Dijlah Journal of Engineering Science (DJES) Vol. 2, No. 3, Aug., 2025, pp. 157-166
ISSN: Printed: **3078-9656, Online: 3078-9664**, paper ID: 62

Smart Grid-Based Integration of Renewable Energy: Toward a Flexible Power System in Iraq

Ahmed Hamid Atshan Khalif
Islamic Azad University Isfahan Khorasgan, electrical power engineering , Baghdad, Iraq

Article Info

Article history:

Received July, 4, 2025
Revised July, 20, 2025
Accepted Aug., 20, 2025

Keywords:

Renewable Energy Integration
Smart Grid Technologies
Energy System Flexibility
Sector Coupling
Battery Storage

ABSTRACT

This research explores the complex challenges and emerging opportunities associated with integrating renewable energy sources into conventional electricity grids. As nations intensify efforts to reduce carbon emissions and embrace sustainability, the role of renewable sources—particularly solar and wind—has become more critical than ever. However, these sources introduce significant variability and uncertainty into the grid, necessitating new approaches in system design, operation, and regulation. The study provides a comprehensive analysis of technical, economic, and institutional barriers to integration, including limitations in grid flexibility, inadequate storage infrastructure, fragmented sectoral coordination, and market structures that fail to incentivize innovation.

To address these issues, the paper investigates advanced technological solutions such as smart grids, battery storage systems, predictive control algorithms, and sector coupling strategies. These innovations are evaluated not only for their technical potential but also for their applicability in real-world contexts—particularly in developing countries. Iraq is presented as a national case study, where infrastructure constraints and regulatory gaps coexist with enormous solar energy potential. The research proposes policy reforms, pilot projects, and capacity-building initiatives as pathways toward a more resilient and diversified energy future. Lastly, the results put into context that a successful energy transition involves an overarching framework that situates technological progress in coordination with regulatory adaptability and stakeholder participation.

Corresponding Author:

Ahmed Hamid Atshan Khalif
Islamic Azad University Isfahan Khorasgan, electrical power engineering , Baghdad, Iraq
Baghdad, Iraq
Email: alshamriahmedalshamari@gmail.com

1. Introduction

The global energy sector undergoes a fundamental change as a conversation is called as a call to go against renewable energy sources. This effort aims to fight climate change and reduce the dependence on fossil fuels. Renewable energy - especially sun and air - has emerged as a promising solution to achieve the environment and economic stability. However, despite their benefits, renewable sources have significant technical, economic and regulatory challenges when integrated into traditional energy systems, which were originally designed for control -up, centralized fossil fuel -based power generation.

The purpose of this study is to detect both challenges and opportunities related to integrating renewable energy into the traditional power grid. On the one hand, new technologies offer equipment such as smart networks, advanced energy storage systems and predictive analysis that can reduce the instability of renewable energyOn the other hand, the integration process still encounters significant obstacles seeking innovative technical and political reactions.

The integration of renewable energy into traditional electrical systems represents one of the most pressured challenges for countries trying to meet the stability goals and reduce greenhouse gas emissions. To achieve this energy infection, not only requires infrastructure investments with large -scale, but also legal and regulatory reforms that enable better coordination between renewable and traditional sources. Therefore, this study wants to present a broad perspective on opportunities and obstacles that shape this change.

This research addresses the following main question:

• What are the primary technical challenges to integrate renewable energy into the current web?
• How can imbalance in the supply deficiency be controlled due to intimacy in renewable energy?
• Can renewable energy provide long -term financial opportunities?
• How can government policy facilitate effective integration of renewable and traditional energy sources?

The main objectives of this study are as follows:

• Identify and analyze the most important challenges of integrating renewable energy into traditional energy systems.
• Discovering financial and environmental benefits of such integration.
• To provide practical recommendations to control infrastructural and operational obstacles, especially in terms of smart networks and system flexibility

2. Literature Review

2.1 Evolution of Renewable Energy Integration into Conven-tional Grids

In recent years, the integration of renewable energy sources into the traditional electric network has attracted considerable attention. Research in the region has accelerated since the beginning of the 2000s, which focuses on techniques such as smart networks and energy storage systems to address the Akshay generation and address the instability.

