



Research on Natural Gas Data Management Model and Operation Mechanism Based on DCMM

Qin Liu, Zhengyan Cao

School of Economics and Management, Southwest Petroleum University, Chengdu, China

ABSTRACT

To respond to the national policies on the development and utilization of enterprise data resources and promote the digital and intelligent transformation of the natural gas industry, this paper first reviews the research status of data management models, natural gas data management, and the Data Management Capability Maturity Assessment Model (DCMM). Subsequently, it analyzes the characteristics of natural gas data management, such as high integration and real-time accuracy, as well as existing issues including data silos, insufficient data quality, and lack of standardization, and points out that current assessments focus on security and value. Furthermore, the paper constructs a natural gas data management capability maturity assessment model based on DCMM(DCMM-NG), defining 8 core capability areas, 5 maturity levels, and the assessment process. Finally, it proposes that DCMM needs to be adjusted in accordance with industry characteristics; this model can help enterprises identify the strengths and weaknesses of their data management and provide support for formulating targeted improvement strategies.

KEYWORDS

DCMM; Natural Gas; Data Management; Maturity Assessment.

1. INTRODUCTION

In December 2024, the National Data Administration (NDA) and other relevant departments issued the Opinions on Promoting the Development and Utilization of Enterprise Data Resources, which emphasizes that data formed, legally obtained, or held by enterprises in the process of production and operation constitutes a crucial resource for enterprise development. Strengthening the development and utilization of enterprise data resources is a key measure to advance the construction of a national integrated data market and achieve the optimization of data resource allocation efficiency and the maximization of benefits. It is also an inevitable requirement for better leveraging the role of market mechanisms and creating a more fair and dynamic market environment. Promoting the in-depth integration of digital technology with the real economy and empowering the digital and intelligent transformation and upgrading of traditional industries is a strategic choice to seize the new opportunities presented by the new round of scientific and technological revolution and industrial transformation.

Therefore, the natural gas industry must closely align with the national digital economy development strategy and leverage big data management models to achieve in-depth transformation. From the policy guidance of the National Energy Administration to the development and utilization of enterprise data resources, big data has become a critical driver for promoting the green and low-carbon development of oil and gas, as well as the intelligent upgrading of oil and gas pipeline networks. As a new-type factor of production, data is characterized by complexity and high value, which requires natural gas enterprises to strengthen data management. This will enable them to seize

the new opportunities of the scientific and technological revolution and industrial transformation, realize digital and intelligent transformation and upgrading, and gain the initiative in future development.

2. LITERATURE REVIEW AND THEORETICAL ANALYSIS

Data management refers to the process of effectively collecting, storing, processing, and applying data using computer hardware and software technologies. Its purpose is to fully and effectively exert the role of data. Du Guoyi et al. (2022) analyzed the current status and problems of energy information data management in the Inner Mongolia Autonomous Region from five dimensions: data management, data dimensions, data collection, data collaboration, and data application. They proposed a management innovation model covering five aspects, including clarifying data management lines, realizing multi-source data aggregation, conducting data integration and analysis, piloting coal big data analysis, and promoting digital application innovation, along with relevant suggestions [3]. Wang Jing et al. (2023) took the Data Management Capability Maturity Assessment Model (DCMM) as the theoretical basis and focused on exploring the application and value of digital twin technology in data governance of smart libraries in universities. By establishing a digital twin-based data governance model for university smart libraries, they aimed to promote the efficient aggregation of library data resources and realize the in-depth integration and application of global spatiotemporal data. This model provides strong support for promoting the open sharing of data resource systems in university libraries [2]. Ma Songzeng et al. (2024) started from the current status of soil and water conservation data resources and their management in Henan Province, aligned with the construction requirements for smart soil and water conservation during the "14th Five-Year Plan" period, and discussed and proposed a provincial-level soil and water conservation data management model of "standardization, modularization, and cloud service" based on a data resource pool [1].

3. CHARACTERISTICS AND CURRENT ASSESSMENT STATUS OF NATURAL GAS DATA MANAGEMENT

3.1. Characteristics and Problems of Natural Gas Data Management

3.1.1. Characteristics of Natural Gas Data Management

In the natural gas industry, data management refers to the process of effectively collecting, storing, processing, and applying data using computer hardware and software technologies. It plays a crucial role in enterprises' operations, decision-making, and strategic planning. Due to the unique nature of the natural gas industry, its data management exhibits a series of distinctive characteristics, which are elaborated in detail as follows:

(1) High integration and complexity of data; (2) Extremely high requirements for real-time performance and accuracy; (3) Paramount importance of data security and privacy protection; (4) In-depth integration of data management and business processes; (5) Data-driven business innovation and development; (6) Sustainability and iteration of data management

3.2. Existing Problems in Natural Gas Data Management

3.2.1. Data silos and fragmentation

Difficulties in cross-system integration: The natural gas industry chain covers multiple links such as exploration, storage and transportation, and sales. Data from each link is scattered across different systems, lacking unified data interfaces and sharing platforms. Furthermore, it is difficult to link exploration data (e.g., geological modeling) with sales data, which affects the accuracy of supply and demand forecasting.

