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Industrial internet of things (IIoT) in energy sector

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Abstract

Internet of Things -IoT- represents a new production reality. Since 2000 the usage of IoT has been steadily increased in almost every sector, i.e., industry, business, entrepreneurs. The information derived from the data gathered from the new devices connected to the internet, i.e. IoT, can be used to develop new services, improve productivity and efficiency, improve decision making in real time, resolve critical problems and create innovative experiences. "Industry 4.0" concept has the flexibility to achieve interoperability between the different industrial engineering systems. Industrial Internet of Things (IIoT) is used to transfer the data from systems that monitor and control the industrial equipments to data processing systems that cloud computing has shown to be important tools for meeting processing requirements by using Wi-Fi, radio, satellite or cellular networks. IoT technologies offer greater availability of information throughout the chain of value, allowing for amortization of better tools for decision making. Using sensor devices in energy sector offers automated execution of the processes and the usage of Machine Learning (ML) and Artificial Intelligence (AI) in energy industry allow systems to communicate with each other, making their own decisions. IIoT enables real-time quality monitoring, which helps identify the nonconformities within the processes and energy production sector easily.

Introduction

Over the previous decade, the Internet of Things (IoT) revolution has had a significant impact on manufacturing, energy, agriculture, transportation, and other industrial sectors. The Industrial IoT (IIoT) is an industry-specific variant of the IoT, which provides an impressive potential for businesses via connected machines, sensors, and applications. It is one of the most exciting technologies now reshaping industrial enterprises, prompting them to modernize their processes, system intelligence, and facilities in order to cope with emerging disruptive technologies. IIoT improves manufacturing efficiency, safety, scalability, production time, and profitability in the industrial sector.

The worth of the Internet of Things (IoT) market in the energy sector is expected to grow at the Compound Annual Growth Rate (CAGR) of 11.8% over the period of 2021-2025. This embarks a significant impact of using IoT-powered solutions to make the energy sector better and more advanced. The use of sensors has enabled real-time monitoring of productivity, simplified applications, and have remote control over the energy consumption patterns. Major factors that drive the growth of IoT in the energy sector include data management and the advantage of using IoT-based agile systems. The inclusion of IoT helps reduce the challenges and allow the management to evolve through all possible issues coming their way. IoT applications in the energy sector focus on improving asset and industrial efficiency create enhanced revenue generation, and effective resource utilization.

The emerging "Industry 4.0" concept is an umbrella term for a new industrial paradigm which embraces a set of future industrial developments including cyber-physical systems (CPS), the Internet of things (IoT), the Internet of services (IoS), robotics, big data, cloud manufacturing and augmented reality. Industrial processes need most

tasks to be conducted locally due to time delays and security constraints, and structured data needs to be communicated over the internet.

Transforming the energy sector with IoT technology is an innovative way to promote improved productivity and recognize/arrange the consumption patterns to cut-short the excessive energy usage. In the energy sector, IoT devices have been able to create intelligent networks, i.e., smart grids, through the collection, transmission and use of large quantities of data. In this way, it integrates in an intelligent manner all of the assets connected to the network, optimizing operation and increasing the flexibility of the systems.

Material and Method

In the study; an integrated Fuzzy AHP- Fuzzy TOPSIS- Fuzzy VIKOR approaches are used to assess/evaluate Industrial Internet of Things (IIoT) in Energy Sector. In literature Fuzzy Multi Criteria Decision Making Methods (FMCDM) are used in different fields by many researchers [1-23] by using MATLAB program.

IIoT in Energy Sector, i.e., measuring scale, consists of 6 dimensions-main criteria and 29 evaluation factors-sub-criteria are evaluated by decision makers (DMs). A questionnaire was developed following the methodology proposed for the below methods, which was answered by 25 experts/DMs.

It uses sensor devices and gateway connectivity to derive actionable insights and use them to develop new and advanced services for enhanced productivity. It further improves real-time decision-making, complex operability, and overall experiences.

1. Process Monitoring and Resource Optimization: Using sensor devices in a power plant offers automated execution of the processes and render better services that are mostly error-free. IoT technology is a smart concept that also protects excessive resource utilization and helps maintain consistency. IoT allows smart process monitoring that gives every detail of the plant-process in the form of data.

2. Advanced Analytics: Sensor-based functioning of the power industry is bringing a revolutionary change. It uses advanced techniques to fulfill the business requirements and generate quality production. The industrialists are making the most out of using advanced analytics with their business. It uses sensor-enabled data to extract information from the assets and make better decisions than before. Data analytics helps the power sector to optimize generation and planning.

3. New Opportunities: IoT brings new business opportunities along with newer and advanced concepts. It involves sensor devices, gateway connectivity, and communication protocols that combine and form IoT architecture for multipurpose businesses. One can use IoT technology to avail business benefits and enable smart techniques for better productivity and growth. IoT is a futuristic technology, which empowers businesses through its real-time monitoring features, smart data management, and analytics.

