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MEANS AND METHODS OF COLLECTING INDICATORS FOR ENERGY SUPPLY COMPANIES

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***Abstract*: This study provides a comprehensive overview of the various means and methods employed in gathering data, emphasizing the need for advanced technologies in the face of increasing energy demands and evolving regulatory environments. A thorough comparative analysis focuses on several key aspects, including technology comparison, data accuracy and reliability, real-time data collection capabilities, cost effectiveness, scalability, and flexibility, consumer interaction, and feedback mechanisms. Particular attention has been given to the security and confidentiality of data, as well as the environmental implications. The analysis extends to explore hardware and technological advancements in the industry, comparing traditional systems with modern automated and digital solutions, such as smart meters and integrated data management platforms.**

***Index terms*: energy management, smart metering, real-time data collection, IoT, AMI, AMR.**

I. INTRODUCTION

Energy companies have a crucial function in guaranteeing consistent and effective provision of essential utilities like electricity, water, and gas to both residential and industrial domains. The optimization of these processes holds significant importance in the quest to maximize economic advantages, enhance customer contentment, and ensure environmental sustainability [1]. Moreover, the accurate collection of data stands as a crucial element in the realm of making well-informed decisions concerning the apportionment of energy resources, predicting future energy requirements, and efficiently managing assets [2]. This evolution encompasses a shift from conventional mechanical measuring devices towards the integration of cutting-edge digital solutions like remote monitoring systems and Internet of Things (IoT) sensors for instantaneous data retrieval [3].

Furthermore, alongside the technological components, the legal dimension of the matter holds significance. Legislative regulation in the field of data collection and processing, privacy of consumer information, data storage and transfer standards - all these aspects are crucial for the stable and legal operation of suppliers. In Ukraine, this regulation is carried out by the law on housing and communal services [4].

Given the increasing focus on environmental concerns, the efficient gathering and examination of data have the potential to support the application of sustainable development principles and the minimization of carbon emissions.

This article aims to critically evaluate the current methods and technological advancements used by energy supply companies for gathering and analyzing metrics on resource consumption and distribution, with a focus on optimizing operational efficiency, regulatory compliance, and environmental sustainability. By examining emerging digital tools such as IoT sensors and remote monitoring systems, the study identifies effective strategies for resource allocation, energy demand forecasting, and asset management. Additionally, the study uniquely addresses the legislative context in Ukraine, exploring how local regulations align with global trends in data privacy and management, thereby supporting sustainable development and reducing carbon emissions.

II. LITERATURE REVIEW AND PROBLEM STATEMENT

Effective management and monitoring of energy resources extend beyond technological advances and have significant economic implications. The surge in prices for essential resources like electricity, water, and heat highlights the necessity for robust monitoring systems. This necessity is fueled by the escalating global demand, diminishing natural resources, and increasing costs of extraction and processing [5].

The economic impact of these escalating costs is considerable. As resource prices climb, both consumers and industries face increasing financial burdens, making the efficient utilization of these resources crucial. Moreover, inadequate supervision and oversight may result in substantial monetary deficits and exacerbate environmental decline. Thus, the deployment of advanced monitoring methods and tools is vital for sustainable economic growth and environmental conservation [6].

A primary motive for enhancing resource monitoring is to address inefficiencies, breakdowns, and theft, which are significant contributors to resource wastage. Through the utilization of sophisticated monitoring methodologies, utility corporations, especially those operating within the domains of electricity, water, and heating, have the capacity to identify challenges and promptly resolve them. Prompt identification of breakdowns or theft not only mitigates losses but also ensures continuous supply to consumers [7].

Complex monitoring systems integrate a combination of technologies, such as intelligent meters, sensors for the IoT, and real-time analysis of data. This integration allows utilities to acquire comprehensive understanding of consumption patterns, improve demand forecasting accuracy, and detect possible occurrences of leaks or theft. Smart meters, for instance, provide real-time electricity usage data, facilitating the immediate detection of abnormal device behaviors that could indicate malfunctions or illicit activities [8].

