# Research on the Path of Smart Grid Data Assetization

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**Abstract.** With the advancement of the digital strategic transformation of power enterprise, how to efficiently use massive smart grid data to serve society and benefit enterprises has become a hot spot in industry research. By transforming data resources into effective data assets, more comprehensive analysis, more accurate prediction, and more valuable decision support can be implemented, which would maximize the data value and benefit appreciation. This article reviews the current situation and challenges of smart grid data assetization, and proposes the realizing path of smart grid data assetization based on the nature of smart grid data and its value-added method. The value assessment and transaction of smart grid data assets are the key links in the path. This article also presents the implementation method of the evaluation system and exchange model of smart grid data assets, which helps boost revenue for the power industry.

**Keywords:** Smart Grid; Data Assetization; Data Value-added; Value Assessment; Exchange Model

## 1 Introduction

The development of new technologies such as big data, cloud computing, and the Internet of Things has changed the way people live their daily lives, and at the same time, has brought new opportunities and challenges to the development of traditional industries. The effective assetization of data resources can support more comprehensive analysis, more accurate forecasting, and more valuable decision, promoting the value of grid data and benefits for grid enterprises. Along with the digital transformation of power enterprises, how to efficiently use the massive smart grid data to serve society and benefit enterprises has become a hot research issue in the power industry.

Data assetization means that a common data language is formed within an enterprise, with each department forming its statistical standards for the purpose of unified analysis, and data is collected and analyzed in real-time during operations, so that management can discuss and communicate data more efficiently. The basic process of data assetization includes four stages: data discovery, data standardization and privacy rating, data processing, and data encapsulation. Specifically, data discovery refers to the process of collecting grid data. Data standardization means establishing data dic-


V. Escudero et al. (Eds.): BADS 2022, AHCS 11, pp. 466–480, 2023.
https://doi.org/10.2991/978-94-6463-102-9_50

tionary, entry, and collection standards to ensure consistency at the source end, as well as rating the degree of data confidentiality, value matching, and business openness. Data processing refers to the process of using cleaning, regularisation, and encryption to process raw data to form using data tables, or further mining and analysis to form corresponding report graphics. Finally, encapsulation means completing the assessment of data assets and opening the corresponding use ports.

After data assetization, data assets will gradually become the strategic assets of the enterprise [15], and the enterprise will further own and strengthen the stock and value of data resources, as well as the ability to analyze and mine them, which will greatly enhance the core competitiveness of the enterprise. Additionally, data assets can also be used by subjects outside the enterprise after aggregation, processing, and treatment, bringing benefits to other subjects, which is also a concrete manifestation of the valorization of data assets. In the era of the digital economy, data exchange is an important part of the big data industry. With the gradual growth of the data trading market and the continuous improvement of the corresponding laws, regulations, and standards system, the future business model with data assets as the core will definitely be more and more favored in the capital market [19].

As power companies continue to optimize their data management levels and various business data application platforms emerge, data assetization helps to form an effective means of adding value to data assets. This article focuses on the path of smart grid data assetization, examines the implementation methods of transforming smart grid data into data assets and evaluating them for trading, intending to optimize management model and business model of smart grid data, and laying the foundation for data empowerment and value-added benefits. The contributions of this article are as follows:

- This article summarises the attributes of smart grid data assets and discusses the situation and challenges of data assetization.
- This article presents the framework of the path of smart grid data assetization, and details the path to realizing the asset value of smart grid data.
- This article concludes the evaluation system of smart grid data assetization, and describes the process of value assessment for smart grid data assets.
- This article talks about several business models and exchange models of smart grid data assets.

The rest of the paper describes a comprehensive picture of the path of smart grid data assetization, and is structured as follows. Section 1 introduces some related works. Section 2 expounds on attributes of smart grid data assets and challenges of data assetization. Section 3 presents the path design of smart grid data assetization. Section 4 shows the evaluation system of smart grid data assetization. The value-added path and exchange model are presented in Section 5 while a conclusion is highlighted in Section 6.

