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OIL AND GAS COMPLEX OF UKRAINE SYSTEM ANALYSIS

Abstract: *In the article the problem of reforming of an oil and gas complex, creation of a favorable investment climate is considered. The economic-mathematical model of forecasting of extraction of energy resources which allows predicting and estimating of volumes, terms, and a recoupment of capital investments is constructed.*

Keywords: *investments, energy resources, oil and gas deposits, gross revenue, gross costs, a mathematical model, and differential equation.*

JEL Classification : C22, C41, C53, O11, Q4.

1. Introduction

The actuality of Oil and Gas Complex analysis consists in a substantiation of new ways to support the economy of Ukraine by energy carriers. The current situation of an Oil and Gas Complex of Ukraine is substantially caused by the absence of a consecutive approach in objects reforming of fuel and energy complex and formation of the market environment in this sphere, and also inconsistency of the reforming processes in the power system with economic relations reforming processes which occur now in Ukraine.

As of today we have the most energetically dependent economy in the world. In connection with acceptance of new members. The European Union considers possibility of further expansion of gas networks. The perspective program provides the creation of new transit routes for deliveries of diversification and dependence reduction on the separate third countries. By the Program INOGATE (Interstate Oil and Gas Transport to Europe) which is designed for 5—10 years, it is providing 5 priority gas projects.

- Project NG 1 provides the construction of a new gas pipeline for Russian gas supplies to Great Britain, Germany, Denmark, Sweden, the Netherlands and Belgium.
- Project NG 2 — new gas pipelines from Algeria to supply gas to Spain, Italy, France and other EU countries.

- Project NG 3 which will improve a gas-transport network of South—East region of EU, opens gas import from Caspian Sea region through Turkey, Bulgaria, Romania, Hungary and Austria, and also through Turkey, Greece and Italy.
- Project NG 4 is an expansion of active and building of new terminals to receive compressed natural gas (CNG) to France, Spain, Portugal and Italy, and also to Poland, Greece and Cyprus.
- Project NG 5 provides creation of new underground gas storehouses in Spain, Portugal, Italy, Greece and region of Baltic Sea to ensure gas storage in the volumes equal to volumes of gas which are in external sources within 60 days.

Additional priority project NG 6 provides creation of the East Mediterranean gas ring for maintenance of giving of gas from Egypt and Libya to Italy and other countries of Southern Europe. Volumes of gas transit are stabilized or will slightly grow, though their specific weight in gas supplying of Europe will decrease by degrees. Therefore the basic accent is necessary to make on support of a modern technological level of Ukrainian gas-transport system successfully to compete in the market of transit services.

2. Problem Definition

In the given work the problem of oil and gas extraction increasing is analyzed. We will consider existing oil and gas extraction, level of deposits exhaustion, the established resources in water areas of the Black and Azov Seas, investments volumes that are necessary for new wells development, strategic directions of oil and gas complex development. We will construct an economic-mathematical forecasting model of energy resources (oil and gas) extraction.

3. Results

The analysis of oil and gas extraction dynamics. For high-grade functioning of economy of Ukraine it is necessary for 40 million tons of oil and gas. The mid-annual oil recoveries over the last ten years from own deposits constitute about 4 million tons. For Ukraine the satisfaction of needs in their own oil constitutes 10 %. A similar picture concerning satisfaction of needs is in gas. At its mid-annual extraction in Ukraine (20 billion cubic meters per year) the need of industry and population constitutes 100 billion cubic meters per year that is 25 % of a cover. During the period of 1990-2000 oil recovery with condensate was decreased in 1,4 time, natural gas — in 1,5 times. For this period standard payments for subsoils to extract mineral raw materials more as in 4 times have grown. Were canceled reducing factors for basic specifications of the majority kinds of minerals, it has led to increasing of payments 5 times. For the majority kinds of minerals production rates declined for 2002 to an average volume for 1997-2002 4 times lower than the data for 1997. So, the falling of oil recovery volumes for 2002 concerning average volume constitutes 1,4 %, to 1997 — 10,3 % to 2000 — 0,3 %.

Thus, the oil and gas complex does not satisfy the needs of the economy of

Ukraine in oil and gas. It, first of all, depends on exhaustion of many oils and gas deposits, and also decreasing of exploration work volumes.

