Chapter 1

Introduction

Background and Significance of Research Problem

At the time, China's resource constraints were tightening, and environmental pollution was a serious concern. It was imperative to develop and utilize renewable energy. Specific commitments were as follows: by 2030, the proportion of non-fossil energy in primary energy consumption in China would increase to about 25%. Compared with 2005, the relative value of carbon dioxide emissions per unit of GDP in China would drop by more than 65% (Hu, et al., 2021). Among all kinds of renewable energy, solar energy was clean, safe, and efficient, widely distributed, inexhaustible, and had incomparable development advantages compared with other energy sources (Yuan, 2022, pp. 413-415). Research on the impact of government subsidies on technological innovation in China's photovoltaic industry.

The photovoltaic industry was the main aspect of solar energy application. According to the 2021 renewable energy installed capacity data released by the Renewable Energy Agency (IRENA), the global PV installed capacity in 2020 was 127GW, an increase of 30.2% over 2019. The submission of such transcripts in 2020, when COVID-19 was raging, was inseparable from the support of governments of all countries for the carbon emission reduction industry, among which the installed capacity of China's new photovoltaic power generation ranked first in the world. It is worth noting that the new installed capacity of all renewable energy sources in 2020 was about 260GW, of which photovoltaic accounted for nearly 50%, showing a strong development trend in the photovoltaic industry. By 2020, the cumulative installed capacity of global PV reached 733GW, an increase of 26.7% over 2019. In 2020, the total installed capacity of renewable energy in the world was 2799GW, of which photovoltaic accounted for 26% (Tang, 2022).

As early as 2000, China had made a preliminary plan for the photovoltaic industry. Subsequently, industrial policies such as the Strategic Action Plan for Energy Development (2014-2020) and the Guiding Opinions on the Establishment of the Target Guidance System for the Development and Utilization of Renewable Energy had been issued successively, providing a systematic guarantee for the development of the photovoltaic industry. In 2020, China announced at the 75th United Nations General Assembly that

China would strive to reach the peak of carbon dioxide emissions by 2030 and achieve the goal of carbon neutrality by 2060. As a relatively mature new energy industry in China, the development of the photovoltaic industry received more attention. According to the data of the National Energy Administration, China's newly added photovoltaic grid-connected installed capacity in 2021 was 54.88 million kilowatts, a record high.

In June 2022, the National Development and Reform Commission and other nine ministries and commissions jointly issued the "Fourteenth Five-Year Plan" for renewable energy development, pointing out that the annual power generation of renewable energy would reach about 3.3 trillion kWh by 2025. During the "Fourteenth Five-Year Plan" period, renewable energy power generation would account for more than 50% of the total increase in electricity consumption, and wind power generation would double (Notice on Printing and Distributing the "Fourteenth Five-Year Plan" Renewable Energy Development Plan (Energy Administration, 2022).

China was the world's largest photovoltaic cell production and application market. The rapid development of the photovoltaic industry and the construction of many photovoltaic power stations rapidly expanded the demand for photovoltaic silver paste and the consumption of silver powder. Silver powder was widely used in photovoltaic silver paste because of its good conductivity. Photovoltaic silver powder referred to the flake aluminum powder or aluminum powder paste used in the photovoltaic market. It was the core raw material of photovoltaic silver paste, and its cost accounted for 98% of the total production cost of photovoltaic silver paste (Cheng, 2022).

China's photovoltaic silver powder market had a huge domestic substitution space. As an important conductive material, the quality and performance of photovoltaic silver powder directly affected the electrical properties, fluidity, adhesion, and other properties of photovoltaic silver paste (Zhong, Wang, & Shi, 2015, pp. 6-13). Research on silver powder for photovoltaic silver paste). It had an indirect influence on the body resistance, contact resistance efficiency, and photoelectric conversion of photovoltaic cells.

