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# The Progress of Industry 4.0 in the Conditions of a Pandemic - Bulgarian Case in Natural Gas Sector

**Petya Biolcheva[1*], Vasil Bozev[2]**

[1]University of National and World Economy,
 Students Town, Sofia, 1700, BULGARIA

[2]University of National and World Economy,
 Students Town, Sofia, 1700, BULGARIA

*Corresponding Author

**Abstract:** Technological digitalization and the capabilities of artificial intelligence are among the main tools recommended to companies to overcome the negative consequences of the economic effects of the COVID-19 pandemic. And this is true not only for companies in the high-tech sector, but also for those who are part of the supply chains of natural resources such as natural gas. Moreover, in addition to the flexibility of technological solutions, natural gas supply companies are expected to protect their place in the renewable / regenerative / economy, which defines natural gas as one of the clean energy sources. To meet these challenges, the article examines how and in what way the ongoing global crisis provoked by the COVID 19 pandemic is slowing down the processes of technological digitalization and integration of business processes in gas supply companies, i.e., to what extent these companies have "walked the path" of the transition from Industry 4.0 to Industry 5.0. We are looking for answers to these questions on the basis of an empirical study conducted in gas companies, showing the change in the level of technological innovation, the development of linkages between individual business processes, and the place of artificial intelligence in their overall activities.

**Keywords:** Industry 4.0, digital transformation, AI, big data, IoT, progress integration

## 1. Introduction

The transition from Industry 4.0 to Industry 5.0 is defined as this strategic company development priority, which has been talked about more and more actively in recent years. The benefits of Industry 4.0, based on the integration of digital technologies in business process management, create "new" good practices that can address a significant part of the risks facing businesses in the face of the ongoing COVID pandemic. The diversity of digital solutions using the capabilities of Industry 4.0 is presented in numerous publications, presenting applied solutions to reduce the negative impacts of the pandemic, namely through the ongoing transition to the digital economy.

According to Lepore, Micozzi, Spigarelli (2021), technology can be a key tool for economic recovery, favoring the transition to sustainable production. Their research is aimed at analyzing the readiness of countries to use the tools of Industry 4.0 in a pandemic. [1] In support of the above, Deshmukh and Haleem (2020) demonstrate that in the COVID-19 era, Industry 4.0 (I4.0) technologies are expected to accelerate the transition to sustainable production [2]. In addition, in their publication Kumar et al., (2020) offer a roadmap for the introduction of Industry 4.0, in order to reduce the impact of COVID-19 [3].

Our goal is to establish the level that has been achieved in the gas sector in terms of progress on I4.0. As key indicators for assessing progress, different researchers use: 1. data collection and storage along the entire value chain, through smart business and technology systems [4] 2. integration of information and communication technologies

(ICT) with industrial ones [1]. 3. digitalization of the processes allowing their management, through remote access, i.e., high level of IoT. 4. Improving the effectiveness of forecasts, analyzes and decisions in AI-based organizations. In this material we use the indicators: 1. The achieved degree of integration between the individual business processes; 2. The introduction of artificial intelligence (AI) and its contributions to the elimination of routine activities, cost reduction, accuracy of analysis and forecasting; 3. The inclusion of IoT in the work, through remote access; 4. Big data in data analysis. In our opinion, despite recommendations for large-scale, rapid entry into the digital age, the gas sector has rather slowed down these processes under the influence of the difficult situation after 2020. To this end, we study the main gas companies operating on the Bulgarian market and analyze the level of progress since the pandemic.

The literature synthesis shows that I4.0 favors the management of organizations in times of crisis, supporting business activities, enabling work through remote access, [5] provides better risk assessment [6], increases corporate social responsibility [7] etc. In this paper, we examine the capabilities of Industry 4.0 in the gas sector and the specific risks and threats it faces in its progress towards business process integration, and then conduct an empirical study and analyze the degree of progress, according to the claims. of experts in the gas gray sector in Bulgaria.

