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Feasibility study for the implementation of solar power plants in the USA

Abstract: The article provides calculations and feasibility study of solar power plants implementation for the states of New Jersey, New Mexico and Michigan. The average cost for grid power, average household kwh use per month and average cost for 6-kw system with 26% federal tax credit applied were taken into account. The approach outlined in this article proposes to take into account changes in the value of money, tariffs and period of service of solar power plant.

The conducted research shows that the construction of SPPs in the USA can be profitable in the conditions of constant growth in prices for electricity produced using traditional energy sources. However, with the stability of electricity prices, the use of solar energy is far from the most profitable investment.

It has been proven that there is a need to focus on the research of the latest energy storage and generation technologies in order to reduce the impact of the instability of renewable energy production on the stability of power grids in the future. Further development of SPPs can help increase their availability and competitiveness, which will contribute to the creation of a sustainable and green

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energy infrastructure. The development of technologies in this area will also lead to a decrease in installation prices and an increase in the efficiency of the panels.

The main limitation of solar power plants is the need for a large area for the installation of panels in order to achieve the level of industrial electricity production. Therefore, now the centralized production of electricity using the sun is possible only in areas that are unsuitable for life and economic activity.

Keywords: implementation, renewable energy sources, solar power plants, Feasibility study, Calculation methodology

Introduction

Solar energy is becoming more and more popular nowadays and its share among renewable energy sources is growing every year (Renewable capacity… 2023). According to the report of the International Renewable Energy Agency (IRENA) dated March 20, 2023, the energy amount, produced by solar power plants (SPP) is 1053 GW in 2022, which is 31% of the energy obtained from all renewable energy sources (Renewable capacity highlights… 2023).

SPPs can be indispensable in conditions where it is impossible to build or use power plants with traditional energy sources. Especially, in case when delivering resources is difficult or even impossible. Such places examples are research stations at the poles of Earth, remote villages, the International Space Station, etc.

Despite the high popularity and advantages, SPPs have a number of disadvantages.

First of all, the effectiveness of SPPs depends on weather conditions, in particular, on the presence of sunlight (Solar Energy Pros and Cons…). The effect of cloudiness, precipitation and seasonal changes will reduce the performance of solar power plants and, as a result, the production of electricity.

Secondly, SPPs require significant areas for placement (Solar Energy Pros and Cons…). This can cause natural habitat loss. In order not to take up space, panels are often installed on the roofs of houses.

Moreover, the production of solar panels requires the use of environmentally harmful materials. In addition to this, the production process needs significant electricity consumption and is accompanied by the emission of a considerable amount of greenhouse gas (Solar Energy Pros and Cons…). Since materials harmful to the environment are used in production, there is a need for a reliable and safe disposal process for solar panels.

Finally, the cost of SPP installation is high, although the prices of solar panels are constantly decreasing due to the popularity and improvement of the technology. On average, a consumer can expect to pay about USD 18,000 for a complete home solar installation, excluding any incentives and the federal solar tax credit (Solar Energy Pros and Cons…).

Therefore, states often have to implement preferential conditions for the purchase and installation of SPPs. For example, according to the US Internal Revenue Service, if you invest in renewable energy sources for your home, such as solar, wind, geothermal, fuel cells, or battery storage technology, you may qualify for an annual clean energy tax credit (Residential Clean…).

There are also various grant programs to encourage collaboration and the solar energy adaptation. For instance, The U.S. Department of Energy (DOE) and Solar Energy Technologies Office (SETO) supports funding opportunities on photovoltaics, concentrating solar-thermal power, systems integration, technology to market, and soft costs projects. Solicitations may include financial or technical assistance (Funding Opportunities).

The purpose of this work is to conduct an analysis to find out the feasibility of using solar power plants from the point of view of economic benefit. For this, the costs of construction and operation of the SPPs and the profits, received as a result of cost savings on the electricity produced by the SPPs, were analyzed. Calculations were made for 3 US states, namely New Jersey, New Mexico and Michigan, since households in these states have almost equal electricity consumption per month which gives an ability to see the difference between the profits from a solar power plant depending on the state (based on electricity rates, installation costs and other factors).

The following parameters were taken into account in calculations according to the approach (How much do… 2023):

- Average price of SPP installation with capacity of 6 kW;
- Average cost of electricity;
- Average household kW·h use per month.

Approaches and methodology for conducting a feasibility study were taken from the article “LED lamps – are they inexpensive and effective?” by Volodymyr Mamalyga (Mamalyga 2022).

1. Methodology

According to the approaches given in “LED lamps – are they inexpensive and effective?” by Volodymyr Mamalyga (Mamalyga 2022), the following Formula (1) was derived.

Calculation of discounted costs D_C for the implementation of a solar power plant:

$$D_C = \frac{-C_E}{(1+i)^n} + \frac{-M_C + (E_{AVG} \cdot t_{el} \cdot 12)}{(1+i)^n} + \ldots + \frac{-M_C + (E_{AVG} \cdot t_{el} \cdot 12)}{(1+i)^n}$$

In this case, the following notation is used.

