Analysis of Digital Technology Application Opportunities in Quality Assurance Processes of the Energy Sector Projects

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ABSTRACT

This research is exceptionally significant for the contemporary energy sector, which constantly faces high-quality requirements and rapid digital transformation. Society's increasing reliance on a reliable electricity supply directly links construction quality to infrastructure longevity and operational costs. However, a major obstacle lies in the insufficient integration of advanced digital technologies, such as the Internet of Things and artificial intelligence, into the quality assurance processes of new energy construction projects. This gap leads not only to a higher risk of defects but also limits effective process optimization, potentially harming long-term grid reliability. This study aims to examine how digital technologies can be integrated into quality assurance processes for new energy construction projects to improve quality control and ensure reliable equipment operation. To achieve this aim, the research tasks included analyzing current quality assurance processes in energy construction projects, evaluating their efficiency, challenges, and areas for improvement; identifying and describing potential digital technologies applicable to new construction project quality assurance, based on expert evaluation; assessing the potential benefits and application possibilities of digital technologies, proposing a process map for integrating digital technologies during new construction projects and subsequent equipment operation. This study employed research methods, including scientific literature analysis, expert evaluation, in-depth interviews, process analysis, and modeling. Based on the empirical research results, a process transformation map for creating a new information technology service was proposed, visually illustrating how and when digital tools (e.g., BIM, IoT sensors, AI analysis) will be implemented and used at each stage of a construction project (from planning to operation). This map highlights how specific digital solutions will contribute to defect prevention, process acceleration, and a longer equipment lifecycle. A continuous monitoring and evaluation system was established to track the impact of digitalization on quality indicators and to adjust the strategy flexibly. Such solutions will ensure the reliability of electricity grids, allow for defect detection earlier than when they manifest as failures, and enable cost savings during operation.

Keywords: digital technologies, project quality assurance, project quality assurance processes, process management, energy sector.

1. Introduction

The relevance of this research is critically important for the strategic energy sector, as it is directly related to meeting high-quality requirements and capitalizing on the opportunities of rapid digital transformation. High project quality in the energy sector is not just a requirement, but a necessity, as it determines equipment reliability and longevity, reduces subsequent operational maintenance costs, and ensures stable energy grid operation. At the same time, digital technologies being implemented in construction and project management, such as data analytics, BIM, and remote monitoring, offer innovative tools for quality control and maintenance. As Wang et al. (2020) note, digital technologies, including BIM, can significantly improve quality management in construction projects, reduce defect risk, and optimize processes. Recent studies also confirm the importance of digital technologies (Čyras, Nalivaikė, 2024; Merkevičius et al., 2024), including data collection, decision-support systems, collaboration platforms (including BIM), and reliability-enhancing tools, for effective quality assurance in the construction sector, especially during the project execution phase. This research is relevant because it analyzes how energy companies can leverage these digital innovations to effectively improve project quality and long-term system operation, thereby contributing to greater energy system resilience and reliability. This is particularly relevant as electricity becomes one of the primary energy sources.

The main problem of this research is the insufficient integration of digital technologies into current quality assurance processes for new construction projects. This phenomenon, whose relevance and links to current construction sector trends and future directions are emphasized by scientific studies, can limit the possibilities to more effectively ensure high construction quality, reduce the number of defects, optimize processes, and potentially have a negative impact on subsequent equipment operation and electricity grid reliability, as confirmed by studies showing how installation quality aspects affect the reliability of critical electrical system components and the entire grid (Permal et al., 2020).

To address the identified problem, the research aim was formulated: to examine how digital technologies can be integrated into quality assurance processes for new energy construction projects to improve quality control and ensure reliable equipment operation. To achieve this aim, the research tasks were set: to analyze current quality assurance processes in energy construction projects, evaluating their efficiency, challenges, and areas for improvement; to identify and describe potential digital technologies that could be applied in the quality assurance field of new construction projects, based on expert evaluation; to assess the potential benefits and application possibilities of digital technologies, and to propose a process map illustrating how digital technologies could be integrated during new construction projects and subsequent equipment operation. This study employed research methods including scientific literature analysis, expert evaluation, in-depth interviews, process analysis, and modeling.

