before, in Croatia only 3×10^6 tons of crude oil was processed in 2013, with 2,4 million coming from import.

The largest quantities are related to fuel oil, diesel fuel and motor gasoline. Aside from refining plants and facilities for fuel and lubricant production, INA also utilizes the necessary networks for the distribution of oil and other products.

Delivery of oil to refineries is conducted by pipeline, and transportation of other products by sea, road and railroad while utilizing available storage capacities. Sale is organised through wholesale as well as a diversified retail network.

Table 8: Processing capacities of oil refineries in Croatia

Processing capacities	Installed (1,000 tons/year)
1. OIL RAFINERY RIJEKA (URINJ)	
atmospheric destilation	5,000
reforming	730
FCC	1,000
visbreaking	600
isomerization	250
gasoil desulphurization	1,040-560
hydrocracking	2,600
2. OIL RAFINERY SISAK	
atmospheric destilation	4,000
reforming	720
FCC	500
coking	240
vacuum destilation	800
bitumen	350
3. LUBE REFINERY ZAGREB	
lubricants	60

The largest share in the total energy consumption in Croatia falls to liquid fuels. Their share was 43,4% in 2008 and decreased to 33,7% by 2013. Aside from liquid fuel shares, shares of liquid gas and imported electrical energy also decreased in 2013.

The total quantity of petroleum products produced in Croatia has progressively declined since 2008, while imported quantities remain unchanged. Congruently, the consumption curve is declining. The gas consumption curve also points to a gradual decline (see **Figure 20**) with marked variations in the quantity of gas for energy transformation (see **Figure 21**).

Table 9: Oil refinery products in Croatia (*1, 2*,3*)

Year/1,000 t)	2000	2005	2010	2013
oil refinery products– total production	5,280	5,139	4,232	3,357
liquefied petroleum gas	284	291	246	209
motor gasoline	1,330	1,168	1,094	928
kerosene and jet fuel	88	99	95	109
diesel oil	1,064	1,081	1,079	1,072
light fuel oil	603	522	228	169
fuel oil	1,111	1,160	868	514
naphtha	103	177	66	30
bitumen	177	181	67	36
refinery gas	262	241	162	175
other products	259	221	328	113

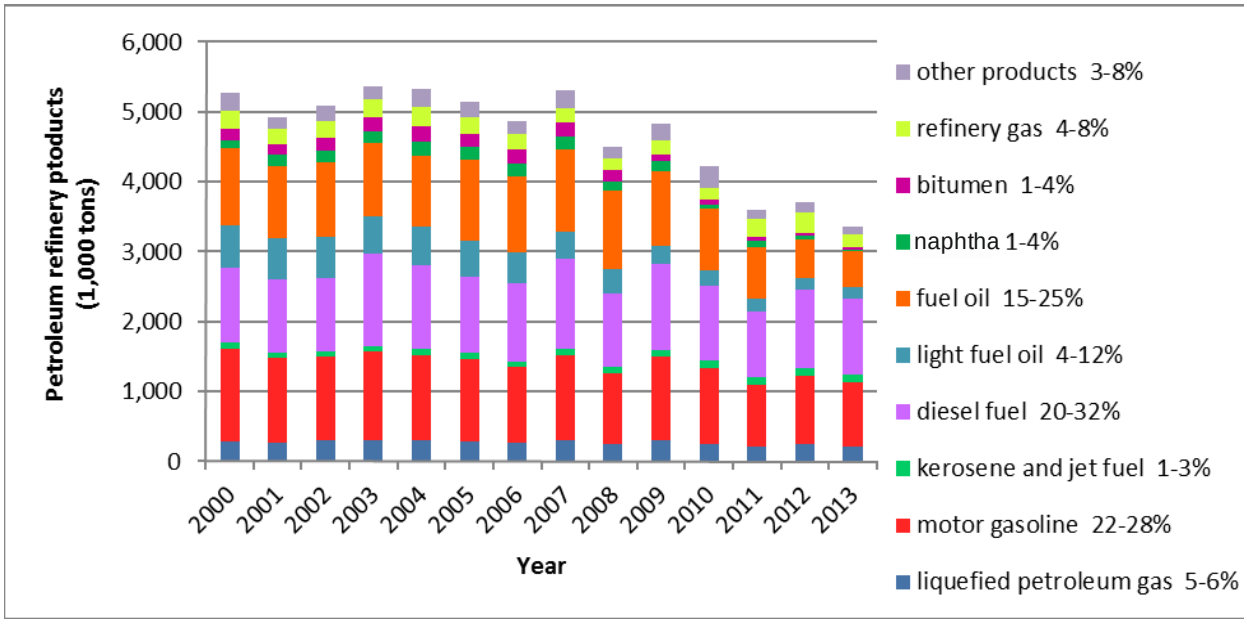


Figure 14: Petroleum refinery products in Croatia from 2000 to 2013 in % (**Kišić, 2015**)

Production decline of motor gasoline and fuel oil is evident, while produced quantities of diesel fuel have remained mostly unchanged in the observed period. On **Figure 14,** the same trend in decline can be observed for the remaining refinery products.

In the observed period, a change in the structure of energy consumption in transportation transpired (see **Figure 15**) where the share of diesel fuel and jet fuel consumption increased, while the share of motor gasoline consumption

decreased (see **Figures 16 to 18**). Due to changes in the structure of liquid fuel consumption in transportation, diesel and jet fuel have maintained virtually the same value in production (or have increased slightly) for the entire observation period.

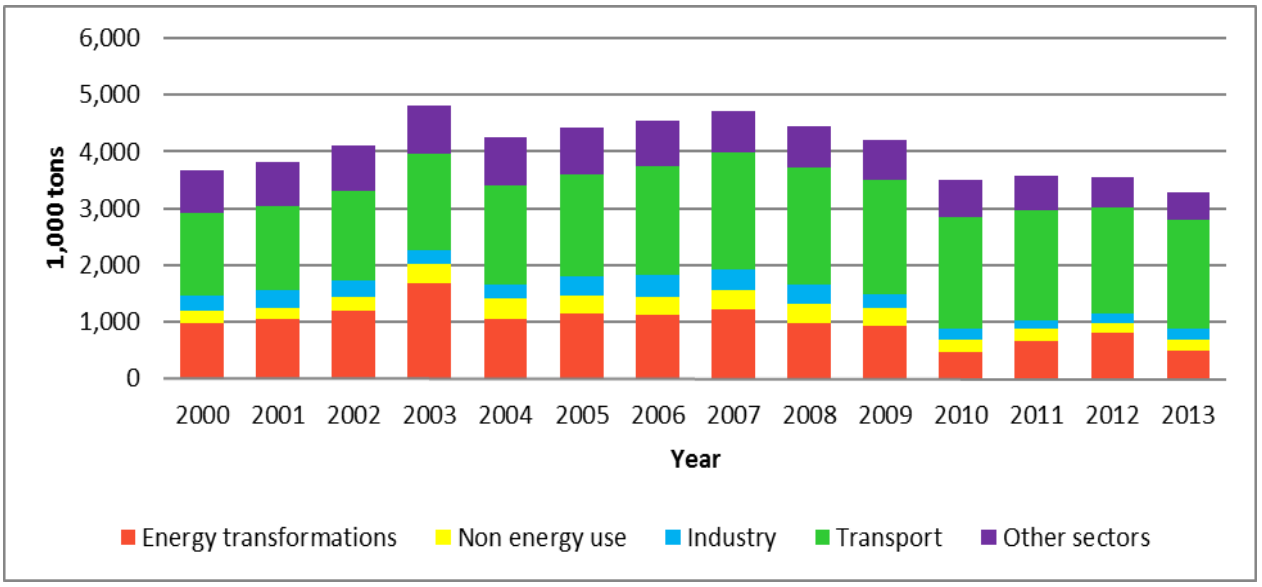


Figure 15: The consumption of oil products per sectors in Croatia from 2000 to 2013 (**Kišić, 2015**)

Today's energy consumption is less than it was in 1988. Aside from direct and indirect damages caused during the Homeland War (1991-1995), Croatian manufacturers have partially changed the market. Traditional economic, primarily manufacturing branches are changing, leading to the restructuring of the economy, with gradual dominance of the services and trade sector. These trends reflect upon the consumption. The largest growth in consumption was experienced in 2007, followed by the decline.

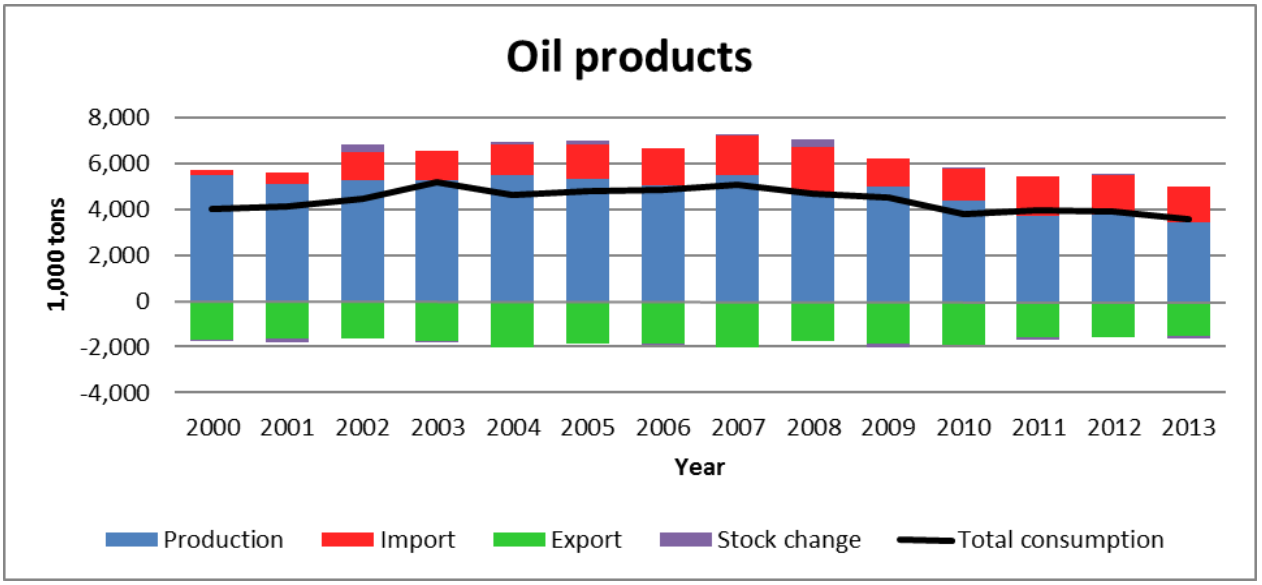


Figure 16: The total amount of oil products produced in Croatia, imported and exported amounts from 2000 to 2013 and the curve of total consumption (**Kišić, 2015**)

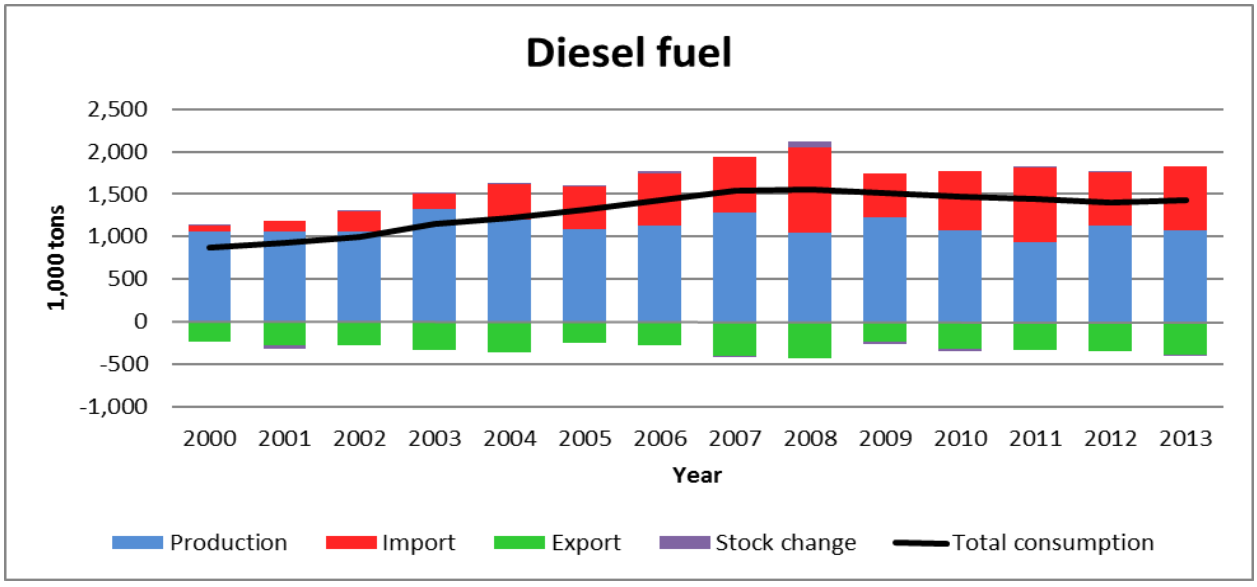


Figure 17: The total amount of diesel fuel produced in Croatia, imported and exported amounts from 2000 to 2013 and the curve of total consumption (**Kišić, 2015**)

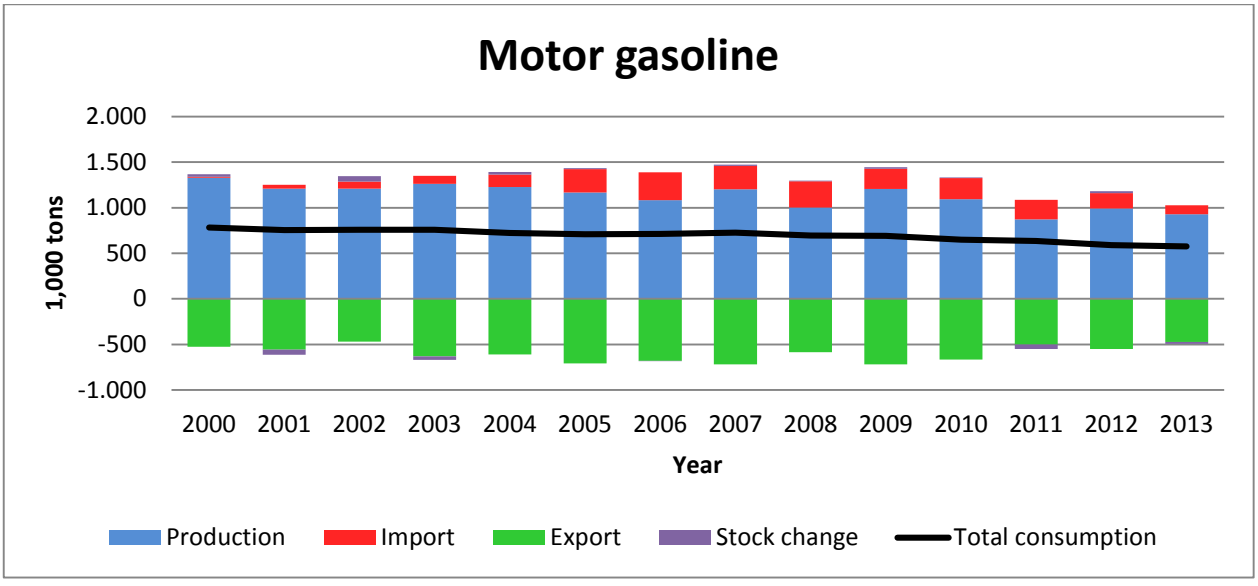


Figure 18: The total amount of motor gasoline produced in Croatia, imported and exported amounts from 2000 to 2013 and the curve of total consumption (**Kišić, 2015**)