By understanding consumption trends, utilities can implement dynamic pricing models that incentivize energy use during off-peak hours, balancing demand and alleviating pressure on supply infrastructures. This not only aids in resource management efficiency but also plays a crucial role in stabilizing resource prices [9].

Furthermore, the utilization of sophisticated monitoring technologies facilitates the shift towards renewable energy sources. The escalating cost of energy of resources justifies the transition to more effective monitoring and management systems. This is important not only for increasing economic productivity, but also for increasing environmental friendliness and the development of renewable energy sources.

III. SCOPE OF WORK AND OBJECTIVES

A. TECHNOLOGY COMPARISON

The evolution from traditional mechanical meters to modern digital meters signifies a transformative shift in energy management technology. Modern digital meters, including smart meters and systems integrated with Advanced Metering Infrastructure (AMI), offer profound enhancements over their mechanical predecessors (Fig. 1.) [10]. Digital meters offer the capability of real-time data tracking, examination of consumption patterns, and the capacity to remotely supervise and manage energy usage via IoT connectivity [11]. This connectivity not only facilitates extensive data collection but also enables dynamic interactions between consumers and energy suppliers, optimizing energy use efficiency and grid management.

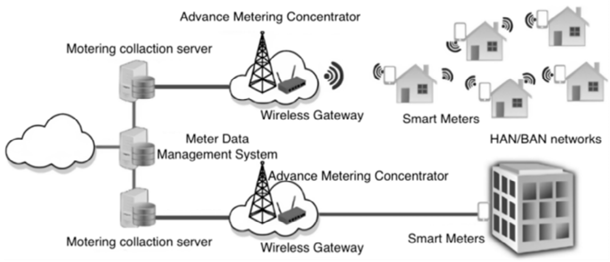

Fig. 1. Schematic representation of Advanced Metering Infrastructure

AMI systems expand these capabilities further by incorporating two-way communication tools that allow for system-wide data transmission and control. On the other hand, Automated Meter Reading (AMR) systems, while beneficial, present a mixed scenario. This system enhances billing accuracy and operational efficiency, as utilities can gather consumption data without on-site visits [12].

However, the limitations of AMR systems are notable. This limitation also affects the potential for integrating AMR systems with emerging technologies that rely on interactive and instantaneous data exchange, such as IoT devices or real-time energy management software.

While AMR systems improve upon traditional metering methods by automating data collection and reducing operational costs, they do not provide the comprehensive benefits of AMI systems, which support enhanced grid management and consumer interaction through advanced data analytics and real-time communication capabilities.

B. DATA ACCURACY AND RELIABILITY

The accuracy and reliability of data collected by various measurement technologies are important for effective energy management and decision-making. Different metering systems, from traditional mechanical meters to advanced digital meters, including smart meters and AMI, influence the accuracy and reliability of the data collected significantly.

In contrast, modern digital meters, particularly smart meters and AMI systems, provide high accuracy and detailed data on energy usage patterns. These technologies employ digital components and communication capabilities that reduce the incidence of errors typically seen in mechanical systems. Studies outlined in article [13] demonstrates how digital meters can simulate various electrical conditions to ensure accurate readings under diverse operational scenarios. The positive impact of the use of IoT and the projected profit for the next years for the Energy Global Market is demonstrated in Fig. 2.

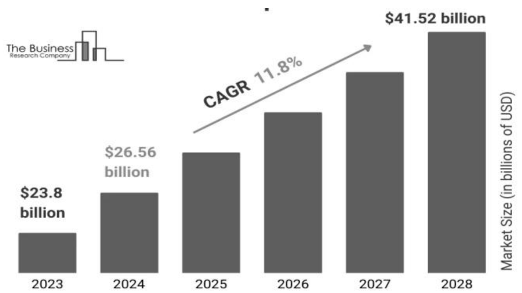

Fig. 2. Internet of Things (loT) In Energy Global Market Report 2024

The reliability of these digital measurement systems is enhanced by their ability to be updated and calibrated remotely, reducing the need for physical inspections and maintenance. A relevant discussion on this can be found in article [17], which analyzes how networked metering systems can provide continuous reliability assessments and prompt error detection.

