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An Analytical Study on Application of Artificial Intelligence in Electricity Market: A Platform Approach

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Abstract:

Renewable energy research is increasingly using artificial intelligence (AI) techniques and methodologies.However, much energy AI research has been focused on overcoming specific technological difficulties. AI's potential to enhance the energy industry, and in particular the electricity market, is widely accepted. For a future power market with huge and distributed renewables, this study aims to provide the platform architectural justification for AI-enabled energy systems. AI platform idea proposal leverages data from an EU Horizon 2020 project and a Finnish government innovation effort to build the theory.Our findings are given in a systematic framework and high-level representation of the AI-enabled energy platform architecture with four layers as fresh information and an addition to previous research.They are: Finally, the paper analyses the AI-powered energy platform's application cases.

Keywords: electricity market; energy market; artificial intelligence; digital platform; peer-to-peer

1. Introduction

An increase in renewable energy sources, aided by intelligent networks, is required to realise the global energy transition. Decentralised and open energy systems will be promoted by smart-grid technologies. But power system researchers recognise the challenges of complex energy networks. A huge infrastructure, the electric grid has physical constraints.

The European Commission sees future power grids with linked and diversified systems generating vast amounts of data. Using only smart metres, and assuming 200 million smart metres installed by 2020, the total memory in Europe is 5.606 TB.If you use every second for network measurement, you'll get roughly 5 exabytes of data each year from smart metres alone. For more complicated and dispersed networks, the electrical business needs big data skills and creative structures. Researchers and academics have been working for decades to better forecast and optimise energy usage.

Artificial intelligence (AI) is a rapidly evolving discipline that is reshaping businesses and economies worldwide. On the innovation front, AI is considered an enabler. The algorithms themselves create "small data" that may be used to enhance decision-making and provide actionable information. This multidimensional technology has far-reaching societal, economic and political repercussions. Some compare AI to steam engines or electricity, which both changed many aspects of human life.

In simple words, AI refers to systems or technologies that resemble human intellect and may develop itself depending on collected data. AI comes in many forms. Some examples:

1. Chatbots employ AI to quickly grasp client issues and deliver solutions.

2. Intelligent assistants employ AI to scan massive free-text datasets for better scheduling.

3. Automatic TV show suggestions may be generated using recommendation engines.

2. LiteratureReviewandMethods

Perception, thinking, learning, communicating, and acting in complicated contexts are all part of Nilsson's definition of AI. The major goal of AI is to create intelligent computers that can perform human-like functions and beyond. Academics classify AI skills into subgroups or categories like as reasoning, problem-solving, natural language processing, perception, and general intelligence.

By analysing issues and devising solutions, AI helps software systems in computer science. Basic AI technologies include machine learning, neural networks, and heuristic search. AI has been extensively studied in big data analytics, information systems, production engineering, and medicine.

2.1The use of AI in Smart Grids and Renewable Energy

According to Quan and Sanderson's paradigm, AI in energy research focuses on numerous techniques and solutions for planning, optimising, and managing many domains. According to the literature study, AI has been researched in solar, wind, geothermal, and hydro.

The use of AI in solar energy: The literature survey on AI applications in solar energy. Artificial neural network techniques for solar simulations are frequently used in single and hybrid approaches.Experts in solar energy are collaborating to improve solar power systems' performance using AI diagnostics. For example, machine learning may enhance solar forecasting accuracy by 30% to 50% compared to traditional forecasting methods.

Wind energy could benefit from AI: -According to industry experts like GE, wind turbines can be optimised to produce electricity at up to 20% peak efficiency using IoT sensors, data networks, and advanced analytics. Jha et al. identify studies relating to physical models, statistical models, and artificial neural network approaches for wind simulation. In general, AI applications in wind energy fall into three categories: neural, statistical, and evolutionary learning.A wind energy field has a complicated control system. Its transfer function is difficult to model mathematically. In nature, wind speed varies erratically. ANN algorithms can extract nonlinear wind speed data characteristics to properly anticipate wind energy production.

