

Article

The Innovation Process of Utilizing Renewable Energy Sources for Sustainable Heat Production

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Abstract: The long-term rise in energy prices leads to reduced consumption, negatively impacting the efficiency of centralized heat supply systems (CHSS). As a result, it is necessary to address the economically inefficient preparation of hot water (HW) at heat transfer stations (HTS). Within the framework of the “Integrated National Energy and Climate Plan” (NECP), which is valid from 2021 to 2030, the industrial sector is aiming to produce 25% of its electricity from renewable energy sources (RES) by 2030. This target, up from 19.2% in 2018, equates to a value of 27.3%, which is at the technical limit of the Slovak electricity system. This article aims to study the installation of PV panels for domestic hot water (DHW) preparation within the central heat supply system (HTS) process, with the decision depending on the results of an economic return analysis. The estimated investment of EUR 5000 excluding VAT would generate annual savings of EUR 311, resulting in a payback period of approximately 16 years. The main limitation is the low efficiency in winter and no production at night, while in summer, a surplus of electricity can be used for preheating cold water.

Keywords: environmental process; renewable sources; sustainability; energy system



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1. Introduction

Pursuant to Directive 2016/2284 of the European Parliament and the Council of the EU on the reduction of national emissions of certain air pollutants, which amends Directive 2003/35/EC, in conjunction with the preparation of the National Emission Reduction Program, addressing air protection is essential. In alignment with the comprehensive program, and linked to the Air Quality Improvement Strategy, it is necessary to eliminate the emissions released into the air. This includes reducing emissions and improving air quality to mitigate negative impacts on human health and reduce risks to the environment and ecosystems [1].

The energy sector is dynamically evolving. Energy suppliers must continuously develop new technologies for the production, storage, and transportation of energy to households and businesses. Energy forms the foundation of our civilization and economy. There are two main parts of the energy industry: renewable “green energy”, and fossil fuels. Fossil fuels are more energy-efficient, but pollute the environment [2]. Figure 1 presents the production of electricity in the EU for the year 2022. Non-combustible primary energy sources, including renewable energy and nuclear power, constituted the predominant share

of net electricity generation within the European Union. In contrast, electricity produced from combustible fuels, such as natural gas, coal, and oil, accounted for less than half of the total output [3].

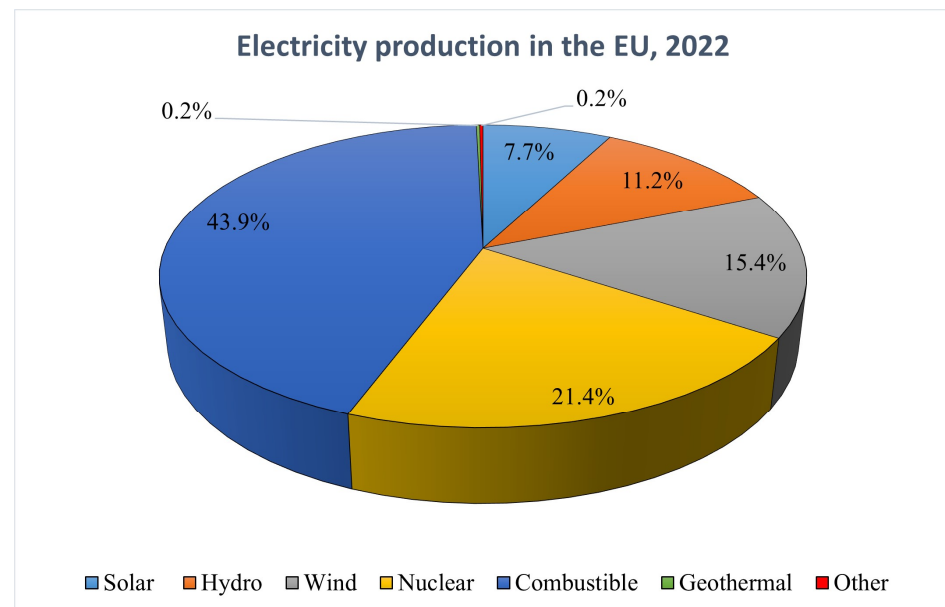


Figure 1. Electricity production in the EU for 2022.

The innovation process in harnessing renewable energy sources for sustainable heat production is crucial for achieving global energy transition goals. Jodeiri et al. [4] emphasize fourth-generation district heating as pivotal for integrating high levels of renewable energy and waste heat, highlighting the role of heat pumps in optimizing the use of low-temperature waste heat and geothermal sources. Duraivel et al. [5] underscore the efficiency advancements achieved through polygenerative systems such as the Trinitor model, which converts waste heat from diesel engines into multiple forms of energy—electricity, cooling, and heating—without additional external energy inputs. Authors Neha and Joon [6] discuss the substantial environmental benefits of renewable energy sources, noting their capacity to significantly reduce greenhouse gas emissions and contribute to sustainable energy practices through ongoing technological innovations. Baskutis et al. [7] highlight the strategic importance of expanding renewable energy sources to enhance energy independence and mitigate environmental impacts, as evidenced by ambitious national targets set for renewable energy adoption in countries like Lithuania. Gruber et al. [8] present cutting-edge technologies like fuel cells and high-temperature heat pumps, which facilitate carbon-free heat production by utilizing renewable sources such as groundwater and geothermal water, thereby minimizing primary energy consumption and CO₂ emissions. These comprehensive insights collectively underscore the multifaceted approaches and technological advancements essential for advancing sustainable heat production systems worldwide, addressing both the energy security challenges and environmental imperatives posed by conventional energy sources.

Solar photovoltaics PV is now a mature technology that is ready to deploy at the multi-terawatt scale and contribute to emission reduction in the short term [9]. Within the European context, the transition has been especially prominent, with the share of electricity produced by renewables in the EU reaching 41.17% in 2022 [10]. Similarly, Slovakia has been strategically expanding the use of renewable sources, seeking to enhance sustainability while navigating the technical constraints of its electricity infrastructure [11].

