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Article

SWOT der Marktchancen für Wärmepumpen für private Wohnhäuser in China

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Abstract: This seminar paper focuses on a comprehensive SWOT analysis of market opportunities for geothermal heat pumps in private households across the Beijing-Tianjin-Hebei region of China, situated within the broader policy context of China's ambitious carbon neutrality target. The study first outlines the global development trends of heat pump technologies, juxtaposed against China's current high energy consumption and significant carbon emission status. It further details the unique climatic characteristics of the Beijing-Tianjin-Hebei region, which features hot summers and cold winters, making it an ideal candidate for advanced thermal regulation systems. Additionally, the classification and technical features of various heat pumps are systematically reviewed. By referring to practical application cases of ground source heat pumps in London residential buildings, this research rigorously evaluates their carbon reduction efficacy, long-term economic performance, and overall technical feasibility. A detailed SWOT analysis is subsequently conducted to critically examine the inherent strengths, weaknesses, emerging opportunities, and potential threats associated with this technology. The analytical results demonstrate that geothermal heat pumps possess immense market potential in the Beijing-Tianjin-Hebei region due to their exceptional energy-saving capabilities and low-carbon advantages. However, widespread adoption remains restricted by high upfront capital costs and complex installation requirements. Ultimately, this paper concludes that geothermal heat pumps are highly suitable for suburban private households endowed with sufficient financial resources and appropriate land conditions, while proposing future research directions focused on system optimization and broader market popularization.

Keywords: heat pumps; swot analysis; carbon neutrality; clean heating; market potential

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1. Introduction

1.1. Problem

This seminar paper examines the SWOT analysis of market opportunities for heat pumps for private homes in China to explore the potential of this market [1]. The study is framed within the broader context of China's carbon neutrality goal and provides a scientific analysis of the introduction of geothermal heat pumps in the Beijing-Tianjin-Hebei region. It evaluates critical factors in the SWOT analysis, such as energy efficiency, installation costs, demand, and restrictions. The practical relevance of the topic lies in the environmental impact of adopting heat pumps in the local context.

1.2. Objectives

This seminar paper aims to address the following research questions: Are heat pumps suitable for private homes in China? Which heat pumps are most needed in specific areas? What are the market opportunities for heat pumps in this region?

The primary research question is further refined and expanded by the subsequent questions. Building on the initial inquiry, the second and third questions delve into more specific aspects. China is a vast country with diverse climate zones. Additionally, there are various types of heat pumps, making certain regions more suitable for specific models. By exploring these questions, the market potential for heat pumps can be thoroughly analyzed [2].

1.3. Background

On 20 February 2023, the European Heat Pump Association reported that heat pump sales had reached a new record high [2]. Based on preliminary data from 16 European markets, approximately three million heat pumps were sold. This represents an increase of 38% compared to sales figures for 2021 and a further increase of 34% compared to 2020.

The reported sales figures indicate that the total number of heat pumps in Europe now stands at around 20 million. These devices heat approximately 16% of European residential and commercial buildings and contribute to avoiding 54 tonnes of CO_2 emissions. This significant market growth, which enhances emissions reduction, energy security, and affordability for end users, is the result of collaborative efforts within the European heat pump community [1].

1.3.1. Current Status of Energy Consumption in China

Global CO_2 emissions reached 33.88 billion tonnes in 2021. China has been the world's largest emitter of CO_2 since 2011, with emissions increasing annually [3]. In 2021, China's CO_2 emissions reached 10.52 billion tonnes, approximately three times higher than Europe's emissions and accounting for 31 percent of total global emissions.

Global coal consumption reached 160.1 EJ in 2021. China, as the world's largest coal consumer, accounted for more than half of this total, with a consumption of 86.17 EJ in the same year [4].

LNG plays a significant role in heating [5]. In 2021, China surpassed Japan to become the world's largest LNG importer, with imports totaling 109.5 billion cubic meters, contributing to nearly 60 percent of global LNG growth.

The analysis of CO_2 emissions, coal consumption, and LNG demand in China highlights the country's substantial energy consumption and demand.