## 2 Related work

Research related to data assetization and evaluation of data assets has been carried out earlier, and its research focuses on the definition of the data asset, data asset management, and value assessment methods. [1] proposes the idea of valuing information assets as tangible assets and researches the method of valuing information assets, arguing that the value of information assets is determined by a combination of three components: information collection costs, information management costs, and information quality. [2] considers data to meet the definition of an asset, as something that has commercial value and can be exchanged, and owned by rights holders, and the potential value of data can also be realized through data mining techniques, and therefore identifies data as an asset. Based on the premise that data is a valuable attribute, [8] suggests that companies must distinguish between data assets and traditional assets and manage data assets in the digital economy. [4] analyzes the flow of data assets in the production and operation process of enterprises and further studies the management of data assets, suggesting that enterprises can manage data assets according to their flow nature, which will help to improve the efficiency of data asset management. [11] innovatively classifies data asset management into the data source, data volume, data quality and data quality by breaking down the attributes of the data.

There are also some studies of more concrete parts of data assetization for smart grid data. In the area of data discovery, [3] provides a vision for a comprehensive and systematic approach to meeting the grid management challenges through new information services, which will have sensor network support as the core of data discovery. For the next step, [7] discusses the coordinated standardization efforts to harmonize communications standards and protocols. And [21] discusses basic concepts and the procedures of the typical data analytics for data processing. For the final step, [9] examines the value creation process of transforming data into data products, and [10] talks about the business models for encapsulated smart grid data products.

In terms of smart grid data assets, [17] analyses the characteristics and value evaluation of power grid data assets by using the data generated from the business operation of a Power Grid Corp. [20] provides deep insights into various big data technologies and discusses big data analytics in the context of the smart grid. [23] proposes a framework for asset data management in power companies, which introduces a holistic approach, provides context and accountability for decision-making, and attributes data flows, roles, and responsibilities to different management levels. [25] suggests that power enterprises need to re-recognize the important role of scientific and technological innovation, and strive to make a greater breakthrough in the development of the energy digital economy.

# 3 Background

## 3.1 Attributes of Data Assets

Data assets are different from traditional assets, and the following will introduce the attributes specific to data assets.

- *Business Attachment*. From the perspective of data generation, the capital attribute of data assets is the business attachment of data. According to the *TOGAF* [12] theory of enterprise architecture, data originates from the business and is the digital achievement of business informatization. As a result, the data represents a specific business meaning.
- *Replicability*. From the perspective of data flow, the characteristics of data are particularly manifested in its replicability. The importance of replicability itself is easily overlooked, but has a key impact on important aspects of data assets such as security control and the scarcity of value realization..
- *Authenticity*. In terms of data integration, there is the subsumption or substitution between data, what should be concern in this process is the authenticity of the data. In the practice of data asset management, an over-emphasis on the value brought by data integration can lead to the sacrifice of data authenticity due to blind integration, which can have an incalculable impact on future in-depth decision-making.
- *Value Uncertainty*. In the process of data processing and value discovery, the most typical data attribute is value uncertainty. The value of data does not necessarily increase as a result of processing but also varies greatly depending on the role of the user accessing it and the application scenario at the same time.

## 3.2 Attributes of Smart Grid Data Assets

Smart grid data is mainly generated in real-time along with electricity production and consumption, which can fully and truly reflect the macroeconomic operation, the development of various industries, residents' living conditions, and consumption structure, etc. Grid companies have a high level of automation and informatization, complete infrastructure for data collection, transmission and application, and timely and efficient data acquisition. Generally speaking, in addition to the general attributes of data assets, the following are also attributes of grid data assets.

- *Large scale and many types*. Smart grid data includes various kinds of data on power generation, grid, electricity consumption, operation and management.
- *Credible, accurate and complete*. Smart grid data involves real-time and intelligent collection. And the data chain is complete, real and closed-loop.
- *Good real-time and continuity*. The data collection is also continuous and reliable.
- *High application value*. It contains rich information on regional economic development and enterprise operations, etc. It is convenient to aggregate with data on meteorology, communications, social economy, public utilities and geographic information to generate great value.