## 2. Industry 4.0 in the Gas Sector

Researchers of the evolution of business processes and technologies are unanimous that the success of I4.0 is due to the growing integration of (digital) information and communication technologies (ICT) with industrial technologies [8]. The scope of modern "smart technologies" includes: cyberphysical system (CPS), Internet of Things (IoT), robotics, cloud computing (CC), big data (Big data), etc., which provide flexibility, visibility, traceability, and reliability of processes in information and production systems [5,9]. At the same time, AI and IoT, as an important part of I4.0, are considered to be one of the most effective tools for dealing with the COVID-19 pandemic [10]. Among the main contributions of I4.0 is the ability to collect and exchange data across the value chain by introducing production systems that are increasingly intelligent, autonomous, and automated [4]. Moreover, the digital transformation of I4.0 does not affect individual elements of the value chain, but covers each unit in the supply chain, i.e., companies adopt new and emerging technologies, digitize, and streamline their production processes [11] together.

The question that worries us is how far the gas companies have "made their way" in the transition from Industry 4.0 to Industry 5.0. It is safe to say that the gas industry is among the sectors in which there is an active interest in technological progress. The many gas operations, in collaboration with unstable risk conditions, both in the external and internal environment of gas companies, are the reason that strengthens their interest in expanding the use of I4.0 instruments in the gas supply chain. The main goal of the technological digitalization of gas companies is to improve process efficiency. In practice, this is achieved by speeding up processes and reducing risks [12]. IoT, AI technologies are the tools through which companies achieve higher process efficiency by making more accurate analyzes and shortening routine activities [13]. Business processes using these IoT and AI tools include monitoring of technological equipment and transmission infrastructure, real-time monitoring of technological operations, digital process optimization, digitalization of the procurement process [13]. Significant advantages of these companies are given by the digital technologies related to seismic images and 4D models in the research processes used for the design of gas routes.

Thus, instead of relying on traditional and human-oriented business processes, companies in these industries are currently creating value using the capabilities of AI solutions [14]. Although artificial intelligence in the gas sector has been of interest since the last century [15], it is only in recent years that its real potential and applications [16,17] for the development of "new value-added models" realized through advanced algorithms, training on large and databases [18].

Along with the undeniable advantages offered by technological advances, research shows that there are a number of barriers that hinder the sector from using the capacity of I4.0 tools. Investment in digital instruments is largely delayed due to the increased level of risk due to the ongoing COVID 19 pandemic. The sharp fluctuations in prices and demand for natural gas during the pandemic further increase uncertainty in the sector. This is a reason for gas companies to focus on their core business processes, guarantee them to a greater extent and reduce investment in technological development.

In addition to these barriers, there are some sector-specific constraints that are also restraining. First of all, the multinationality of the gas companies' market is an obstacle to their technological development. The cross-border and decentralized nature of supply operations and the many actors involved make it difficult for a number of Industry 4.0 innovations to enter the entire supply chain. Secondly, the resistance of the staff, whose origins lie in their fear of being displaced by artificial intelligence. Concerns that the capabilities of AI may exceed the expertise of the best employees in the field [19] are a serious reason for organizational resistance to digital transformation. Thirdly, the lack of digital maturity and sufficient technical experience, combined with a reluctance to change traditional working practices and complex regulatory compliance. All this freezes a number of technological investments, and most business projects for the use of Industry 4.0 are still at an early stage and with limited use [13].

The outlined picture makes us ask ourselves, what is the actual development of I4.0 in the natural gas sector? His answer is given below, where we checked the answer in practice.

## 3.   Study of the Level of Development of I4.0 in the Gas Sector

The current study aims to examine the level of use of I4.0 tools in gas campaigns. The main thesis that is being studied is that in the years of the pandemic of COVID-19 technological development in the world has slowed down new digital technological solutions, providing a transition from I4.0 to I5.0 of companies in the sector. The verification of the thesis thus defined was carried out by means of an online survey conducted among experts from the gas sector in Bulgaria. The respondents are representatives of natural gas companies, part of the Bulgarian Gas Association and have extensive experience in this industry. The study was conducted in the first quarter of 2022. The analysis of the obtained results takes into account the current state of the natural gas market in Bulgaria, including higher natural gas prices [20], government intervention in the management of the national gas supplier [21], strong international tensions with the main gas supplier for the country - Russia [22]. The main questions in the study are related to finding expert answers about the current state of companies in the gas industry, as well as the main directions of development of gas companies in terms of technological innovation in companies; digitalization and integration between the individual business processes, use of artificial intelligence in business process management, etc.