4 Intelligent Grid: IoT provides a smart grid system to get control over the power flow or curb the energy consumption at significant levels. It further curtails the energy load to match the real-time generation or near real-time. IoT is an automated concept that offers a cost-effective approach to interconnect the users for effective power usage.

5. Cost-savings and Data Management: IoT in the energy sector is an advanced process that includes planning and energy management of the consumption patterns in multiple domains. It allows the managers to take complete control of energy data from scratch and optimize the process significantly. Using an IoT-powered solution in the energy sector utilizes sensor-based methods to establish the automated functioning of the industry.

6. Sustainability: All assets/machines/equipments have been made to talk to each other through IoT. The energy sector is the major driver of accountability that seeks smart ways to reduce environmental issues. IoT facilitates automated maintenance and reporting, optimization of smart grids, renewable energy generation, and measure carbon consumption in real-time. The technology is enabling sustainability around the industrial world through its smart techniques and is allowing the managers to make informed decisions for better business growth.

Machine-to-machine (M2M) Communication

Machine-to-machine (or M2M) is a broad term that describes any technology that allows networked devices, without human assistance, to exchange information and take action. Machine Learning (ML) and Artificial Intelligence (AI) allow systems to communicate with each other, making their own decisions. M2M technology was initially adopted in industrial and manufacturing settings. Initially, technologies like Supervisory Control and Data Acquisition (SCADA) or remote monitoring are used to control and manage data from the equipment remotely, especially in energy sector. However, M2M technology has been used in many other industries, including healthcare, insurance, and other businesses. M2M is also the foundation of the Internet of Things (IoT), allowing

effective communication among equipment/machines. IoT provides b/m advantages; improved operational efficiency, better product quality and services, detail-oriented decision-making, cost-efficiency and increased Return on Investment (ROI), unlimited scalability, remote machine monitoring, accurate asset tracking, reduced power consumption, packet-switch services, real-time monitoring, time tolerance and control, geo-fencing, continuous data transfer, predictive maintenance.

Results

Sensor technology, big data and analytics are used to optimize operations, such as efficiently balancing supply and demand as customers connect to a smart grid. The usage of IoT in energy production helps to satisfy the energy demands in smart cities in an efficient way. However, a robust digital infrastructure is crucial for the roll-out of an architecture of connectivity and data.

After acquiring the fuzzy comparison matrices, importance weights of IIoT's dimensions; evaluation criteria is calculated by using Fuzzy method. According to the calculated criteria weights for IIoT's weights; the most important evaluation dimension/main-criteria is "Cost-savings and Data Management", the second important evaluation dimension is "Process Monitoring and Resource Optimization" and the third important evaluation dimension is "Advanced Analytics".

Conclusion

Industry is taking advantage of ever more complex and sophisticated systems. Systems not designed to communicate across production lines often require integration with pre-existing devices. The challenge of interoperability is thus one of the main concerns in designing intelligent human-to-machine and machine-to-machine cooperation.

"Industry 4.0" concept has the flexibility to achieve interoperability between the different industrial engineering systems. To connect the different industrial equipment and systems, the same standards and safety levels are required. The "Industry 4.0" concept was born to apply the ideas of cyber-physical systems (CPSs) and IoT to industrial automation and to create smart products, smart production, and smart services. It involves cyber-physical systems, IoT, cognitive computing and cloud computing and supports what has been termed "smart factory". IoT technologies offer greater availability of information throughout the chain of value, allowing for amortization of better tools for decision making.

IIoT is used to transfer the data from systems that monitor and control the industrial equipment to data processing systems that cloud computing has shown to be important tools for meeting processing requirements by using Wi-Fi, radio, satellite or cellular networks.

In the study by using Fuzzy method; the calculated criteria weights for IIoT's weights are as follows: the most important evaluation dimension/main-criteria is "Cost-savings and Data Management", the second important evaluation dimension is "Process Monitoring and Resource Optimization" and the third important evaluation dimension is "Advanced Analytics".

IIoT provides the necessary connectivity, security, and manageability, while some of the existing devices cannot share data with the cloud. They should be modified to share their data. IIoT enables real-time quality monitoring, which helps identify the nonconformities within the processes and energy production sector easily. Many applications have already been implemented in the construction and the infrastructure fields. The net market value of deploying UAVs in support of construction and infrastructure inspection applications accounts for about 45% of the overall UAV market. UAVs are also used for the real-time inspection of power lines. Drones are used to detect trees and buildings close to power lines. They can also be deployed to monitor oil, natural gas and water pipe lines. UAV and IoT technologies are used for building inspections, oil and natural gas pipelines inspections in North America using the powerful machine learning to process the data collected. They provide asset inspection and data acquisition, advanced data processing with 2D and 3D images and detailed reports on the property inspected.

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