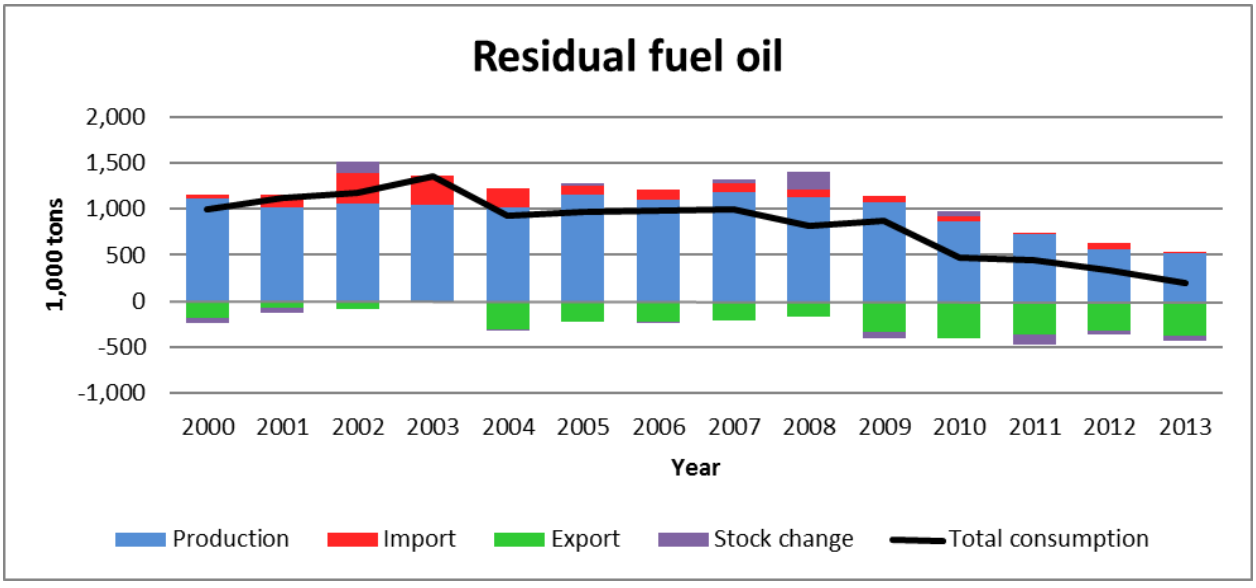


Figure 19: The total amount of residual fuel oil produced in Croatia, imported and exported amounts from 2000 to 2013 and the curve of total consumption (**Kišić, 2015**)

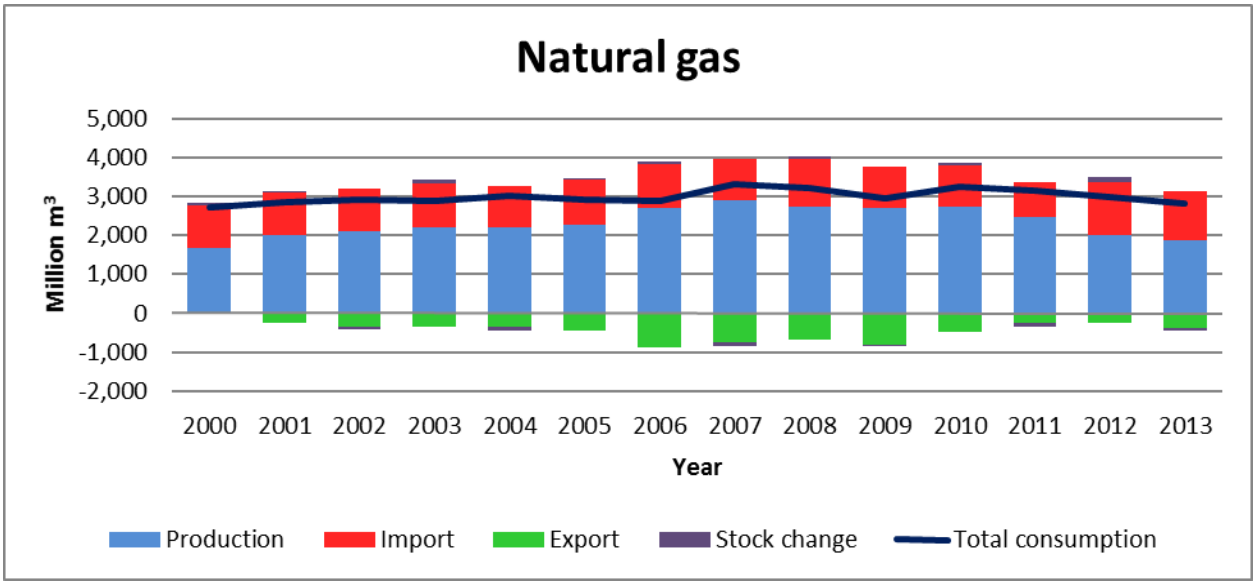


Figure 20: The total amount of natural gas produced in Croatia, imported and exported amounts from 2000 to 2013 and the curve of total consumption (**Kišić, 2015**)

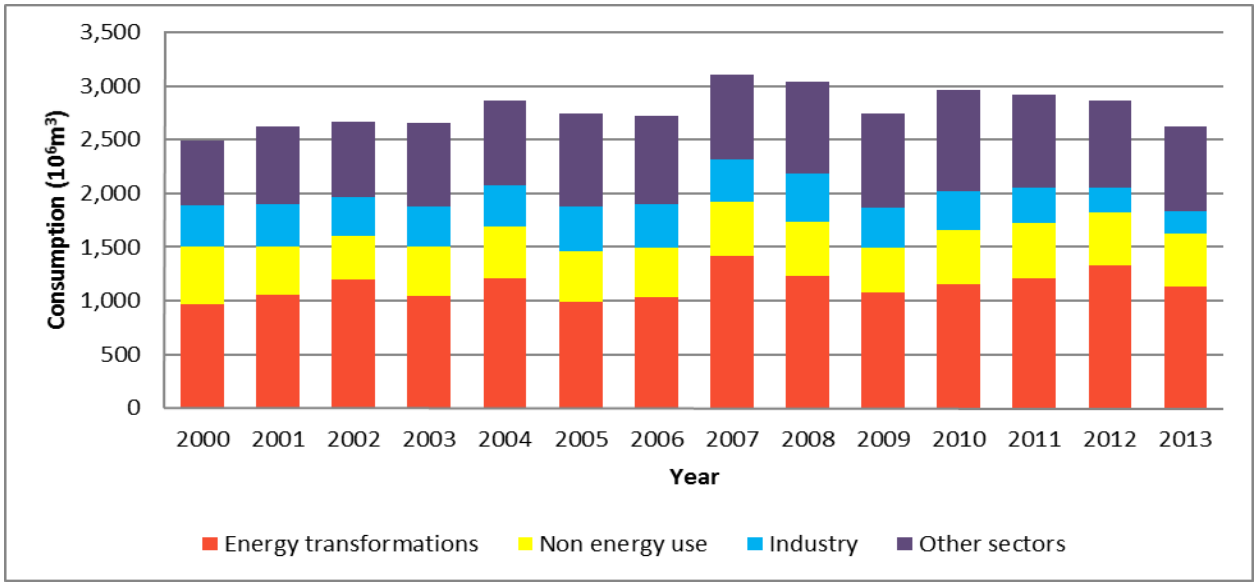


Figure 21: The consumption of natural gas per sectors in Croatia from 2000 to 2013 (**Kišić, 2015**)

6. Discussion

Karasalihović-Sedlar et al. (2009) assess that the role of liquid fuels in the energy consumption in Croatia will remain significant and their share would not decrease significantly in the period from 2020 reaching to 2030. A rise in direct liquid fuel consumption of around 2% is expected in the period up to 2030.

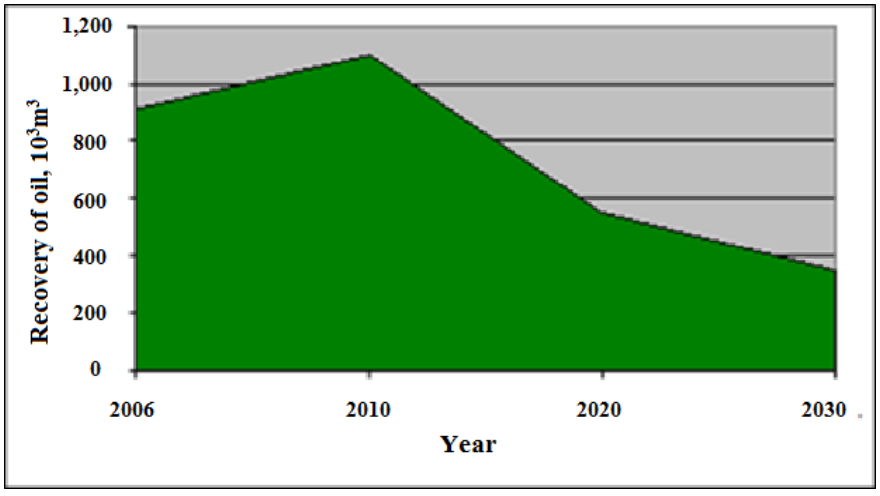


Figure 22: The projection of oil recovery in Croatia (**Karasalihović et al., 2009**)

Figure 22 shows a projection of oil and condensates in Croatia (according to **Karasalihović et al., 2009).** During the drafting of the projection for the period up to 2020, the future extraction of oil and condensates from existing local exploitation fields as well as the use of new technologies and methods for increasing recovery (EOR-*Enhanced Oil Recovery)* was taken into consideration. Based on the data from this scientific work, the decline in recovery is somewhat slower. Dependence on imported oil is expected to increase, ranging at around 80% for the last few years (see **Figure 11**), and rising to around 90% of total oil needs in Croatia by 2020. After 2020, the inclusion of the energy infrastructure in the infrastructure of the immediate and wider environment is of particular importance, as well as the diversification of

supply with new sources and ensuring new import routes, thus empowering the energy sector in Croatia. To enable development of strategic supplies of oil, it is necessary to ensure additional storage capacities.

For the last two decades, consumption of natural gas is steadily growing (see **Table 6 and Figure 12**), and natural gas is gaining an increasingly strategic role. It is predicted that the share of natural gas consumption in world energy consumption will rise from 23% today to almost 45% by 2050. In Croatia, according to **Hrnčević et al. (2008),** direct consumption of natural gas is expected to rise by 4,2% annually.

An assessment of future extraction of natural gas in The Republic of Croatia, in the period reaching to 2030, is shown on **Figure 23**. It is visible that natural gas extraction will decline in the future. According to assessments, import of natural gas will satisfy 50% of local needs in 2015, and up to 65% by 2020. It should be noted that these assessments are relatively accurate, since import accounted for 45% of the necessary quantities of natural gas in 2013, therefore somewhat less than anticipated (see **Figure 13**).

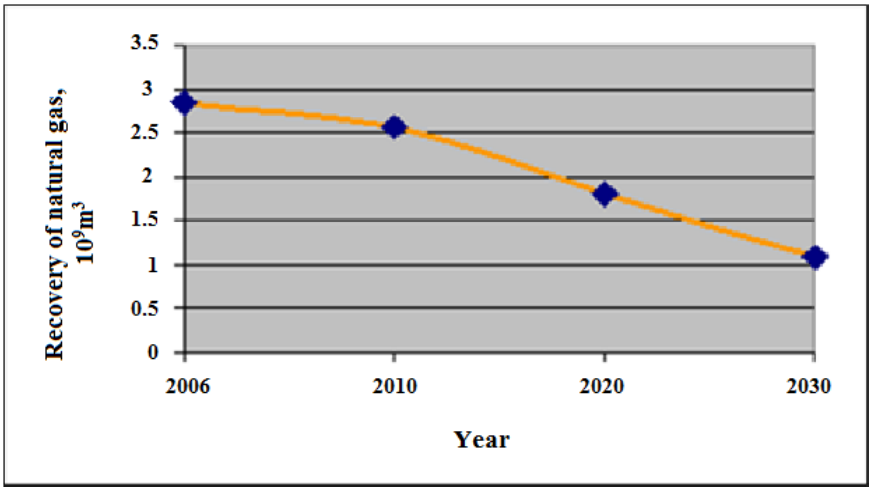


Figure 23: Evaluation of domestic recovery of natural gas in the period up to 2030 (**Hrnčević at al., 2008**)

By following the recorded trend of decreased extraction, by 2030, supply with locally extracted primary energy in Croatia will amount to somewhere between 21 and 23%. Considering the aforementioned estimations, it is evident that Croatia will be increasingly dependent on the import of energy.

7. Conclusion

The Republic of Croatia has a rich history in oil and natural gas extraction and processing. Currently around 60% of the needs for gas and 20% of the needs for oil are covered by local extraction.

Local extraction in Croatia is in decline, and in regards to expectations of increasing demand in the future, it will become necessary to import larger quantities. In the Croatian consumption balance sheet of primary energy, oil and petroleum products make up the largest share. That should certainly not change significantly in the following few decades. Only changes in the structure of petroleum products consumption are expected, with natural gas consumption shares on the rise. In regards to this state of affairs, Croatia should decrease its energy dependence on imported energy. It is necessary to construct an efficient energy infrastructure, which would guarantee the safety of supply, for which surely there are numerous solutions.

Extraction of oil and natural gas will continue to decline due to deposit depletion. Therefore, investment into new research is mandatory, as well as further development with secondary and tertiary methods. The Croatian segment of the Pannonian Basin System is a well-researched territory, however so-called residual hydrocarbons and satellite deposits are bound to exist, and numerous conducted research papers endorse their existence.

In the Northern Adriatic offshore, additional deposits of natural gas can also be expected, especially in parts that were not explored thoroughly. Considering the fact that import, as well as extraction from local deposit fields, is following consumption trends, it can be concluded that the situation in local extraction is not overly pessimistic.

Refinery operation is a pronouncedly complex process influenced by numerous factors, particularly the market. In order for our refineries to operate successfully, they must meet the demands of a constantly changing market. INA's refineries are in the process of technological restructuring, which should accomplish an increase in product quality and market price reflecting changes in the structure of petroleum product consumption.

