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CHOOSING THE BEST SOLUTION: COMPARATIVE ANALYSIS OF AUTOMATION AND CONTROL EQUIPMENT

Industrial automation and control equipment are witnessing unprecedented advancements, with a multitude of technologies now available to flow through the value chain. Competing against each other, it is increasingly challenging for decision-makers to choose the most effective solutions. With so many manufacturers now offering products, industry professionals often lack the insights required to make proper comparisons. This situation results in inefficiencies and poor investments. This challenge is particularly pronounced in areas such as power generation, manufacturing, and other industries where these analytics are used, but no standardized parameter checks were taken on analytics. This study focuses on these aspects by showcasing a thorough reflection of prominent automation and control technologies, assessing their profiling parameters, and respective brand-specific advantages. This thesis employs a "mixed-methods approach" that rests on quantitative and qualitative analysis, both based on a unique dataset synthesized from publicly available data. The research assists industry professionals, procurement experts, and

decision-makers in making better selections, resulting in greater efficiency, lower costs, and improved industrial automation strategies.
Keywords: Industrial Automation, Control Systems, Power Industry, Modernization, Decision-Making, Technology Selection, Adaptive Automation, Power Systems.

Introduction

The speed of growth and the explosion of available solutions in the industrial automation and control technologies space can be debilitating to decision-makers in finding the best-fit tools for their needs. The plethora of competing products from numerous manufacturers creates a challenge for industry professionals who do not have the insights to accurately compare options, resulting in inefficiencies and investments that lack optimization [1]; [2].

From power generation and manufacturing to quality assurance, automation is the key to improving functionality and maintaining standards, leading to a vast amount of research being conducted around developing digital control systems [3], automated inventory management [4], and model-based test generation [5].

Help them find the right solutions among the vast number of options available in the world. For example, the efficiency of control algorithms in hydroelectric plants [6] and for photovoltaic inverter networks [7] has been shown, and numerous organizations struggle to identify reliable, low-cost systems, which have been shown capable of optimizing [8]; [9].

In a similar vein, limited availability of standardized benchmarks greatly hinders process control development tools [10], ideas that should aid the automation of refrigeration [11] and sales funnel automation [12].

Managing system redundancy [13] is another important aspect of industrial automation. Improvement results have been shown with research on supervisory control [14], and optimal algorithms, only if a structured comparative study is performed, else it is a trial-and-error-based approach that still many businesses take.

With advances in the realm of predictive adaptive control and automated quality assurance [15], the requirement for a standardized evaluation framework is further accentuated.

Although existing studies have focused on decision-making strategies [16] in the context of mechanical engineering control systems and automation in manufacturing, the organized comparative approach has not gained much traction in existing literature.

To this aim, this paper proposes an evaluation framework specifically designed to automate and control equipment, comparing leading manufacturers and performance metrics in a systematic way to guide technicians and engineers in choosing the most suitable solution.

Materials and methods

By employing mixed methods, this study aims to provide a thorough analysis of the competitive structure of automation and control equipment, with an emphasis on the comparative assessment of power measurement and analysis devices. The core component of the study is a quantitative framework, enriched by qualitative insights extrapolated from the technical specifications of the devices examined.

The essence of this method is the novel and unique database, which is created. Drawn from publicly available information, this database carefully documents similar equipment from a diverse list of manufacturers. Data used in this study are original, unique, and have not been used in any known research. The dataset has various advantages over traditional frameworks such as knowledge bases like Wikidata and traditional ontologies such as the semantic web by providing a unique point of view on the technical specifications and feature sets of power metering and analyzing devices heretofore not available in the databases as other available resources do not cover this type of devices in comparison. This has been a multi-faceted process where the analysis is based on a detailed study of the market offerings.

To enable a systematic quantitative analysis, major technical attributes of each device were grouped and then encoded as being present (+) or absent (-) for each device, forming a binary matrix of device features. The binary data enabled a systematic comparison of device features. These binary data points were then aggregated together using Python scripts for each product to build a numerical indicator of how many positive features each device had to offer. That was a great way of going from qualitative description of characteristics to quantitative values that could be compared.

Numerical data was then plotted on a number of graphs. All plots contain the total count of positive features (similar to the inclusion of a feature) on the y-axis and the associated manufacturer on the x-axis. Such a graphic allows you to see at a glance how the manufacturers' products stack up against each other to find which ones offer more feature-laden and/or better-quality devices. These visualizations are a powerful analytical tool that allows for a quantitative assessment of the competitive strengths and weaknesses of each of the manufacturers with respect to the breadth of functionality and capability incorporated into their products.