Here we reveal the causal link between the various I4.0 instruments, the impact of the crisis on them and the effects achieved in the form of innovation and technological innovation in gas companies. The main research tools are reduced to the following four: 1. Integration of processes; 2.AI; 3. IoT; 4. Big data.
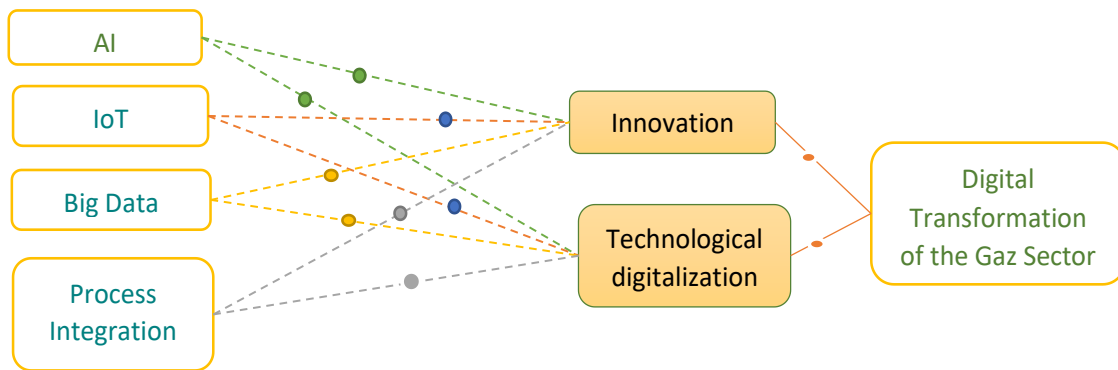


**Fig. 1 - Level of absorption of I4.0 instruments under the influence of the COVID crisis 19**

Figure 1. the connections between individual instruments of I4.0 and the achieved level of digital transformation in the gas sector are illustrated. Assuming that the individual lines between the respective instrument and innovation and technological digitalization are an expression of 100% penetration, the respective points on them show the path that has been traversed so far under the negative effects of the crisis. In the same way, the points on the lines connecting innovation and technological digitalization with the digital transformation of the sector show the progress made.

The progress of I4.0 can be established through the integration of business processes and the introduction of innovations in the field. This is a reason to seek the opinion of the respondents in this regard. First, the experts give their opinion on the level of innovation that the main groups of business processes in the gas sector need. For this purpose, a five-point scale was used, according to which 1 is "No need" for innovation in the given group of business processes, and 5 is "There is a great need" for innovation. Figure 2 presents the results of this issue, and the opinion on the need for the given innovation of the companies is averaged. This results in an average level of innovation for each area. The highest degree of innovation should be done in those groups of business processes in which the calculated average value is the highest.
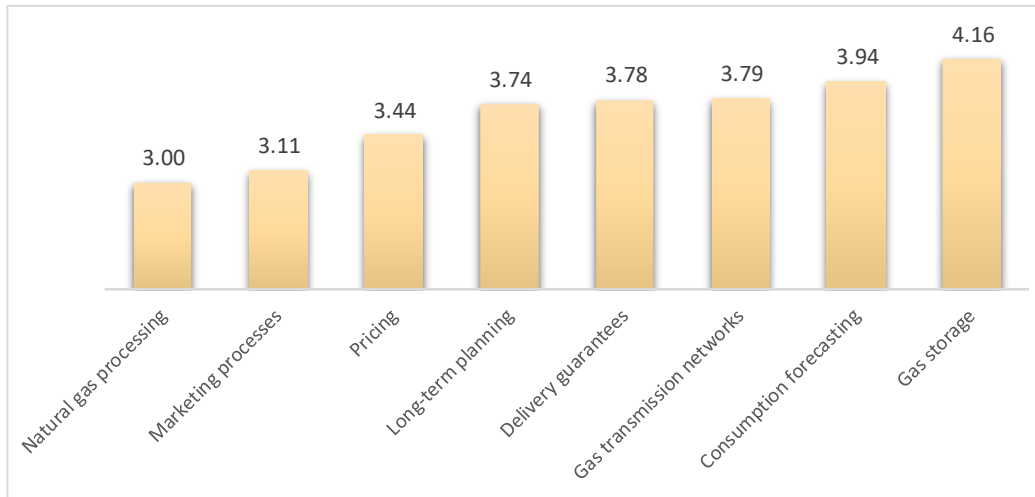
**Fig. 2 - Availability of software to organize the activity**

