The International Scientific Seminar
BIOMASS FOR ENERGY
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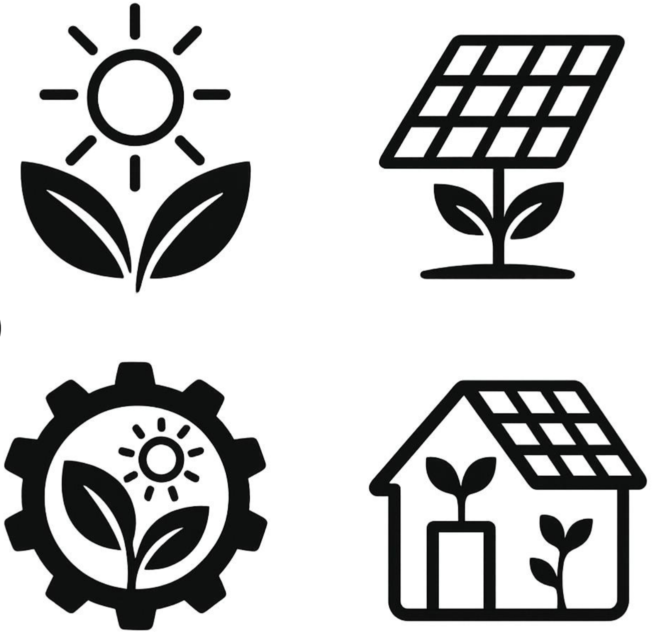
Sustainable integration of solar energy sources into agricultural activities



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Relevance of the work

The use of solar energy is becoming one of the key directions for achieving a sustainable energy transformation. Because of climate change, rising energy costs and the need to ensure energy security, the importance of renewable energy sources in agriculture is increasing. Traditionally the energy needs of agriculture were met using fossil fuels, but there is now a growing effort to reduce dependence on polluting energy. By integrating solar power plants into agricultural processes, it is possible to ensure a stable energy supply, increase farm autonomy and reduce carbon-dioxide emissions. One of the most advanced solutions is east–west-oriented PV module systems, which allow electricity generation to be distributed more evenly during the day.

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Hypothesis

Sustainable integration of solar energy into agricultural activities can create energetically self-sufficient farms, and applying advanced technologies such as east–west-oriented modules and agro-PV a can ensure stable energy generation, reduce environmental impact and increase farming efficiency.

Use of agrovoltaic systems for grape cultivation

Use of agrovoltaic systems for growing grain crops

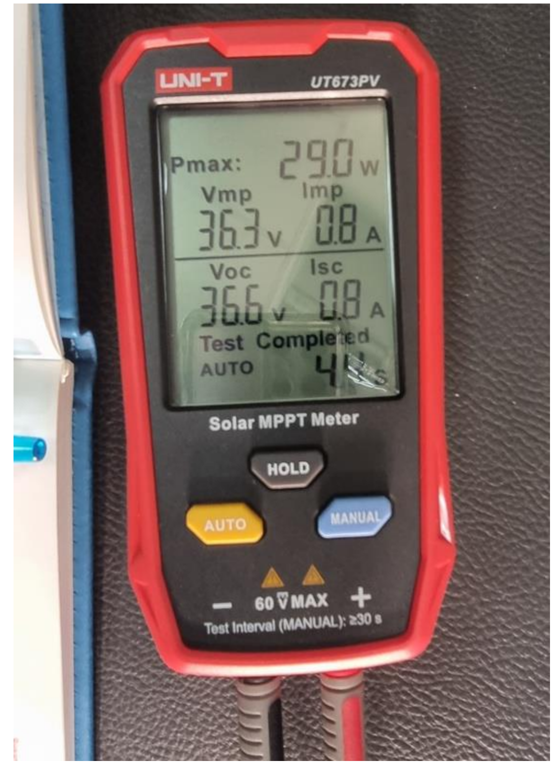
Solar power plant located on agricultural crops

