Energy Internet Theory



Overview

Energy Internet: Redefinition and categories | Energy InternetIn this paper, we propose the redefinition of EI, based on a comprehensive literature review.

Key Takeaways

Energy Internet Theory conceptualizes a decentralized, intelligent, and interconnected energy system where energy, information, and financial flows are bidirectional, enabling efficient, resilient, and flexible energy management.

Concept and Definition

The Energy Internet (EI) is a futuristic evolution of the electricity system, designed as a networked energy-sharing platform that integrates distributed energy resources, storage systems, electric vehicles, and smart loads. It enables real-time bidirectional flows of energy, information, and money, allowing prosumers (consumers who also produce energy) to participate actively in energy markets and transactions. Unlike traditional centralized grids, EI emphasizes decentralization, flexibility, and self-organization.

Architecture and Components



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The theoretical framework of the Energy Internet includes several key elements: Energy Routers (ERs) and Energy Hubs: Devices that manage energy flows between distributed sources and loads, analogous to data routers in the Internet. Hierarchical and Regional Control: EI employs a regional coordination and hierarchical control mechanism, transforming traditional tree-like grid topologies into hierarchical partition networks that enhance reliability and clean energy integration. Multi-layer Networks: EI spans from home energy LANs to urban, regional, and global networks, enabling scalable energy management.

Plug-and-

Play Integration: Small-scale renewable systems, storage devices, and electric vehicles can be seamlessly integrated into the network.

Operational Principles

Energy Internet Theory relies on several operational principles: Bidirectional Energy and Information Flow: Energy and data move in both directions, supporting dynamic balancing and real-time optimization. Energy Routing: Graph theory and game theory are applied to optimize energy transfer, subscriber matching, congestion management, and distributed energy trading.

Decentralized Decision-

Making: Prosumers and microgrids interact strategically, often modeled as Stackelberg games or coalition formations, to achieve fair pricing and efficient resource allocation. Integration of Emerging Technologies: IoT, blockchain, AI, digital twins, and smart sensing enhance monitoring, control, and predictive management of energy flows.

Theoretical Implications

Energy Internet Theory extends beyond physical energy flows to include economic, social, and cyber-physical dimensions: Virtual Power Plants and P2P Trading: Aggregated distributed resources can participate in energy markets, enabling peer-to-peer energy trading and carbon trading. Resilience and Security: The decentralized and autonomous nature of EI improves fault tolerance and cybersecurity, while hierarchical control ensures stability.

Self-

Learning and Adaptive Systems: Future EI models aim to incorporate multi-agent systems and AI-based learning to achieve autonomous, optimized, and resilient energy routing.

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Summary

Energy Internet Theory provides a comprehensive framework for a next-generation energy system that is decentralized, intelligent, and highly integrated. It combines physical energy networks, information systems, and market mechanisms to enable efficient energy distribution, renewable integration, and active prosumer participation. The theory underpins ongoing research in energy routing, hierarchical control, and cyber-physical integration, aiming to transform traditional grids into flexible, resilient, and sustainable energy ecosystems.

Article Content

Energy Internet: Redefinition and categories | Energy Internet

In this paper, we propose the redefinition of EI, based on a comprehensive literature review, some latest trends and driving forces in the global energy industry, as well as its

Energy Internet: Redefinition and categories

Energy Internet (EI) is an energy ecosystem, with physical layer, information layer and value layer combining energy and carbon emission flows, in which the Internet thinking and emerging

Construction of energy internet technology architecture based on ...

Based on electrical power systems, leveraging renewable energy generation technology, and information technology, the energy internet fuses power grids, gas networks, heat/cold supply

Energy Internet, the Future Electricity System: Overview, Concept ...

First, a comprehensive overview of Energy Internet is presented along with its aptness as a future evolution of electricity system. Second, concepts, architectures, and features that underpin

Energy Internet: Systems and Applications | Springer Nature Link

This textbook provides an ideal resource for students in advanced graduate-level courses and special topics in energy, information and control systems. It comprehensively describes the energy Internet,

Energy Internet: State of the Art and Challenges

This survey provides a comprehensive overview of the Energy Internet Concept, strategies for achieving energy-efficient communications and data centers, and the dynamic interplay between the Energy

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Development and Evolution of Energy Internet and Its Impact on

Recent years witness certain progress in both theory and practice of energy Internet. However, with the proposal of new strategies such as carbon dioxide peaking, carbon neutrality and new power

Recent advancement of energy internet for emerging energy

Key features of the energy internet such as energy sources, communication technologies, data computation, energy management systems and financial analysis are highlighted to enhance

Energy Internet

Energy Internet is an innovative concept based on synergy of multi-energy systems including electricity, gas, cooling and transportation.

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Graph/Game Theory-Based Energy Routing Methods in the Energy Internet ...

Graph/Game Theory-Based Energy Routing Methods in the Energy Internet: A Review Abstract: The power network is evolving to a new concept called the Energy Internet (EI) by integrating smart grids,

Energy Internet, the Future Electricity System: Overview, Concept ...

Energy Internet, a futuristic evolution of electricity system, is conceptualized as an energy sharing network. Its features, such as plug-and-play mechanism, real-time bidirectional flow of energy,

What is Energy Internet? Concepts, Technologies, and

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

Graph theory based topology design and energy routing control of the ...

Applying graph theory, the ER-based energy internet can be represented as an abstract mathematical model. To seek for the minimum weight path of graph theory means reducing costs or losses in

Entropy theory of distributed energy for internet of things

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In this paper, we use the entropy theory to describe the distribution and powering of small electronics in the era of internet of things. We refer the power transmitted from power plants to utility

Graph theory based topology design and energy routing

Applying graph theory, the ER-based energy internet can be represented as an abstract mathematical model. To seek for the minimum weight

Graph theory based topology design and energy routing control of the ...

Considering the real-time and the asynchrony of power transmission in the above topology determined energy internet, an energy routing control method based on Dijkstra algorithm is

What Is Energy Internet? Concepts, Technologies, and Future Directions

To realize renewable-energy-based electri cation goals, a new concept the Energy Internet (EI) has been proposed, inspired by the most recent advances in information and telecommunication network ...

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