Enquiry Question: **Should nuclear power be developed in China to alleviate its energy problems?**

Year of Examination: ________________________________

Name of Student: ________________________________

Class/ Group: ________________________________

Class Number: ________________________________

Number of words in the report: 3630

Notes:

1. Written reports should not exceed 4500 words. The reading time for non-written reports should not exceed 22 minutes and the short written texts accompanying non-written reports should not exceed 1100 words. The word count for written reports and the short written texts does not include the covering page, the table of contents, titles, graphs, tables, captions and headings of photos, punctuation marks, footnotes, endnotes, references, bibliography and appendices.

2. Candidates are responsible for counting the number of words in their reports and the short written texts and indicating it accurately on this covering page.

3. If the Independent Enquiry Study Report of a student is selected for review by the School-Based Assessment System, the school should ensure that the student’s name, class/ group and class number have been deleted from the report before submitting it to the Hong Kong Examinations and Assessment Authority. Schools should also ensure that the identities of both the schools and students are not disclosed in the reports. For non-written reports, the identities of the students and schools, including the appearance of the students, should be deleted.
Table of Contents

A. Problem Definition  
P. 3-5

B. Relevant Concepts and Knowledge/ Facts/ Data  
P. 6

C. In-depth Explanation of the Issue  
P. 7-10

D. Judgement and Justification  
P. 10-12

References  
P. 13-14
A. Problem Definition

Background Information
With advanced technology and ever increasing world population, energy consumption has been rocketing every year. This has given rise to many energy-related problems including energy crisis, soaring and fluctuating fuel prices and serious environmental problems caused by the combustion of fossil fuels.

The use of nuclear power, which is a rather clean and efficient energy, has always been seen a panacea to many of the energy problems mentioned above. It was also recorded that nuclear (fission) power stations, excluding the contribution from naval nuclear fission reactors, provided about 5.7% of the world's energy and 13% of the world's electricity in 2012. However, there has been an ongoing debate about the use of nuclear power.

This study aims at examining the appropriateness of developing nuclear power to address China’s current energy problems. The analysis will include various dimensions, namely the efficiency, environmental friendliness and safety of nuclear energy.

Energy Problems in China
China, like most regions in the world at present, is experiencing significant growth in energy demand, thereby putting enormous pressure on the global supply. Fossil fuels, as one of the largest sources of energy, are facing depletion and the whole world is undergoing a potential energy crisis. Energy use (kt of oil equivalent) in China was last measured at 2432504.85 in 2011, according to the World Bank. Table 1 shows some important indicators in terms of energy use in China. The shortage of fossil fuels has raised the price of electricity, thereby impeding China’s economic growth and pushing up the general cost of living.

On the other hand, the heavy reliance on fossil fuels has led to environmental degradation. The amount of energy consumption has been increasing, and with such a huge energy production and use, China has been dealing with the most serious energy and environmental problems it has ever faced.

There is also another energy problem that China is confronting: energy efficiency. The energy intensity of China was 35,766 British thermal units per U.S. dollar in 2005. In the U.S., the Btu/dollar ratio was 9,113. In the U.K. and Japan, the figures (6,145 and 4,519 respectively) were even lower. Thus finding an energy source that is efficient enough is also pertinent to China in order not to hinder its rapid economic growth.

Due to the increasing concerns about air quality, climate change and fossil fuel shortages, nuclear power has been regarded as an alternative to coal power in China. As of April 2014, the People's

---

3 U.S. Energy Information Administration http://www.eia.gov/
Republic of China has 21 nuclear power reactors operating on 6 separate sites and 28 under construction. Table 2 shows the locations as well as capacities of the nuclear power plants which are either recently completed or are under construction. China's National Development and Reform Commission has also indicated the intention to raise the percentage of China's electricity produced by nuclear power from the current 2% to 6% by 2020. However, is nuclear power really an appropriate way to alleviate the energy problems in China? Will its development bring more good than harm to China?

Focus questions
- Can nuclear power alleviate the energy problems in China?
- Does nuclear power bring more good than harm to China?
- Is nuclear power the best among alternatives in addressing the energy problems in China?

