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TRADITION, ACTUALITY AND FUTURE PERSPECTIVES OF SOLAR ENERGY AT POLITEHNICA UNIVERSITY TIMISOARA

Abstract: *Politehnica University of Timișoara (UPT) has been at the forefront of solar energy research and applications in Romania, with a history spanning almost five decades, since its early beginnings in the 1970s. UPT has engaged in both thermosolar and photovoltaic (PV) projects, contributing significantly to the advancement of renewable energy technologies. In the first years, solar energy was studied by research teams with good positive impact on fields such as construction, thermotechnics, electromechanics, and electric and electronic fields. Different research teams performed measurements and simulations with good results on solar radiation, study of materials, different solar collectors, solar concentrators, a solar house, and many more.*

Keywords: solar energy, concentrated solar power, photovoltaics

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INTRODUCTION

This paper provides an insight into the work that has been performed at Politehnica University of Timisoara (UPT) for a period of more than 49 years, with added history, results, and perspectives on the use of solar energy. The main directions that were taken during this time frame are: actinometry, studies of the greenhouse effect, thermal collectors, solar concentrators, photovoltaic systems, industrial and home thermosolar setups, Fresnel lens, PV applications, and others. This paper focuses on the conception and building of a dedicated research laboratory and on the experimental results and simulations that allowed the development of industrial and home applications.

The activities related to solar energy have been performed during a long period of time within the Department of Fundamentals of Physics for Engineers at the Faculty of Electrical and Energetic Engineering, Faculty of Mechanics, and Telecommunications Faculty, and with the help of third-party collaborators and companies through projects or grants.

HISTORICAL OVERVIEW OF SOLAR ENERGY UTILIZATION AT UPT

Research in solar energy has been conducted from the early 1970s, when the first solar laboratory in natural conditions was built on the south-facing garage terrace, in the backyard of the then building of the Department of Physics, as shown in Figure 1.

Because it was difficult at the time to receive supplies and equipment from other countries, most of the building and maintenance work was done by 24 researchers-teachers and 7 technicians, and repairs were made in two workshops for electromechanics and electronics.

The main objective of the solar laboratory was to establish the weather-climatic database for the western part of Romania and to conduct theoretical and experimental research on the capture and use of solar energy for the supply of hot water and technological hot air, drying of ceramic and wood, fluidization of bitumen, concentration of radiation, obtaining of biomass, simulation of the physical phenomena involved in the thermo-conversion of solar energy, etc.

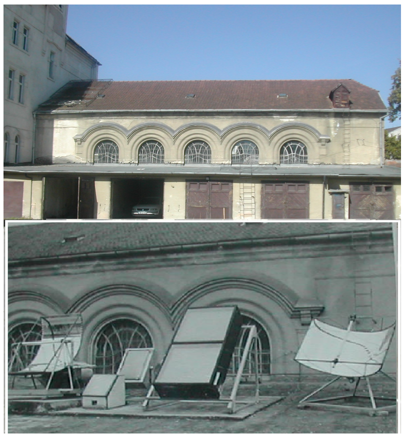

Figure 1. *First solar laboratory*

The first industrial application of solar energy technology ended up to be a hall for drying ceramic products, where the circulated air was heated by solar means. The cooperation between UPT and the Ceramic Plant from the city of Jimbolia began in 1976.

After many measurements and analysis, researchers concluded that clear window glass no thicker than 5 mm should be used for the best capture and conversion of solar energy. Spinning panels with controllable orientation are also essential for a good water vapour evacuation without energy waste. Considering the 45-degree northern parallel, over which this city is situated, and considering environmental, climate, and building factors, a six-month period solar energy would be of good use. Details are shown in Luminosu, De Sabata, & De Sabata (2011).

In one of the first studies, tools to measure solar radiation were built, two devices specifically. The first one, Solaris 1, is a sensor with two thermally conductive plates painted in black. When the solar radiation falls on one plate, it heats it up until thermal equilibrium is reached, while the other plate is protected by the radiation with a silver-plated mirror, as shown in Figure 2 (Luminosu, De Sabata, & Ilie, 2013).

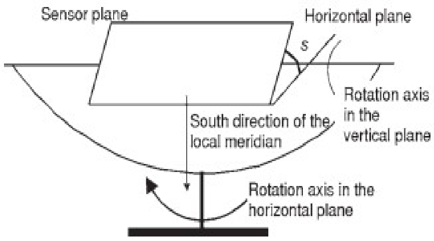

Figure 2. *Solaris 1*

The second one, Solaris 2 (Figure 3), a pyranometer, needed for measuring the global radiation in the horizontal plane, was built with a radiation sensor made from eight copper rings, as shown in Luminosu, De Sabata, & De Sabata (2010).