Among the various renewable technologies, solar PV has emerged as a versatile solution for both electricity and thermal energy generation. Its potential to be integrated into household and industrial settings makes it particularly appealing for hot water and heating applications. The integration of PV systems into heat supply networks, especially for HW preparation at heat transfer stations, aligns with this trend. The synergy between a heat pump and a photovoltaic system is to reduce the energy consumption of buildings to the zero energy level in the annual energy balance [12,13], indicating that solar applications for heating are not only feasible but economically beneficial.

Problem Formulation in the Case Study Company

The research results indicate that the annual solar radiation in the geographical conditions of the Slovak Republic averages around 1055 kWh/m², with approximately 805 kWh/m² occurring between April and September. From the perspective of utilizing solar energy (SE) through solar collectors (SCs), there is little variation between different regions of Slovakia. However, the highest solar radiation is recorded in the southern and south-western parts of the country, while the lowest levels are found in the Orava and Kysuce regions [14,15]. Figure 2 presents a view of the so-called solar map of the Slovak Republic [16]. The difference in SE between the coldest and warmest regions is approximately 15%.

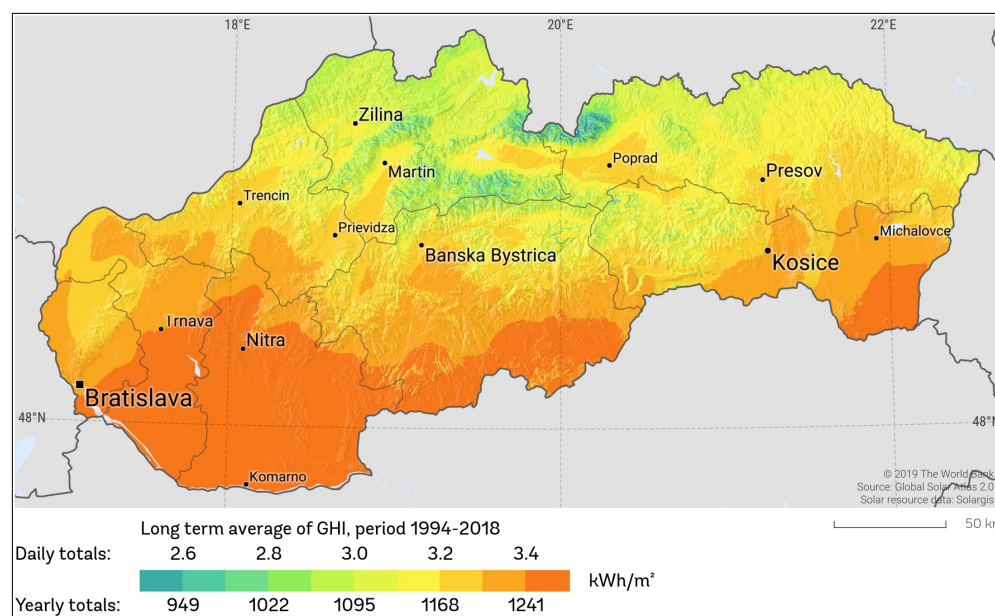


Figure 2. Solar map of Slovakia, global horizontal irradiation (Solar resource map © 2021 Solargis; www.solargis.com accessed on 3 June 2023).

According to the Global Solar Atlas [16], an online map-based tool providing data on solar resources and PV energy potential worldwide, the distribution of PV energy potential in Slovakia can be observed. The natural conditions in eastern Slovakia are favorable for utilizing solar radiation through both passive and active solar systems. Passive systems can reduce heating costs by 20 to 30%, typically covering 10 to 30% of the initial investment in house construction. Active solar systems, which use solar collectors to heat water, offer another renewable energy source with significant potential in urban areas [14,17]. Using data from the Global Solar Atlas, a PV system was designed for a small residential house. The azimuth of the PV panels was set at 180°, with a tilt angle of 37°, and an installed capacity of 2 kWp. The system produced a total PV output of 2.292 MWh per year, with a

global inclined irradiance of 1423.0 kWh/m² annually [16]. Figure 3 shows the estimated annual PV energy production for the area studied.

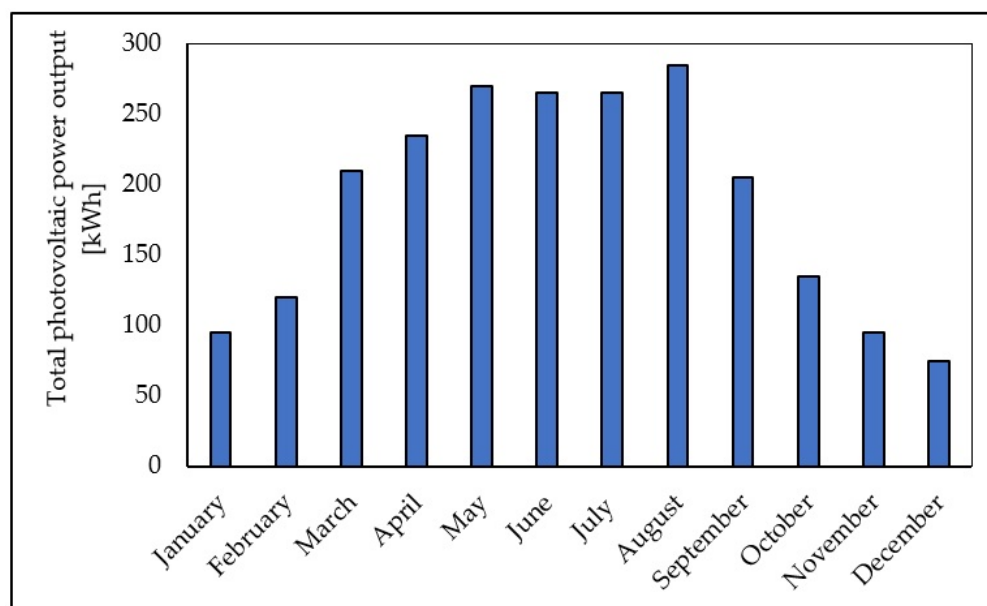


Figure 3. Estimated annual production, monthly averages (Solar resource map © 2021 Solargis; www.solargis.com accessed on 3 June 2023).

