Autonomous Solar Tracking on a PLC for CPV in the Built Environment

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Introduction

Energy consumption for climate control in buildings and greenhouses can be very high. Still, sufficient entry of light through façades or windows is essential. Admission of light, however, also means that large amounts of heat enter the interior in summer.

A significant reduction of energy consumption may be achieved by collecting the available solar energy for the production of electric as well as thermal energy. With Fresnel lenses, visible and near-infrared radiation is focussed on triple-junction solar cells. These cells must be actively cooled: the cooling circuit extracts the thermal energy from the building or greenhouse interior. This concept, however, only works when the solar panels are kept perpendicular to the sun. We have implemented a robust method for solar tracking of such CPV systems, as part of the HCPV-GO project (Highly Concentrated Photo-voltics for the Built Environment) currently carried out at HAN University.

Major goals

- Supply of electrical energy
- Delivery of thermal energy in cooling circuit
- Reduced energy consumption for climate control

Results and Discussion

Solar tracking with 0.1° accuracy under all weather conditions during all seasons poses a challenge for CPV systems in the built environment. Our investigations in a model greenhouse indicate that reflection of windows or outdoor white surfaces make optical sun tracking devices unreliable. These devices also react unpredictably on sudden changes in weather conditions.

Our solution for this tracking challenge is using an algorithm which predicts the position of the sun’s altitude above the horizon with high accuracy, without using excessive computation time. It is an improvement of the PSA algorithm which allows accurate tracking even when the sun is at low altitude. Validation with VSOP87 [3] shows an average zenith angle error of less than 0.004°, an improvement factor of about 19.

Input variables for the improved PSA-algorithm are collected by a GPS device. These variables are: longitude, latitude and GPS time, which is corrected to Universal Time (UT1).

Changing weather conditions are detected by a Class 1 pyranometer, which measures direct and diffuse sunlight. If direct sunlight exceeds 120 W/m², the sun’s position is tracked. In the absence of direct sun light, the CPV system automatically assumes a favorable position for overcast skies [2] is automatically realized (see flow chart in fig. 4).

In the flow chart, the criterion for sunrise and sunset is set at a zenith angle of 90.5°, assuming an angular altitude above the horizon.

In clouded circumstances, controlled motion is guaranteed.

Main requirements

- Follow the sun’s position with 0.1° accuracy.
- Follow the sun’s position in the built environment
- Follow the sun’s position in all weather conditions
- Implemented on a PLC
- Autonomous under normal operation conditions
- No unnecessary motion

Conclusions

We have achieved an improved performance of the PSA solar tracking algorithm by adding a lightweight calculation for atmospheric refraction.

Accuracy has improved sufficiently to rely completely on predictive tracking. This opens opportunities to perform solar tracking in the built environment.

A PLC system is able to do the necessary calculations while observing the incoming data of a GPS receiver and a pyranometer.

References


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