Gas Pricing Mechanisms: Overview, Comparative Analysis and Recommendations

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***Abstract*—With the development of natural gas trade on an international scale, pricing issues have become of serious importance for market participants. Natural gas is not a standard commodity, the main differences are that it is a natural resource, the reserves of which are unevenly distributed, and the investments in production and transportation are highly specific. This paper discusses the main gas pricing mechanisms and their use in key regions. The result of the study is the development of recommendations for the Republic of Moldova.**

Keywords—tariff; natural gas; pricing mechanisms; pricing and tariff policy

I. Introduction

The importance of energy resources for the contemporary economy is undeniable. One of the indicators that reflects the level of development of the national economy is the consumption of energy resources. The more industrially developed country needs more energy.

Compared to oil and coal, natural gas is a relatively environmentally friendly fuel, but in terms of consumption it ranks third in the world after these two types of fuel. In 2020, in the structure of world primary energy consumption by fuel, natural gas amounted to 24.72% (in exajoules). Analysis of consumption for each region showed that in the Middle East and the CIS countries natural gas ranks first in the consumption structure – 54.56% and 52.21%, respectively. The leader in gas consumption is the United States (29.95 exajoules), followed by the Russian Federation (14.81 exajoules) [1], but gas price formation is different in these countries. Therefore, the object of this study is the gas pricing mechanisms, and the main goal is to develop recommendations for improving the methodology for calculating gas price in the Republic of Moldova.

II. Gas Pricing Mechanisms: Classification and Regional Overview

A. Pricing Mechanisms for Natural Gas: Classification and Structure

The role of natural gas in a country's energy balance depends on the gas pricing mechanism. The following two groups can be distinguished: market pricing and regulated pricing (Fig. 1).

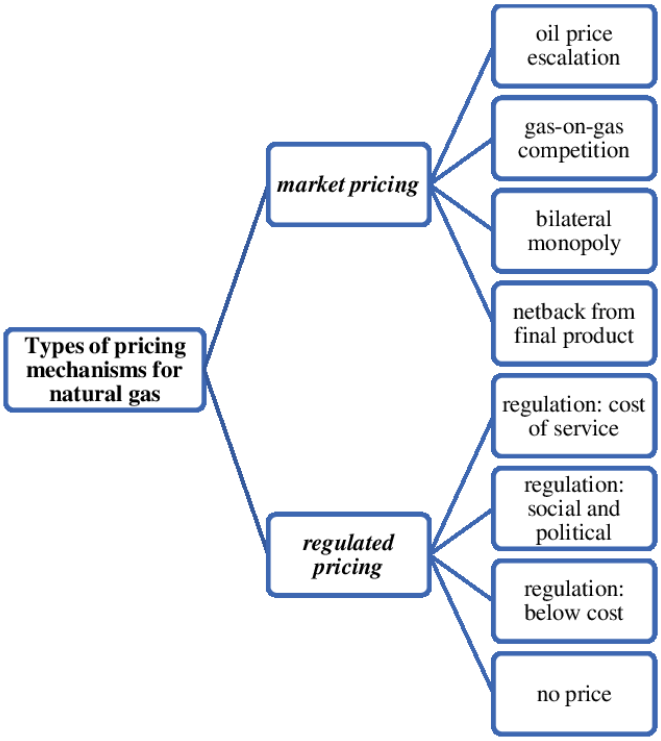

Fig. 1. Types of price formation mechanisms for natural gas.

Since 2006, International Gas Union has published, first every two years, and then annually, the Wholesale Gas Price Survey. According to the Survey 2021 edition, in the period 2005-2020, the market pricing share in the world gas markets increased by 9.4 percentage points and amounted to 71.5% in 2020, respectively, the regulated pricing share fell to 28.5% (Fig. 2). Thus, more and more countries are moving from regulated pricing to market pricing. Basically, the share of the regulated price RBC (Regulation Below Cost) has decreased, if in 2005 it was 25%, then in the period 2016-2020 it varied from 5.3 to 5.5% (Fig. 3).

Analysis of the structure of world price formation 2005 to 2020 showed that the OPE share (Oil Price Escalation) in global gas consumption decreased by 5.8 percentage points, while the GOG share (Gas-on-gas Competition) increased by 18.0 percentage points. points and amounted to 49.3% in 2020 [2].

