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The impact of smart grids in the electricity sector

“Analyze its impact on the productivity of workers, improve performance indicators, and reduce operational costs”

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Abstract

Technology has revolutionised many industries in the 21st century, but smart grid applications have had a particularly profound effect on the power sector. As the backbone of countless businesses, services, and everyday activities, the electricity sector is fundamental to human survival and progress. Power generating and distribution firms are confronted with increasing challenges in efficiently and sustainably operating electrical networks due to the rising demand for electricity. Utilising cutting-edge technology like automated control, big data analytics, and remote sensing, smart grids have become an essential tool for tackling these issues. Focusing on the implications on operational expenses, performance measures, and worker productivity, this article seeks to analyse the multiple repercussions of smart grids in the electrical business. The study also delves into smart grids' function in eco-friendly city power management, focusing on how they might incorporate renewable power sources, lessen pollution, and strengthen reliability. This research sheds light on the ways smart grid technology might transform the power sector, promoting sustainability and efficiency, by analysing real-life examples and prior studies. This study adds to our knowledge of smart grids' revolutionary potential and their importance in reaching sustainable development targets in urban energy management by providing a thorough analysis of the topic.

Keywords: technology, electrical, energy, development, management.

المخلص:

أحدثت التكنولوجيا ثورة في العديد من الصناعات في القرن الحادي والعشرين، ولكن تطبيقات الشبكة الذكية كان لها تأثير عميق بشكل خاص على قطاع الطاقة. باعتباره العمود الفقري لعدد لا يحصى من الشركات والخدمات والأنشطة اليومية، فإن قطاع الكهرباء أساسي لبقاء الإنسان وتقدمه. تواجه شركات توليد وتوزيع الطاقة تحديات متزايدة في تشغيل الشبكات الكهربائية بكفاءة واستدامة بسبب الطلب المتزايد على الكهرباء. وباستخدام التكنولوجيا المتطورة مثل التحكم الآلي، وتحليلات البيانات الضخمة، والاستشعار عن بعد، أصبحت الشبكات الذكية أداة أساسية لمعالجة هذه القضايا. من خلال التركيز على الآثار المترتبة على النفقات التشغيلية، ومقاييس الأداء، وإنتاجية العمال، تسعى هذه المقالة إلى تحليل التداعيات المتعددة للشبكات الذكية في الأعمال الكهربائية. وتعمق الدراسة أيضًا في وظيفة الشبكات الذكية في إدارة الطاقة في المدن الصديقة للبيئة، مع التركيز على كيفية دمج مصادر الطاقة المتجددة، وتقليل التلوث، وتعزيز الموثوقية. يسلم هذا البحث الضوء على الطرق التي يمكن لتكنولوجيا الشبكة الذكية أن تحول بها قطاع الطاقة، وتعزز الاستدامة والكفاءة، من خلال تحليل أمثلة من الحياة الواقعية والدراسات السابقة. تضيف هذه الدراسة إلى معرفتنا بالإمكانات الثورية للشبكات الذكية وأهميتها في تحقيق أهداف التنمية المستدامة في إدارة الطاقة الحضرية من خلال تقديم تحليل شامل للموضوع.

الكلمات المفتاحية: التكنولوجيا، الكهرباء، الطاقة، التنمية، الإدارة.

Introduction

In light of the rapid technological development that the world is witnessing in the twenty-first century, smart grids have become one of the most prominent technologies that have a great ability to transform different sectors, and among these vital sectors, the electricity sector is emerging as one of the most prominent areas that have benefited greatly from smart grid applications.

The electricity sector is one of the most vital sectors for the continuity of human life and development. Many industries, services and daily activities depend on the reliable and efficient provision of electrical energy. With the increasing demand for electricity over time, power generation and distribution companies face great challenges in managing electrical networks and meeting the needs of consumers in a sustainable manner.

Smart grids come as a leading technology aimed at improving the efficiency and management of electrical networks, through the use of modern technology such as remote sensing, massive data analysis and automated control, smart grids offer a range of potential benefits including increased energy efficiency, improved service quality, reduced operational costs, energy saving, and reduced harmful emissions.

Understanding the impact of smart grids in the electricity sector on workers' productivity, improving performance indicators, and reducing operational costs is vital to keeping pace with digital transformation and achieving sustainability and development goals in this vital sector. The electricity industry is also witnessing a huge technological transformation through the adoption of smart grids, which are one of the most important technologies that affect workers' productivity, improve performance indicators, and reduce operational costs. Therefore, this scientific paper aims to analyze and study the impact of smart grids in this important sector.

