Prospects of Solar Water Heating in China

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HSA 10-5 Economic of Oil and Energy

With the dramatic economic growth in China, the consumption and production of electricity increased significantly over the two decades.[1] However, China does not use a clean source of energy to produce electricity, instead, China choses the dirty and cheap energy source, coal. There are many negative aspects of the usage of coal. One of them is the environmental cost of coal. As the environmental issues get worsen in China, the Chinese government have the renewable energy policies that promote the implementation of renewable energy source such as solar and wind.

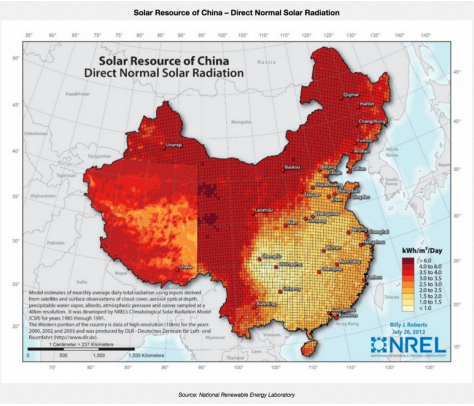
I. Background

a. What is solar energy?

Solar energy is a kind of energy from the sun that is converted into electric or thermal.[2] Solar energy is renewable and abundant. There are solar cells, photovoltaic, that converts solar energy into electricity by exciting electrons in the semiconductor. There are also solar thermal energies that uses the heat directly instead of the light.

b. Solar energy in China

The solar energy is abundant in China where the chance that have low resource is very low. As shown in the picture,



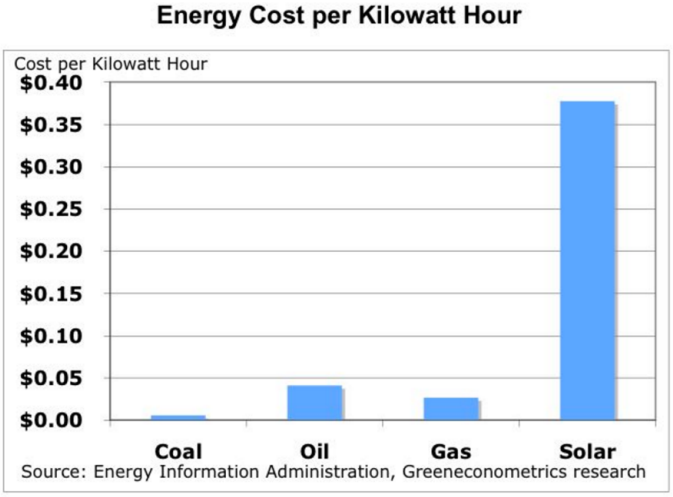
[1] Energy Information Administration and Short-Term Energy Outlook, May 2015

[2] http://www.seia.org/about/solar-energy

The solar resource of China is abundant and they are all in the rural area of China where the smog is not dense. Therefore, a lot of solar cells are implemented in those areas where the smog is not severe enough to block the sunlight. Because of the abundant solar energy, the solar PV installations are 10.6 GW which is nearly 25% of the total solar PV installation in the world 38.7 GW[3]. As shown there are growths in the solar PV installations were photovoltaics convert sunlight into electricity. However, it is not significant enough to reduce the coal consumption in China.

c. Disadvantage of Solar Energy

Although Chinese government and the policies are promoting the installations of solar cells, the actual cost of solar cells is expensive. As shown in the graph,



[4]

Cost per kilowatt Hour of solar energy is significantly higher than that of coal, oil and gas all combined. Therefore, solar energy is an expensive source of energy. However, the main reason of solar energy being expensive is the solar panels themselves.[5] That is only one-time investment, so the cost would eventually be even out as the time gone by. Therefore, as long as the people are able to afford

[3] http://www.eos-intelligence.com/perspectives/?p=1331
[4] http://greenecon.net/understanding-the-cost-of-solar-energy/energy_economics.html
[5] http://energyinformative.org/solar-panels-cost/

the initial cost of solar energy. Then the cost would not be that significant compared with other source of energy.

Cost of coal is the cheapest among all the energy sources, but the CO_2 emissions are the highest among the all. The environmental cost of coal is unable to be solved with money. As we see the environmental issues in China are causing not only environmental changes, acid rain and smog, but also are affecting people's health that leads to cardiovascular and lung issues. The health problems are unable to be solved with money. Even though, the solar energy has the highest cost, the environmental cost is minimal with nearly no carbon and greenhouse emissions.