Unfortunately, the implementation of advanced measurement technologies is not without problems. For instance, discrepancies can still arise from communication errors or data processing anomalies. The research in article [18] discusses various sources of errors in metering systems designed for complex environments, highlighting the need for robust data validation processes to maintain the integrity of the measurements.

While advanced digital metering systems offer significant improvements in data accuracy and reliability over traditional mechanical meters, maintaining these systems and ensuring the accuracy of the data they collect requires careful management and continual technological refinement. This ensures that energy supply companies can rely on the data to make informed decisions about resource management and customer billing.

C. REAL-TIME DATA COLLECTION

The capacity of metering systems to offer real-time or near-real-time data represents a crucial aspect of contemporary energy management. Advanced digital systems, such as those integrated with smart meters and IoT devices, enable continuous monitoring and data transmission almost instantaneously, enhancing decision-making processes and operational efficiency.

The impact of real-time data on utility operations and customer service is profound. For instance, a real-time dynamic energy management and control system, as described in article [19], leverages instant data to optimize energy use within buildings, significantly reducing wastage and improving energy efficiency.

Moreover, real-time data collection enhances the reliability of the energy distribution network. For example, in article [20] it is discussed how real-time grid monitoring can predict and manage distribution loads effectively, preventing outages and ensuring a stable energy supply. This capability is crucial for maintaining system integrity and customer satisfaction, particularly during peak demand periods.

The availability of real-time data also revolutionizes customer service in the utility sector. It allows for more accurate billing, immediate detection of irregular consumption patterns that may indicate leaks or faults, and enhanced customer interaction through timely updates and energy usage insights.

The transition to metering systems that provide real-time data collection is pivotal for the future of energy management. These systems provide significant enhancements compared to conventional approaches in terms of operational effectiveness, precision, customer support, and the overall dependability of energy distribution networks.

D. COST EFFECTIVENESS

For energy companies considering new investments in metering technology, it is necessary to compare the initial and operating costs of different meter reading systems to determine which approach will be more profitable for them. The shift from manual to automated systems can lead to substantial long-term savings. These savings are primarily driven by reduced labor costs and minimized human errors in reading and data entry, which also decreases the financial impacts of billing inaccuracies.

A study discussed in article [21] explores how selecting the right communication architecture for AMI deployment can impact the cost-effectiveness of utility services, enhancing the financial viability of smart metering investments. Moreover, the implementation of AMI systems has demonstrated the ability to facilitate the adoption of dynamic pricing strategies and demand response initiatives, leading to further cost reductions and enhanced operational efficiency. A Cost-Effective CNN-LSTM-Based Solution, detailed in article [22], demonstrates how machine learning models can predict and mitigate faults in metering devices, thereby reducing maintenance costs and prolonging the lifespan of the infrastructure.

While the initial cost of digital and AMR systems is higher than traditional systems, the operational savings, improved efficiency, and enhanced service quality they offer justify the investment Energy utilities need to carefully evaluate the financial implications in both the short and long term while selecting a metering system, ensuring that it aligns with cost-effectiveness and sustainability goals in their operational activities.

E. SCALABILITY AND FLEXIBILITY

Metering systems must be capable of expanding or modifying their functions efficiently to accommodate growing customer bases, new energy sources, and technological advancements. Furthermore, digital metering systems, such as smart meters and AMI, exhibit enhanced scalability and adaptability. These systems are designed to integrate easily with new technologies and can be updated or expanded with minimal physical alterations to the infrastructure.