### 3.3 Challenges of Data Assetization

Smart grid data assetization is the process of giving smart grid data the nature of an asset, transforming it into data assets. In terms of the nature of data assets, and transforming data resources into assets should be three-fold in nature, namely controllable, quantifiable and profitable. Controllable means that an enterprise must have control over its data assets. Quantifiable means that data assets can be quantitatively evaluated according to privacy level, quality, value and other indicators, rather than relying on storage size as simple data. Profitable refers to the fact that the capitalized data can generate certain benefit appreciation at present or in the future.

However, smart grid data assetization faces the following challenges. Firstly, there are no uniform standards for grid data. Currently, there are no laws or regulations governing grid data standards, and in power enterprises, smart grid data involves generation, transmission, substation, distribution, consumption and dispatch, which means it is cross-unit,cross-discipline and cross-business. Business system differences between departments result in different data standardization. Secondly, grid data is both structured and unstructured. Structured data includes marketing, asset, financial and human resources systems, while unstructured data includes collaborative office systems, e-commerce systems, digital archives, etc. Thirdly, the exchange model and trading market of smart grid data are not yet mature. With the development of the digital economy, the number of digital trading centers is increasing, but these current data trading centers mainly provide services for the use of commercial data, and still lack a perfect trading mechanism in terms of smart grid data exchange.

## 4 Path Design of Smart Grid Data Assetization

### 4.1 Path of Smart Grid Data Assetization

According to the basic process of data assetization and the attributes of smart grid data assets, seven key links of smart grid data assetization are proposed as follows.

**4.1.1 Asset Value Realization.** The most important part of smart grid data assetization is realizing the asset value of smart grid data. The path to realizing the asset value of smart grid data is designed in the next subsection.

**4.1.2 Right Confirmation.** The first step of right confirmation is to clarify the ownership of data rights. From the perspective of data management, according to the bundle of rights theory of data rights, there are many kinds of data ownership, the right to use the data, the right to benefit from the data, and so on. Different subjects may have different operational rights to the same data. If the issue of data ownership is ambiguous, it will cause great trouble to data management. There is a need to clarify the owner of smart grid data and the various rights associated with it, such as the right to use, copy and trade, as well as to authorize management.

**4.1.3 Value Recognition and Quality Control.** High-quality data is what produces good value [18]. High-quality grid data should be accurate, consistent, complete, confidential and available on time. The identification of the value of data and the development of quality rules need to be determined through the development of data standards for the power industry and concerning the specific needs of the companies involved.

**4.1.4 Measurement and Warehousing.** It refers to statistics and storage of data [5], accompanied by data loading. Drawing on physical assets, a data catalog should be established after a unified specification design to clarify the data asset category, name, size and scope of attribution for various subsequent retrieval and use.

**4.1.5 Evaluation.** It includes three aspects: value assessment, depreciation of data assets and appreciation of data assets. Smart grid data has time and volume attributes, and the value of data may depreciate, or it may get higher. For example, the value of electricity consumption data of users is not high on a single day, but the larger the volume of data, the higher the value reflected. The evaluation system is described in detail in section 5.

**4.1.6 Value-added.** Adding value to smart grid data assets through the operation of various business models, which helps to maximize the value of data assets and boosts the smart grid data market. It is discussed in detail in section 6.

**4.1.7 Data Exchange.** Smart grid data that each subject has ownership of can be traded with other subjects for realization, which is also described in section 6.

Starting from the asset value realization, through a series of links including right confirmation, value recognition, quality control, data measurement, warehousing, evaluation and data exchange, the capitalization is completed finally. It helps power enterprises to obtain the value of smart grid data to enhance the rise. Based on the above, the path of smart grid data capitalization can be designed, which is presented in Figure 1.