1.3.2. Introduction to the Climate in China

China has an immense land area of approximately 9.6 million square kilometres [6]. A considerable part of its latitudes extends across temperate and subtropical zones, while a small part falls within the tropics. The terrain includes plains, hills, mountains, basins, and plateaus. As a result, China has a significant variety of climates: there is a temperate monsoon climate, a temperate continental climate, a subtropical monsoon climate, a high mountain climate, and others. The monsoon climate is the most widespread climate variant.

The Beijing-Tianjin-Hebei region, which surrounds the Chinese capital Beijing, is characterized by a temperate monsoon climate [7].

This is characterized by hot and rainy summers and cold and dry winters. The inhabitants of this region have a high demand for cooling in summer and heating in winter [8]. The following two tables show the temperatures in Beijing from 2 to 15 July 2023 and from 2 to 15 January 2024.

Due to the typical climate in the Beijing-Tianjin-Hebei region, this paper analyzes the market opportunities for heat pumps in this region [9].

1.3.3. Types of Heat Pumps

The cooling system that utilizes the heat emitted by the condenser for heat supply is called a heat pump. In modern society, the development of science and technology aimed at replacing fossil fuels with renewable energy is highly prioritized by governments worldwide. Heat pump technology effectively utilizes surface geothermal energy resources by consuming a small amount of electrical or mechanical energy to perform work through a heat exchange system. This technology achieves the dual function of heating and supplying hot water during winter and cooling during summer, making it a multifunctional and efficient method for utilizing renewable energy [10].

In a heat pump, environmental energy is converted into thermal energy using electricity. The energy source can be air, groundwater, or geothermal energy. Accordingly, there are various types of this heating system. Among these, air source heat pumps are widely recognized. Additionally, geothermal energy is used as a source to provide heat to many homes [1]. These brine-water heat pumps collect energy through probes or collectors and then convert it into heating energy.

1.3.4. Selecting the Region and Heat Pumps

The Beijing-Tianjin-Hebei region is situated in the North China Plain and faces limited water resources. This area is densely populated and experiences significant heating and cooling demands during winter and summer. Geothermal heat pumps, also referred to as ground source heat pumps, facilitate heat transfer between indoor air and the ground. Although their installation costs are higher, they are generally more efficient and have lower operating expenses due to the consistent ground temperature throughout the year [11].

Geothermal heat pumps present an optimal solution for addressing heating and cooling requirements in this region while promoting energy efficiency and environmental sustainability. This thesis examines the market potential for geothermal heat pumps in the Beijing-Tianjin-Hebei region.

2. Use of Heat Pumps in London

This chapter examines the use of ground source heat pumps in London and evaluates their feasibility for residential applications in developed areas [12]. The findings aim to provide a reference for the application of ground source heat pumps in the Beijing-Tianjin-Hebei region.

2.1. Background to the Application

In light of global climate change and increasingly serious environmental problems, the British government places significant emphasis on the development and use of renewable energy. As the economic and cultural center of the United Kingdom, London experiences high energy consumption and carbon emissions, making it particularly important to identify efficient and environmentally friendly energy solutions. Geothermal heat pump technology, with its distinct advantages, has emerged as a key option for London's energy transition [8]. The city possesses unique conditions for the application of geothermal heat pump technology due to its favorable geological characteristics and abundant groundwater resources. Fifteen buildings in London have been selected for assessment under a heat pump retrofit program aimed at achieving net zero carbon targets. These buildings include both residential and commercial properties, with the primary goal of improving energy efficiency and reducing carbon emissions through the implementation of heat pump technology.

2.2. Practical Example 1: Enfield High-Rise Building with 50 Flats

The building was constructed in the 1960s and has a floor area of approximately 2,900 square metres. The building is surrounded by extensive green areas within the property boundaries, which are easily accessible for drilling [13]. There is insufficient space in the building for a large central heat pump, and retrofitting insulated hot water pipes in the building was considered too costly. However, pipes for ambient temperature can be accommodated relatively easily in the existing house connection pipes.

The impact of installing ground source heat pumps was compared and evaluated with the impact of the original use of electricity for heating [14].

