Hogeschool van Arnhem en Nijmegen
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Sustainable Electrical Energy Centre of Expertise

New Energy Systems

# Investigating the Advantages of CPV for Building Integrated PV

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## Introduction

Energy use of buildings and greenhouses can be very high (more than 25% of natural gas consumption in the Netherlands). For facades, windows and greenhouses, light entry is essential. However, in these constructions which have a lower isolating value than i.e. a wall there is also a need for sun blinds because a lot of heat enters in the summer. The objective of this concept is a significant reduction of energy consumption by using available solar energy. This concept will be used in the construction of glass roofs of offices, factories, homes and greenhouses. The light entry (important for greenhouses) also remains well on track. The system generate sufficient heat and electrical energy to make a building energy neutral.

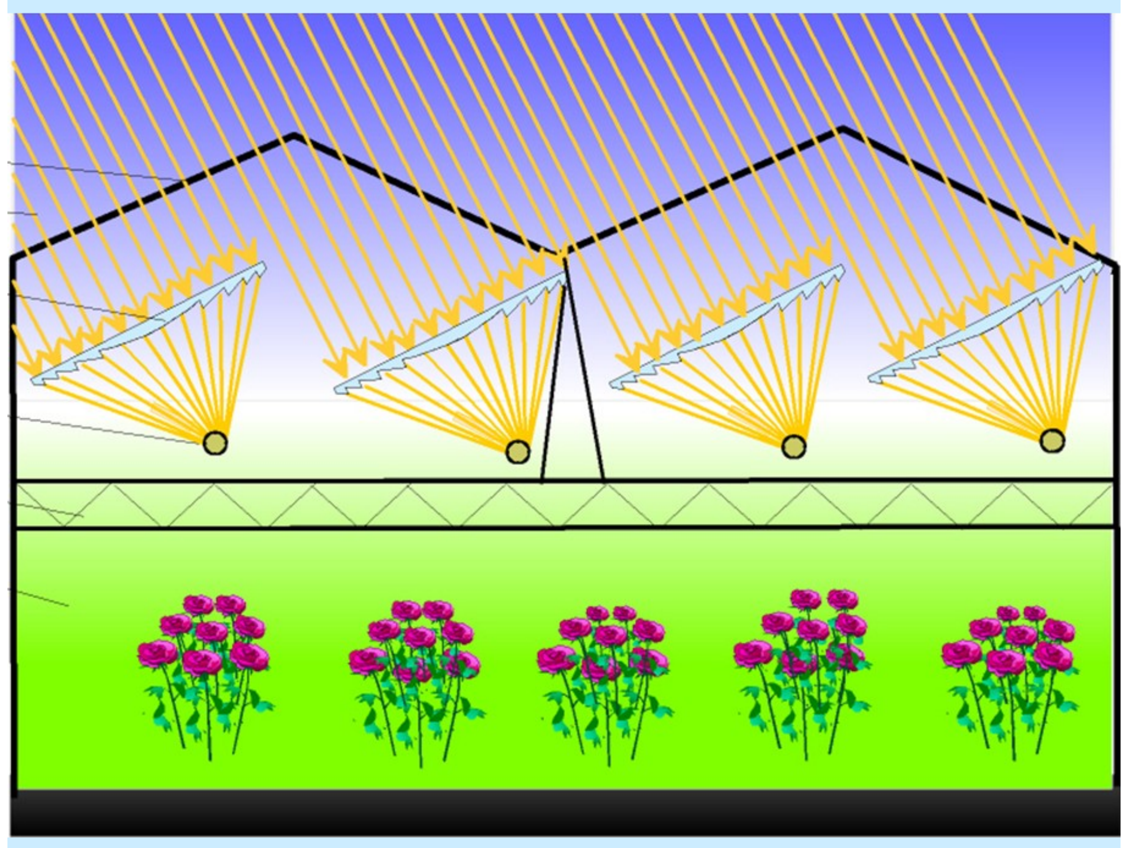

**Fig. 1 The CPV-units consists of a number of Fresnel lenses that direct solar radiation to central receivers where the thermal energy is captured which can then be used further.**

In Fig. 4 the mechanical and hydraulic system of the CPV system is presented. For Dutch climate circumstances a yield of 120 W/m$^2$ electrical energy and 300 W/m$^2$ thermal energy is expected.