Most industrial sectors, including the energy industry, require continuous process modifications and innovative strategies. Successfully implementing these innovations in the energy sector can significantly reduce energy consumption costs while enhancing environmental sustainability and social well-being [18]. However, it is worth considering whether such cost reductions directly benefit energy producers and under what specific conditions this advantage is realized. For instance, could lower energy prices stimulate increased energy sales? This possibility largely depends on consumer demand patterns, as well as the operational efficiency and capacity of the infrastructure owned by energy companies. Efficient infrastructure can play a pivotal role in determining whether producers can capitalize on reduced production costs to maintain profitability while meeting market demands. Balancing these dynamics is essential for the sustainable growth of energy companies [19,20].

The production and consumption of electricity in the Slovak Republic are shown in Figure 4. A total of 26.903 GWh of electricity was produced by the Slovak Republic in 2022. However, in 2023, an increase in electricity production was recorded, with the value rising to 29.961 GWh. By using nuclear and hydro-energy, up to 95% of electricity was added to the network in a so-called green way, without CO₂ emissions from the production of nuclear, hydro, and PV power plants, and also by co-combustion of biomass [21].

In alignment with the European Green Deal, achieving climate neutrality necessitates the decarbonization of the energy system. Central to this effort is the provision of safe, clean, and affordable energy across the European Union. Key priorities include the increased use of renewable energy sources, enhanced energy efficiency, and the development of smart infrastructure. Within the framework of the Slovak Republic's national strategy, this contribution focuses on the role of renewable energy in sustainable heat production.

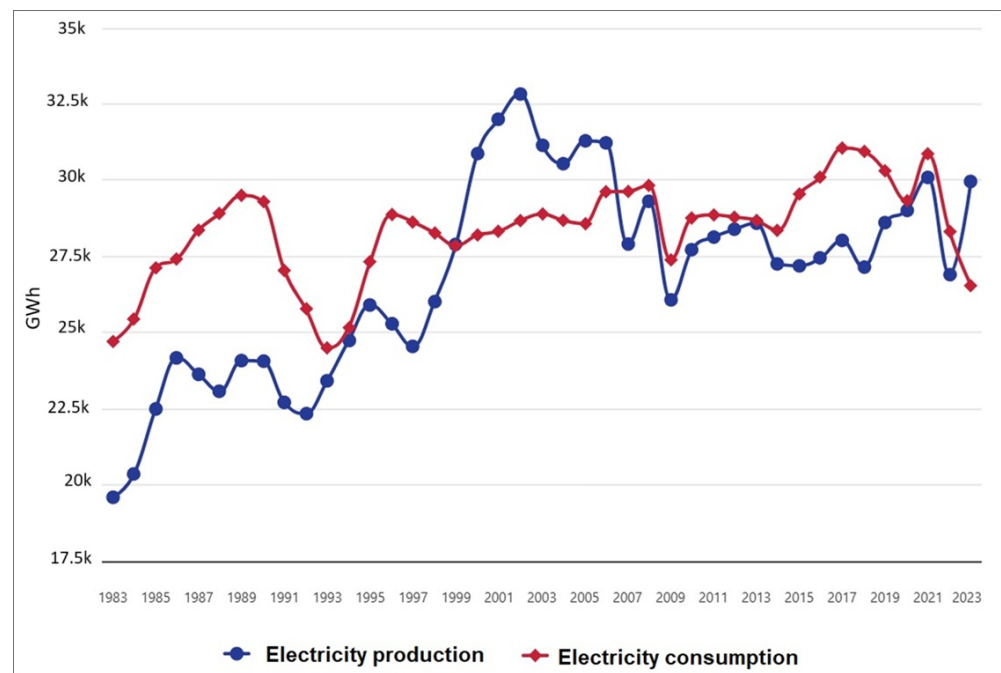


Figure 4. Production and consumption of electricity from 1983 to 2023.

The presented case study focuses on using PV panels for CH and HW preparation in heat consumption facilities. Combined with optimized heat consumption, the CHSS is considered a more efficient method of heat supply. The article is focused on an innovative system using PV panels in order to minimize (eliminate) fossil fuels.

The main objective is to minimize carbon oxide emissions and to contribute to the sustainable use of renewable energy sources. Based on this objective, the following hypotheses have been formulated: the implementation of photovoltaic (PV) panels will lead to the effective utilization of renewable energy sources, and the use of PV panels will contribute to the reduction of costs associated with heat and hot water production. Both hypotheses also assume a positive impact on the improvement of environmental quality.

2. Materials and Methods

2.1. Specification of the Energy Mix in Slovakia

From the point of view of energy security, according to “§ 37 par. 6 letters o) Act No. 251/2012 Coll. on energy and on amending and supplementing some laws,” it is important to focus on the ambitious energy development plan of the Slovak Republic aimed at making the energy mix more efficient [22]. The specification of the national energy mix considers the shares of individual energy sources in the total produced electricity. To determine the national energy mix, it is necessary to follow the methodology of the Association of Issuing Bodies (AIB). In connection with the total consumption of electricity in the country, it is appropriate to refer to the “Total Supply Mix,” which considers the total volume of tributes specified in the provided country as well as the physical size. Figure 5a presents the composition of the energy mix in Slovakia in 2023. According to the European Green Deal, there is a necessity to phase out the use of fossil resources and increase the emphasis on electricity production from nuclear sources. In 2023, nuclear resources account for 46.70% of Slovakia’s energy mix.