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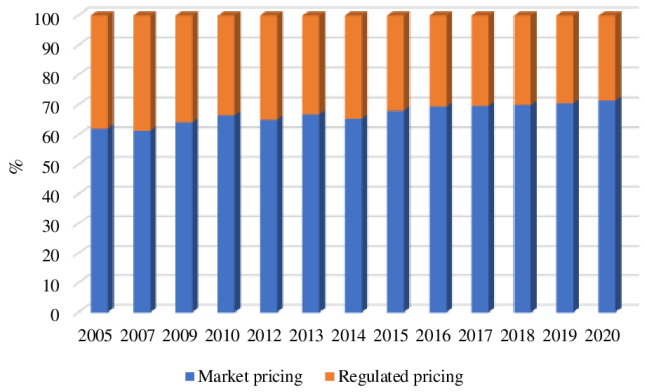

Fig. 2. Market and regulated pricing, 2005-2020.

When using the OPE pricing mechanism, oil prices (or oil products prices) are taken into account in forming natural gas prices, the dynamics of which have registered very high amplitudes of fluctuations in recent years. BRENT crude oil price, for the period August 2020 - July 2021, reached its minimum value on October 30, 2020 ($37.46 per barrel) and its maximum on July 5, 2021 ($77.16 per barrel) [3], i.e. the fluctuation amplitude was $39.7/barrel, and the maximum value was more than two times higher than the minimum. Since oil prices reflect the demand and supply of oil, but not of natural gas, in modern studies on the mechanism of gas pricing, the following idea is circulating: not to apply the practice of indexing the gas prices in correspondence with the oil prices.

Hong Li et al. in their studies have demonstrated that the following factors influence the gas price formation on the market: industrial production, GDP, personal consumption, stock market. risk-free interest rate, unemployment rate, coal consumption, gas consumption, oil consumption, carbon dioxide emissions, gas imports, exchange rate, etc. [4].

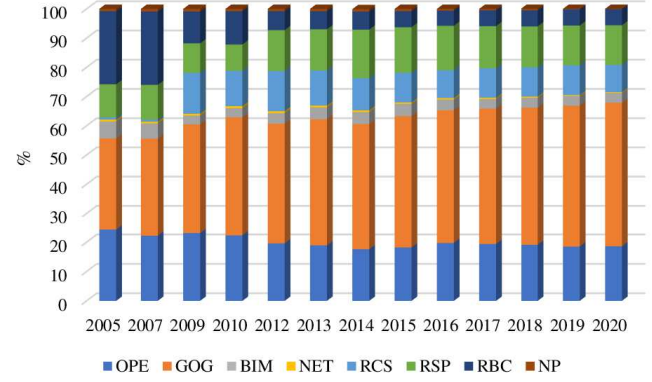

Fig. 3. Structure world gaz price formation, 2005-2020.

Note: OPE - Oil Price Escalation; GOG - Gas-on-gas competition; BIM - Bilateral Monopoly; NET - Netback from final product; RCS - Regulation: Cost of Service; RSP - Regulation: Social and Political; RBC - Regulation: Below Cost; NP - No Price.

J. Geng, Q. Ji, and Y. Fan believe that supply and demand are the main determinants of natural gas prices in the US gas market, while oil prices are the main determinants of the Japanese and European markets [5]. Andreas Seeliger researched the wholesale gas price in Germany and proved that due to net-back pricing based on oil indexation, gas prices are higher than they would be if another pricing mechanism was used, such as GOG [6].

"A bidirectional causal relationship between gas and crude oil prices" was identified by Wolfe and Rosenman [7]. They proved the impact of excess and shortage of crude oil and gas on price volatility and the cross-commodity effect. Thus, when using the GOG pricing mechanism, there may be sharp jumps in the price of gas. However, recent studies have shown that the relationship between natural gas and crude oil prices is not so straightforward, it changes over time. Jonathan Batten, Cetin Ciner and Brian Lucey studied evolution of natural gas and crude oil prices for period 21 years and concluded that until 2006 the price of natural gas outpaces the price of crude oil with a price side effect that lasts up to two weeks, and in subsequent years the dependence of prices between these two energy resources became insignificant [8].

B. Evolution of Gas Pricing Mechanisms

Over the past 70 year, in North America and Europe there has been a transition from a monopoly gas market to competitive markets, from prevalence a regulated gas prices and then OPE prices to mostly market prices: gas spot prices and hub-based prices. The regulated gas pricing mechanisms in North America differed from one in other countries. It was based on the protection of private property, on the concept of regulation, taking into account the interests of large corporations.