Previous studies show a continuous increase in the use of solar and wind energy in power systems, resulting in hybrid networks that combine traditional energy sources - such as coal and natural gas - with renewal (Zhang and Jhao, 2018) (Fig.1). Innovative solutions such as smart networks have been introduced to facilitate this integration. These smart systems are able to monitor and sync data from different energy sources in real time, reducing the effect of ups and downs and improves online stability.

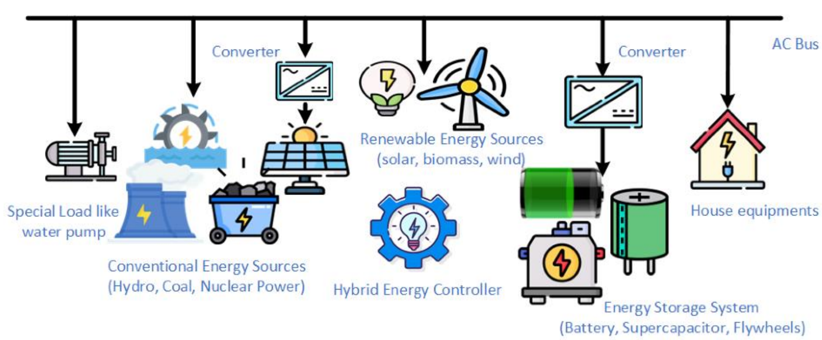

Fig1. Structure of a basic HES system.

2.2 Technical Challenges of Renewable Integration

According to the International Energy Agency (IEA, 2020), one of the most important technical challenges of integrating renewable their periodic and non-discatisable nature is one of the most important technical challenges. While fossil fuel-based plants allow controlled and stable generations, sun and wind outputs depend on much of the weather conditions, which are naturally varying and difficult to predict with accuracy.

Gärttnner and Stroe (2020) emphasize that most of the existing nights were not initially designed to accommodate such variability. Consequently, considerable upgrading - for example, requires investing in flexible infrastructure, smart grid properties and advanced storage systems. These investments are necessary to ensure that grids can meet growing and ups and downs in modern societies.

2.3 Smart Grid and Storage Technologies

One of the most promising solutions for renewable intimacy is contained in smart network technologies, which increases the integration and management of various energy resources. Many studies emphasize that smart networks enable real -time data collection and automatic delivery control, making energy distribution more efficient and responsible.

Irena (2019) reports emphasizes the important role of storage systems to support renewable integration. When renewable generations are low, the energy stored during high demand periods can be distributed, which means that the system is stabilized. It highlights the need to invest in batteries and other storage methods with renewable distribution.

2.4 Economic and Financial Challenges

Despite the long-term capacity of renewable energy, sufficient financial challenges remain-specially related to infrastructure upgrading and the cost of advanced technologies. Zhang and Jhao (2018) found that the high capital investment required for modernization and storage solutions online continues to serve as a significant obstacle.

In addition, an increase in dependence on renewable energy may threaten the economic viability of hereditary power plants (coal, gas), which is referred to as "trapped property" - which is unprotected or obsolete. This economic risk policy can prevent speed and cannot address investors properly.

2.5 The Role of Government Support Policies

Policy frameworks have a critical function in stimulating the use of renewable energy. Financial incentives, as highlighted by IRENA (2019), such as feed-in tariffs and auctions, are crucial to spur investment in clean energy, especially considering the fact that initial costs are prohibitively expensive.

But regulatory barriers can cause the delay. Gärttner and Stroe (2020) say that tardy policy action and legislative uncertainty will likely cause friction among the various stakeholders, i.e., producers of energy, grid operators, and consumers. A successful integration strategy therefore needs a harmonized and open regulatory framework. [3]

2.6 Future Directions and Research Trends

New trends indicate embracing decentralized energy systems and new storage technologies such as green hydrogen and gravity storage. Green hydrogen, for example, presents a promising way of converting excess renewable energy into storable fuel, which can be utilized to generate electric power or in industry (Zhang & Zhao, 2018).