Double-sided photomodules with east-west orientation

Influence of incidence angles of rays on the photovoltaic panel efficiency

Research methodology

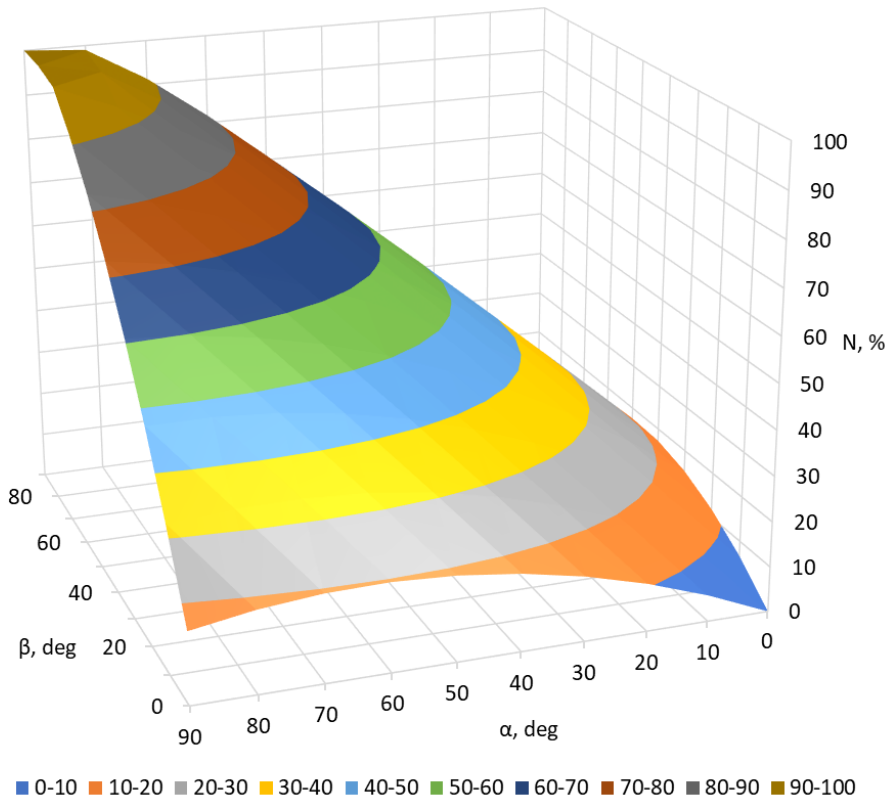
Equipment for investigating the efficiency of solar modules by changing the angle of incidence of solar rays



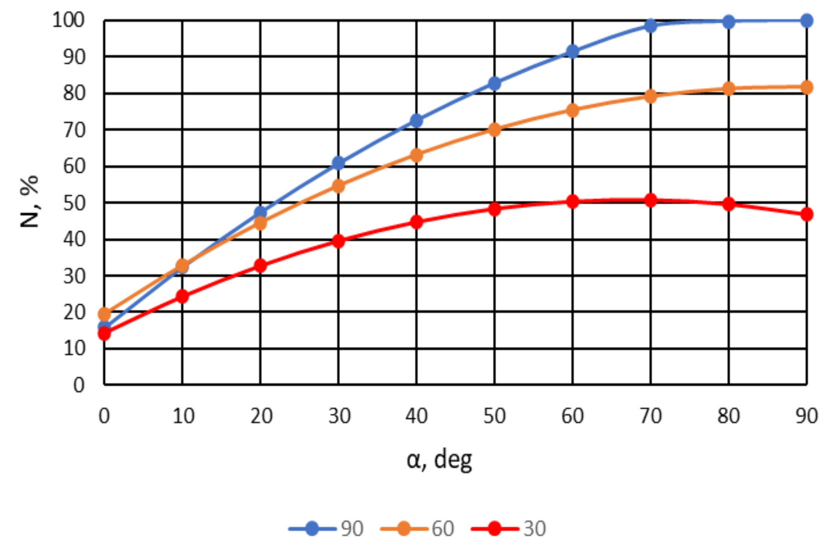
UT673PV solar MPPT meter

Influence of incidence angles of rays on the photovoltaic panel efficiency
Research results

$$N = 0.751\alpha + 0.625\beta - 0.008\alpha^2 - 0.005\beta^2 + 0.011\alpha\beta$$



Influence of the incidence angles of rays on photovoltaic panel efficiency: N – power (% of maximum); α – vertical incidence angle of the rays (°); β – horizontal incidence angle of solar rays (°).