Table 1 Indicators of Energy Use in China

<table>
<thead>
<tr>
<th>Indicators of Energy Use</th>
<th>1990</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative and nuclear energy (% of total energy use) in China</td>
<td>1.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Fossil fuel energy consumption (% of total) in China</td>
<td>75.5</td>
<td>79.2</td>
</tr>
<tr>
<td>Energy use (kg of oil equivalent) per dollar 1:000 GDP (constant 2005 PPP) in China</td>
<td>691.6</td>
<td>325.1</td>
</tr>
<tr>
<td>Energy use (kt of oil equivalent) in China</td>
<td>863075.0</td>
<td>1094871.4</td>
</tr>
<tr>
<td>Combustible renewables and waste (metric tons of oil equivalent) in China</td>
<td>200407.0</td>
<td>203632.5</td>
</tr>
<tr>
<td>Combustible renewables and waste (% of total energy) in China</td>
<td>23.2</td>
<td>18.6</td>
</tr>
<tr>
<td>Electric power consumption (kWh) in China</td>
<td>58020000000.0</td>
<td>1254102000000.0</td>
</tr>
<tr>
<td>Electric power consumption (kWh per capita) in China</td>
<td>511.1</td>
<td>993.2</td>
</tr>
<tr>
<td>Energy use (kg of oil equivalent per capita) in China</td>
<td>760.3</td>
<td>867.1</td>
</tr>
</tbody>
</table>

5 Wikipedia: Nuclear power in China http://en.wikipedia.org/wiki/Nuclear_power_in_China
<table>
<thead>
<tr>
<th>Location of Nuclear Power Reactors</th>
<th>Maximum capacity</th>
<th>Current phase capacity</th>
<th>Active capacity</th>
<th>Scheduled completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tianwan</td>
<td>8,400 MW</td>
<td>4,000 MW</td>
<td>2,000 MW</td>
<td>2018</td>
</tr>
<tr>
<td>Ningde</td>
<td>6,000 MW</td>
<td>4,000 MW</td>
<td>1,000 MW</td>
<td>2013/2015</td>
</tr>
<tr>
<td>Hongyanhe</td>
<td>6,000 MW</td>
<td>4,000 MW</td>
<td>1,000 MW</td>
<td>2013/2014</td>
</tr>
<tr>
<td>Yangjiang</td>
<td>6,000 MW</td>
<td>4,000 MW</td>
<td>0 MW</td>
<td>2013/4/5/7</td>
</tr>
<tr>
<td>Qinshan</td>
<td>6,828 MW</td>
<td>5,428 MW</td>
<td>4,028 MW</td>
<td>?</td>
</tr>
<tr>
<td>Fangjiashan</td>
<td>2,000 MW</td>
<td>2,000 MW</td>
<td>0 MW</td>
<td>2013/2014</td>
</tr>
<tr>
<td>Fuqing</td>
<td>6,000 MW</td>
<td>4,000 MW</td>
<td>0 MW</td>
<td>2013/4/5/7</td>
</tr>
<tr>
<td>Sanmen</td>
<td>6,000 MW</td>
<td>2,000 MW</td>
<td>0 MW</td>
<td>2014/2015</td>
</tr>
<tr>
<td>Haiyang</td>
<td>8,000 MW</td>
<td>2,000 MW</td>
<td>0 MW</td>
<td>2014/2015</td>
</tr>
<tr>
<td>Taishan</td>
<td>6,800 MW</td>
<td>3,400 MW</td>
<td>0 MW</td>
<td>2013/2014</td>
</tr>
<tr>
<td>Xianning</td>
<td>10,000 MW</td>
<td>2,000 MW</td>
<td>0 MW</td>
<td>2015</td>
</tr>
<tr>
<td>Fangchenggang</td>
<td>6,000 MW</td>
<td>2,000 MW</td>
<td>0 MW</td>
<td>2015</td>
</tr>
<tr>
<td>Changjiang</td>
<td>2,600 MW</td>
<td>1,300 MW</td>
<td>0 MW</td>
<td>2014/2015</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80,628 MW</strong></td>
<td><strong>40,128 MW</strong></td>
<td><strong>8,028 MW</strong></td>
<td></td>
</tr>
</tbody>
</table>
B. Relevant Concepts and Knowledge/ Facts/ Data

Nuclear power
Nuclear power, or nuclear energy, is the use of exothermic nuclear processes to generate useful heat and electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. The objective of using nuclear power is to increase energy provision due to the abundance of uranium, as well as minimizing the environment problems caused by energy generation. Its appropriateness to be used in China is to be discussed.