Regional energy integration is also being increasingly pushed wherein the surrounding countries cooperate through interconnect projects. The regional integration lowers the risks of renewable variability and improves grid stability across the borders.

3. Theoretical Framework

3.1 Key Concepts and Definitions

a. Renewable Energy: Renewable energy is energy based on natural resources that are replenished continuously, for example, sunlight, wind, flowing water, biomass, and geothermal heat. Unlike fossil fuel, upon manufacturing these sources, few or no greenhouse gases are released, thereby the focus of sustainable energy policy (IRENA, 2019).

b. Traditional Power Systems: Traditional power systems are centralized, fossil-powered generation plants (natural gas, coal, oil). Traditional systems are generally characterized by single-direction flow of electricity from large plants to consumers and are highly regulated but at huge environmental and economic costs (IEA, 2020).

c. Renewable Energy Integration: This is the integration of renewable sources of power into a system grid without compromising system reliability and stability. To integrate requires the control of the variability and uncertainty of renewable generation (Zhang & Zhao, 2018).

3.2 Theoretical Foundations of Energy Integration

ISSN: Printed: **3078-9656, Online: 3078-9664**, paper ID: 62

Energy System Flexibility: Power system flexibility refers to the capacity to respond to a sudden or gradual change in energy supply or demand without disturbing grid stability (Gärttner & Stroe, 2020). Flexibility can be realized through many different ways, such as:

- Fast-ramping generation units.
- Effective energy storage system.
- Demand-side responsiveness.
- Cross-border power interconnections.

For systems with high proportions of sun and air, flexibility becomes an essential position for operational safety and economic efficiency.

3.3 Dimensions of Energy Flexibility

Energy flexibility can be analyzed in many interconnected dimensions:

One. Supply page Flexibility: This involves a generation's ability to adjust production quickly. This also involves integrating control -gown renewable sources and storage technologies that absorb or release power as needed.

B. The Demand Party Flexibility: Here, the consumer value adjusts the use of your power in response to the status of the signs or grid. This is supported by technologies like smart meters and demand management systems.

c. Interconnection Flexibility: This refers to the capacity of power networks to import or export electricity through regional or transnational links. It reduces the need for local storage and enhances energy security.

d. Storage Flexibility: Stored energy can be deployed during peak demand or low generation periods, thus absorbing variability. Technologies include lithium-ion batteries, green hydrogen storage, compressed air, and pumped hydro systems.

3.4 Metrics for Assessing Flexibility

Quantifying system flexibility involves several indicators, such as:

- Response Time: How fast generation or demand can be adjusted.
- Reserve Capacity: Extra available capacity to be deployed when needed.
- Operating Range: The extent to which a system can deviate from normal conditions while remaining stable.

According to IEA (2021), systems with more than 30% variable renewable generation require at least 25% additional flexibility to avoid disruptions.

3.5 Technologies That Support Flexibility

- Battery Energy Storage Systems (BESS): These can inject or absorb energy within milliseconds, providing rapid stabilization.
- Demand Response Mechanisms: These allow industries and households to reduce or shift energy use during peak times.
- Smart Grids: These provide real-time data and automated adjustments to balance supply and demand.
- Predictive Control Systems: Powered by machine learning, these systems forecast changes and preemptively stabilize the grid.

3.6 Challenges to Achieving Flexibility

Even with mature technology, several barriers remain:

- High initial costs, especially for grid-scale storage.
- Lack of regulatory incentives to treat flexibility as a paid service.
- Weak coordination between energy, transportation, and construction sectors, limiting the scope of integrated solutions.

3.7 The Value of Flexibility in Renewable-Based Systems

The more intermittent energy sources are added to a grid, the greater the need for flexibility (Fig.2). For instance:

- In Germany, renewable generation has occasionally exceeded 50% of the supply, requiring highly responsive balancing mechanisms.
- In Australia, the Hornsdale Power Reserve (a 100 MW battery system) helped maintain frequency stability during grid faults, saving millions in backup costs.

