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Research on ROI Model of Empowering Enterprise Digital Transformation with Intelligent Computing Center

——Cost Benefit Analysis of AI Projects throughout Their Lifecycle in the Energy Industry

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Abstract: At present, the energy industry is in a critical stage of transitioning from traditional power generation to new energy generation, and the entire chain of power generation, transmission, and other businesses urgently need to achieve intelligent upgrades through digital technology. Energy companies represented by a power generation central enterprise face practical issues such as construction mode selection and cost-benefit evaluation when exploring the application of intelligent computing centers. Although existing research has explored the digital transformation of intelligent computing centers and enterprises, there is still a gap in systematic research on constructing ROI models based on the full lifecycle perspective of the energy industry characteristics. This article takes AI projects in the energy industry as the research object, analyzes the application scenarios of intelligent computing centers in energy enterprises, and constructs a cost-benefit analysis framework covering the entire process from planning, construction, operation to retirement. The aim is to quantify the value contribution of intelligent computing centers to the digital transformation of enterprises, and provide theoretical basis and practical reference for energy enterprise investment decision-making and industry policy formulation.

1. Introduction

With the acceleration of the global energy structure towards clean and low-carbon transformation, the energy industry, especially in the field of new energy generation, is facing multiple challenges of efficiency improvement, cost control, and technological innovation. [1] At the same time, advanced computing infrastructure represented by intelligent computing centers is becoming the core driving force for enterprise digital transformation. In this context, in-depth research on the return on investment (ROI) of intelligent computing centers empowering digital transformation of energy enterprises, constructing a scientific full lifecycle cost-benefit analysis model, is of great practical significance for energy enterprises to optimize resource allocation and enhance core competitiveness.

2. Mechanisms and models for empowering digital transformation of energy enterprises through intelligent computing centers

2.1 Application scenarios of intelligent computing centers in the energy industry

The intelligent computing center, with its powerful computing power and intelligent algorithms, has demonstrated extensive and in-depth application potential in the entire industry chain of the energy industry. In the power generation process, for traditional thermal power, the intelligent computing center can optimize combustion efficiency and reduce coal consumption and pollutant emissions through real-time monitoring and analysis of key parameters such as boiler combustion and turbine operation using AI algorithms; For new energy power generation, such as wind power, the intelligent computing center can predict the change of wind speed and direction, adjust the angle of fan blades in advance, improve power generation efficiency and reduce equipment loss by combining meteorological data and fan operation status data. In photovoltaic power plants, by analyzing factors such as light intensity and temperature, the cleaning and maintenance strategies of photovoltaic panels are optimized to ensure power generation efficiency.

2.2 Empowering the Mechanism of Digital Transformation

The intelligent computing center empowers energy enterprises with digital transformation through three core paths. Firstly, providing strong computing power support, energy enterprises generate massive amounts of data during production and operation, such as equipment operation data, real-time power grid data, etc. The intelligent computing center can quickly process these data and transform them into valuable information.

Secondly, driving the deep application of AI technology, the intelligent computing center provides a running environment for AI algorithms such as machine learning and deep learning, enabling energy companies to develop more intelligent application systems. In power dispatching, intelligent dispatching systems based on AI algorithms can dynamically adjust power generation plans and grid operation modes according to real-time power supply and demand, fluctuations in new energy generation, and other situations, enhancing the flexibility and consumption capacity of the power system.

2.3 Comparative analysis of different intelligent computing power construction models

The three construction modes of intelligent computing power have their own advantages and disadvantages in the application of energy enterprises. Under the autonomous construction mode, enterprises have complete control and can customize computing infrastructure according to their own business needs, ensuring data security and privacy, and achieving deep integration with existing systems of the enterprise. For example, large energy groups can seamlessly integrate their intelligent computing centers with their own power production monitoring systems and management information systems to meet the computing power needs of complex business scenarios. However, this model requires a huge initial investment, involving hardware procurement, data center construction, and the formation of operation and maintenance teams, with a long construction period and high requirements for enterprise funds and technical strength.

The rental sales model is between self construction and renting public clouds. Enterprises rent external computing equipment and place it locally, which can ensure data security to a certain extent without the need for a large one-time investment. This mode is suitable for enterprises with phased demand for computing power and high requirements for data security. However, the subsequent maintenance and upgrade of the equipment depend on the supplier, which poses certain cooperation risks.

The rental model of public cloud resources has high flexibility and convenience. Enterprises pay as needed, without having to bear hardware construction and operation costs, and can quickly obtain the required computing power resources. For small and medium-sized energy enterprises or those conducting short-term AI projects, this model reduces the threshold for computing power usage. However, there are certain risks in terms of data security and compliance, and the long-term usage cost may be high. At the same time, there may be issues such as network latency, which may affect some business applications that require high real-time performance.