Energy problems
Energy problems include the lack of energy provision due to the foreseeable deficiency of non-renewable energy and low efficiency of most renewable energy. Secondly, there is the climate and environmental problems due to the overuse of energy and fossil fuels/coal extractions and use.

Quality of life
If alternative energy providing method is not developed and used, human kind will soon face energy crisis where the energy supply cannot meet the huge demand of energy nowadays. On the other hand, if cleaner and renewable energy are not used, China will have more and more serious environmental problems due to the extraction and use of non-renewable energies such as fossil fuel and coal. These problems will pose negative impact to people’s quality of life in social and environmental contexts.

Sustainable development
Sustainable development posits a desirable future state for human societies, where it fulfills people’s needs in economic, social and environmental aspects while not compromising future generation’s interests. To develop and use an energy that can ensure sustainable development of that energy and China is important. Fossil fuel, for example, cannot enhance sustainable development due to its huge damage to the environment. Whether nuclear energy is good enough for China in promoting sustainable development will be explored.

Appropriateness as an energy source
The appropriateness of an energy source could be assessed with reference to the possibility of increasing energy provision, decreasing environmental harms caused by the use of the energy and its efficiency. The study will investigate the feasibility and effectiveness of using nuclear power or other energy alternatives in solving the energy problems in China.

---

7ZME Science
http://www.zmescience.com/tag/nuclear-power/
C. In-depth Explanation of the Issue

As of April 2014, the People's Republic of China has 21 nuclear power reactors operating on 6 separate sites and 28 are under construction. It was also suggested by the State President of China Xi that China should increase the pace of nuclear power development, especially in the eastern part of China. Xi mentioned that after long time of development, China has already become the country with the largest energy production and usage. Such a high demand for energy as well as damage to the environment has become a burden for China in its course of development.\(^8\)

The key stakeholders involved in the issue are the Chinese government, green groups, all households in China and the businesses involved in coal/fossil fuels mining.

The controversial nature of this issue can be shown from the two surveys conducted in 2012 and 2013 respectively.

In 2012, a survey conducted by the International Journal of medical sciences shows that only 40.3% respondents believed that nuclear power would bring more good than harm to China. While 34.7% of the subjects supported China's great efforts to develop nuclear power plants, 54.7% people opposed the building of nuclear power plants in local region.\(^9\) On the other hand, a survey conducted by the Ipsos in 2013 shows that 45% of the respondents in the world supported the development of nuclear energy and in China, a good amount of 59% showed their approval, a percentage which is significantly higher than other countries.

From both surveys, around half of the respondents either support or object to nuclear power development in China. In other words, there is no overwhelming agreement or disagreement to the issue, and the situation remains the same for most other countries as well. However, it is worth noting that during the survey in 2012, nearly 70% of the respondents believe renewable energy such as solar energy should be developed in China.

In relation to the development and use of nuclear power in China, conflicts may arise, firstly, due to the different views about nuclear power’s environmental performance. Different from coal or fossil fuels energy generation, nuclear power does not produce any greenhouse gases, which is the culprit of global warming and other serious pollution problems. This is one of the reasons why many, especially green groups, support the use of nuclear energy. When compared to other generation staples like coal, natural gas or renewables, nuclear energy is considered more capable of reliably meeting the demands of a growing population while being a clean energy. Some people, however, believe that nuclear power is not environmental friendly due to the severe waste problems created by it. Given that the wastes from nuclear power production can be dangerous and that the danger may last for thousands of years, developing nuclear energy extensively to tackle the energy problems faced in China remains a difficult decision to make.\(^10\)

---

Apart from that, people have conflicts on the safety issue of nuclear power. There have been quite a number of nuclear power plant accidents including: Three Mile Island accident (1979), Chernobyl disaster (1986), and Fukushima Daiichi nuclear disaster (2011), where the nuclear power plants exploded and killed many people. Worse still, the impact has not yet subsided till now. There were some nuclear submarine accidents as well. Numerous studies have been carried out on the possible effects of nuclear power in causing cancer. The New York Times has also reported that China is placing many of its nuclear plants near large cities, and there is a concern that tens of millions of people could be exposed to radiation in case of an accident. That’s why many, including the general public, objects to the plan of developing nuclear power in local areas as it may lead to long lasting devastation whenever there is an accident of leakage or explosion.