The level of deposits exhaustion. Level of deposits exhaustion in the basic oil and gas regions of Ukraine is evaluated as follows: by oil — closed to 70 %, by gas — closed to 65 %. The real resource base is estimated in 69,3 million tons of oil with a condensate and 223,9 billion cubic meters of gas. Security of oil with condensate extraction in modern volumes constitutes 20 years, and gas — 13 years. Besides, long-term deposits operation has led to a significant depleting of easily extracted stocks: 56,4 % of oil with condensate and 12,1 % of gas belong to hard extracted (tab. 1 [4]).

Table 1. Indicators of working out of the greatest oil, gas and gas-condensate fields of Ukraine

Deposit	The year of discovery	The year of development beginning	Primary stocks of oil, thousand ton; gas, million m^3; gas-condensate, million ton		Production on01.01.01		Amount of wells	Recovery ratio	
			Balance	Produced	Oil, K ton	Oil gas, million m^3; gas, million m^3; gas-condensate, million ton		The design total	Current on 01.01.01
Petroleum deposit									
The Dolinsky	1950	1950	113760	38390	36751	10340	192	0,337	0,318
The Kachanovsky	1957	1961	37906	17291	17214	4191	99	0,456	0,448
Glinsko-Rozbishivskoe	1958	1959	50276	26675	16748	1824	97	0,530	0,326
The Gnidintsivsky	1959	1961	61120	38045	38038	1479	100	0,622	0,621
The Leljakovsky	1962	1964	83696	52364	49796	4138	121	0,625	0,594
The Anastasevsky	1971	1973	40587	16502	13262	–	18	0,407	0,326
Gas and gas-condensate deposits									
The Shebelinsky	1950	1956	656000 (13,000)	8,320*	–	590046 (7,54)	556	0,64	90,8** (0,58)
West Hrestishchensky	1968	1970	318178 (22,027)	12,912*	–	281180 (7,10)	138	0,61	0,84** (0,55)
The Efremovsky	1965	1967	119971 (3,328)	2,856*	–	66095	67	0,85	0,61** (0,48)
The Jablunevsky	1977	1983	101773 (12,486)	9,219*	–	41698	48	0,68	0,39** (0,35)

* Extracted stocks of a gas condensate, other indicators of a gas condensate are resulted in brackets.
** The part of extracted gas from current balance stocks.

The explored resources in water areas of the Black and Azov Seas. Approximate quantity of oil in the Northern-Western shelf of Black Sea according to accounts of "UkrTatNeft" is about 604 million tons of conditional fuel and 306 million

more tons in a deep-water gulf [2]. As of today it is known three wells in the Northern-Western shelf of Black Sea: the Golitsinsky, the Storm, and the Arkhangelsk. The data of satellite photographing has shown that on depth of 55-65 meters of water there are significant gas torches which testify oil and gas availability about.

In Ukraine the maximum level of hydrocarbons extraction (in the middle of 70 years) was ensured by operation of ten the greatest oil and gas deposits that are exhausted today on 90—98 %.

Within the exclusive (marine) economic area of the Black and Azov Seas till the end 2010 it was provided to prepare 55 new very perspective objects a total area of 1580 sq. km with resources in 650 million tons of oil and a gas-condensate (figure 1) [3].

It is necessary to increase volumes of exploration work and stock addition of hydrocarbons in Ukraine which as a whole are evaluated almost in 5 billion tons of conditional fuel. The third of not explored resources of gas and 19% of not explored oil supplies contains in water area of the Black and Azov Seas.

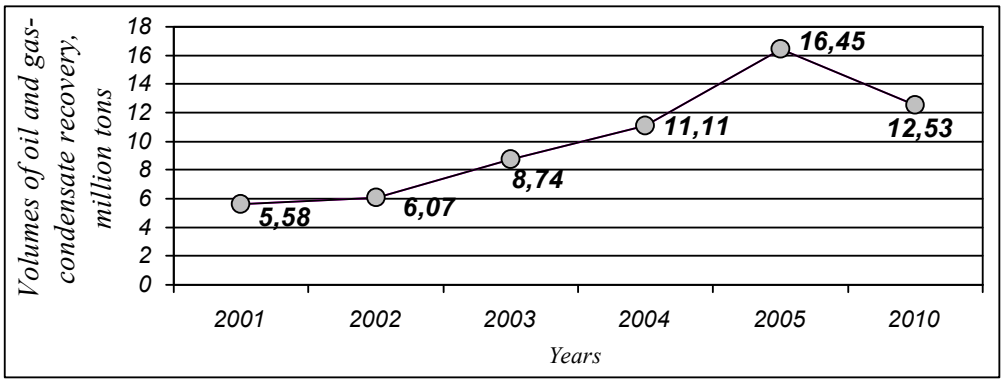

Figure 1. Stock addition of oil and gas-condensate (million tons)

By the Decree of the Cabinet Council of Ukraine №1141 from 6/17/1999 had been approved «The Program of hydrocarbon resources development of Ukrainian sector in the Black and Azov Seas» which was not executed as the acts of low directed on investment appeal increasing of the program and filling by its real means till now have not been accepted.

