Highlighting Key Gas 4.0 Distribution Business Processes A Greek Case Study

Nikolaos A. Panayiotou[1], Vasileios P. Stavrou[2] and Konstantinos E. Stergiou[3]

[1]*Professor, National Technical University of Athens, School of Mechanical Engineering, Section of Industrial Management and Operational Research, Greece, Athens, Zografos Campus, 15780, panayiot@central.ntua.gr*
[2]*Researcher, National Technical University of Athens, School of Mechanical Engineering, Section of Industrial Management and Operational Research, Greece, Athens, Zografos Campus, 15780, vstavrou@central.ntua.gr*
[3]*Researcher,National Technical University of Athens, School of Mechanical Engineering, Section of Industrial Management and Operational Research, Greece, Athens, Zografos Campus, 15780, stergiouke@mail.ntua.gr*

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Abstract - *The paper highlights key business processes in the Natural Gas distribution sector which can adopt Gas 4.0 and accompanying Information Technology solutions. A Greek Natural Gas distribution company was selected as a case study. A project team formulated by researchers, company's process owners and key users identified 155 business processes, 44 of which were highlighted as candidates for redesign based on the Gas 4.0 approach. The analysis identified four business process groups with high Gas 4.0 potential: End User and User Management, Project and Network Management, Infrastructure Network Maintenance and Infrastructure and Network Operation. The enabling technology recognized was a Customer Relationship Management system integrated with smart metering equipment, a Project Management system for network expansion integrated with a Document Management System and a Predictive Maintenance application integrated with sensors and actuators for network monitoring, utilising Machine Learning algorithms. All the collected data from the network was designed to be routed to a Control Room, using a Network Monitoring application. The identification of the key business processes that can benefit from Gas 4.0 is going to guide redesign initiatives and corresponding technology solutions, increasing organizational efficiency and minimizing costs.*

Key Words: Gas 4.0, Gas Midstream Sector, Smart Grid, Gas Distribution, Pipeline Maintenance, Business Process Management, Industry 4.0.

1. Gas 4.0 Concept and Key Characteristics

As a concept, Gas 4.0 is considered a sectoral division of Industry 4.0 focused on the Natural Gas sector, having three major areas of activity (upstream, midstream and downstream) [1,2,3,4]. Industry 4.0 was introduced in Germany in 2011, as the country was trying to gain a strategic competitive advantage over its key industrial competitors [5, 6]. Industry 4.0 allows companies to implement the digital redesign of its processes based on a variety of technologies. More specifically, each company willing to adopt Industry 4.0 concept, can choose from a pool of options regarding IT (Information Technology), production or supply chain technologies in order to meet the needs of its customers. Any company that aims to be prepared for the adoption of Industry 4.0 should develop specific components regarding the modernization of its processes and equipment. Interoperability, Virtualization, Decentralization, Real time Operation, Service Orientation and Adaptability / Scalability can be defined as main principles during the major implementation steps [7].

Internet of Things (IoT) and Cyber Physical Systems (CPS) are probably considered the most critical components of Industry 4.0 [8]. Cyber Physical Systems can be defined as industrial automation systems, integrating innovative functionalities through network in order to enable connection of the operations of the physical reality with computing and communication infrastructures [9]. Examples of CPS include smart grids, autonomous automobile systems, medical monitoring systems, industrial control systems, robotics, and automatic pilot avionics. IoT can be defined as a global network infrastructure based on standard and interoperable communication protocols where both physical and virtual 'things' have identities, physical attributes, virtual personalities, intelligent interfaces, and are seamlessly integrated into the information network [10]. In other words, IoT refers to the billions of physical devices around the world that are connected to the internet, all collecting and sharing data. According to GTAI [9], IoT has been revolutionizing many existing systems, and is considered to be a key enabler for Industry 4.0 [6, 11, 12]. Moreover, key tools such as big data [13, 14] and digital twins play a key role in the success of Industry 4.0. Especially the digital twin [15, 16] uses real world data in order to create simulations which can predict the way a process will perform in a future or an unpredictable situation.

