

INCREASED USE OF SOLAR SYSTEMS, ADVANTAGES AND EXPECTED NEGATIVE EFFECTS ON HEALTH AND THE ENVIRONMENT, THAT IS, TREATMENT OF WASTE FROM SOLAR PANELS

Pregledni znanstveni članak

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Abstract

First and foremost, the main inspiration for the specific problematic in this paper is the increased use of the solar systems as renewable source of energy in accordance with the changes in the electricity sector in the countries from West Balkan and the actual global energy crisis.

The arising questions are: if there is a real possibility for production for own use and trading with the surplus of the produced electricity from photovoltaic systems by the households and what are the possible negative consequences of the excessive use of solar systems in the long run in terms of waste management resulting from the used and dilapidated panels.

Necessary data is provided through analyze and elaboration of the legal framework and available data for the Republic of North Macedonia and other countries from this region and by comparison of their legal solutions with those one from European Union and America.

Also, the results and conclusions of the research shall be achieved via comprehensive analysis and by finding the answer to the posed questions through the: theoretical analysis, the inductive and deductive methods, whereas the techniques utilized shall be: official data, information from public media and studies, questionnaires, interviews and observations as well.

The answers of the posed questions are:

- that in this region there is some progress and legal approval for the production and trade of solar energy by the households,*
- that there is not enough awareness about the toxicity and danger of the waste from solar systems and the management of this type of waste is not elaborated in detail, nor there are mandatory measures for action by households.*

The main conclusion is that on one side, we have the increase use of solar panels as one of the answers for the energy crises and on the other side, no applicable and effective solution has been offered in the region so far, nor is the management of the waste of solar panels legally regulated at the state level.

Key words: energy, solar systems, panels, photovoltaic, households, West Balkan, waste management, toxic waste, recycling.

1. INTRODUCTION:

All the developments in the world in recent years were primarily related to the health crisis caused as a result of the spread of the Covid-19 pandemic, which was followed by the energy crisis from 2021.

In doing so, the international community imposed sanctions on Russia for its economic isolation, and it was clear that the crisis with the war in Ukraine would affect the global economy.

The European Commission has published a plan "REPowerEU: A plan to rapidly reduce fossil fuel dependence on Russia (due to the war in Ukraine) and encourage green transformation" which, among other things, established mandatory installation of photovoltaic (solar) panels for existing public and commercial buildings and all new apartment buildings starting in 2026.*

The green transformation is intended to boost economic growth, security and climate action for Europe and its partners.

In the countries of the region, before and after the global energy crisis, which was not absent in these countries, innovations are rapidly proposed and introduced in the legislation for greater and more mass production of electricity from renewable sources.

One of the innovations that is being introduced, in addition to the existing possibility for production for own use, is to enable trading with the surplus of the produced electricity from photovoltaic systems by the households.

The state action plans are aimed at using the numerous benefits and planned increase of the share of solar systems in the total production of

* https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

electricity in response to the energy crisis and mitigation of the consequences of the imposed European sanctions that are felt by the countries in the region.

At the same time, the state strategies neglect the possible negative consequences of the possible excessive use of solar systems in the long run in terms of treatment and waste management resulting from the used and dilapidated panels.

After the performed analyzes, one gets the impression that there is not enough awareness about the toxicity and danger of this type of waste and that the management of this type of waste is not elaborated in detail, nor are there mandatory measures for action by households.

2. PRODUCTION OF ELECTRICITY FROM SOLAR SYSTEMS INSTALLED BY HOUSEHOLDS IN EUROPE AND AMERICA NEXT TO THE NEAR

There are several ways and methods used in Europe and America through which the production and transmission of solar energy from households in the energy system is allowed, encouraged and stimulated.

These good and functional examples could find appropriate application in the countries of the Western Balkans if they make sufficient efforts to overcome some located obstacles, which are referred to by the energy institutions and use as an excuse for the situation in the past.

Options available and already operating in Europe and America are the introduction of monthly, seasonal, annual or kWh-credits indefinitely time from unused solar energy produced by households.

It is necessary to enable the users-natural persons who produce their own to be able to use solar energy at any time, not just when it is generated (alternating / weather dependent). That way, on a monthly basis it allows users overnight to use the solar energy produced during the day.