## Advantages

- Supply electrical energy
- Delivery thermal energy
- Supply of diffuse light in the building
- Less heat load therefore less power required for the cooling

And for greenhouse applications:

- Reduce ventilation requirements will reduce the water consumption and:
- Higher $CO_2$ concentrations in greenhouses increase the yield of the crops

**Fig. 2 Glass-glass panels integrated into the roof**

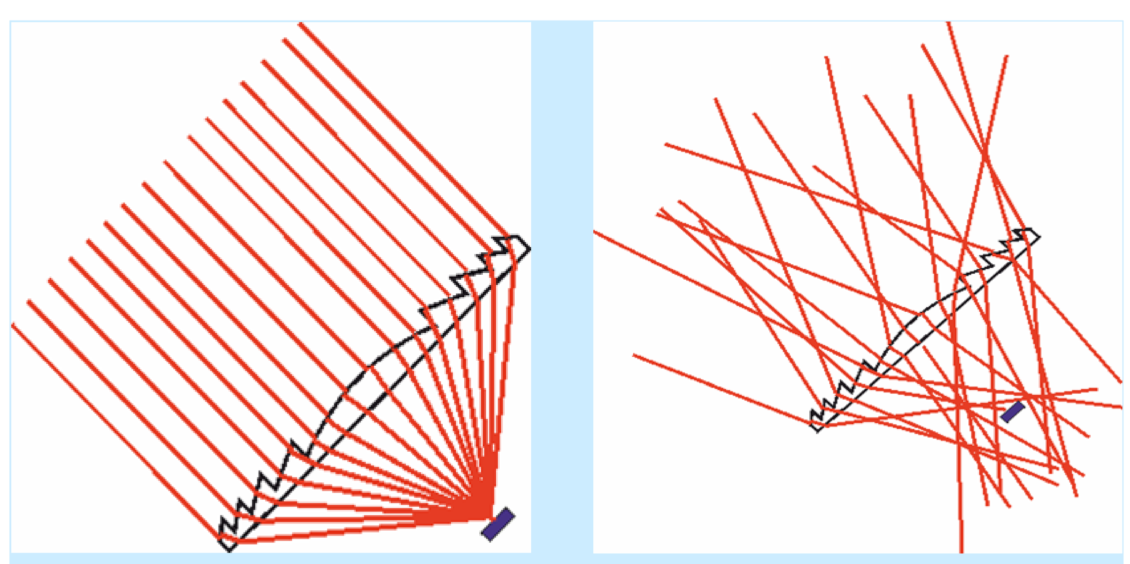

**Fig. 3 Operation of the concentration system**
**a. Direct solar radiation is absorbed and converted into electrical and thermal energy**
**b. Diffuse solar radiation is available as illumination of the building**

