consumed for performing the bi-axial tracking: E_C = 67.08 Wh/day. The supplementary energy obtained by tracking the sun path is obtained in the following way: $\varepsilon = E_{PT} - (E_{PF} + E_C) = 13863.88 - (10305.65 + 67.08) = 3491.15$ Wh/day, representing an effective energy gain (reported to the fixed PV system) of 33.87%. Such computations were performed for all intervals during the year, the average annual energy gain being of 38.71%, thus justifying the use of the proposed dual-axis azimuthal tracking mechanism.

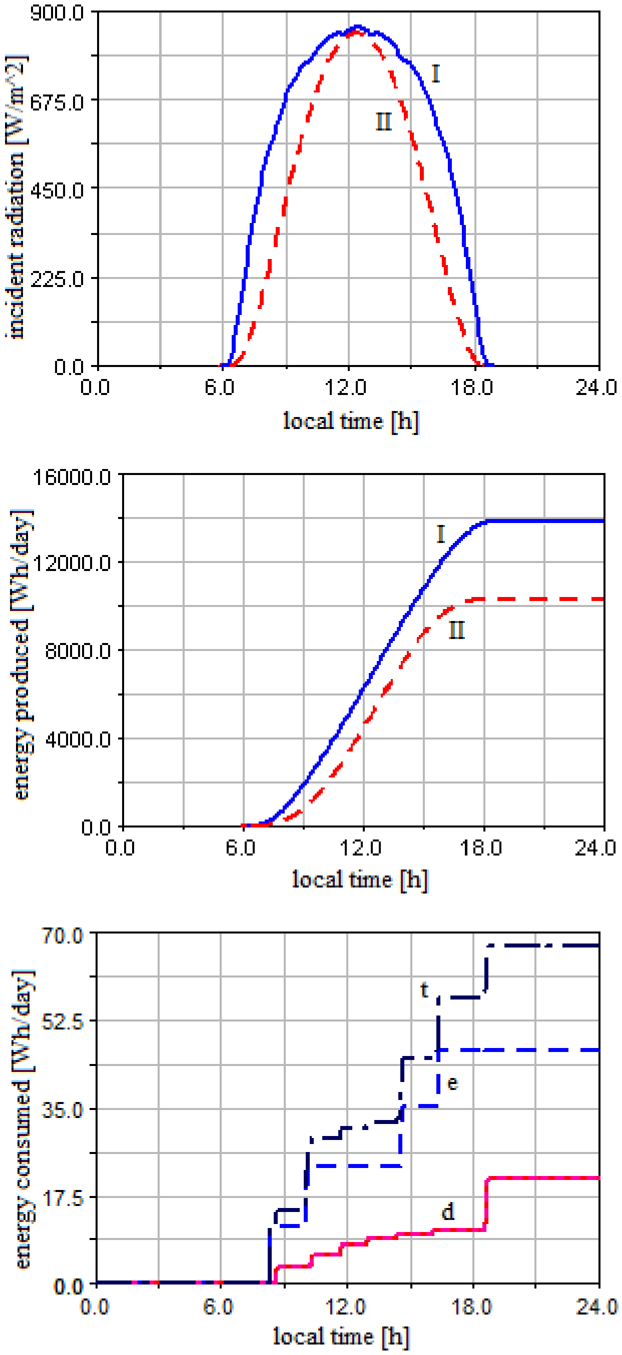

Fig. 7. Results of the simulation in a virtual prototyping environment for the spring equinox day.

4. Conclusions

The application presented in this paper is an edifying example of the possibilities offered by virtual prototyping in the optimal design of PV tracking systems. The proposed dual-axis solar tracker has several important advantages, such as the ability to orient medium and large PV platforms, reducing the cost by minimizing the number of motor sources relative to the classical solution of individual modules, ensuring very good tracking accuracy while proving high stability and robustness performance. By the way in which the proposed dual-axis solar tracker is designed, the energy gain (by reference to the equivalent fixed system) is maintained to values that prove its usefulness/viability.

References

[1] C. Alexandru, M. Comşiţ, "Virtual prototyping of the solar tracking systems", Renewable Energy and Power Quality Journal (2007), Vol. 1, nr. 5, pp. 105-110.
[2] C. Alexandru, C. Pozna, "The optimization of the tracking mechanism used for a group of PV panels", Renewable Energy and Power Quality Journal (2009), Vol. 1, nr. 7, pp. 245-249.
[3] S. Seme, B. Stumberger and M. Hadziselimovic, "A novel prediction algorithm for solar angles using second derivative of the energy for photovoltaic sun tracking purposes", Solar Energy (2016), Vol. 137, pp. 201-211.
[4] S.A. Sharaf Eldin, M.S. Abd-Elhady, H.A. Kandil, "Feasibility of solar tracking systems for PV panels in hot and cold regions", Renewable Energy (2016), Vol. 85, pp. 228-233.
[5] R. Singh, S. Kumar, A. Gehlot and R. Pachauri, "An imperative role of sun trackers in photovoltaic technology: A review", Renewable & Sustainable Energy Reviews (2018), Vol. 82(3), pp. 3263-3278.
[6] C. Alexandru, "A novel open-loop tracking strategy for photovoltaic systems", The Scientific World Journal (2013), Vol. 2013, pp. 205396(1-12).
[7] M.E.H.Chowdhury, A. Khandakar, B.M. Hossain, R. Abouhasera, "A low-cost closed-loop solar tracking system based on the sun position algorithm",. Journal of Sensors (2019), Vol. 2019, pp. 3681031 (1-11).
[8] D.A. Flores-Hernández, S. Palomino-Resendiz, N. Lozada-Castilloc and A. Luviano-Juárez, "Mechatronic design and implementation of a two axes sun tracking photovoltaic system driven by a robotic sensor", Mechatronics (2017), Vol. 47, pp. 148-159.
[9] Z. Mi, J. Chen, N. Chen, Y. Bai, R. Fu and H. Liu, "Open-loop solar tracking strategy for high concentrating photovoltaic systems using variable tracking frequency", Energy Conversion and Management (2016), Vol. 117, pp. 142-149.
[10] C. Alexandru, "Optimal design of the dual-axis tracking system used for a PV string platform", Journal of Renewable and Sustainable Energy (2019), Vol. 11(4), pp. 043501(1-14).
[11] C. Alexandru and C. Pozna, "Dynamic modeling and control of the windshield wiper mechanisms", WSEAS Transactions on Systems (2009), Vol. 8(7), pp. 825-834.
[12] *** Getting Started Using ADAMS/Controls, MSC.Software, 2005
[13] *** EASY5 Guide, MSC.Software, 2005.
[14] C. Alexandru, "Optimization of the bi-axial tracking system for a photovoltaic platform", Energies (2021), Vol. 14(3), pp. 535(1-30).
[15] C. Alexandru, "Innovative bi-axial tracking mechanism for PV modules", Renewable Energy and Power Quality Journal (2020), Vol. 18, pp. 184-189.
[16] M. Meliß, Regenerative Energiequellen: Praktikum, Springer (1997).