2. Literature Review

In recent years, rapidly advancing digital technologies have had a significant impact on many industries, including the strategic energy sector. Digitalization is defined as the rapid progress of technologies such as the Internet of Things (IoT), artificial intelligence (AI), smart grids, and big data, which transform the ways energy is produced, distributed, and managed (Masanet et al., 2017; Perrons, 2021; Latif et al., 2022; Monaco et al., 2024). The digitalization of the energy sector is driven by increasing data volumes, computing power, and the growing accessibility of digital technologies, as well as the continuous need to enhance modeling, analysis, and planning (IEA, 2024; Zhang, 2024). The digitalization process is essential for increasing the energy system's efficiency, reliability, and resilience. The review by Hwang et al. (2025) highlights the significance of digitalization in driving energy renovations and influencing EU policy in this area.

The digitalization of the Architecture, Engineering, Construction, and Operations (AECO) industry, particularly in construction project management, is closely linked to Building Information Modeling (BIM) (Sacks et al., 2018). BIM, as a fundamental approach, helps manage the increasing volume of information and data generated throughout the entire construction project lifecycle (Zhang et al., 2022). This technology enables better coordination, more effective detection of potential defects, and process optimization even before the construction phase, thereby contributing to higher quality assurance. Digital documentation management systems, as noted by Jordanas et al. (2022), are an essential step towards digital transformation, ensuring information consistency and accessibility.

Project quality in the energy sector is not only a requirement but a necessity, as it determines equipment reliability and longevity, reduces subsequent operational and maintenance costs, and ensures stable energy grid operation. Quality assurance in construction projects is inextricably linked to risk management, which is defined as the process of identifying, analyzing, mitigating, and monitoring events or conditions that could impact project objectives (PMI, 2017). Construction projects, especially in the energy sector, are characterized by large capital investments, long durations, abundant resources, multiple stakeholders, volatile environments, and a high level of complexity (Cagliano et al., 2015), making effective risk and quality management critically important. In recent years, there has also been an increasing focus on integrating artificial intelligence and machine learning models into diagnostic and assessment processes, particularly to improve the analysis of existing building conditions, indicating a general trend towards more innovative solutions.

Over the last decade, the implementation of advanced digital tools has become essential for companies seeking to successfully navigate the complex modern construction environment and ensure high quality. For example, companies that have implemented similar digital solutions report an average 25% increase in project efficiency and a 20% reduction in operating costs (McKinsey & Company, 2017). An important aspect of digital transformation is selecting the right technology provider that aligns with the company's vision for growth and efficiency, while strictly adhering to health, safety, environmental, and quality standards (Blanco et al., 2016). Blockchain technology is also gaining increasing importance in the construction sector, as it helps ensure data reliability and transparency throughout the supply chain (Sun et al., 2023). Data analysis and process optimization, leveraging big data, are essential for continuous process improvement in manufacturing (Stojanovic et al., 2015; Ungermann et al., 2019). However, it is important to consider data hazards and their management (Zelenka et al., 2025).

Despite the apparent benefits, the adoption of new technologies in construction often faces significant resistance from local specialists. This "change fatigue" arises from years of unfulfilled promises that each new tool would simplify tasks, despite many solutions complicating them. For instance, only 30% of workers aged 25 and older felt their industry supported technological advancement (Brown, 2024). The study by Paudler et al. (2022) highlights the significance of human factors and the necessity for human-centered integration in the digitalization of the energy sector. Employees should be reluctant to abandon familiar methods, especially when previous experiences with technologies have led to frustration rather than improvement. Therefore, successful integration of digital technologies requires considering not only technical but also human aspects, ensuring proper training and demonstrating real benefits in daily operations. Digital twins also pose new challenges in governance, particularly within the energy industry (Michalec, 2025).