Croatia can withstand the challenges of energy dependency by improving the efficiency of energy use, as well as by using alternative forms of energy such as renewable sources, which should increase in importance in total consumption. It is also important to ensure the diversity of import routes and storage capabilities of oil and natural gas, to ensure safety in delivery under hazardous conditions.

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Značajke pridobivanja i preradbe nafte i prirodnoga plina u Hrvatskoj u razdoblju od 2000. do 2014. godine

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Sažetak
U radu su analizirane značajke pridobivanja i preradbe nafte, kondenzata i prirodnoga plina u Republici Hrvatskoj od 2000. do kraja 2014. godine. Iznos bilančnih (eksploatacijskih) rezervi nafte i kondenzata kreće se od 9330,92 × 10^3 m^3 (2005. godina) do 13 471,08 × 10^3 m^3 u 2013. godini, dok količine njihova pridobivanja postupno opadaju od 1332,61 × 10^3 m^3 na 639,96 × 10^3 m^3. Odnos pridobivanja i rezervi postupno opada, što znači da blagi porast rezervi uopće ne utječe na količine crpljenja. Eksploatacijske rezerve prirodnoga plina tijekom promatranoga razdoblja uvelike osciliraju. Najveće su bile 2007. godine (40 919,70 × 10^6 m^3), a najmanje 2014. godine (17 932,98 × 10^6 m^3). Za razliku od tekućih ugljikovodika, odnos pridobivenih i eksploatacijskih količina raste i najveći je 2014. godine. Svekolike potrebe u Hrvatskoj za naftom (prikazano kao ukupna potrošnja sirove nafte) u 2013. bile su 3032,8 × 10^3 m^3 te plina 2809,90 × 10^6 m^3. Zanimljiv je podatak da potrošnja nafte brzo opada, što je povoljan trend sa stajališta emisije stakleničkih plinova. Dio se podmiruje iz vlastite eksploatacije, međutim ovisnost o uvozu nafte i prirodnoga plina i dalje je evidentna i kreće se od 75 % do 84 % (nafta), odnosno od 28 % do 46 % (prirodni plin) i to se jače ne mijenja. Količine prerađenih ugljikovodika postupno opadaju, poglavito motornoga benzina i loživoga ulja, dok dizelskoga goriva ostaju približno jednake. Iznimno su važna daljnja istraživanja te razvoj eksploatacije nafte i plina, poglavito ulaganjem u educiranje kadrova i nove tehnologije.

Ključne riječi
nafta, prirodni plin, rezerve, pridobivanje, preradba, Hrvatska

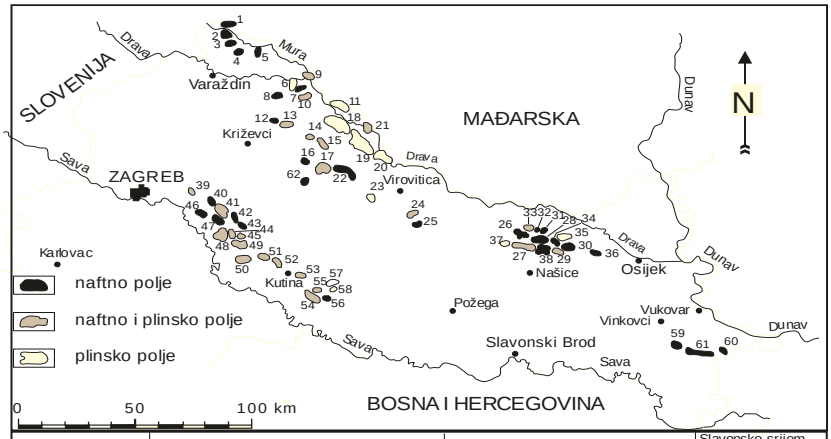
1. Uvod

Porast potrošnje svih oblika energije nameće rješavanje pitanja sigurnosti opskrbe u budućnosti, a posebice nafte i prirodnoga plina kao izrazito ključnih izvora energije i industrijske sirovine. Unatoč porastu potrošnje vidljivo je da je i danas više od polovice energije (59,4 %) u svijetu podrijetlom iz nafte (60 %) i prirodnoga plina (40 %), što će u odnosu na povećavanje njihovih zaliha ostati još razmjerno dugo, pri čemu prirodni plin dobiva sve veću ulogu u ukupnoj potrošnji energije. U tome je smislu zanimljiva planirana izgradnja plinovoda za dobavu prirodnoga plina u Europu nazvanih „Južni tok" i „Nabucco" (**Sučić et al., 2011**). Dakle, zalihe se povećavaju, a tzv. Hubertov maksimum (teorija o dostizanju pridobivenosti polovine dokazanih zaliha i maksimalnoga pridobivanja nafte nakon čega bi se one morale početi smanjivati) stalno se pomiče u budućnost uz spoznaju da fosilna goriva nastaju tijekom milijuna godina, a troše se nerazmjerno brzo. Primjerice, 1939. godine dostatnost nafte procijenjena je na 13 godina, a 1959. godine zalihe nafte (dokazane i izgledne) bile su 159 × 10^9 m^3 što je procijenjeno kao dostatno za sljedećih nekoliko desetljeća. Prema najnovijim dostupnim podatcima (**BP**, **2015**) rezerve nafte dostatne su za pridobivanje još 52 godine, a plina još 54 godine.

Dakle, nafta i plin ostaju i u budućnosti glavni energenti koji će se prema predviđanju upotrebljavati do 2050. godine, ali u kombinaciji sastavljenoj od ugljena, energije Sunca, vjetra, valova, strujanja u moru, nuklearne energije i dr. Budući da eksploatacija nafte i plina (ipak) ima svoj vijek trajanja, bitno je voditi brigu o njihovoj racionalnoj potrošnji i korištenju.

Cijena ugljikovodika pokazuje se kao važan čimbenik racionalne potrošnje. Naime, istraživanja postaju sve kompleksnija, u sve težim uvjetima, a samim tim i sve skuplja. Nafta i plin stoga će u budućnosti biti sve skuplji iako je cijena sirove nafte u drugoj polovici 2015. godine drastično pala; najniža je u zadnjih 12 godina.

Republika Hrvatska ima dugu i bogatu povijest iskorištavanja ugljikovodika (**Velić et al., 2010**, **Velić et. al., 2012**). Hrvatska naftna industrija ima tradiciju od 150 godina i često se predviđalo drastično smanjenje zaliha ugljikovodika s obzirom na to da su neobnovljivi. Međutim, analizom rezervi i pridobivanja pokazalo se da se rezerve stanovito održavaju, pa i povećavaju. Najstarije je polje Bujavica – prvo plinsko polje otkriveno 1917. godine koje je bilo aktivno do 1937. godine. Prvo znatno pridobivanje nafte počelo je 1941. godine iz ležišta polja Gojlo.



Murska depresija	Dravska depresija		Savska depresija		Slavonsko-srijem. depresija
1. Mursko Središće	10. Peteranec	25. Cabuna	39. Dugo Selo	51. Voloder	59. Privlaka
2. Zebanec	11. Gola-Ždala	26. Crnac	40. Lupoglav	52. Mramor-Brdo	60. Ilača
3. Selnica	12. Lepavina	27. Bokši ć	41. Kloštar Ivani ć	53. Gojlo	61. Đeletovci
4. Mihovljan	13. Jagnjedovac	28. Beničanci	42. Šume ćani	54. Lipovljani	
5. Peklenica	14. Mosti	29. Obod	43. Bunjani	55. Jamarica	
6. Veliki Otok	15. Čepel.-Hampovica	30. Števkovica	44. Hrastilnica	56. Kozarica	
7. Kutnjak-Đelekovec	16. Leti čani	31. Ku čanci-Kapelna	45. Vezišće	57. Janja Lipa	
8. Cvetkovec	17. Šandrovac	32. Krunoslavlje	46. Ježevo	58. Bujavica	
9. Legrad	18. Molve	33. Ladislavci	47. Ivani ć		
	19. Kalinovac	34. Obod-Laci ć	48. Žutica		
	20. Stari Gradac	35. Sje če	49. Okoli		
	21. Ferdinandovac	36. Bizovac	50. Stružec		
	22. Bilogora	37. Obradovci			
	23. Gakovo	38. Kloko čevci			
	24. Pepelana	62. Galovac-Pavljani			

Slika 1: Smjestišta naftnih i plinskih polja u hrvatskome dijelu Panonskoga bazena (**Velić, 2007**)

Slika 2: Smjestišta plinskih polja u Sjevernome Jadranu (**Velić, 2007**)

Intenzivne aktivnosti istraživanja i eksploatacije nafte i plina u Hrvatskoj traju zadnjih 70 godina te se danas na području hrvatskoga dijela Panonskoga bazenskog sustava (dalje u tekstu – HPBS) (**slika 1**) pridobivaju ugljikovodici iz 33 naftna polja, plinski kondenzat iz 9 plinskokondenzatnih polja te plin iz 17 plinskih polja. Istraživanje jadranskoga podmorja traje preko 40 godina, a pridobivanje prirodnoga plina ostvaruje se od 1999. godine iz ležišta 9 polja (**slika 2**).

Prema **Velić et al. (2010)** ukupne geološke rezerve iznose $740 \times 10^6\,m^3$ ekvivalenata nafte. Početne rezerve nafte iznose $112 \times 10^6\,m^3$, kondenzata $10{,}74 \times 10^6\,m^3$ te plina $100{,}67 \times 10^9\,m^3$ (**tablica 1**). Razlika između procijenjenih početnih rezervi i ukupno pridobivenih količina daje preostale rezerve koje su također prikazane u **tablici 1**, gdje su količine kondenzata označene u zagradi. Preostale rezerve nafte iznose $8{,}01 \times 10^6\,m^3$, a plina $35{,}76 \times 10^9\,m^3$. Prema preostalim rezervama **Dobrova et al. (2003)** svrstali su 2002. godine Hrvatsku na treće mjesto među državama središnje i istočne Europe, ali prema novim podatcima vrijednosti su preostalih rezervi niže (**Velić et. al., 2010, Malvić et al., 2011**).

I na kraju ovoga uvoda, jedna napomena o dostupnosti podataka: u **tablici 8** i **9** te na **slikama 8, 12, 14** do **22**, obradba se odnosi na podatke do 2013. godine.

Tablica 1: Početne rezerve, ukupno pridobivene te preostale količine ugljikovodika u Hrvatskoj (**Malvić et al., 2011**)

Dobrova et al. (2003)						**Velić et al. (2010)**					
Početne rezerve		*Ukupno pridobiveno*		*Preostale rezerve*		*Početne rezerve*		*Ukupno pridobiveno*		*Preostale rezerve*	
nafta	plin	nafta	plin	nafta	plin	nafta	plin	nafta	plin	nafta	plin
141,18	**108,11**	**109,70**	**26,16**	**31,48**	**81,95**	**112,06 (10,73)**	**100,67**	**104,45 (6,93)**	**64,91**	**8,01 (3,80)**	**35,76**
nafta $10^6\,m^3$; plin $10^9\,m^3$											

2. Rezerve nafte, kondenzata i prirodnoga plina

Eksploatacijske (bilančne, komercijalne ili P-rezerve (engl. *proven*)) rezerve nafte, kondenzata i prirodnoga plina promatrane za razdoblje od 2000. do 2014. godine u Republici Hrvatskoj prikazane su u **tablicama 2**, **3** i **4**, odnosno **slikama 3, 4** i **5.** U **tablici 3** te na **slici 3** prikazuju se odvojeno nafta i kondenzat. U eksploatacijske rezerve svrstavaju se utvrđene količine nafte, kondenzata i prirodnoga plina u ležištu koje se poznatom tehnikom i tehnologijom mogu rentabilno-komercijalno iskoristiti.

Eksploatacijske rezerve nafte i kondenzata do 2004. godine općenito su opadale. Tada su bile $9348{,}71 \times 10^3\,m^3$, što je u odnosu na stanje u 2000. godini 80 %. Od 2006. godine rezerve se povećavaju, osobito u 2013. godini, kada su iznosile $13\,471{,}08 \times 10^3\,m^3$. Uspoređujući rezerve odvojeno za naftu i kondenzate, uočljiv je nerazmjer; naime rezerve nafte rastu, dok su rezerve kondenzata pale s $3468{,}82 \times 10^3\,m^3$ u 2000. godini na samo $1435{,}47 \times 10^3\,m^3$ u 2014. godini, što je razlika od 40 %.

Što se tiče prirodnoga plina (**tablica 4**, **slika 5**), uočavaju se znatne oscilacije. Najveće rezerve bile su 2007. godine ($40\,919{,}70 \times 10^6\,m^3$) i od tada postupno opadaju – na $17\,932{,}98 \times 10^6\,m^3$. Uzroci su smanjeno ulaganje u istraživanja jer se HPBS smatra dobro istraženim, a većina ležišta gotovo je iscrpljena. O tome postoje i drugačija stajališta, prikazana npr. u radu **Velić, 2007.** Prema nekim istraživanjima koja su provedena za HPBS generirano je 2 do 4 puta više nafte nego što je utvrđeno u postojećim ležištima (**Malvić et al., 2011**). Iako su to možda precijenjene

vrijednosti, znatan dio rezervi ugljikovodika može se dobiti povećanjem iskoristivosti ležišta i otkrivanjem novih. U tome se smislu navodi stajalište **Velić et al. (2012)** da se važnija ležišta mogu očekivati u stijenama neogenske podloge (ispod repera Tg, odnosno PT unutar paleozojskih magmatita i metamorfita te mezozojskih sedimentnih stijena), uz rubove depresija ili gdje postoje izdignuća u paleoreljefu, te u stratigrafskim zamkama unutar miocenskih naslaga jer se one sastoje se od raznovrsnih litofacijesa iz vrlo različitih okoliša sedimentacije.