Volumes of capital investments. For capital investments it is necessary to analyze an existing condition of going oil and gas complex concerns and to justify needs of production (fig. 2). On figure 2 we see that volumes of capital investments in oil and gas extraction every year decrease. If in 2002 the sum of funds for exploration works has constituted 90,3 million UAH, in 2003 it has decreased to 50 million UAH and at that in 2003 the budget of Ukraine has received from the tax for exploration

works 352,4 million UAH, and in 2004 — 424,0 million UAH. Such state of affairs leads to reduction of scales of new wells drilling. For this reason it is heavy to expect essential increase in annual own oil extraction, and, hence, supply by domestic raw materials of oil refining factories which operate on territory of Ukraine.

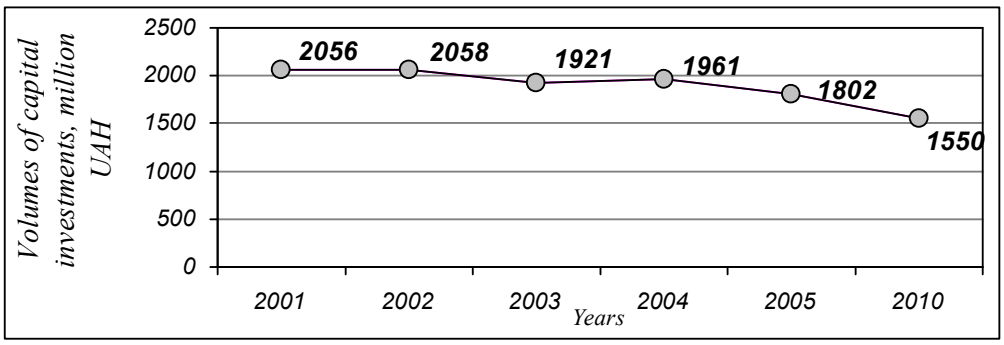

Figure 2. Investments in oil, gas and a gas-condensate recovery (million UAH)

New technologies are moderately introduced into oil refining: in 2003 investments of domestic oil refining enterprises in own reconstruction were evaluated only in 210 million UAH. Active methods of extraction on given time allow to extort from layers only 30 % of oil whereas using of modern technologies on old wells would allow to increase extraction of own oil from existing 4 million tons per year to 6-7 million tons.

Economic-mathematical model of forecasting of energy resources extraction (oil and gas).

For the oil and gas extraction forecasting we will create toolkit which will allow to estimate efficiency of established businesses activity, availability, profitableness and recoupment of capital investments into oil and gas infrastructure development. It advances research problem definition: to develop a mathematical model which will allow forecasting of volumes, terms, a recoupment of investments.

For working out of mathematical model of the oil and gas extraction forecast we will describe the input and output variables (Table 2).

Table 2. Classification of mathematical model variables

Symbols	Meaning	Units
INPUT VARIABLE		
$x_{1\varphi i}$	Investment goods of φ— energy resource on i—welle	standard units
$x_{2\varphi i}$	Sale price of φ— energy resource on i—well	standard units /ton
$x_{3\varphi i}$	Stores of φ— energy resource on i—well	ton
$x_{4\varphi i}$	Yearly out put of φ— energy resource on i—well	ton
$q_{1\varphi i}$	Stores of φ— energy resource on a new i—well	ton
$q_{2\varphi i}$	Yearly out put of φ— energy resource on a new i—well	ton
$q_{3\varphi i}$	Reprocessing power of φ— energy resource	ton/day
$q_{4\varphi i}$	Production of φ— energy resource after reconstruction of i—well	ton
$N_{\varphi i}$	Life cycle of i—well of φ— energy resource	year
$N_{1\varphi i}$	Lifecycle of a new i—well of φ— energy resource	year
T	Investment period	year
$x_{2\varphi world}$	World sale price of φ— energy resource	standard units /ton
$W_{\varphi i}$	Reprocessing power of φ— energy resource on i—well	ton/day
$W_{1\varphi i}$	Reprocessing power of φ— energy resource on a new i—well	ton/day
x_{11}	Reconstruction costs of production capital stock of φ— energy resource	standard unit
x_{21}	Exploration cost of one well	standard unit
x_{22}	Purchase price of φ— energy resource	standard unit /ton
$Y_{2\varphi}$	Volume of purchased φ— energy resource	ton
G	Royalties	standard unit.