Natural gas import price from Canada to the United States rose substantially in the 1960s. It was not beneficial to the United States, so the US regulator turned to the Canadian regulator to develop criteria for determining a fair gas export price. Regulators decided that gas price should compensate for the cost of gas production and transportation, it should not lead to the establishment of significantly lower prices for gas on the American market than for alternative energy resource.

In the 1970s, the concept of "substitution value" was developed, which corresponded to the cost of oil purchased on the world market, adjusted for cost of gas transportation. This concept led to the development in 1980 of the Duncan-Lalonde formula for calculating export price for Canadian gas supplied to the United States. This price is indexed to crude oil prices; "the gas price in US$/MMBtu was calculated as FOB price of Canadian oil import divided to 5.796 (conversion factor from dollars per barrel to dollars per MMBtu) minus transportation adjustment factor plus the weighted average transportation cost of exporting the gas to USA" [9].

In this period, the United States decided to move from regulated gas prices to market prices within 7 years. This transition led to a threefold increase in gas prices, as a result of which gas demand fell and an excess of produced gas was formed, and a spot market was organized. Then, a gas futures market has been formed on the New York Mercantile Exchange. The United States pursued a natural gas policy aimed at achieving a trade surplus for natural gas. Only in 2017, gas exports equaled with imports, and in the following years, exports were higher than imports (Fig. 4).

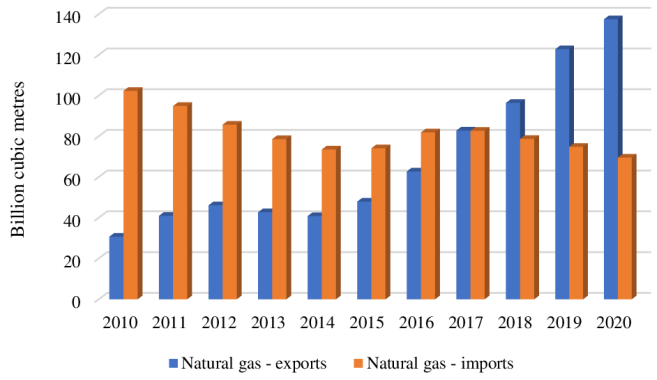

Fig. 4. US natural gas foreign trade, 2010-2020.

In continental northwestern Europe, the Groningen principle (replacement cost principle) has been used for a long time. In accordance with this principle, „the gas price is negotiated at the level of the weighted average cost for other fuels adjusted for the cost of transportation and storage from the coast or border plus taxes" [10]. The negotiated base price is between the highest and the lowest of the three cost values and is calculated as a weighted average for the different categories of end users. For 40 years (1960-2000) this concept was the dominant form of pricing in long-term European contracts. In the 2000s, this gas pricing mechanism came under increasing criticism.

The creation in October 1994 of the National Balancing Point (NBP) virtual center with transparent and widely quoted gas prices has accelerated the development of the free market in the United Kingdom (UK). The introduction in 1998 of the Interconnector (IUK) gas pipeline in Belgium, has left the Northwest countries of continental Europe exposed to the pricing mechanisms that were used in the UK market. Since the creation of the virtual hub and free trade market, it has meant that any gas, whether domestic or imported, has had to be bought and sold at BNP prices.

In 2008, gas price indexed to crude or oil products rose significantly above gas spot prices, so European companies had to reduce sales prices to retain customers. All gas importers on the basis of long-term contracts, which stipulated the pegging of gas prices to prices for oil products, suffered significant losses. In the middle of 2021, the opposite situation has arisen. Gas spot prices in Europe in July 2021 increased almost sevenfold by July 2020 and by 70% from January 2021. On the Dutch TTF (Title Transfer Facility) hub, the spot price reached its multi-year high of $12.2 per MMBtu (Metric Million British Thermal Unit).

At the same time, the principle of setting gas prices in hubs as the main pricing mechanism also has disadvantages. European hubs are not liquid enough to serve as a reliable pricing mechanism that is not manipulated by various stakeholders in the market. In the 2010s, the situation began to change, and in the 2020s it will change even more with the production of natural gas from LNG (Liquefied Natural Gas) and the emergence of new cross-border interconnecting gas pipelines. In 2010-2020, LNG imports increased, while of pipeline imports in total imports fell (Fig. 5).