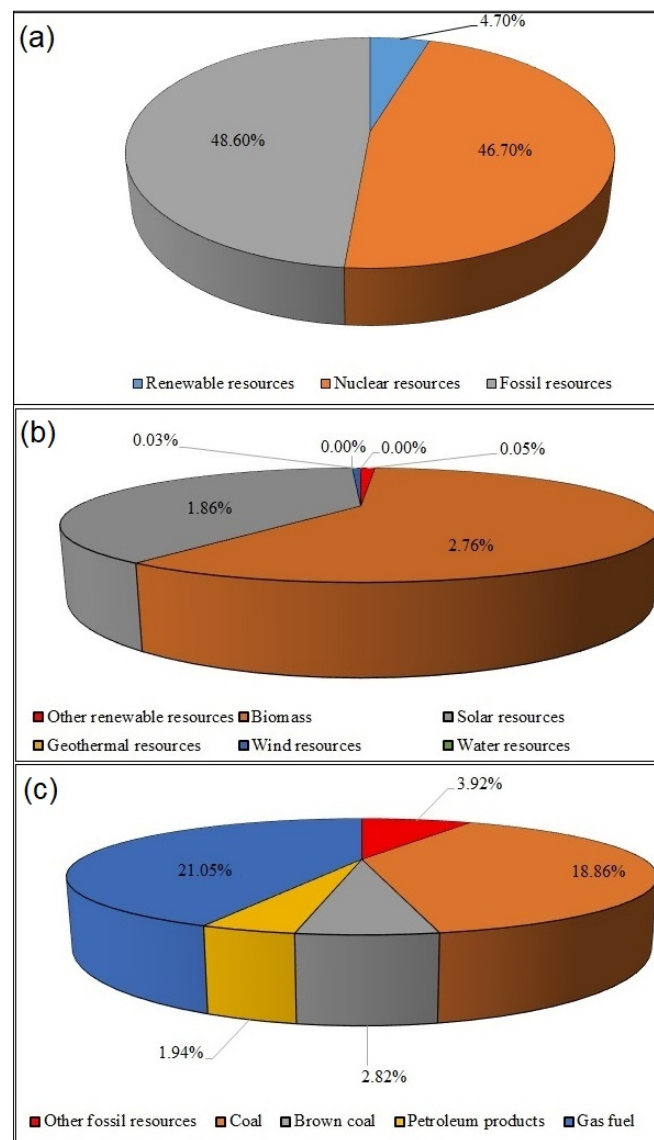


Figure 5. Specification of resources of energy mix (sum 100%) (a); identification of specific types of renewable resources (sum 4.70%) (b); and fossil resources (sum 48.6%) (c).

This demonstrates a positive trend towards the use of nuclear resources, with only a 1.9% difference compared to fossil resources. Renewable energy sources are used as an alternative to nuclear sources to produce electricity. Figure 5b presents the individual types of renewable energy resources that are used to produce heat and electricity in Slovakia. Figure 5c shows the use of fossil energy sources for heat and electricity production.

The utilization of nuclear resources for electricity production is generally perceived positively. It is a low-emission source of energy, although not emission-free. With the increasing demand for electricity due to the adoption of electromobility and heat pumps, the demand for this commodity is also expected to rise. Strategically, there is a need to prioritize the use of nuclear resources. Heat supply is characterized as self-produced heat supplied to the distribution system, which includes heat consumed in various operations and plants [22,23].

2.2. Centralized Heat Supply Systems

The CHSS is a modern, highly energy-efficient, safe, and ecological method of supplying heat for CH and HW preparation for heat-consuming objects in cities for heat distribution. The CHSS system comprises several components: one or more heat sources,

primary distributions, heat transfer stations (HTS), secondary distributions, object HTS, and collection points. The primary heat production source is typically a thermal device known as a heating plant. This plant combines heat and electricity production efficiently, often referred to as co-generation or combined heat and power [24,25].

Other heat sources include specific facilities such as exchange stations or boiler houses dedicated solely to heat production. Heat generated from these sources is distributed via primary distributions through pipelines to various parts of the city, ultimately reaching HTS. At HTS, heat from primary distributions is used to heat water for secondary distributions within the CH system and for domestic HW. The heat from HTS is further distributed to individual collection points through secondary distributions. Automatic regulation of water temperature occurs at HTS, adjusting based on external temperatures according to predefined thermal curves or specific customer needs [24,26,27].

CHSS supplies heat to urban areas, housing estates, industrial plants, and individual homes (family houses). In this system, water, the heat-carrying medium, is centrally heated in one or more sources. The heat is transferred from these sources by the heat carrier to HTS, where it is adjusted to suitable parameters for HW and CH. The components of a CHSS include the following:

- One or more heat sources where the primary heat carrier is prepared to meet necessary transfer parameters.
- Primary heat networks equipped with pumping and reduction stations (PaRS) to transport the primary heat carrier to transformation sites.
- Heat transfer stations featuring internal technological equipment that converts the heat of the heat carrier into suitable parameters for CH and HW preparation.
- Secondary distribution systems that transport the secondary heat carrier to points of consumption (e.g., apartment buildings).
- Appliances directly serving consumers (e.g., faucets and radiators in buildings) [26,28].

2.3. Solar Thermal Technologies

Solar thermal technologies serve as an additional heat source, particularly for producing domestic HW in residential and industrial settings through thermal collectors. Concentrated solar heat technologies can also provide heat for industrial applications and district heating. The primary advantage of solar thermal technology lies in its utilization of solar energy, which is carbon-neutral, relatively predictable, and independent of fuel sources. Solar panels can be easily installed on building roofs using standard solar panel configurations photovoltaic panels (PV panels) can be also integrated on the vehicle roof it can provide energy for up to 6.32% of the range on a full charge of the battery during the sunniest summer months [29–31].

Solar panels are devices designed to absorb sunlight and convert it into energy. They are categorized into PV panels and solar collectors (SCs) based on their energy conversion method. Photovoltaic panels utilize PV cells that convert sunlight directly into electricity through the PV effect. In contrast, solar collectors convert solar energy into heat [32,33]. Nowadays, wherever residential buildings are connected to the CHSS, it is necessary to give priority to the use of renewable energy sources as supplementary sources to the HTS that should be provided by the power company. Ways to use solar energy in panels are explained in Table 1.

Installing solar collectors on residential rooftops can significantly reduce the costs associated with hot water heating, although this benefit is mostly limited to sunny days, as solar collectors primarily generate heat for water heating. To enhance flexibility, PV panels offer an alternative approach by producing electricity, which can also be used for water heating. PV panels achieve maximum output during daylight hours, especially in

direct sunlight, which optimizes electricity production for household use. PV panels or SCs can be installed on the roof of a family house to generate electricity and HW, providing cost-free electricity and water heating. Typically, this results in savings of approximately EUR 300–400 per year on water heating costs, depending on HW consumption [34]. Solar energy, combined with SCs, can meet up to 70% of annual HW consumption and halve heating costs. The higher the electricity consumption, the more beneficial it is to consider PV panels [35]. Current energy company objectives should prioritize the use of renewable energy sources, including additional sources necessary for producing HW for HTS.