On an annual basis, the net kilowatt credit is shifting, allowing households to use the solar energy, which, for example, was produced in July and delivered to the system, in December.

A similar practice would it also existed in periodic network measurements (for example, every 6 months / one year).

What is also proposed and necessary, and which already works in other European countries, is the possibility for the household as a producer and

consumer of solar energy to transfer to the system the excess electricity that it can not use and at the same time to get a loan on the account which applies in relation to future electricity consumption.

Conversely, if the household-consumer spent more than what was handed over to the system, then it would pay the same price as any other consumer (retail price / price of electricity for households).

Whereas, if the household manages to save on spending, another option is in case there is a surplus of production credits left on the account on the date of the anniversary when the offset / spent is performed, so that the distribution company can repay that loan at market (current price per MWh on the free market) or at retail price, which depends on how this issue would be regulated by law.

The idea is based on purely economic motives, but also on environmental benefits, and the point is to first satisfy one's own consumption, and only then to "go back" to the system.

In the Western Balkan countries, legal entities are successfully and actively involved in the production and transmission / sale of produced solar energy through a model of premiums and a model of feed-in tariffs and other similar models .

As for the natural persons, efforts are made for their active involvement in the production of the produced solar energy.

In the Republic of Serbia, changes occurred with the adoption of the new Law on Renewable Energy Sources and the amendments to the Law on Energy last year, followed by the adoption of the Decree on criteria, conditions and method of calculating demand and liability between buyer-producer and supplier and formulating a model contract for manufacturers. In parallel with the legal changes, subsidies for solar panels have been introduced. However, although last month a household boasted of being a successful producer of its own energy that is consumed after many years of unsuccessful attempts, there are still no conditions for full revival of the process of production / sale of solar energy in households. In this country there is an opinion that there are still obstacles to the implementation of legal changes such as the complexity of the procedure and the volume of necessary documentation and the treatment of households with more than two apartments as a housing community which makes the process impossible for them due to inapplicability of the procedure.

The new Law on Renewable Energy Sources in Republika Srpska allows households to be both producers and consumers of electricity by installing photovoltaic panels, and a similar solution in the Federation of BiH is still pending.* In Bosnia and Herzegovina, with the support of German governmental organizations for technical assistance and cooperation (GIZ) and the Energy Community, a new law has been prepared that allows citizens to install solar panels in their homes. However, the implementation and revival of this process is dragging on, and the public has a wrong picture of higher energy prices from renewable sources and at the same time the state did not subsidize the installation of solar panels from households such as other neighboring countries.*

In Croatia, on the other hand, there are three models for the use of solar energy in households.

It is possible for the owner of the building to live at his own expense (with loans and state aid) to install a solar system and thus become the owner of the produced energy that he uses for the needs of his household. There is also the possibility for a third party to finance the purchase and installation of the solar system, usually legal entities that deal with the production of electricity. In this second case, the legal entity that installed the solar system of the household sells the produced solar energy to it until it pays off its investment (up to 10 years) after which period the household becomes the owner of the solar power plant.

The third and latest model that exists in Croatia is suitable for people living in apartments or buildings with a small roof area on which solar panels can be placed. This model enables multiple users to build a larger solar power plant on the roof of a residential or public building. Joint users share the energy produced and enjoy the benefits.

Otherwise, in Croatia today it is possible to transfer the excess solar energy produced by households to the national electricity network, which earns additional financial resources for the household.*

In Croatia from 2026, a mandatory obligation is introduced for the installation of solar panels for the production of electricity in all new

* <https://business-magazine.ba/2022/05/06/88193/>

* <https://www.klix.ba/biznis/kakvi-su-uslovi-za-postavljanje-solarnih-panela-u-bh-domacinstvima-nuzne-velike-promjene/211013090>

* <https://www.jutarnji.hr/native/ovdje-su-svi-odgovori-koje-trebate-strucnjacima-smo-postavili-32-pitanja-o-solarnim-elektranama-15124735>

residential buildings *, in order to implement the plan to reduce dependence on fossil fuels. - " REPowerEU ".

