Single-Axis Mechanisms with Limited Stroke for Tracking Solar Thermal Collectors and Photovoltaic Modules Integrated in Building Façades

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Abstract: The paper presents comparative study on the solar energy collected by a fixed vertical *vs.* a limited tracked solar convertor, installed on south-facing facades. One degree of freedom mechanisms with horizontal motion axis and limited strokes (±15°) meets the functional requirement imposed by the narrow spatial gap between the solar convertor and the wall, allowing to increase the solar radiation (i.e. increasing the output) by direct tracking (PV modules or ST collectors) or to protect the solar thermal collectors during stagnation by inverse tracking. The direct irradiance collected by south-facing façades is modeled and simulated over one year for middle latitude (45°N), completed with experimental validation using an outdoor testing rig and limited tracking strokes. The results show a significant impact of the limited tracking on both the collected solar energy and the output.

1. Introduction

In line with the European strategy on nearly zero-energy buildings implementation, the solution of flat plate solar thermal collectors (FPSTCs) and photovoltaic modules (PVs) installed on façades can be used as an additional measure (Visa and Duta, 2016) to meet the domestic hot water (Buker and Riffat, 2015) and on-site electricity (Shukla et al., 2016) demand in buildings. However, the variability of the solar radiation leads, for vertical converting surfaces, to low thermal/electric output during the cold and transient seasons, while thermal overproduction or stagnation (thus accelerated deterioration of solar collectors) can be expected during summer. Therefore, this paper proposes a solution to control the thermal output/power production, based on controlled tracking using horizontal single-axis mechanisms with limited stroke. Two options are considered: forward tracking (to increase the solar energy input) and inverse tracking to decrease this input (Neagoe et al., 2014). Maximum strokes of 30^o ($\pm 15^o$) are considered acceptable having as reference the vertical mounting of solar convertors. The impact of the limited tracking on the solar radiation amount is modelled for a continental temperate climate (Brasov, Romania), and a comparative analysis of the direct solar energy collection by fixed vertical vs limited tracking is performed.

2. Theoretical approach

The direct solar irradiance (B_n) is theoretically estimated based on the Meliss model, in clear sky assumption, adapted for the Brasov (Romania) implementation location (lat. 45.65^o, mountain temperate climate). The model was applied for two cases: (1) fixed vertical convertor, (2) single horizontal-axis tracked with limited azimuth stroke (±15°), aiming both at maximizing and minimizing the collected direct solar irradiance B_n.

3. Results and discussion

The results in Fig. 1a show the maximum incident solar energy simulated one year for the three variants (vertical – V, $+15^o$ noted as Max, and -15^o noted as Min), while Fig. 1b outlines

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the energy gain (red) and the energy loss (blue) considering the traditional vertical mounting as reference. These results outline the significant role of inverse tracking (thus overheating protection) during the warm season (May – August). Although not large, the gain also contributes to meeting the target of 100% solar DHW in the built environment. These results are validated based on infield data, on the outdoor testing rig in Fig. 1c. Possible single axis mechanisms able to be implemented for facades are further presented and comparatively analysed considering the prerequisites: accurate tracking, small size, reliability, etc.

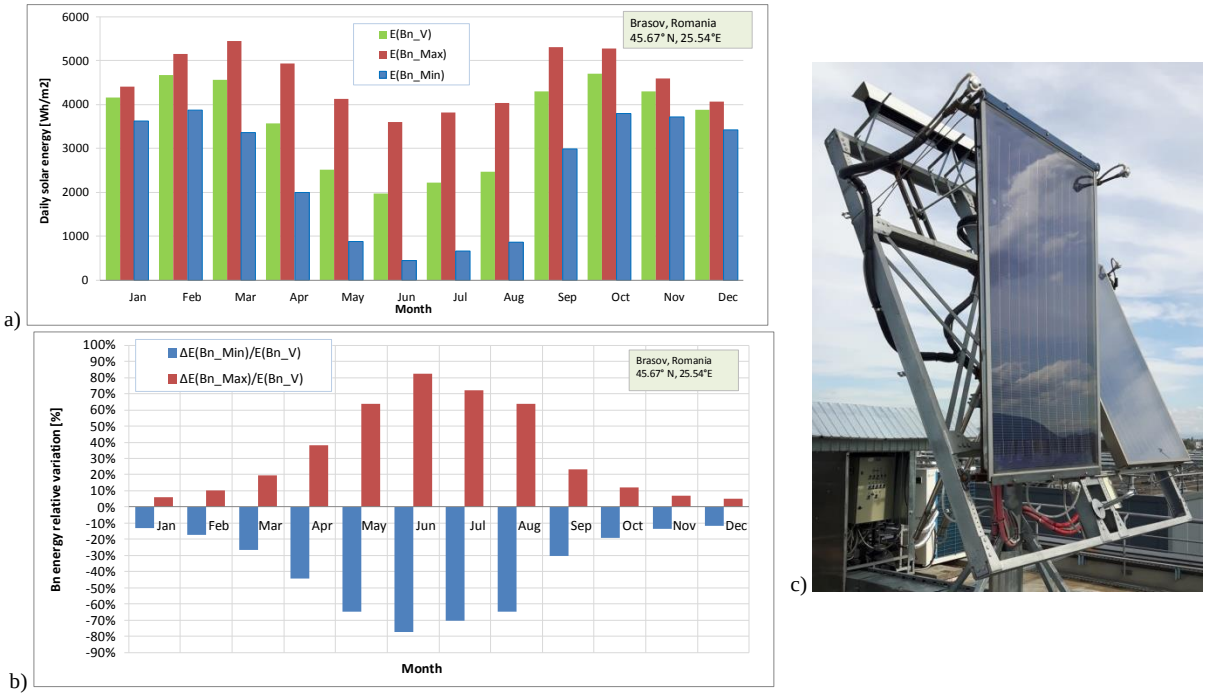

Fig. 1. Simulation results for a South-facing solar façade: a) collected daily beam energy over one year in the vertical plane (V), on a plane limited oriented (± 15°) for increasing/decreasing the solar energy gain (Max/Min), b) relative variation of the collected solar energy on Max/Min oriented plane vs. fixed vertical plane V; c) experimental outdoor FSTC testing rig in the R&D Center "Renewable energy systems and Recycling"

4. Conclusions

Using single horizontal-axis mechanisms with limited stroke to track solar convertors integrated in building façades allows a significant increase in the energy gain by forward tracking (up to 83% as compared to fixed vertical FPSTCs, June); oppositely, the maximum inverse tracking (fixed at -15°) reduces about 3 times the collected beam irradiance in June.

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5. References

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