In the pursuit of sustainable urban energy management, smart grids are emerging as a core technology, enabling cities to efficiently harness renewable energy resources. This technology represents a major shift from traditional energy systems, integrating advanced digital solutions for electricity management and distribution. The development of smart grids is pivotal for urban centers that aim to reduce carbon emissions, enhance energy security, and provide reliable and cost-effective energy to meet the growing demands of their populations. This research addresses the role of smart grids in sustainable urban energy management, and explores their functions, benefits, and challenges.

This paper aims to analyze and discuss the impact of the uses of smart grids in the electricity sector, focusing on their impact on worker productivity, improving performance indicators, and reducing operational costs.

This research will analyze the impact of smart grids in the electricity sector, focusing on analyzing how they affect worker productivity, improving performance indicators, and reducing operational costs. Real-life examples will be used to illustrate the potential outcomes and impacts of grid applications in the field of electricity.

Through this research, we will understand how smart technology can transform the electrical sector and enhance its efficiency, through the use of real examples and deep analysis of the results of previous research and studies.

Chapter One: Smart Grids.

Preamble:

Smart grids are one of the most prominent technological developments in the energy sector, and constitute a modern and effective solution to improve the management and operation of electricity networks. The shift towards smart grids comes as part of a larger digital transformation strategy aimed at improving efficiency, sustainability and flexibility in the electricity sector. In this chapter, we will review the concept of smart grids and their importance in the electricity sector.

Smart grids enable the use of modern technology, such as intelligent sensing, massive analytics and artificial intelligence, to make electricity grids smarter, controllable and adaptable, as these technologies allow the collection of real-time data about energy consumption, grid status and equipment performance, enabling companies and operators to make more accurate and efficient decisions.

First: The concept of smart grids.

Smart grid is an electricity grid that uses digital and other advanced technologies to monitor and manage the transmission of electricity from all generation sources to meet the diverse electricity requirements of end users. Smart grids coordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders to operate all parts of the system as efficiently as possible, and reduce costs and environmental impacts while increasing the reliability, flexibility and stability of the system. Most of the technologies involved have already reached maturity, so tracking investments provides insights into deployment levels.

Smart grids are advanced technological systems used to manage and operate electrical grids in a more efficient and intelligent way. Smart grids rely on modern communication and information technology such as remote sensing, massive data analysis, automated control, and artificial intelligence, to achieve several goals, including increasing efficiency, improving service quality, and reducing costs.

A smart grid is not just an electricity grid; it is a digital marvel that facilitates two-way communication between service providers and consumers. Designed to meet the evolving needs of the 21st century, the grid includes transmission lines, substations, transformers, and more, ensuring seamless electricity delivery from power plants to homes and businesses.

The basic concept of smart grids is to provide an integrated and advanced system to manage electrical energy more effectively and intelligently. These systems include a set of technologies and devices that allow continuous monitoring of the state of the network and the analysis of the data generated from it to make the right decisions more accurately and quickly.

Second: Characteristics of smart networks.

- **Sensing and Monitoring:**

Smart grids rely on smart sensors installed at different points in the electrical network to accurately monitor their status, and data from these smart devices are collected and converted into analyzable information to provide a comprehensive and accurate picture of the status of the network.

- **Big Data Analytics:**

Massive data analysis techniques are applied to data collected from the smart grid, and these techniques are also used to detect patterns and trends in the data, predict future events, and identify gaps and opportunities to improve network performance.

- **Intelligent control and automation:**

Smart grids rely on intelligent control systems and automatic operation to carry out decisions and actions immediately and accurately. Smart systems can use artificial intelligence and machine learning to analyze data and make appropriate decisions more efficiently.

- **Interacting, communicating and participation**

Smart grids allow interaction and communication between devices and equipment connected to them, and information and data are effectively exchanged between the various components in the network, allowing integration and cooperation between them.

- **Adaptive and Flexible:**

Smart grids have the ability to adapt to changes in energy demand and environmental conditions, and smart systems can modify their operations and improve their performance based on incoming data and current conditions.

- **Safety and Security**

Smart grids provide advanced security mechanisms to protect data and information from cyber threats, and encryption and verification techniques are applied to ensure the safety of data and information transmitted over the network.

In short, smart grids are an advanced and comprehensive technology aimed at improving the management and operation of electrical networks comprehensively, which contributes to increasing their efficiency, quality, flexibility and security.