x_{31}	Stores of φ— energy resource on a new i—well	ton
x_{41}	Yearly out put of φ— energy resource on a new i—well	ton
TE_{φ}	Current component operating costs of φ— energy resource production	standard unit
ST	Aggregate tax	standard unit
STATUS VARIABLE		
φ	Index of kind of energy resource: $\varphi = 1$— oil, $\varphi = 2$— natural gas	$\varphi = \overline{1,2}$
i	Index of well	$i = \overline{1,m},\ m \in M$
OUTPUT VARIABLES		
$Y_{\varphi i}$	Volume of φ— energy resource production on i—well	Ton
$Y_{1\varphi i}$	Volume of φ— energy resource production after i—well reconstruction	Ton
$Y_{3\varphi i}$	Volume of φ— energy resource production from a new i—well	Ton
$\xi_{1\varphi i}$	Capital investments on equipment reconstruction of i—well and φ— energy resource	standard unit
$\xi_{2\varphi i}$	Capital investments on exploring and development of new wells of φ— energy resource	standard unit
$V_{\varphi i}$	Gross revenue from φ— energy resource of i—well	standard unit
$V_{1\varphi i}$	Gross revenue from a new well development of φ— energy resource	standard unit

The mathematical model of the oil and gas extraction forecasting describes dynamic changes of oil and gas extraction from the old, explored and reconstructed wells, and also dynamic changes of investments and profit. The mathematical model is described by the connection system from 10 differential equations with nonlinear right parts. The equations look like the usual differential equations of the first order. The differential equations are parametrical as contain 7 unknown factors which are included into system of the equations: $b = \{b_1, b_2, b_3, b_4, b_5, b_6, b_7\}$.

Equations of mathematical model:

1. Production volume:

$$\frac{dY\varphi i}{dt} = b_{1\varphi i} \cdot x_{1\varphi i} \cdot \left(1 - \frac{x_{4\varphi i}}{x_{3\varphi i}} \cdot N_{\varphi i}\right) \cdot W_{\varphi i} \cdot \frac{x_{2\varphi worl}}{x_{2\varphi i}}$$

2. Gross revenue:

$$\frac{dV\varphi i}{dt} = b_{\varphi i} x_{2\varphi i} Y_{\varphi i}(t)$$

3. Gross expenses

$$\frac{dE_{\varphi i}}{dt} = b_{3\varphi i} x_{1\varphi i} x_{2\varphi i} Y_{\varphi i}(t)$$

4. Well reconstruction cost:

$$\frac{d\xi_{1\varphi i}}{dt} = \left(1 - \frac{x_{4\varphi i}}{x_{3\varphi i}} \cdot N_{\varphi i}\right) \cdot x_{11\varphi i}$$

5. Volume of φ — energy resource production after well reconstruction:

$$\frac{dY_{1\varphi i}}{dt} = \left(1 - \frac{x_{4\varphi i}}{x_{3\varphi i}} \cdot N_{\varphi i}\right) \cdot W_{1\varphi i} \cdot \frac{x_{2\varphi worl}}{x_{2\varphi}}$$

6. Capital investments into new wells exploring and development:

$$\frac{d\xi_{2\varphi i}}{dt} = b_{4\varphi i} x_{2\varphi i} \frac{x_{21\varphi i}}{Y_{\varphi i}(t)} - b_{5\varphi i} Y_{2\varphi i}(t) x_{22\varphi i} + G_{\varphi}$$

7. Volume of φ-energy resource production from a new well:

$$\frac{dY_{3\varphi i}}{dt} = b_{6\varphi i} x_{1\varphi i} \left(1 - \frac{x_{41\varphi i}}{x_{31\varphi i}} \cdot N_{1\varphi i}\right) \cdot W_{1\varphi i} \frac{x_{2\varphi world}}{x_{2\varphi}}$$

8. Gross revenue from a new well operation:

$$\frac{dV_{1\varphi i}}{dt} = b_{7\varphi i} x_{2\varphi i} Y_{3\varphi i}(t)$$

9. Gross expenses of φ-energy resource production from a new well:

$$\frac{dE_{1\varphi i}}{dt} = b_{4\varphi i} x_{21\varphi i} \frac{Y_{3\varphi i}(t)}{Y_{\varphi i}(t)} - b_{5\varphi i} Y_{2\varphi i}(t) x_{22\varphi i} + G_{\varphi} - TE_{\varphi i}$$