3. Research Methodology

Expert evaluation is a process in which qualified specialists or experts analyze and assess specific information, a product, or a service based on their knowledge and experience in a particular field (Hughes, 1996; Macijauskienė et al., 2023; Mohammadi et al., 1991). Given this, high-quality and professional evaluation results can be expected. To gather comprehensive expert insights and connect them with theoretical foundations, the survey questions are formulated in consideration of the discussed scientific literature and research objectives. Each question aims to reveal specific aspects related to the integration of digital technologies into quality assurance processes in energy construction projects.

A total of 21 experts were surveyed, including: 12 experts who are energy sector specialists (engineers, technical managers responsible for grid reliability and development); 6 experts who are construction project managers with experience in large energy infrastructure projects; and 4 experts who are digital technology specialists (BIM (Building Information Modeling) managers, digitalization project managers, IT solution architects). The experts were presented with 25 questions on an online platform concerning current quality assurance processes in energy construction projects, aiming to ascertain which digitalization opportunities are relevant and what benefits and risks experts perceive in digitalizing construction and operation processes.

The experts were presented with the following questions, grouped by processes.

General Overview of Quality Assurance and Digitalization

1. How do you assess the effectiveness of current project quality assurance processes in energy construction projects, taking into account the importance of equipment reliability and longevity?
2. Are you satisfied with the current quality control processes and methods, considering the need to minimize subsequent operational maintenance costs?
3. Do you agree that current technologies meet the future quality assurance needs in the energy sector, given the rapid advancement of digital technologies?
4. Do you think that existing quality assurance processes are flexible enough to adapt to the integration of digital solutions, considering the general resistance to change in the energy industry?
5. How important is it to integrate digital solutions into quality assurance processes to enhance the resilience and reliability of the Lithuanian energy system?
6. Would you recommend to your colleagues to integrate digital technologies into project quality assurance processes, considering the overall benefits of digitalization for the energy sector?

Impact and Application of Digital Technologies in Project Stages

1. Do you agree that digital technologies can significantly enhance the quality of project implementation and post-completion outcomes?
2. How do you assess the potential of data automation and its impact on quality assurance processes, given the growing volume of data in the energy sector?
3. How do you evaluate the importance of digital documentation in project management and information management throughout the entire construction project lifecycle?
4. How do you evaluate the capabilities of digital technologies in reducing construction defects and improving quality management?
5. Do you think that implementing digital solutions can reduce operational risks and costs?
6. How do you assess the impact of new technologies on the project planning stage and their potential to optimize processes even before physical construction begins?
7. How familiar are you with BIM (Building Information Modeling) technology and its potential in managing the volume of information in construction projects?
8. How do you evaluate construction project risk management using digital solutions, considering the connection between quality assurance and risk management?
9. Do digital technologies have the potential to optimize quality monitoring processes and ensure stable operation of the energy grid?
10. Do you agree that digital technologies help reduce construction time and optimize project progress?
11. How important is the automation of data collection and analysis after construction projects are completed, considering the continuous need for modeling, analysis and planning improvement?
12. In your opinion, how significant is the impact of digital technologies on long-term equipment operation and grid reliability?
13. How do you evaluate the impact of digital technologies on project management, considering the complexity and abundant resources of construction projects?
14. How do you evaluate the potential to integrate artificial intelligence into quality control processes and its capabilities in energy generation and distribution management?

Challenges of Digital Solution Implementation and Investment Perspective

1. How do you assess employees' readiness to utilize new digital systems, taking into account the "change fatigue" phenomenon?
2. How do you evaluate the impact of IT infrastructure reliability on improving quality assurance processes, considering its significance for the success of digital technologies?
3. Do you agree that the implementation of digital solutions will significantly contribute to construction project quality assurance, considering the return on investment and efficiency?
4. How do you evaluate the return on investment when integrating digital solutions into project quality assurance processes, compared to traditional methods?