Third: The difference between smart and traditional networks.

Smart and traditional networks differ significantly in many aspects, including the technology used, the ability to control and manage, the ability to communicate and exchange data, and the ability to adapt to changes in demand and environmental conditions. The differences are as follows:

Technology used

- **Traditional networks** rely on specific technologies such as centralized control and software-specific controllers.
- **Smart grids** use modern technology such as intelligent sensing, massive data analysis, and automated control.

Integrated Control and Management

- In **traditional networks**, control and management are centralized and linked to a traditional system.
- In **smart grids**, control and management are distributed and multi-directional, allowing for greater flexibility and efficiency.

Communication and data sharing:

- **Traditional networks** are often isolated and lack the ability to communicate with other devices or exchange data effectively.
- **Smart grids** have the ability to intelligently communicate and exchange data between different devices, allowing for improved collaboration and integration between different systems.

Adaptive and Flexible:

- **Traditional grids** are usually less flexible and adaptive in dealing with changes in energy demand or environmental conditions.
- **Smart grids** are highly flexible and adaptive, as they can adapt to changes in demand and improve their efficiency according to changing conditions.

Fourth: International applications of smart grids.

There are many countries that have adopted smart grids and have seen an improvement in their electrical systems according to multiple reports and statistics, such as:

1- United Arab Emirates:

The UAE has adopted smart grid technologies in cities such as Dubai and Abu Dhabi, in several areas including energy, transportation and infrastructure. Smart grids have also contributed to improving energy efficiency, improving service quality and enhancing environmental sustainability. According to a report by IDC, the UAE's investment in smart grid projects is expected to reach about \$8 billion by 2025.

2- Kingdom of Saudi Arabia:

Saudi Arabia has begun to adopt smart grid technologies in several areas, including energy and urban infrastructure. Some Saudi cities have also seen an improvement in service quality and energy efficiency thanks to the adoption of smart grid technologies. According to a report by Frost & Sullivan, Saudi investments in smart grid projects are expected to reach about \$7 billion by 2025.

3- Qatar:

Qatar has adopted smart grid technologies in some areas such as energy and urban infrastructure. Smart grids have contributed to improving energy efficiency, reducing disparities in distribution and improving service quality. According to a report by Research and Markets, Qatar's investments in smart grid projects are expected to reach about \$1.5 billion by 2025.

4- Japan:

Japan has adopted smart grid technologies in several cities, including Tokyo and Osaka, and Japan has seen significant improvement in energy efficiency, waste reduction and improved service quality, according to a report by Frost & Sullivan, Japan's smart grid market is expected to reach \$30 billion by 2025.

5- United States of America:

Many cities in the United States have adopted smart grid technologies, such as San Francisco and New York, and the United States has seen an improvement in energy efficiency, with a study by Navigant Research showing that the adoption of smart grids could save between \$2.8 trillion and \$5 trillion to the US economy by 2030.

6- China:

China has adopted smart grids in several major cities such as Beijing and Shanghai, and China has seen an improvement in service quality, reduced disparities in distribution, and improved security and reliability, according to a report by IHS Markit, China's investment in smart grids is expected to exceed \$100 billion by 2025.

7- European Union:

Many EU member states have adopted smart grids, with a focus on improving efficiency and sustainability, and the EU has seen progress in meeting renewable energy targets and reducing harmful emissions.

According to a report by the European Commission, the size of the EU smart grid market is expected to exceed €27 billion by 2025.

Fifth: Advantages of the Smart Grid.

- **Advanced Metering Infrastructure: (AMI)**

Smart meters provide real-time data on electricity use for both utilities and consumers, enhancing transparency and promoting energy conservation.



- **Net Automation**

Automated control systems enable real-time network monitoring and management, improving response times to service outages and system disruptions.

- **demand-responsive system**

DR allows utilities to adjust demand in response to supply conditions, such as reducing load during periods of peak demand or when the availability of renewable energy is low.

- **Energy storage systems**

Integrating energy storage solutions, such as batteries, helps mitigate the volatility of renewable energy sources, ensuring a stable energy supply.

- **Energy Resources**

Distributed energy resources, including rooftop solar panels and small-scale wind turbines, contribute to power generation near where it is consumed, reducing transmission losses and enhancing grid flexibility.

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Smart grids improve energy delivery and use, and reduce waste by improving demand forecasting and the ability to dynamically match supply and demand. This leads to more efficient use of resources and lower energy costs for consumers.