Of the companies that indicated that they use software to organize their activities, 68% said that this software makes a visible connection between individual business processes. The remaining 32% do not consider that their software has this capability.

The next research area is related to the opinion of gas experts on achieving a high degree of integration between individual business processes and compliance with I4.0. Regarding the need for full integration between the individual processes, almost all respondents believe that this is necessary (95%). It should be mentioned that those 5% who do not consider full integration necessary are different from those 5% of companies that do not have software to organize their activities. However, the question of whether full integration is possible at this stage is 50% optimistic and 50% pessimistic. In conclusion, it can be said that almost everyone is of the opinion that integration in the gas industry is necessary, but only half believe that it is possible at this stage.
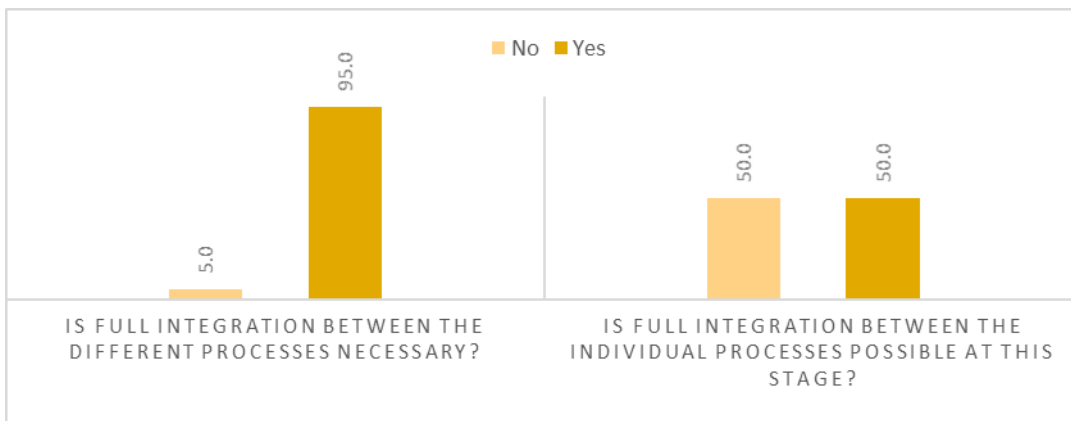


**Fig. 3 - Necessity and possibility of full integration between the processes**

The answers to the next question are logical, to which the respondents indicate what degree of integration they have achieved in their companies.
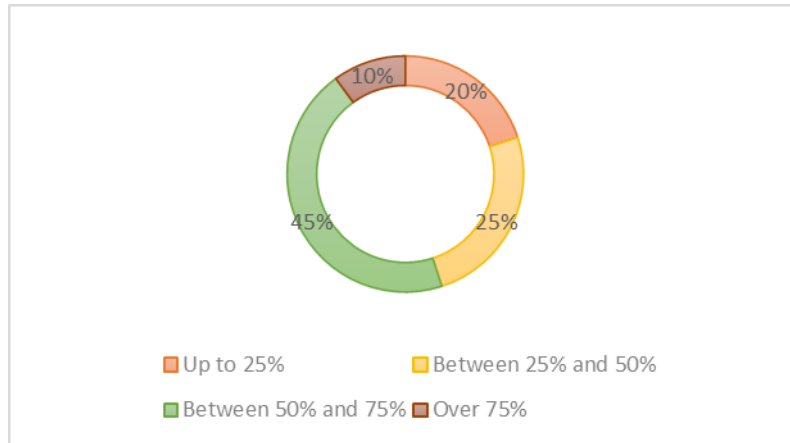
**Fig. 4 - Degree of integration of the processes in the company**

