Three-Tier Architecture of the Energy Internet

Article Overview

The Energy Internet employs a three-tier architecture--Edge, Platform, and Enterprise tiers--to integrate distributed energy resources, IoT devices, and data analytics for efficient, reliable, and flexible energy management.

Overview of the Three Tiers

o Edge Tier The edge tier consists of IoT sensors, controllers, and advanced metering infrastructure (AMI) attached to energy-generating assets such as solar panels, wind turbines, or battery storage systems . These devices monitor real-time performance metrics, including energy output, environmental conditions, and equipment status. The edge tier enables local intelligence, allowing for diagnostics, prognostics, and optimization directly at the energy source, which enhances system stability and responsiveness .

o Platform Tier The platform tier serves as the data processing and analytics layer. It collects information from the edge tier, performs storage, modeling, and machine learning analysis, and provides decision-support services through open APIs . This tier enables predictive energy management, load forecasting, and optimization of distributed energy resources (DERs), ensuring efficient energy flow and integration of renewable sources .

o Enterprise Tier The enterprise tier focuses on end-user interaction and management. Building managers, utilities, or consumers access real-time energy data, control energy consumption, and implement demand-response strategies through secure web portals or applications . This tier supports energy trading, billing, and operational decision-making, bridging the gap between energy production and consumption.

Functional Benefits

o Decentralization and Flexibility: By separating generation, distribution, and consumption management, the architecture supports distributed energy resources and prosumer participation .

o Enhanced Reliability: Real-time monitoring and predictive analytics reduce transmission losses and improve grid stability .

o Scalability: Modular design allows integration of new energy sources or IoT devices without disrupting existing operations .

o Data-Driven Optimization: Continuous sensing and forecasting enable efficient energy utilization and dynamic load balancing .

Real-World Example

The Metropolitan Energy Center (MEC) in Denver demonstrates a practical implementation of a three-tier energy system. Its primary tier includes multiple generation facilities, the secondary tier features intelligent distribution networks, and the tertiary tier provides advanced metering and user interfaces. This setup reduced

transmission losses by 23% and enabled real-time consumption management for over 50,000 data points daily .

Conclusion

The three-tier architecture of the Energy Internet integrates edge intelligence, centralized analytics, and enterprise-level management to create a resilient, efficient, and flexible energy ecosystem. It supports the transition from traditional centralized grids to distributed, renewable-focused energy networks, forming the backbone of smart cities and sustainable energy systems .

This chapter presents the development of the Energy Internet throughout the history as an evolutionary solution based on modern

The benefits of the energy Internet, along with the challenges of its implementation on a large-scale distributed architecture with the

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

The two-tier (collapsed core) architecture simplifies the design for smaller networks by combining distribution and core into one layer.

Abstract The Internet of Energy (IoE) transforms energy production, supply, and consumption to fulfill high energy

The three-tier hierarchical model (see Figure 1) is the approach typically employed to achieve a high performance, highly available,

To realize renewable-energy-based electri cation goals, a new concept the Energy Internet (EI) has been proposed, inspired by the

Thanks to digitalization, it is possible to reduce costs during the operation of the energy system and achieve its

In this chapter, we will discuss an overview of the Energy Internet and its major characteristics, the key technologies,

The article provides an analysis of the concept of the Internet of Energy: the structural elements of the Internet of

Three-Tier Architecture of the Energy Internet

In this paper, the power grid architecture of Beijing is evolved in the direction of the Energy Internet by constructing a

Internet of Energy (IoE) is a subset of the Internet of Things which covers all aspects of electrical energy systems and

Subsequently, an exploration of energy-routing devices and algorithms employed in prior studies is undertaken. Finally,

Mainstream research only divides the complex system of energy internet into three systems: energy grid system, value

Abstract With the intensifying energy crisis and envi-ronmental pollution, the Energy Internet and corresponding patterns of energy

Firstly, the essential concept and main features of the energy Internet are expounded. Secondly, according to the

Web: https://www.kremgroup.co.za