2.2PlatformThinkingandApproach

Various platform types with varying definitions and attributes are described. Literature on economics and technology/engineering use platform thinking.Gawer's work integrates technical systems.

The two basic categories of digital platform designs are economic transactional platforms and technology platforms.It enables transactions between disparate groups of customers and/or providers. The platform connects supply and demand that are traditionally dispersed. In economic terms, digital platforms operate as intermediaries between parties who otherwise would not be able to deal. Uber is a two-sided market. Economists think this is true.

The engineering/technical platform is digital with cutting-edge technologies. Also, the platform may be enhanced with other technologies. One well-known digital platform is Apple's mobile app ecosystem (App Store). Simple systems are broken down into manageable components connected through interfaces.

2.3. Research Method

A system architecture is a conceptual model that specifies the structure, behaviour, and additional viewpoints of a system (ADR). We apply the 4C systemic paradigm to current energy research by providing value and utilising a digital system. The EU's smart grid market layer (SGAM).A system's structure, behaviour (and component) behaviour, and view (of a system) are all discussed in the article.

Energy system and market design studies benefit from the AI energy platform architecture.There is a lot written about information systems.For example, action research connects theory to practise by combining theory formulation with researcher intervention.Design science is employed in another area of information systems study to generate constructive IT creations. IT artefacts are "formed by diverse groups of creators, investors, and users."

3. Results

The AI energy platform is created utilising ADR and system architecture concepts.The findings are presented and explored in terms of structure, behaviour and components, and system view.

3.1 System Architecture: The AI Energy Platform's Architectural Framework

The business/market layer can be specified by the platform architecture (SGAM). (Process, Field, Station, Operations, Business, and Market) (Components, Communication Information, Function, and Business).As a result, the AI platform design contributes to the enhancement of the current smart grid platform to support growing penetration of renewable energy sources.As a result, the business layer is split into four levels, as shown in Table 1 below, based on the 4C architecture.

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Table 1. The 4C framework for artificial intelligence (AI) energy platform.

Layer	Description
Commerce	The information and communication technology (ICT) solutions that provide all stakeholders with an application or marketplace for trading alternative connectivity solutions, content or context data.
Context	The ICT solutions that provide data and information-related contextual-based services.
Content	The ICT solutions that provide any data, information, and content that the users would want or need.
Connection	The connectivity-related solutions to connect one or several networks.

Various empirically-inspired digitalization research employ the 4C systemic framework to construct theories and frameworks. Energy and smart grid research in a digital system, there are four value types (as shown in Table 1). SGAM is a formal system model. Logic, provisioning and consumption.In the smart grid value chain, each 4C layer derives from smart grid design. So the AI platform encompasses energy actors, domains, and smart grid hierarchies. The content and context layers enable data- and context-aware services.For example, Nordpool (the Nordic regional energy trading platform) uses AI and deep-learning technology to estimate intra-day trade prices. Figure 1 depicts the study's simplified conceptual framework, whereas Figure 2 shows the SGAM's business/market layer's strong interaction and integration with 4C frameworks.