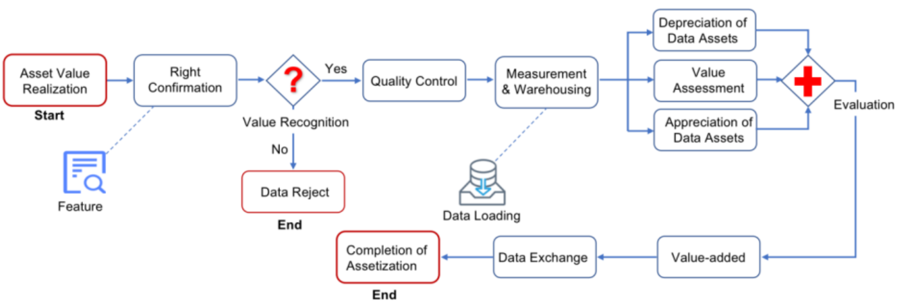


**Fig. 1.** The path of smart grid data capitalization.

### 4.2 Path of Asset Value Realization

Asset Value Realization is the first link in the path of smart grid data assetization. And the path to realizing the asset value of smart grid data can be considered as the process of acquiring various types of data from within and outside the power enterprise, processing and analyzing the data, forming valuable information and knowledge, and assisting the power grid industry to make business decisions, which helps provide services and generate economic and social benefits. The key links of the value realization path can be divided into five parts: data generation, data acquisition, data storage and integrated management, data analysis, and value generation, as shown in Figure 2. It covers the whole process of data discovery, standardization, data processing and encapsulation. The five parts are described in detail as follows.

**4.2.1 Data Generation.** Data generation is the first part of the path, including the accumulation of internal and operational data from the power company's measurement system and management, as well as the dynamic generation of external data from the Internet and public services.

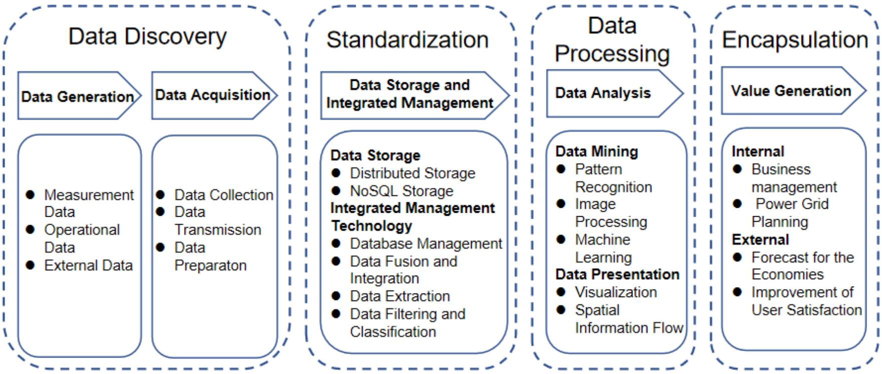


**Fig. 2.** The path of Asset Value Realization.

**4.2.2 Data Acquisition.** The second part is data acquisition, which includes three stages: data collection, data transmission and data preparation. It is the process of obtaining unprocessed grid data from the internal and external environment with data acquisition technology. Once data acquisition is complete, the data is transmitted and stored in a big data management system, such as NoSQL database, through an effective mechanism. However, the collected data may contain a large amount of redundant or invalid data, so the data should be pre-processed to ensure the effectiveness of data storage and data utilization.

**4.2.3 Data Storage and Integrated Management.** Smart grid data comes from a variety of sources and has complex data type. For that reason, smart grid data needs to be extracted and integrated before it can be analysed [16]. After correlation and aggregation, the data is stored in a structure that facilitates fusion and utilisation, and data filtering is performed during data integration and extraction to ensure data quality and reliability. Storage technologies for smart grid data mainly include distributed storage and a NoSQL storage. Integration management technologies for smart grid data mainly include database management, data fusion and integration, data extraction, data filtering and data classification.

**4.2.4 Data Analysis.** Data analysis is the most important part of the path. By modeling and analysis, pattern recognition and pattern discovery, potential patterns are identified in the vast amount of smart grid data [13]. The main techniques used to analyze smart grid data include pattern recognition, data presentation, image processing and machine learning. Data presentation technology can represent the data, information and knowledge obtained after analysis intuitively. Through data presentation technology, the relationships and patterns contained in big data can be made more intuitive and valuable.