Table 1. Ways to use solar energy in panels.

Solar Panels		
	Solar Collectors (SC)	PV Panels
Principle	Solar energy is converted into thermal energy	PV energy is converted into electrical energy
Application	Domestic water heating Heating (minimum) Water heating in the pool (minimum)	Connection of electrical appliances to the domestic solar power plant Electric car charging

This article focuses on harnessing solar energy within energy companies to improve technical and economic efficiency in supplying heat to central heat supply systems. As part of the implementation proposal, it is crucial to analyze the current economic status of specific heat consumption at all HTS connected to the central heat supply system.

3. Results and Discussion

3.1. Specification and Design of the Innovative System Using PV Panels

The proposed innovation system using PV panels includes 12 Cheetah HC 60M panels, specifically the “JKM325M–60V” type, planned for installation on the flat roof of the building (Figure 6). The installation design involves fitting the panels into aluminum profiles mounted on a self-supporting aluminum structure.

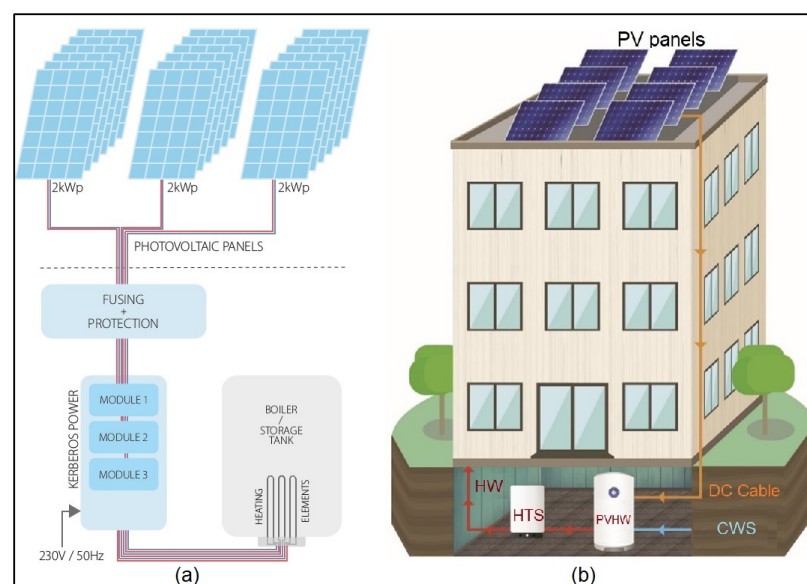


Figure 6. PV panels planned for installation on the flat roof of the building: (a) wiring diagram of KERBEROS POWER [36]; and (b) PV panels on the roof of the building (CWS—cold water supply; PVHW—photovoltaic heat water).

This structure will be securely positioned on the roof and reinforced against spontaneous movement with additional loading. Adapters placed in the central groove of the base profile will support the PV panels at a 15° tilt.

The unit kWp (kilowatt peak) denotes the nominal power of a PV panel or the entire power plant, representing the maximum power output achievable under specific conditions. kWh (kilowatt hour) is a unit of electrical energy measured by the electricity meter, representing the energy produced by the power plant. Table 2 details the specifications of the PV panel parameters [37].

Table 2. Parameters of the PV panel Cheetah HC 60 M type JKM 325 M–60 V.

Specification	
Maximum power (Pmax)	325 Wp
Open-circuit voltage (Voc)	40.4 V
Maximum power voltage (Vmp)	33.37 V
Short-circuit current (Isc)	10.5 A
Maximum power current (Imp)	9.76 A

An HTS serves the investigated apartment building, providing heat for CH and HW to 55 apartments. The average annual consumption is 180 MWh for CH and 53 MWh for HW. Additionally, the HTS requires electricity for its own operations, supplied by VSE with an annual consumption of approximately 2200 to 2300 kWh (annual cost of around EUR 470 excluding VAT). The proposed solution aims to reduce operational costs and utilize excess electricity for heating HW by installing a system of PV panels on the building's roof (Figure 6b). The inverters selected for the proposed PV system ensure direct consumption of the solar electricity generated. KERBEROS POWER 6000.B (UNITES Systems a.s., Valašské Meziříčí, Czech Republic) inverters will be employed to handle the electrical energy produced from the rooftop system (Figure 6a) [36].

The objective is to cover the HTS's electricity needs and eliminate nominal costs for heating HW using electrical heating in the HTS's tanks. To cover the HTS's electricity consumption, the proposal suggests installing four panels with a total output of 2 kWp (each panel approximately 2 × 1 m with a maximum output of approximately 460 Wp). The estimated specific annual production is 1273 kWh/kWp, resulting in approximately 2550 kWh for 2 kWp, which partly meets the HTS's electricity needs. The electricity produced in kWh from a 2 kWp source, its distribution by month, and the consumption of electricity to the heat transfer station for 2021 are shown in Figure 7. As is shown in Figure 8, in the months of January, February, October, November, and December, it will be necessary to purchase approx. 781 kWh from the electricity supplier, which amounts to approx. EUR 162 per year excluding VAT.

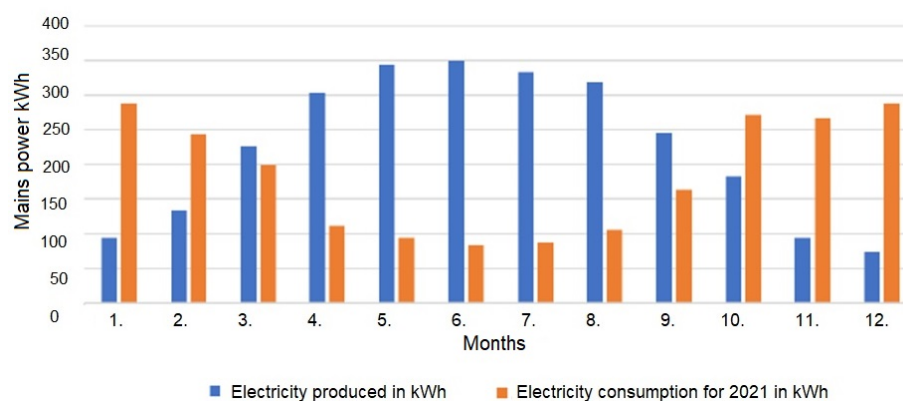


Figure 7. The electricity produced in kWh from a 2 kWp source.