In Industry 4.0, the term "Industry" is expanded and refers to the overall value chain [5]. In the utilities sector, Industry 4.0 can be applied in a variety of cases. Utilities include companies operating in the Natural Gas sector, implementing a number of innovative solutions, such as

Cyberphysical Systems and Internet of Things. Under this perspective, Industry 4.0 technologies and tools are applied with relative success in the Gas industry. A new concept, Gas 4.0 has been put on the agenda as an instantiation of Industry 4.0 and gained ground among businesses in the Gas industry [4]. Although the gas sector has some special characteristics, the profit from the reengineering and digitalization of processes in upstream, midstream or downstream sections pushes many industry companies to adopt similar practices [17].

More specifically, in the Natural Gas sector, Industry 4.0 has significant research and practical interest [18]. The research interest focuses on all the stages of the Natural Gas supply chain, emphasizing on distribution to final consumers [18]. Special equipment, tools and assets are used, aiming to integrate digital technologies with the equipment already used and the company's processes. Digitalization in the Gas sector increases the industry productivity, using IoT, cloud computing, industrial internet of things, artificial intelligence, and blockchain [19]. It is highlighted that Natural Gas as a product is classified as "non intelligent" as it cannot add embedded information or connectivity to it. There are, however, a number of Natural Gas companies which are involved in the extraction or distribution of Natural Gas (which means that the main product differs). Gas 4.0 can completely change the status quo of the Natural Gas industry, bringing huge benefits and accelerating the digitization and intelligentization. However, Gas 4.0 as a concept is still in its infancy [4].

The paper aims to highlight key business processes in the Natural Gas distribution sector which can adopt Gas 4.0 and accompanying Information Technology solutions. This effort will aid both industry and the research community in order to apply Industry 4.0 technologies in a gas distribution company. In the following paragraphs, an analysis of main Gas 4.0 business processes takes place, focusing on a Natural Gas Distribution Network Operator operating in Greece (which is practically the article's case study). Section 2 of the paper provides a short literature review, analyzing main Gas 4.0 tools identified in the literature. Section 3 presents the methodological approach followed in order to analyze the business processes of the company. Section 4 analyzes the main business processes in which Gas 4.0 can be utilized. Finally, Section 5 provides the conclusions, the implications and the limitations of the research presented in the article.

2. Technologies Involved in Gas 4.0

In the midstream sector, equipment and gas network are usually controlled by a control room using appropriate software, sensors and actuators [5]. Design and implementation of the control room in order to implement data collection, integration and decision making processes are based in a human machine interface.

In most cases, the communication between the control room, the pipeline equipment and smart meters is performed using a pipeline surveillance software [5]. Different technologies and tools are used in order to establish the communication between the control room and the network points of interest [20]. Nowadays, the most preferred solution is to develop optical fiber based networks [21]. On the contrary, wireless technology provides a secure and high speed connection for sending and receiving a huge amount of information [5]. In addition, satellite networks are used in some cases due to long distance coverage [4]. In all the abovementioned cases, specific equipment is installed next to the pipeline network, which receives signals related to the condition of the network, while intervenes whenever deemed necessary, receiving the appropriate commands from the control room (through the use of sensors and actuators). This way, detection of malfunctions is possible, and after proper processing respective maintenance systems or supply interactions are activated [22].