**4.2.5 Value Generation.** Value generation is the last link in the path to realizing the asset value of smart grid data. Based on cleaning, analysis, mining and fusion, the additional value of smart grid data is explored and obtained. Value generation of smart grid data is mainly for the internal management of power enterprises as well as for the external users and social development of the grid enterprise. For the former, the value of smart grid data is to improve the efficiency of the internal management of the power enterprises and to strengthen the construction of the power grid. For the latter, the value of the data is to improve the efficiency and effectiveness of social and economic development forecasting, to provide accurate and personalized power supply services, and to improve the satisfaction of customers.

## 5 Evaluation System

### 5.1 Classification

To evaluate smart grid data assets more accurately, it is necessary to investigate and analyze the data sources, generation methods, collection methods, data size, data items and sensitivities of smart grid data and other attributes. This allows for the identification and study of various types of data assets and their possible application scenarios and product characteristics from different perspectives. This article classifies smart grid data assets according to data sources, user needs and sensitivity, as shown in Table 1.

**Table 1.** Classification of smart grid data assets.

| Classification | Types of Resources | Description |
|---|---|---|
| Data Sources | Enterprise Information | Market-related data collected by smart grid data centers from individual companies. |

| | | |
|---|---|---|
| | Production Scheduling | Relevant data from the smart grid data centers through internal monitoring. |
| | External Data | Data collected by smart grid data center relating to the external use of interfaces provided by companies. |
| User Require-ments | Decision Management | Users refer to this type of grid data when making decisions. |
| | Production Operation | The smart grid data that users need to refer to in their common production. |
| | Data Regeneration | Users use grid data for reproductive pro-cessing to obtain new usable data and create value. |
| | Academic Research | Users use grid data as a basis for academic activities |
| Sensitivity Lev-els | Insensitive | This type of grid data can be exchanged or made available to the public. |
| | Generally Sensitive | This type of grid data is only available internal use or for government requisition. |
| | Extremely Sensitive | Classified data needs to be kept confiden-tial. |

### 5.2 Factors Affecting Data Value

According to the current situation of smart grid data assets and the process of asset value realization, this article proposes four main factors affecting the value of smart grid data assets, including data quality, data circulation, data scarcity and data value realization risk. Based on these four factors, the evaluation rules for the value of smart grid data assets can be constructed.

- *Data Quality*. The quality value of grid data assets reflects the intrinsic value of the data, which means the nature and value of the data itself. Data quality can be evaluated by selecting quantifiable indicators in terms of data completeness, accuracy and timeliness, consistency, standardization and accessibility.
- *Data Circulation*. Data circulation refers to the act of using data as an object between the supplier and the demander of data according to certain circulation rules. Smart grid data assets can be divided into four categories according to the type of circulation: open data, public data, shared data and non-shared data.
- *Data Scarcity*. The scarcity of a data asset is determined by the amount of data held by that data asset as a proportion of the total amount of data of that type and can be measured by the proportion of data of a particular category within one or more industry sectors, i.e. by comparing the total amount of data of the same type.
- *Data Value Realization Risk*. Risks affecting the realization of data value exist at all links in the data value chain. Data value realization risk can be evaluated in terms of data management risk, data flow risk, value-added development risk and data security risk.

### 5.3 Process of Value Assessment

The value assessment of smart grid data assets is an important part of the assetization path. Similar to general assets, the value of smart grid data assets is not in stone, but also has depreciation and appreciation. Based on data attribute classification, combined with certain evaluation rules, we can form the value assessment result after judging the data value-added and depreciation levels. Figure 3 shows the process of value assessment of smart grid data assets.

