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Problems and Suggestions on Energy Saving Management in Silicon Smelting Enterprises

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Abstract: Under the background of building the"photovoltaic capital of the world"in Yunnan Province,and combined with the previous experience of conducting energy-saving diagnostic services in silicon smelting enterprises,the foundation of enterprises in energy-saving management is not very good.Some enterprises will be eliminated,if they fail to achieve a higher level of energy efficiency.This paper summarizes the situation and problems of silicon smelting enterprises,it is suggested that enterprises should improve their energy management ability from the following aspects:paying attention to policy documents,establishing working mechanism,grasping the key points of management,purchase professional services,and improving energy-saving consciousness.

Keywords: silicon smelting, energy saving management, problems, suggestions.

1. Background

Industrial silicon is mainly used in aluminum alloy industry, non-ferrous alloy additives and chemical industry. Polycrystalline silicon and monocrystalline silicon are formed after a series of purification processes, which are used in photovoltaic and electronic industries. In 2021, China's industrial silicon production was 2.7 million tons and consumption was 1.86 million tons, accounting for 78% and 55% of the global total, respectively. In the same period, exports were 778000 tons, accounting for more than 50% of the total overseas industrial silicon consumption[i]. Yunnan Province, as an area with good conditions for silicon resources and electric power resources, has large reserves of silicon resources and rich renewable resources[ii]. The output of Yunnan in 2018 totaled 480000 tons, ranking second in the country[iii]. At the same time, Yunnan Province, centering on the development of the integrated green energy pattern of "scenery and water storage", promotes the deep integration of green energy with advanced manufacturing industries such as green aluminum and green silicon, and creates a "photovoltaic capital of the world"[iv].

In May 2019, the Ministry of Industry and Information Technology issued the Action Plan of Industrial Energy Saving Diagnostic Services, proposing to implement omni-directional, full-process and full-coverage energy-saving diagnostic services for enterprises with weak energy management or poor energy efficiency every year[v]. Our team continuously participated in this work from 2020 to 2022, and carried out energy-saving diagnostic services to 11 silicon smelting enterprises in Lincang City, DehongCity and Nujiang City, Yunnan Province.

Combined with the problems existing in energy-saving management in enterprises, the author finds out the relevant papers. Kegang Bi (2020) proposed to help industrial enterprises find energy-saving potential accurately through energy-saving diagnosis work, promote enterprises and market-oriented organizations to carry out energy saving and consumption reduction work, and improve the energy efficiency level and energy-saving management ability of enterprises[vi]. Based on the energy composition and consumption status of a domestic industrial silicon production enterprise, Fuzhong Wu (2010) discussed the energy consumption of industrial silicon production, and put forward the main energy-saving directions and approaches of industrial silicon industry in the future[vii]. Hongmei Zheng (2015) and others studied the production process of industrial silicon and refined the direction of saving energy and reducing consumption. According to the

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historical policy documents and relevant industry data[viii]. Xiangyang Mei (2019) summarized the industrial silicon production capacity and its proportion in the whole country in Yunnan Province, combined with the current situation of industrial pollutant discharge, raw material use and dust removal methods of flue gas precipitator. the existing environmental problems such as ecological destruction and environmental pollution in industrial silicon enterprises are put forward. From the point of view of raw material particle size and raw material composition[ix]. Hongxing Bi (2020) analyzed in detail the influence of raw material quality on industrial silicon production, and expounded how to improve the raw material quality, which plays an important role in the management and control of industrial silicon production[x]. Rongqiang Wu (2022) describes the speed regulation control of the frequency converter in the start-up of the main water pump of the industrial silicon electric furnace, according to the return water temperature and inlet pressure of the water cooling parts of the furnace core, control the output frequency of the frequency converter and the rotational speed of the pump, so as to complete the energy-saving transformation[xi]. Through the review of the literature, it is found that most scholars analyze from the perspective of production technology, put forward measures to save energy and reduce consumption, and do not sort out the problems and put forward countermeasures and suggestions from the work of enterprise energy-saving management.

Therefore, under the background of Yunnan Province opening up the green silicon photovoltaic industry chain and building "the photovoltaic capital of the world", combined with the previous energy-saving diagnostic services, this paper summarizes the common problems existing in the energy-saving management of silicon smelting enterprises. some countermeasures and suggestions are put forward to help silicon smelting enterprises improve their energy-saving management ability.