Apparently, the general public and the government are divided over the use of nuclear power for they perceive the energy issue different. Many people disapprove of the further development of nuclear power in China for they are afraid of nuclear leakage or even explosion. Yet, it is understandable that the government is more concerned about the reliability and perhaps efficiency of energy provision. China is experiencing civic protest over its plans to build more nuclear power plants following the Fukushima nuclear disaster. More than 1,000 people protested in Jiangmen City Hall in July 2013 to urge the authorities to abandon a planned uranium-processing facility that was designed as a major supplier to nuclear power stations.

On the other hand, there are also people who maintain that nuclear power is the safest among alternatives and cause the least harm. Once the technology level of the country has been met and that the power plant was under good maintenance, the risk of having nuclear power accident is extremely low. It was also asserted that aside from Chernobyl, no one, from nuclear workers to the general public, has ever died from radiation exposure due to a commercial nuclear reactor incident.

There are also conflicts of interest between businesses that produce energy using non-renewable energy in China and the green groups. The development and use of nuclear energy in China means there would be a decrease in the demand for fossil fuels/coal energy provision. Thus the profit of the businesses that are engaged in non-renewable energy provision will be lower, and many of those businesses will thus oppose the idea of developing nuclear power in China. While on the other hand, the government and the green groups advocate the development of nuclear power because of the limited provision of fossil fuel energy and the accompanying environmental problems, and they avow that nuclear power might be the best way out.

14 PBS Frontline http://www.pbs.org/wgbh/pages/frontline/
There are debates in society whether other alternatives are better than nuclear power. The general public in China preferred solar power the most among different energy provision alternatives, with a number of around 70%, while nuclear power is only getting a 40.3%. It shows that many people consider other renewable energies to be a better choice than nuclear power for China. Some believe that solar and wind energy are better as they are not only environmentally friendly and renewable, but that they do not pose threat to human beings like nuclear power might do. However, some might also think nuclear power is better as its energy efficiency is way much higher than that of other renewable energies.

Last but not least, stakeholders also have conflicting views about China’s capability to develop, use and manage nuclear power. As the safe running of nuclear power plants requires advanced technology and expert knowledge, China’s competence to develop this energy is the concern of many stakeholders.

Many argue that China cannot meet the international nuclear safety standard under a national business culture where quality and safety sometimes take a back seat to cost-cutting, profits and outright corruption — as shown in scandals involving the food, pharmaceutical and toy industries. Due to all these problems, it might be hard for China to develop and maintain the nuclear power plant well, and the risks of having nuclear accidents might be high. Thus many state that China should not develop nuclear energy. “At the current stage, if we are not fully aware of the sector’s over-rapid expansions, it will threaten construction quality and operation safety of nuclear power plants,” Li Ganjie, the director of China’s National Nuclear Safety Administration, said in his speech.15 There are of course, people who affirm nuclear development is suitable for China as they believe China has the most resources to develop such energy, and Xiao Guoqing also said, “there are factories specially designed for nuclear waste disposal in China now, and China has the technology to manage the nuclear waste as well as maintaining power plant’s safety.”16


16 中国科学报
D. Judgement and Justification

It is believed that nuclear power should be developed in China so as to alleviate the local energy problems.

Focus Question 1: Can nuclear power alleviate the energy problems in China? (high price, sustainable?)

Nuclear power can alleviate the energy problems in China. Firstly, nuclear power is very environmentally friendly, solving the pollution problems caused by using non-renewable energy sources. Nuclear power energy releases the least greenhouse gases. As per the reports in 1998, it has been calculated the emission of the greenhouse gas has reduced for nearly half due to the popularity in the use of nuclear power. According to foreign example, Areva NC claimed in 2007 that, due to their reliance on nuclear power, France's carbon emissions per kWh are less than 1/10 that of Germany and the UK, and 1/13 that of Denmark, which has no nuclear plants. Its emissions of nitrogen oxide and sulfur dioxide have been reduced by 70% over 20 years, even though the total power output has tripled during the same period.\(^\text{17}\) All these show how nuclear power will be useful for China to solve its non-environmentally friendly energy extraction and provision problems. With the serious air quality and haze problem in China, China needs to speed up the pace of nuclear power development so as to cut the release of greenhouse gas from other energy sources.