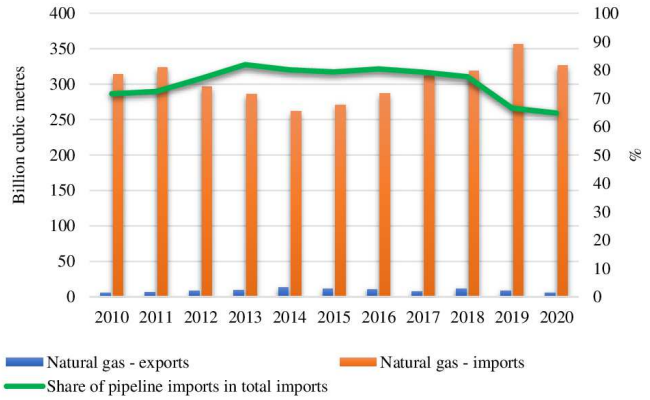

Fig. 5. Foreign trade in natural gas in Europe, 2010-2020.

By the early 2010s, different pricing mechanisms were operating in the four main gas markets (North America, Europe, CIS, Asia), which led to large price differentials.

C. *Analysis of the Use of Gas Price Formation Mechanisms by Region*

Due to the fact that the report for 2020 lacks data by region, the analysis of the gas pricing structure was carried out on the basis of "Wholesale Gas Price Survey" for 2019 year. The North America and Europe regions primarily use the GOG pricing mechanism. While in Asia and Asia-Pacific, OPE category accounts for the largest share 64.7% and 63.1% respectively. On the other hand, GOG's share is 3 percentage points more than OPE one in Latin America (Fig. 6). Regulated pricing is used in the other three regions. Only difference is in the price category, in Middle East - the main share is RSP pricing (75.3%), in Africa - RBC pricing (54.4%), in the Former Soviet Union - RCS pricing (39.7%).

According to the "Wholesale Gas Price Survey", the highest levels were recorded for OPE $7.40 per MMBtu and GOG prices. Although it should be noted that the range of GOG prices is very wide (Fig. 7).

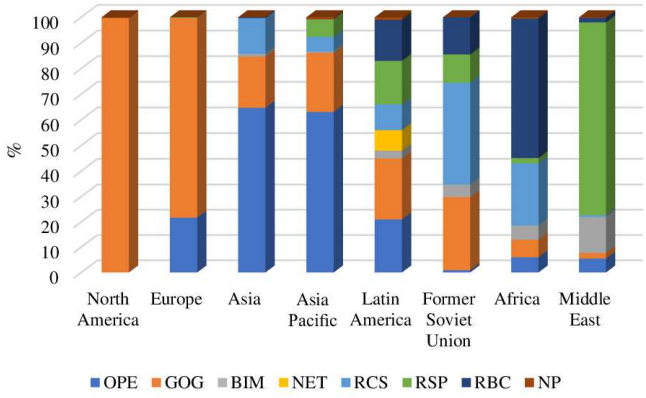

Fig. 6. Structure gaz price formation by region, 2019.

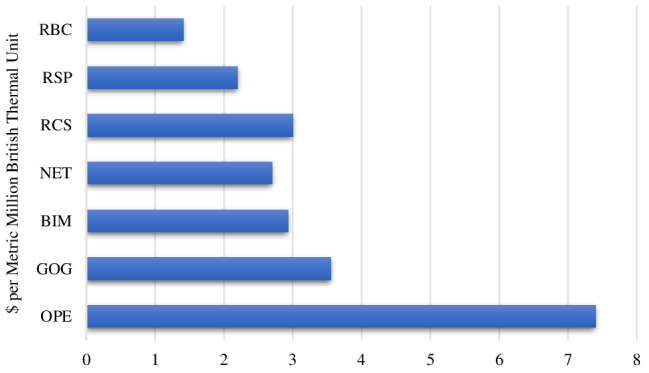

Fig. 7. Wholesale Prices by Price Formation Mechanism, 2019.

For comparison, the average GOG price for all regions was $3.55 per MMBtu in 2019, but the average GOG price except North America and Russia was $6.02 per MMBtu. The level of regulated gas prices is relatively higher than the level of market prices of natural gas. The lowest level was registered by the RBC category ($1.41 per MMBtu) [11].