4. Research Results

The survey results indicate that energy sector specialists recognize the importance and significant potential of digital technologies in improving quality assurance processes. While current processes are generally rated positively, there is strong agreement on the necessity to improve them and integrate digital solutions. A comprehensive expert evaluation was conducted using the expert evaluation method (involving 21 energy sector experts: 12 energy sector specialists – engineers, technical managers responsible for grid reliability and development; 6 construction project managers with experience in large energy infrastructure projects; 4 digital technology specialists – BIM (Building Information Modeling) managers, digitalization project managers, IT solution architects). Their summarized opinions are presented in the process transformation evaluation table (Table 1). The majority of respondents consider the current quality assurance processes to be sufficiently effective; however, a larger proportion (63%) identifies areas for improvement, suggesting that there is still room for advancement and optimization, especially given the rapid progress of the sector. This gap is expected to be filled through digitalization of the process. The absolute majority of respondents are convinced that digital technologies will significantly improve quality and are essential for modernizing the energy sector. The importance of data automation and digital documentation for efficient management is particularly emphasized. Digital solutions are also recognized as highly effective tools for managing risks and reducing operational risks and costs. While employees' readiness for new digital technologies is rated as good, "change fatigue" is also noted, indicating a need for thoughtful change management and training. Furthermore, the critical importance of a reliable IT infrastructure for successful digitalization implementation is highlighted. In summary, the energy sector is poised for digital transformation, recognizing it as a vital means to enhance quality, efficiency, and reliability, despite certain challenges related to process adaptation and human resource management.

Table 1: Expert Evaluation of the Digitalization Process: Effectiveness of Current Quality Assurance Processes, Impact of Digital Technologies on Quality Improvement, Need for Digital Technology Integration, Data Automation, Satisfaction with Quality Assurance Processes, and Importance of Digital Documentation.

Evaluated Aspects	Expert Evaluation Results
Effectiveness of current quality assurance processes.	Thirty-three percent of experts evaluate current processes favorably, noting that most processes are effective. However, 63% of respondents indicate areas for improvement, suggesting room for advancement and optimization, especially considering the rapid progress of the sector.
The Impact of Digital Technologies on Quality Improvement.	76% (an absolute majority) of experts firmly underlined that digital technologies will significantly improve quality. This highlights strong confidence in the potential of digital solutions throughout the entire project lifecycle – from initial planning to long-term operation.

Evaluated Aspects	Expert Evaluation Results
Need for digital technology integration.	More than half (67%) of experts stated that integrating digital technologies is necessary and urgent to remain competitive. The other 33% also underlined that it is crucial for efficiency and modernization, indicating unanimous agreement among experts.
Opportunities for data automation and impact on quality assurance.	All experts unanimously agree that the possibilities for data automation are very high, representing a fundamental step towards quality improvement. With the increasing volume of data in the energy sector, manual management becomes increasingly inefficient. Automation enables more effective data collection, analysis, and utilization for proactive quality control and informed decision-making.
Satisfaction with quality assurance processes in reducing operational costs.	The majority (33%) of experts are either satisfied or dissatisfied but see room for improvement. While processes ensure quality during construction, their long-term impact on operational costs is not fully optimized. This suggests a need for proactive measures to prevent costly failures and future maintenance.
Importance of digital documentation.	More than half (52%) of experts emphasized that digital documentation is critical; effective management is impossible without it. The other 48% of experts confirm that digital documentation improves efficiency.
Flexibility of quality assurance processes for digital solution integration.	The majority (57%) of experts state that existing processes are sufficiently flexible. This is a crucial argument suggesting that the sector's culture is conducive to digitalization, and significant integration obstacles related to resistance to change should not arise. However, a portion (29%) still sees a need for corrections.
Capabilities of digital technologies in reducing construction defects.	Sixty-two percent of experts stated that the capabilities of digital technologies are very high, enabling them to reduce defects significantly. This includes defect detection at early stages, better planning, and continuous monitoring during construction.
The Impact of Digital Solutions on Equipment Operation.	The absolute majority (81%) of experts undoubtedly stated that this will greatly reduce risks and costs. This is one of the strongest arguments for digitalization, emphasizing long-term financial and operational benefits.
Impact of new technologies on the project planning stage.	The majority of experts (57%) evaluate the impact as positive, indicating a significant improvement in planning. New technologies, such as BIM, allow for detailed simulations and precise resource planning, eliminating errors during the design phase. 38% of experts see the impact as exceptionally positive.
Familiarity with BIM technology.	Although the most significant proportion (73%) of experts have heard of BIM but are not intimately familiar with it, it is worth noting that almost half are well or very well familiar with it and see great potential. This suggests a growing yet underutilized potential of this technology.