The results show that electric heating would emit a total of 567,252 kg of CO2 in 2030 and 816,697 kg of CO2 in 2050, while geothermal heat pump heating would emit 206,274 kg of CO2 in 2030 and only 296,981 kg of CO2 in 2050. With the geothermal heat pump system, the building will generate 64 percent less carbon dioxide for heating.

In addition, the ground source heat pump programme includes a clean heat grant of £4,000 per dwelling, totalling £200,000.

Ground source heat pumps are proving to be superior and more cost-effective for such buildings.

2.3. Practical Example 2: Ground Floor Flat in Camden

The building was constructed in the 1980s and covers an area of approximately 52 square metres. During on-site inspections, it was determined that there was no space for digging trenches, but there was space for drilling.

The apartment block is surrounded by sufficient communal areas to set up a shared geothermal energy cycle within the building boundaries. Most of the flats in the neighbourhood are owned by the local authority. If the local authority is willing to invest in a shared environmental cycle for the building, there is a possibility that private tenants will connect to the system and contribute to the overall costs [7].

As part of this study, the results of installing geothermal heat pumps were compared and evaluated with the results of the original natural gas heating system [7].

The results show that natural gas heating is expected to generate 15,347 kg of CO2 by 2030 and 43,251 kg of CO2 by 2050, while the geothermal heat pump system will generate 4,619 kg of CO2 by 2030 and only 6,650 kg of CO2 by 2050. The difference in CO2 emissions by 2050 is 6.5 times. There is also a significant difference in cost between the two heating methods [6]. The cost of installing natural gas heating is £2,017, while installing a ground source heat pump costs £18,426 plus the cost of a radiator, which is £1,758. There is a tenfold difference in fixed costs between the two heating options. In addition to the fixed costs, users also have to pay annual fuel and service charges.

The difference in fuel costs between the two types of heating is not significant [15]. However, the maintenance of geothermal heat pumps involves twice the costs compared to gas heating.

The lifetime costs for geothermal heat pumps are also high.

The slight additional efficiency of the ground source heat pump could not compensate for the higher acquisition costs due to the lack of space, which made the installation of a ground source heat pump system more difficult and costly [13]. However, ground source heat pump systems also have other advantages, such as quieter operation.

3. SWOT Analysis of Market Opportunities

SWOT analysis stands for Strengths, Weaknesses, Opportunities, and Threats. It is essential to understand SWOT analysis, particularly because it is frequently discussed in marketing meetings. The four fundamental questions and common errors in creating a SWOT analysis are briefly outlined below.

Strengths refer to what an organization excels at and how it distinguishes itself from competitors. Weaknesses are factors that hinder an organization from achieving optimal performance [12]. Opportunities are favorable external conditions that can provide a competitive edge. Threats are external elements that may negatively impact the organization.

3.1. Strengths

3.1.1. Energy Efficiency

Geothermal heat pumps are characterized by their exceptional energy efficiency. These systems utilize geothermal resources from the ground and water to provide heating and cooling services. The use of geothermal resources offers numerous environmental benefits, including cleanliness, environmental friendliness, stability, and recyclability. Compared to conventional heating methods, geothermal heat pumps are significantly more energy-efficient, achieving efficiencies of up to 400% or higher. For every 1 kW of energy consumed, users can typically obtain more than 4 kW of heat. Due to their high efficiency and energy-saving properties, geothermal heat pumps are widely utilized in the Beijing-Tianjin-Hebei region.

3.1.2. Environmental Friendliness

The use of geothermal resources through geothermal heat pumps offers numerous environmental benefits. Unlike conventional heating systems that burn fossil fuels and produce pollutants such as exhaust gases and waste residues, geothermal heat pumps operate without emissions. Additionally, they do not require cooling towers or other heat dissipation equipment, thereby eliminating the noise and air pollution typically associated with such systems. These environmentally friendly and pollution-free characteristics make geothermal heat pumps an ideal choice for eco-friendly buildings in the Beijing-Tianjin-Hebei region.