Figure 3. *Solaris 2*

Both devices were calibrated and compared to a standardized albedometer from the local weather station for Solaris 1, and for Solaris 2, the reference was a pyranometer from the National Meteorology and Hydrology from Bucharest. The results measured for solar radiation were highly accurate and are presented in detail in Luminosu, De Sabata, & De Sabata (2010).

In the following years, at the same department, an installation intended for measurement of the energy intake of diffuse radiation when conducting a thermal panel study was built.

In addition, over a period of many years, measurements and simulations were performed for solar radiation with locally built equipment. More in-depth details are presented in Table 1 and in Luminosu, De Sabata, & De Sabata (2010).

Table 1. *Solar radiation measured with built pyranometer*

Hour / Month	09	10	11	12	13	14	15	16
Jan	73	102	154	188	190	174	104	36
Feb	106	169	247	291	282	210	165	84
Mar	190	286	336	384	380	345	293	214
Apr	330	374	508	512	470	412	352	280
May	480	580	610	615	605	590	512	384
June	590	704	745	807	810	720	629	431
July	475	681	771	801	778	693	602	504
Aug	416	612	691	704	701	646	538	426
Sept	312	414	487	538	543	476	413	279
Oct	183	276	334	364	367	315	273	127
Nov	97	163	231	261	252	182	116	44
Dec	46	94	137	158	146	107	82	14

Over a period of many years, this pyranometer has been used and compared to a later acquisitioned Kipp&Zonnen class A pyranometer. The results are remarkably accurate, thus proving the quality of the device. Table 2 shows the global solar radiation measured with Kipp&Zonnen pyranometer over a period of 3 years.

Table 2. *Solar radiation measured with Kipp&Zonnen pyranometer*

Hour / Month	09	10	11	12	13	14	15	16
Jan	71	133	175	197	190	153	95	38
Feb	101	167	206	231	216	173	126	72
Mar	285	376	441	454	424	363	276	175
Apr	247	374	485	545	562	550	464	386
May	324	427	507	570	589	566	497	442
June	406	526	615	657	680	652	576	477
July	384	494	589	632	644	630	574	485
Aug	357	504	620	685	694	671	606	499
Sept	217	338	425	484	506	486	426	327
Oct	144	249	332	384	399	360	296	197
Nov	140	209	260	262	246	189	109	33
Dec	67	119	135	145	129	95	52	13

Thermosolar initiatives

In early 2000s, a thermosolar pilot system was built and integrated into the solar house. The solar house is shown in Figure 4. The building is still functional today, but was renovated. The thick brick walls are insulated with mineral wool and the roof is made of double reinforced concrete plates, insulated with bitumen. The building has two rooms, a lobby, and an access hall. All equipment for the thermal and solar installations is kept on the ground floor, including boilers, pumps, the control panel, etc.

The original building was constructed with a stone-filled tank for water and flat solar collectors (Figure 5), but during the following years, modifications were made.

The measurements made on the system with solar water collectors, air–water heat exchange, a heat accumulator bedrock, and a highly insulated building, resulted in the efficiency of the system of 30%, with solar energy accounting for 60% of the heating.

Figure 4. *Solar house, present view*

In addition, some of the first solar collectors built are shown in Figure 5. More details about the initial use and experiments made in the solar house with the initial destination are presented in Luminosu (2003).

Figure 5. *Flat solar collectors*

Nowadays, the solar house with the main side of the building orientated south has vacuum tube panels in front of the building, which are placed there for experiments, as shown in Figure 6. On top of the building, a concentrating solar thermal power installation was built and PV panels were installed this year.

Figure 6. *Vacuum tube panels*

In parallel with the research already ongoing for several years, in 2005 researchers from the department and from other faculties developed solar equipment for preheating bitumen. This system utilized solar energy to heat bitumen in industrial conditions, demonstrating an efficiency of 25-30% and achieving temperatures between 54-57°C, according to Luminosu, De Sabata, & But (2007).

Research on solar installations for heating bitumen was developed earlier in the 1980s at the physics department, and even then, researchers concluded that the process of passive solar heating may increase bitumen temperature up to 60-80°C. After many analyses, the use of solar energy for bitumen preheating has been regarded as reasonable.

Later on, as previously mentioned, pressurized thermal panels were installed on the south side, in front of the solar house. The panels were used for educational purposes and to produce hot water for the solar house, as shown in Figure 6 and Figure 7.

The solar house shown in Figure 4 has 3 circuits as follows:

Circuit 1: the capture area is 17.1 m^2; 3 pressurized panels, connected in parallel, and each panel equipped with 12, 18, or 24 tubes; the orientation of the panels is south; the inclination of the panels is 45°; there are two boilers with a capacity of 200 litres and 500 litres respectively and the surplus heat is transferred to an external tank.

