Exploration of the construction path of an energy ecosystem adapted to the power Internet of things

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Abstract. Building an energy Internet ecosystem is an effective mode to expand new energy businesses, give digital energy to traditional energy enterprises and promote energy transformation and development. In this paper, by analyzing and expounding the concept, development situation, construction theory, practice summary, exploration path and other dimensions of the energy Internet ecosystem, putting forward countermeasures and suggestions on the construction path and other aspects. Energy Internet ecological construction should take electric energy as the core, and establish the development factors of commercial ecology, so as to achieve "drainage + empowerment" of the energy Internet ecological system and support energy transformation and high-quality economic development in Henan province.

Keywords: Energy Internet; Ecosystem; Construction path.
2. The development situation and evolution path of the energy internet ecosystem

2.1. Development situation of the energy Internet ecosystem
Judging from the development experience of domestic and foreign enterprises, digital development has gone through three stages: informatization, networking and intelligence. Informatization is the only way for digital development. It mainly realizes the process of business from offline to online, and promotes the generation, exchange and application of data. Networking is a product of the integration and development of informatization and industrialization. It mainly realizes the empowerment of the real industry by platform technologies such as the Internet of Things and mobile Internet. Intelligence represents the new trend of digital development. The more in-depth application of new digital technologies such as the Big Cloud Mobile Smart Chain has mainly realized the evolution of the control of the physical world from manual and automatic to autonomous. The characteristics of digital development at this stage mainly refer to the transformation process from informatization to networking and intelligence. For enterprises, this means not only the innovative application of a series of new technologies, but also profound changes in cultural concepts, economic models, and governance. In summary, digital transformation refers to the application of a new generation of information technology, fully integrating data production elements, breaking the limitations of traditional development methods, building a lean, efficient, flexible and intelligent operation and management model, and creating an ecological development pattern of cross-border integration and organic coordination, so as to realize new value creation.

2.2. Evolution mechanism of energy Internet ecosystem
The ecosystem usually consists of an industry ecosystem and an enterprise ecosystem. The industry ecosystem is a core enterprise with a clear value goal that uses a variety of means to integrate resources and build a network of dynamic value relationships. The enterprise ecosystem is based on the continuous integration and evolution of the industry ecosystem, which expands new businesses, new skills and products through the means of resource information circulation and sharing, and then gains a broader ecosystem.

Relying on the theory of industry ecological evolution, the construction and evolution of the energy Internet ecosystem includes three stages: construction, application and management. In the process of ecosystem construction, it focuses on building a business model based on core business, through breaking down barriers of relationships with external partners, achieving business synergy and industrial development, and then expanding the extension of the ecosystem with the help of the core business upstream and downstream sub-ecosystem construction. In the application stage, it is necessary to open
up barriers and merge boundaries between the sub-ecological businesses that the enterprise has formed, coordinate and co-govern the platforms, and obtain new model changes; At the same time, from the perspective of energy enterprise development, it is also necessary to evaluate the usefulness of different ecological businesses, so as to judge the overall energy industry’s commercial value orientation and innovation success rate. In the management stage, it is a more objective way to evaluate the availability and cohesion of the ecology, and to achieve lean adjustments between different business ecology within the energy industry through the collaborative construction of government and enterprises. In this process, the government must fully play the role of "promising government", optimize the top-level design, and break down the barriers and connect with the energy industry-related ecological groups based on the effective integration of different internal ecological businesses.

3. Design of Typical Ecological Model of Energy Internet

3.1. The foundation and evolution of ecological elements
The construction of the Energy Internet Ecosystem is a business model for the coordinated development of multiple energy industry chains and diverse individuals under a common strategic vision. It is a process of the continuous development and improvement of clean energy concepts and the self-evolution of the function and structure of the ecosystem. This paper divides the basic elements of ecosystem construction into five aspects: common vision, interconnection model, empowerment mechanism, governance system, and expansion path, so as to achieve the co-evolution and update iteration of the company's business ecosystem construction and business development.