The smart meter is an advanced energy metering device which can be easily integrated with the rest Gas 4.0 network equipment. Its main activity is to obtain information from the end users and measure the gas consumption, providing added information to the gas company and/or the system operator for better monitoring and billing [5]. Smart meter supports bidirectional communications between the end users and the control room. In addition, smart meter has the ability to disconnect and reconnect gas supply remotely, while it can be used in order to monitor and control the users' devices [23]. Smart meters also increase company's flexibility, as consumption changes lead to distribution grid load alterations [4]. Operation can be implemented in a number of different ways. Automated Meter Reading (AMR), allows gas companies to remotely read the consumption records and main status information from customers' sites. AMR can also detect outage or tamper. The next generation of AMR (AMR – Plus) exports hourly data from points of interest, taking daily consumption measurements, while it sends outage notifications to the control room. However, AMR potential is limited, due to its one-way communication capabilities. For this reason, many utility companies moved towards Advanced Metering Infrastructure (AMI). AMI provides gas companies with bidirectional communication abilities. AMI systems allow gas companies to perform grid control and management, remote emergency shutdown in case of danger or leakage, manage time based rates and implement remote smart meter programming and gas quality control.

Special emphasis should be given to the network security, as in the past there have been numerous attempts from external sources in order to interfere in the gas network software and data and create serious problems [24, 25]. In order to improve network security, blockchain technologies can be used, allowing data transparency [26, 27, 28]. In addition, Augmented Reality (AR) is worldwide recognized as one of the pillars of Industry 4.0 and Gas 4.0 [29, 30, 31]. AR technology could assist in the training of expert workers in real conditions, before the implementation of the actual operation. Moreover, Preventive Maintenance with the aid of machine learning is a key parameter in order to reduce costs and downtime within a production unit, improving the overall experience of gas customers, improving operational safety [32, 33].

The support of employees through digitization and Information Systems introduction can offer a significant contribution to gas distribution companies, improving their productivity in collaboration with Gas 4.0 tools. One of the main aims of digitalization is considered the creation of digital files containing materials and equipment, based on principles of automation and digitization. In addition, the collaboration between sensors, actuators and Information Systems increases pipelines efficiency. Gas companies aim to integrate the abovementioned data with maintenance Information Systems, in order to enhance maintenance monitoring. Customer Relationship Management systems are also used in order to establish communication with company's stakeholders [34]. Enterprise Resource Planning and Document Management Systems can also help internal communication (business processes and existing workflows handling). Moreover, the introduction of Business Intelligence systems ensures vertical communication between information systems and automations in different levels of Information Systems architecture, utilizing cloud technology and Internet of Things (IoT) philosophy. Information Systems aim to operate in conjunction with Gas 4.0 in a single framework in order to optimize business processes, customer service and cost savings [35].

Integration between Gas 4.0 and Business Process concepts is considered critical for the operation of Gas Distribution companies. A range of modeling tools is used for the complete recording of processes and for the integration of appropriate technologies [36]. Some researchers [35, 37] proposed a complete Industry 4.0 architecture, aiming to reflect the unified way in which business processes, Information Systems and automations operate. In the following chapters, a case regarding Public Gas Distribution Networks (DEDA S.A.) is presented, analyzing the company's Business Processes specific needs and introducing new Gas 4.0 technologies, giving particular emphasis on smart pipelines, operation, maintenance and metering. The main goal is to correlate specific business processes with specific Gas 4.0 tools, in order to demonstrate in practice the added value of Gas 4.0 in the midstream sector.

3. A Methodology for Highlighting Key Gas 4.0 Business Processes

DEDA S.A. (Public Gas Distribution Networks) is a newly established company, aiming to operate as the Distribution Network Administrator (in Medium and Low Pressure) for Natural Gas in Greek Territory. Development of the gas network, monitoring of the distribution process, network maintenance and connection of new customers to the network are DEDAS's main priorities. DEDA is aiming to cover the whole country in the next few years.