In 2021, China's PV silver paste market consumption was about 3,079,000 kg, up 24.8% year on year. In this context, according to the "2022-2027 Photovoltaic Silver Powder Industry Deep Market Research and Investment Prospect Forecast Analysis Report" released by the New World Industrial Research Center, the domestic demand for the photovoltaic silver powder market was close to 2,000,000 kg in 2021, and it was expected that the domestic demand for the photovoltaic silver powder market

would reach 4,325,000 kg by 2025. It had a good industry development prospect (Wang Qing, Jiang Hua, 2022. Analysis of the development status and problems of China's photovoltaic industry in the first half of 2022). Silver powder and silver paste had always been the key research content in the field of ABC Company. In addition, since the 1980s, many electronic components production lines had been introduced, resulting in the market driving force. The domestic silver powder and silver paste market had developed greatly, and most of the low-end products had been localized. However, silver powder and silver slurry were related to many fields such as powder metallurgy, chemical industry, electronics, etc., and there were certain technical difficulties. In addition, there was no systematic accumulation of research, development, and application in this field in China, lack of talents, and insufficient investment funds, so the quality management level and innovation ability were inferior to those of Japan, the United States, and other developed countries (Boland, et al., 2022).

In terms of silver powder, the production of major categories of silver powder for the electronic industry could also be realized in China, and the quality level of some products could also reach the same level as that of foreign countries. The main differences were reflected in the poor applicability of silver powder, the poor consistency in the quantitative production process, and the transition between research results and quantitative production. In terms of hardware, equipment level, automation level, and quality evaluation system were not perfect, and personnel quality and quality management level in software were poor (Azamfirei, et al., 2023, pp. 1-22).

The basic quality level of silver nitrate or electrolytic silver as the basic raw material was the same as that of foreign countries, but there were also problems in the quality of other related chemical materials. Another major factor was that the development level of the electronic industry was still at a low level in China. Generally, the new requirements for silver powder were first put forward by foreign countries, leading to preemption. The domestic silver powder was still in the imitation stage.

However, for domestic silver powder or silver paste users, domestic products had advantages in product supply, timeliness of technical services, and cost, which resulted in the current situation of the silver powder and silver paste market. With the continuous progress of domestic equipment manufacturing technology, talents, and research and development accumulation, the gap between domestic silver powder and silver paste and foreign countries would continue to narrow, market share would increase, and innovation capacity would also be strengthened.

In the context of the localization of silver powder and silver slurry, the research and application of new technologies can promote the rapid improvement of the quality

and performance of domestic photovoltaic silver powder and silver slurry, promote the continuous increase of localization rate, and eliminate inefficient and technologically backward related enterprises in the continuous process of technological innovation, playing a positive role in industry competition, and the industry competition pattern is expected to be more concentrated. The X technology of ABC Company emerged in this context, demonstrating a strong competitive advantage, and further expanding market share through continuous technological progress, updates, iterations, and applications.

Research Objectives

1. To compare the quality of silver powder before and after the implementation of X technology.
2. To examine the production cost and profit margin of silver powder products after the application of X technology by the ABC Company.
3. To evaluate the benefits of applying X technology to ABC Company competitiveness, in terms of customer product system, production cost, profit margin and market share.

Research Hypothesis

1. The product quality will increase after the application of X technology.
2. The production cost of silver powder products will decrease after the application of X technology, resulting in an increase in profit margin.
3. The application of X technology to silver powder products will lead to competitiveness which is assessed based on customer product system, production costs, profit margins, and market share.

Scope of the Study

1. Carried out technical research and development (X technology research) to control the nucleation of silver powder single crystal particles, refine the particle size of silver powder single crystal particles, and use dispersants. Provided improvement strategies for products to meet the needs of market development and technological development.

2. To accelerate the promotion and application of X technology in the ABC Company, we controlled the average particle size, particle size distribution, and other performance indicators of spherical silver powder by controlling various process parameters (specifically including reduction system temperature, silver ion concentration, reducing agent concentration, feeding speed, dispersant addition, etc.) during the reduction process. We met the customer's demand for product performance by strengthening cooperation with downstream customers.