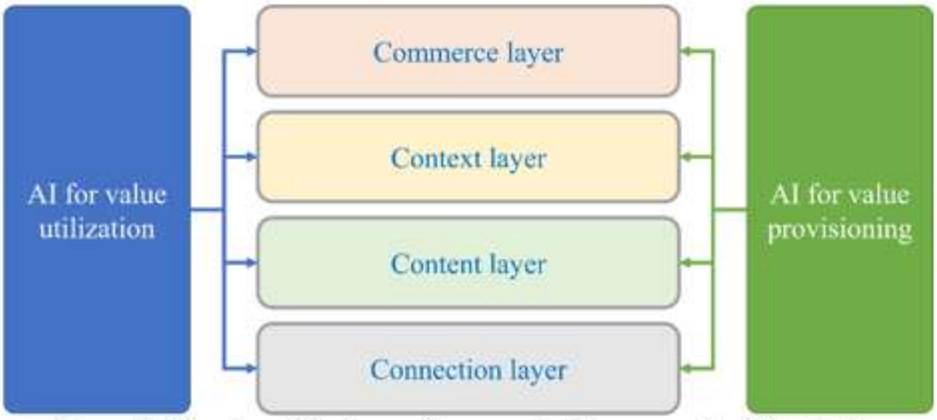

Figure 1. The simplified overall conceptual framework of the study.

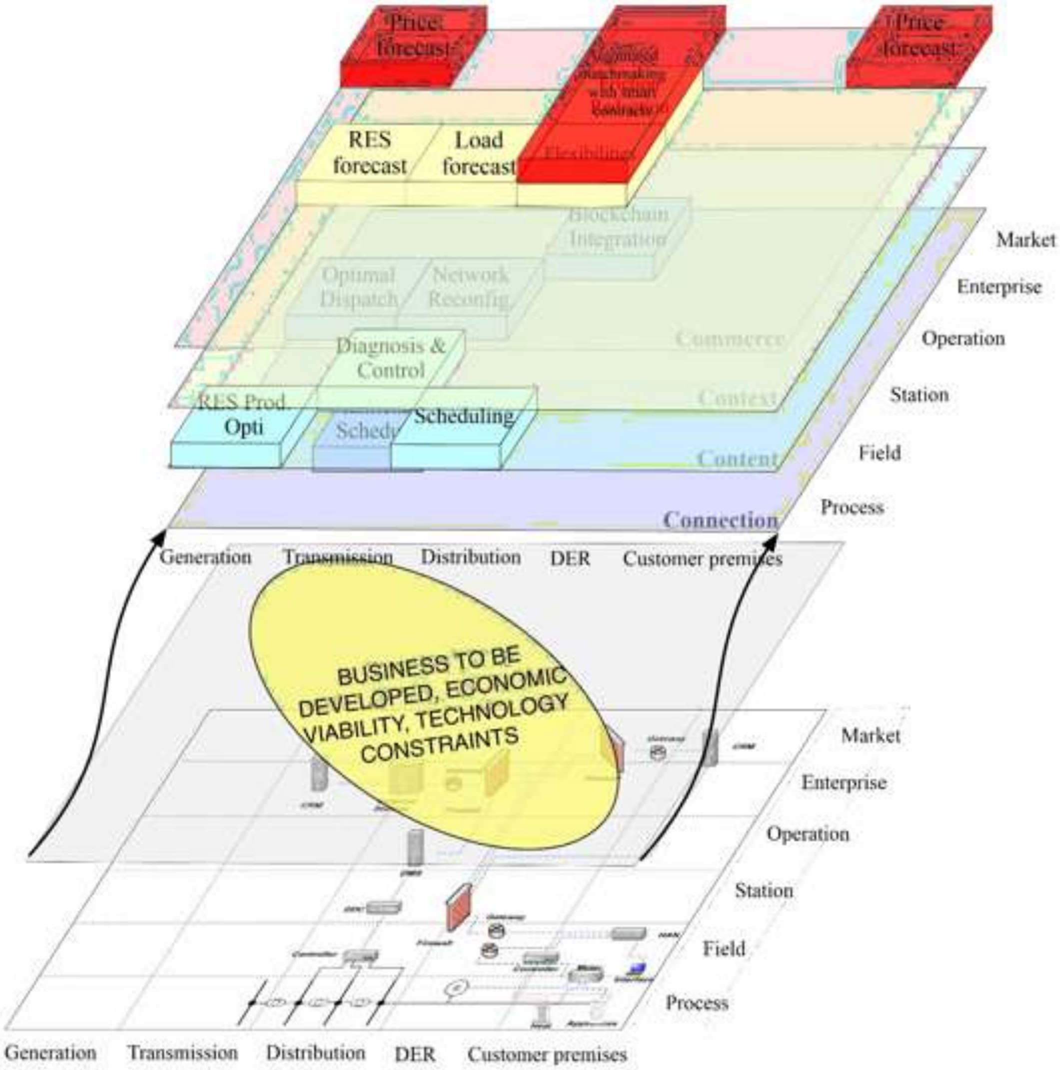

Figure 2. Integrating the 4C framework within the smart grid architecture model (SGAM).