The construction of ecosystem is a dynamic process. The construction of an industry ecosystem generally requires three core steps: clear ecological positioning, establishment of ecosystem connections, and expansion of value connection points. Determine the ecological status, functions and business boundaries of the enterprise, establish close connections with potential partners in the ecosystem, and ultimately expand the value connection points of the ecosystem and develop derivative businesses.

| Three steps                | Core issue                                                                 | Construction method                                                                 | Core tasks                                                                 |
|---------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| clear ecological positioning | Determine the ecological status, functions and business boundaries of the enterprise | Determine the infrastructure and operation mechanism of the ecosystem based on the business strategy and business model of the enterprise | Analyze and occupy multiple common links in the value chain, empower major ecological partners, and jointly create higher value |
| establishment of ecosystem connections | establish close connections with potential partners in the ecosystem | Expand the scope and strength of connections through free services, transactions, alliances, investment and mergers and acquisitions | Connect closely related upstream and downstream partners and potential customers, expand value connection points, and form a value chain |
| expansion of value connection points | expand the value connection points of the ecosystem and develop derivative businesses | Identify the changing trends of industry development and customer demand, and open up potential value connections with partners | Organize ecosystem partners to lean towards more valuable value chain links and develop derivative products and services with high growth potential |

3.2. Exploration of typical models of regional energy Internet ecology
According to the idea of "platform + ecology", achieve the "drainage + empowerment" of the energy Internet ecosystem. To achieve the balance of total factor supply and demand, optimize the allocation of resources, stimulate the industrial growth, drive the development of upstream and downstream of the
industry chain and build a mutually beneficial and win-win Energy Internet in Henan province, we should take distributed photovoltaic, comprehensive efficiency, electric vehicles, energy e-commerce, data commercialization, online industry finance services and other ecological construction as a breakthrough point while integrating upstream and downstream energy enterprise resources and serving the government departments, energy suppliers and end-users.

3.2.1. Typical mode 1: Distributed photovoltaic service ecology. To achieve “full data access, status holographic perception, and brand new and thoughtful services, open cooperation and sharing” by collecting data on equipment operation, climate and weather, load energy consumption and other related equipment on the power station side and the grid side, sharing distributed photovoltaic industry, full service, and full value chain resources. Objects of distributed photovoltaic service ecology:

1) For equipment manufacturers: based on the comprehensive equipment evaluation system, provide the kind of customization, equipment verification and certification services that combine the needs of users’ customized services;
2) For the users of distributed photovoltaic: create a photovoltaic product package that covering a full set of solutions, optional product portfolios, and featured application products;
3) For the users of photovoltaic poverty alleviation: help "blood-forming" targeted poverty alleviation through targeted access to photovoltaic poverty alleviation power stations.

3.2.2. Typical mode 2: Comprehensive efficiency service ecology. In order to form a business community that co-built and win-win, open sharing, orderly competition, and co-evolution, we must gather integrated energy service providers, upstream and downstream suppliers in the industry chain, end-users, government and industry institutions, financial and investment institutions, and scientific research institutions and universities, micro enterprises, and makers and other industry stakeholders while integrating comprehensive energy and serving the entire industry, full service, and full value chain resources. Objects of comprehensive efficiency service ecology:

1) For end-users: It will provide several services such as collection of data resources, provision of green power usage, energy saving transformation, supply and demand matching, transaction matching and so on;
2) For other energy service entities: In order to build a good development atmosphere for product, technology, and project expansion, orderly competition, industry-finance collaboration, and co-promoting development, we should aggregate front-end traffic and back-end service/product supply chain partners, while promoting efficient supply-demand connection and resource optimization;
3) For upstream and downstream suppliers in the industry chain: In order to promote the common development of the upstream and downstream of the industrial chain, it is necessary to establish a strong network connection capability and service industry transformation and upgrading.