Departmental and regional barriers: Data standards vary among different departments within enterprises and cross-regional units, resulting in the formation of "information silos".

3.2.2. Data quality and accuracy

High error rate in manual data entry: Some small and medium-sized gas enterprises still rely on manual meter reading and data entry, leading to data duplication, omissions, or format errors. Poor data timeliness and completeness: Traditional data collection relies on periodic inspections, resulting in insufficient real-time performance.

3.2.3. Standardized and sharing

Ununified industry standards: There are no national standards for natural gas data formats and interface specifications, making cross-enterprise collaboration difficult. Insufficient willingness to share and incentive mechanisms: Enterprises are reluctant to open core data due to concerns about data security or commercial interests.

3.2.4. Data security

Risk of sensitive data leakage: Sensitive gas user information is vulnerable to hacking if not stored or transmitted in an encrypted manner. Inadequate regulatory compliance: The Data Security Law and Personal Information Protection Law require enterprises to implement classified and hierarchical management of user data. However, small and medium-sized gas enterprises often fail to establish compliance audit mechanisms due to insufficient technical capabilities.

3.2.5. Level of intelligence

Weak data analysis capabilities: Most enterprises remain at the data storage stage and lack advanced analysis tools. Insufficient coverage of intelligent equipment: The application of intelligent sensors and IoT (Internet of Things) devices in old pipeline networks is limited.

3.2.6. Talent cultivation

Imperfect governance system: Enterprises lack dedicated data governance organizations (e.g., data committees), leading to ambiguous division of responsibilities and authorities.

Shortage of professional talents: There is a scarcity of interdisciplinary talents such as data scientists and security engineers, especially in central and western regions. Lack of dynamic assessment mechanisms: DCMM has not been normalized, making it difficult for enterprises to identify improvement directions in a timely manner.

4. CONSTRUCTION OF A NATURAL GAS DATA MANAGEMENT CAPABILITY MATURITY ASSESSMENT MODEL BASED ON DCMM

4.1. The Content Scope

Natural Gas Data Management Capability Maturity Assessment Model Based on DCMM (DCMM-NG) divides data management capabilities into 8 core capability areas, with each area containing several process items and detailed indicators, totaling 28 process areas and 445 capability maturity standards. DCMM covers data governance, data architecture, data application, data security, data quality, data standards, and data lifecycle.

DCMM-NG classifies data management capabilities into 5 maturity levels, reflecting an organization's evolutionary path from disorder to optimization:

Initial Level (Level 1): Data management activities are scattered without standardized processes, relying on individual experience.

Managed Level (Level 2): Preliminary standardized processes are established but not yet fully promoted.

Established Level (Level 3): A standardized and documented management system is formed, enabling cross-departmental collaboration.

Quantitatively Managed Level (Level 4): Performance is tracked through a data measurement system to support continuous improvement.

Optimizing Level (Level 5): Data management is integrated into corporate culture, achieving adaptive optimization and innovation.

Each capability area corresponds to 3–5 capability items. For each capability item, several assessment contents and objectives are defined, and 5 assessment capability maturity standards are established. In the specific assessment process, in addition to generating an overall maturity evaluation level for natural gas enterprises, evaluation results are also produced for each capability item, helping enterprises make targeted improvements and optimization adjustments.

4.2. DCMM Assessment Process

The assessment process of DCMM is divided into three phases. Combined with the characteristics of the natural gas industry, DCMM-NG focus on energy data security, cross-system integration, and real-time monitoring. The specific process and process diagram are shown in Figure 1.