Companies that think full integration is possible are those that have achieved integration above 50%. Of these, 45% have achieved integration between 50% and 75%, and 10% have achieved integration over 75%. With the lowest degree of integration (up to 25%) are 20% of the companies, and with a degree between 25% and 50% are 25% of the companies. The main reasons for the slowdown in the pace of integration between business processes is due to the reduced capacity of human resources dealing with software integration of all processes, difficulties in external procurement, difficulties in ensuring the continuity of key business processes in building integration and a number of contractions caused by the crisis. The analysis of the impact of the crisis on this tool confirms the thesis that there is a rather slowdown in the processes related to technological digitalization and innovation.

Significant place in Industry 4.0. occupies artificial intelligence. The possibility of full integration in the sector largely depends on it. Here we explore the place of Industry 4.0. and achieving full automation and integration of processes (including the use of artificial intelligence) in the sector.

The prevailing opinion is that the sector is pursuing an ever-widening entry into Industry 4.0 through investments in process automation systems (55%). Of the remaining respondents, 20% believe that processes still need a human factor, and 25% are at the other extreme - that automation will be achieved through software solutions.

Companies do not have a single opinion on where artificial intelligence would best fit. Of all the experts, 32% believe that it is important for their overall work. The other highest percentage, also 32%, believe that artificial intelligence can fit into time-consuming analyzes and complex calculations based on databases and machine learning for the development of the sector. Use in early warning related to security and reliability of gas supplies was indicated by 26%. The most inappropriate, according to the respondents, is the application of artificial intelligence for forecasting and planning, taking into account the correlation dependencies of many variables. Probably, they believe that at the moment this area of decision-making for planning and forecasting still belongs to the people.
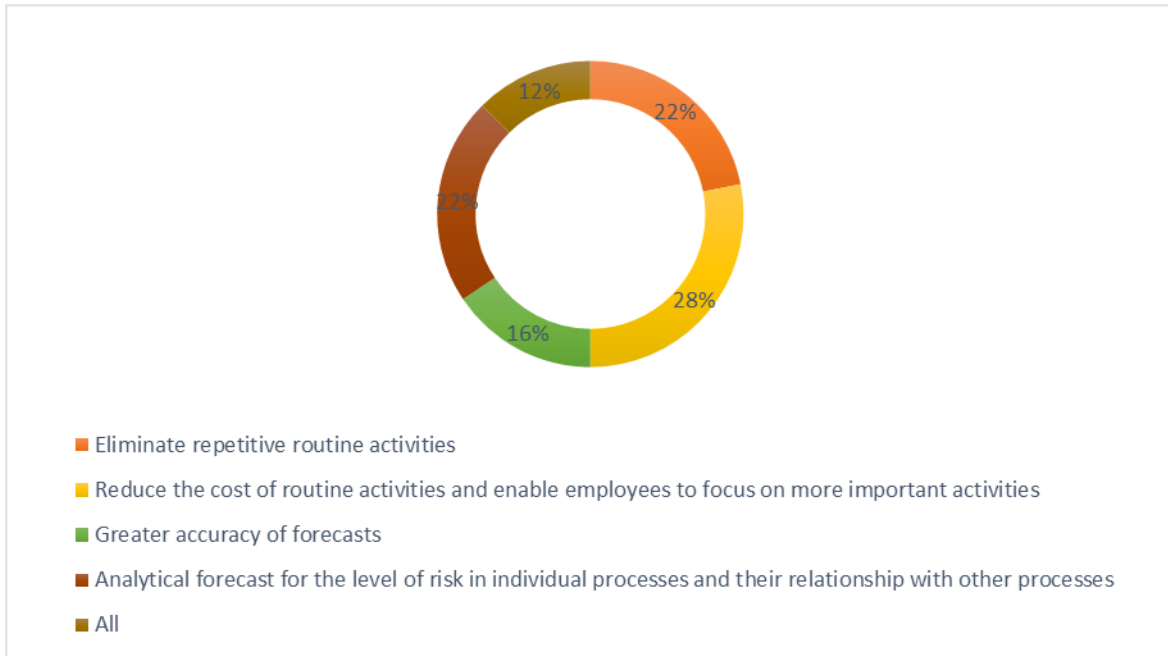
**Fig. 5 - Contributions from the use of artificial intelligence**