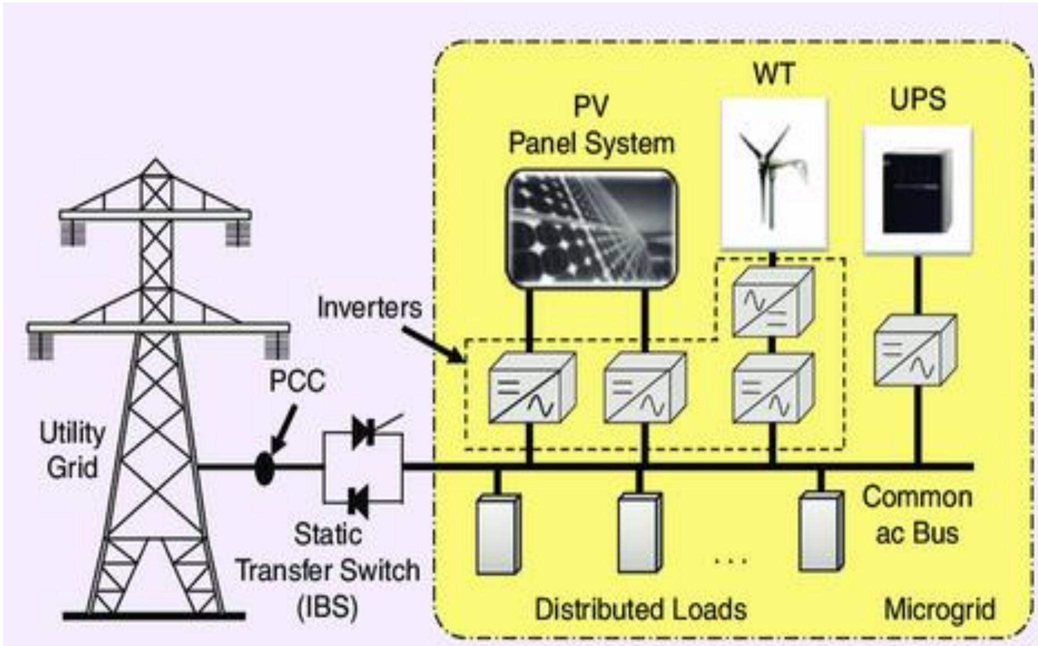

Fig.2. Typical structure of a flexible smart (micro) grid based on renewable energy resources.

4. The Role of Smart Grids in Renewable Energy Integration

As the global transition toward renewable energy accelerates, power grids are being pushed beyond their original design limits. Traditional grids, which were built to handle stable, one-way electricity flows from centralized fossil-fuel plants, are ill-equipped to accommodate the fluctuating and decentralized nature of modern renewable sources. In this context, smart grids emerge not just as a technological upgrade—but as a fundamental enabler of a flexible, sustainable, and responsive power system.

4.2 Managing Renewable Intermittency with Real-Time Flexibility

Renewable sources, particularly solar and wind, exhibit variability throughout the day and across seasons. This intermittency poses a serious challenge to maintaining the balance between electricity supply and demand.

Smart grids tackle this challenge through:

- Real-time monitoring systems that continuously track voltage, frequency, and load conditions.
- Artificial intelligence algorithms that forecast demand and generation based on weather and historical data.
- Automated load shifting, which reschedules electricity usage across residential, commercial, and industrial sectors during peak or low production periods.

These functions collectively enable grid operators to respond proa-ctively, minimizing the risk of blackouts or overloading.

4.3 Empowering Prosumers (Producer-Consumers)

One of the transformative features of smart grids is their ability to redefine the role of the electricity consumer. Through smart meters, dynamic pricing, and secure interconnection protocols, consumers can now:

- Generate their own electricity (e.g., via rooftop solar).
- Monitor real-time energy consumption and surplus.
- Feed excess energy back into the grid and receive compensation.

This shift toward a "prosumer" model decentralizes energy production and enhances overall system resilience.

4.4 Enhancing Energy Efficiency and Reducing Technical Losses

Smart grid technologies contribute significantly to reducing energy waste and improving operational efficiency. Key strategies include:

- Dynamic load balancing, which reroutes electricity in real-time to avoid congestion.
- Fault detection and automatic rerouting, which minimize downtime.
- Predictive maintenance, which uses sensor data to prevent equipment failures before they occur.