The methodology followed consists of a series of distinct steps. At the beginning of the process, the main concern was the identification and grouping of DEDA S.A. processes, with the aid of the company's process owners. 16 personal and group interviews took place, involving 11 DEDA employees (process owners), resulting in a Value Added Chain Diagram (VACD). As a next step, a literature review took place in order to identify Gas 4.0 technologies which could apply and improve DEDA's business processes. The literature review focused exclusively on the Natural Gas industry, trying to identify technologies that could be used. Subsequently, business processes in which Gas 4.0 techniques could be adopted were identified. Literature review and interviews' results were combined in order to identify candidate business processes. Finally, an effort took place with the aim of planning the future situation regarding the 44 business processes which have been identified. 44 personal and group interviews took place, involving 25 DEDA employees (senior executives and company officers). In total, 60 personal and group interviews took place. Figure 1 depicts the suggested methodological steps to be followed regarding the methodology development.

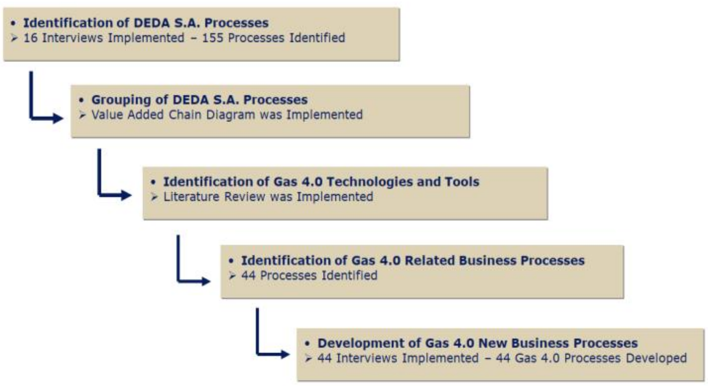

Fig -1: Methodology for Highlighting and Reengineering Key Gas 4.0 Distribution Business Processes

As a total, 155 processes have been identified, divided into 7 process groups, as follows:

•Corporate Governance (17 processes)

•Financial Management (7 processes)

•Strategy Management, Partnerships and Market Monitoring (10 processes)

•Project and Network Management (65 processes)

•Infrastructure and Network Operation (22 processes)

•Infrastructure Network Maintenance (26 processes)

•End User and User Management (8 processes)

The corresponding Value Added Chain Diagram is depicted in Figure 2. The literature review results are presented in the second chapter of the article. As regards the forth step, a total of 44 processes were found in which Gas 4.0 concepts and technologies could be used in an integrated way. In order to understand the nature of DEDA's Business Processes, as well as their improvement possibilities, a Business Process Management architecture was created. The views of the architecture analysis have been detected and categorized as follows [15]:

•Organization View: It encompasses the organizational structure of the company according to employees' positions and its allocation in departments.

•Process View: It composes of the processes, sub-processes and activities of the organization.

•Information Systems View: It depicts the Information Systems used by the company as well as the applications included in them and their interconnections.

•Industry 4.0 and Internet of Things View: It analyzes the utilization of automations in the operations of semi-autonomous functions using sensors, actuators and tele-communication networks.

•Documents/Files View: Recording and classification of significant documents and files for the Business Processes operation are included in this view.

•Rules/Legislation View: It refers to the business rules and laws which influence organization processes and should be noted down.

•Risks/Controls View: It includes risks listing according to their category and their implications in business processes.

•Products/Services/Customers View: It contains the analysis of products and services provided by the organization and the approaches on the basis of which its main customer categories are served.

Depending on the views described, ARIS (Architecture of Integrated Information Systems) was decided to be used as the business process modeling architecture. ARIS was selected not only because it completely encompasses the views which have to be included in the analysis, but also because it can be completely understandable and easily accessible by DEDA's employees.

4. Incorporation of Gas 4.0 in DEDA's Business Processes

Concerning the identification of Business Processes in which Gas 4.0 technologies could be used, a total of 44 processes were found. Each process was analyzed with the aid of ARIS architecture using BPMN (Business Process Model and Notation) diagrams, while specific additional architecture diagrams were implemented, in case it was deemed appropriate. 44 interviews with DEDA employees were conducted in this stage of the methodology. The processes identified are highlighted (both in bold and with red colour) in Figure 2.