In the Republic of North Macedonia, a Rulebook on renewable energy sources has been adopted (Official Gazette of RNM no. 112/2019) according to which a household, small consumer, budget user and individual user can build a plant for production of electricity from a renewable energy source at which will use the produced energy for its own consumption, and will transfer the excess energy produced to the electricity distribution network.

According to this Rulebook, a consumer-producer can hand over the surplus of produced electricity in the electricity distribution network if:

- is not supplied with electricity by the universal supplier,
- installs a photovoltaic system or a small faithful power plant as a plant for production of electricity from a renewable source on construction on which he/she has the right of ownership or use,
- the installed capacity of the power plant for production of electricity is not greater than 4 kW, for household,
- the installed capacity of the power plant for production of electricity is not greater than 20 kW, for small consumer, budget user, single user,
- delivers the surplus of produced electricity at the same point to which the supplier delivers electricity and an agreement is concluded between the consumer-producer and the electricity supplier for supply and surplus supply.

In addition to the listed as special conditions are the plant to meet the technical-technological requirements, the manner of connection to the electricity distribution network determined by network rules for electricity distribution and the measurement of produced and delivered electricity to be performed through metering devices that meet the conditions prescribed in the same network rules.

However, in practice there are some obstacles due to which the production and transmission of surplus electricity can still not be effectively implemented for households in the Republic of North Macedonia, unlike legal entities.

* <https://pari.com.mk/solarnite-paneli-stanuvaat-zadolzitel/>

In any case, there is a great movement in the process of enabling mass installation and use of solar panels for electricity generation / transmission in the period and near future, including for households.

3. WASTE FROM SOLAR SYSTEMS, CLASSIFICATION, TREATMENT AND THE IMPACT OF ITS IMPROPER MANAGEMENT ON PEOPLE'S HEALTH AND THE ENVIRONMENT

The expected increased installation and use of electricity produced by solar panels both for own consumption and for transmission to the electricity distribution system requires the provision of measures for their maintenance and treatment of waste resulting from unusable panels.

According to the current Law on Energy in the Republic of North Macedonia, the user of the energy system (including the system from renewable sources) is obliged, among other things, to use and manage its energy facilities, devices or installations in accordance with this and other law, other regulations and relevant network rules and *not to endanger life and human health, the environment and property.*

The State Inspectorate for Technical Inspection is responsible for determining and ordering the elimination of possible deficiencies in energy facilities, devices or installations.

Special treatment of waste from worn out, dilapidated or non-functional solar systems is not provided in the country, nor is there a wider awareness and professional development of the effect of improper handling and disposal on human health and the environment.

About 26,000 tonnes of solar panels will end up as waste this year. This is only a small part of the global electronics waste, which amounted to 54 million tons in 2019.

The greatest effect of solar panels occurs in the first 25-30 years, and the reasons why they end up as waste, are usually damage due to natural disasters or defects in the production process, and others due to replacement with newer and more efficient than the latest technological generation.

It is estimated that by 2030 annual waste from photovoltaic (solar) panels (" PV ") will be 8 million tons, and in 2050 the annual PV waste will be 80 million tons globally.*

Rejected panels are often stripped of their aluminum frame and junction box, which are taken to metal and plastic dumps.

Unfortunately, old used panels are appearing on the market in Macedonia at attractive prices, with already worn out function and use value, with a remaining life of only a few year, which increases the risk of pollution from this type of waste. In our country and in the world, the use of solar systems is increasing as a result of government policies and European trends, which would mean deepening the problem with the storage and treatment of hazardous waste that will be produced in the future.

As a possible option for resolving the issue, it may be possible during the procurement and installation to impose obligations for waste management in case of use, obsolescence or non-functionality.

Industry and government policies have not yet found a way to solve the problem that will escalate in the years to come as solar panel waste has been found to be highly hazardous and toxic.



Picture 01.06.2018 - 11:17 Author: H. Domazet

Namely, according to some research, it has been determined that this waste is 300 times more toxic than nuclear waste and due to the lack of regulations for its disposal, this waste is usually sent to poor countries.

* <https://youtu.be/UJYpw606tXsyu>

Solar panels contain carcinogenic cadmium, lead and mercury that are not removed without breaking the panel, and their lifespan is at least 25 years. For these reasons, the entire solar panel is considered *hazardous waste*.