3. Cost benefit analysis framework for the entire lifecycle of AI projects in the energy industry

3.1 Division of project lifecycle stages

The entire lifecycle of AI projects in the energy industry can be clearly divided into four closely interconnected stages: planning, construction, operation, and retirement. In the planning stage, enterprises need to comprehensively investigate their own business pain points and needs, combine industry development trends, and clarify AI project goals, such as improving power generation efficiency and optimizing power grid scheduling. [2]

The construction phase involves a significant investment of resources, including the procurement of intelligent computing hardware such as high-performance servers and GPU clusters, whose specifications and quantities need to be accurately configured according to project requirements; The development or procurement of computing power scheduling software and AI platforms requires human and material resources for code writing and testing if developed independently, while software compatibility and licensing fees need to be considered for procurement.

The operation phase is the period when the project continues to generate benefits, covering daily operation and maintenance of equipment and software, data management and updates, personnel training and technical support, and other related work. Over time, the performance of hardware devices may decline and require regular maintenance and upgrades. Software also needs to be optimized for functionality based on business changes and technological developments. At this stage, operating costs exhibit a continuous expenditure pattern, and as business expands and data volume increases, the demand for operational capabilities continues to rise, resulting in corresponding cost increases.

3.2 Cost composition analysis

The cost composition of AI projects in the energy industry is complex and diverse. In the planning phase, the main costs are market research, feasibility studies, and expert consulting fees. According to relevant data statistics, for AI projects of medium-sized energy enterprises, the cost of this stage accounts for about 3% -5% of the total project cost. For example, a certain enterprise invests 500000 yuan in market research and consulting fees to plan an AI assisted power generation optimization project, in order to understand the current status and technological development trends of AI applications in the industry and provide a basis for project decision-making.

The construction phase has the largest proportion of costs, with hardware procurement costs accounting for about 40% -60%. Taking an energy AI project with an investment of 50 million yuan as an example, the procurement of intelligent computing hardware may reach 20-30 million yuan. The software cost accounts for about 20% -30%, including the authorization of computing power scheduling software and the development cost of AI platforms. If an open-source platform is used for secondary development, the cost will be relatively reduced, but a large amount of manpower costs still need to be invested in customized development. The cost of infrastructure construction accounts for about 10% -20%, covering aspects such as computer room construction, power supply, and network cabling.

During the operation phase, the cost of operation and maintenance personnel accounts for about 30% -40%. Due to the high technical requirements of AI projects in the energy industry for operation and maintenance personnel, professional hardware maintenance engineers, software engineers, and data analysts need to be equipped, and personnel salary expenses are relatively high. The cost of equipment maintenance and upgrade accounts for about 20% -30%, and hardware equipment needs to be maintained and repaired every year, while software needs to be updated for functionality and vulnerability fixes. The cost of data management accounts for about 10% -20%, involving tasks such as data storage, cleaning, and labeling. As the amount of data increases, the cost of expanding storage devices and processing data continues to rise. The cost during the retirement phase is relatively small, mainly consisting of equipment scrapping and data migration expenses, accounting for about 1% -3% of the total project cost.

3.3 Analysis of Benefit Composition

The benefits of AI projects in the energy industry are significant. In the power generation process, optimizing the operating parameters of power generation equipment through AI algorithms can effectively improve power generation efficiency. After applying AI technology, the power generation efficiency of a certain thermal power plant has increased by 5%. Calculated based on an annual power generation of 10 billion kilowatt hours and a profit of 0.1 yuan per kilowatt hour, the annual profit can be increased by 50 million yuan. In terms of power grid dispatching, AI helps achieve precise load forecasting and intelligent dispatching, reducing power grid losses. Related studies have shown that using AI intelligent scheduling systems can reduce power grid losses by 3% -5%. If the annual transmission loss of a certain region's power grid is 1 billion kilowatt hours, the cost can be saved by 30-50 million yuan per year after the loss is reduced.

4. ROI model construction and empirical research

4.1 Principles and Approach for ROI Model Construction

The construction of ROI (return on investment) models should follow the principles of scientificity, systematicity, and practicality. Scientificity requires the model to be built on a rigorous theoretical foundation to ensure reliable data sources and reasonable calculation methods; systematicity emphasizes the comprehensive consideration of the costs and benefits of the planning, construction, operation and decommissioning phases from the perspective of the full life cycle of AI projects in the energy industry; Practicality requires the model to provide effective references for practical decision-making in enterprises, simplify complex calculation processes, and highlight key influencing factors.[3]

In terms of construction ideas, with full lifecycle cost-benefit analysis as the core, the first step is to clarify the constituent elements of the cost and benefit of AI projects in the energy industry. The cost is subdivided into hardware investment, software procurement, operation and maintenance expenses, and the benefit is divided into power generation efficiency improvement, operation and maintenance cost reduction, management optimization benefits, etc. Secondly, by quantifying the relationships between various elements, a mathematical model is established.

4.2 Selection and Definition of Key Indicators for the Model

The selection of key indicators for ROI models directly affects the accuracy and practicality of the model. [4] Cost indicators include:

(1) Initial investment cost (C_0): This includes one-time investments such as research and consulting fees during the planning phase, hardware equipment procurement during the construction phase, software system development, and infrastructure construction. It is the basic data for model calculations.

(2) Operation and maintenance costs (C_{op}): including ongoing expenses such as equipment maintenance, software upgrades, personnel training, and data management, which need to be calculated annually.