3.2.3. Typical mode 3: Electric vehicles service ecology. In order to promote cross-industry information integration and business integration, and serve the healthy development of the electric vehicle industry, we must use high-quality charging services as the cornerstone and entrance to promote the extensive interconnection of resources such as people, vehicles, ships, piles, networks, electricity, and storage, while aggregating the resources from all parties such as government departments, industry associations, electric vehicle companies, battery and other component companies, equipment manufacturers, charging operators, travel operators, parking operators, communication service providers, Internet companies, power companies, financial investment institutions and so on. Objects of electric vehicles service ecology:

1) For government: the project can provide relevant data analysis results of charging facilities, so as to support the government to carry out scientific and efficient industry supervision, and at the same time provide a reference for the planning of the construction of charging facilities;
2) For the users of electric car: we should provide basic services such as finding piles and charging to meet the orderly charging needs of electric vehicles and improve customers experience. At the same
time, we should provide the services of V2V and V2G, as well as green electricity transactions based on the Internet of Vehicles, and continue to improve service functions;

3) For charging implementation operators: strengthening the in-depth interconnection of charging facilities. Strengthening the in-depth interconnection of charging facilities nationwide is based on the operation of charging facilities that is based on the operation of charging facilities;

4) For other stakeholders: they want to be provided with emerging business models such as new retail of electric vehicles, smart mobility of electric vehicles, smart manufacturing of electric vehicles and charging piles, and they need to integrate into the consumer Internet, smart cities and other ecology.

3.2.4. Typical mode 4: Energy e-commerce service ecology. To build a new retail service ecosystem for energy e-commerce, it is co-construction, co-governance, sharing and win-win, we need to gather customers, data, and ecological resources, and then we will build a global IoT hub for energy e-commerce new retail, and build a new retail development path named "five-all" which includes global Internet of things, panoramic services, full chain value-added, comprehensive cost reduction, national electric. Objects of energy e-commerce service ecology:

1) For users: provide online sales and supporting services for electricity fee collection, smart home, electric vehicles and other products;

2) For the users of electrical equipment industry: create a vertical cross-border B2B trade platform for the "Electrical Equipment Industry" to help companies explore overseas markets with low cost and high efficiency;

3) For the main body of internal and external innovation: provide them with high-quality innovative and entrepreneurial resources, and establish a comprehensive service system for innovative and entrepreneurial that integrates demand matching, entrepreneurship cultivation, project incubation, achievement transformation, financial services, etc.

3.2.5. Typical mode 5: Data commercialization service ecology. To fully tap the value of data, develop value-added data products, and explore the business model of data value-added monetization, we mainly adopt two main lines: externally serving the government's scientific decision-making, serving enterprise intelligent operation, serving residents' interesting energy use as the main line; internally serving the company to improve quality and efficiency, lean management, and risk prevention as the main line. Take this approach to build a power data commercialization service ecosystem. Objects of data commercialization service ecology:

1) For government and social institutions: we provide professional energy big data analysis and consulting services;

2) For commercial enterprises and equipment suppliers: assist corporate credit financing, risk prevention and control, operation management, investment decision-making and so on;

3) For society: try to provide personalized and interesting interactive services to enhance power users' satisfaction.

3.2.6. Typical mode 6: Online industry finance service ecology. In order to build an all-round, one-stop online industry chain financial ecology, we need to pool the funds, assets, credit, customers, channels, brands and other resources carried by the power grid, and aggregate various financial products and services such as financing, insurance protection, and asset management, innovate business scenarios, improve transaction efficiency, deepen data use, broaden promotion channels, optimize customer experience, and deeply release the value of various resources. Objects of online industry finance service ecology:

1) For cooperative financial industry stakeholders: Provide information on corporate electricity consumption behavior and financing needs, and serve financial institutions’ credit review, credit issuance and other businesses;
2) For business users: provide the contract performance and the electricity charges payment status of the upstream and downstream partners, so as to promote the win-win cooperation of the upstream and downstream of the industrial chain.

4. Construction Path of Energy Internet Ecosystem in Henan Province

Energy Internet Ecosystem model includes four core modules in Henan province: data collection management, new infrastructure construction, digital platform construction, and digital business model. We need to design the province's energy Internet ecology with a safe, efficient, green and low-carbon energy system as the construction goal, and truly integrate data as a production factor into the construction of the energy ecology. To promote the development of a single business model industry to a diversified business model in the energy, we use data as a platform to connect the entire industry closely, and at the same time break down the information barriers of departments, enterprises, and industries, and truly improve the production efficiency of enterprises and industries, and change the positioning and thinking between companies.