Almost 90% of photovoltaic panels are made of glass, but that glass can not be recycled due to dirt. "Glass is most often contaminated with plastic, mercury, cadmium and antimony," warns prof. Dustin Mulwain from Environmental Studies at the University of San Jose in the United States.

The global market for photovoltaic panels has grown in the last 10 years, and what has been installed so far will end up in waste in about 20 years or later.

According to this claim, it is an environmental problem that will literally escalate in two to three decades because it is a large amount of hazardous waste that will not be easily recycled.

The International Renewable Energy Agency IRENA in cooperation with the Association of Panel Manufacturers in 2016 estimated that 250,000 tons of solar panel waste will be generated in the world that year alone and estimates that by 2050 this amount will increase to 78 million tons.

This is the first such assessment made in the world.

For example, in the United States alone, 10.6 GW of new solar capacity was installed in 2017, and if we take an average of 300 W, that means that 35.3 million new panels have been installed.

The lack of an answer as to what to do with such hazardous waste is slowly starting to worry the industry, which is not yet looking for a solution, but sporadically stores such waste until a recycling program is in place.*

According to another study, solar panels now end up mostly in ordinary waste because the systematic recycling of this type of waste has not yet been established anywhere in the world.

Well-known experts in industry and science warn that solar panels exposed to rain and other heavy rainfall and strong winds break the panels, and that in contact with rain, contrary to previous beliefs, can still lead to leakage of heavy metals into the soil.

Environmental activists are also aware of this and are less satisfied with the installation of large solar power plants.

* <https://portal.efixelectrical.com.mk/site/recikliranje-na-solarnite-paneli/>

Most experts believe that recycling panels is a must, but the problem is that the cost of recycling is higher than the cost of producing new panels. Chinese manufacturers say that if the panels are recycled "according to the rules", their product would be more expensive.

Low waste demand and high labor costs for dismantling aluminum frames and other components are unlikely to be a profitable business unless panel manufacturers are burdened with recycling costs, which will make the product more expensive, they have already calculated in Japan.

If all solar panels were completely recycled by 2050, they would bring in a new value of \$ 15 billion. The disadvantage of this estimate is that it did not link this figure to the cost-effectiveness of producing new panels, although rare metals are known to be a long-term limiting factor for growth or the cost of producing solar panels.

In 2012, US company "First Solar" began investing part of its revenue in a long-term waste disposal fund, and Washington became the first U.S. state last year to require manufacturers to build a recycling plant, but legislation does not require them to pay a fee. those purposes. But the problem arises when companies go bankrupt - in 2016, seven panel companies in the world went bankrupt, in which case future recycling falls on taxpayers.

Rich countries can handle this, but not poor ones. Due to gaps in legislation (OEEE Directive on electrical and electronic waste) solar panels often end up as electronic waste. It should be noted that 70% of such waste ends up in undeclared and unknown destinations, according to the UN Environment Program.

Many communities in Ghana, Nigeria, Vietnam, Bangladesh and Pakistan are already living near the world's largest e-waste landfills, which are heavily polluting both air and soil and drinking water, which is already in short supply.*

In near future we can expect a period when the huge number of worn salt panels that are now used will have to be withdrawn from use. And that brings us a problem with their waste management. With that, solar panels will be a problem that we will all have to start working on, says scientist Garvin Heath of the National Renewable Energy Laboratory and a solar

* *Res publica* <http://www.energetika-net.com/u-fokusu/res-publica/potrgani-i-stari-solarni-paneli-su-opasni-otpad-27007>

energy expert. Many people think that recycling is part of the solution. But part of the problem is that solar panels are complicated to recycle. They are made of many materials, some dangerous, and are made of glue and other materials, so the real challenge is to disassemble them. "The longevity of these panels, the way they are assembled and how they are made makes it quite difficult to disassemble," said Mark Robards, director of special projects for "ICS Refining", one of the largest electronics recycling companies in America. The panels are mechanically disassembled and decomposed with acids to separate crystalline silicon, the semiconductor material used by most photovoltaic manufacturers. Thermal adhesive combustion systems are used. Robards says nearly 75 percent of the material that separates is glass, which is easy to recycle into new products but has a very low resale price. As solar panel technology improves, manufacturers are slowly finding ways to use components that would be of value to recyclers, such as copper and iron. This basic commodity value of these things continues to fall - says Roberds . The lower the value that can be recycled, the less incentive there is to recycle.* Evelyn Butler, director of codes and standards at "Solar Energy Industries Association", says she works with recyclers to share data on which components and materials are being processed and although they were in a fairly early stage of the process, they hope to have 5 or 10 years will have the data you .