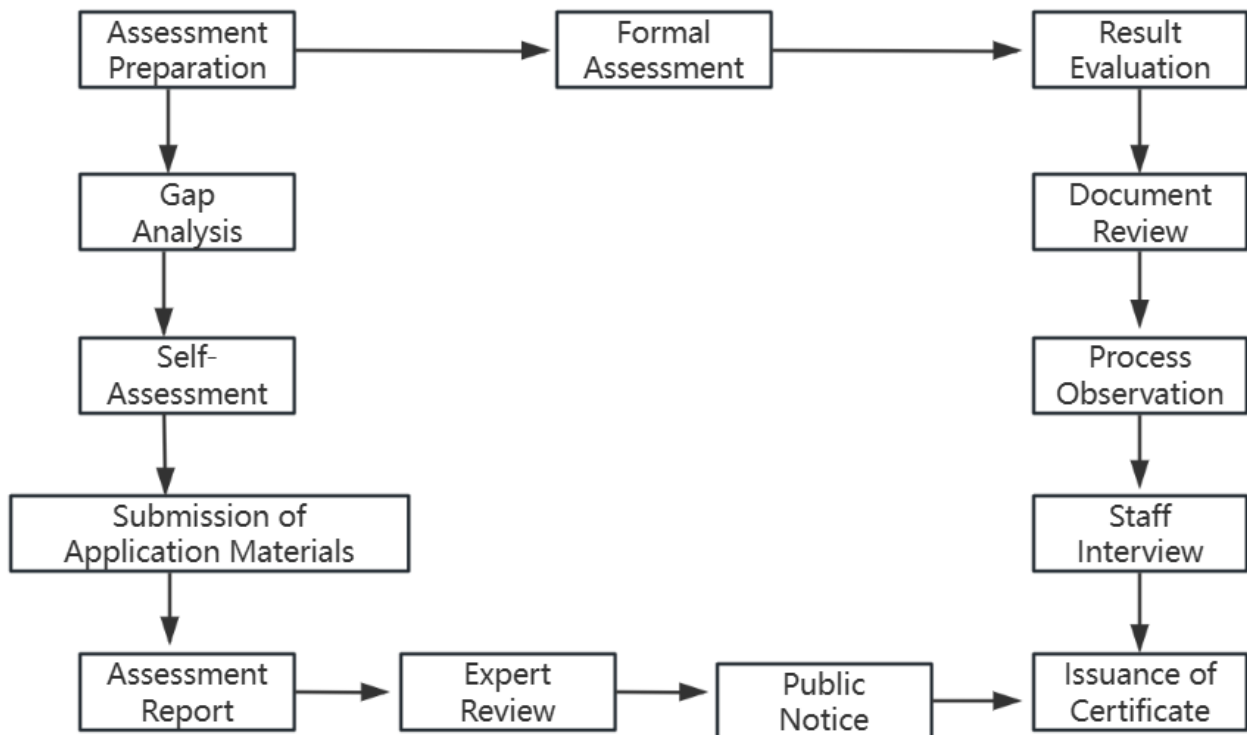


Figure 1: DCMM Assessment Process

5. SUMMARY

Data quality management runs through the entire process of the data lifecycle and is a long-term, continuous improvement effort. DCMM provides solid model support and process guidance for data quality management. Natural gas enterprises can refer to the DCMM model to carry out a series of management activities—such as identifying, measuring, monitoring, and early warning of quality

issues that may arise at each stage of the data lifecycle—and establish a data quality management system for continuous improvement.

Although DCMM offers a general assessment framework for data management, when specifically applied to the natural gas industry, it still needs to be refined and adjusted based on the characteristics of specific business operations and data management. For instance, data management in natural gas enterprises involves multiple business fields, including exploration, extraction, processing, transportation, and sales. Each field generates massive volumes of data, which requires a high level of integration to enable unified management and analysis of data from different sources and in different formats. Additionally, the production and operation of natural gas enterprises have extremely high requirements for data real-time performance and accuracy. During the production process, real-time data updates and accurate feedback are essential to ensuring production safety and meeting other such requirements. If during the assessment process, certain shortcomings are identified in areas like data strategy implementation and evaluation, and data standards, failure to address these issues in a timely manner may affect the overall effectiveness of the enterprise's data governance. Therefore, it is necessary to target these weak points, strengthen the development of relevant systems and processes, enhance data strategy management capabilities, and promote the formulation and implementation of data standards.

In summary, DCMM-NG provides natural gas enterprises with a comprehensive and systematic assessment framework, helping them identify their strengths and weaknesses in data management. Through assessment, enterprises can gain a clearer understanding of their actual capabilities in aspects such as data strategy, data governance, data architecture, and data application, thereby formulating targeted improvement strategies.

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REFERENCES

- [1] Ma, S. Z., Shang, Z. R., & Ma, F. Z. (2024). A Smart Soil and Water Conservation Data Management Model for Henan Province Based on Data Resource Pool. *Henan Water Resources & South-to-North Water Diversion*, 53(03), 14-15.
- [2] Wang, J., & Wang, P. (2023). Research on the Data Governance Model of Smart University Libraries Based on Digital Twin. *Library Science Research*, (11), 41-50.
- [3] Du, G. Y., Luo, W., & Gao, F. (2022). Research on the Innovation of Energy Information Data Management Model—A Case Study of Inner Mongolia Autonomous Region. *Energy of China*, 44(04), 81-84.