

2024 "Huashu Cup" International Mathematical Contest in Modeling

ICM

Problem B: Photovoltaic Power



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Background

The composition of China's electricity includes traditional energy generation (such as coal, oil, and natural gas) renewable energy generation (such as hydropower, wind, solar, and nuclear), and other forms of electricity. These power generation modes play a crucial role in meeting China's huge demand for electricity. According to the latest data, China's total power generation exceeds 20 trillion kilowatt-hours, ranking first in the world overall. The electric energy industry is closely related to factors such as economic status, household consumption level, urbanization rates, and marketization. Electric energy is the foundation of economic development and social progress, which plays a key role in industrial and agricultural production, commercial services, and family life. With the growth of China's economy and the continuous improvement of people's living standards, the demand for electric energy has increased. However, to achieve the Chinese government's goal of carbon peaking and carbon neutrality, China needs to change the structure of electricity. Under the premise of meeting the demand for electric energy, it is necessary to reduce the dependence on traditional energy generation gradually and increase the proportion of renewable energy generation. This requires increasing the development and utilization of renewable energy, improving energy efficiency, and promoting the innovation and application of clean energy technologies.

Photovoltaic power generation is an important renewable energy source. The conversion of solar energy into electricity can reduce the dependence on traditional energy sources, with significant environmental protection and sustainable development advantages. Globally, photovoltaic power generation is developing rapidly. At present, many countries are using photovoltaic power generation as an important means to promote clean energy transition. These countries have increased investment and support for photovoltaic power generation in terms of policy support, technological innovation, and market development, resulting in increasing photovoltaic power generation capacity. In China, photovoltaic power generation has also made remarkable progress. China has the largest photovoltaic market and photovoltaic power station in the world. China has vast non-arable resources, such as

deserts and saline-alkali land, which can be used to build photovoltaic power stations. However, there are still some shortcomings in photovoltaic power generation. First of all, there is still space for improvement in the efficiency of photovoltaic power generation, and the power generation capacity is not the same in different regions, different seasons, and different day periods. Secondly, the development of photovoltaic power generation also faces some technical challenges, such as the cost, stability, and reliability of photovoltaic modules need to be further improved. In addition, the sustainability of photovoltaic power generation also needs to be considered, including environmental issues such as the recycling and reuse of photovoltaic cells, and component maintenance issues. Moreover, to promote the development of photovoltaic power generation, it is necessary to incorporate it into the overall strategy of the national economy and achieve gradual and orderly development. This includes strengthening policy support, providing investment and financing mechanisms, strengthening technological research and development and innovation, and establishing sound market mechanisms and management systems. At the same time, it is also necessary to strengthen the coordination between photovoltaic power generation and the grid, improve the predictability and schedulability of power generation, and ensure a stable supply of photovoltaic power generation.

The conversion efficiency of photovoltaic cells varies with different technologies and materials. The conversion efficiency of a photovoltaic cell refers to the ability of solar energy to convert into electricity, usually expressed as a percentage. Currently, the most advanced commercial photovoltaic cells can achieve a conversion efficiency of more than 25%. Moreover, photovoltaic power generation faces competition from other clean energy sources, such as tidal power and wind power. Factors such as the domestic demand for electricity, the efficiency of electricity production, the export market, and the technological progress of photovoltaic products may have an impact on China's photovoltaic power generation industry.

Requirements

Create a mathematical model to answer the following questions:

- The electricity supply in China and many factors interact. Please study the relationship between them, and predict the development trend of electricity supply in China from 2024 to 2060.
- There are many factors to consider when building a photovoltaic power plant. This requires consideration of costs and benefits, as well as geography and lighting conditions. Please select an area and discuss the feasibility of building a photovoltaic power plant there.
- If you want to build multiple photovoltaic power stations in China, combined with China's geographical resources and investment capacity, cost and income factors, what is the maximum potential of photovoltaic power generation in China.

In other words, what is the maximum photovoltaic power generation?

- To achieve the Chinese government strategic goal of carbon peaking and carbon neutrality by 2060, replacing coal-fired power generation with clean energy is a wonderful idea. Can this idea be realized? Please study the strategic planning for the sustainable development of photovoltaic power generation in China and answer this highly anticipated question.
- Based on the results of your research, please write a 1-page letter to the Chinese government.

Your PDF solution of no more than 25 total pages should include:

- One-page Summary Sheet.
- Table of Contents.
- Your complete solution.
- One-page letter.
- Reference List.

Note: The Contest has a 25-page limit. All aspects of your submission count toward the 25-page limit (Summary Sheet, Table of Contents, Report, One-page letter, Reference List, and any Appendices). You must cite the sources for your ideas, images, and any other materials used in your report.