4.1. Data collection and management

4.1.1. Government-enterprise cooperation and data sharing. We aim to promote the unified management and open sharing of data resources, and build a “horizontal collaboration and vertical linkage” government-enterprise collaboration and interaction unified data management organizational structure. In order to achieve this goal, we strengthen government-enterprise cooperation, improve the energy big data resource catalog and data dictionary, and form a batch of standards under the premise of relying on the construction of the province's energy big data center.

4.1.2. Improve the data system of energy companies. Based on the concept of open data sharing, data analysis services are standardized from the standard level. For whole-process management from data access, computing storage, and shared services, we should improve the enterprise-level data center, and promote the aggregation and migration of the province's energy enterprise data center orderly. Optimize the data management process, establish a refined management mechanism for enterprise data, and build a data quality audit and assessment system.

4.1.3. Pilot data capitalization operations. In order to create an integrated data asset operation system for government, enterprise and research, and form an operation model for product development, pricing, trading, and cooperation, we must continue to gather and integrate data resources in the energy industry across the province, strengthen technology research and development, improve the data asset operation system, consolidate the foundation of operations and build a unified data asset operation service platform.

4.2. Construction of new infrastructure

4.2.1. Promote the construction plan of digital basic industry. In order to give full play to the "promising" government attributes and seize the window of policy opportunities brought by new infrastructure, we should plan ahead and make a comprehensive layout plan for the digital industry, and build new digital products and industries including cloud data centers, energy big data centers, 5G, and smart terminals to serve the province's energy Internet ecological construction.

4.2.2. Promote the sharing and co-construction of enterprises across industries. It is necessary to clarify the strategic value of energy Internet ecological construction, break the inherent mode of inertial thinking of traditional enterprises, promote industry associations to play a leading role, and formulate practical, feasible and detailed new infrastructure plans that are in line with themselves, if we want to promote the construction of shared infrastructure between industries.
4.3. Construction of digital platform

4.3.1. Optimize the government-enterprise collaboration platform. The reason why we are exploring the construction of an energy data ecological blockchain alliance chain in Henan Province with “government-led, participation of all parties and mutual benefit” is to build a data sharing model that can be confirmed, traceable, and trustworthy, so that the data of all parties can be perceived and without leakage. Through the deployment of security policies, the edge security defenses of the government and enterprises are considered.

4.3.2. Strengthen the construction of basic platform. For the unified registration, release and management of shared services provided by basic platform functions, as well as access control, we must integrate the data resources of energy companies such as coal, oil, natural gas, and electric power, promote cross-enterprise and cross-professional energy data integration, sharing and reuse, deepen the integration of cloud platform, data center, and Internet of Things management platform, and promote the sharing of terminals and data at the perception layer.

4.3.3. Strengthen the construction of analysis and application capacity. To improve the accuracy of user portraits, status maintenance, and fault diagnosis in large sample data, we should encourage companies to build standard and unified algorithm libraries, tool libraries, and theme libraries. We should encourage companies to build some unified standard about algorithm libraries, tool libraries, and theme libraries. At the same time, it is necessary to accelerate the deployment and application of mature models to achieve flexible online docking with data centers, and realize distributed data processing capabilities through edge computing.

4.4. Design of business model

4.4.1. Carry out research on energy ecological business model with Henan province characteristics. In order to strengthen the design and research on the monetization model, operation model and profit model of data products, we must rely on the construction of the province’s energy big data platform, aggregate the national and provincial think tank resources and the demands of energy companies, and develop perfect product and service positioning for government, enterprises, and the public.

4.4.2. Create a digital platform collaborative operation business model. Explore the energy big data platform, cloud platform, enterprise middle station, and Internet of Things platform government-enterprise linkage data sharing mode, which can break through the platform data barriers. We can use data-driven optimization of platform system management capabilities to innovate collaborative work methods, improve platform intelligence, and enhance the depth and breadth of online application of operating processes.