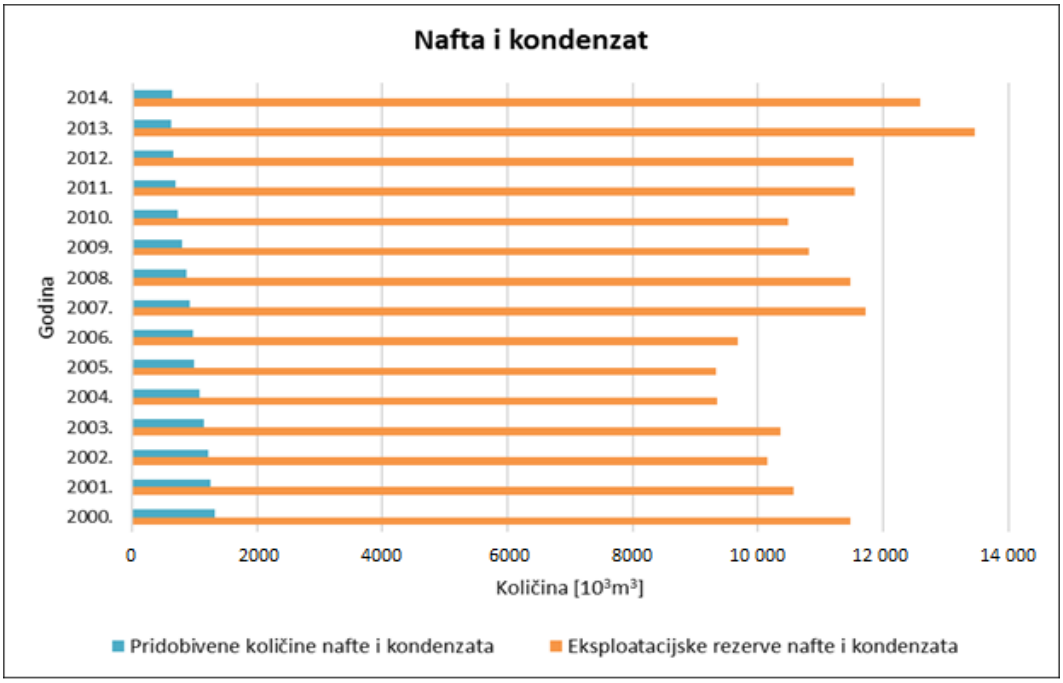
Tablica 2 i tablica 5: Eksploatacijske rezerve i pridobivanje nafte i kondenzata te uvezene količine sirove nafte i ukupna potrošnja sirove nafte u Hrvatskoj od 2000. do 2014. godine

	Tablica 2			**Tablica 5**		
	Preuzeto iz: *Godišnja bilanca stanja rezervi mineralnih sirovina Republike Hrvatske* – Ministarstvo gospodarstva			Preuzeto iz: *Energetska bilanca Republike Hrvatske 2003. – 2011. (Eurostat), Energija u Hrvatskoj 2012. – 2013.* – Ministarstvo gospodarstva		
Godina	**Eksploatacijske rezerve nafte i kondenzata** $[10^3\,m^3]$	**Pridobivene količine nafte i kondenzata** $[10^3\,m^3]$		**Uvezene količine sirove nafte** $[10^3\,m^3]$	**Ukupna potrošnja sirove nafte** $[10^3\,m^3]$	
	A	**B**	**B/A**	**C**	**D**	**C/D**
2000.	11 477,34	1332,61	0,116	-	-	-
2001.	10 564,45	1262,16	0,119	-	-	-
2002.	10 152,69	1217,40	0,120	-	-	-
2003.	10 356,13	1152,48	0,111	3814,20	5096,60	0,75
2004.	9348,71	1085,37	0,116	4250,90	5324,20	0,80
2005.	9330,92	1005,19	0,108	4049,50	5113,50	0,79
2006.	9689,11	977,49	0,101	3847,30	4856,30	0,79
2007.	11 719,10	930,10	0,079	4251,60	5177,00	0,82
2008.	11 472,48	867,87	0,076	3517,40	4508,30	0,78
2009.	10 823,58	807,45	0,075	4119,00	4919,20	0,84
2010.	10 481,58	743,93	0,071	3598,00	4362,00	0,82
2011.	11 554,00	697,50	0,060	2894,70	3444,20	0,84
2012.	11 531,60	659,32	0,057	2325,00*	3108,30*	0,75
2013.	13 471,08	636,78	0,047	2461,80*	3032,80*	0,81
2014.	12 597,80	639,96	0,051	-	-	-

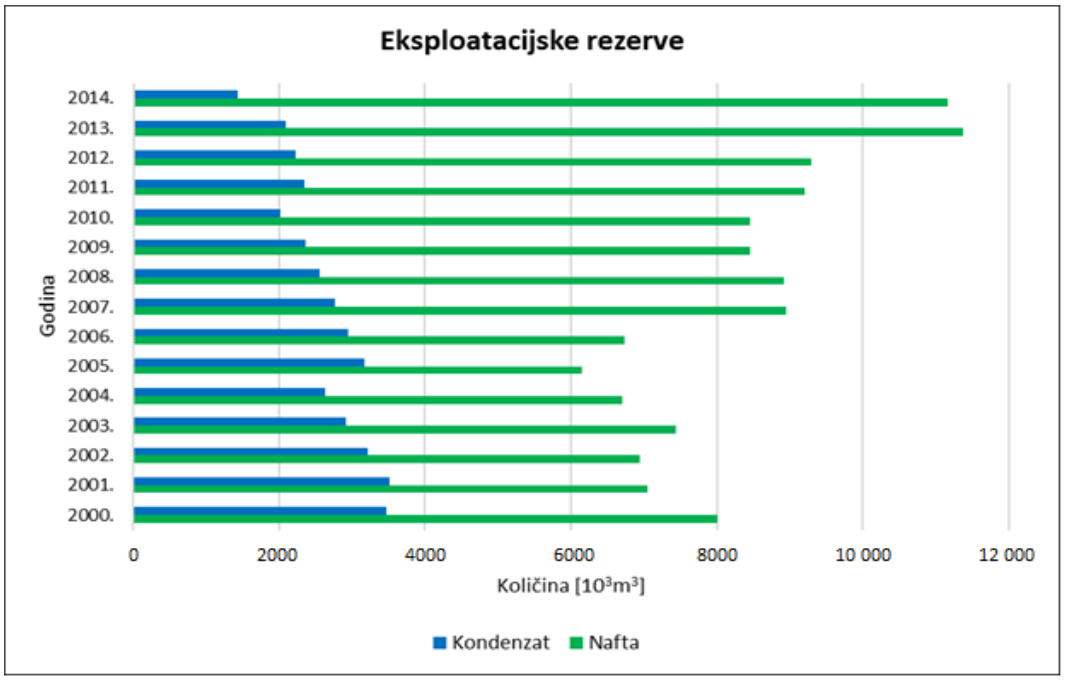
* podatci iskazani u 1000 tona

Tablica 3: Eksploatacijske rezerve i pridobivene količine nafte i kondenzata od 2000. do 2014. godine u Hrvatskoj

	Eksploatacijske rezerve nafte i kondenzata [10^3 m^3]		**Pridobivene količine nafte i kondenzata** [10^3 m^3]	
Godina	Nafta	Kondenzat	Nafta	Kondenzat
2000.	8008,52	3468,82	1003,87	328,74
2001.	7040,30	3524,15	934,35	327,81
2002.	6935,47	3217,22	906,95	310,45
2003.	7435,20	2920,93	853,00	299,48
2004.	6707,18	2641,53	802,62	282,75
2005.	6152,09	3178,83	745,59	259,60
2006.	6736,64	2952,47	728,65	248,84
2007.	8949,30	2769,80	702,19	227,91
2008.	8917,39	2555,09	653,15	214,72
2009.	8454,81	2368,77	619,65	187,80
2010.	8460,94	2020,64	563,11	180,82
2011.	9199,24	2354,76	528,45	169,05
2012.	9295,68	2235,92	511,68	147,64
2013.	11 370,71	2100,37	499,51	137,27
2014.	11 162,33	1435,47	518,27	121,69



Slika 3: Eksploatacijske rezerve i pridobivene količine nafte i kondenzata u Hrvatskoj od 2000. do 2014. godine



Slika 4: Eksploatacijske rezerve nafte i kondenzata u Hrvatskoj od 2000. do 2014. godine prikazano odvojeno

Tablica 4 i tablica 6: Eksploatacijske rezerve i pridobivanje prirodnoga plina te uvezene količine i potrošnja u Hrvatskoj od 2000. do 2014. godine

	Tablica 4			**Tablica 6**		
	Preuzeto iz: *Godišnja bilanca stanja rezervi mineralnih sirovina Republike Hrvatske* – Ministarstvo gospodarstva			Preuzeto iz: *Energetska bilanca Republike Hrvatske 2003. – 2011. (Eurostat)*, a podatci označeni zvjezdicom * iz: *Energija u Hrvatskoj 2012. – 2013.* – Ministarstvo gospodarstva (***3**)		
Godina	**Eksploatacijske rezerve prirodnoga plina** $[10^6\,m^3]$	**Pridobivene količine prirodnoga plina** $[10^6\,m^3]$		**Uvezene količine prirodnoga plina** $[10^6\,m^3]$	**Ukupna potrošnja prirodnoga plina** $[10^6\,m^3]$	
	A	**B**	**B/A**	**C**	**D**	**C/D**
2000.	29 204,51	1888,35	0,065	-	-	-
2001.	33 203,17	2851,87	0,086	-	-	-
2002.	35 906,14	2880,48	0,080	-	-	-
2003.	28 150,91	2278,40	0,081	827,40	2095,80	0,39
2004.	26 574,65	2352,25	0,089	855,60	2443,80	0,35
2005.	30 358,60	2432,42	0,080	921,00	2363,10	0,39
2006.	30 110,54	2863,70	0,095	914,80	2337,00	0,39
2007.	40 919,70	3001,04	0,073	856,80	2685,30	0,32

	Tablica 4			**Tablica 6**		
	Preuzeto iz: *Godišnja bilanca stanja rezervi mineralnih sirovina Republike Hrvatske* – Ministarstvo gospodarstva			Preuzeto iz: *Energetska bilanca Republike Hrvatske 2003. – 2011. (Eurostat)*, a podatci označeni zvjezdicom * iz: *Energija u Hrvatskoj 2012. – 2013.* – Ministarstvo gospodarstva (***3**)		
2008.	36 436,12	2847,18	0,078	996,30	2602,80	0,38
2009.	34 500,20	2819,07	0,082	848,00	2403,30	0,35
2010.	31 163,58	2833,22	0,091	868,60	2632,30	0,33
2011.	23 959,91	2571,46	0,107	711,50	2570,20	0,28
2012.	24 315,39	2086,38	0,086	1357,70*	2971,70*	0,46
2013.	21 368,61	1963,32	0,092	1270,40*	2809,90*	0,45
2014.	17 932,98	1824,03	0,102	-	-	-

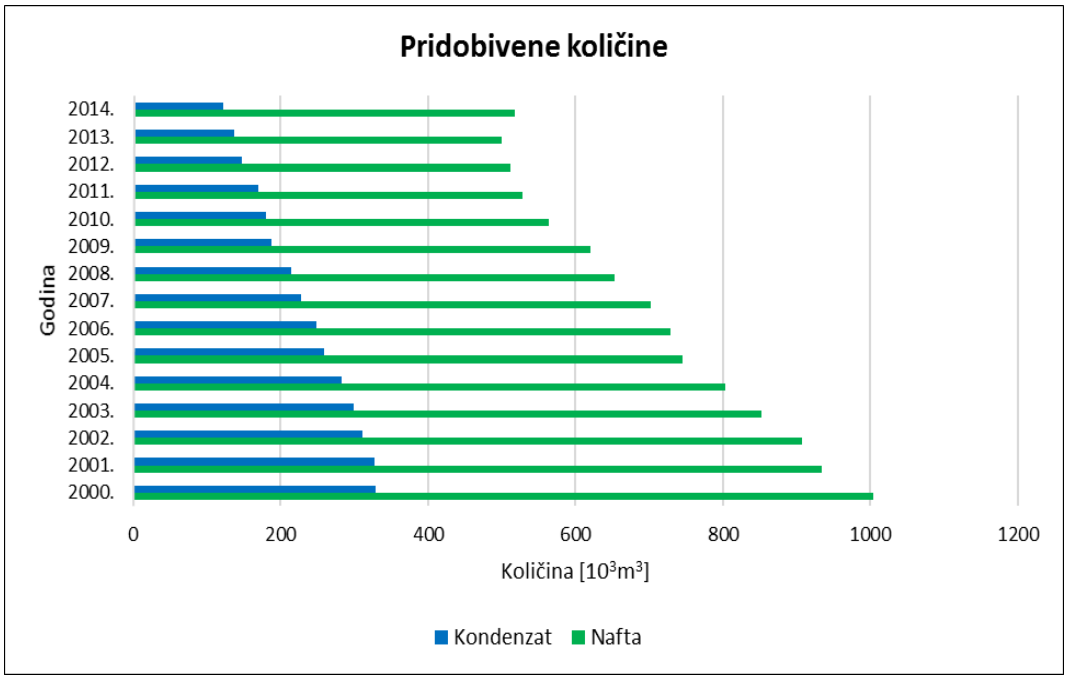
3. Pridobivanje nafte i prirodnoga plina

U Hrvatskoj se nafta pridobiva pomoću prirodne ležišne energije, zavodnjavanjem, plinskim liftom i dubinskim sisaljkama. Postignuti iscrpak za neka od najvećih hrvatskih polja iznosi samo 16 % (Žutica), no iz većine ležišta iscrpak je znatno veći, kao primjerice iz ležišta polja Kloštar 31 %, iz polja Stružec 39 % te čak 51 % iz polja Beničanci.

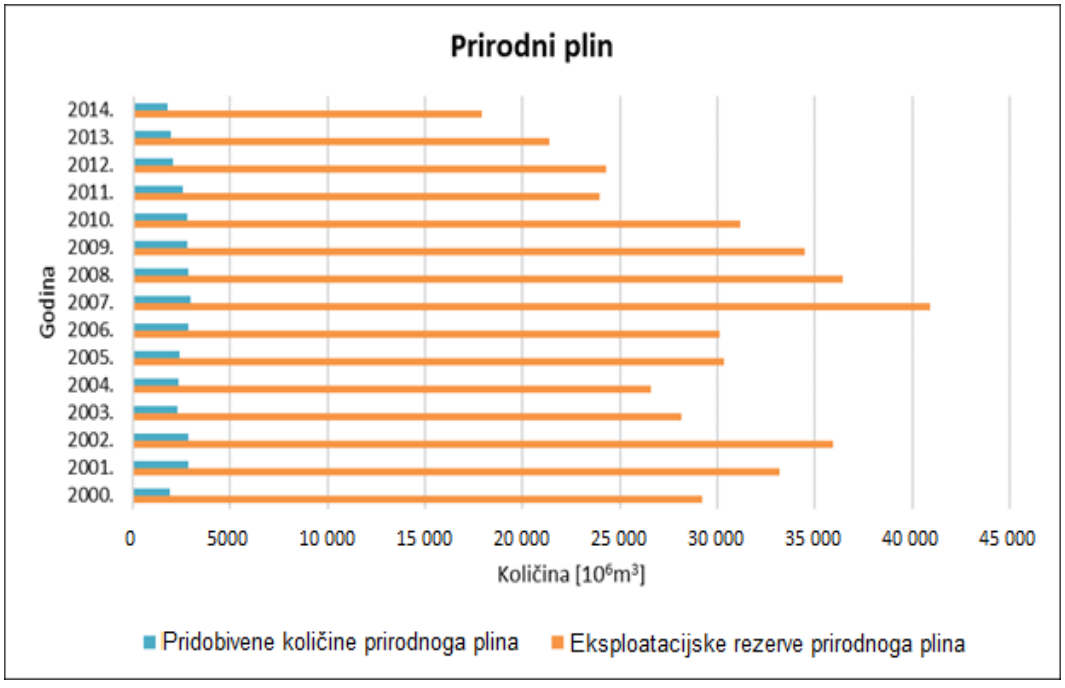
Najčešća sekundarna metoda jest utiskivanje vode, ali se istražuju i neke druge mogućnosti, kao primjerice primjena utiskivanja CO_2 pod uvjetima miješanja, što je testirano za 14 polja u laboratorijima INA-e (**Goričnik & Domitrović, 2003; Novak et al., 2013 a, b**) te analizirano i na Rudarsko-geološko-naftnome fakultetu Sveučilišta u Zagrebu (**Vulin, 2010, Novak, 2015**). Treba spomenuti i mišljenja o nekonvencionalnim ležištima ugljikovodika i načinima njihove procjene, što je svakako jedan od važnih podataka u planiranju rezervi i pridobivanja (**Rusan, 2014**).