The research serves as a useful practical guide for assessing automation and control equipment, and will be of significant interest to all industry professionals, particularly for those in procurement and decision-makers intending on investing in energy infrastructure upgrades.

Data for this study, including device specifications and manufacturer information, were assembled from publicly available resources. Note: The analysis was conducted on data available prior to October 2023; however, numerous devices and manufacturers were included to provide as comprehensive a comparison as possible.

Results and Discussion

The visualization of the data, achieved through the plotting of device features, allows for a clear assessment of each manufacturer's competitive standing within the defined categories. The following subsections detail the specific findings for each meter type, highlighting key distinctions and overall performance.

An analysis of single-phase electric meters reveals the following observations:

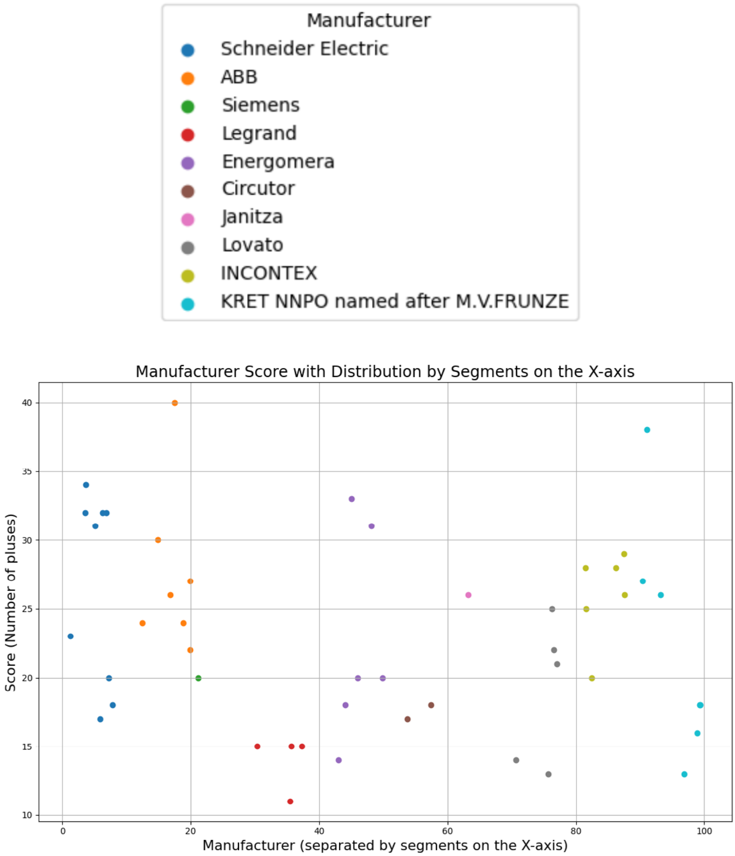

Figure 1 – Single-phase electricity meters' comparison

Considering unmarried-segment electric meters, numerous key factors can be highlighted: The businesses are divided alongside the X-axis, every occupying its personal variety. This makes it clean to examine their gadget. The height of the dots on the graph displays the wide variety of benefits, which shows the best of the technical characteristics. The better the factor, the more benefits the system has. In this study, a comprehensive comparative analysis was conducted, evaluating various three-phase electricity meters based on a range of critical performance and functional characteristics. These included Direct current measurement, the accuracy class of active energy measurement, and the accuracy class for measuring reactive energy. The meters were also assessed for their ability to perform measuring energy in four quadrants, supporting Export/Import Accounting, and their response to Harmonics. Further comparison focused on the number of tariffs they support, display availability, and the presence of a discrete output and a discrete input. The availability of a real-time clock and Modbus communication was also evaluated. Regulatory compliance, specifically MID compliance, was a key consideration, alongside pulse output frequency, operating frequency, and operating temperature. The meters' capabilities in measurement of active energy, measurement of reactive energy, measurement of active power, and their measurement of reactive power were also analyzed, as well as their ability to determine power factor, perform current and voltage measurement, and accurately measure frequency. The verification interval for each meter was considered to assess long-term reliability and regulatory compliance. The analysis revealed that the equipment from all manufacturers exhibited a generally comparable level of performance across the evaluated characteristics. While minor variations were observed, no single manufacturer demonstrated a consistent and significant advantage over the others. Graph analysis for single-phase electricity meters: Considering the data on single-phase electric meters shown on the graph, the following key points can be highlighted: Schneider Electric (blue): This company demonstrates the highest results, as its points are consistently located at the top of the chart. This indicates the high quality and reliability of the equipment. Lovato (yellow): Also shows excellent results by having multiple points at the top of the graph. Circutor (purple): It is haracterized by high scores, which makes its products one of the best in its class. Averages: ABB (orange): The points are located closer to the top of the chart, but their spread is wider than that of the leaders. This indicates the variability of quality. INCONTEX (turquoise color): Although most of the dots are located high, there are instances with average characteristics. Energomera (brown): Generally, shows average results, which may be a sign of a balanced price/quality ratio. Segment outsiders: Legrand (red) and KRET NNPO (light blue): These companies have dots at the bottom of the graph, which indicates less competitive hardware characteristics.