For example, the study [23] discusses how digital metering systems can adapt to new market conditions and regulatory requirements more swiftly than traditional systems. This adaptability is crucial for energy companies looking to capitalize on smart grid technologies and renewable energy integration.

Moreover, the implementation of IoT-based solutions in metering systems further enhances their scalability. The work by publication [24] illustrates how IoT devices can be harnessed to expand the functionalities of existing metering infrastructures, enabling real-time data gathering and analysis across a scalable network.

The ability to scale and adapt metering systems is not just about handling increased demand but also about improving operational efficiency and customer service. As energy systems become more complex and interconnected, the flexibility to integrate new technologies and adapt to regulatory changes becomes a strategic advantage, ensuring that energy companies remain competitive and compliant.

Digital and IoT-enabled metering systems offer the necessary scalability and flexibility required by modern energy companies. These systems lay the groundwork for resilient energy management plans that can adjust to emerging challenges and opportunities within the energy industry.

F. CONSUMER INTERACTION AND FEEDBACK

Different metering systems enhance consumer interaction through various platforms, significantly impacting how consumers manage and understand their energy usage. For instance, in-home displays (IHDs) and online energy usage tracking tools are two common interfaces provided by advanced metering systems like smart meters and AMI.

IHDs provide real-time information about energy consumption, cost, and other relevant data directly to consumers in an easily understandable format. The effectiveness of such tools in helping households manage their energy consumption more effectively is discussed in the study [25], which shows significant improvements in energy savings when consumers are directly engaged with their usage data.

Online platforms for energy usage tracking offer similar benefits by allowing consumers to monitor their energy consumption patterns over time, compare different billing periods, and set personal energy-saving goals. The research [26] highlights how these systems not only foster greater awareness among consumers about their energy consumption but also promote long-term behavioral changes towards energy efficiency.

Analyzing consumer feedback and acceptance of various metering technologies, it is clear that user-friendly interfaces and actionable insights are highly valued. Systems that provide detailed, understandable, and actionable data tend to be more favorably received, as evidenced by the study [27]. This study demonstrates that when consumers understand how to use the data effectively, the acceptance of these technologies increases, along with their potential impact on energy conservation.

The scalability and flexibility of metering systems play a critical role in their implementation success. Technologies that adapt easily to changing consumer needs and regulatory environments while providing actionable and comprehensive data insights will lead the future of energy management systems. These systems not only support the operational goals of energy companies but also empower consumers to play an active role in energy conservation.

G. SECURITY AND DATA PRIVACY

The shift to digital metering systems introduces significant cybersecurity risks, necessitating robust measures to protect both the infrastructure and the consumer data handled by these systems. In order to tackle cybersecurity apprehensions, it is imperative for energy corporations to deploy all-encompassing security strategies that cover threat identification, data encryption, secure communication protocols, and routine security evaluations. For instance, the study presented in article [28] discusses various encryption techniques and privacy-preserving methods are discussed that ensure data transmitted from smart meters to utility companies remains confidential and secure from unauthorized access.

Moreover, the safeguarding of consumer data privacy stands as a significant concern. Energy companies must adhere to stringent data protection regulations, such as GDPR in Europe, which mandate the safeguarding of consumer information against misuse. Paper [29] explores various security protocols that can be integrated into smart metering infrastructures to mitigate risks associated with digital threats and ensure robust system integrity.

Lastly, consumer feedback on the security and privacy measures of these metering technologies is generally positive when transparency and strong security protocols are in place. Thus, continuous improvement and adaptation of security measures in line with evolving cyber threats are essential to sustain consumer confidence and the secure operation of digital metering systems.

Addressing cybersecurity risks and ensuring data privacy are critical components of deploying digital metering systems. Through the implementation of sophisticated security measures and adherence to stringent privacy regulations, energy firms can shield themselves against potential cyber risks and uphold the credibility and reliability of their offerings.