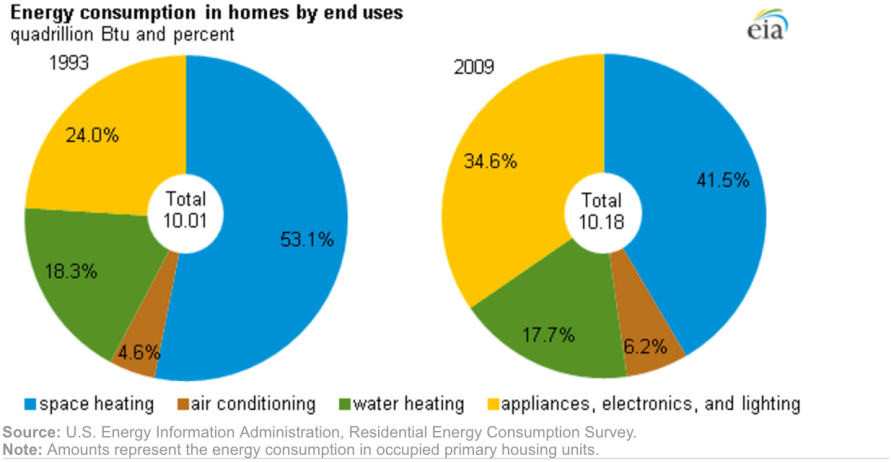
II. Solar Water Heating System

a. What is Solar Water Heating System?

Solar water heating is to use sun's thermal energy to heat water using a solar thermal collector. One type of the solar water heating system is evacuated tube. Comparing to the solar cells' efficiency, 10%- 18%, it can have up to 50%- 70% efficiency. [6]

b. Why?

20% of electricity used in homes by end uses is for water heating. As shown in the chart,

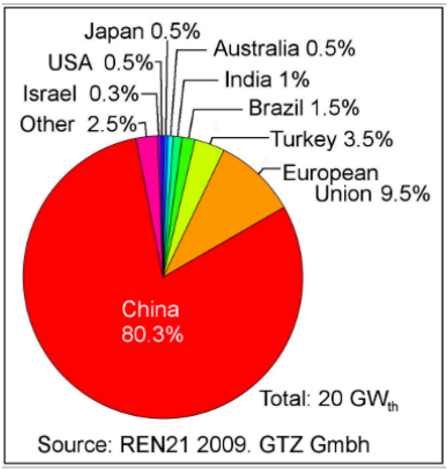


[6] http://www.pveducation.org/pvcdrom/appendices/solar-cell-efficiency-results2

The electricity used to water heating has not been decreased from 1993 to 2009. If you could replace this use of energy with solar water heating, around 20% of the electricity could be saved. Maybe can be used for other purposes, or maybe can even decrease the production and consumption of coal which China heavily rely on. Although this is not a big scale movement, the small steps can reduce residential utility costs and the specific amount of energy can be used for other purposes rather than to heat water purely which can be substituted by the renewable energy, solar.

c. Evacuated tube

There are a lot of types of solar water heating systems. One of them is evacuated tubes. Solar water heating system in China is cheaper than in Western countries because the labor is cheaper. As shown in the graph,



New solar hot water installations during 2007, worldwide. [7]

China has the highest percentage of the solar hot water installations during 2007. However, population is huge in China, the increase in the installations is not significant compared to the overall population and electricity usage in China. Usually, evacuated tube solar water heating systems are mounted on top of the roof and require a pump to make the water flow in the apartment. This design makes the house less attractive in appearance because of the huge water

[7] REN21 2009

heating system on the roof. However, there is the new kind solar water heating, evacuated tubes that can mounted as fences. In this picture,

The fences are next to a swimming pool and it does not affect the appearance that much. All the hot water that the swimming pool needed can be obtain from this system. We can now move on the analyze the actual cost of this implementations to see if this is a feasible plan.

III. Cost of the evacuated tubes

The costs of the evacuated tubes are mainly the installation fee, and the its maintenance. There is merely no cost of heating the actual water because it utilizes the solar thermal to heat the water.

a. Evacuated tube cost

Each evacuated water heater tube costs about $40 and a system of the solar water heating for 4-5 people usually needs 30 tubes. From the calculation, the tubes cost around $1200. Adding the cost of the installation fee, the whole system costs is around $2000. There is no other maintenance cost and it requires only little electricity to run. These tubes can get fixed easily because all the compartments are separable and individual. Broken parts can be replaced with a new one easily.

b. Electricity heating water

Average electricity bill is around $100/ month. As we previously mentioned, around 20% of the electricity is used for water heating. Therefore, $20 is saved per household. Given the amount of population in China, the money that can be saved is significant. Not only, money is saved, a lot of energy is being saved also.

c. Energy saved

The amount of CO_2 emissions due to coal consumption is increasing dramatically. 153.7 million short tons of coal is consumed for heat plants.[8] 1349 kWh/year [9]of electricity is used for each household in China and 20% of them is used for heating water 270 kWh/year. Although it seems like this is not a significant amount of electricity comparing with the amount of US and Canada, the large population and number of households are able to add up to the amount of electricity that is consumed in US. With the implementation of the system, the amount of the CO_2 is reduced which is better for the environment and the energy if saved at the same time.