An analysis of three-phase electric meters reveals the following observations:

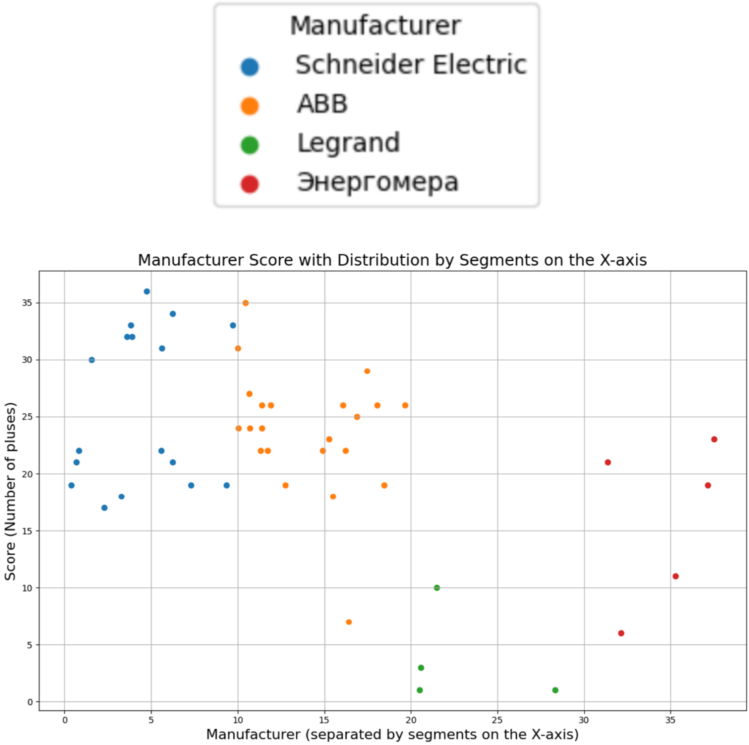

Figure 2 – Three-phase electric meters' comparison

Analysis of various three-phase electricity meters was undertaken, evaluating them across a range of technical and functional characteristics. The considered parameters included the Catalog number for identification, the Width of the device, and the Measurement of the direct-on current. The Accuracy class of active energy measurement and the Accuracy class of reactive energy measurement were also primary focus points, along with the ability to perform Measuring energy in four quadrants and support Export/Import Accounting. The analysis also included the meters' performance regarding Harmonics, the Number of tariffs they support, Display availability, and the presence of a discrete output, a discrete input, and an analog input, etc.

Schneider Electric (blue): The company is showing good results, as most of the points are located at the top of the graph. This indicates reliable and high-quality equipment. ABB (orange): Shows good results, although the point spread is wider, which indicates a greater variety of models, from medium to high performance.

Average indicators: Energy meter (red): Mainly has dots at the bottom of the graph, which indicates less competitive characteristics. However, this may indicate the affordable cost of the product. Legrand (green): Has a minimum number of points, all of them are located at the bottom of the graph, which indicates the low quality characteristics of the three-phase meters of this company.

An analysis of single-phase electric meters reveals the following observations:

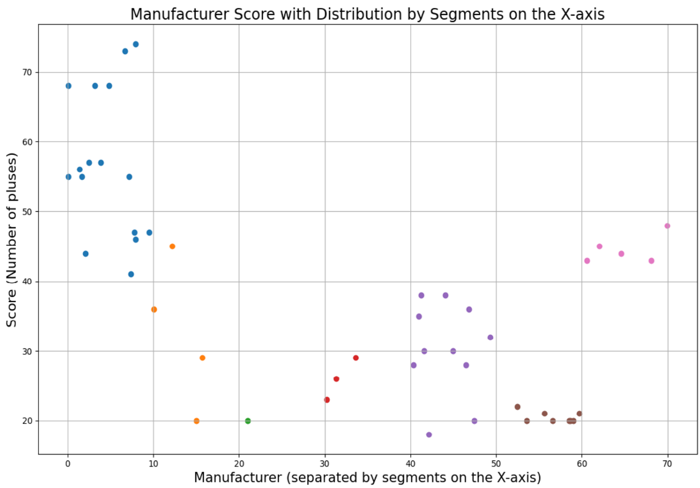

Figure 3 – Power quality analyzers' comparison

In analysis of Electricity Quality Analyzers, a comprehensive set of performance and functional characteristics was evaluated. This included the Catalog number for identification and device tracking, along with the Installation method. The analyzers' core measurement capabilities were assessed, encompassing

Measurement of active energy, Measurement of reactive energy, Measurement of active power, Measurement of reactive power, as well as the calculation of Power factor. Further analysis encompassed the devices' capacity for Current and voltage measurement, Frequency measurement, and their ability to function with switching on. We examined the Frequency of measurements, the Accuracy class of active energy measurement, and the Accuracy class for measuring reactive energy. Crucially, the Quality analysis by standards was considered, as well as the ability to support. Export/Import Accounting. Data capture capabilities including Oscillography and Flicker measurement were assessed, alongside the capability of Saving parameters to a log and the capacity of Internal memory. Additional features evaluated included the availability of Alarms, the Number of tariffs supported, the presence of a built-in display and options for Connecting an external display, as well as web interface availability and Ports. The analyzers' Supported protocols for communication, the availability of Analog inputs/outputs, and relay outputs were also taken into account. Finally, considerations included the presence of a Real-time clock and Time synchronization, Password protection, ease of Installing the seal, the Operating frequency, Hz, Operating temperature, the verification interval, and the expected Service life.

Schneider Electric (blue): A significant number of points are located at the top of the graph (above 60 points), which indicates high-quality equipment. Satec (pink color): Also shows high performance, with points located closer to the top of the chart. Averages: ABB (orange): Has dots in both the middle and bottom of the graph, indicating a wider range of product quality. Janitza (purple): There are quite a lot of points, most of which are located in the middle part of the graph. This indicates stable, but not outstanding quality. Circutor (red): The dots are located mainly in the lower and middle parts, indicating moderate characteristics. Segment outsiders: Legrand (green): The minimum number of points is shown, which are located at the bottom of the graph, which indicates low performance. Lovato (brown color): It has dots at the bottom of the graph, which indicates less competitive characteristics.

Conclusions

This study has provided a comparative analysis regarding the performance analysis on automation and control equipment with distinctive segmentation, such as power quality analyzers and electricity meters. It has identified competitor products and highlighted the gap in the existing market with respect to features, price point, and technology.

Nonetheless, our results must be understood in the general landscape of the difficulties associated with upgrading industrial automation and management systems. The myriad of promising technologies offered by a wide range of producers makes the selection process extremely difficult – there is no clear signal for the best solution to a particular application. Advanced control structures are frequently highlighted in relation to power technology, as well as distribution; however, the number of options often does not allow for a clear comparison to be established for the decision-maker. In fact, small and medium enterprises face the complexity of selecting and implementing automation systems due to the lack of expertise, financial challenges, integration issues, and the challenge of selecting the right technologies.

As noted by at [2], «the implementation process was technologically complex and was technically demanding for the organization».

For single-phase electricity meters, we shall highlight Schneider Electric, Lovato, and Circutor, leading brands that provide high-performance equipment tailored for applications where reliability and functionality are a must. Other manufacturers, such as ABB, INCONTEX, and Energomera, offer a more favorable combination of quality and price, allowing for their devices to be used in a wider variety of applications. Legrand and KRET NNPO products are available for less complex tasks or budget options.

Schneider Electric is the leader in the segment of three-phase electricity meters in terms of quality, having high-performance characteristics of equipment. ABB deserves mention too, just because they offer a good variety of models for different needs. Energomera and Legrand are more suitable for project budgets with lesser quality requirements.

Lastly, the event has advanced power quality analyzers where Schneider Electric and Satec have generally been the leading manufacturers providing the best quality equipment. The solution is to use ABB and Janitza, which have desirable advantages in the applications that need the price-performance ratio. Circutor, Legrand, and Lovato fare better in lower-stress applications or cost-sensitive products.