Influence of the vertical incidence angle of rays (α) on the power of the photovoltaic panel at three horizontal angle (β) values: 30°, 60° and 90°.

Influence of incidence angles of rays on the photovoltaic panel efficiency

Conclusions

- A special equipment was designed and manufactured to measure the efficiency of the photovoltaic panel under various incidence angles of solar rays.
- A double sided monocrystalline module (nominal power 435 W) illuminated by halogen spotlights was used for the tests.
- The main evaluation parameter was relative power (N, %) depending on the vertical and horizontal angles (0–90°). A second degree regression was used to describe the relationship between angles and power.
- Experimentally determined: when $\beta = 90°$, the power increases almost linearly to the maximum value at $\alpha \approx 80°$; when $\alpha < 20°$, the relative power decreases to 47 % ($\beta = 90°$), 44 % ($\beta = 60°$) and 32 % ($\beta = 30°$); when α and $\beta < 30°$, the use of the photovoltaic panel is energetically unprofitable.
- These results make it possible to select optimal operating angles of photovoltaic panels, important for their broad application in agroenergy and other fields.

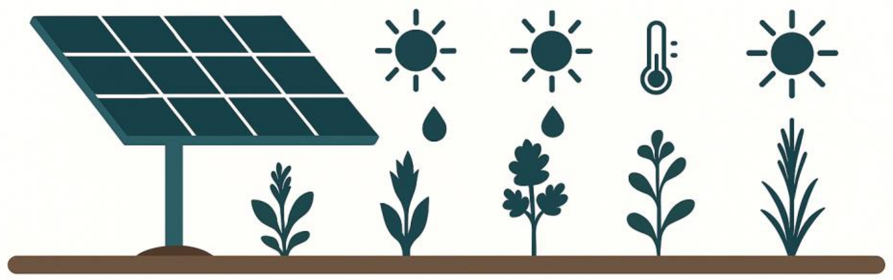
Sustainable agrivoltaics: influence of microclimate on biomass crops near ground mounted solar power plants.

Brief research methodology.

1. Experimental setup. Four sets of containers ("blocks") were placed in different microclimate zones: under the modules, on the eastern side, on the western side, and on the southern side without shade. Each set has four sections separated by partitions with plants: Phalaris arundinacea, "Robustica" grass mix, Trifolium pratense, Lolium perenne "Temprano".
2. Observed parameters. Microclimate (continuous recorders): photosynthetically active radiation (PAR), air and soil temperature, soil moisture. Growth indicators: height, number of leaves / leaf area, phenological phases (every 2 weeks). Harvest: twice per year; biomass is dried at 65 °C, weighed (g of dry mass per m^2).
3. Duration of the study. 24 months – covering two growing seasons to evaluate seasonal variations.

Sustainable agrivoltaics: influence of microclimate on biomass crops near ground mounted solar power plants

Expected scientific results



1. Microclimate differences. Under the modules: lower PAR, about 2–3 °C lower soil temperature, higher moisture. Eastern/western side: moderate PAR, short term shading, balanced moisture. Southern side: highest PAR, higher soil temperature, greater drought.

2. Biomass productivity. P. arundinacea and 'Robustica' are likely to make the best use of the wetter environment under the modules, achieving a stable though slightly lower yield. T. pratense can benefit from moderate lighting on the eastern/western side, generating the highest amount of protein and fixing N_2. L. perenne 'Temprano' will likely make maximum use of full sun in the south, but will be sensitive to lack of moisture; the greatest variability is expected.

3. Synergy energy + agriculture. Practical recommendations will be provided regarding the arrangement of containers or field beds, irrigation schedule, and species combinations for specific microclimate niches.

4. Sustainability insights. Dual land use (agrivoltaics) can increase land productivity by 30–50 % (kWh + t of biomass per ha) and improve soil moisture balance. The results will contribute to regional policies promoting renewable energy and climate resilient farming.