With AI technologies and algorithms, contemporary ICT systems can compute the worth of a digital environment.They are produced and trained utilising a variety of tools and resources, including hardware and software. It is then taught to generate models that may be used to automate processes on a big scale.

3.2 System Behavior: AI Energy Platform from the Perspectives of Market Design and Value Utilization

A "simple" market model promotes value transfer from providers to customers via a central aggregator.Platform models integrate varied groups of value producers and users via market processes like matching and bridging.

These authors discuss the value utilisation of a digital platform designed by Gandia and Parmentier. Platform owners usually subsidise one side of the platform, users. One actor can consume and generate value on a multi-sided platform.A multi-sided platform also allows different user groups to communicate and produce good network effects. This market's design may be affected in two ways by Milgrom and Tadelis' work.

First, AI has the potential to increase trust in digital markets (hereafter, digital platforms). Trust, according to Milgrom and Tadelis, is a major difficulty in digital information sharing. Platform actors must have confidence and trust in one another in order to transact and establish a market.Platform actors can build

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trust by reviewing and rating each other online. Milgrom and Tadelis contend that present internet reputation systems exaggerate seller ratings and mislead purchasers. For example, eBay merchants receive an average of 99.4% favourable feedback. This might lead purchasers astray while picking today's finest decision. Natural language processing (NLP) can access online conversations and assess consumer and vendor quality.

Second AI can help match. One of the most essential uses of AI, particularly machine learning, for digital platforms is to improve and optimise search. Google and Bing utilise AI algorithms to enhance search results, matching, and user experience.Airbnb, for example, uses AI to improve search results for its consumers. This pleases customers. As a result, AI may improve user experience by strengthening trust mechanisms and lowering matching friction.

3.3System Behavior: AI Energy Platform from a Value-Provisioning and Technology Innovation Perspective

One of its functions is to provide value to platform users. To foster system-wide innovation and value generation with other ecosystem players, the AI platform's 4C design was adopted.

For example, the lower layers serve as foundations for the upper levels to facilitate commerce or power market trading.

The tiers are similar to the EU's SGAM model for smart grids, which comprises five levels: physical, data, functional, and commercial. Unlike SGAM, the 4C framework's layers may be blended and stacked to increase system value.

Environment, energy supply, load balancing, and market pricing are all areas where the AI platform may create value (commerce).

3.4 System Behavior: AI Energy Platform from a Value-Provisioning and Technology Innovation Perspective

The value-provisioning side of an AI platform produces AI features and capabilities for platform users.The 4C framework is utilised when an AI platform crosses business borders. It enables co-creation of value with other ecosystem actors and system-wide innovation.
These layers support the higher levels and facilitate trading. The EU's SGAM model has five levels: physical, component, data, functional, and business.Because the 4C framework's layers may be mixed and layered dynamically, the energy system can benefit more from them than SGAM.

3.5 SystemView:thePropositionofanAI-EmpoweredEnergyPlatform

An AI platform model or framework can be used to build an energy market model. Customers and prosumers may therefore help the electrical market by delivering distributed renewable energy and helping to balance the network in exchange for monetary or non-financial rewards, such as environmental and social benefits. In this case, a multi-sided platform might be constructed to collect non-monetary value as well. AI can oversee and automate market transactions. Inputs from increasing market activity might help AI and algorithms (e.g., how Google employs neural networks to improve data centre energy efficiency). This type of AI platform uses human-controlled power market transactions.