IV. Feasibility

a. Structure

In China, most of people live in the apartment where the buildings are nearly 20 floors. These kind of buildings make the installation of solar panels difficult. However, solar evacuated tubes can be installed from the interior of the building without doing dangerous maneuvers during installation and maintenance. As shown, in the picture, 

[8] http://www.iea.org/stats/coaldata.asp?COUNTRY_CODE=CN

[9] http://shrinkthatfootprint.com/average-household-electricity-consumption

these fences can be replaced with the solar evacuated tubes. Therefore, the structure of the evacuated tubes is feasible for the apartments in China. This structure also avoids the bad appearance of solar panels that people do not like. People would be more willing to use this system instead of installing solar panels that is not so good in the appearances.

b. Affordable?

From the reports, Chinese average annual salary is about $4,755.[10] However, many of the Chinese do not have to worry about their housing payments or mortgages. This is because the Chinese culture that their parents will give their children a set of apartment when their children get married. Therefore, they do not have to worry about the housing mortgages. The cost of solar evacuated tube heating systems seems to be a lot compare with the average annual salary. The gap between the wealth and poor is significant. So that we cannot use the average annual salary to determine whether the solar evacuated tube water heating system is affordable for everyone. However, the wealthy household can definitely afford the heating systems.

V. Disadvantages

a. Storage

There are many advantages of this system, for example, no water storage, low cost and reduce the use of electricity. There water that has been heated is from stored in the tubes so that there is limited amount of water that can be stored. Thus, this limits the wide use of this system to the industrial area that requires large amount of water. However, if we only limit the use of this system in the residential area and every household have enough hot water to use, this technology still saves energy and utilizes the renewable energy to the full potential because the large population in China.

b. Location

[10] http://qz.com/170363/the-average-chinese-private-sector-worker-earns-about-the-same-as-a-cleaner-in-thailand/

In order to heat the water, the system requires the solar energy, sunlight. This system would not be sufficient at where the sunlight is limited.

In order to solve this problem, engineers design the second compartment of the system. The water is initially heated by the sunlight and it reaches to certain temperature based on the solar energy. A thermometer can determine the temperature of the water, then an electrical heater can heat the water to the desired temperature. Because large amount of heating is done by the sun, the electrical heater required such less energy than the electricity needed to heat the water from cold to hot.

VI. Conclusion

With many advantages and some disadvantages of the solar water heating system, we can see that it is environmental friendly and use the renewable energy as the source of energy. The system utilizes the sunlight source directly where it can reach to the efficiency 50%. Compare with the photovoltaics' efficiency, 14%, the more direct usage and higher efficiencies show that solar water heating system is a viable option. With a lot of research done on the conversion between the renewable energies to electricity, large amount of money and resources are spent on this solar technology. However, direct usages are sometimes more sufficient. There are limitations such as sunlight and storage for it to be widely used. Other technology can solve these problems. For example, there is the CO_2 heat pump water heaters that has a water storage and uses the greenhouse gas CO_2 heat to heat the water up to 90 degrees Celsius. However, CO_2 requires a large space to install which might not be viable due to the crowded apartment in China. Therefore, there are all kinds of disadvantages of the renewable energies usage. There must be a balance where we can use these renewable technologies to the maximum potential and maintain the ecosystem at the same time.

Although the use of renewable energies would be better for China because of the air pollution, the government and regulations might be preventing the project of renewable energies to start. There are many factors that contribute to the air

pollution in China as of today. Many of the officials get benefits from the coal company for not promoting new technologies. The corruption of the Chinese government causes that not a lot of people are willing to change the energy system in China. A lot of data, such as average annual income, cannot be trusted completely because filing taxes is not required in China. Therefore, we cannot have an accurate estimate on the cost and feasibility of implementation of the technology, but the the system is not that pricy comparing with the photovoltaics where the lands are not available.

Solar water heating system is not the perfect solution for the environmental problems in China. It solves a small amount of energy that is being used in the residential areas. There are other renewable energies that can be converted into electricity or direct usage of those renewable energies. With a balanced system of renewable sources of energy, China can stop burning coal as their source of energy. Although natural gas is an increasing trend in China, the environmental factor and effect are not immediate but cannot be ignored.