2. General situation of enterprises

The process flow of silicon smelting enterprises in which the team carries out energy-saving diagnostic services is similar, mainly including silica crushing, washing and screening, batching and electric furnace smelting, oxygen refining, pouring, silicon block crushing and packaging. The comprehensive energy consumption per unit product of enterprises is better than the national limit value 3500kgce/t stipulated in the Industrial Silicon Energy consumption limit per Unit Product (GB31338-2014), and a few enterprises are lower than the advanced value 2500kgce/t.

Table 1. Statistical table of Energy Saving Management.

Numble	Name	Number	
		Yes	No
1	Organization construction and responsibility division		
1.1	Set up an energy management department and clarify its responsibilities	11	0
1.2	Set up energy management posts and define the job responsibilities	2	9
1.3	The employed energy managers have professional background in energy related and practical experience in energy conservation	2	9
2	Manage file		
2.1	Prepare energy management procedures, such as "Enterprise Energy Management Manual", "main Energy equipment Management procedures", etc	4	7
2.2	Prepare energy management system documents, such as measurement management system, statistical management system, quota management system, assessment management system, etc	7	4
2.3	Establish relevant standards for enterprise energy conservation, such as energy consumption quota standards for departments, processes, equipment, etc	10	1
3	Measurement statistics and informatization construction		
3.1	List of energy measuring instruments and measurement network diagram	3	8
3.2	List of energy measuring instruments and measurement network diagram.	4	7
3.3	Establish original records and statistical accounts of energy consumption	11	0

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3.4	Carry out energy consumption data analysis and report statistical results on time	2	9
3.5	built or is building an enterprise energy management center	5	6
3.6	Realize online collection and real-time monitoring of energy consumption data	3	8
4	Publicity, education and on-the-job training		
4.1	Carry out energy conservation publicity and education activities	1	10
4.2	Carry out on-the-job training for energy metering, statistics, management and equipment operators	2	9
4.3	Carry out pre-post training for operators of major energy-using equipment	11	0

The production process of enterprises is basically similar and the level of energy utilization is similar, but there are some common problems to be solved in energy-saving management.

3. Problems of Energy Saving Management in Silicon smelting Enterprises

3.1 incomplete understanding of industry policies.

Most of the silicon smelting enterprises served by the team are private companies, and they are distributed in the cities far away from Kunming and even in the border areas where the epidemic is more serious. The management cost of the enterprise is mainly in the aspects of production and operation, epidemic prevention and control, and employee stability maintenance, and there is no much energy to pay attention to the documents, policies, regulations and systems of energy conservation, so we cannot effectively understand the importance of energy conservation work and the seriousness of energy conservation management situation.

3.2 the energy management system is not perfect.

Most of the silicon smelting enterprises have established energy management leading groups and formulated energy-saving related institutional documents, but most of the relevant systems are qualitative and non-quantitative, and form relevant management methods and management assessment mechanisms according to the actual situation of the enterprises. At the same time, most enterprises do not have full-time energy-saving management departments or personnel, energy management leading groups play little role, energy-saving related systems are too general, and do not combine the organizational structure of the enterprise to clarify the responsible person, responsibility objectives and reward and punishment measures.

3.3 the thinking of energy saving management is not clear.

Energy conservation management involves production, finance, equipment, testing, training, publicity and other departments. Most silicon smelting enterprises do not have full-time managers or even trained energy managers. After receiving the task assigned by the government, there is no way to start, let alone carry out the daily energy consumption calibration and other work.

3.4 employees' awareness of energy saving is weak.

The management of silicon smelting enterprises focuses on production and income, but does not pay enough attention to energy-saving publicity and staff training, and does not realize the role of energy-saving management in improving the efficiency of enterprises; at the same time, there are not many personnel with training ability in enterprises. Energy conservation publicity work is carried out less. Combined with the regional distribution of silicon smelting, the present situation of operation and the on-site visit of diagnostic services, the problems of enterprises in policy understanding, system establishment, management ideas and energy saving consciousness are summarized.

Next, some countermeasures and suggestions will be put forward according to the production process and management basis of the enterprise.

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4. Suggestions on Energy Saving Management in Silicon smelting Enterprises.