As a result, smart grids reduce both transmission losses and operational costs while increasing the lifespan of grid infrastructure.

4.5 Supporting Grid Stability and Reserve Capacity

By integrating energy storage systems and activating flexible loads, smart grids enhance the stability of electricity networks. This includes:

- Absorbing sudden generation surpluses, such as during sunny or windy periods.
- Activating reserve units or storage to meet unexpected demand surges.
- To trigger the demand response system, which automatically adjusts the load in response to grid conditions.

This operational flexibility reduces the requirement for expensive spinning reserves and supports smooth renewable integration

4.6 Accelerating the Transition to Sustainable Energy Systems

Beyond their technical abilities, smart networks play a key role in enabling a broad change in the energy system. They support:

• To adjust everything from centralized and decentralized renewable integration, large wind farms to residential sun units.

• Local energy market, where small manufacturers and consumers change electricity in real time.

• Believe in reliability of the web, and encourages both public and private investments in pure energy technologies.

These abilities are in the position of a smart network in the form of basic infrastructure for future energy ecosystems.

Smart networks go beyond automation and digitalization-they are a flexible, decentralized and low carbon energy that enables the future. By incorporating real -time control, strengthening consumers and increasing system responsibility, smart networks provide practical solutions for structural challenges generated by integration of renewable energy.

5. Key Challenges in Integrating Renewable Energy into Power Grids

5.1 Limited Flexibility of Traditional Grids

The traditional power grid was designed for a directional current-which was made to eliminate users from centralized power plants. However, integrating renewable sources such as rooftop solar panels and distributed wind turbines introduces multi-directional and highly variable energy flows. Traditional grid infrastructure lacks the operational flexibility to manage these dynamics.

As a result, technical issues arise, including:

- Overvoltage in certain areas during high solar production,
- Degradation of power quality.
- Increased transmission and distribution losses.

Example: In urban zones, mid-day solar surplus can reverse energy flow and overload grid components if not managed via local storage or automated control.

5.2 Inadequate Energy Storage Capabilities

The intermittent nature of renewables demands reliable storage to balance production and consumption across time. While solar generation peaks at noon, demand often surges in the evening—creating a mismatch that conventional grids struggle to handle.

Yet, many countries lack large-scale, cost-effective storage systems.

- Battery technologies (e.g., lithium-ion) remain expensive for utility-scale use.
- Hydropower-based storage requires specific geography and long lead times.
- Thermal and hydrogen storage are still emerging and not widely deployed.

According to IEA (2024), current global storage capacity meets less than 20% of what is required to stabilize high-VRE (>40%) systems.

5.3 Weak Cross-Sector Integration (Sector Coupling)

An effective renewable transition depends not only on electricity networks, but also on their integration with other sectors—such as transport, heating, and industry. However, most countries still manage these domains separately.

This fragmentation limits the ability to absorb excess renewable energy into electric vehicles, thermal systems, or hydrogen production. In turn, the overall flexibility and efficiency of the energy system is reduced.

5.4 Lack of Real-Time Data and Intelligent Control Systems

In many grids, outdated infrastructure hinders the deployment of smart control and monitoring tools.

- Absence of smart meters limits visibility into real-time consumption.

- SCADA and DMS systems are often limited or underdeveloped.
- Operational decisions rely on static schedules rather than adaptive algorithms.

This delay in digitization reduces the system's ability to react swiftly to renewable fluctuations or demand peaks.

Only 19% of global power grids utilize advanced SCADA systems and widespread smart metering (IRENA, 2023). [4]

5.5 Inadequate Market Structures and Pricing Mechanisms

In many regions, electricity markets are not designed to reward flexibility, storage, or demand-side participation. This leads to:

- Under-compensation of battery operators or flexible loads,
- Lack of time-sensitive pricing.
- Insufficient financial signals to balance supply and demand in real time.

Solution: Developing "flexibility markets" where participants are paid for rapid-response services could incentivize innovation and investment.