Količine pridobivenih ugljikovodika razvrstanih kao nafta i kondenzat (tekući ugljikovodici) te prirodni plin prikazane su u **tablicama 2, 3** i **4** te na **slikama 3, 5** i **6**. Razvidno je da pridobivene količine nafte i kondenzata opadaju, i to od $1332{,}61 \times 10^3$ m^3 na samo $639{,}96 \times 10^3$ m^3 u 2014. godini (**tablica 2**, **slika 3**). Stanovite oscilacije rezultati su remontnih radova na naftnim poljima, što je dovelo do povećanja pridobivanja nafte u 2014. godini za 3,7 % u odnosu na 2013. godinu.

Količine prirodnoga plina stanovito osciliraju (**tablica 4**, **slika 5**). Prema **tablici 7** može se uočiti da je na početku promatranoga razdoblja najvažniju ulogu u ukupnome pridobivanju prirodnoga plina imala količina iz ležišta HPBS-a (odnos 7 : 1). Preokret označava 2009. odnosno 2010. godina, kada malo veći udio pridobivenoga plina ima jadransko podmorje, a na samome kraju promatranoga razdoblja, u 2013. godini, odnos je 1 : 1 (**slika 7**). Pad pridobivanja prirodnoga plina u 2014. godini od 6,4 % u odnosu na 2013. posljedica je zastoja bušaćih aktivnosti na polju Ika, restitucije na polju Anamaria i na ugovornome području Sjeverni Jadran te povećanja udjela vode na ugovornome području Aiza Laura.



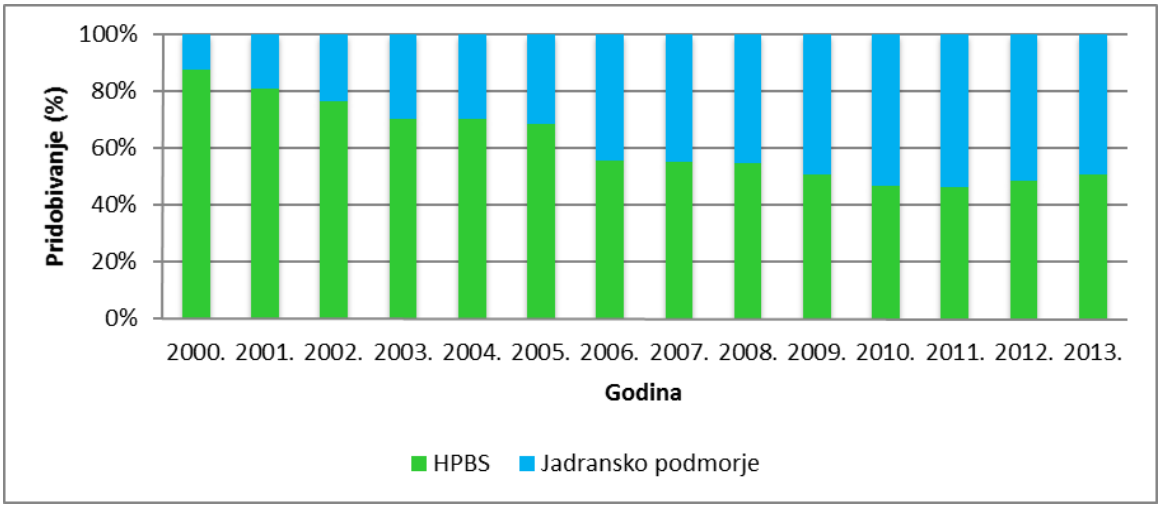
Slika 5: Pridobivene količine nafte i kondenzata u Hrvatskoj od 2000. do 2014. godine



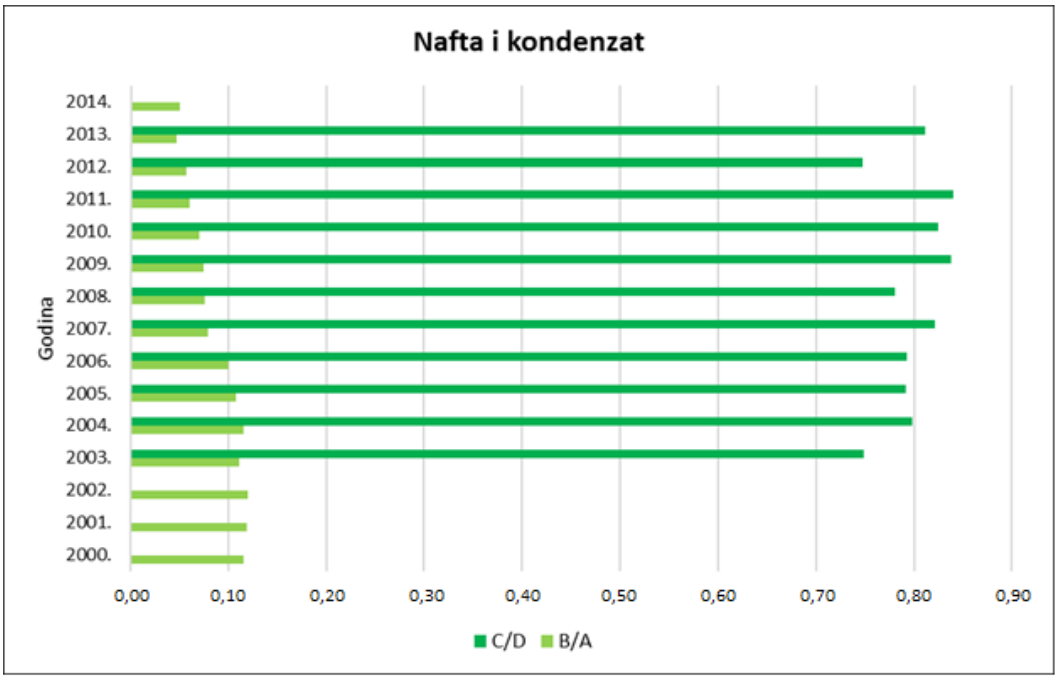
Slika 6: Eksploatacijske rezerve i pridobivene količine prirodnoga plina u Hrvatskoj od 2000. do 2014. godine

Tablica 7: Usporedba količine pridobivanja prirodnoga plina iz HPBS-a i jadranskoga podmorja

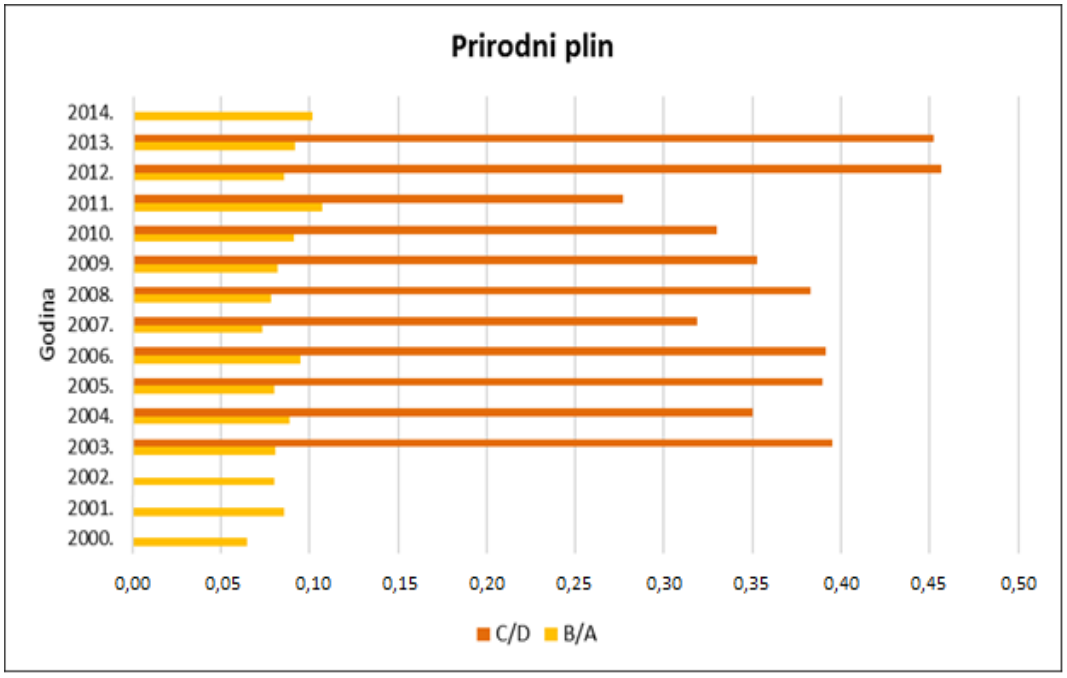
Područje pridobivanja prirodnoga plina	**HPBS**	**Jadransko podmorje**	**Odnos količina, HPBS / jadransko podmorje**
Godina	Količine A [10^6 m^3]	Količine B [10^6 m^3]	A/B
2000.	1654,15	234,19	7,06
2001.	2314,36	537,52	4,30
2002.	2199,17	681,31	3,23
2003.	1597,06	681,34	2,34
2004.	1678,01	712,55	2,35
2005.	1955,95	892,21	2,19
2006.	1747,38	1386,16	1,26
2007.	2084,14	1687,98	1,23
2008.	1930,95	1601,35	1,20
2009.	1737,94	1680,50	1,03
2010.	1577,08	1803,82	0,87
2011.	1378,44	1608,29	0,86
2012.	1145,20	1227,86	0,93
2013.	1177,64	1147,26	1,03



Slika 7: Histogram omjera pridobivanja prirodnoga plina iz HPBS-a i jadranskoga podmorja od 2000. do 2013. godine **(Kišić, 2015)**



Slika 8: Odnos pridobivenih količina nafte i kondenzata i eksploatacijskih rezervi (B/A) te odnos uvezenih količina sirove nafte i ukupne potrošnje (C/D) u Hrvatskoj od 2000. do 2014. godine (B/A i C/D iz **tablice 2**)



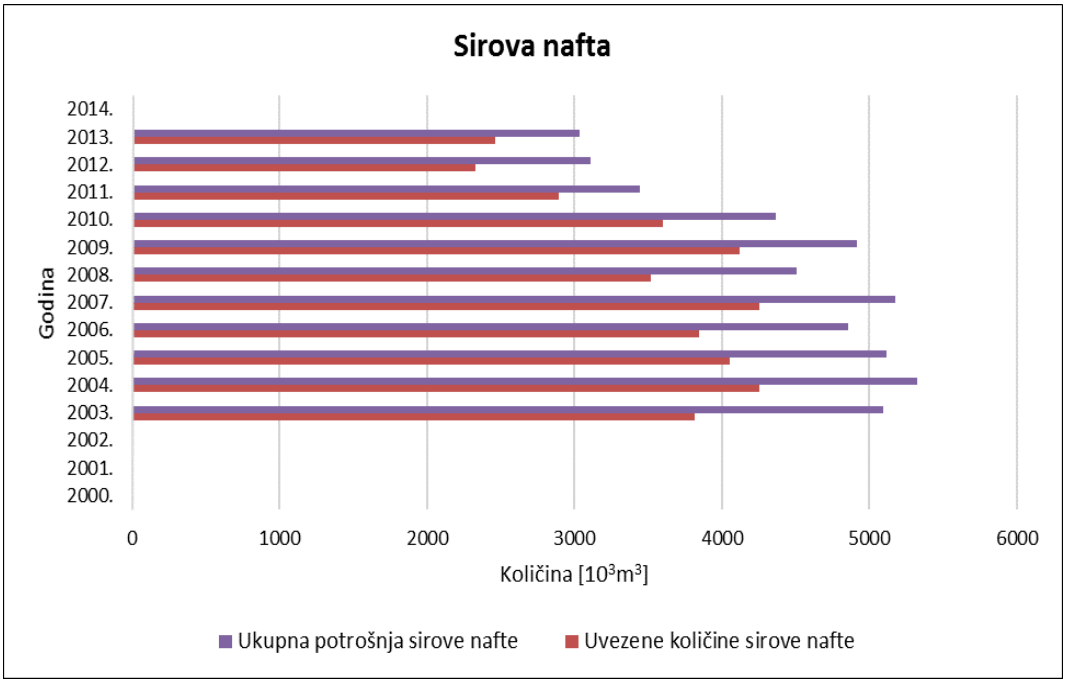
Slika 9: Odnos pridobivenih količina prirodnoga plina i eksploatacijskih rezervi i (B/A) te odnos uvezenih količina prirodnoga plina i ukupne potrošnje (C/D) u Hrvatskoj od 2000. do 2014. godine (B/A i C/D iz **tablice 4)**

U razmatranju rezervi i pridobivanja važan je i podatak kakav je odnos ukupnih rezervi i pridobivanja, također po promatranim godinama (**tablica 2** i **4**, **slika 9** i **10**). Općenito omjer „pridobivanje : eksploatacijske rezerve" za tekuće ugljikovodike postupno opada od 0,12 (2002. godina) na 0,051 u 2014. godini; ili, drugim riječima, na početku promatranoga razdoblja crpilo se oko 10 % rezervi, a na kraju oko 5 %. Pitanje je: zašto pridobivanje nafte i kondenzata opada iako se rezerve obnavljaju?