Conceptual Framework

Conceptual framework as shown in Figure 1.1

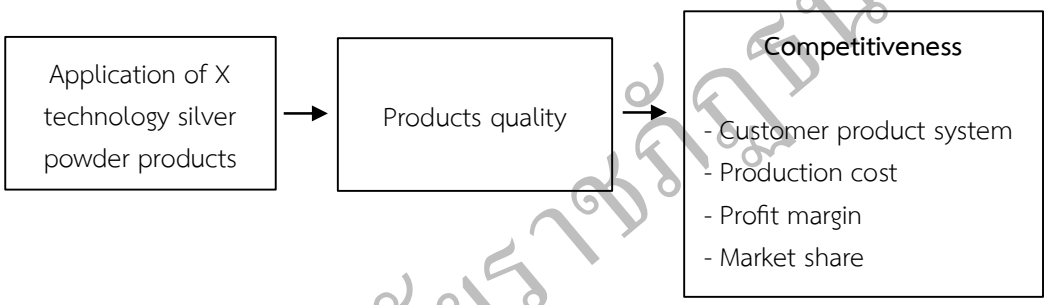

Figure 1.1 Conceptual Framework

The conceptual framework started with the independent variable, which was the application of X technology to silver powder products by the ABC Company. This technology was expected to impact the key performance indicators (KPIs), such as specific surface area, particle size distribution, and ignition loss, which served as the intervening variables in the framework. It was expected that the quality of the products would improve after the application of X technology.

In addition, it was anticipated that using X technology would lower production costs and boost profit margins. Additionally, it was anticipated that the implementation of X technology would lead to improvements in the customer product system and market share, all of which were measures of the ABC Company's competitiveness

Definition of Terms

1. Solar photovoltaic industry referred to as PV (photovoltaic), is a new power generation system that uses solar energy resources for power generation. Photovoltaic power generation is a technology that uses the photovoltaic effect of semiconductor interface to directly convert light energy into electrical energy.

2. Silver powder refers to the powdered material of metallic silver, which is the main raw material for making conductive silver paste. It has high specific surface area and strong sintering activity. It is mainly used as conductive filler in high-temperature sintered silver paste.

3. Silver paste is a conductive material composed of silver powder and resin materials, solvents and additives in a certain proportion to increase its conductivity and achieve the goal of maximizing the use of silver conductivity and thermal conductivity with the least amount of silver powder.

4. X technology refers to the new technology being developed by ABC Company, which is applied to the silver paste on the back of solar photovoltaic. Through the production process, the average particle size, particle size distribution, ignition loss and other key performance indicators of silver powder are controlled within a narrow fluctuation range, gradually replacing the existing technology and better adapting to the development requirements. Specific surface area refers to the total area of silver powder materials per unit mass.

5. Particle size distribution refers to the percentage of particles with different particle sizes in the total particles in the powder sample reflected by specific instruments and methods.

6. Loss on ignition refers to the percentage of the mass loss of raw materials that have lost external moisture after being dried within the temperature range of 400-600 °C and burned for a long time under certain high temperature conditions.

7. Product quality refers to the characteristics, features, and attributes of silver powder, which is evaluated based on key performance indicators such as specific surface area, particle size distribution, and ignition loss.

8. Competitiveness refers to the firm's ability to create, deliver, and capture value in a competitive market environment, which is assessed based on customer product system, production costs, profit margins, and market share.

Expected Benefits

The benefits that can be obtained from this research are as follows:

1. The application of X technology is expected to improve the quality of the products, which will increase customer satisfaction and enhance the company's reputation and credibility in the industry.

2. The reduction in production costs due to the application of X technology will result in increased profit margins and potentially higher prices for higher quality products.

3. The improved product quality and reduced production costs are expected to increase market share and enhance the competitiveness of the ABC Company in the industry.

4. Potential improvements in the customer product system may result in better customer loyalty and retention. Overall, the benefits of applying X technology to silver powder products by the ABC Company have the potential to lead to significant improvements in the company's profitability, market position, and reputation.