All in all, the environment for power quality analyzers and source meters is an undifferentiated one, requiring diligence to make sure the products meet needs and are within budget constraints. These findings highlight the need to look beyond specs alone, with performance, price, and use cases all informing purchasing decisions.

This study focuses on the complexities of selecting appropriate automation and management systems in Kazakhstan's energy sector, specifically through the lens of international practices and decision-making advice. The findings of this study can assist its stakeholders in making an educated decision which will provide greater efficiency and reliability for our energy infrastructure and automation systems.

REFERENCES

1 **Lartey, S.** A Comparative Analysis of Automatic and Manual Systems in Modern Technology [Electronic resource]. – URL: https://www.researchgate.net/publication/383945474 (Accessed 02.04.2025).

2 **Salih, H. S., Ghazi, M. and Aljanabi, M.** Implementing an Automated Inventory Management System for Small and Medium-sized Enterprises // Iraqi Journal for Computer Science and Mathematics. – 2023. – №4 (2). – P. 1–8.

3 **Enoiu, E. P., Causevic, A. T., Ostrand, J. and Pettersson P.** Automated Test Generation using Model-Checking: An Industrial Evaluation [Electronic resource]. – URL : https://www.researchgate.net/publication/317072722 (Accessed 02.04.2025).

4 **Eren, H.** Automation and Control Equipment and Implementation [Electronic resource]. – URL : https://www.researchgate.net/publication/295147947 (Accessed 02.04.2025).

5 **Li, Y., Zheng, Y., Teo, Y. S. and Lin, S.-W.** Is AI Testing Beneficial for the Manufacturer and Social Welfare? Optimal Test Strategy of a Smart Product // Expert Systems with Applications. – 2023. – № 213.

6 **Oliveira Hansen de, J. P., Silva da, E. R. and Bilberg, A.** Agile Digital Machine Development // Computers in Industry. – 2024. – № 145.

7 **Haugen, R. A., Skeie, N.-O. and Muller, G.** Automation Processes for Efficient Verification of Complex Systems : An Empirical Case Study [Electronic resource]. – URL: https://www.researchgate.net/publication/317072722 (Accessed 02.04.2025).

8 **Srikar, A., Nadig, G., Alawani, Y., & TK, S. K.** Test Automation of DCS Controller's Communication Interface [Electronic resource]. – URL : https://ieeexplore.ieee.org/document/10307114 (Accessed 02.04.2025).

9 **Shamshiri, S., Just, R., Rojas, J. M. and Arcuri, A.** Do Automatically Generated Unit Tests Find Real Faults? An Empirical Study of Effectiveness and Challenges [Electronic resource]. – URL: https://www.researchgate.net/publication/317072722 (Accessed 02.04.2025).

10 **Bhanushali, A.** Impact of Automation on Quality Assurance Testing : A Comparative Analysis of Manual vs. Automated QA // International Journal of Advances in Scientific Research and Engineering. – 2023. – № 9(10). – P. 45–52.

11 **Yadu, P. and Narain, B.** An Integration of Software Testing Tools and Techniques with Visual GUI Interface in Industrial Practice. [Electronic resource]. – URL: https://www.Researchgate.Net/publication/385039360_an_integration_of_software_testing_tools_and_techniques_with_visual_gui_interface_in_industrial_practice (Accessed 02.04.2025).

12 **Haas, R., Noemmer, R., Juergens, E. and Apel, S.** Optimization of Automated and Manual Software Tests in Industrial Practice : A Survey and

Historical Analysis [Electronic resource]. – URL: https://www.se.cs.uni-saarland.de/publications/docs/HNJ+24.pdf (Accessed: 02.04.2025).

13 **Han, R., Xing, L., Zhong, M., Yin, K. and Yang, Y.** Research on the Reactive Power Adjusting Ability of PV Inverter and Demonstration Application of PV Power Plant on Rapid Reactive Power Regulation // Asia Energy and Electrical Engineering Symposium (AEEES), IEEE. – 2020. – P. 908–913. – https://doi.org/10.1109/AEEES48850.2020.9121344.

14 **Gazizova, O. V. and Sokolov, A. P.** Research of the Effectiveness of Existing Laws of Automatic Regulation of Excitation of Synchronous Generators of Industrial Power Plants under Various Conditions of Connection to the Electric Power System // Russian Workshop on Power Engineering and Automation of Metallurgy Industry : Research & Practice (PEAMI). – 2020. – P. 50–55.

15 **Galka, G. A., Gritsenko, A. E. and Kolodko, S. A.** Review of Modern Control Systems in Refrigeration Automation // Technical Sciences : Theory and Practice, Proceedings of the IV International Scientific Conference. – Kazan, 2018. – P. 22–25.