Table 1 data reveal that while existing quality assurance processes are considered sufficiently effective (63% identify areas for improvement), experts uniformly (76%) emphasize the significant potential of digital technologies to enhance quality throughout the entire project lifecycle. The potential of data automation (100% of experts) and the importance of digital documentation (52%) were highlighted as essential elements for effective quality management. Furthermore, 81% of experts are convinced that digital solutions will substantially reduce operational risks and costs.

Table 2: Expert Evaluation of the Digitalization Process: Flexibility of Quality Assurance Processes, Capabilities of Digital Technologies in Reducing Construction Defects, Impact on Equipment Operation and Project Planning Stage, Familiarity with BIM Technology

Evaluated Aspects	Expert Evaluation Results
Flexibility of quality assurance processes for digital solution integration.	The majority (57%) of experts stated that existing processes are sufficiently flexible. This is a crucial argument suggesting that the sector's culture is conducive to digitalization, and significant integration obstacles related to resistance to change should not arise. However, a portion (29%) still sees a need for corrections.
Capabilities of digital technologies in reducing construction defects.	Sixty-two percent of experts emphasized that the capabilities of digital technologies are very high, enabling them to reduce defects significantly. This includes defect detection at early stages, better planning, and continuous monitoring during construction.
The Impact of Digital Solutions on Equipment Operation.	The absolute majority (81%) of experts stated that this will greatly reduce risks and costs. This is one of the strongest arguments for digitalization, emphasizing long-term financial and operational benefits.
Impact of new technologies on the project planning stage.	The majority of experts (57%) evaluate the impact as positive, indicating a significant improvement in planning. New technologies, such as BIM, allow for detailed simulations and extremely precise resource planning, eliminating errors during the design phase. Thirty-eight percent of experts view the impact as exceptionally positive.
Familiarity with BIM technology.	Although the largest proportion (73%) of experts have heard of BIM but are not intimately familiar with it, it is worth noting that almost half are well or very well familiar with it and see great potential. This suggests a growing yet underutilized potential of this technology.

Table 2 indicates that the majority of experts (57%) view current QA processes as sufficiently flexible for integrating digital solutions. A large portion (62%) emphasized that digital technologies have significant potential to reduce construction defects, and an even larger portion (81%) was convinced that digitalization will substantially reduce equipment operational risks and costs. Despite most experts (73%) having only heard of BIM rather than being intimately familiar with it, the overall outlook on the benefits of digital solutions in planning and defect prevention is very positive.

Table 3: Expert Evaluation of the Digitalization Process: Construction Project Risk Management, Potential of Digital Technologies, Employee Readiness, Importance of Digital Solution Integration, IT Infrastructure Reliability, Contribution of Digital Solutions, and Return on Investment

Evaluated Aspects	Expert Evaluation Results
Construction project risk management with digital solutions.	The majority of experts (63%) stated that this is an effective and excellent way to manage risks. Digital tools allow real-time monitoring and analysis of risks associated with quality deviations.
Potential of digital technologies to optimize quality monitoring processes.	The majority (67%) of experts undoubtedly underlined that they have immense potential. Digital monitoring enables continuous data acquisition on grid status, facilitates the prediction of failures, and facilitates proactive responses.
Employee readiness to use new digital systems.	The majority (43%) of experts rated readiness as very good, indicating that employees are willing to embrace innovations. This is a positive sign, but 24% experience "change fatigue," necessitating thoughtful change management.
The Importance of Digital Solution Integration for Energy System Resilience.	52% of experts emphasized it is vital, contributing to system reliability. Another 33% consider it critically important for enhancing resilience.
Impact of IT infrastructure reliability on quality assurance process improvement.	The majority of experts stated that the impact is significant; reliable IT infrastructure is essential. This emphasizes that without a strong technological foundation, the success of digitalization would be limited.
Contribution of digital solutions to construction project quality assurance and return on investment.	52% of experts strongly emphasized that the return on investment will be high. Another 48% also underlined that it will contribute significantly, indicating almost unanimous agreement.
Return on investment when integrating digital solutions (compared to traditional methods).	95% of respondents rate the return on investment as "very high" (52%) or "high" (43%), emphasizing the efficiency of digital solutions compared to traditional methods. This confirms that initial investments in digitalization pay off through long-term efficiency gains and cost reductions.