- **Improve network reliability and flexibility:**

Advanced monitoring and control capabilities allow smart grids to provide a more reliable power source by quickly identifying and resolving faults within the network. This reduces downtime and reduces the impact of power outages on consumers and businesses.

"Chapter Two: The Impact of Smart Grid on Worker Productivity"

Preamble:

The use of modern technology and the development of smart grids in various sectors, including the electricity sector, are among the most prominent trends in the industry today. With the increase in adoption of these technologies, new opportunities emerge to improve work efficiency and enhance workers' productivity. Smart grids are also a technology platform that combines telecommunications infrastructure, cloud computing, smart devices and big data analysis, with the aim of improving the management of systems and services in a variety of sectors. In the electricity sector, smart grids play a vital role in improving the efficiency of energy production, distribution and consumption.

Through this topic, we will discuss in detail how smart grids affect the productivity of workers in the electricity sector, based on research, scientific studies and practical experiences. We will review the technical mechanisms that contribute to improving work efficiency and increasing productivity, and provide practical examples of how smart grids are applied in the sector and their impact on service quality and consumer satisfaction. We will also address the challenges that may face the process of adopting smart grids and how to overcome them to maximize benefits.

Smart grids enable better energy management and increased efficiency in the use of electrical resources, which contributes to reducing the burden on workers and improving their productivity. For example, smart systems can be used to improve maintenance planning and reduce breakdowns, which increases workers' productivity and reduces total unexplained downtime. The impact of smart grids on workers' productivity is due to several factors and mechanisms that contribute to improving work efficiency and providing a more integrated and effective work environment.

First: The impact of smart networks on the productivity of workers.

1- Improving the operations of

Through the use of smart grids, companies can optimize production processes and reduce inefficient lead times. For example, connected production systems can be used to continuously adjust and monitor processes, reducing the occurrence of unplanned stops.

According to a McKinsey Global Institute report, full adoption of smart grids in the industry can increase productivity by between 10% and 25%.

2- Delivering advanced analytics:

Using big analytics and AI helps better understand and analyze data, enabling companies to make better decisions based on available data.

According to an IDC report, the MENA data analytics market is expected to grow at an annual growth rate of about 12.7% between 2021 and 2026.

3- Increased communication and collaboration:

Enabling workers to communicate and collaborate better and faster can improve work coordination and increase productivity. According to a Deloitte study, 82% of companies that use digital collaboration tools consider that these tools have contributed to increased productivity.

4- to improve the working environment;

Smart grids can provide a smarter and more integrated work environment, contributing to improved employee satisfaction and increased productivity.

Overall, points and practical experiences show that the use of smart grids can significantly contribute to improving worker productivity across a variety of mechanisms and practices.

Second: The impact of smart networks on the productivity of workers in the Kingdom of Saudi Arabia.

The impact of smart grids on the productivity of workers in the electricity sector in the Kingdom of Saudi Arabia depends on several factors and applications, namely:

- **Improving the efficiency of the electrical network:**

Through the use of smart technology such as smart grids, electricity companies in Saudi Arabia can improve the efficiency of their grids, and reduce energy loss and unplanned downtime.

According to a report by the Saudi Electricity Authority, power loss in the Saudi electrical grid has decreased from 8.53% in 2016 to 8.03% in 2019, an indication of improved grid efficiency.

- **Operation & Maintenance:**

Using smart grids, electrical companies in Saudi Arabia can effectively monitor and maintain their equipment, and predict malfunctions before they occur. For example, Saudi Electricity Company has adopted a smart system for managing and maintaining switching stations, which has reduced operation interruptions and improved productivity efficiency.

- **Availability of service**

Thanks to smart grids, electric companies in Saudi Arabia are able to provide a more available service to consumers, as the network can be monitored continuously and take the necessary actions in a timely manner.

According to a report by the Saudi Ministry of Energy, service availability rates in the Saudi electrical grid have risen to levels exceeding 99.9% in recent years.

- **security push**

Smart grids contribute to enhancing the security of the electrical grid and improving its sustainability by analyzing data, predicting events and taking preventive action, according to a report by the International Energy Agency, the adoption of smart technologies in the energy sector can reduce work accidents and stoppages and improve overall safety.

In general, investment in smart grids in the electricity sector in the Kingdom of Saudi Arabia shows a positive impact on the productivity of workers, and contributes to improving network efficiency and providing better service to consumers.

Third: Technical mechanisms that contribute to improving work efficiency and increasing productivity.