10. Profit from φ-energy resource production:

$$\frac{d\,\mathrm{Pr}\,of_{\varphi}}{dt} = \sum_{i=1}^{M} \left(\begin{array}{l} \left(b_{2\varphi i} x_{2\varphi i} Y_{\varphi i}(t) + b_{7\varphi i} x_{2\varphi i} Y_{3\varphi i}(t)\right) - \\ \left(b_{3\varphi i} x_{1\varphi i} x_{2\varphi i} Y_{\varphi i}(t) + b_{4\varphi i} x_{21\varphi i} \frac{Y_{3\varphi i}(t)}{Y_{\varphi i}(t)} - b_{5\varphi i} Y_{2\varphi i}(t) x_{22\varphi i} + G_{\varphi} - TE_{\varphi} \right) \end{array} \right) - ST_{\varphi}$$

The developed model is a parametrical structure with factors which are indicated by identification procedure on real figures.

Strategic directions of fuel and energy complex development.

Proceeding from the data of existing oil and gas extraction, considering an examination of the greatest oil and gas deposits, it is necessary to formulate the following strategic directions to develop an oil and gas complex:

- Increase in own oil and gas extraction in 2010 to 5,4 million (fig. 3) and 28 billion cubic meters by a new explored deposits developing of the Northern-Western shelf of the Black and Azov Seas;
- Attraction of investments to modernize new wells; reduction of oil and natural gas imports share.

So, Ukraine satisfies 10 % of needs in oil and 25 % in gas. More than 80 % of oil and about 75 % of gas the Russian Federation delivers. If this fuel to extract in Ukraine: the first, expenses for its extraction will constitute only 34,8 billion UAH, among them approximately third is wages of branch workers; the second, state receive about 43 billion UAH in a type of tax that will not be by realization of import fuel; the third, subsoil user will have 31,8 billion UAH of net income.

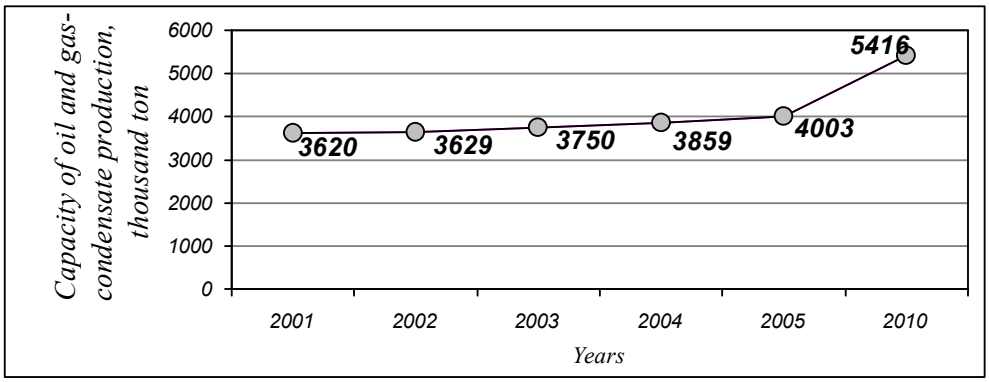

Figure 3. Oil and gas-condensate production (thousand ton)

The decision of this question is restrained by the absence of the necessary funds. Attraction of foreign investors would allow us to change the state of oil and gas complex affairs. Thus, the problem of means passes from a plane of their absence in a plane of favorable investment climate creation for their receipt in this branch.

4. Conclusions

The increase in own oil and gas extraction and reduction of import of these kinds of raw materials will allow to improve essentially a situation at the enterprises of the oil and gas companies. And it, in turn, will have positive influence on economy as a whole. To revive the national economy is possible through stabilization of work in the oil and gas complex.

In this connection it is necessary to create a toolkit which would allow an estimate activity efficiency of the domestic enterprises of oil and gas complexes, profitableness and investments recoupment into oil and gas infrastructure development: realization of exploration works, reconstruction and modernizing of active wells. It identifies scientific novelty of research. The practical importance consisting of creation of a mathematical model of the forecast of domestic oil and gas extraction, the period of deposits operation, volumes of capital investments, and also in automation of jobs that will promote efficiency increase of active oil and gas wells.

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