4.1 Pay attention to policy documents and grasp the trend of management.

With the goal of "carbon peak and carbon neutralization" put forward, the CPC Central Committee, the State Council, the carbon neutralization work leading group and local governments will hold meetings and release documents from time to time.

On October 16, 2022, the report of the 20th CPC National Congress pointed out that we should speed up the adjustment and optimization of industrial structure, energy structure, transportation structure and so on. Implement the comprehensive conservation strategy, promote the economical and intensive utilization of all kinds of resources, and speed up the construction of waste recycling system[xii].On November 15, 2021, the Ministry of Industry and Information Technology issued the 14th five-year Plan for Industrial Green Development; on September 30, 2021, the Department of Industry and Information Technology of Yunnan Province issued the 14th five-year Plan for Industrial Green Development of Yunnan Province. eight key tasks are put forward, such as optimizing and adjusting the industrial structure, improving the level of industrial energy efficiency, and promoting industrial low-carbon development.

Silicon smelting enterprises can forward, print or study news manuscripts or policy documents according to the actual situation, so as to keep up with the pace of government management timely, effectively and correctly.

4.2 Establish the working mechanism and improve the management organization.

4.2.1 Establishment of energy management system.

The energy management system starts from the whole process of the system, follows the system management principle, and establishes a complete, effective and documented energy management system in the organization through the implementation of a complete set of standards and norms. achieve energy management policies and commitments and achieve expected energy consumption or use goals.

Silicon smelting enterprises establish and implement an energy management system in accordance with the requirements of the guidelines for the requirements and use of Energy Management system (GB/T 23331-2020) and the Circular of Yunnan Provincial Industry and Information Technology Commission on promoting the Construction of Enterprise Energy Management system, so as to provide a guarantee for the establishment and improvement of an energy management organization structure that interconnects, restricts and promotes each other.

4.2.2 improve the energy management system.

The existing energy management system of most enterprises is too general, and the post responsibility and responsible person should be determined in combination with the enterprise management process. mainly implement energy statistics, measuring instruments management, unit product energy consumption, energy testing, data reporting, documentation and other aspects of responsibility and reward and punishment measures.

4.2.3 to set up full-time management departments or personnel.

The enterprise shall set up full-time management departments and personnel, responsible for implementing the ideas of the top leaders on energy management, and responsible for formulating enterprise energy management objectives and performance appraisal methods, responsible for docking and analyzing the data of statistics department, laboratory department, purchasing and finance department, organizing and reporting their documents, collecting, collating, reporting and publicizing policy documents, and responsible for energy consumption calculation and calibration, and work with the production department to analyze the reasons for the change of energy consumption.

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4.3 Grasp the key points of management and reduce the unit consumption of products.

4.3.1 manage the calibration and energy consumption calibration well.

Enterprises should make use of the inherent ideas of the energy management system, combined with their own characteristics and needs, compare with the excellent enterprises in the industry, and check whether it is necessary and conditional to improve the deficiencies in the management department and personnel; gradually improve the relevant systems that are conducive to job management and acceptable to employees.

Enterprises refer to the document "Industrial Silicon Unit Product Energy consumption quota" (GB/T 31338-2014), compile calculation tables that meet the needs of their own management, and compare the energy efficiency of products regularly and in compliance to find out the room for improvement.

4.3.2 improve energy measuring instruments and laboratory reports.

The configuration degree and accuracy of energy measuring instruments are the basis for enterprises to carry out energy-saving work[xiii]. The enterprise shall, in accordance with the requirements of the territorial market supervision and administration bureau and the energy conservation supervision department, and combined with the requirements of the General rules for the equipment and Management of Energy Metering Instruments for Energy users (GB/T 17167-2006), improve and check the energy metering instruments in a timely manner.

Energy metering instruments such as electricity meters, water meters, ground scales and steam Flowmeters shall be checked regularly in accordance with the requirements of the standard; energy sources such as coal, charcoal and petroleum coke shall be sent to institutions certified and qualified by the state for testing, the original inspection report shall be kept properly, and the paper documents related to the inspection process shall be preserved as far as possible in order to prove the authenticity and validity of the inspection report.

4.3.3 analyze the data of energy consumption online monitoring system.