There are several technical mechanisms that contribute to improving work efficiency and increasing productivity in the electricity sector using smart grids, such as:

- 1- **Automated control and monitoring systems: (SCADA)**

SCADA systems allow monitoring and control of production and distribution processes in the electrical network remotely, and SCADA also provides multiple data that helps to understand network performance, analyze processes, and make strategic decisions based on data.

- 2- **Analytics and**

Massive analytics and artificial intelligence technologies enable the analysis of big data generated from smart grids, as these technologies help detect patterns and trends in data and provide accurate forecasts to guide decision-making.



3- Process Automation and Robotics:

Automation is used in many electrical network maintenance and repair operations, which increases work efficiency and reduces human errors, and robots can also perform specific tasks such as inspecting electrical wires with high accuracy and in less time.

4- Communication Technology and Wireless Networks:

Wireless communication and broadband (WAN) technologies provide a fast and secure connection between electrical network components, and these technologies can route data quickly and effectively and provide expanded network coverage.

5- Smart Apps and Smartphones:

Smart applications for monitoring and controlling household appliances and electrical equipment provide remote access and control, and workers can use smart applications to monitor energy consumption and improve efficiency of use.

6- Energy storage

Energy storage technologies allow excess energy to be stored and used at times when energy demand is high, and energy storage helps improve the sustainability of the electrical system and improve energy availability.

These technical mechanisms come together to improve electricity production and distribution processes, improve work efficiency and increase productivity in the electricity sector.

Fourth: Practical examples of how smart grids are applied in the sector and their impact on service quality.

Here are some practical examples of how smart grids are applied in the electricity sector and their impact on service quality and consumer satisfaction, such as:

1- Scheduled Smart Meter Reading Fetches

Instead of using traditional meters that require periodic visits to read the meters, smart meters use wireless communication technologies to transmit data in real time, and this application can increase the accuracy of invoices and reduce errors that arise from manual meter readings, which increases consumer satisfaction.

2- Demand Management

Smart grids use massive analytics to understand consumers' energy consumption patterns, and by applying demand management optimization methods, energy can be diverted to areas where demand is high more effectively, reducing the likelihood of power outages and improving service quality.

3- Fault forecasting and predictive maintenance:

Using big data and intelligent analysis, smart grids can predict potential malfunctions and problems in the network before they occur, as electric companies can take predictive maintenance actions based on these analyzes, which reduces unplanned operation interruptions and improves the quality of service provided to consumers.

4- Interaction with Consumers:

Smart applications and digital platforms provide consumers with the means to interact with the electric company directly, and consumers can monitor their energy consumption, analyze their bills, and submit complaints and suggestions via these applications, which increases their sense of control and satisfaction.

5- Intelligent operation

Smart grids rely on advanced control systems and real-time analytics to ensure balanced and efficient power distribution.

Intelligent operation reduces outage incidents and improves network emergency response, enhancing service quality and increasing consumer satisfaction.

These examples illustrate how smart grids are applied in the electricity sector and how this affects service quality and consumer satisfaction, as businesses' interaction with consumers is improved and more efficient and reliable services are provided.

Chapter Three: The impact of smart grids on improving performance indicators.

Preamble:

In light of the rapid developments in the field of technology, smart grids have become one of the main innovations that enhance the performance of different sectors, including the electricity sector. Smart grids have the ability to collect and analyze data in an advanced manner, and provide smart control and interaction capabilities, which enhances the effectiveness of electrical grids management and improves performance indicators in general.

This chapter aims to explore the impact of smart grids on improving performance indicators in the electricity sector, and to highlight the benefits that can be achieved by adopting this advanced technology. We will discuss how to improve the quality of service, increase operating efficiency, enhance security and sustainability, and other important indicators that can be improved using smart grids.

With this context in place, we can understand how the electricity sector is shifting to a smarter and more efficient model, enhancing the overall user experience and pushing the sector towards new levels of development and sustainability.

Smart grids provide accurate and efficient data on grid status and power consumption, enabling the grid to be managed more efficiently and effectively. This data can be used to analyze performance and improve processes, contributing to improved performance indicators such as efficiency rates, service quality, and response to queries.

First: The impact of smart grids on improving performance indicators.

Smart grids influence performance indicators by improving them through:

1- INCREASE EFFICIENCY OF OPERATION

According to a study by McKinsey, smart grid systems are estimated to provide opportunities to improve energy efficiency by between 18% and 23%, through the use of artificial intelligence technologies and massive analytics, smart grids can improve the prediction of consumption and the distribution of energy more efficiently, reducing waste and increasing the sustainability of the system.