As the capital of China and the central hub of the Beijing-Tianjin-Hebei region, Beijing's environmental quality has long been a significant concern domestically and internationally [16]. Rapid industrial development in Tianjin and Hebei led to severe environmental pollution, including excessive emissions of carbon dioxide and other exhaust gases, which contributed to high levels of smog in the region. To address these environmental challenges, the Chinese government implemented the Beijing-Tianjin-Hebei coordinated development strategy in 2014, which included measures such as closing numerous heavy industrial factories and relocating the Beijing Shougang Group's factories from Beijing.

The low carbon emissions of geothermal heat pumps align with the objectives of energy conservation and emission reduction, making them suitable for large-scale promotion [1, 4].

3.1.3. Consistent Performance

The underground temperature in the Beijing-Tianjin-Hebei region remains relatively stable and is minimally influenced by seasonal and climatic changes. As a result, the heating and cooling performance of geothermal heat pumps is consistent and reliable, avoiding the temperature fluctuations commonly associated with conventional heating methods due to weather variations. This stability has led to the widespread adoption of geothermal heat pumps in the Beijing-Tianjin-Hebei region.

3.1.4. Analysis of Nissan's Price Differentiation

3.2. Weaknesses

The initial investment for geothermal heat pumps primarily includes the costs for equipment, installation, and commissioning. The installation and operating costs of geothermal heat pump systems are relatively high due to expenses associated with drilling wells, burying pipes, and installing heat pump units. This results in increased initial investment costs for the project, posing a challenge for households with limited capital. The initial costs, including equipment prices, range from approximately £8,500 to £10,000, or more than 80,000 yuan, which is slightly higher than other types of heat pumps. In 2003, per capita GDP in Beijing reached 200,000 yuan, while per capita GDP in Hebei Province was 59,332 yuan, and per capita GDP in Tianjin was 122,752 yuan. The lower per capita income in Hebei Province, combined with the significant initial investment costs for geothermal heat pumps, has limited their adoption in the region.

3.2.1. High Installation Requirements

The implementation of geothermal heat pump projects requires expertise in various fields, including geology, thermodynamics, and air conditioning technology. Consequently, significant technical demands are placed on the planning and construction personnel, necessitating a high level of expertise and experience [15]. This means that during project implementation, additional time and effort are required for technical training and guidance, thereby increasing the complexity and risk associated with the project.

3.2.2. Difficult Construction

The construction of geothermal heat pumps requires underground drilling, pipe laying, and other work that places higher demands on the environment and site conditions. In areas with complex geological conditions or limited construction space, the challenges of construction are compounded. The underground pipes of geothermal heat pumps occupy a certain amount of space, which can be restricted by urban planning, land use, and other factors. In mountainous regions, geothermal heat pump technology cannot be utilized due to complex geological conditions and dense rock distribution.

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3.3. Opportunities

3.3.1. Increasing Demand

With growing awareness of environmental protection and energy conservation, more private households are adopting geothermal heat pump technology. Demand for geothermal heat pumps has risen rapidly, particularly in the Beijing-Tianjin-Hebei region, due to air quality concerns and high heating requirements during winter. Data from the Ministry of Natural Resources indicates that the heating and cooling area of the geothermal heat pump industry in the country has grown significantly, with an average annual growth rate of over 20%, increasing from approximately 100 million square metres in 2010 to over 800 million square metres in 2020. This trend suggests that the scope of application for geothermal heat pumps will continue to expand.

3.3.2. Political Support

Geothermal heat pump technology has received substantial policy support, particularly within the framework of the national emphasis on renewable energy and environmentally sustainable buildings. National and local governments have implemented various preferential policies and subsidies to promote the adoption of geothermal heat pump technology among residents. The Beijing-Tianjin-Hebei region, which is pivotal in efforts to prevent and control air pollution in China, is at the forefront of the clean heating renovation initiative and receives significant attention from the state. Among the initial 12 demonstration cities approved for clean heating, half were located in the Beijing-Tianjin-Hebei region, including Tianjin, Shijiazhuang, Tangshan, Baoding, Langfang, and Hengshui. In subsequent batches of demonstration cities, all cities within the Beijing-Tianjin-Hebei region were included in the funding scope. Over the full three-year subsidy period, the 13 cities in Hebei Province are projected to receive 16.5 billion yuan in central financial support, Tianjin 3 billion yuan, and Beijing 900 million yuan.