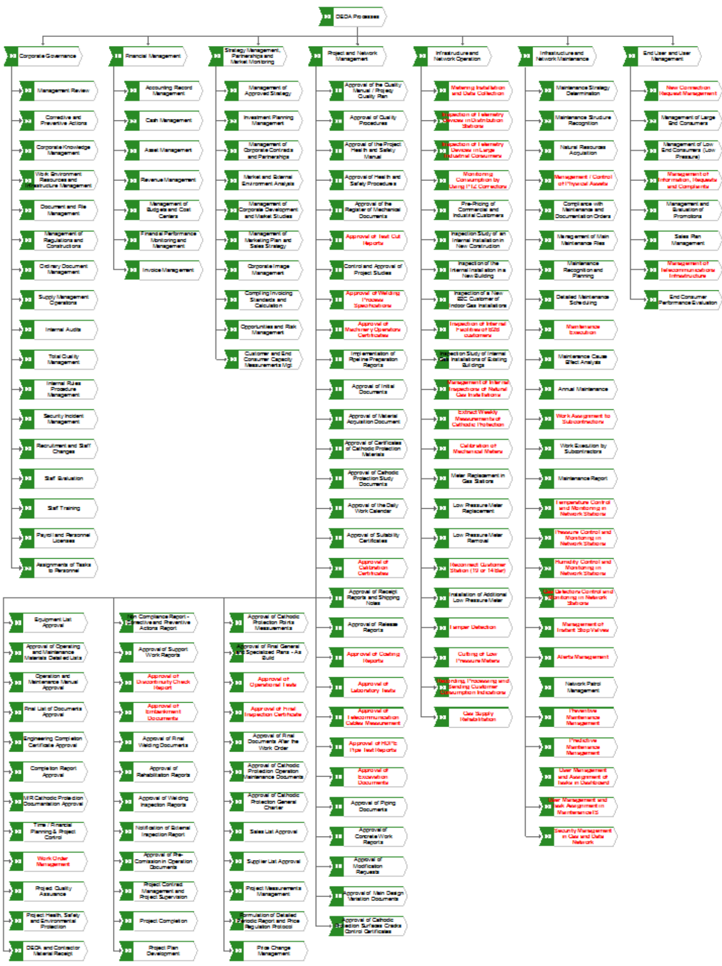

Fig -2: DEDA Value Added Chain Diagram

The Business Process analysis indicated that the main processes of DEDA focus on the gas network construction (at least until the network is fully developed), the network maintenance and operation, as well as the final connection of users to the network and customer service. This leads to four business process groups that could be radically improved (Project and Network Management, Infrastructure Network Maintenance, Infrastructure and Network Operation, End User and User Management). All the proposed innovations, automations and Information Systems should be introduced around these process groups.

4.1 Project and Network Management group of processes

Project and Network Management group of processes is considered critical regarding the Natural Gas network, especially for DEDA, which aims to expand its network and serve a larger amount of customers. At this time, network expansion projects are being carried out in almost the entire Greek territory. However, the management of these processes faces a number of intractable problems. For example, the processes are implemented without using Information Systems, and there is no possibility to utilize data from past completed projects. In order to improve the existing situation, a number of processes related to the development of the company's network will be reengineered (Selection of Contractors, Management of Bid Evaluation, Project Time Management, Project Supervision and Contract Management, Pay Approvals, Delivery of Materials, Project Completion, Work Orders Management) using a Project Management Information System supported by a Document and Workflow Management system.

It should be highlighted that all the company’s projects are implemented with the aid of subcontractors, while the company is limited to a managerial and supervisory role [2]. The lifecycle management of subcontractor’s contracts will be implemented through the new appropriate Information System. This system has the main aim to monitor the progress of the company’s projects, correcting and updating schedules. At predefined time windows, the system deals with the approval of payments regarding subcontractors (in collaboration with the Information Systems of the financial department of the company). For this reason, special attention was paid in order to link the project management procedures with corresponding financial processes regarding the issuance of invoices, through an existing Information System. The whole interface is going to serve both the materials procurement and subcontractor’s payments, in an integrated and IT supported way. In addition, the systemic roles for all the stakeholders involved in Project and Network Management processes were defined. Standardization of all the documents (electronic or not) existing in the abovementioned processes also took place, as well as configuration of the corresponding automated workflows.