H. ENVIRONMENTAL IMPACT

Improved metering systems offer significant potential environmental benefits by enhancing energy efficiency and facilitating better resource management. One of the key advantages of such systems lies in their capacity to promote and empower consumers to adopt energy-saving practices. By providing accurate and timely data, they help in managing the variability and intermittency of renewable sources like wind and solar.

The study [30] highlights how modern AMI can optimize grid performance and reduce losses, further contributing to environmental sustainability. The reduction of losses not only decreases unnecessary energy generation but also minimizes the environmental impact associated with power production.

Improved metering systems lead to significant reductions in carbon emissions and support the broader adoption of renewable energy technologies. The environmental benefits of these technologies, coupled with their economic and operational advantages, make them essential components of modern energy infrastructure aimed at sustainable development.

IV. HARDWARE AND TECHNOLOGICAL COMPARISON

The use of IoT technologies integration within the energy sector presents novel prospects for enhancing the efficiency and accuracy of data collection and resource management. One of the options is the use of Salesforce IoT, it is an advanced, internationally recognized platform that allows you to automate the collection of indicators from energy supply meters, providing a high level of integration, analytics and forecasting.

In countries characterized by sophisticated energy infrastructures like the United States, Germany, and Japan, the application of IoT for monitoring and controlling energy usage stands as a pivotal component of energy efficiency. Ukraine is actively working on harmonizing its legislative and regulatory bases with European standards. Salesforce IoT can offer solutions that adapt more easily to these requirements due to its flexibility and customization.

Popular smart meters that can be used for IoT and technologies that support meters: (1) The Schneider Electric Wiser Energy System offers a versatile solution for monitoring energy consumption in both residential and commercial settings. (2) Siemens provides a robust smart metering solution designed for precise measurement and in-depth analysis of electricity consumption. (3) Honeywell's Smart Energy Meter is another prominent choice, offering effective electricity measurement capabilities with integration options for IoT platforms through wireless communication protocols such as Zigbee and Wi-Fi. (4) The ItronOpenWay Riva series stands out for its high level of compatibility with IoT systems, thanks to its integration with the OpenWay Riva IoT platform.

Salesforce IoT, with its extensive ecosystem and integration with other business platforms, can provide the necessary flexibility and scalability. Salesforce IoT serves the purpose of amalgamating extensive datasets sourced from various outlets, encompassing energy gauges, temperature gauges, humidity gauges, and more.

Comparing Salesforce IoT with alternative systems such as Google Cloud IoT, Microsoft Azure IoT, and IBM Watson IoT (Table), it becomes apparent that Salesforce IoT offers more potent tools for overseeing and managing resource allocation, enhancing efficiency, and curbing expenses. With it, integration with other systems, even those not from the Salesforce line, is easily and quickly created.

Compare Salesforce and other systems

	Salesforce IoT	Google Cloud IoT	Microsoft Azure IoT	IBM Watson IoT
Scalability	High	Average	High	Average
Integration	Wide		Wide	Limited
Predictive analytics	Advanced	Basic	Intermediate	Intermediate
Cross-platform	Excellent	Good	Good	Satisfactory
Security	Good	Excellent	Excellent	Excellent
User interface	Intuitive	Complex	Moderate	Complex
Settings	High	Average	High	Low

V. CONCLUSION

The study demonstrated that transitioning from traditional to digital metering systems delivers significant benefits across several critical areas. Advanced metering technologies, such as AMI and smart meters, improve data accuracy, enabled real-time monitoring, and reduced costs by automating manual processes.

Moreover, digital metering systems play a crucial role in reducing environmental impact by optimizing energy usage and minimizing waste, which directly contributes to lower carbon emissions. These technologies also support the integration of renewable energy by addressing supply variability, aiding in the transition away from fossil fuel dependency.

Overall, the adoption of advanced metering systems represents a transformative step towards achieving regulatory, operational, and environmental goals, establishing a sustainable framework for future energy management.

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