4.4.3. Promote innovation in energy finance business models. We need to develop comprehensive energy financial services, energy financial markets, and other content construction, and fully aggregate energy companies, industries, and financial data resources; we must learn from the platform ecological strategy of Internet companies "entry + platform + traffic", and build a province-wide energy ecological financial service platform that integrates energy, finance, and data transactions; we must deepen synergy between industry and finance, strengthen synergy between finance and digital technology, and innovate to realize integrated Internet inclusive energy financial services.
5. Suggestions

5.1. Strengthen top-level design and promote shared governance by government and enterprise

The regional energy industry must seize key tasks in combination with its own superior position and adhere to the goal-oriented establishment of an energy ecosystem. To build a policy support system for the ecological construction of the energy Internet, we must do a good job in top-level design and long-term planning that matches the long-term development of the energy ecology in Henan Province. We must strengthen the coordination and interaction with the provincial government and energy companies, fully mobilize the massive data resources of enterprises and users, and provide the government and society with diversified services such as data credit investigation and information consultation. We must take advantage of the infrastructure resources of energy companies to further deepen the commercial utilization of communication resources and interact with the national digital development strategy. We must actively build a framework for government-enterprise collaborative development cooperation, relying on network carriers, to create an industrial digital upgrade program that integrates "online + offline" development, promote the sharing and co-governance of government and enterprise, and serve the province's economic development and social people's livelihood.

5.2. Straighten out the system and mechanism, promote and accelerate digital transformation

In terms of the establishment of institutional mechanisms, if we want to clarify the strategic consensus on digital transformation, we must actively build and establish digital transformation management and control processes, optimize the technological path of digital development, and coordinate the development of digital transformation across the province. Promote energy companies to accelerate the implementation of corresponding management business innovation mechanisms, fully integrate digital concepts into the continuous iterative innovation space, capital guarantee, and supervision and audit process, and further play the role of mechanism innovation in undertaking the digital transformation of enterprises. In terms of personnel training mechanisms, we must strengthen the publicity and implementation of the construction of digital energy ecology, and stimulate the vitality of talents through regular ecological forums, government-enterprise symposiums, active push of results, and special training, and form a digital thinking mode. For digital-related energy scientific research units, we will cultivate and recruit core technical talents through long-term centralized training, flexible market-based recruitment and other methods, tackle key issues of digital transformation, and take multiple measures to promote digital transformation.

5.3. Promote the construction of new infrastructure to achieve network scale effect

The development of the energy industry must be closely integrated with the construction of new infrastructure in seven areas, including 5G networks, UHV, inter-city high-speed railways and inter-city rail transit, new energy vehicle charging piles, big data centers, artificial intelligence, and industrial Internet, and the development of the energy industry must seize the opportunities given by industrial digitization and digital industrialization, and give full play to the spillover effects and scale effects of new infrastructure construction. In the case of the province's energy industry layout and resource endowments, to form a benign construction and operation ecology for new infrastructure construction, we must coordinate information infrastructure, integrated infrastructure, and innovative infrastructure, accelerate the formation of standards for new energy infrastructure, supporting systems to ensure long-term operation mechanisms, build a closed-loop project management mechanism, explore a new operating model of "separation of management and operation" for new infrastructure, improve the government-enterprise cooperation mechanism for new infrastructure construction, and play to the "1+1>2" network scale effect.

5.4. Focus on business model design and optimize the energy ecological chain

We must make full use of the energy Internet thinking to organically integrate the more successful business models implemented in the current energy and power market reform environment with the
integrated energy platform, and expand a variety of new business models. We must actively develop energy industry business models such as energy production models, asset investment models, energy trading models, and value-added service models from the perspective of the integrated energy service industry chain structure. In order to build an entire integrated energy industry chain from production to consumption to value-added services, it is necessary to encourage diversified investment, optimize market access regulations, build an industrial chain, it is necessary to improve the market access standards for power generation companies, grid companies, heating companies, gas companies, energy equipment manufacturers, and specialized energy service companies, and promote the establishment of a business model based on the signing of long-term and unified entrusted operation agreements for energy facilities in each link of "source-network-load-storage".

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