2- Improve Quality of Service

According to a report from the International Telecommunication Union (ITU), smart grid systems are estimated to reduce the number of power outages by between 20% and 40%, and with the ability to detect faults faster and guide maintenance measures accurately, smart grids reduce the duration of service outages for consumers and improve their experience.

3- up regulation

According to a report from the International Renewable Energy Agency (Irena), smart grids can increase the system's ability to adapt to changes in demand and supply in real time, and smart grids provide a flexible system that can be better controlled, allowing for improved distribution and a better balance between produced and required power.

4- Ensure financial sustainability

According to a report from the European Commission, smart grid systems are estimated to reduce carbon emissions by between 3% and 5%, and thanks to improved energy management and enhanced use of renewable energy, smart grids contribute to long-term environmental sustainability goals.

Second: How smart grids affect the improvement of performance indicators.

Improve Quality of Service

- Rapid fault detection: Smart grids use advanced monitoring systems that enable them to quickly detect faults and accurately locate them, allowing them to be fixed quickly and reducing the duration of service outages.
- Intelligent power distribution: Using intelligent control, smart grids can better direct power and achieve equal power distribution, improving the quality of the electric current provided to consumers.
- Data analysis and fault prediction: Massive analytics and artificial intelligence contribute to continuously analyzing network data and anticipating potential failures before they occur, allowing for early corrective action.

INCREASE EFFICIENCY OF OPERATION

- Waste reduction: Using smart grid technologies, wastage in power transmission and distribution can be reduced, whether by improving power routing or improving appliance efficiency.
- Improved energy use: Consumption data can be used and analyzed to understand consumption patterns and improve energy management, reducing wasted energy and improving operating efficiency.

security push

- Network protection: Smart grids enable advanced security capabilities such as threat detection, access control, and encryption, improving network security.
- Use of renewable energy: Smart grids can better integrate renewable energy sources into the grid, increasing the sustainability of the energy system and reducing harmful emissions.
- Improved planning and forecasting: Using mass analysis and demand forecasting techniques, smart grids can improve planning for future needs and improve the sustainability of the energy system.

By using smart grids and artificial intelligence technology, the electricity sector can achieve a significant development in service quality, operating efficiency, system security, and environmental sustainability, which contributes to improving the consumer experience and enhancing the effectiveness of the sector in general.

Chapter Four: The impact of smart grids on reducing operational costs.

Preamble:

Nowadays, companies and organizations in all sectors face constant challenges to maintain their competitiveness, improve their efficiency and reduce operational costs. Electricity is one of the sectors that faces these challenges in particular, but with the development of technology and the emergence of smart grids, there are new opportunities to improve efficiency and reduce operational costs.

In this chapter, Naimed to explore the impact of smart grids on reducing operational costs in the electricity sector. We will address how to use smart technology to improve resource management, improve energy efficiency and reduce waste, helping to achieve tangible cost savings, increase corporate competitiveness and improve services to consumers.

With the increased adoption and application of smart technology in the electricity sector, radical changes can be achieved in how networks are managed and operated, making them more efficient, sustainable and economical at the same time. Thanks to improved energy management, fault prediction and better maintenance processes, smart grids

contribute to significantly reducing operational costs. For example, costs associated with emergency maintenance can be reduced and energy use improved, reducing operating costs and boosting profitability.

First: The impact of smart grids on reducing operational costs in the electricity sector.

The impact of smart grids on reducing operational costs in the electricity sector has a significant and tangible impact, and this can be illustrated by the following:

- **Reducing waste.**

According to a report by the International Energy Agency (IEA), technical improvements offered by smart grids can reduce energy losses by between 10% and 15% in countries that rely heavily on smart technology.

By improving power distribution and reducing interruptions and losses, significant savings in production and distribution costs can be achieved for electricity companies.

- **(i) Increasing energy efficiency;**

According to a report from Navigant Research, smart grids could save up to \$2 trillion in energy use over the next decade, due to improved energy efficiency.

Through the use of data analytics and artificial intelligence, smart grids can optimize energy use and identify points that can be optimized for additional savings.

- **Improving water resources management**

Smart grids provide better energy resource management capabilities, allowing for better resource utilization and reduced costs.

For example, smart grid technologies such as smart meters and automated energy control systems can allow overconsumption points to be identified and actions taken to reduce them, reducing energy bills and saving costs.