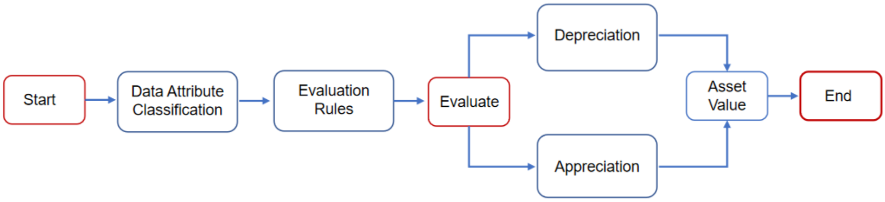


**Fig. 3.** The process of value assessment of smart grid data assets.

## 6 Value-added Path and Exchange Models

### 6.1 Value-added Path of Smart Grid Data Assets

The value-added path of smart grid data assets is a significant part of data assetization. The key to adding value to data assets lies in the application, circulation, and financial derivative services of data assets. Through these three paths, the value of data assets can be enhanced from different aspects. The following business models with data assets as the core can be used as the value-added path of smart grid data assets.

- *Data Self-management Model*. This model is mainly based on a large amount of data and technology, using big data and other data analysis technologies to carry out data analysis and data applications on existing data assets. Power companies have an integrated enterprise group information system that comprehensively covers multi-domain applications and supports multi-level analysis and processing of data, so the value-added path is mainly the application of data assets.
- *Data Rental and Sale Model*. This model focuses on the leasing of collected data to external parties. Power companies can use their large smart grid data sets to share and develop data assets with partners through data asset circulation using data rental and sale.
- *Data Platform Model*. Mainly based on enterprise influence, relevant data platforms are built to provide data services. Smart grid data assets need to be applied and circulated to achieve the integration of data analysis type, data sharing type and data trading type multi-platform types.
- *Data Warehouse Model*. This model combines multiple types of data to provide decision support. Power companies can use multiple types of data, such as power

business data, environmental data, policy data, etc., to realize smart grid data capitalization through the application and circulation of data assets.

- *Data Crowdsourcing Model*. The model focuses on innovative design and shifting product design to the customer. Also, through the application and circulation of data assets, the model conducts data analysis and evaluation in combination with upstream and downstream enterprises, as well as users [14].
- *Data Outsourcing Model*. This model allows companies to outsource relevant business processes to specialist organizations, optimizing resource allocation and reducing costs [6]. Power companies have certain technical and analytical capabilities to solve all kinds of decision-making and technical problems.
- *Data Financial Services Model*. It mainly focuses on he development of financial derivative products and services that can add value to smart grid data assets through financial derivative services such as collateral, investment and custody.

## 6.2 Exchange Model of Smart Grid Data Assets

Data exchange is the final step before the competition of smart grid data assetization. The seller of the smart grid data transaction is the data owner and depending on the rights ownership and pricing method. There are three exchange models of smart grid data assets: one-time transaction of data ownership, multi-transaction of data usage right and retained data value-added revenue right.

**6.2.1 One-time Transaction of Data Ownership Model.** The one-time transaction of data ownership model is a one-time transfer of the right to possess, use, dispose of and benefit from data in a data transaction. This model is more applicable to agreed pricing and auction pricing methods.

When the data transaction seller decides to transfer the data ownership in a one-time transaction, the negotiated pricing method can form a bargaining game between the two sides of the data transaction, and a transaction price agreed by both sides of the transaction can be formed. However, in the process of the game, the data buyer can constantly test the bottom line of the data seller's price, which will be detrimental to the final income of the data seller. The data seller can emphasize the complete transfer of data ownership to ensure its dominant position in the game process.

With the one-time transaction of data ownership model, the sellers of a smart grid data transaction can agree to a full transfer of ownership when trading pure data products and decision solutions and can choose any of these pricing methods, except for per-transaction pricing (VIP Membership).

Under auction pricing, the seller of the data gives the rules of the auction, such as the starting price and the markup, based on its assessment of the value of the data, but in effect gives the final pricing rights to multiple buyers participating in the auction. Therefore, in the face of the one-off ownership profit model under the agreed and auction pricing methods, the data seller is passive about the final pricing rights, and the final profit margin is reduced. As a result, how to transfer the ownership of the data in a single transaction while maximizing the profitability of the data seller is central to making a profit by using this model.

