Energy Internet Backbone Planning

Article Overview

Energy Internet backbone planning focuses on hierarchical, zoned, and autonomous network structures to integrate renewable energy, enhance reliability, and enable flexible energy management.

Core Principles of Energy Internet Backbone Planning

Hierarchical and Regional Control: The Energy Internet adopts a regional coordination and hierarchical control mechanism, transforming traditional tree-like power networks into hierarchical partition networks. This allows for intra-layer partitioning, interregional interconnection, and regional autonomy, ensuring clean energy compatibility and reliable operation across multiple scales of the grid . Backbone Network Topology: The backbone network is designed using a Hierarchical Ring Network Autonomy (HRNA) approach, which evolves from existing power grid structures. This topology emphasizes equivalence among nodes, avoiding centrality dominance, and mimics Internet-like characteristics in terms of average degree, network diameter, and aggregation coefficient . Such a design supports scalability and resilience. Layered and Zoned Architecture: Planning involves layered and zoned topology evolution, starting from local energy networks (home or building level) to urban, regional, and global Energy Internet layers. Each layer integrates distributed energy resources, storage systems, and controllable loads, while higher layers coordinate energy flows across regions and countries .

Integration with Existing Grids

Energy Internet backbone planning does not replace existing grids but enhances and adjusts current infrastructure. It leverages smart grid technologies, digital control, and energy management systems to enable bidirectional energy flows, real-time monitoring, and flexible dispatch of renewable energy . This ensures continuity, cost-effectiveness, and gradual evolution toward a fully integrated Energy Internet.

Key Technologies and Operational Mechanisms

o Distributed Energy Resources (DERs): Integration of solar PV, wind, and storage devices at local and regional levels.
o Smart Grid and IoT: Real-time monitoring, predictive control, and automated energy routing.
o Vehicle-to-Grid (V2G) and Blockchain: Facilitate energy transactions and peer-to-peer energy sharing.
o Energy Hubs: Coupling of electricity, gas, and thermal networks for multi-energy optimization .

Planning Considerations
o Scalability: The backbone must support expansion from local microgrids to global networks.
o Reliability and Flexibility: Hierarchical control ensures stable operation despite variable renewable generation.

o Digitalization: Advanced communication and control systems are essential for real-time energy management.
o Sustainability: Prioritize clean energy integration and reduction of carbon emissions.

Global Context

Countries worldwide are experimenting with Energy Internet concepts at various scales, from home energy LANs to regional and global networks, often using pilot projects to test smart grid, digital grid, and energy hub technologies . These initiatives inform backbone planning strategies and highlight the importance of interoperability, standardization, and regulatory frameworks. Conclusion: Effective Energy Internet backbone planning requires a hierarchical, zoned, and autonomous network design that integrates renewable energy, leverages digital technologies, and evolves from existing grid infrastructure. This approach ensures reliability, flexibility, and scalability, forming the foundation for a sustainable and intelligent energy system.

In this paper, we propose the redefinition of EI, based on a comprehensive literature review, some latest trends and

Based on general system structure theory, the technical system framework for the provincial power grid corporations to

The benefits of the energy Internet, along with the challenges of its implementation on a

First, a comprehensive overview of Energy Internet is presented along with its aptness as a future evolution of

Huge shifts in the structure and functionality are brewing in the sector of power and energy with the wide deployment

This article deals with a thorough investigation of the energy internet towards future emerging technologies for energy

Scholars have studied and expounded the concept, architecture, key technologies, and management schemes of the Energy Internet

The association"s vision is that by 2050, the gas infrastructure will be the backbone of the new innovative

In recent years, green networking has attracted a lot of attention from device manufacturers and Internet Service

The EICC serves as a focal point within the Power and Energy Society (PES) for the identification of

challenges and opportunities

Abstract Energy Internet (EI) envisions a future energy system with sustainable concerns of efficiency, economy and

Our findings contribute to a comprehensive understanding of the symbiotic relationship between communication and power networks,

The Annual Energy Outlook 2026 (AEO2026) explores medium- and long-term alternative futures in the United States.

Based on the comparison and analysis of the network characteristics constructed in this paper with relevant literature

Some of those relevant concepts are the Internet of Energy (IoE), the Internet of Anything, and more. Ref. states

Our research addresses the critical intersection of communication and power systems in the era of advanced information

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