The energy consumption online monitoring system collects the energy consumption data of enterprises in real time through the data acquisition terminal, and then uploads it to the government management platform through the network to the energy data center[xiv]. According to the data collected by the system, enterprises can simply analyze the current situation of energy utilization, such as power quality, transformer operation efficiency, plant water balance, energy balance and so on. Big data technology can also be used for in-depth analysis[xv]. Referring to the standards such as GB/T 3484-2009 "General principles of Enterprise Energy balance" and GB/T 2589-2020 "General principles for Comprehensive Energy consumption calculation", the energy consumption of enterprises is analyzed according to the ideas of energy balance of purchase and storage, processing conversion, transportation and distribution, terminal use and recycling.

4.4 Buy professional services and find your own problems

4.4.1 Energy audit

Energy audit is based on the principle of conservation of matter and energy, the principle of hierarchical embedding, the principle of repeated iteration and the principle of exhaustive enumeration. this paper analyzes the project compliance of the audit unit, the energy consumption standard of the unit product, the energy efficiency level of the key energy-consuming equipment and the energy-saving space, so as to timely analyze and grasp the energy management level and energy use status of the unit. It is suggested that enterprises should conduct a comprehensive energy audit at least every three years to investigate energy management problems and weak links, tap energy-saving potential and find energy-saving direction.

4.4.2 Energy saving diagnosis

Energy-saving diagnosis is a zero-distance, face-to-face, free pulse consultation for energy-using enterprises, its purpose is to promote those energy-saving technologies that have been tested and proved to be effective, and tap the energy-saving potential of enterprises[xvi]. It is suggested that enterprises should actively sign up to participate in energy-saving diagnosis in order to further

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improve the level of industrial energy efficiency and promote industrial green development. At the same time, it is suggested that the regional development and reform or industrial and credit departments should carry out energy-saving diagnostic services for the silicon smelting enterprises in the region by purchasing services.

4.4.3 efficiency test of main energy-consuming equipment

The main energy-consuming equipment of silicon smelting enterprises mainly includes transformers, electric furnaces, high-power fans or pumps, etc., which account for a large proportion of energy consumption in the production process. Enterprises can carry out special tests on the main energy-consuming equipment through third-party institutions with testing capabilities to understand the operating efficiency of the equipment in order to carry out maintenance and replacement. Enterprises of the nature of the group can purchase relevant equipment by themselves, train relevant personnel, and regularly carry out energy efficiency testing of major energy-consuming equipment.

4.5 Strengthen skill training and raise energy-saving awareness.

With the help of the advantages of universities, scientific research institutes, experts and leading enterprises, experts from two provincial scientific and technological innovation platforms, Yunnan Silicon Industry Engineering Research Center and Yunnan Silicon Industry Research Institute (Innovation Center), are invited to visit and exchange with enterprises, introduce new production technology, equipment and management concepts, and strengthen the professional skills training of employees with the help of the convenience of the Internet.

To strengthen the training of employees' energy-saving technology and awareness through the help of expert lectures, encouraging employees to apply for professional titles, publicizing and organizing learning policy documents, energy-saving knowledge halls, energy-saving technological renovation seminars, energy-saving slogans, and so on. Improve the level of energy-saving skills and learning enthusiasm of employees.

5. Conclusion

Combined with the previous energy-saving diagnosis experience of silicon smelting enterprises, this paper finds that with the continuous improvement of energy efficiency, the current situation of energy-saving management can not meet the goal of building silicon industry in Yunnan Province. The main results are as follows:

(1) the energy consumption foundation of enterprises is good, but the current situation of management is generally weak. The comprehensive energy consumption per unit product of 11 silicon smelting enterprises diagnosed by the team on the spot is better than the national limit stipulated in the Industrial Silicon Energy consumption limit per Unit Product (GB31338-2014), but the current situation of energy saving management is uneven.

(2) there are some problems in energy-saving management of enterprises. The main performance is that the understanding of industry policy is not comprehensive, the energy management system is not perfect, the train of thought of energy-saving management is not clear, and the employees' awareness of energy-saving is weak.

(3) combined with the problems of enterprises, this paper puts forward some suggestions on energy-saving management. From the aspects of paying attention to policy documents, establishing working mechanism, grasping the key points of management, inviting third-party organizations to provide services, and improving energy conservation awareness, this paper puts forward some suggestions for silicon smelting enterprises for reference, in order to help enterprises improve management ability, reduce energy consumption intensity, and achieve the purpose of improving quality and efficiency.

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