Table 3 illustrates that the majority of experts (63%) consider digital solutions a highly effective method for managing risks in construction projects. They also uniformly (67%) see immense potential for digital technologies to optimize quality monitoring processes. While employee readiness for innovation is rated well (43%), "change fatigue" (24%) is noted, indicating a need for thoughtful change management. Reliable IT infrastructure is recognized as critically important (by the majority of experts), and almost all (95%) experts highlight a significant return on investment when comparing digital solutions to traditional methods.

Table 4: Expert Evaluation of the Digitalization Process: Impact of Digital Technologies on Construction Time, Data Collection and Analysis, Impact of Digital Technologies on Long-Term Equipment Operation, Project Management, Current Technology Suitability, Artificial Intelligence Potential, and Recommendations.

Evaluated Aspects	Expert Evaluation Results
Impact of digital technologies on construction time and project progress.	The majority of experts fully agree that they are beneficial. This confirms that digital technologies not only improve quality but also increase efficiency and speed.
Importance of data collection and analysis automation after construction projects are completed.	Most experts stated it is critically important and necessary for continuous improvement. This shows an understanding of the value of data for learning and continuous process improvement.
Impact of digital technologies on long-term equipment operation and grid reliability.	Experts unanimously agree that digital technologies have a particularly significant impact on long-term equipment operation and grid reliability (62% of respondents indicated this as a key factor). This argument emphasizes that digitalization is not just a short-term efficiency tool, but a strategic solution that ensures the long-term stability and reliability of the energy sector.
Impact of digital technologies on project management.	52% of experts evaluate the impact as very positive; these technologies simplify management and resource utilization.
Suitability of current technologies for future quality assurance needs.	81% of experts stated that they fully meet and even exceed future needs. This shows great optimism regarding existing technologies and future prospects.
Potential to integrate artificial intelligence into quality control processes.	62% of experts rate the potential as significant, indicating great opportunities. The remaining 48% emphasized that it is immense.
Recommendations to integrate digital technologies.	86% of experts would recommend integrating digital technologies into the processes under consideration, confirming that digitalization is an effective direction.

Table 4 reveals that most experts fully agree that digital technologies improve construction time and project progress. They unanimously (62%) emphasize the particularly significant impact of digital technologies on long-term equipment operation and grid reliability, seeing them as a strategic guarantee of stability and sustainability. Furthermore, 81% of experts are optimistic about the suitability of current technologies for future QA needs, and almost all (86%) would recommend integrating digital solutions into processes, recognizing the immense potential of artificial intelligence (62% rate as significant, 48% as immense).

5. Recommendations for Improving Quality Assurance Processes in Energy Sector Projects

Based on theoretical grounding, comprehensive expert evaluation, and in-depth analysis, including internal company documents and process descriptions, problematic stages in the organization of new construction projects within the energy sector were identified. These challenges manifest in various areas, including project delays, recurring errors, significantly increasing operational costs, and a direct negative impact on overall grid reliability. Considering these problems, a potential process map for new construction projects, operations, and organizations in the energy sector was formulated and proposed. In this section, two separate process maps are presented – the existing one (Figure 1) and the improved one (Figure 2) – to visualize the need for transformation and the proposed changes in detail.