5.6 Limited Regional Grid Interconnection

Some countries operate in electrical isolation or with minimal interconnection to neighboring grids. This limits their ability to export surplus or import electricity during deficits—especially relevant for renewable integration.

- Curtailment becomes common when local demand is saturated.
- Storage reliance increases, adding cost pressures.
- Renewable investments may be deterred due to lack of scalability.

North African countries, for instance, could export excess solar energy to Europe through strategic interconnections, reducing local overloads and boosting revenue.

5.7 Institutional and Political Resistance to Change

Transitioning to a renewable-based energy system can disrupt established market structures and vested interests. Incumbent utilities or fossil fuel companies may perceive distributed renewables or smart technologies as threats.

This resistance can manifest as:

- Delays in legislative reform,
- Opposition to decentralized energy models, and
- Reduced policy support for emerging actors and technologies.

5.8 Cybersecurity and Data Privacy Risks

Smart grids rely heavily on interconnected digital systems, which expose them to potential cyber threats. Risks include:

- Unauthorized access to grid control systems,
- Manipulation of demand or pricing signals, and
- Privacy breaches from smart meter data.

Robust cybersecurity protocols, data governance frameworks, and institutional preparedness are crucial to safeguard critical infrastructure.

Table 5.1: Summary Core Challenges

Domain	Primary Challenge
Infrastructure	Inflexible design; insufficient storage capacity
Market Design	No incentives for flexibility or storage
Control Systems	Lack of real-time monitoring and automation
Sector Coupling	Disconnected energy domains (e.g., transport, industry)
Policy & Governance	Institutional inertia and lack of reform
Cybersecurity	Vulnerabilities due to system digitalization

6. Technological Solutions and Future Opportunities

6.1 Energy Storage Systems: Enhancing Grid Reliability

To mitigate the intermittency of renewable sources and ensure grid stability, storage technologies play a central role. Various storage methods are being developed and deployed (Fig.3), each offering specific advantages:

a. Chemical Storage (e.g., Lithium-ion Batteries): High response-veness and energy density, suitable for short- to medium-term balancing, and decreasing costs make them increasingly viable for grid-scale deployment.

b. Mechanical Storage (e.g., Pumped Hydro): Ideal for long-duration storage and efficient and mature but limited by geographic constraints.

c. Thermal Storage: Converts excess energy into heat for later use in electricity generation or heating systems.

d. Green Hydrogen: Renewable electricity is used to produce hydrogen via electrolysis and hydrogen can be stored for long periods and later used in fuel cells or industrial applications.

Best practices include co-locating storage with renewable power plants and establishing economic incentives (e.g., subsidies, tax breaks) to encourage investment.

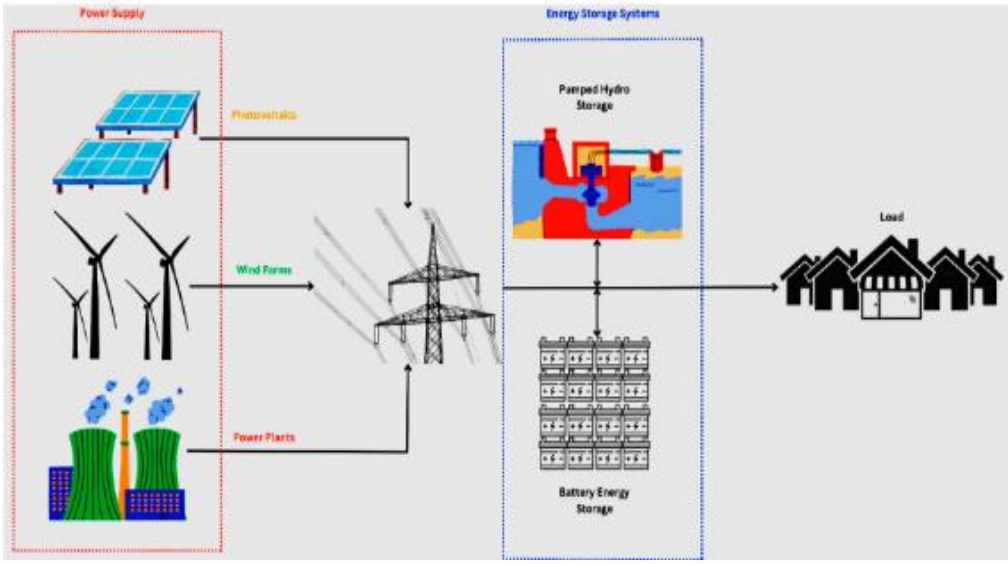

Fig. 3. Schematic of hybrid wind/PV/thermal power plants integrated with different energy storage systems.