Here, too, respondents are not unanimous about the contributions of the use of artificial intelligence in the sector. The largest percentage of responses indicated it is used to reduce the cost of routine activities and enable employees to focus on more important activities (28%). This is followed by its use for analytical forecasting of the level of risk by individual processes and their relationship with other processes (22%) and its use to eliminate repetitive routine activities (22%). Only 16% of respondents think that artificial intelligence can increase the accuracy of forecasts. This reinforces the view from the previous question that artificial intelligence is not effective for forecasting in the sector. The smallest percentage believe that artificial intelligence will contribute to all levels in the sector, which means that only a small 12% currently think that it is a panacea at every level of the business process. Despite the demonstrated reservations about AI, respondents are aware that it is one of the most significant preventive measures to counter economic shocks and an important part of progress in I4.0. According to 10% of respondents, he is already part of the sector. The majority of companies (75%) believe that in the near future, within 5 to 10 years, artificial intelligence will significantly enter the gas industry.

All respondents are affected by the pandemic that began in 2020. and the economic crisis it provoked. As many as 60% of them have reduced their capacity but continue to work. At 10% there are serious reductions in power shrinkage. There are also those (30%) in which no serious consequences have been registered. None of the respondents felt a positive effect and did not increase their grief. The negative effects of the pandemic have made 10% of the respondents more flexible and adaptable to the changes and high dynamics of the environment. Another 30% have successfully adapted to the new market requirements. A significant proportion of them have frozen their development projects, including AI implementation projects. This reaffirms the thesis of the negative retarding effect of the crisis on the technological digitalization of the gas sector.

The IoT is crucial for increased digitalization due to the need to work remotely through moments of global "world shutdown" during this crisis. Through the IoT, a large part of the gas experts during the period (75%) communicate with devices and actuators, control bodies of a technical nature in the chain. Although in the context of very difficult supplies (eg microcontrollers for their construction), gas companies have made progress in implementing this I4.0 tool.

The gas sector in a crisis is unprepared for Big Data. The analysis of the study shows the transformation of natural gas consumption; severe difficulties in planning and forecasting deliveries; optimization of geopolitical dependencies in consumption; gas stock planning; dependence on resource providers. In the crisis, only about 30% of gas companies have managed to implement Big Data projects. The application of this instrument reaffirms that no progress has been made in the technological development of gas companies under the influence of the negative effects of the external environment.

## Conclusions

In this paper we sought an answer to the question related to the level of technological digitalization of I4.0, in the ongoing global crisis provoked by the COVID 19 pandemic. the gas sector. We also explored barriers and risks that have a deterrent effect. Then we checked the level of use of basic I4.0 instruments in practice, using a large part of the Bulgarian gas companies. As a result, we found the following:

• The main tools of I4.0 - Integration of processes, AI, IoT, Big Data are crucial for the development of the gas sector. Although they are considered to be the main source of optimization, risk reduction, efficiency increase, their introduction has been delayed due to the deteriorating financial situation of gas companies.

• The achieved high degree of integration between its core business processes is still unsatisfactory. Although most gas companies have software that provides some degree of integration between the main, interconnected business processes, it is necessary to supplement the overall picture, including all processes and activities carried out by the gas company.

• In addition to financial barriers, gas companies need to overcome the restraints of their staff, helping them realize the potential for full digital transformation. This, in turn, is related to improving technological skills in organizations - raising skills and / or new workforce.

In conclusion, due to the high uncertainty and dynamics of the environment in recent years, the gas sector has slowed down the processes related to technological digitalization, integration and use of high technology and artificial intelligence. Most of the projects aimed at I4.0 are frozen or in the initial stage.

## Acknowledgement

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