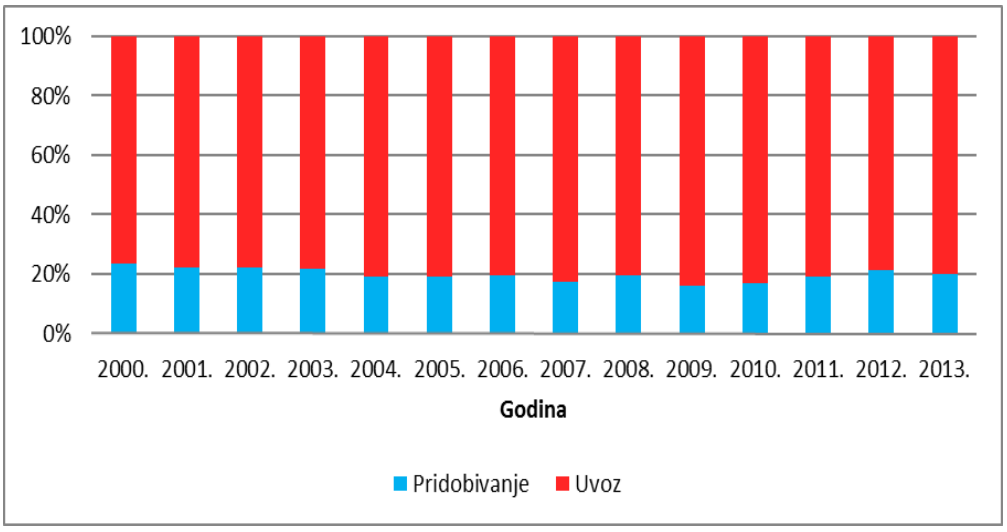
S prirodnim plinom situacija je drugačija. Idući prema 2014. godini, crpe se sve veće količine u odnosu na rezerve: od 6,5 % na početku pa do 10 % u 2014. godini. Jedan od spekulativnih zaključaka jest da se možda nafta čuva za budućnost, a plin se kao jeftiniji energent sve više eksploatira. Ili se radi o poslovnoj politici Ine?

4. Potrošnja i uvoz nafte i prirodnoga plina u Hrvatsku

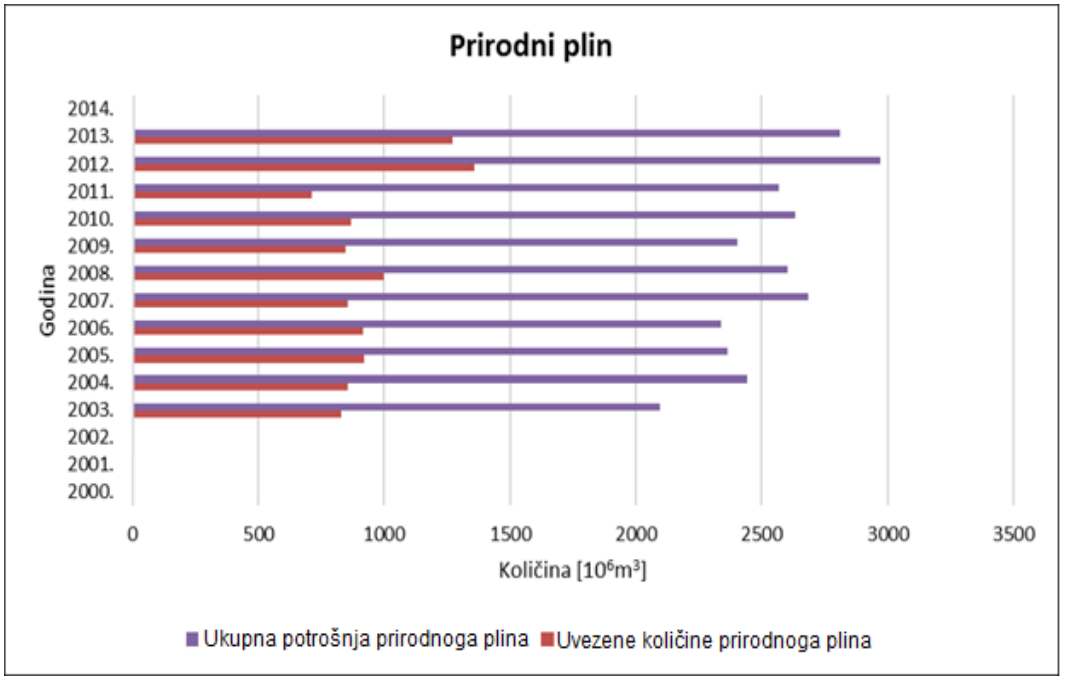
Republika Hrvatska svoje potrebe za ugljikovodicima samo djelomice podmiruje vlastitim pridobivanjem nafte i prirodnoga plina, što znači da veći dio uvozi. Tijekom promatranoga razdoblja, od 2000. do 2014. godine, ukupna količina uvezene sirove nafte iznosi 50 360 × 10^3 tona. Hrvatske potrebe za sirovom naftom recentno su oko 40 % manje, promatrajući od 2003. godine. Konkretno, od 5096,60 × 10^3 m^3 ukupna se potrošnja do 2013. godine smanjila na 3032,80 × 10^3 m^3. S tim u svezi od 2000. do 2014. godine količine uvezene nafte nepravilno, ali postupno opadaju (**tablica 5**). Ali u međusobnom odnosu, 20 % potreba podmiruje se iz hrvatskih izvora, a 80 % se uvozi i taj se omjer godinama bitno ne mijenja (**slika 10** i **slika 11**). Međutim, može se uočiti da je uvezena količina zadnje tri godine bila bitno manja (2325,00 × 10^3 m^3) u odnosu na najveću uvezenu količinu koja je ostvarena 2004. i 2007. godine (4251,60 × 10^3 m^3). Pritom količina nafte koja je pridobivena u Hrvatskoj ima pravilan trend opadanja. Ukupna potrošnja prirodnoga plina načelno postupno raste pa je tako u 2013. godini ona bila 2810 × 10^6 m^3. Da bi se zadovoljile potrebe, uvozi se oko 1300 × 10^6 m^3, što je 40 % hrvatske potrošnje (**tablica 6**, **slika 9**, **12** i **13**).



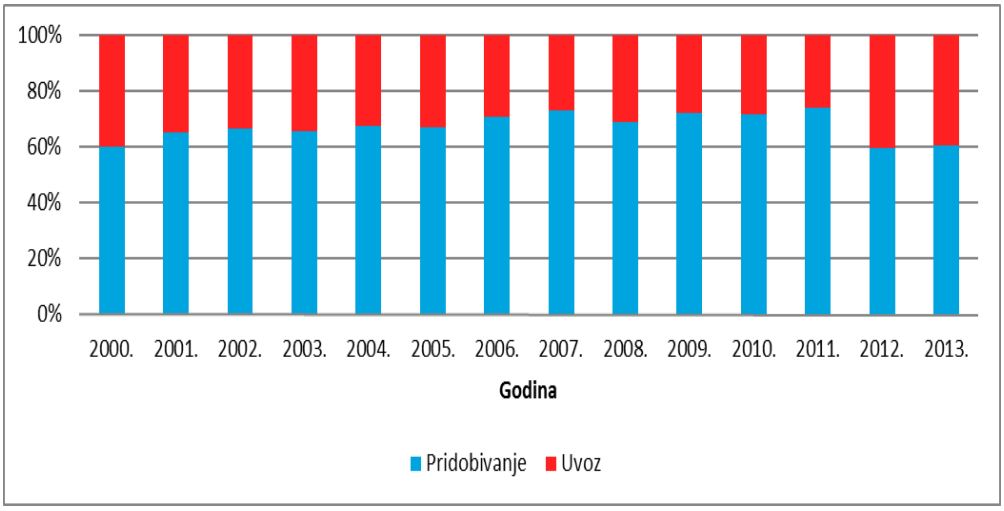
Slika 10: Ukupna potrošnja i uvezene količine sirove nafte u Hrvatskoj od 2000. do 2014. godine



Slika 11: Odnos domaćega pridobivanja nafte i uvoza nafte u Hrvatsku od 2000. do 2013. godine (**Kišić, 2015**)



Slika 12: Ukupna potrošnja i uvezene količine prirodnoga plina u Hrvatskoj od 2000. do 2014. godine



Slika 13: Odnos domaćega pridobivanja i uvoza prirodnoga plina u Hrvatsku od 2000.do 2013.godine (**Kišić, 2015**)

5. Preradba

Budući da sadržava mnogo vrsta ugljikovodika, među kojima postoje velike razlike u sastavu, tlaku parâ i vrelištu, nafta se ne može izravno upotrebljavati ni kao ekonomično gorivo ni kao kemijska sirovina. Uporabivi naftni proizvodi dobivaju se njezinom preradbom. Nafta se prerađuje u rafinerijama procesima odvajanja (separacija), pretvorbe (konverzija) i obradbe (čišćenje). Procesi odvajanja nazivaju se i primarnima, a procesi pretvorbe i obradbe sekundarnim procesima.

Po svojemu kemijskom sastavu nafta se pretežno sastoji od ugljikovodika te u manjemu dijelu od organskih spojeva s kisikom, dušikom i sumporom, a mogu biti prisutne i anorganske tvari npr. metali u vrlo malim količinama. Fizičko-kemijska svojstva nafte jako se mijenjaju ovisno o podrijetlu, odnosno o kemijskome sastavu nafte.

Prema **Sertić-Bionda (2006)** svojstva koja su bitna kod obradbe nafte većinom su određena neugljikovodičnim sastavom (sumpor, kisik i dušik). Organski sumporovi, kisikovi i dušikovi spojevi imaju tendenciju koncentriranja u naftnim frakcijama s višim temperaturama vrelišta i na taj način bez obzira na njihov početni sadržaj u sirovoj nafti znatno otežavaju obradbu tih naftnih frakcija. Ugljikovodični dio nafte većinom se sastoji od parafinskih, naftenskih i aromatskih organskih spojeva. Olefinski spojevi uobičajeno se ne nalaze u sirovoj nafti, kao ni acetilenski ugljikovodici.

Naftni derivati proizvodi su rafinerijske preradbe nafte, u prvome redu proizvodi atmosferske i vakuumske frakcijske destilacije koji se mogu izravno upotrijebiti kao gorivo ili kao sirovine za dobivanje različitih organskih spojeva. Najvažnije skupine naftnih derivata jesu naftni plin, petroleter, motorni benzin, dizelsko gorivo, mlazno gorivo, odnosno kerozin i petrolej (za mlazne motore), loživo ulje (lako i teško), mazivo ulje, bitumen i naftni koks, parafin (vosak) te olefinski i aromatski ugljikovodici kao petrokemijske sirovine, posebice etilen, propilen, benzen, toluen i ksileni.

Rafinerije u Hrvatskoj imaju dugu povijest i veliku ulogu u gospodarstvu. Preradba nafte u Republici Hrvatskoj odvija se u rafinerijama u Rijeci i Sisku te u pogonu Maziva u Zagrebu koji su u vlasništvu kompanije INA, d.d. U **tablici 9** nabrojeni su rafinerijski proizvodi. Naftni proizvodi koji nastaju preradbom najvećim su dijelom iz uvezene sirove nafte. Količina sirove nafte koja ulazi u rafinerije kreće se od 5 milijuna tona nafte na početku promatranoga razdoblja (2000. godina) do 3 milijuna tona (2013. godina). Iz kapaciteta kojima raspolažu hrvatske rafinerije (**tablica 8**) jasno se može uočiti da se preradba u promatranome razdoblju odvijala puno manjim kapacitetom od raspoloživoga. Ukupno ove rafinerije imaju kapacitet za preradbu atmosferskom destilacijom u iznosu od 9 milijuna tona godišnje. U Hrvatskoj se 2013. godine ukupno preradilo 3 milijuna tona sirove nafte, od čega su 2,4 milijuna iz uvoza.

Najveće količine odnose se na loživo ulje, dizelsko gorivo i motorni benzin. Osim rafinerijskih postrojenja i pogona za proizvodnju goriva i maziva INA se koristi i određenim opsegom potrebne mreže za distribuciju nafte i drugih proizvoda. Isporuka nafte rafinerijama obavlja se cjevovodima, a prijevoz drugih proizvoda morem, cestom i željeznicom uz korištenje skladišnih kapaciteta. Prodaja je organizirana kroz veleprodaju i razgranatu maloprodajnu mrežu.

Tablica 8: Kapaciteti preradbe u rafinerijama nafte u Republici Hrvatskoj

Kapaciteti preradbe	Instalirani (1000 tona/god.)
1. RAFINERIJA NAFTE RIJEKA (URINJ)	
atmosferska destilacija	5000
reformiranje	730
FCC	1000
visbreaking	600
izomerizacija	250
HDS/MHC	1040 – 560
hidrokreking	2600
2. RAFINERIJA NAFTE SISAK	
atmosferska destilacija	4000
reformiranje	720
FCC	500
koking	240
vakuumska destilacija	800
bitumen	350
3. MAZIVA ZAGREB	
maziva	60

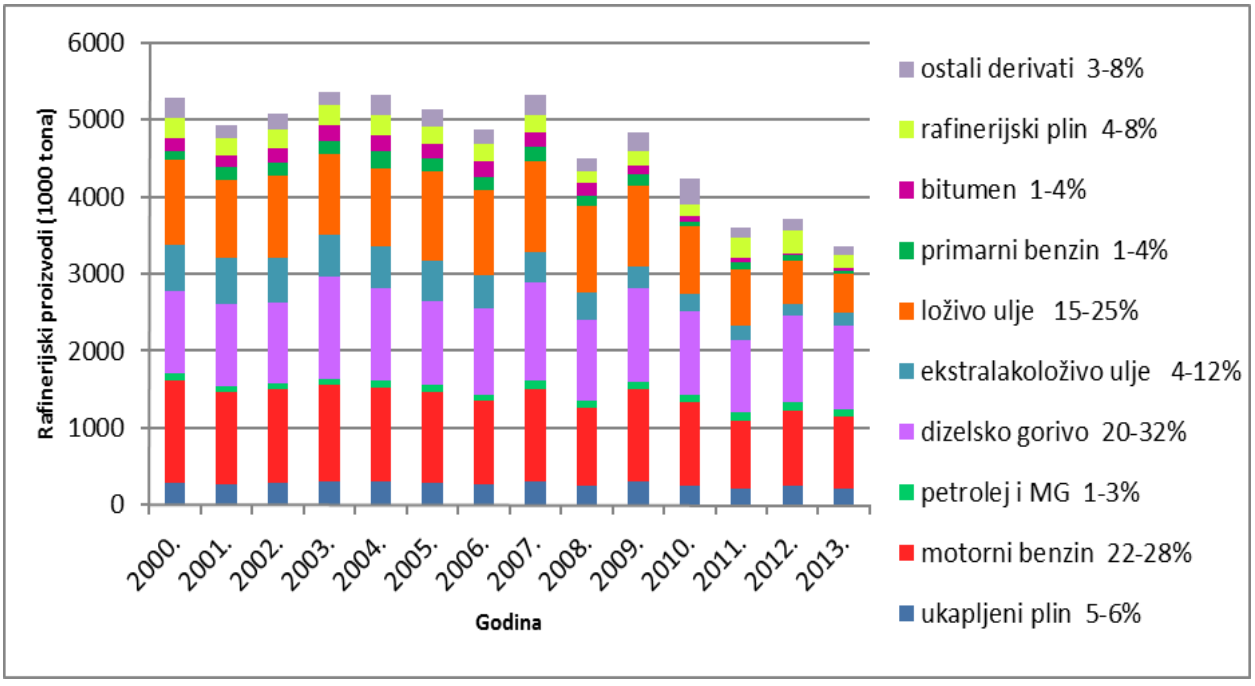
Najveći udio u ukupnoj potrošnji energije u Hrvatskoj ostvaruju tekuća goriva. Njihov udio iznosio je 43,4 % u 2008. godini te se do 2013. godine smanjio na 33,7 %. Osim udjela tekućih goriva u 2013. godini smanjio se još i udio prirodnoga plina i uvozne električne energije.