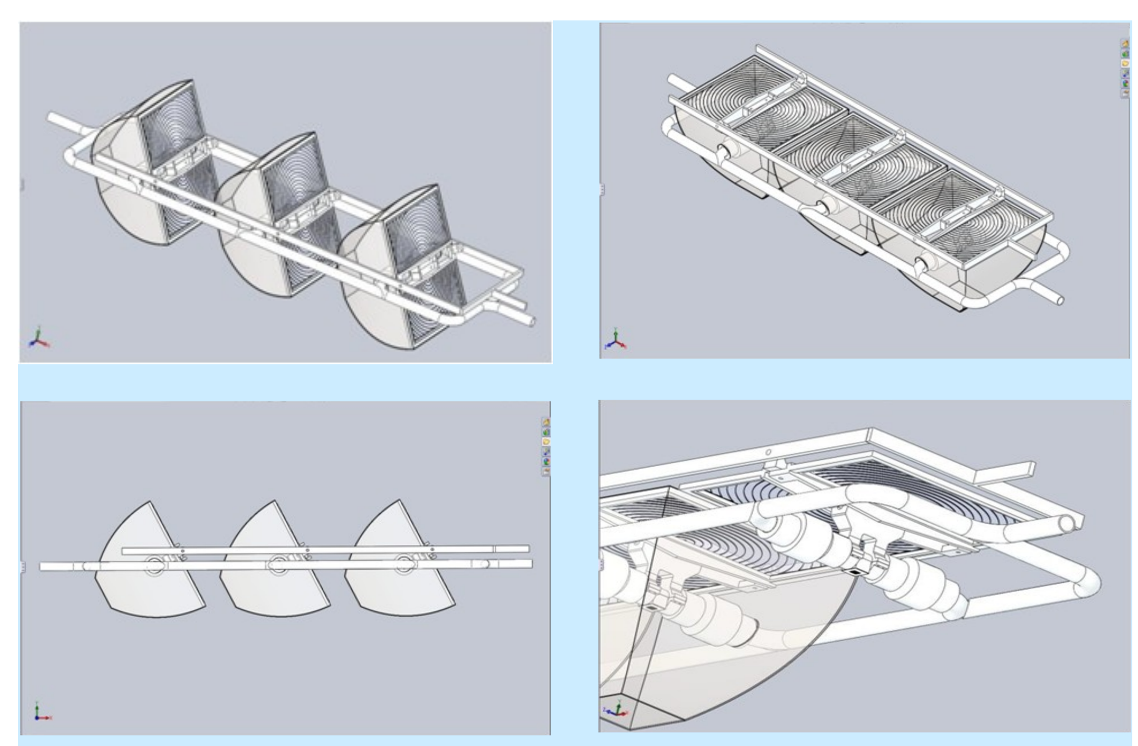

**Fig. 4 Operation of the concentration system**
**a. b. Three mechanicaly coupled Fresnel lenses**
**c. d. Detail of the flow system for cooling of the triple junction cells**

## Results and Discussion

It is possible to integrate solar panels in transparent roofs with so called glass-glass modules. In Northern European countries at summer time this will operate very well, although broad shadows can result in strong illumination differences. In winter the amount of sunlight is further limited by the solar panels. Combines with cloudy days this can result in too much reduction of daylight accession to the underlying space. In this study the properties PV (See Fig. 2) are compared with Concentrating PV systems (CPV) with Fresnel lenses. A Fresnel lens works like a normal lens but is much thinner. When the sun shines the lens receives both direct and indirect sunlight. The lens will concentrate all direct sunlight, which can be collected in the focal point. This concentrated radiation can be converted to electrical energy using triple junction cells.

In conjunction with this the cells can be cooled via a cooling circuit and this can deliver hot water to the building. The collection of the direct radiation during periods of high solar intensity results in better climatic conditions in the building, while the diffuse radiation is available for illumination purposes. Because of the removal of all direct radiation the heat load to the building is largely diminished. The aim of the investigation is to optimize the four outputs mentioned below with a good design of the CPV system. In standard CPV systems only the electrical energy part is utilized. To optimize this energy output triple junction cells are chosen, which can reach an efficiency up to 40%. In addition to the electric energy is in this research the optimal collection of the thermal energy too is investigated, aiming to avoid heat losses. This can be optimized by a good insulation of the cooling system.

## Conclusions

With CPV systems in roofs both electric and thermal energy can be delivered. The produced is estimated on 120kWh/m$^2$ electrical energy and 300 kWh/m$^2$ thermal energy and can be used for energy supply and/or extra cooling. The remaining diffuse radiation is available for illumination of the building. This natural illumination creates a better environment through a reduced heat load on the building. For greenhouse water and $CO_2$ is saved and the crop yield increase. This advantages can be translated in financial benefits. calculations will give an payback time of 6 year of these building integrated CPV system.

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