4. Discussion

This section describes the mapping and validation of an AI platform architecture model.Figure 3 depicts the early AI platform architectural mapping.

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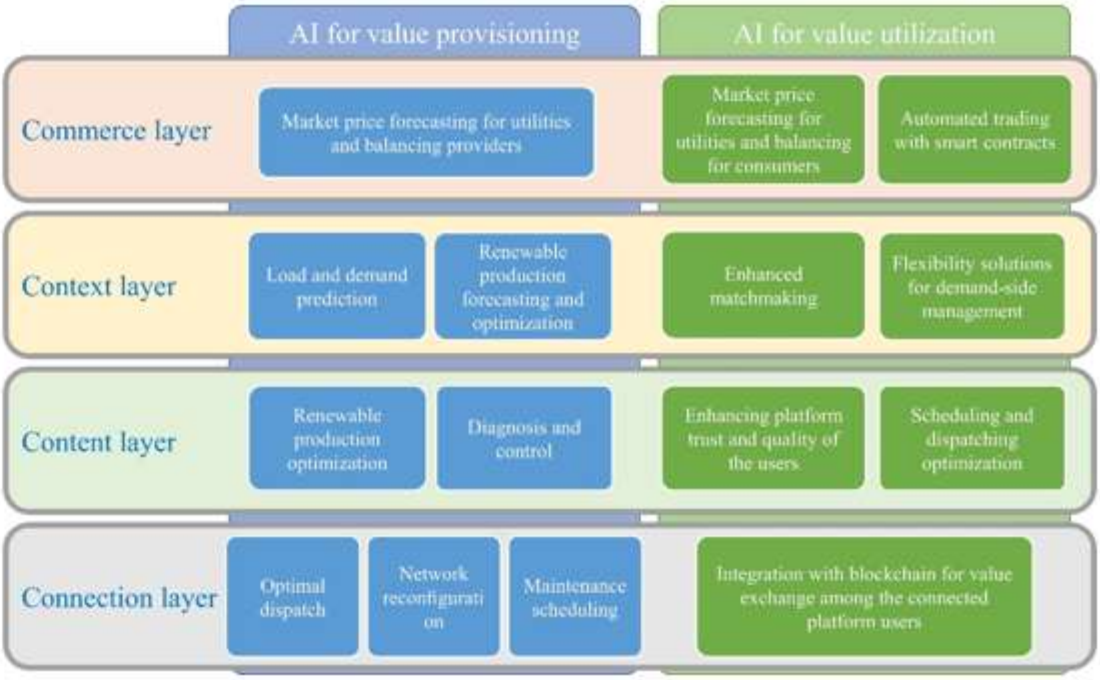

Figure 3. How AI can impact the value provisioning and utilization on the energy platform.

4.1 Enhancing Value Provisioning on the Energy Platform through the use of AI

Also, AI can help integrate renewable energy into the smart grid. In dispatch, reconfiguration of networks, and maintenance planning.Ramos and Porto assert that operational difficulties typically use AI technologies like artificial neural networks and fuzzy systems.

AI can improve energy supply and production at the content layer. For example, GE uses clever algorithms to increase wind turbine performance. When enormous renewable energy nodes are connected to grids, AI can also help diagnose and regulate issues. Utilities utilise intelligent tutoring systems to enhance network control. They're tried and tested.

Contextual data and information may be utilised to train AI models for load and demand prediction, which is not limited to traditional energy utilities.

Price forecasting for power markets has been accomplished using fuzzy logic at the commerce layer. Global power trading and price prediction also employ deep learning. To handle growing renewables in a local flexibility trading market, the article uses AI algorithms.

4.2Using Artificial Intelligence to Improve Value Utilization on the Energy Platform

Many areas of smart grids and renewable energy utilisation might be affected by AI.