An additional crucial factor during the project implementation is the supply of project materials. DEDA is responsible for the materials procurement, which are subsequently transported to the project site in order to be used by the subcontractors. Through the appropriate Information System, the project materials are selected (based on price and specifications) with methods that may differ depending on the case (open tender, closed tender, reverse auction) [2]. As regards the project completion step (which is the final step of the projects), the Project Management Information System aids in the project final control, so that both the company and the subcontractors are guaranteed that the project meets the specifications of the initial contract.

A number of interviews with the process owners (who will be the future Project Management Information System users) were conducted in order to more accurately record the requirements and functional specifications of the system. As the company's Natural Gas network is going to expand considerably, the reengineering of Project and Network Management processes with the simultaneous introduction of a Project Management Information System are considered critical factors. These parameters, along with the training of subcontractors on the new processes, specify a secure and sustainable way, allowing the company to proceed safely to the next implementation steps.

4.2 Infrastructure Network Maintenance Group of Processes

Infrastructure Network Maintenance can be implemented either in a preventive or in a predictive way. In the reengineered processes, which will be based on the Gas 4.0 techniques, real time network status will be monitored through the control room and possible malfunctions will be detected. The Control Room will be the heart of the data transmission “to” and “from” the network points of interest, communicating with sensors, actuators and smart meters, through the operation of a parallel data network. The Control Room will be based on a Network Monitoring application, in order to monitor pipelines points of interest and end users information, taking the appropriate decisions. The Network Monitoring application will operate in close cooperation with the communication network (and the corresponding equipment), based on wireless technology (LoraWan protocols). Wireless systems will transmit information from the metering devices and the entire network infrastructure to the Control Room.

The Network Monitoring application will be closely associated with a Predictive Maintenance application. Predictive Maintenance application is going to utilize the wireless network (placed at various points of the pipeline) enabling the company to predict the time remaining until failure. Predictive maintenance also involves the repairing of the machinery in order to keep it working longer. The application will be based on Machine Learning techniques, supporting business needs. The aim of Machine Learning is to construct a predictive maintenance model containing multiple variables. Based on Machine Learning, the application will be able to identify equipment condition, and proceed with predictive maintenance processes. In case of equipment failure, the company has to proceed with reactive maintenance, which means that the replacement cost would be much higher, as would be the replacement time.

In combination with predictive maintenance, the Network Monitoring application can also support preventive maintenance processes. In this way, a preventive maintenance program is exported, in order to carry out specific maintenance tasks related to different network equipment. The abovementioned program could assist the company in order to save resources during the maintenance process. Moreover, the use of long-term data is going to assist during the lifespan estimation of the manufacturing equipment.

Restoration of gas network leakages or outages, caused by malfunction or malware, is also considered a difficult situation which usually takes much longer than expected. Especially if the problem occurs during the summer months when there is no high demand for Natural Gas, then it can be identified days or even weeks after its occurrence. Although "standard" repair times have not been calculated, they are certainly not considered satisfactory. In the reengineered process, based on the use of sensors along the entire network, the leakage location is quickly identified. In case of emergency, a vehicle may be sent and transmit image from the damage area so that appropriate personnel and equipment can be dispatched. All data are stored in the Network Monitoring application implemented in the control room.

Finally, it should be highlighted that Infrastructure Network Maintenance processes are usually carried out in collaboration with subcontractors who undertake part of the work assigned. Subsequently, training of subcontractors in the new improved processes is a matter of particular importance. Nevertheless, and in contrast to the Projects and Network implementation, the company's strategy is to become independent from subcontractors in the field of maintenance. In this context, all the processes implemented exclusively by subcontractors are reengineered in order for the company to acquire the appropriate know-how, and to be able to perform the necessary activities with its own means.