6.2 Smart Grids: Enabling Flexible and Efficient Integration

Core components of smart grids include:

- Smart Meters: Enable real-time monitoring and dynamic pricing.
- SCADA & DMS Systems: Provide centralized visibility and operational control.
- High-speed Communication Networks: Facilitate data exchange between grid assets.
- Automation and Self-Healing Capabilities: Allow the grid to adjust flows and recover from disturbances autonomously.

Benefits of smart grid deployment**:**

- Reduces technical losses.
- Enhances real-time responsiveness.
- Supports integration of intermittent and distributed renewable sources.
- Empowers consumers to contribute to demand balancing.

Example: Micro-grids—local networks that can operate indepen-dently or as part of the main grid—are increasingly used to integrate renewable energy, especially in remote or disaster-prone areas.

6.3 Sector Coupling: Linking Power with Transport, Heating, and Industry

To fully harness the potential of renewable energy, electricity must be linked with other sectors through a process known as sector coupling. This strategy multiplies flexibility across the entire energy system.

Key tools and strategies:

- Electric Vehicles (EVs) and Smart Charging:
  - EVs can charge during low-demand periods.
  - Vehicle-to-Grid (V2G) systems allow EVs to return stored electricity to the grid.
- Electric and Thermal Heating Systems:
  - Heat pumps reduce reliance on natural gas.
  - Thermal storage systems shift heat use to times of renewable surplus.
- Electrolysis and Hydrogen Production:
  - Enables de-carbonization of hard-to-abate sectors like steel or aviation.
  - Converts excess solar/wind power into hydrogen for use in transport or industry.
- Smart Energy Management Systems:

- Used in buildings and factories to synchronize energy use with renewable availability.

Sector coupling not only boosts renewable utilization but also reduces overall emissions and enhances grid stability.

Table 6.1: Summary of Technical Solutions and Their Benefits

Solution	Function	Technologies/Examples
Energy Storage	Balances supply-demand and improves reliability	Lithium-ion batteries, pumped hydro, hydrogen storage
Smart Grids	Real-time control and integration of renewables	Smart meters, SCADA, IoT, microgrids
Sector Coupling	Expands renewable use beyond electricity sector	EVs, V2G, heat pumps, industrial electrolysis

7. Conclusion

The integration of renewable energy sources into traditional power grids represents a pivotal step in the global pursuit of environmental sustainability and energy security. This study has highlighted the multifaceted challenges of this transition, including technical limitations, regulatory gaps, market inefficiencies, and institutional resistance. The inherent variability of solar and wind energy demands a paradigm shift in how power systems are designed, operated, and governed. Smart grid technologies, advanced storage systems, and cross-sector integration have emerged as critical enablers of this transformation. Their combined implementation can offer a high degree of operational flexibility, improve real-time system management, and empower consumers as active participants in energy markets. Additionally, the strategic use of digital infrastructure and predictive analytics can enhance forecasting accuracy and grid stability. The research also underscores the importance of policy alignment and financial mechanisms in creating a conducive environment for innovation. Without proper encouragement, infrastructure modernization and renewable distribution may be less than their full capacity. For countries like Iraq, investing in pilot projects, workforce training and regional energy cooperation can pave the way for the future and diverse energy time. Finally, requiring a permanent power system more than technical preparedness - it requires a comprehensive structure that integrates innovation, regulation, market design and public commitment. If this wide sight is squeezed, the nation can switch to a cleaner, smart and more inclusive energy landscape.

8. Reference

[1] H. Alshamri, T. Cockerill, A. S. Tomlin, M. Al-Damook, and M. Al Qubeissi, “On–off-Grid Optimal Hybrid Renewable Energy Systems for House Units in Iraq,” *Clean Technol.*, vol. 6, no. 2, pp. 602–624, May 2024.

