Solar energy for single-family houses in Botswana

A popular science article based on the Master's Thesis "Theoretical study of the potential to improve indoor comfort in Botswana using solar water heating, solar PV and solar PV/T" by Elias Kull and Eric Olsson, LTH.

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In combination with building insulation, indoor comfort can be improved both during cool winters and hot summers through the use of air conditioning systems, powered by electricity generated by solar photovoltaic cells. Additionally, the hot water demand of the household is met by generation from solar thermal collectors.

Botswana has one of the highest solar irradiations in the world, receiving about twice as much solar energy as in northern Europe. Yet, electricity and heat generation from this potent energy source is non existing. At the same time Botswana consume a lot more electricity than what is generated domestically, leaving them dependent on expensive foreign imports from neighbouring countries. Due to the desert climate, Botswana has hot summers and cold winters, where temperatures occasionally go below zero. The goal of the study was to investigate whether solar energy could be harvested during hot sunny days and used during cold nights to improve thermal comfort. Three systems were modelled. Firstly a solar collector system for hot water generation and space heating. Secondly a solar collector in combination with solar photovoltaic (PV) panels for hot water and electricity generation. Lastly a system using a hybrid photovoltaic/thermal (PV/T) solar collector for both hot water and electricity generation. Fieldwork for the Master's Thesis was carried out in Gaborone, the capital of Botswana, in cooperation with a local research institute. Through this fieldwork, parameters of an average residential house in Botswana could be found. A four person house of 100 m^2, with no insulation and with a hot water consumption of approximately half of a low Swedish consumption was found to be an average house. These parameters among many others were used when simulating the different systems and scenarios in an appropriate software. It was early found that any heating system would have little impact due to the non-insulated houses. It was also found that the heating system worked optimally with approximately 10 mm of insulation added where it could reduce the amount of heating hours under the chosen set point temperature of 19 °C by 71 %. This is a considerable improvement but better solutions were found. By insulating further, using approximately 60 mm of insulation, no heating of any type would be needed. However, while reducing the amount of cold hours during winter, a large amount of warm hours are added during summer with such high insulation. With the use of two or more AC units the indoor climate was improved also during summer. It was found that, by insulating houses properly and designing the solar energy system according to the energy needs, 84 % of the energy need can be provided from solar energy on an annual basis. This when assuming a household energy consumption of 5 000 kWh/year, including energy for both heating, hot water and appliances. A value that can be compared to the average Swedish house consumption of 25 000 kWh. However, PV/T collectors are more expensive so in most cases, the regular thermal collector in combination with PV panels will be the most cost efficient solution. Although not investigated in this report, passive shading could be another solution to improving indoor climate during summer.

To conclude, a solar based system could help relieve the pressure on the national electricity grid. To avoid the cool nights during winter, insulation should be used instead of heating systems. This in combination with AC units results in improved indoor climate during both winter and summer. Also, unless roof space is a strict limitation, a solar thermal system in combination with solar PV is the most cost efficient solution for generation of hot water and electricity.