Nuclear power can also address the problem of energy crisis, as uranium is not going to be depleted until several hundred years later. On the other hand, nuclear power is of very high efficiency, Nuclear energy have an efficiency of 32 % to 38 %, which is close to the efficiency of coal and a lot higher than that of other energy sources. Thus it can provide a huge amount of energy to China for a very long time and this alleviates the problem of energy shortage.

As coal and fossil fuels are becoming rare nowadays, the cost of coal mining and energy provision is higher. This pushes up the price of electricity and hinders economic development in China at large. Nuclear power is a possible solution as the cost of uranium, which is used as a fuel in generating electricity, is quite low. Though the set-up cost of nuclear power plants is relatively high, the running cost is generally low. The average life of a nuclear reactor ranges from 4 to 60 years depending upon its usage. All these mean that the cost of producing electricity is very low. Even if the cost of uranium rises, the increase in cost of electricity will not be as high. This can solve the problem of high energy cost in China.

According to the above, nuclear power is a more sustainable energy source. Its low carbon and greenhouse gas emission fulfills public’s demand in the environmental aspect. It is better than energy sources like coal or other fossil fuels, which pollute the environment severely and took away future generation’s right to enjoy a clean and healthy environment. In social aspect, nuclear power is reliable due to the abundance of uranium as well as its high efficiency. The public do not need to

\(^{17}\) “Nuclear energy and the greenhouse effect”
worry about energy depletion for at least quite some time if nuclear power is to be developed in a large scale manner. In economic aspect, the low costs of uranium as well as maintenance of nuclear power plants make the cost of developing and using nuclear power a lot lower than that of other energy sources in the long run. Not only can the government cut its cost in energy investment, the cost of living can also lowered. This will certainly be welcomed by people for their quality of life can be elevated. It can therefore be concluded that the development of nuclear power can bring environmental, social and economic benefits to China and there is no reason why its development should be obstructed.

Focus Question 2: Does nuclear power bring more good than harm to China?
Undeniably, the generation of electricity using nuclear power does result in the waste problem. The uranium waste is difficult to manage and it takes many years for it to lose its radioactivity and danger. The world's nuclear fleet creates about 10,000 metric tons of high-level spent nuclear fuel each year. This kind of waste will cause serious water and land pollutions later on after accumulation, and the radioactivity of the waste may also pose harms to people’s lives. There has been no solid solution about how to manage the nuclear waste so far. Currently, the nuclear industry stores the waste in massive concrete structures. France is storing its nuclear waste far underground and the impact is yet to be evaluated. This is certainly a valid concern for China to further develop its nuclear power since the nuclear waste can also produce environmental problem which is proved to be difficult to manage.

Despite this, nuclear power is still worth developing. At present, nearly one third of the world's energy demands are met by nuclear power plants. The waste and potential environmental hazards posed by nuclear power are minimal when compared with other major energy sources, such as fossil fuels. It is discovered that the same amount of electricity generated by nuclear energy, if produced using coal, would release nearly 147 million metric tons of carbon dioxide into the atmosphere. With nuclear energy, waste production is smaller and contained. The total volume of nuclear waste produced since the nuclear power industry began its operation is only enough to fill a football pitch to a depth of about 15 yards. This can be easily managed and held on site or in underground repositories, safely out of environmental or public contact.

Moreover, there are worries about nuclear accidents. Nuclear accidents can spread 'radiation producing particles' over a wide area, this radiation harms the cells of the body which can make humans sick or even cause death. Illness can appear or strike people years after they have been exposed to nuclear radiation and genetic problems can occur too. Famous accidents such as the Three Mile Island accident (1979), Chernobyl disaster (1986) and Fukushima Daiichi nuclear disaster (2011) show the potential danger nuclear power posed to the local residents of China if it is to be developed.