Circuit 2: the capture area is 3.6 m^2; 1 panel equipped with 24 tubes; the orientation and inclination of the panel is variable and it is connected to 1 boiler with a capacity of 200 litres.

Circuit 3: the capture area is 3 m^2; 1 unpressurized panel, with natural circulation, equipped with 24 tubes; the orientation of the panel is south; the inclination of the panel is 45°.

These circuits are used for laboratory work for educational and demonstrative purposes.

Figure 7. *Pump and boiler connected to the thermosolar panels*

Photovoltaic (PV) developments

In parallel with the study of solar radiation in Timisoara for many years and with thermosolar research, in 2008 a PV installation consisting of 14 SOLWATT M220-60GET AK panels (Figure 8) with a 3 charging batteries system and with a total surface of 18.3 m^2 was built to be used for educational and practical applications for students, for public dissemination of information on solar energy, and as an uninterruptible power supply for local servers.

The system operated with an average efficiency of 12.66%, producing 1267.5 kWh/kWp annually. Details of the measurements, simulations, and conclusions are found in Toader et al. (2012).

Figure 8. *PV panels installed for educational purposes*

In addition, over a period of many years, measurements and simulations continued to be made for solar radiation with locally built equipment and acquisitioned through grants. More in-depth details, simulations, and mathematical models are shown in Luminosu, De Sabata, & De Sabata (2010), Luminosu, De Sabata, & De Sabata (2011), Luminosu et al. (2014), Jurca et al. (2011a and 2011b) and De Sabata et al. (2014).

Concentrated solar energy (Fresnel lens)

From 2010, for more than a decade, interest in concentrated solar energy, mainly Fresnel lens has emerged. Many setups have been built, through grants and partnerships and with financial help from the Research Ministry; numerous measurements were made with equipment that included Fresnel lens in combination with pressurized heat pipes, a Stirling engine, copper pipes with thermal agent, one-axis system, two-axis system, fixed inclination, etc.

Interest in this field and the results obtained led to a part of the prototypes being implemented in industry, with Energosophia Company as the beneficiary of this research conducted over the years.

Research on the design, testing, and certification of the two prototypes of solar collectors/concentrators with Fresnel lens was conducted over a period of 5 years, in order for the setup to be produced and used for internal and European market.

No fewer than 53 modules were built in order to determine the best possible option to obtain domestic hot water with minimal cost of investment and maximal efficiency.

The first prototype, LS01, has the most different units, which include lenses of different sizes with a focus spot and lenses with a linear spot of different sizes. Figure 9 shows some of the built units with 250x250 mm spot focus lenses, 22.5 mm focal length, whereas Figure 10 shows units with 320x400 linear focus lenses and a total focal depth of 62mm projecting on vacuum tubes.

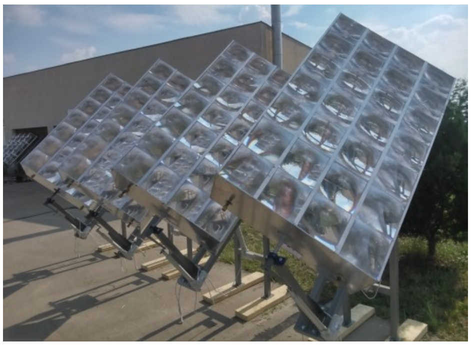

Figure 9. *LS01 prototype – units 6-9 (250x250 mm spot focus lenses, 22.5 mm focal length)*

More of the builds are shown in Figure 11 to Figure 14. Results were largely discussed and showed in (Șorandaru, 2013; De Sabata, 2013; Ilie, 2015; Ilie, 2017).

Figure 10. *LS01 prototype – units 16-18 (320 x 400 mm linear focus lenses, 62 mm focal length and vacuum tubes*)

Unit 19 of the LS01 prototype (Figure 11) is the only one with a gear-driven motor, but due to the cost involved for building and operation, only one setup was made.

Figure 11. *LS01 prototype – unit 19 (120x120 mm spot focus lenses, 120 mm focal length and driven by gear motors)*

Figure 12 shows an independent array where the lenses used for obtaining hot water are focusing on copper heat pipes, not on vacuum tubes, with a spot focus.

The second prototype, LS02, was intended to supply the Olympic swimming pool from Resita with warm water. The initial build was made in accordance with this request. Figure 13 shows the first unit from the LS02 prototype. Here the frame with the lenses follows the sun in the sky in order to keep its focal point.