[2] L. F. Al-Mamory, M. E. Akay, and H. A. Abdul Wahhab, “Technical and Economic Assessment of the Implementation of 60 MW Hybrid Power Plant Projects (Wind, Solar Photovoltaic) in Iraq,” *Sustainability*, vol. 17, no. 13, Art. 5853, Jun. 2025.mdpi.com

[3] R. Kandari, N. Neeraj, and A. Micallef, “Review on Recent Strategies for Integrating Energy Storage Systems in Microgrids,” *Energies*, vol. 16, no. 1, Art. 317, 2023. mdpi.com

[4] A. M. Adeyinka *et al.*, “Advancements in Hybrid Energy Storage Systems for Enhancing Renewable Energy-to-Grid Integration,” *Sustain. Energy Res.*, vol. 11, Art. 26, Jul. 2024.
sciencedirect.com+2SpringerOpen+2arxiv.org+2

[5] S. O. Rey *et al.*, “Powering the Future: A Comprehensive Review of Battery Energy Storage Systems,” *Energies*, vol. 16, no. 17, Art. 6344, Sep. 2023.mdpi.com

[6] Z. W. J. Al-Shammari *et al.*, “Green Micro-grid Based on PV/WT Hybrid System for Remote and Rural Population in Iraq: A Case Study,” in *Intell. Manuf. Mechatronics*, Lecture Notes in Mech. Eng., Singapore: Springer, 2021, pp. -.link.springer.com

[7] A. Foles, L. Fialho, P. Horta, and M. Collares-Pereira, “Economic and Energetic Assessment of a Hybrid Vanadium Redox Flow and Lithium-ion Batteries Considering Power Sharing Strategies Impact,” arXiv, Jan. 2023. arxiv.org

[8] G. N. Psarros, P. A. Dratsas, and S. A. Papathanassiou, “A Comprehensive Review of Electricity Storage Applications in Island Systems,” arXiv, Jan. 2024. arxiv.org

[9] M. Moradi-Sepahvand and T. Amraee, “Integrated Expansion Planning of Electric Energy Generation, Transmission, and Storage for Handling High Shares of Wind and Solar Power Generation,” arXiv, Oct. 2023. arxiv.org

[10] “Challenges and Opportunities in Implementing Smart Grid Technologies in Kurdistan: A Comprehensive Review,” *J. Ind. Intell.*, vol. 2, no. 2, pp. 94–105, 2024. acadlore.com

[11] “We’ve unlocked a holy grail in clean energy. It’s only the beginning,” *Vox*, Apr. 2025. vox.com

[28] Zimmerli, B. (2012). Materials and Corrosion, 63(9), 787–792. doi:10.1002/maco.201206727

[29] Zucchi, F., et al. (2011),Corrosion Science, 53(10), 3463–3471. doi:10.1016/j.corsci.2011.06.024

ISSN: Printed: **3078-9656, Online: 3078-9664**, paper ID: 62

BIOGRAPHIES OF AUTHORS (10 PT)

The recommended number of authors is at least 2. One of them as a corresponding author.
Please attach clear photo (3x4 cm) and vita. Example of biographies of authors:

Author 1 picture	**Asst. Prof. Dr. Majid S. Naghmash**, Received His Msc. degree in the satellite Master of communication engineering from University of Technology Baghdad – Iraq in 2004 and Doctor of philosophy wireless and mobile system from University Sains Malaysia (USM) Malaysia –Penang -2011. He has been a full-time lecturer and head of power engineering department in the Electrical Engineering Technical College, Baghdad, Iraq, since March 2012. He also worked as senior researcher in the Iraqi Center of Development and Research since 1994., Currently, he has a head of computer engineering techniques Department/ Dijlah University College/ Baghdad/ Iraq since 2017, ongoingHe can be contacted at email: majid.salal@duc.edu.iq.
2 Author 2 picture	Mini cv
Author 3picture	Mini cv
Author 4 picture	**Mini cv**
Author 5picture	**Mini cv**