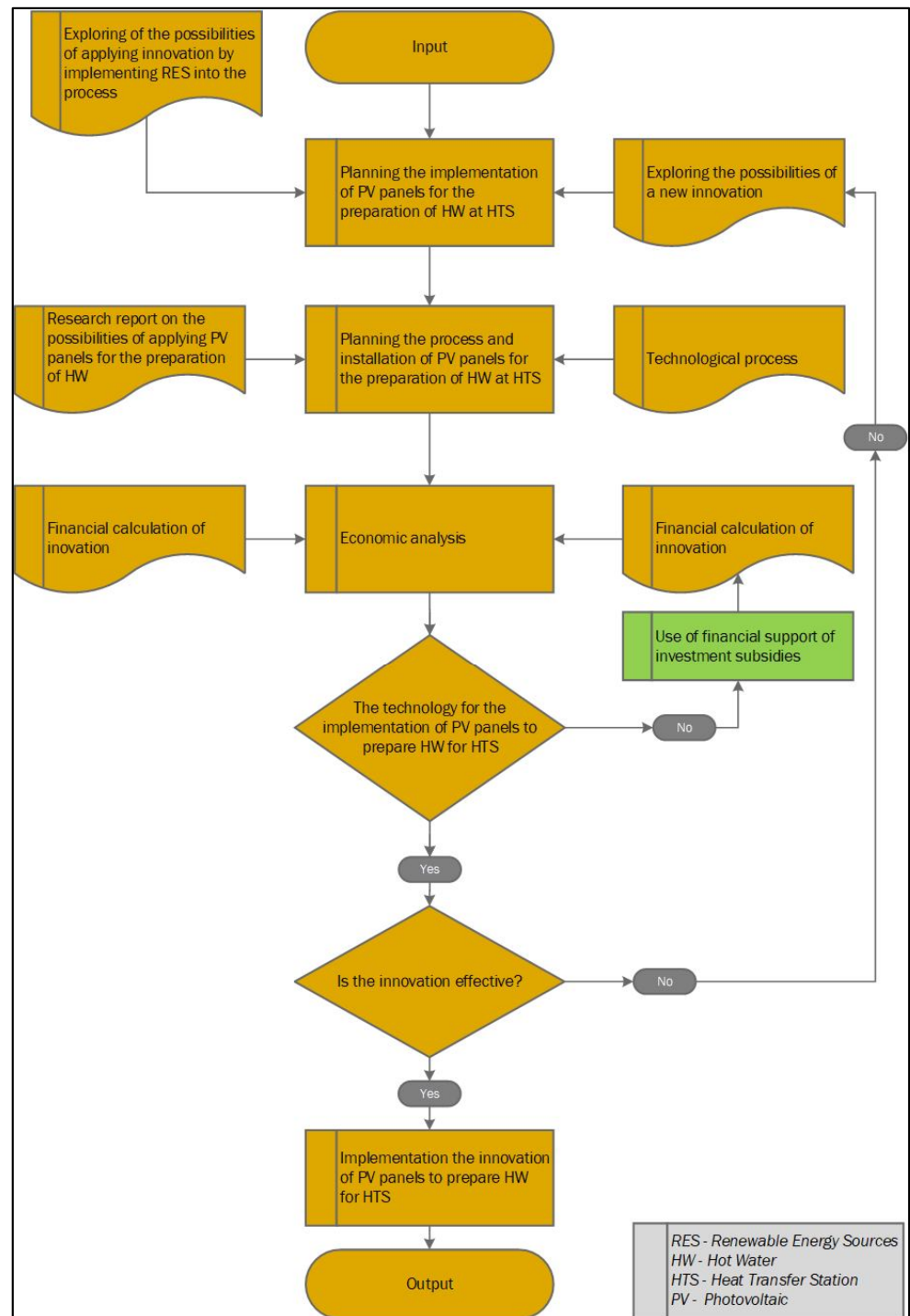


Figure 8. Proposed innovation process for introducing PV panels for HW preparation at HTS.

These inverters are equipped with a fuse disconnecter that automatically isolates the solar generator. KERBEROS POWER is a modular system designed for efficient PV water heating. Table 3 provides the technological specifications of the KERBEROS POWER 6000.B inverter [36].

Table 3. Technological parameters of the KERBEROS POWER 6000.B inverter.

Electric Data of one PV Power Module ¹	
Input open-circuit voltage (limits)	200–340 VDC
MPP tracking range	185–320 VDC
Maximum power voltage (V _{mp})	33.6 V
Short-circuit current (I _{sc})	10.2 A
Maximum output current	9 A
Maximum efficiency	99%
Electric data-mains electricity	
Input voltage	230 V AC 50Hz
Power consumption	<5 W
Construction parameters	
Measurements (h × w × d)	498 × 210 × 270 mm
Weight	11.2 kg
Ingress protection	IP 20

¹ KERBEROS POWER can be equipped with 1, 2, or 3 power modules.

The alternating current (AC) output from the device is exclusively used to power the electric coils within the storage tank, thereby heating water solely with solar energy. The mains supply is solely utilized for powering the control unit and communication module. The power component operates sharply and is thus electrically isolated from the mains section. A communication module facilitates remote management. The photovoltaic field's energy will be directed through KERBEROS POWER devices to feed electric heating units (electric coils) located within the storage tank [36]. Figure 8 illustrates the proposed scheme for the innovation process.

The initial step involves researching the feasibility of integrating renewable energy sources into heat production processes to enhance the competitiveness of the energy industry. This phase highlights areas of inefficiency or ineffectiveness in current processes, focusing on opportunities for improvement and optimization. Based on the findings of this research, the next recommended step is to strategically plan the implementation of PV panels for heating HW in HTS. The flowchart diagram of the proposed scheme for the innovation process was created using the following program: Visio Professional 2013.