Figure 12. *LS01 prototype – unit 20 (lenses with spot focus of 250x250 mm, focal length of 22.5 mm)*

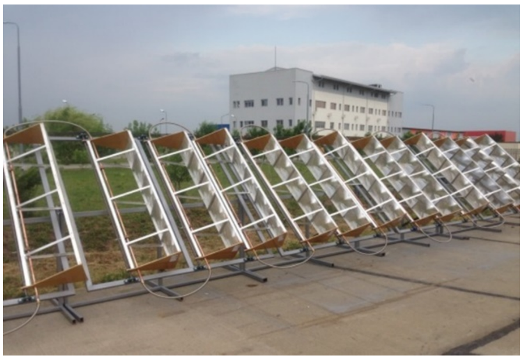

Figure 13. *LS02 prototype – unit 1 (350x350 mm spot lenses, 32.5 mm focal length and copper tube)*

The second unit from the LS02 prototype (Figure 14) is fixed – only the top part with the lens follows the sun in the sky, driven by a chain to synchronize all units. This unit was the least feasible due to the height of the system, instability of the whole setup, and difficulty of manipulating the automatic system for following the sun in the sky.

Figure 14. *LS02 prototype – unit 2 (320x400 mm linear focus lenses, 62 mm focal length and vacuum tubes)*

A different experiment was conducted (Figure 15), which was the subject of a doctoral thesis. An overview of the experimental model of a solar thermoelectric power plant with a Fresnel lens and a beta-type Stirling engine, and the measuring devices used in the experimental determinations are shown.

The notations in the figure have the following meaning:

a – Fresnel lens, b – beta-type Stirling engine, c – electric generator, d – lens support frame, e – lower support frame, f – actuators, g – anemometer for measuring wind speed, h – pyranometer, i – actuator command and control module, j – insulated funnels, k – discs, l – voltmeter, m – ammeter, o – National Instruments module for data acquisition, p – standard resistor, q – variable resistor 100-1100Ω, r – laptop with LabView software, s – multimeter with temperature probe (hot zone), t – multimeter with temperature probe (cold zone), u – multimeter with temperature probe (hot zone), v – laser thermometer, and w – tachometer.

Figure 15. *Fresnel lens and Stirling engine prototype*

In-depth results of this setup, measurements, simulations, and applications are shown in Ilie et al. (2016), Ilie et al. (2017), and Maghet et al. (2018).

PRESENT AND FUTURE PROSPECTS

From 2014, UPT has a Research Institute for Renewable Energy ICER-TM, which was built over a period of 5 years. The research encompasses the following fields: photovoltaic piles, combustion piles, biogas production and use, wind power, nanomaterials and nanotechnologies used in conversion of renewable energy, aerodynamics and vibrations, electronics for renewable energy conversion, digital equipment for renewable energy, and automatic and electrical equipment.

Alongside this institute, many research teams work on areas of solar energy in order to contribute to the development of new technologies and systems for obtaining electrical and thermal energy from the sun.

In addition, it may be economic to use solar energy to reduce reliance on imported oil, particularly if Romania has a good solar potential, as shown in Luminosu, De Sabata, & Ilie (2013), Luminosu et al. (2019), and other studies.

Likewise, a prospective doctoral thesis that focuses on the use of PV cells in all types of conditions, from rough environments to local conditions is currently under way. Many results have been presented in papers found in the list of references below.

Figure 16 shows a small initial setup of the ongoing work for the aforementioned thesis, with a note that it is scaled to a 63.7 kWp on-grid PV park with 309.3 m^2 installed PV panels and with 140 PV modules.

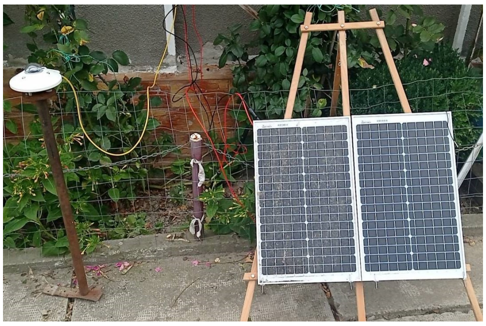

Figure 16. *Small PV setup*

CONCLUSION

Local solar conditions that apply to the western part of Romania, mainly where Politehnica University of Timisoara is located, offer the opportunity for multidisciplinary studies and applications of solar energy. Now, in 2025, Politehnica University of Timisoara is in the process of establishing a photovoltaic laboratory designed as a microgrid. This facility will integrate energy production, storage, and management, providing students with hands-on experience in simulating real-world energy scenarios.

This paper presented an ongoing work spanning half a century and experimental studies of solar energy in multiple fields. With Romania making significant strides in developing large-scale photovoltaic projects with over 880 large-scale PV power plants, with a cumulative capacity of more than 46600 MW, we believe that Politehnica University of Timisoara can make a significant contribution in this direction.

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