As can be seen from Fig. 6, the price level depends on the pricing mechanism, although the choice of one or another price formation mechanism does not guarantee that a certain price level will be achieved. There are attempts to modify some of the pricing mechanisms. For example, China proposed the option of indexing gas prices to coal prices. However, given that China produces more than half of the world's coal and has the ability to influence their prices not only on the domestic market, but also on the world market, it is not rational to agree to this indexation option. The option of indexing gas prices to the Henry Hub price is also not the best one, because the main regions that practice OPE prices are Asia and Asia-Pacific, and the Henry Hub prices reflect the balance of supply and demand in the United States.

Wholesale gas prices change from year to year. The COVID-19 pandemic has led to a drop-in economic activity in the global economy. In 2020, the demand for primary energy fell by 4.5% (except hydroelectricity and renewables), including the decline for natural gas was by 2.1%, which affected the price level. For the period 2005-2020, the lowest level of the average wholesale gas price was recorded namely during the pandemic, in 2020 ($3.24 per MMBtu). Given that the gas market is abundant, it can be assumed that during the period of heightened competition for sales markets between the United States of America and the Russian Federation, the average of wholesale gas price will not increase, which of course does not mean that the natural gas tariff for the end consumer will not increase too in some countries.

Analysis of the dynamics of gas prices showed that the fall in spot prices in 2019 and 2020 had the greatest impact on the European market, and not on the Asia and Asia-Pacific regions. If in 2018 the gas price in Europe was high, was second after the price of the Asia-Pacific region and was higher than the gas price in the Asian region, then in 2019-2020 it fell significantly and was approaching the average world prices. Thus, we can conclude that if the established dynamics of gas prices by regions does not change, they will converge, which indicates the globalization of gas markets.

III. The Evolution of Gas Pricing in Regions

A. The Correlation Between Brent Crude Oil Prices and Regions' Natural Gas Prices

Dynamics of Brent crude oil price and natural gas in the main gas markets, namely the average import border price and a spot price component, including UK (Europe), spot price at Henry Hub (USA) and the price of imported (CIF) liquefied natural gas (LNG) to Japan are reflected in Fig. 8.

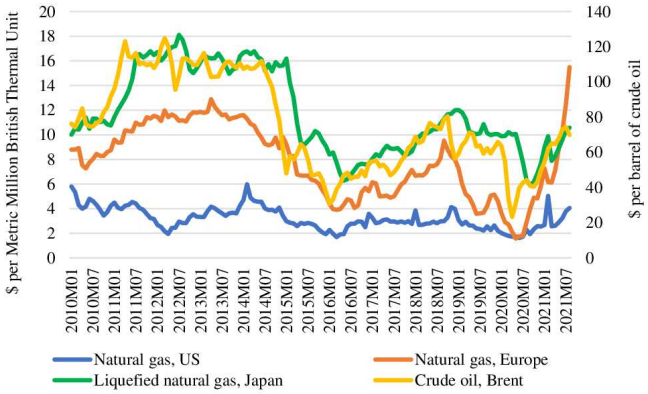

Fig. 8. Brent Crude Oil Prices and Natural Gas Prices.

Analysis of the dynamics of monthly prices from January 2010 (2010M01) to August 2021 (2021M08) showed that there is a close relationship between the crude oil price and the gas price in the Japanese market, and the response of this gas price to changes in the Brent crude oil price (effect hysteresis). The EViews 9.0 package was used to test the hypothesis that there is an interdependence between oil price and gas prices. The null hypothesis H0 is that the Brent crude oil price does not affect the gas prices. Accordingly, the alternative hypothesis H1: the relationship described above exists. The analysis has been done separately for each region. Research results are shown in Table 1.

TABLE I. Testing the Null Hypothesis That the Regression Parameters are Equal to Zero

Exogenous variable, dummy	f(gas_us)		f(gas_eu)		f(gas_japan)	
	t-statistic	*p-value*	*t-statistic*	*p-value*	*t-statistic*	*p-value*
price_oil	8.02	0.00	22.78	0.00	20.80	0.00
D15M01	–	–	–	–	4.54	0.00
D21M08	–	–	6.17	0.00	–	–
Marginal level of the test	1.9773	0.05	1.9774	0.05	1.9774	0.05

The following linear regression models were developed and they are tested in Table 2:

$$gas\_us = 1.76 + 0.02 \times price\_oil \quad (1)$$

$$gas\_eu = 0.39 + 0.10 \times price\_oil + 8.29 \times D21M08 \quad (2)$$

$$gas\_japan = 3.34 + 0.11 \times price\_oil + 7.56 \times D15M01 \quad (3)$$

where:

gas_us – Henry Hub Natural Gas Spot Price (USA);

gas_eu – the average import border gas price (Europe);

gas_japan – price of imported LNG to Japan;

price_oil – Brent crude oil price;

D21M08 – dummy variable for August 2021;

D15M01 – dummy variable for January 2015.

