

Article Overview

The Energy Internet faces technical challenges in communication, data management, cybersecurity, integration of distributed energy resources, and user behavior modeling.

Communication and Information Infrastructure

A core technical issue in the Energy Internet is the need for a scalable and reliable information and communication architecture. Energy routing relies on energy routers (ERs) that manage energy flows similarly to data packets in the Internet, requiring robust protocols to ensure efficiency and reliability across distributed networks . The integration of smart grids with ICT demands high-speed, low-latency communication to coordinate energy generation, storage, and consumption in real time .

Data Management and Analytics

The proliferation of sensors, smart meters, and IoT devices generates massive data streams on energy usage and network states. Managing, storing, and analyzing this data is a significant challenge, particularly for forecasting demand, optimizing energy distribution, and supporting decentralized energy markets . Advanced AI and optimization algorithms are required to process this data efficiently while maintaining system reliability .

Cybersecurity and Privacy

The Energy Internet is vulnerable to cyber threats due to its reliance on ICT. Ensuring data security, privacy, and protection against attacks is critical, especially when handling sensitive user information and controlling energy flows . Standardized protocols and secure communication channels are necessary to prevent disruptions and maintain trust in the system.

Integration of Distributed Energy Resources

The inclusion of renewable and distributed energy resources (DERs) introduces variability and complexity in energy management. Coordinating multiple energy types (electricity, heat, gas) and ensuring stable operation under fluctuating supply conditions is a technical challenge . Energy Internet platforms must support multi-energy system coordination and flexible energy conversion technologies.

Cyber-Physical-Social Modeling

End-user behavior significantly impacts energy efficiency. Modeling the interactions between physical

systems, cyber infrastructure, and social-economic factors is essential for accurate forecasting and decision-making . Developing privacy-preserving models and market mechanisms that account for diverse user motivations remains a technical hurdle.

Standardization and Complexity

The Energy Internet requires uniform standards, protocols, and regulatory frameworks to ensure interoperability among devices, networks, and energy markets . The complexity of integrating multiple layers--physical, cyber, and social--adds to the technical challenges, making system design, operation, and maintenance more demanding.

Conclusion

Addressing these technical issues is crucial for the Energy Internet to achieve efficient, reliable, and secure energy distribution. Future research focuses on enhancing communication networks, developing advanced data analytics, improving cybersecurity, integrating DERs effectively, and modeling user behavior to support a sustainable, low-carbon energy ecosystem .

Energy Internet, a futuristic evolution of electricity system, is conceptualized as an energy sharing network. Its

Energy internet features are highlighted to enhance efficiency, security and reliability. Energy internet architectures and

1 Introduction Along with science and technology developing and social progress, human social activities have a higher

This comprehensive survey aims to offer a panoramic perspective on the Energy Internet, illustrating its conceptual intricacies and

Highlights o This paper aims to provide an overview of the Internet of Energy concept in the Industrial Internet of Things

Next, we focus on blockchain solutions for the energy industry and inform the state-of-the-art by thoroughly reviewing

We identify challenges and potential solutions for future communication technologies, and provide research directions

Renewable energy sources such as photovoltaic (PV), wind, tidal, and ocean waves have increasingly penetrated the

Energy crisis and carbon emission have become two seriously concerned issues universally. As a feasible solution,

The Energy Internet is expected to transform the landscape of electricity generation portfolio, distribution, and consumption through

Challenges and requirements for advancing the energy internet (EI) technologies; future researches can focus on

Comprehensive analysis of renewable energy challenges including technical, economic, and policy barriers. Expert

This review discusses the technical challenges and solutions that contribute towards achieving net-zero energy systems.

The concept is emphasized in close relation to the Internet of Things, Industrial Internet of Things and Industry 4.0. o

Cyber security of energy systems. Cloud computing/edge technology for energy systems. Big data and AI for energy systems.

In this paper, we introduce the development stages of energy systems starting from the conventional energy systems

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