4.3 Infrastructure Network Operation Group of Processes

As regards the Infrastructure and Network Operation processes which are reengineered involving Gas 4.0 techniques, they concern a number of measuring devices which are deployed along the network. A number of metrics are monitored by the control room in real time, using appropriate sensors. Both the consumption measurement process and the customer life cycle process will be monitored and supported by a corresponding Information System. This Information System will manage all the available information regarding the status of each customer (or potential customer), while it can transmit data from one business department to another in order to complete the required actions. In addition, the installation of new smart metering equipment is taking place in order to exchange information between the final consumers and the control room of the company. A smart secure gateway will be installed in the metering system of the clients in order to ensure data transmission. Smart meters are going to facilitate and automate the Consumption Management Process, while reducing the costs involved. These smart meters also undertake a number of other processes (leak detection, gas tamper detection). The reengineered tamper detection process is depicted in Figure 3, as an example:

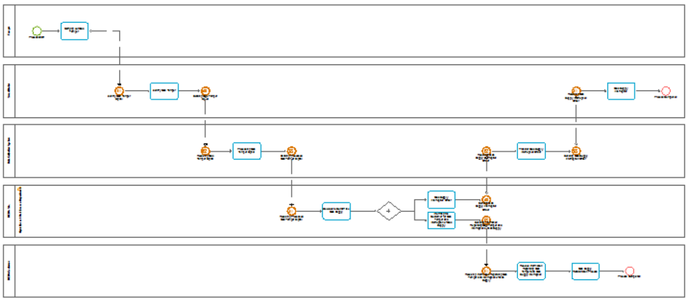

Fig -3: DEDA Tamper Detection Process

A critical part regarding the network operation is the measurement of gas quality through telemetry equipment. For this purpose, a series of detectors (pressure, temperature and humidity detectors) are placed in specific and preselected points of the network in order to transmit data to the control room, measuring the gas quality. In a similar way, gas consumers (and especially large industrial consumers) are required to comply with certain standards regarding gas quality. Indoor detectors are installed in order to collect data from industrial customer facilities, while they sent data to the control room in order to control the proper facility operation.

As a final step, after the provision of services, DEDA's invoicing process takes place. The invoicing process is managed through an integrated Information System with full visibility, while employees have the ability to monitor invoices throughout their life cycle. When the accounting department receives an invoice, this typically follows an approval process, while the invoice is matched with a purchase order or contract. The integrated Information System streamlines this workflow by scanning invoices, while all approvals are implemented through the system. Once invoices are approved, they are stored on the cloud for easy access at a later date.

4.4 End User and User Management Group of Processes

Finally, in the End User and User Management group of processes, the potential customers express their interest in order to be connected to DEDA's network. In case gas network is available in the customer's area, the connection can be implemented. In addition, the group includes a set of technical and managerial processes which facilitate both the connection of new customers and their consumption measurement at predefined time windows.

In the current situation, the abovementioned group of processes requires constant effort from the part of the company and a huge workload to be processed. The automation of the process leads to resource savings which could be placed to other company's processes. A new CRM (Customer Relationship Management) software is going to handle new connection requests, in order to be completed smoothly. The same CRM software is going to handle stakeholder's complaints, in order to have a unified view of the customer's behavior during their lifecycle.

Specialized techniques were implemented in order to ensure vertical communication of all the company's Information Systems, display the whole available information in a single point and facilitate decision making. Vertical communication will be secured using a Business Intelligence module, using cloud technology and Internet of Things philosophy. It is highlighted that technologies adopted by DEDA S.A. are not the only Gas 4.0 technologies which can be applied in a gas distribution company. On the contrary, there is a high probability that DEDA is going to adopt additional Gas 4.0 technologies in the next maturity steps, in order to further improve its efficiency.