16 **Palchevsky, B. O. and Varanytsky, T.** Analysis of Variability in Packaging Solutions and the Design of a Universal Packaging Machine // Applied Computer Science. – 2012. – № 8(2). – P. 22–32.

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ЕҢ ҮЗДІК ШЕШІМДІ ТАҢДАУ: АВТОМАТТАНДЫРУ ЖӘНЕ БАСҚАРУ ЖАБДЫҚТАРЫН САЛЫСТЫРМАЛЫ ТАЛДАУ

Өндірістік автоматтандыру және басқару жүйелерінің жеделдетілген дамуы көптеген технологиялардың пайда болуына *себеп болды, бұл шешім қабылдаушылар үшін ең тиімді шешімдерді анықтау қиындық тугызуда. Нәтижесінде, көптеген өндірушілердің деректері әртүрлі болып келеді, бұл салалық мамандар үшін салыстырмалы тасымалдауды дамыту үшін қажетті түсініктердің жоғалуына және ақпаратталған шешімдерді бағалауда тиімсіз тиімділікке және оптималды емес инвестицияларға алып келеді. Сонымен қатар, энергия, өндіріс және сапа бақылау процестерінің біркелкі бағалау құрылымы жоқ. Автоматтандыру технологияларын жүйелі түрде салыстырамыз, баса назар аудару қажет өнімділік көрсеткіштерін талқылаймыз және қызығы бар брендтермен қорытындылаймыз. Зерттеу бірегей ашық дереккөз жиынтығына негізделген сандық және сапалық талдау арқылы әртүрлі әдістер қолданды. Автоматтандыру құрылғыларындағы басым техникалық сипаттамаларды ұйымдастыру және кодтау автоматтандыру шешімдерін бағалау үшін ұйымдастырушылық әдіснаманы ұсынады. Нәтижелер салыстырмалы диаграммаларда көрсетіледі, осылайша ең функционалды және жоғары өнімді шешімдерді ұсынатын өндірушілерді оңай анықтау мүмкін болады. Бұл салалық мамандар, сатып алушылар және шешім қабылдаушылар үшін тиімді, әртараптандырылған секторизацияны қамтамасыз етіп, олардың өндірістік автоматтандыру стратегияларын оңтайландыру кезінде тиімді және үнемді құралдарға ие бола алуы үшін шешімді шешім қабылдауды қамтамасыз ететін әдебиет ұсынуды мақсат етеді.*

Кілтті сөздер: Өнеркәсіптік автоматтандыру, басқару жүйелері, энергетика саласы, жаңғырту, шешім қабылдау, технологияларды таңдау, бейімделгіш автоматтандыру, энергетикалық жүйелер

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ВЫБОР НАИЛУЧШЕГО РЕШЕНИЯ: СРАВНИТЕЛЬНЫЙ АНАЛИЗ ОБОРУДОВАНИЯ АВТОМАТИЗАЦИИ И УПРАВЛЕНИЯ

С быстрым прогрессом индустриальной автоматизации и инструментов контроля существует большое количество доступных технологий, что значительно усложняет процесс принятия решений о том, какие решения будут наиболее эффективными. Поскольку так много разных производителей предлагают так много различных вариантов, сравнение трудно, и специалисты сталкиваются с неэффективностью и неудачными инвестициями. Отсутствие наблюдаемого общепринятого метода оценки усугубляет эту ситуацию, особенно в области энергии, производства и контроля качества. В данном исследовании, описанном в отчете, мы сравниваем существующие технологии автоматизации и контроля и анализируем некоторые ключевые показатели эффективности и преимущества для различных брендов. Используется комбинированный метод (интеграция количественных и качественных данных, полученных из оригинального набора данных из открытых источников). Предлагается структурированная методология для оценки решений автоматизации, подкреплённая категоризацией и кодированием технических спецификаций автоматизированных средств. Результаты, представленные графически в виде сравнений, позволяют четко идентифицировать производителей, которые предоставляют наиболее функциональные, безопасные и высокотехнологичные решения. Исследование является попыткой ознакомить знающих специалистов отрасли, закупщиков и администраторов с такими методиками для повышения эффективности, снижения цен и улучшения стратегий индустриальной автоматизации.

Ключевые слова: Промышленная автоматизация, системы управления, энергетическая отрасль, модернизация, принятие решений, выбор технологий, адаптивная автоматизация, энергетические системы.

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