- **Maintenance costs**

Smart grids offer advanced monitoring and maintenance systems, which help identify potential problems in the network and reduce costs resulting from emergency maintenance.

Using massive analytics, smart grids can identify parts that are damaged or in need of maintenance before malfunctions occur, allowing for preventative maintenance and reducing costs resulting from emergency repairs.

Second: Applied examples of smart grids in the electricity sector.

- **Installation of Smart Meters**

Smart electricity meters have been implemented in many countries around the world, allowing consumers to monitor electricity consumption accurately and in real time. For example, Spanish electricity company Iberdrola has installed more than 10 million smart meters in Spain.

- **The intelligent,**

Smart grids use network management systems to intelligently monitor and control power distribution. For example, the "Distribution Management System (DMS)" used in some electrical companies allows for real-time network monitoring and analysis of load, loss and fault data to improve distribution efficiency.

- **Smart Lighting:**

Smart lighting uses smart grid technologies to improve public lighting management in cities. For example, the City of Los Angeles has installed sensor-based smart LED lighting to save energy and improve the quality of street lighting.

- **Smart grids in renewable energy:**

Smart grids are used in the integration of renewable energy sources into the electrical grid. For example, a smart grid system has been implemented in Austin, Texas in the United States, to effectively integrate solar and wind energy into the grid.

- **Analytics and**

Huge analytics and artificial intelligence are used in smart grids to continuously analyze network data and anticipate potential malfunctions before they occur, reducing maintenance cost and increasing operating efficiency.

Third: The impact of smart grids on reducing operational costs in the electricity sector in the Kingdom of Saudi Arabia.

Saudi Arabia has a prominent position in the electricity sector and has seen increased adoption of smart grid technologies in recent years, resulting in significant improvements in operating efficiency and reduced operational costs. Here are some evidence and statistics that support this impact in Saudi Arabia:

- **Reducing waste.**

According to a report by the Saudi Electricity Authority (SEC), the Kingdom has witnessed a significant reduction in the percentage of losses in the electrical network thanks to the adoption of smart technology. Statistics indicate that the percentage of losses has decreased from nearly 12% in 2015 to about 8% in 2020.

- **(i) Increasing energy efficiency;**

According to data from the Saudi Electricity Authority, smart grid technologies have been used to increase energy efficiency and improve its overall use. The figures show that improved energy efficiency has resulted in savings of approximately SAR 500 million (approximately USD 133 million) per year.

- **Improving water resources management**

Thanks to intelligent resource management systems, significant savings in operating costs have been achieved. Statistics show that the use of smart systems to improve resource management has resulted in savings of more than SAR 300 million (approximately USD 80 million) per year.

- **Maintenance costs**

Thanks to the application of smart maintenance technologies, the Kingdom has seen a reduction in maintenance and repair costs. Data shows that this improvement has resulted in savings of more than SAR 200 million (~ US \$53 million) per year.

Based on this evidence and statistics, it can be said with confidence that the adoption of smart technology in the electricity sector in Saudi Arabia has led to a significant reduction in operational costs, which enhances efficiency and supports sustainability in the sector.

Fourth: Challenges of implementing smart networks.

Despite the great benefits offered by smart grids in the electricity sector, there are challenges facing the process of adopting them, the implementation of smart grids is not without obstacles. Several challenges need to be addressed to fully unlock their potential, including:

- 1- Modernization and development

The costs of upgrading electrical infrastructure to be compatible with smart grids can be prohibitive.

This requires replacing old hardware with smart ones, updating software, and providing appropriate updates.

2- SECURE AND PRIVATE:

The presence of huge amounts of sensitive data and information in smart networks poses a major challenge to security and privacy, and electric companies must take appropriate security measures to protect data and ensure the safety of the network from cyber attacks.

3- STATUTES AND REGULATIONS

Electric companies may face challenges in terms of compliance with domestic and international legislation and regulations related to privacy, security and the use of smart technology, as this requires continuous action to review policies and procedures and ensure compliance with legal requirements, and the absence of a policy framework such as areas that lack a comprehensive policy and regulatory framework for smart grid development.

4- Technical Compliance Challenges:

Companies may face challenges regarding the technical compatibility between existing network systems and the new technology required for smart grids, and this requires good planning and investment in modernizing systems and technology to ensure compatibility and smooth operation.

5- Adoption and training challenges:

Companies may face challenges in adopting new technology and qualifying workers to use it effectively, and this requires the provision of intensive training programs and continuous technical support to ensure the use of smart grids with high efficiency.