First, just as energy utilities, aggregators, and balancing service providers estimate market prices today, AI can predict platform utilisation statistics for clients.AI might also help energy-intensive enterprises generate more money and save money by scheduling jobs depending on energy usage.

Second, According to Milgrom and Tadelis, adding AI to the context layer can improve how users search for products and services.On a digital energy platform, it might be renewable trade items and other energy services. Also, storage capacity has a market. Aside from emergency reserves, there is a concept that energy customers might sell and purchase battery power from public facilities.

Third, AI can transform today's digital platforms' content layer trust procedures (e.g., at the content layer). This improves the commerce layer's utilisation of the energy platform. Chui et al. employed genetic algorithm support vector machine multiple kernel learning (GA-SVM-MKL) to accurately identify 20 home appliances.An app like this might help consumers better manage their energy usage at home.

For enhanced market matching and transactions on additional tiers, AI may be coupled with other technologies like blockchain at the connection layer. It is feasible to automate the matching of excess renewable energy, storage, and electric vehicles (EVs) using AI, smart contracts, and distributed ledger technology.

4.3Empirical Cases for Validating the Platform Model

This study uses action design to validate the suggested system architecture using empirical data from desk research. The empirical cases revealed two things (Figure 4):

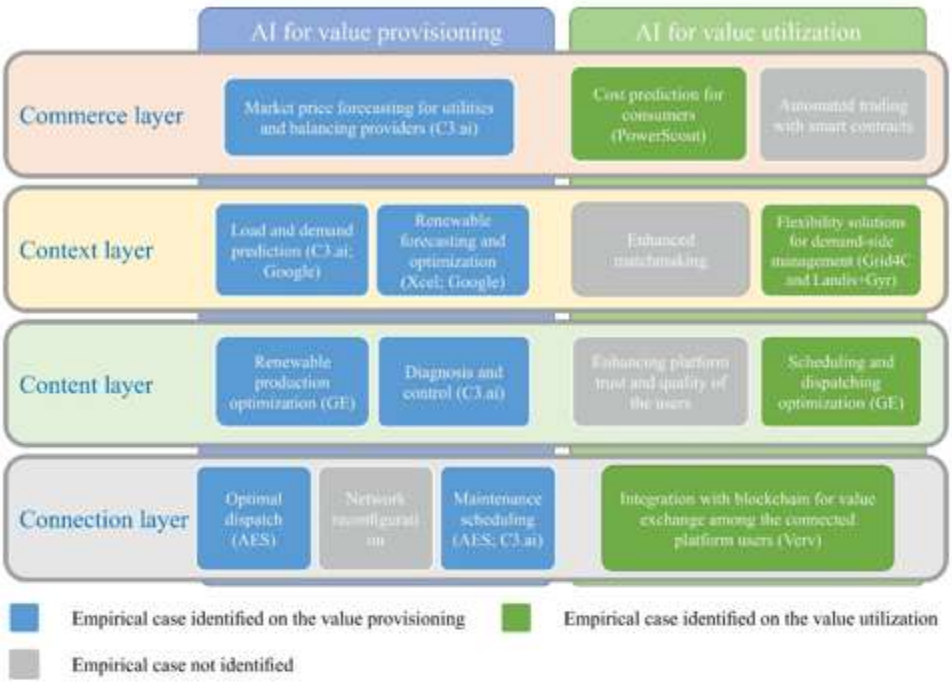

Figure 4. Validation results of the proposed platform architectural model

First, the present empirical evidence backs up the paper's initial thesis that AI applications in energy are quite specific.However, the 4C framework can map both value providing and usage in these circumstances. Second, new firms are using the platform concept to build an AI-enabled energy platform, spanning two or three tiers inside the 4C model. These examples don't cover the entire 4C framework, but they demonstrate how the framework may be used to analyse and explain an AI-powered energy platform's architecture.