However, such potential risks can be minimized under close supervision and with the application of

---

19 “The Status of Nuclear Waste Disposal”
high technology. China’s State President Xi Jinping, has also declared that technical labour and skills are important for nuclear development and that China will focus on the supervision and control of the nuclear power plants to ensure safety. On the other hand, China, with its vast land and water resources, could build nuclear power plants in places farther away from the densely populated cities so as to minimize the impact of any possible nuclear leakage or even explosion. Therefore, when considering the foreseeable benefits nuclear power may bring, nuclear explosions or accidents, which are rare, should not be a hindrance to the use of nuclear power.

Focus Question 3: Is nuclear power the best among alternatives in addressing the energy problems in China? (efficiency, cost)

There are, of course, other alternatives to replace coal energy such as solar power and wind power. Solar and wind powers are both as environmentally friendly as nuclear power for they do not emit any green house gases as well. At the same time, they are free from the waste disposal and explosion concerns.

However, the efficiency of solar and wind powers is only 12-15%, which is extremely low when compared to that of nuclear power. Also, solar and wind powers are not reliable, since they need sunlight or wind which are not available 24 hours a day or under different weather conditions. Unlike solar and wind energies, nuclear energy can be produced regardless of the weather conditions.

Apart from that, the costs of both building and maintaining renewable energy power plants are much higher than that of nuclear power plants. At the same time, the materials essential to solar power plants require huge energy to produce, consuming much energy as well as resources. Nuclear power plants, on the other hand, do not share the same problem.

Conclusion: The benefits nuclear power brings can largely tackle the energy problems in China. Although there are some concerns relating to the use of nuclear power, these problems can be alleviated either through technology and supervision. They are considered negligible when compared to the huge benefits it brings. At the same time, there are not many alternatives that can replace nuclear power and bring similar benefits to China. Thus, it is asserted that China should continue with its huge nuclear power project, and could rely on nuclear power as one of the main energy sources in the coming decades.

(3630 words)
References


Wikipedia: Nuclear power in China
http://en.wikipedia.org/wiki/Nuclear_power_in_China


U.S. Energy Information Administration
http://www.eia.gov/

ZME Science
http://www.zmescience.com/tag/nuclear-power/

PBS Frontline
http://www.pbs.org/wgbh/pages/frontline/

“China faces civic protests over new nuclear power plants”, The Economic Times,
http://articles.economictimes.indiatimes.com/2012-02-17/news/31071199_1_nuclear-power-nuke-plant-pengze
<table>
<thead>
<tr>
<th>項目</th>
<th>分數*</th>
<th>評語</th>
</tr>
</thead>
</table>
| Should nuclear power be developed in China to alleviate its energy problems? | AB 7 | • Explained clearly the enquiry focus  
• Was able to identify highly relevant concepts and knowledge and outline the significance of these to the enquiry (e.g. introducing “sustainable development” as one of the criteria for assessing the use of nuclear power on P.6)  
• However, more elaboration on “alternatives in addressing the energy problems in China” (in the third focus question) was necessary for defining the scope of the study and confining the study to a manageable scale. Besides, Tables 1 and 2 should have been further analysed to depict the energy problems in China |
| CD 7 | • Was able to analyse the controversial nature of the use of nuclear power in China clearly, from which some dimensions for consideration were identified in response to the focus questions (e.g. safety concerns, long term energy usage, alternatives)  
• Formulated some evidence-based arguments and logical rebuttals (e.g. in the third paragraph on P.11)  
• But more consideration of the situation in China was necessary (e.g. in the arguments about the use of alternative energy resources on P.12) |
| PO 7 | • Was able to communicate ideas clearly and presented arguments in an orderly manner, though lacked clarity in parts (e.g. the central idea of Paragraph 2 on P. 7 was not clearly articulated)  
• Sources were acknowledged |

* AB: 題目界定和概念／知識辨識 (A 及 B 部分)  
Problem Definition and Identification of Concepts/Knowledge (Parts A & B)  

CD: 解釋和論證 (C 及 D 部分)  
Explanation and Justification (Parts C & D)  

PO: 表達與組織 (整分報告)  
Presentation and Organisation (the whole report)