6- Difficulties of automation and measurement techniques:

Control of electrical distribution The automation of substations and switches requires advanced technologies and integration tools, along with sensing and measurement technologies, the implementation of large-scale monitoring systems, dynamic line classification, and temperature monitoring.

7- High costs

Investment of high capital The large cost of modernizing existing networks using IT-enabled technologies, the cost of installing renewable energy technology, especially when integrating storage technology, as well as the shortage of trained manpower The shortage of skilled staff for service, installation and maintenance, and the existence of some financial challenges such as obtaining funding from financial institutions for smart grid projects.

Fifth: Overcoming the challenges of the smart grid.

To overcome these challenges and maximize the benefits from smart grids, electrical companies and stakeholders must take critical steps, including investing in infrastructure and security, providing appropriate training to employees, and ensuring compliance with local and international regulations and legislation.

- Overcoming the challenges associated with smart grid implementation requires strategic initiatives and concerted efforts.
- Increasing Smart Grid Investments The U.S. Department of Energy's Smart Grid Grant Program encourages its wider adoption through large investments, scarce resource alternatives, improved energy storage technologies, and the exploration of alternative energy sources.
- Cybersecurity measures Ensure strong physical and cybersecurity measures to protect the network, provide path instability solutions, and implement solutions to address energy source path instability.
- Change management effort by communicating the vision, educating consumers, aligning stakeholders, active leadership to navigate change, assessing company needs, conducting comprehensive assessments, creating detailed plans, ensuring employee awareness and monitoring system performance.

- By directly addressing these issues, the potential benefits of smart grids can be fully realized.

The employee:

This scientific paper shows that smart grids play a vital role in improving the performance of the electricity sector by increasing worker productivity, improving performance indicators, and reducing operational costs. Smart grids can be a worthwhile investment for businesses in this sector, with notable improvements in efficiency and effectiveness.

In concluding this topic on "The impact of smart grids in the electricity sector", we realize the great importance played by smart technology in improving the efficiency of the work of electrical networks and achieving several advantages for workers in this sector. By analyzing the impact of smart grids, we found that:

Improving the productivity of workers in the electricity sector is one of the most important benefits offered by smart grids, as it enables them to better monitor and analyze the network, and make the right decisions faster and more accurately.

Improving performance indicators such as service quality, energy savings and reducing outages are the last salient benefits of smart grids, as they contribute to providing better services to consumers and improving their experience.

In addition, smart grids are an effective way to reduce the operational costs of electric companies, by improving energy and resource management, reducing waste and improving strategic planning.

As technology evolves and adoption of smart grids increases, further improvements in the performance of the electricity sector and increased sustainability and efficiency can be expected. With the challenges of smart grid adoption, we need to focus on effectively identifying and resolving these challenges to ensure that the benefits from these innovative technologies are maximized.

In conclusion, the adoption of smart technology in the electricity sector represents a significant development that contributes to a range of important benefits. By improving production efficiency, improving the quality of service provided and reducing operational costs, smart grids become an essential tool for sustainability and development in the electrical sector. Focusing on innovation and technical development is an essential part of the vision of the future to improve the performance of electrical networks and meet the aspirations of sustainable societies. Thanks to the efforts of innovation and continuous cooperation between the public and private sectors, a real shift towards a more efficient and sustainable future in the electricity sector can be achieved.

Hence, it can be said with confidence that smart grids represent a promising future for the electricity sector, offering innovative and effective solutions to improve the generation and distribution of energy, improve the consumer experience and increase the sustainability of the electrical system.

Concluion:

In conclusion, smart grids alter the electrical sector, improving efficiency, production, and sustainability. Smart grids use modern technologies like big data analytics, artificial intelligence, and remote sensing to improve energy resource management, power system dependability, and operational costs. These advances boost electrical network performance and worker efficiency and decision-making.

Smart grids increase electrical grid monitoring and control, reducing outages, conserving energy, and improving consumer service. Smart grids also reduce pollution and integrate renewable energy sources.

Smart grids must overcome infrastructure upgrades, cybersecurity, regulatory compliance, and technological and adoption constraints to reach their full potential. The electrical sector can overcome these hurdles and maximise smart grid benefits by investing in infrastructure, security, personnel training, and innovation.

Smart grids are essential to a more efficient, sustainable, and resilient electrical sector. Energy management's future is bright with innovative solutions that increase electricity generation and distribution, user experience, and sustainability.

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