Ukupna količina naftnih derivata proizvedenih u Hrvatskoj od 2008. godine postupno opada, dok se uvezene količine ne mijenjaju. Sukladno tome krivulja je ukupne potrošnje u opadanju. Krivulja ukupne potrošnje plina pokazuje također postupno opadanje (**slika 20**) s naglašenim varijacijama količine plina za energetsku transformaciju (**slika 21**).

Primjetan je pad proizvodnje motornoga benzina i loživoga ulja, dok su proizvedene količine dizelskoga goriva približno ostale jednake u promatranome razdoblju. Na **slici 14** isti trend u opadanju može se uočiti i za ostale rafinerijske proizvode.

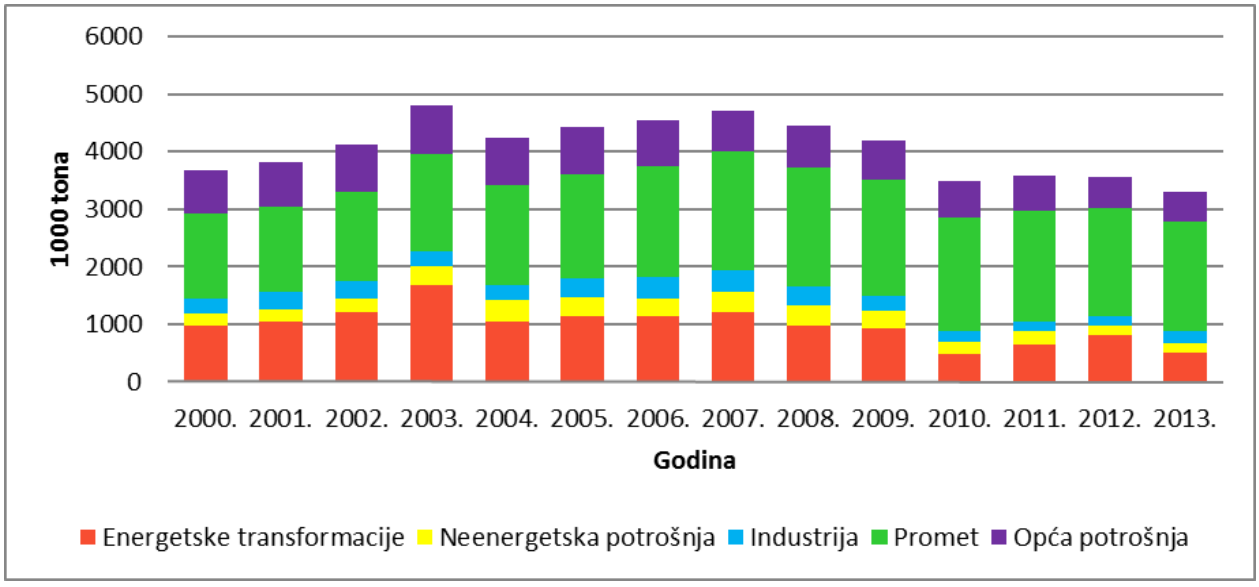
Tablica 9: Rafinerijski proizvodi u Hrvatskoj (*1, *2, *3)

Godina/(1000 t)	2000.	2005.	2010.	2013.
rafinerijski proizvodi – ukupna proizvodnja	5280	5139	4232	3357
ukapljeni plin	284	291	246	209
motorni benzin	1330	1168	1094	928
petrolej i mlazno gorivo	88	99	95	109
dizelsko gorivo	1064	1081	1079	1072
ekstralakoloživo ulje	603	522	228	169
loživo ulje	1111	1160	868	514
primarni benzin	103	177	66	30
bitumen	177	181	67	36
rafinerijski plin	262	241	162	175
ostali derivati	259	221	328	113



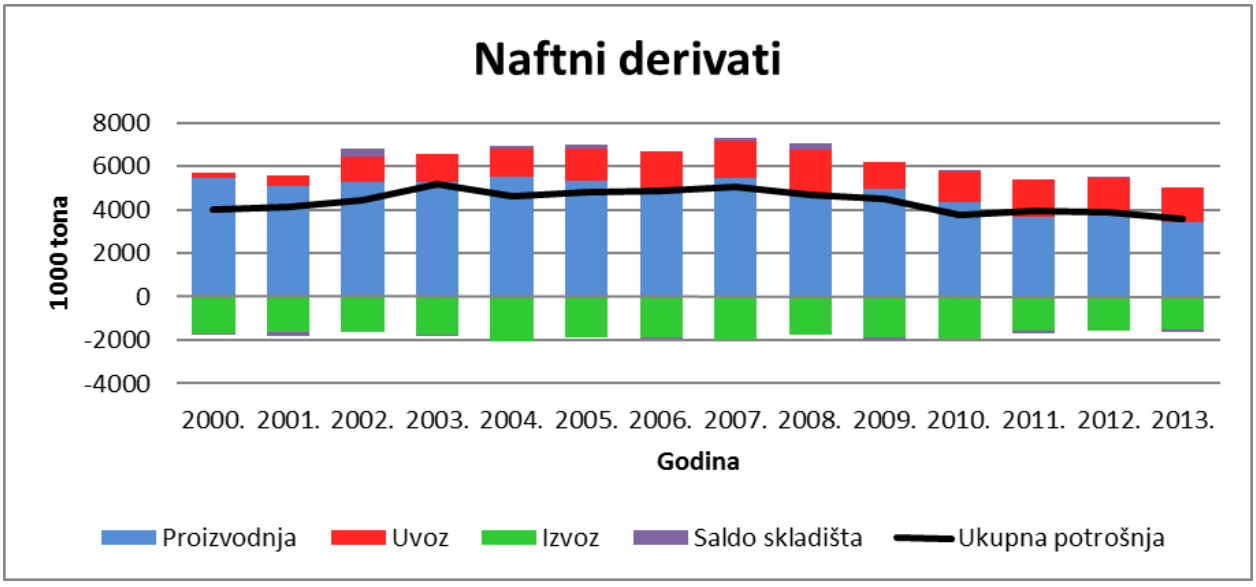
Slika 14: Rafinerijski proizvodi u Hrvatskoj od 2000. do 2013. godine izraženi u % (**Kišić, 2015**)

U navedenome razdoblju došlo je do promjena u strukturi potrošnje energije u prometu (**slika 15**), i to takvih da je udio dizelskoga goriva i mlaznoga goriva povećan, dok je udio motornoga benzina smanjen (**slika 16**, **17** i **18**). Zbog promjena u strukturi potrošnje tekućih goriva u prometu dizelsko i mlazno gorivo održali su gotovo jednaku vrijednost u proizvodnji (ili uz blago povećanje) za cijelo promatrano razdoblje.

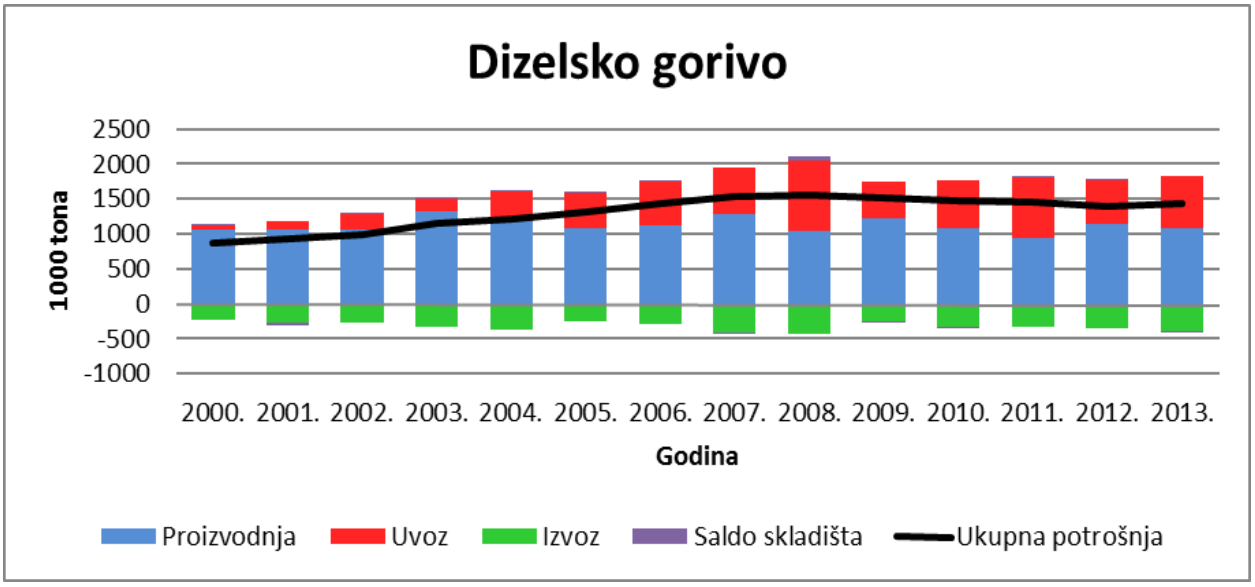


Slika 15: Upotreba naftnih derivata u Hrvatskoj od 2000. do 2013. godine (**Kišić, 2015**)

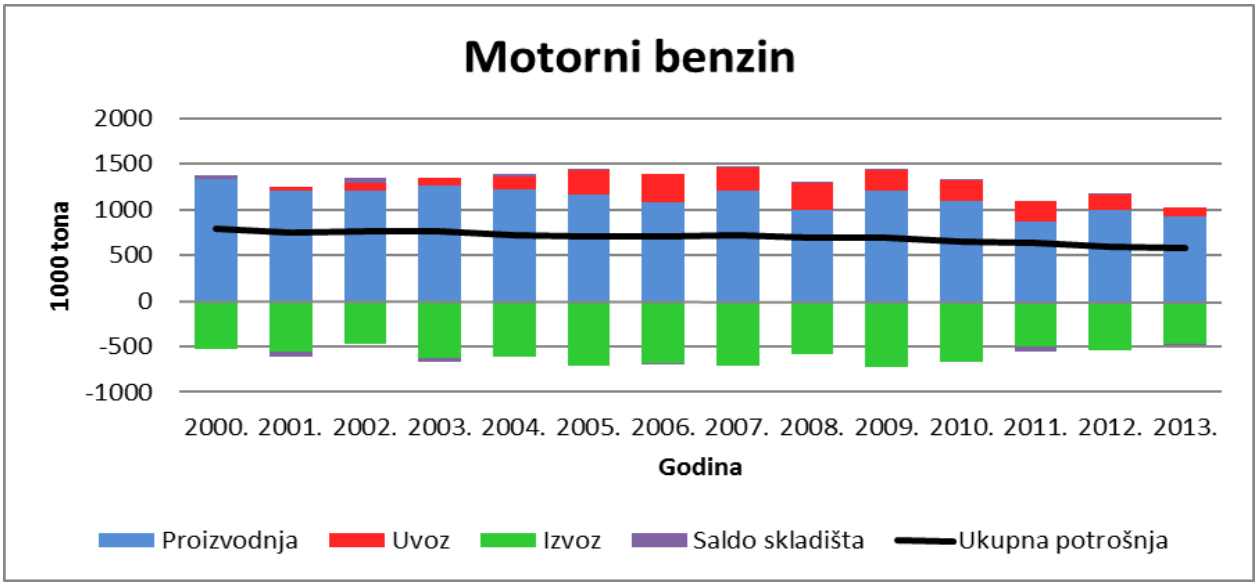
Današnja potrošnja energije manja je od potrošnje iz 1988. godine. Osim izravnih i neizravnih šteta nastalih tijekom rata (1991. – 1995.) hrvatski proizvođači dijelom su promijenili ciljano tržište. Tradicionalne gospodarske, ponajprije proizvodne grane mijenjaju se i dolazi do restrukturiranja gospodarstva, uz postupnu dominaciju sektora usluga i trgovine. Takvi trendovi odražavaju se na potrošnju. Najveći porast potrošnje ostvaren je 2007. godine, nakon čega se bilježi pad.



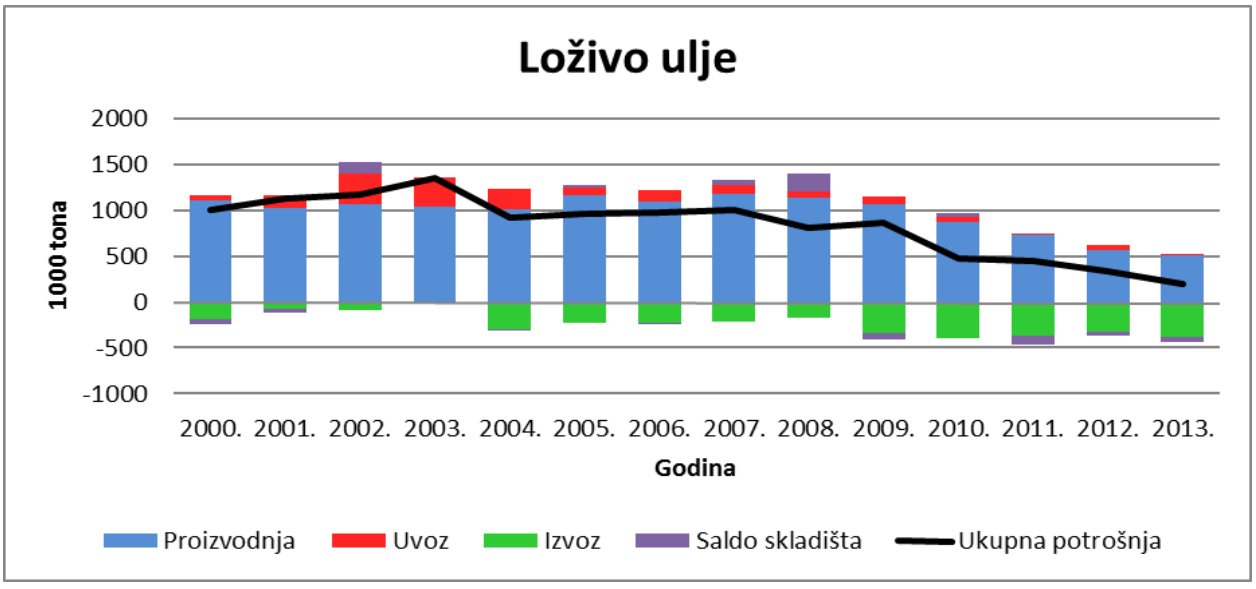
Slika 16: Ukupna količina naftnih derivata proizvedenih u Hrvatskoj, uvezene i izvezene količine od 2000. do 2013. godine te krivulja ukupne potrošnje (**Kišić, 2015**)