TABLE II. STATISTICAL TESTING

Statistical tests	f(gas_us)	f(gas_eu)	f(gas_japan)
R-squared	0.3179	0.8012	0.7625
Adjusted R-squared	0.3129	0.7983	0.7590
F-statistic	64.31	276.13	219.89
Probability (F-statistic)	0.0000	0.0000	0.0000
Akaike info criterion	2.2501	3.4443	3.8661
Schwarz criterion	2.2922	3.5073	3.9292
Durbin-Watson statistic	0.4220	0.4321	0.4090

Analyzing the values of t-statistic and p-value indicators, we conclude that in the case of regressions described in equations (1), (2) and (3) the null hypothesis that the parameters are equal to zero is rejected, but the alternative hypothesis is accepted - the linear regression coefficients are different from zero.

In order to further verify the null hypothesis, the author relied on a set of statistical tests. The coefficient R-squared measures the successes with which the estimated regression equation manages to explain the value of the dependent variable in the sample. Normally, this statistic can be interpreted as the fraction of the variant of the dependent variable, explained by the independent variables.

The regression f(gas_eu) and f(gas_japan) obtained the best results, the coefficients of determination registered comparatively higher values. Therefore, the average import border gas price to Europe and the price of imported liquefied natural gas to Japan are influenced by the Brent crude oil price. At the same time in the case of the Henry Hub Natural Gas Spot Price (USA) and the Brent crude oil price, the coefficient of determination is very small and is only 0.3179, which indicates that only 31.79% of the changes of the dependent variable are explained by the regression model (1) and 68.21% – depend on other unknown factors.

B. Regional gas markets in the modern period

For the analyzed period, starting from June 2020, an ascending trend in gas prices in Europe was registered. According to the data of the ICE Futures exchange, on September 15, 2021, the next maximum price of a day-ahead contract on TTF was registered 75.565 € per MWh, or $923 per thousand m3. One of the reasons is the low level of gas reserves in European storage facilities, which is at a historic low (Fig. 9).

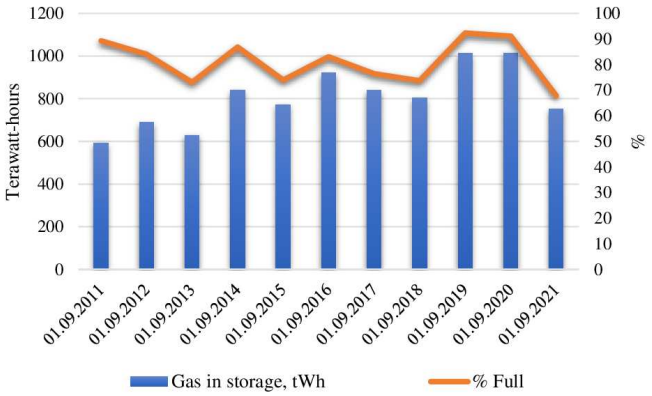

Fig. 9. Gas in European Storage.

According to the Aggregated Gas Storage Inventory, as of September 11, 2021, 74.3 billion m3 were accumulated in gas storage facilities in Europe, and the gas storage capacity was 70.45% [12]. The second reason for the increase in the spot price for gas in Europe is due to the redirection of uncontracted volumes towards the Asian market, where gas prices are currently more than $1.0 per MMBtu higher than European ones. A decrease in supply will inevitably lead to an increase in prices. LNG supplies to Europe in April 2021 were at the level of 321 million m3 per day, and in September they fell 2.2 times, and amounted to 145 million m3 per day.

This dependence of Europe on LNG is explained by the shift from the OPE to GOG pricing mechanism, from oil pegged gas prices to spot trading, from long-term contracts to more volatile short-term trading. As a result, fluctuations in the global balance affect the price of gas in Europe. High spot prices affect both the end consumer and whole economy. It causes the bankruptcy of some sales companies, an increase in gas bills, an increase in prices for domestic products, after a certain period of time, which will inevitably lead to inflation. Following the gas price, the price of electricity also rose. In just a year, the price of electricity in the UK has jumped seven times, reaching 331 euro/MWh. And in Germany, during a month, the price of electricity increased by one third and reached 130 euro/MWh.