5. Conclusions

The reengineering and modernization of companies activating in the utilities sector with the aid of Industry 4.0 tools and techniques are steadily gaining ground. In the DEDA's case, through the reengineering using Gas 4.0 techniques and technologies, critical business processes were enhanced with automation equipment and IT solutions. Gas 4.0 has the potential to increase business processes' efficiency and effectiveness, aiding in rational decision making. End User and User Management, Infrastructure and Network Operation, Infrastructure Network Maintenance, Project and Network Management are major Natural Gas distribution activity areas around the Gas 4.0 concept.

Gas 4.0 use in DEDA'S business processes affects a wide group of stakeholders. DEDA will have an undeniable benefit as Gas 4.0 reengineering will allow the company to utilize state-of-the-art technologies to provide high quality services to its customers with economical and sustainable way. But in reality, the results of these improved services are finally reaped by both customers and the customers of DEDA customers, who are the end users of Natural Gas. Improvement of services provided to DEDA customers will offer the possibility of a faster and more accurate pricing to final consumers, recording at the same time a number of other consumption parameters which are important to all network users. In addition, efficient gas handling can bring multiple economic benefits to the whole industry but also to other industries, multiplying the benefits for the national economy. Further, the issue of the safe operation of the network and the possibility of improved preventive or even predictive maintenance or immediate intervention in case of problem (due to damage, accidental events or deliberate actions) is a parameter that affects the general economic and social activity of the country.

The contribution of Gas 4.0 in process groups such as Infrastructure Network Maintenance, Infrastructure and Network Operation and Project and Network Management became immediately evident. The effective monitoring and control of the gas network through the control room implementation, utilizing automations (sensors, actuators, smart meters) in line with Gas 4.0 philosophy, pushes the company towards a "doing more with less" philosophy. In other words, the company reduces maintenance costs while increasing automation, digitalization, safety and security.

In collaboration with Gas 4.0 technology, the introduction of supportive Information Systems (a collaborative Customer Relationship Management, a Project Management System, a Document and Workflow Management system, a Network Monitoring Application and a Predictive Maintenance Application) proved to play a key role in order to achieve fully integrated Business Processes. As CRM was the key to bring the company closer to the other stakeholders, the Project Management software facilitated the monitoring of network projects. The Network Monitoring application provides complete integration with Predictive Maintenance application, coordinating and facilitating Network Monitoring and Network Maintenance.

As regards research limitations, it should be emphasized that the study refers to a Natural Gas company, and more specifically to a company which operates in the Natural Gas distribution sector. In the case of a company operating in a different sector, different tools should be selected, as the company's business process may differ significantly. It should also be highlighted that DEDA S.A. has as its main activity to operate as the Natural Gas Distribution Network Administrator, in Medium and Low Pressure. Corresponding companies may need to adopt different tools and methodologies if they activate in different fossil fuels such as oil, or if the implementation takes place in high pressure. The case study took place is a company operating in Greece, a market with specific characteristics (such as low maturity). Special attention should be given to the market maturity issue, and different tools are about to be selected for a similar company in a different country. In case the results of the research have to be applied to another similar company, a detailed study of the company's processes must have preceded (as it was mentioned in the methodology chapter).

Such studies are considered very important for the research community, as they can obtain a clear picture regarding the industry development. On the other hand, industry executives can obtain specialized knowledge regarding specific issues, such as business process reengineering and the introduction of Industry 4.0 technologies into industrial business processes. In the future, particular attention should be paid to other sections of the gas sector, as the midstream section is currently attracting the main research effort. Businesses in the gas industry, in whatever section they belong to, and in order to reap the benefits of Gas 4.0, should put business processes at the center of their design, trying to adapt the appropriate tools. In addition, the evaluation of any redesigned process based on the Gas 4.0 and the corresponding tools should be based on a carefully designed evaluation process, in order for the adoption of the new process to bring the desired results.

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