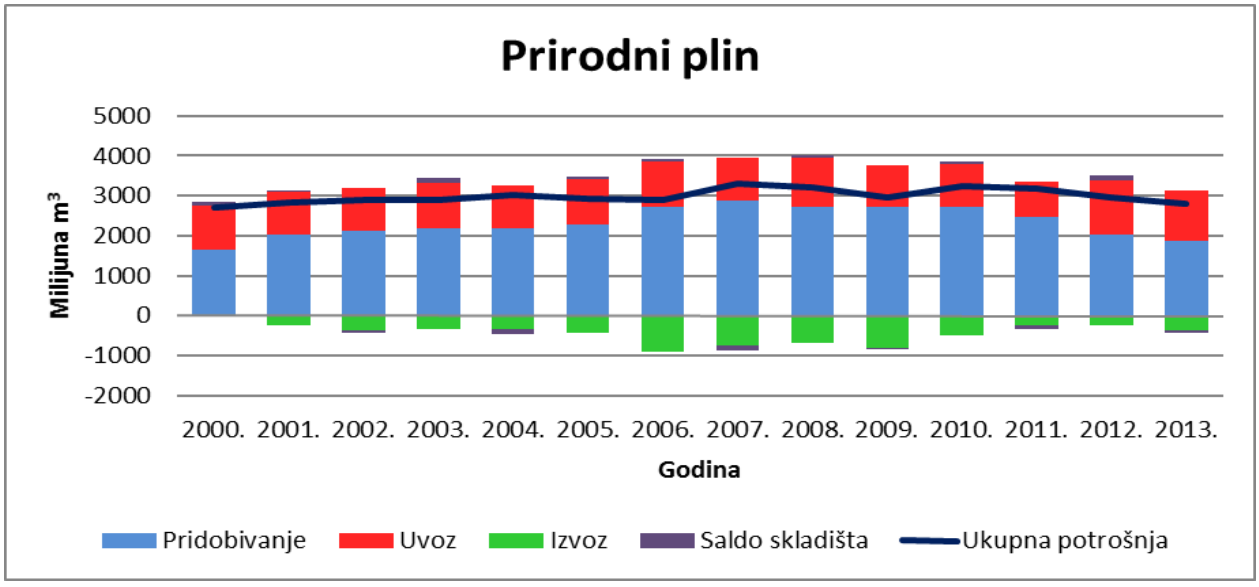
Slika 17: Ukupna količina dizelskoga goriva proizvedenoga u Hrvatskoj, uvezene i izvezene količine od 2000. do 2013. godine te krivulja ukupne potrošnje (**Kišić, 2015**)



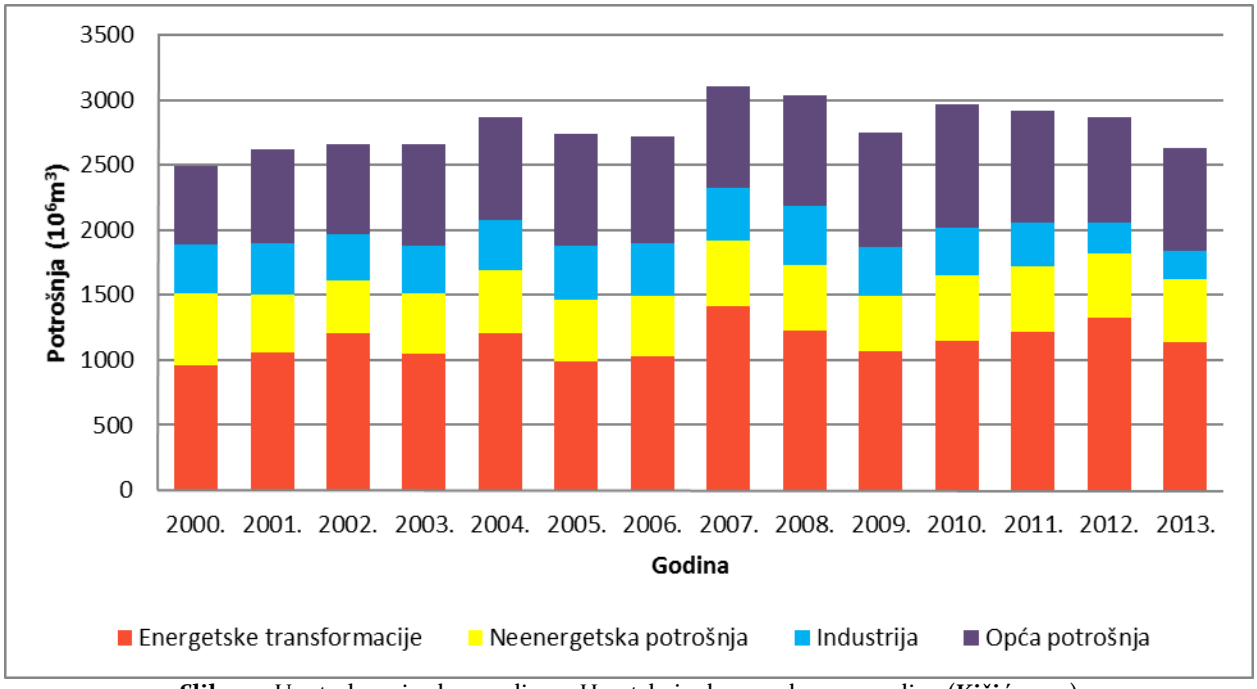
Slika 18: Ukupna količina motornoga benzina proizvedenoga u Hrvatskoj, uvezene i izvezene količine od 2000. do 2013. godine te krivulja ukupne potrošnje (**Kišić, 2015**)



Slika 19: Ukupna količina loživoga ulja proizvedenoga u Hrvatskoj, uvezene i izvezene količine od 2000. do 2013. godine te krivulja ukupne potrošnje (**Kišić, 2015**)



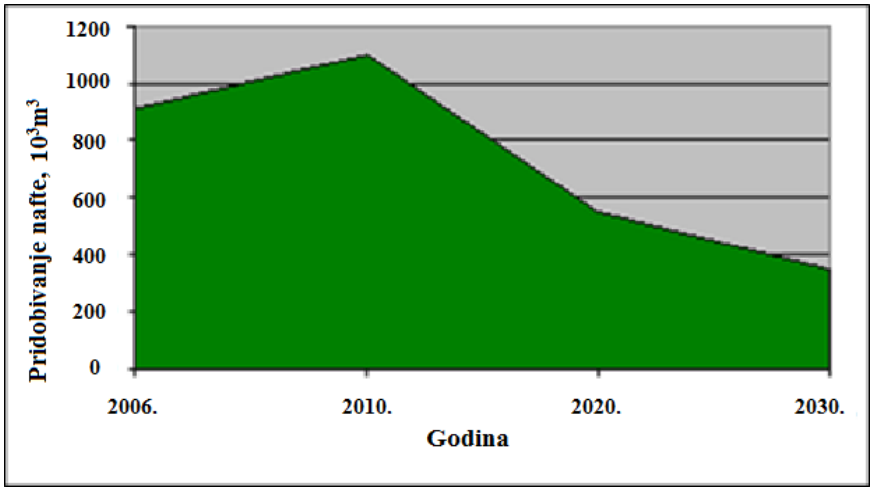
Slika 20: Ukupna količina pridobivenoga plina u Hrvatskoj, uvezene i izvezene količine od 2000. do 2013. godine te krivulja ukupne potrošnje (**Kišić, 2015**)



Slika 21: Upotreba prirodnoga plina u Hrvatskoj od 2000. do 2013. godine (**Kišić, 2015**)

6. Rasprava

Karasalihović Sedlar et al. (2009) procjenjuju kako će uloga tekućih goriva u energetskoj potrošnji u Hrvatskoj i dalje biti vrlo važna te da se njihov udio neće znatnije smanjivati u razdoblju do 2020., pa i do 2030. godine. Očekuje se porast potrošnje tekućih goriva u neposrednoj potrošnji od oko 2 % godišnje u razdoblju do 2030. godine.

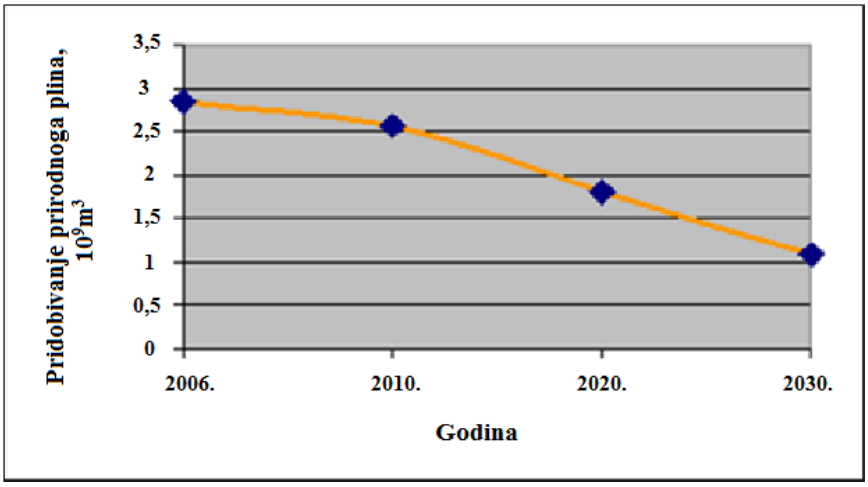


Slika 22: Projekcija pridobivanja nafte u Hrvatskoj (preuzeto iz **Karasalihović Sedlar et al., 2009**)

Na **slici 22** prikazana je projekcija pridobivanja nafte i kondenzata u Hrvatskoj (prema **Karasalihović Sedlar et al., 2009)**. Prilikom izradbe projekcije za razdoblje do 2020. godine u obzir je uzeto buduće pridobivanje nafte i kondenzata iz postojećih domaćih eksploatacijskih polja te korištenje novih tehnologija i metoda za povećavanje iscrpka (engl. EOR – *Enhanced Oil Recovery*). Na osnovi podataka iz ovoga rada opadanje pridobivanja ipak je nešto sporije. Predviđa se rast ovisnosti o uvoznoj nafti, koja se već niz godina kreće oko 80 % (**slika 11**), a što će

nakon 2020. godine činiti preko 90 % ukupnih potreba za naftom u Hrvatskoj. Nakon 2020. godine osobito važno postaje uključivanje energetske infrastrukture u infrastrukturu neposrednoga i širega okruženja te diversificiranje opskrbe novim izvorima i osiguranje novih pravaca uvoza, a time i osposobljavanje energetskoga sustava Republike Hrvatske. Kako bi se omogućio razvoj strateških zaliha nafte, potrebno je osigurati i dodatne skladišne kapacitete.

Posljednja dva desetljeća potrošnja prirodnoga plina postupno raste (**tablica 6**, **slika 12**), a prirodni plin dobiva stratešku ulogu. Predviđa se da će udio prirodnoga plina u svjetskoj potrošnji energije do 2050. godine porasti sa sadašnjih 23 % na gotovo 45 %. U Hrvatskoj se, prema **Hrnčević et al. (2008)**, predviđa porast potrošnje prirodnoga plina u neposrednoj potrošnji po stopi od 4,2 % godišnje.



Slika 23: Procjena domaćega pridobivanja prirodnoga plina u razdoblju do 2030. godine (**Hrnčević at al., 2008**)

Procjena budućega pridobivanja prirodnoga plina u Republici Hrvatskoj u razdoblju do 2030. godine prikazana je na **slici 23**. Vidljivo je kako će u budućnosti eksploatacija prirodnoga plina padati. Prema predviđanjima uvozom prirodnoga plina 2015. godine zadovoljavat će se 50 % domaćih potreba, a nakon 2020. godine već 65 % potreba. Treba spomenuti da su predviđanja razmjerno točna jer se u 2013. godini uvezlo 45 % od potrebnih količina plina, dakle nešto manje od predviđenoga (**slika 13**).

Prateći dosadašnji trend smanjenja pridobivanja, 2030. godine opskrbljenost ukupnom vlastitom primarnom energijom u Hrvatskoj će iznositi od 21 do 23 %. S obzirom na navedena predviđanja razvidno je da će Hrvatska sve više ovisiti o uvozu energenata.

7. Zaključak

Republika Hrvatska ima bogatu povijest pridobivanja i preradbe nafte i plina. Trenutačno se pridobivanjem s hrvatskih polja pokriva oko 60 % potreba plina i 20 % potreba nafte. Domaće pridobivanje u Hrvatskoj pada, a s obzirom na to da se u budućnosti može očekivati porast potrošnje nafte i plina, bit će potrebno uvoziti još veće količine. U hrvatskoj bilanci potrošnje primarne energije nafta i naftni derivati sudjeluju s najvećim udjelom. To se zasigurno neće znatnije promijeniti u narednih nekoliko desetljeća. Očekuju se samo promjene u strukturi potrošnje naftnih derivata te prirodnoga plina koji dobiva sve veću važnost u ukupnoj potrošnji. S obzirom na takvo stanje Republika Hrvatska mora ublažiti svoju energetsku ovisnost o uvoznoj energiji. Potrebno je izgraditi dobru energetsku strukturu koja će jamčiti sigurnost opskrbe, a za to zasigurno ima mnogobrojnih načina.

Pridobivanje nafte i prirodnoga plina zbog iscrpljenja ležišta i dalje će opadati. Zbog toga treba ulagati u nova istraživanja, ali i razradu sekundarnim i tercijarnim metodama. Hrvatski dio panonskoga bazenskog sustava dobro je

istraženo područje, ali tzv. zaostali ugljikovodici i satelitska ležišta svakako postoje, na što upućuju rezultati dosadašnjih svekolikih istraživanja. U Sjevernome Jadranu također se mogu očekivati dodatne količine plina, posebice u dijelovima koji do sada nisu detaljno istraženi. S obzirom na to da uvoz, a onda i pridobivanje na domaćim eksploatacijskim poljima, prati trendove potrošnje, može se zaključiti da situacija s domaćim pridobivanjem i nije pesimistična.

Poslovanje rafinerija izrazito je kompleksan proces koji je pod utjecajem mnogobrojnih faktora, a osobito je pod utjecajem tržišta. Kako bi naše rafinerije poslovale uspješno, moraju odgovarati zahtjevima na tržištu koji se stalno mijenjaju. Inine rafinerije u procesu su tehnološke obnove, čime bi se trebalo ostvariti dobivanje kvalitetnijih proizvoda koji bi postizali bolju cijenu i koja će biti u skladu s promjenama u strukturi potrošnje naftnih derivata.

Republika Hrvatska izazovima energetske ovisnosti može se oduprijeti i poboljšanjem učinkovitosti uporabe energije te korištenjem drugih oblika energije kao što su obnovljivi izvori energije, koji bi trebali dobiti sve veću ulogu u ukupnoj potrošnji. Također je bitno osigurati raznolikost dobavnih pravaca i mogućnosti skladištenja nafte i plina kako bi se u nesigurnim uvjetima mogla jamčiti sigurnost opskrbe.

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