3.2. Steps to Improve Efficiency of the Business Process and Return Investment

The next step consists of conducting a survey focused on the possibilities of applying PV panels for the preparation of HW for the central heat supply system. The outputs of the implemented case study, in cooperation with the technological procedure, will form the basis for implementing activities related to the planning of the procedure and the installation of PV panels for the preparation of HW at the HTS. An economic analysis is necessary to determine whether the process of introducing PV panels is suitable for the preparation of HW at the HTS and to assess its economic return. If the economic analysis confirms an effective return on investment, the process of introducing the innovation will proceed. Conversely, if the company's financial capacity to introduce the technology is insufficient, the company will seek financial support in the form of investment subsidies.

The main problem is that PV panels do not produce electricity at night, and their efficiency in the winter months is minimal, not even covering the HTS's own consumption. On the other hand, in the summer, a surplus of electrical energy from PV is expected, and this surplus (approx. 30 to 250 kWh per month) could be used for preheating cold water or heating water in the HW storage tank.

At an average cost of EUR 2500 without VAT per 1 kWp (including panels, inverter, solar cable, protection, solar construction, assembly material, assembly work, and commissioning), the estimated investment costs are EUR 5000 without VAT. The average annual payment for consumed electricity at HTS is approximately EUR 470 without VAT (for one apartment building or a family). EUR 162 must be deducted from this amount in accordance with the previous paragraph, and for the return calculation, we will consider the amount of EUR 311 without VAT. The gross return is calculated according to the relationship, Equation (1):

$$\text{Returnability} = \frac{\text{Estimated costs}}{\text{Annual savings on sales}} = \frac{5000}{311} = 16 \text{ years} \quad (1)$$

The use of PV panels for the preparation of HW for the HTS and the impact on the supply from the CHSS. To ensure the necessary supply of heat for heating HW through PV panels, the installation of additional panels is planned according to the load-bearing capacity of the roof. Table 4 presents the amount of heat for heating HW by month for the year 2021 at the HTS.

Table 4. Amount of Heat for HW Heating in 2021.

Month of Tracking	Variable Component–Households MJ	Unit of Measure
1	5160.00	kWh
2	5780.00	kWh
3	5560.00	kWh
4	5150.00	kWh
5	4730.00	kWh
6	3950.00	kWh
7	3510.00	kWh
8	4140.00	kWh
9	3830.00	kWh
10	3790.00	kWh
11	4520.00	kWh
12	3580.00	kWh

The simplicity of the comparison is based on the assumption that 1 kWh of electrical energy can produce approximately 1 kWh of thermal energy in the HW storage tank. When comparing monthly consumption for HW at the HTS with monthly values from the use of PV panels, a reduction in heat consumption for HW preparation at the HTS of approximately 1/5 to 1/4 can be observed from April to August (see Table 4). For comparison, measured values from a similar apartment building in Košice, where 12 panels are installed on the roof, are used. The research assumes a total output of 6 kWp and 8100 kWh of energy produced for HW heating (see Table 5).

Table 5. Amount of Electricity Produced.

6 kWp	Month											
Produced electrical energy	1	2	3	4	5	6	7	8	9	10	11	12
	279	402	678	912	1032	1050	999	957	738	549	279	219

The total annual heat consumption is 53.7 MWh, with 8.1 MWh produced from PV panels, representing 15%. The minimization of annual revenues from the HTS amounts to a reduction of 17%, specifically EUR 903.42 without VAT per year. The financial impact from the sale of HW to the HTS is detailed in Table 6.

Table 6. Revenues from the Sale of HW to the Heat Transfer Station.

A Month of Tracking	Fixed Component (kW)	138.8436 EUR	Variable Component–Household (kW)	0.066 EUR
1	0.9387	130.33	5160.00	340.56
2	0.9387	130.33	5780.00	381.48
3	0.9387	130.33	5560.00	366.96
4	0.9387	130.33	5150.00	339.90
5	0.9387	130.33	4730.00	312.18
6	0.9387	130.33	3950.00	260.70
7	0.9387	130.33	3510.00	231.66
8	0.9387	130.33	4140.00	273.24
9	0.9387	130.33	3830.00	252.78
10	0.9387	130.33	3790.00	250.14
11	0.9387	130.33	4520.00	298.32
12	0.9389	130.33	3580.00	236.28
Sum		1563.99	53,700.00	3544.20
Total annual sales		5108.19		

The application of PV panels without heat supply in financial terms is presented in Table 7.

Table 7. Revenues from Introduction of PV Panels Without Heat.

A Month of Tracking	Fixed Component (kW)	138.8436 EUR	Variable Component–Household (kW)	0.066 EUR
1	0.7171	99.56	4881.00	322.15
2	0.7171	99.56	5378.00	354.95
3	0.7171	99.56	4882.00	322.21
4	0.7171	99.56	4238.00	279.71
5	0.7171	99.56	3698.00	244.07
6	0.7171	99.56	2900.00	191.40
7	0.7171	99.56	2511.00	165.73
8	0.7171	99.56	3183.00	210.08
9	0.7171	99.56	3092.00	204.07
10	0.7171	99.56	3241.00	213.91
11	0.7171	99.56	4241.00	279.91
12	0.7171	99.56	3361.00	221.83
Sum		1194.78	45,606.00	3 010.00
Total annual sales		4204.77		

Assuming an average cost of EUR 2500 per 1 kWp excluding VAT, the investment cost for PV panels with an output of 6 kWp amounts to EUR 15,000 excluding VAT. In the case of financing PV panels by apartment owners, the payback period, calculated according to formula (2), based on annual savings from sales, is 16.6 years (Equation (2)).

$$\text{Returnability} = \frac{\text{Estimated costs}}{\text{Annual savings on sales}} = \frac{15,000}{903} = 16.6 \text{ years} \quad (2)$$

It is assumed that the use of PV panels compared to solar panels yields similar results, i.e., the heat-carrying medium is directly heated and subsequently fed into the HW tank. By preheating cold water or by heating the water in the HW tank using PV panels or a heat pump, it is possible to reduce the demand for heat from the central heat supply system, which could potentially decrease system efficiency during the summer season. In the modeled scenario of the investigated company, we concluded that using an alternative source could reduce the demand for heat for HW heating from the central heat supply system by approximately 15%. To address this situation, the investigated company or the heat producer can utilize subsidy financial programs for the construction of renewable energy sources. Table 8 presents the input data for the return calculation for an apartment building.