5.1. Existing Organization Map for New Energy Construction Projects

Figure 1 presents the current, typical process map for organizing new construction projects in the energy sector. It illustrates a linear progression, starting from Project Initiation and Planning. This stage is characterized by traditional methods, including manual needs analysis, paper-based drawings, and obtaining construction permits, often without utilizing advanced simulation or clash detection tools. This is followed by the Design Stage, characterized by siloed work across disciplines with limited integration and manual checks. The Construction Stage is characterized by a significant influence of the human factor, sporadic on-site inspections, and manual data recording, which increases the risk of errors and defects. This stage also sees limited real-time monitoring and reactive problem-solving. The Handover and Operation Stage is characterized by static documentation and higher subsequent operational and maintenance costs, as defects are often detected only after failures occur, rather than being prevented. Such a structure often leads to information fragmentation, delays, and a lack of optimization, directly affecting project quality and long-term equipment reliability. The process is relatively inflexible and slow to adapt to the rapidly changing energy environment.

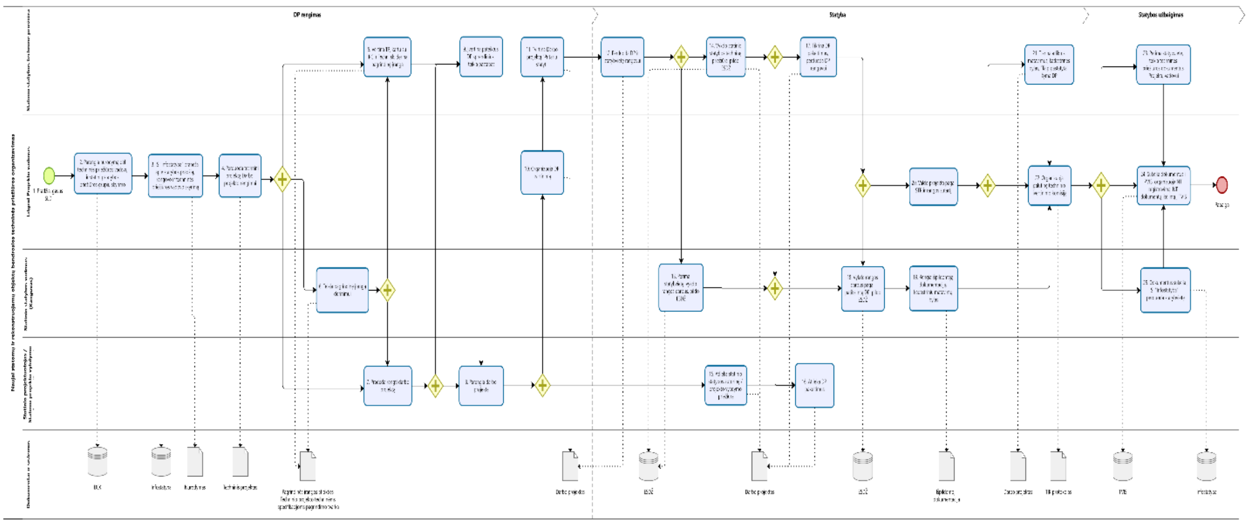

Figure 1: Existing Organization Map for New Energy Construction Projects

5.2. Improved Organization Map for New Energy Construction Projects

Figure 2 presents the proposed, improved organization map for new energy construction projects, integrating digital technologies at each stage. It begins with Smart Planning and Concept Development, where BIM (Building Information Modeling) is actively utilized for detailed simulations, clash detection, and resource planning, even before physical construction commences. This reduces design errors and optimizes the schedule. Moving to Digital Design and Modeling, tools such as digital twins and advanced data analytics are implemented, ensuring high accuracy and effective collaboration among all stakeholders.

In the Smart Construction and Quality Control Stage, extensive use of IoT and sensors is envisioned for real-time monitoring of work progress, material properties, and environmental conditions, enabling the immediate detection of deviations and the prevention of defects. Drones with computer vision perform automated inspections, and blockchain technology ensures a transparent and immutable record of all quality documentation.

In the Optimized Operation and Maintenance Stage, digital twins and AI algorithms remain key tools. They enable predictive maintenance, detecting defects before they manifest as failures, thereby significantly reducing operational costs and extending equipment lifecycle. The implemented continuous monitoring and evaluation system will enable tracking the impact of digitalization on quality indicators and allow for flexible adjustment of the strategy. This improved map signifies a shift from reactive to proactive and data-driven processes, ensuring higher project quality, reduced risks, and lower long-term costs, thereby strengthening the reliability and sustainability of the entire energy system.