3.3.3. Ample Space

The suburbs of the Beijing-Tianjin-Hebei region are expansive and characterized by low building density. Most residences consist of low-rise structures, country houses, or villas, which facilitate the efficient installation of geothermal heat pump systems.

3.4. Risks

3.4.1. Strong Competition in the Market

The continued expansion of the geothermal heat pump market has attracted numerous companies, resulting in a diversification of available heat pump types. Among these, air source heat pumps and water source heat pumps stand out due to their lower installation and maintenance costs, while delivering nearly equivalent performance to geothermal heat pumps. This allows consumers greater flexibility in choosing the type of heat pump for their homes. Consequently, the geothermal heat pump sector faces intensified market competition and significant challenges.

3.4.2. Incomplete Laws

Currently, the adoption of geothermal heat pumps remains limited, and the legal framework governing geothermal heat pump technology is insufficient, with no standardized regulations or norms in place. This lack of uniformity can result in challenges and disputes during the planning, construction, and operation of certain projects. For instance, there may be uncertainty regarding whether the excavation of underground pipelines can be approved by residential area administrations [12]. To facilitate the promotion of geothermal heat pumps as a clean energy source and address potential issues, it is essential for the government to promptly enhance relevant laws and regulations.

4. Summary

4.1. Key Findings and Conclusion

This paper analyses the different types of heat pumps, energy use and demand in China, and the application of geothermal heat pumps in some London residential buildings. In addition, typical geothermal heat pumps and the Beijing-Tianjin-Hebei region, which faces significant environmental challenges and has high potential for the development of clean energy, are selected. Finally, the two are combined in a SWOT analysis of the market opportunities for geothermal heat pumps in private homes in the Beijing-Tianjin-Hebei region. The results of the SWOT analysis suggest that geothermal heat pumps have achieved a certain market share in private residential construction in the Beijing-Tianjin-Hebei region due to their advantages, such as low carbon emissions and energy savings, high efficiency in heat generation and stable operation, as well as the climatic conditions of the region with cold winters and hot summers. To achieve the goal of energy conservation and emission reduction, significant financial resources have been invested in the field of clean energy to promote the rapid development and widespread application of the heat pump industry. The market potential of geothermal heat pumps can be described as extremely high.

Nevertheless, it should be noted that the use of geothermal heat pumps in private homes in the Beijing-Tianjin-Hebei region is limited by a number of factors, such as high costs and installation difficulties. Competition in the heat pump market is intensifying as a result of scientific and technological developments, with more and more products offering similar, if not identical, advantages to geothermal heat pumps at a lower price. This is leading to a shift in market share in favor of pressure pumps.

Therefore, geothermal heat pumps can be considered ideal heating and cooling systems for residents of the Beijing-Tianjin-Hebei region with sufficient financial resources and an appropriate amount of land around their buildings.

4.2. Limitations of the Work

The significance of this study is constrained by several limitations. The SWOT analysis focuses exclusively on evaluating market opportunities for geothermal heat pumps in private homes located in the suburban areas of the Beijing-Tianjin-Hebei region. Applications in central urban areas are not considered, which limits the generalizability of the findings to urban zones characterized by high building density and large populations. Additionally, a small portion of the suburban areas in this region includes mountainous terrain with complex geological structures, where geothermal heat pumps may not always be the most suitable solution. In such cases, a thorough geological survey is a prerequisite before installation, as the feasibility and effectiveness of geothermal heat pumps depend heavily on local geological conditions. Installation work can only proceed after the completion of this survey to ensure optimal outcomes.

4.3. Future Research Opportunities

Considering the aforementioned aspects, future research should thoroughly examine the market potential for geothermal heat pumps in the region. Greater focus is needed on optimizing the design and operational strategies of geothermal heat pump systems under varying geological conditions to enhance their energy efficiency and reliability.

Additionally, research should explore methods and technologies to improve the integration of geothermal heat pump systems and maximize land-use efficiency, particularly in areas with limited land resources. Efforts should also be directed toward reducing the initial investment costs of geothermal heat pump systems through technological advancements and supportive policy measures, thereby encouraging their adoption and application in the private housing sector.

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