Phased implementation of AI for value providing. Forecasting supply is contextualised.In Colorado, Xcel, a major energy provider, is employing AI to enhance weather forecasts. Accurate weather forecasts using AI-based data mining Patterns are found in data from local satellites and wind farms to anticipate future energy supply. Google's ICT and AI forecasts of wind farms.For example, Google's London-based DeepMind subsidiary used AI to anticipate wind farm output. DeepMind's neural networks can forecast wind power output 36 hours in advance.

GE's Predix platform optimised wind farm productivity at the content layer. The platform can analyse data from sensors on the wind turbine and forecast production and operational failures. The Predix platform can assist maximise a wind farm's assets. AES developed complex neural networks, natural language processing, and machine intelligence.AES's AI is primarily used to increase grid awareness, efficiency, and maintenance, as well as "preventative maintenance" for grid operations.

Several new AI enterprises have emerged in the energy sector. This California–based company specialises on the 4C framework's commerce layer. The firm uses AI to educate and engage customers in the energy industry. Ai-powered PowerScout shows users where to save money on power. So PowerScout's AI gathers data from over 45 million households.The data helps solar providers meet up with potential buyers and forecasts if a certain family should invest in solar energy.
GE employs AI to optimise battery-to-content and context power transfer. To support operations and customer-facing apps, Grid4C will give precise real-time forecasts and data. Apps can employ "AI grid edge" to analyse granular demand and optimise distributed energy supplies. Now it can identify grid and appliance issues.Home demand can be reduced.

5. Conclusions

Renewable energy and smart networks demand enormous distributed energy supplies and resources.Clearly, AI can help solve many of today's non-linear and unpredictable energy system issues.

These include energy market design and information systems. Platform thinking is our key contribution to the AI-enabled energy business. An established energy economics idea. The business model method may be applied to both operational and business operations. Not yet explored as a general-purpose technology that may affect energy platform technological and market architecture.In this work, we are simply concerned in the market's overall architecture, not how to describe it mathematically.

A consumer- and prosumer-friendly power system design aided by AI is essential.The improvements in big data, IoT, and computer technologies can enable a more autonomous, optimal, and adaptable energy system design. Numerous research suggest that AI can increase energy system efficiency, dependability, and intelligence. Overall, AI is anticipated to improve the power industry's security, economics, and dependability.

The study's main contributions are: First, an AI-enabled energy system/market design architecture is provided. Smart energy systems and renewable energy have been proven beneficial in several technical sectors. A comprehensive view of how AI may be used in the energy sector has been lacking. The 4C paradigm is utilised in ICT and energy ecosystem research. They also highlight how AI may be applied in energy-related industries.

Second, present AI and energy research has focused on narrow AI applications. An AI platform that can integrate, coordinate, and administrate AI applications may be useful. The study suggests an AI-powered energy platform or marketplace may benefit future distributed renewable energy systems. In order to manage tens of thousands of research requests per second, Google, Amazon, and Airbnb have developed a system and platform.

Third, this technique exemplifies current energy research's focus on value providing for Due to centralization and supply chain thinking. Value generation and utilisation in the electricity sector. So the market's provisioning and utilisation sides may and should collaborate and optimise. With AI, players may benefit from enhanced market trust, reduced research and matching friction, and decreased costs. It's worth noting that AI's value utilisation talents extend beyond these domains. This study inspires more energy research. More energy research.

The study's flaw is that it is inductive and uses secondary data. In future energy and AI, platform thinking is a revolutionary notion. The study proposes ideas rather than confirms. More empirical case studies are needed to evaluate and enhance the methodology proposed here. This report presents a complete picture of the AI energy platform. More dispersed energy and power marketplaces are coming.Research on AI in energy markets is also invited. One such service is smart city transportation. Renewables will put pressure on current power plants and utilities to stay viable. But we need base load electricity. AI technology may be used in the future in the pan-European energy and transportation industries.

So, for example, the pan-European energy and power market has enormous potential for using AI technology today and in the future.

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