Photo: First Solar Company - " First Solar "

* <https://www.fakulteti.mk/news/05022019/shto-kje-se-sluchi-so-solarnite-paneli-koga-nema-da-funkcioniraat>

Some photovoltaic companies offer recycling, such as “First Solar”, one of the largest photovoltaic suppliers that has long offered recycling for its products. Over the years, they note that they gradually improve the process. The company has installed over 100 million panels and expects it to take 10 to 15 years to complete their lifespan. According to the company, as time goes on, the cost of their technology decreases and the volume of waste increases - says Sukhvant Rayu, director of recycling operations at “First Solar”. The company's long-term goal is to ensure that the process is cheap and efficient to deal with the expected wave of panels that will no longer be used. To have better recycling methods, the panels designed by this company are made to be recyclable. According to their information, 90 percent of the material of the panels is glass, and the semiconductor in the panels can be reused for new panels or other glass products.*

4. CONCLUSION

Europe and America offer good and functional examples of ways and models of using and transmitting solar energy produced by households from photovoltaic systems that could find appropriate application in the countries of the Western Balkans. Certainly application of these examples can be found if the countries of the region make sufficient efforts to overcome some located obstacles, to which the institutions in the field of energy refer and use them as an excuse for the situation in the past period. In any case, there is a great movement in the process of enabling mass installation and use of solar panels for electricity generation / transmission in the period and near future, including for households. The expected increased installation and use of electricity produced by solar panels for both own consumption and handover in the electricity distribution system, requires the need to provide measures and procedure for their maintenance and treatment of waste arising from unusable used or non-functional panels. It is estimated that by 2030 annual waste from solar panels will be 8 million tons, and in 2050 the annual waste from solar will be 80 million tons globally.* Well-known experts in industry and science warn that solar panels exposed to rain and other heavy rainfall

* <https://www.fakulteti.mk/news/05022019/shto-kje-se-sluchi-so-solarnite-paneli-koga-nema-da-funkcioniraat>

* <https://youtu.be/UJYpw606tXsyu>

and strong winds break the panels, and that in contact with rain, contrary to previous beliefs, can still lead to leakage of heavy metals into the soil. Namely, according to certain researches, it has been determined that this waste is 300 times more toxic than nuclear waste and due to the lack of regulations for its disposal, most often this waste is sent to poor countries.

Solar panels contain carcinogenic cadmium, lead and mercury that are not removed without breaking the panel, and their lifespan is at least 25 years. Well-known experts in industry and science warn that solar panels exposed to rain and other heavy rainfall and strong winds break the panels, and that in contact with rain, contrary to previous beliefs, can still lead to leakage of heavy metals into the soil.

For these reasons, the entire solar panel is considered *hazardous waste*.

According to research, it has been determined that solar panels now end up mostly in ordinary waste because the systematic recycling of this type of waste has not yet been established anywhere in the world.

Most experts believe that recycling panels is a must, but the problem is that the cost of recycling is higher than the cost of producing new panels.

Many people think that recycling is part of the solution. But part of the problem is that solar panels are complicated to recycle. They are made of many materials, some dangerous, and are made of glue and other materials, so the real challenge is to disassemble them. The longevity of these panels, the way they are assembled and how they are made makes it quite difficult to disassemble.

Many large and successful companies for the production of solar panels are working intensively to improve and reduce the process of recycling solar panels due to certain predictions of increasing waste that will result from solar panels that are already in use.

Apart from the attempts to improve and reduce the cost of recycling the waste from solar panels in the world, no applicable solution has been offered in the region so far, nor is the management of this type of waste legally regulated at the state level.

In order to resolve the issue, the imposition of users' obligations for waste management in case of utilization, obsolescence or non-functionality of the panels when the procurement and installation of solar systems is made, should be considered as a possible option.

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