**6.2.2 Multi-transaction of Data Usage Right Model.** Unlike one-time transaction of data ownership, the multi-transaction of data usage right model does not transfer data ownership once, but only the right to use the data over multiple transactions, which can result in more revenue for the data seller. With the multi-transaction data usage right model, the sellers of a smart grid data transaction can only transfer the right to use data when trading pure data products and decision-making schemes.

The data seller retains ownership of the data and is able to repeatedly trade the data for more profit, especially with per-use pricing or API calling techniques that emphasize multiple invocations of the data. A one-time transaction of data ownership profit model will bring immediate, one-time revenue to the data seller, but repeated trading of data usage rights after retaining ownership will bring long-term, multiple revenues to the business. Therefore, the multi-transaction of data usage right model should be the preferred option for data sellers to trade data currently.

Nevertheless, due to the low-cost replicability and easy transferability of data products, under the multi-transaction of data usage right model, how the data seller can secure, confidential and control the transfer of the trade data to avoid the data being replicated and used on a large scale becomes the key to the realization of this profit model.

**6.2.3 Retained Data Value-added Revenue Right Model.** The data seller is more aware of the source of the data and the process of data collection, processing and analysis. The data seller is therefore in a better position than an intermediary such as a big data trading platform to directly and accurately evaluate the value of the data and predict whether there is the potential for value-added revenue after the data transaction. Based on such advantages, the data seller can more accurately determine whether it is necessary to retain possession of the right to proceed and in what proportion to contractually agree.

If the data seller is involved in the entire process of generating the data product, the final profit may be greater. However, the process of generating most data products may involve many different rights holders, and the data seller may have to allocate different levels of profits to the data collector, data cleaner, data analyzer, and other rights holders after the transaction, which may reduce the data seller's interests. In such cases, the best profit model for the data seller is to accurately determine the value-added of the data after the transaction and then to reserve and agree on the data revenue rights.

## 7 Conclusion

Making full use of smart grid data assets is conducive to the classification, integration, and sharing of internal and external data of power enterprises. In-depth mining and analysis can create greater added value and support the innovative development, transformation, and upgrading of power enterprises. As power enterprises continue to optimize their data management levels and various business data application platforms emerge, data capitalization helps to form an effective means of data empowerment and value-added benefits.

This article concludes on the attributes of smart grid data assets and the basic way of data assetization. According to these, the path to realizing the asset value of smart grid data is proposed and the path of smart grid data capitalization is designed. This article also discusses the value-added path and exchange models of smart grid data assets. To sum up, it contributes to the implementation method of transforming smart grid data resources into data assets as well as conducting evaluation and exchange. It is of great significance to improve the smart grid data assets management system, enhance the value of data assets, serve the new form of grid business and create a new commerce model in the future. The approach proposed in this paper needs to be further optimized and adapted in practice, aiming to form a data assetization path that is universally applicable to the power industry and help to create rich service, management, operational, and even social value from smart grid data.

## References

1. Moody, D. L., & Walsh, P. (1999, June). Measuring the Value of Information-An Asset Valuation Approach. In ECIS (pp. 496-512).
2. Gargano, M. L., & Raggad, B. G. (1999). Data Mining-a powerful information creating tool. OCLC Systems & Services: International digital library perspectives..
3. King, R. L. (2008, July). Information services for smart grids. In 2008 IEEE Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century (pp. 1-5). IEEE.
4. Insight, P. B. B. (2009). Managing your data assets. White Paper, IDC Government Insights.
5. AlMabhouh, A., Saleh, A. R., & Ahmad, A. (2012). A framework of data warehouse systems success: an empirical study. International Journal of Electronics Communication and Computer Engineering, 3(3), 664-677.
6. Zhou, M., Mu, Y., Susilo, W., Yan, J., & Dong, L. (2012). Privacy enhanced data outsourcing in the cloud. Journal of Network and Computer Applications, 35(4), 1367-1373.
7. Fan, Z., Kulkarni, P., Gormus, S., Efthymiou, C., Kalogridis, G., Sooriyabandara, M., ... & Chin, W. H. (2012). Smart grid communications: Overview of research challenges, solutions, and standardization activities. IEEE Communications Surveys & Tutorials, 15(1), 21-38.
8. Sebastian-Coleman, L. (2012). Measuring data quality for ongoing improvement: a data quality assessment framework. Newnes.
9. Miller, H. G., & Mork, P. (2013). From data to decisions: a value chain for big data. It Professional, 15(1), 57-59.
10. Rodríguez-Molina, J., Martínez-Núñez, M., Martínez, J. F., & Pérez-Aguiar, W. (2014). Business models in the smart grid: Challenges, opportunities and proposals for prosumer profitability. Energies, 7(9), 6142-6171.
11. Gallaugher, J. (2015). Information systems: A Manager's guide to harnessing technology. University of Minnesota Libraries Publishing.