(3) Retirement processing cost (C_{de}): Refers to expenses related to equipment scrapping, data migration, and destruction, usually incurred in a lump sum at the end of the project.

Benefit indicators include:

(1) Benefit from improving power generation efficiency (B_1): By optimizing the operating parameters of power generation equipment through AI, additional income can be generated from increasing power generation. For example, after applying AI technology, the power generation efficiency of a certain thermal power plant has increased by 5%, and the annual power generation has increased by 500 million kilowatt hours. If the electricity price per kilowatt hour is 0.5 yuan, the annual revenue will increase by 250 million yuan.

(2) Benefit of reducing operation and maintenance costs (B_2): The benefits of AI predictive maintenance in reducing equipment downtime and lowering maintenance costs. Assuming a wind power enterprise reduces equipment maintenance costs by 10 million yuan and downtime losses by 20 million yuan annually through AI operation and maintenance, the annual revenue will increase by 30 million yuan.

(3) Management optimization benefits (B_3): The indirect benefits brought by AI assisting enterprises in optimizing resource allocation and improving management efficiency can be quantified through cost savings and improved decision-making accuracy.

The ROI calculation formula is: $ROI = \frac{\sum_{t-1}^{n}(B_t - C_t)}{C_0} \times 100\%$

Among them, $B_t$is the total benefit in year t, C_t is the total cost in year *t*, and *n* is the project lifecycle.

4.3 Data collection and organization based on case studies of power generation enterprises

To verify the effectiveness of the ROI model, a certain offshore wind power AI project of a Chinese central enterprise engaged in new energy power generation was selected as the main research case, and data from other energy companies were collected for comparative analysis. During the data collection phase, cost and benefit data for the entire project lifecycle are obtained through enterprise research, project reports, and publicly available materials. [5]

In terms of cost data, the cost of a feasibility study detailing the planning phase is ¥0.8 million; During the construction phase, the procurement of intelligent computing hardware costs 12 million yuan, software system development costs 5 million yuan, and computer room construction costs 3 million yuan; During the operation phase, the annual equipment maintenance cost is 1.5 million yuan, software upgrade cost is 800000 yuan, and personnel training cost is 500000 yuan; The estimated cost for handling equipment during the retirement phase is 300000 yuan.

In terms of benefit data, after the project is put into operation, by optimizing the operation of wind turbines through AI, the power generation efficiency is improved by 12%, and the annual power generation is increased by 120 million kilowatt hours. Calculated at a local electricity price of 0.45 yuan/kilowatt hour, the annual revenue is increased by 54 million yuan; AI predictive maintenance reduces equipment maintenance costs by 30% and saves 2 million yuan annually; Improving management efficiency reduces labor costs by 1.5 million yuan. At the same time, data from similar projects of enterprises will be collected to organize and analyze the differences in cost input and benefit output among different enterprises, providing rich data support for model validation.

4.4 Model solving and result analysis

Substitute the data of Guodian Investment's offshore wind power AI project into the ROI model for solving. Assuming a project lifecycle of 10 years, the initial investment cost C_0 =80+1200+500+300=20.8 million yuan; The annual operation and maintenance cost, C_{op}=150+80+50=2.8 million yuan. The total operating cost over 10 years is 280x10=28 million yuan. The retirement treatment cost, C_{de} =300000 yuan. The total cost, C=2080+2800+30=49.1 million yuan.

The annual total benefit B=5400+200+150=57.5 million yuan, and the 10-year total benefit B_{total}=5750x10=575 million yuan. Substituting the ROI formula yields: ROI=2568.27%.

The result analysis shows that the investment return rate of the project is extremely high, indicating that the AI project empowered by the intelligent computing center has significant economic benefits in energy enterprises. Meanwhile, by comparing data from other companies, it was found that there are differences in cost control, depth of technology application, and other aspects among different enterprises, resulting in varying ROI.

5. Conclusion

This study constructs an ROI model for empowering digital transformation of energy enterprises through intelligent computing centers, and conducts a cost-benefit analysis of AI projects in the energy industry from a full lifecycle perspective. Research has confirmed that the deep integration of intelligent computing centers and AI technology can significantly improve the economic efficiency of enterprises. Taking the offshore wind power AI project of State Power Investment Corporation as an example, the investment return rate is as high as 2568.27%, effectively optimizing the efficiency of power generation, operation and management. At the same time, different intelligent computing power construction models have a significant impact on project ROI. Enterprises need to choose between independent construction, leasing for sale, or renting public cloud resources based on their own scale, funding, and business needs to achieve maximum benefits. In addition, the full lifecycle cost-benefit analysis framework can provide accurate basis for enterprise investment decisions through scientific quantitative tools. Based on the research findings, three suggestions are proposed: enterprises should optimize their investment and construction models and establish dynamic monitoring mechanisms; The industry needs to improve its standard system and promote ecological co construction and sharing; The government should strengthen policy support, increase research and development investment, and improve regulations to promote the deep application and high-quality development of intelligent computing centers in the energy industry.

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