Table 8. Calculation of return for an apartment building: input data.

Flat House 55 Flats	Value/Unit of Measure	Notes
Consumption of CH	180 MWh	-
HW consumption	53 MWh	-
Electricity consumption	2300 kWh	-
Annual payment for electricity	EUR 470	-
Average price of electricity	EUR 204 MWh ⁻¹	Without VAT
Fixed component of the heat price	EUR 139	-
The variable component of the heat price	EUR 0.066/kWh ⁻¹	Without VAT
Total price of heat	EUR 92	-
Photovoltaics		
Installed power	2 kWp	-
Installed power density	241 Wp.m ⁻²	-
Area of panels	8.3 m ²	-
Built-up area on the roof	12.2 m ²	735JZ
Measured production	1273 kWh/kWp	-
Specific production	882 J	-
Efficiency of PV generation	100%	-
Electricity production	2546 kWh/year	-
Electricity production per m ²	307 kWh.m ²	-
CAPEX		-
Relative investment cost	EUR 2500/kWp	Without VAT
Investment cost of photovoltaics	EUR 5000	Without VAT
Investment cost of accumulation	EUR 1500	Without VAT
Total investment	EUR 6500	Without VAT
Subsidy	0%	-

Solar panels and PV panels are both technologies that harness solar energy, but they operate in distinct ways and serve different purposes. Solar panels, in the traditional sense, often refer to solar thermal panels, which use sunlight to heat water or air for residential or industrial use. These panels typically consist of a collector that absorbs the sun's heat, which is then transferred to a fluid that circulates through a system, providing heating for homes or businesses. In contrast, PV panels are designed to convert sunlight directly into electricity. They utilize semiconductor materials, typically silicon, which generate an electric current when exposed to sunlight. This technology is more commonly used for

electricity generation, either feeding power into the grid or providing off-grid electricity for homes, businesses, or other applications. While both types of panels are driven by solar energy, the key difference lies in their function: solar thermal panels focus on heating, whereas PV panels focus on electricity generation. The two technologies can complement each other, but each has specific uses, with solar thermal systems typically used for heating applications and PV panels being central to renewable electricity production.

In 2023, under the auspices of the Ministry of the Environment of the Slovak Republic, the national project “Green Households II” was implemented as part of the Operational Program Environmental Quality, specifically under priority axis no. 4, titled Energy-efficient low-carbon economy in all sectors. This pilot project was allocated a budget of EUR 48,000,000 and aimed to promote the use of small renewable energy sources (RES) in both family houses and apartment buildings. Financial support from this project was focused on equipment for electricity production, including PV panels, as well as equipment for heat production such as solar collectors, biomass boilers, and heat pumps [38]. The primary objectives included reducing households’ dependence on non-renewable energy sources and minimizing associated greenhouse gas emissions. One requirement for installing solar collectors was that households remained connected to the CH supply system for domestic HW without significant deterioration of domestic HW parameters. Financial contributions for PV panels were capped at EUR 1500 for installations up to 3 kW. Installing more panels did not increase the subsidy amount beyond EUR 1500. However, installations with less than 3 kW received a proportionally reduced subsidy amount; for example, a 2.25 kW installation would receive EUR 1125 in subsidy [39].

Specified subsidies were intended for all households, owners of family houses, communities of apartment owners, and non-residential premises such as apartment buildings. However, companies and other business entities were not eligible to apply for these subsidies. It is advantageous for these entities to save financial resources and simultaneously eliminate negative impacts on various environmental components. However, challenges are evident, particularly concerning the financing of these renewable resources. The issue primarily revolves around the demanding administrative procedures. It should be noted that the subsidy amount of EUR 1500 is quite low, especially considering the installation of several panels. To ensure the future financing of specified innovations, it is imperative to address this by increasing the financial contribution to a range of EUR 2500–3000.

Among the new financial instruments available for implementing renewable energy sources, including subsidies from the state budget and various EU funds, is the Green Solidarity project. This project, launched on the market in October 2024, is intended primarily for low-income households and will cover up to 90 percent of eligible expenses for the purchase and installation of equipment [40].

The new approach discussed in this paper is based on the existing theoretical knowledge in the given issue, as presented in the literature review. The proposed methodology with its outputs was tested on a practical example, which is elaborated within the case study in the submitted article. This is a new approach that could have the potential for further progress in the field of innovative approaches to solving the issue in the mentioned area.

4. Conclusions

If historical data indicate above-standard heat consumption for HW preparation at HTS, or if excessive consumption persists, implementing additional heat sources using PV panels should be considered.

The installation of PV panels in the energy sector aims to stimulate research into reducing energy consumption. Consequently, national and international entities are seeking ways to optimize costs, reduce losses, streamline processes, adjust prices, and enhance

interactions with consumers. The benefits of introducing innovative processes in the energy sector can lead to cost reductions and environmental improvements, including reduced energy consumption and subsequently lower greenhouse gas emissions.

Assuming an average unit investment cost of EUR 2500 per 1 kWp (excluding VAT), the total investment in a photovoltaic system with an installed capacity of 6 kWp amounts to EUR 15,000 (excluding VAT). In the case of financing the project by apartment owners, the payback period, calculated based on annual savings from energy sales, is estimated at approximately 16.6 years.

When introducing innovations in the energy sector, cooperation with financial instruments from the state and leveraging various schemes offered by the European Union for financing green activities are crucial. Currently, several financial instruments are available for implementing RES, including subsidies from the state budget and various EU funds such as structural funds, the recovery plan, and the modernization fund. The adoption of RES will not only contribute to meeting decarbonization goals but also fulfill quotas for heat production from RES.

For example, subsidies for PV installations for systems up to 3 kW are EUR 1500. For smaller systems, subsidy support is proportionally reduced. An example is a system with an output of 2.25 kW, which is supported in Slovakia at EUR 1125.

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