12. Josey, A. (2016). TOGAF® Version 9.1-A Pocket Guide. Van Haren.
13. Galar, D., Kans, M., & Schmidt, B. (2016). Big data in asset management: knowledge discovery in asset data by the means of data mining. In Proceedings of the 10th World Congress on Engineering Asset Management (WCEAM 2015) (pp. 161-171). Springer, Cham.
14. Garcia-Molina, H., Joglekar, M., Marcus, A., Parameswaran, A., & Verroios, V. (2016). Challenges in data crowdsourcing. IEEE Transactions on Knowledge and Data Engineering, 28(4), 901-911.
15. Galar, D., & Kans, M. (2017). The impact of maintenance 4.0 and big data analytics within strategic asset management. In Maintenance Performance and Measurement and Management 2016 (MPMM 2016). November 28, Luleå, Sweden (pp. 96-104). Luleå tekniska universitet.
16. Boyes, G. A., Ellul, C., & Irwin, D. (2017, October). Exploring BIM for operational integrated asset management-a preliminary study utilising real-world infrastructure data. In ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences (Vol. 4, No. 4W5, pp. 49-56).
17. Song, W., Zhang, Y., Wang, J., Li, H., Meng, Y., & Cheng, R. (2018). Research on characteristics and value analysis of power grid data asset. Procedia computer science, 139, 158-164.
18. Bokrantz, J., Skoogh, A., Lämkull, D., Hanna, A., & Perera, T. (2018). Data quality problems in discrete event simulation of manufacturing operations. Simulation, 94(11), 1009-1025.
19. Liang, F., Yu, W., An, D., Yang, Q., Fu, X., & Zhao, W. (2018). A survey on big data market: Pricing, trading and protection. Ieee Access, 6, 15132-15154.
20. Syed, D., Zainab, A., Ghrayeb, A., Refaat, S. S., Abu-Rub, H., & Bouhali, O. (2020). Smart grid big data analytics: survey of technologies, techniques, and applications. IEEE Access, 9, 59564-59585.
21. Zhang, Y., Huang, T., & Bompard, E. F. (2018). Big data analytics in smart grids: a review. Energy informatics, 1(1), 1-24.
22. Faroukhi, A. Z., El Alaoui, I., Gahi, Y., & Amine, A. (2020). Big data monetization throughout Big Data Value Chain: a comprehensive review. Journal of Big Data, 7(1), 1-22.
23. Gavrikova, E., Volkova, I., & Burda, Y. (2021). Implementing asset data management in power companies. International Journal of Quality & Reliability Management.
24. Pei, J., Zhu, F., Cong, Z., Luo, X., Liu, H., & Mu, X. (2021, August). Data Pricing and Data Asset Governance in the AI Era. In Proceedings of the 27th ACM SIGKDD Conference on Knowledge Discovery & Data Mining (pp. 4058-4059).
25. Xu, Y., Liu, S., Song, B., & Liu, R. (2021, June). Innovative Development of Power Grid Enterprises Under the Background of Energy Digital Economy Transformation. In 2021 International Conference on Enterprise Management and Economic Development (ICEMED 2021) (pp. 185-189). Atlantis Press.