The increasing of gas prices was influenced by other factors. In addition to the decline in LNG supply and renewable energy supply (in the absence of wind), there was an increase in demand due to the cold front called “The Beast from the East-2”, which hit Europe at the beginning of the year, and due to the increased demand for indoor air conditioning caused by the steady heat.

In Northeast Asia, in July 2021 the gas price reached $13 per MMBtu, which is 5.5 times higher than the level of the corresponding month of 2020. Demand has increased on the gas market in this region, one of the reasons is the energy security. As a result, spot prices exceeded $30 per MMBtu. Natural gas prices in the United States (Louisiana's Henry Hub) reached a 30-month high level in July 2021 of $3.79 per MMBtu, double the corresponding period in the previous year. The reason for the growth is the higher-than-expected energy consumption for indoor air conditioning, as well as the growth in demand in key regions of consumption.

C. The Evolution of the Gas Price in the Republic of Moldova

In the Republic of Moldova, the evolution of gas prices for non-household consumers in the last five years did not register major disturbances compared to the price dynamics in neighboring countries, but gas prices for household consumers decreased considerably by 18.4% in the first semester of 2018 (2018S1) compared to the previous period. This reduction was made as advertising during the run-up to the elections in Moldova. After the parliamentary elections, in the first semester of 2019 the gas price had returned to the level of the second semester of 2017 (Fig. 10).

In the middle of August 2021, National Energy Regulatory Agency (NERA) adopted a new methodology for calculating, approving and applying regulated prices for the supply of natural gas. According to this methodology, the regulated rate of return of the supplier is determined annually according to the Weighted Average Cost of Capital (WACC) method. At the same time, it is specified that “the equity per total capital ratio is 0.5 and the borrowed capital per total capital ratio is 0.5.” [13]. The regulated rate of return consists of two parts, the second part is calculated as the multiplication of the cost of borrowed capital by the ratio of borrowed capital per total capital.

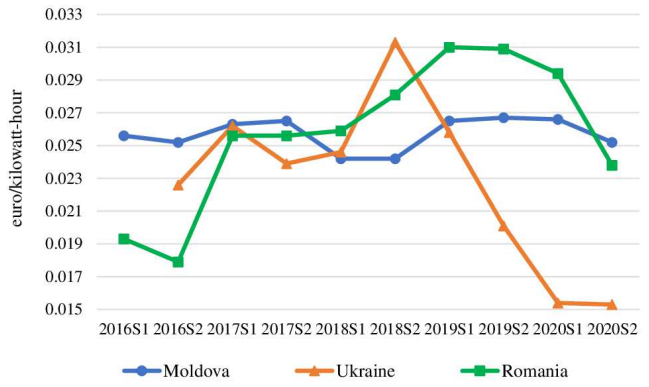

Fig. 10. Evolution of gas prices for non-household consumers – bi-annual data, including taxes and levies.

According to the algorithm for calculating the regulated rate of return, the latter can be rose by increasing the cost of borrowed capital, which in turn does not depend on the efficiency of the activity of the economic unit providing services related to gas supply. In the author's opinion, the implementation of this methodology will lead to an increase in the natural gas tariff for final consumers.

IV. Conclusions and Recommendations

The analysis of natural gas price dynamics on the European market and price formation mechanisms showed market price volatility. It is necessary to diversify energy resources before fully switching from regulated pricing to market pricing. Taking into account the evolution of the gas price on the world market and the new algorithm for calculating the natural gas tariff in the Republic of Moldova, the tariff increase for final consumers in Moldova can be forecast. The vertical decoupling of the supply of other activities leads to an increase in the price of energy resources [14]. In a small state such as the Republic of Moldova, whose population is declining, vertical decoupling is not economically viable.

Recommendations: performing horizontal decoupling, because it is more advantageous; modification of the methodology for calculating, approving and applying regulated prices for the supply of natural gas, in particular in the chapter "calculation of the rate of return", which must take into account the efficiency of the activity of the natural gas supplier; during evaluating efficiency, it is necessary to take into account: how efficiently are you generating profits; the optimization of expenses; the reduction of losses.

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