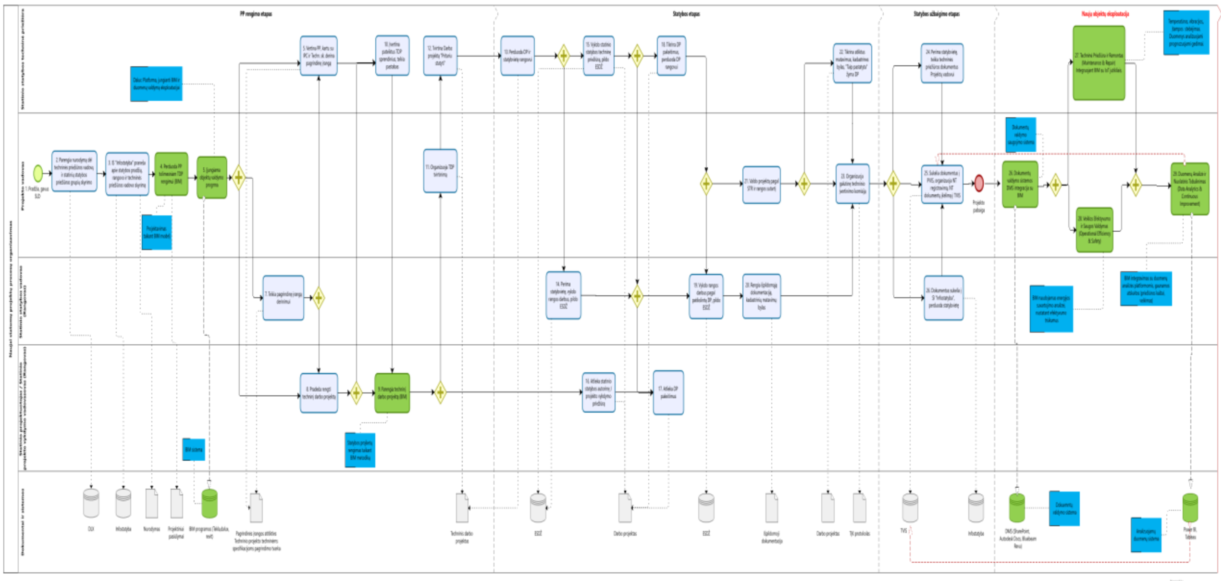

Figure 2: Improved Organization Map for New Energy Construction Projects

6. Conclusions

Upon analyzing current quality assurance processes in energy construction projects, it was found that they are sufficiently effective. Nevertheless, a significant portion of experts identify areas for improvement and point out shortcomings (design errors, project time optimization, lack of modernization, high operational costs). The biggest challenge is the insufficient reduction of subsequent operational maintenance costs, indicating that existing processes are not proactive enough and require review and modification. It is crucial to properly analyze the organization's construction project processes, as this would help strategically transform them, add new ones, or abandon outdated ones.

Through a comprehensive expert survey and analysis of their responses, it was determined that experts unanimously agree that digital technologies will significantly improve quality and are essential for competitiveness and modernization. Data automation and digital documentation are considered crucial for quality improvement and efficient data management. BIM technology is recognized as valuable; however, the level of knowledge is not yet optimal, and employee training is necessary. The immense potential of artificial intelligence integration into quality control is rated as "significant" or "immense," indicating a future vision. It is recommended that the organization transforms its construction project execution processes and adapt digital technologies, which would fundamentally help optimize projects both during their progress and after completion, during the operational period.

The proposed process transformation map for creating a new information technology service visually illustrates how and when digital tools (e.g., BIM, IoT sensors, AI analysis) will be implemented and used at each stage of a construction project (from planning to operation). This map highlights how specific digital solutions will contribute to defect prevention, process acceleration, and an extended equipment lifecycle. Establishing a continuous monitoring and evaluation system that allows tracking the impact of digitalization on quality indicators and facilitating flexible strategy adjustments is also proposed. Such solutions will ensure the reliability of electricity grids, enable defect detection earlier than when they manifest as failures, and allow for cost savings during operation.

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