C_E – capital expenditure (CAPEX). These are the costs of the construction and installation of solar power plants (SPP). The CAPEX formula for SPPs consists of costs for panels, inverters, fixtures, electrical equipment, batteries, installation;

M_C – maintenance costs. The annual operation and maintenance cost of home solar systems is around USD 31 per kilowatt (kW) of installed capacity (The Cost of…). As a result, for an SPP with a capacity of 6 kW, the cost of annual maintenance will be USD 186 (USD 31 × 6 kW);

E_{AVG} – average monthly amount of consumed electricity in kW·h;

t_{el} – electricity tariff (measured in cents/kW·h);

i – value for money;

n – service life of SPP (n = 25 years);

2. Results and discussion

Average indicators of electricity use for the states of New Jersey, New Mexico, and Michigan, according to (How much do… 2023):

Table 1. Average figures related to the installation and payback period of a 6 kW SPP for the states of New Jersey, New Mexico, and Michigan, according to (How much do… 2023)

Tabela 1. Średnie dane dotyczące instalacji i okresu zwrotu SPP o mocy 6 kW dla stanów New Jersey, Nowy Meksyk i Michigan

STATE	New Jersey	New Mexico	Michigan
Average cost for 6-kW system with 26% federal tax credit applied [USD]	10,745	12,343	11,855
Average cost for grid power (july 2022) [¢/kW·h]	17.21	15.09	18.03
Average household kwh use per month	673.24	669.89	675.6
Derived estimated yearly savings assuming 100% solar coverage of electrical needs	1,390.38	1,213.04	1,461.73
Derived estimated number of years to “break-even” on the investment	7.73	10.18	8.11

Three US states (New Jersey, New Mexico, and Michigan) were selected to create a diagram showing the discounted implementation cost of SPPs because they have a similar average usage of electricity by one household per month, with a difference of 0.35 to 0.5%. The data for the mentioned states was taken from the article “How Much Do Solar Panels Cost In 2023?” (How much do… 2023) on the Forbes website.

The article (How much do… 2023) describes in detail the differences between diverse types of solar panels, the installation cost, and the associated costs. The article also mentions what factors to consider when installing a power plant. It even includes links to the best SPP installation companies for each state. Such a detailed description enables a person to study all the advantages and risks and, as a result, determine the expediency of investing in solar energy.

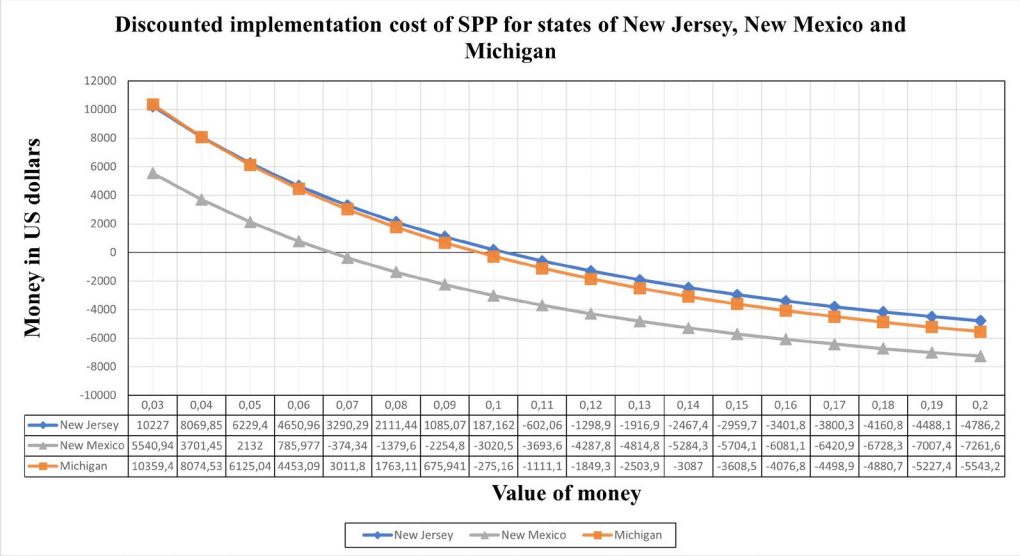
However, the article (How much do… 2023) provides the calculation of the undiscounted cost of implementation and the payback period of the SPP, which does not take into account changes in the value of money. As the operating life of SPPs is very long (25 years and more), ignoring changes in the value of money leads to the calculations becoming extremely simplified and may lead to incorrect results.

The approach outlined in this article proposes to consider changes in the value of money, which will make it possible to evaluate the worst and best scenarios during the SPP's service life. This article also considers other factors, such as changes in electricity tariffs and the cost of SPP installation. When calculating using this approach, future cash flows are converted into their current value, which allows for the evaluation of possible options for the development of events and their effects on the SPP project's economic efficiency throughout the entire period of operation.

Below are the results of calculations according to Formula (1), which is significantly different from the approaches given in the article (How much do… 2023).

The diagram analysis presented in Figure 1 shows that when the cost of money is more than 10%, the construction of a solar power plant is unprofitable.

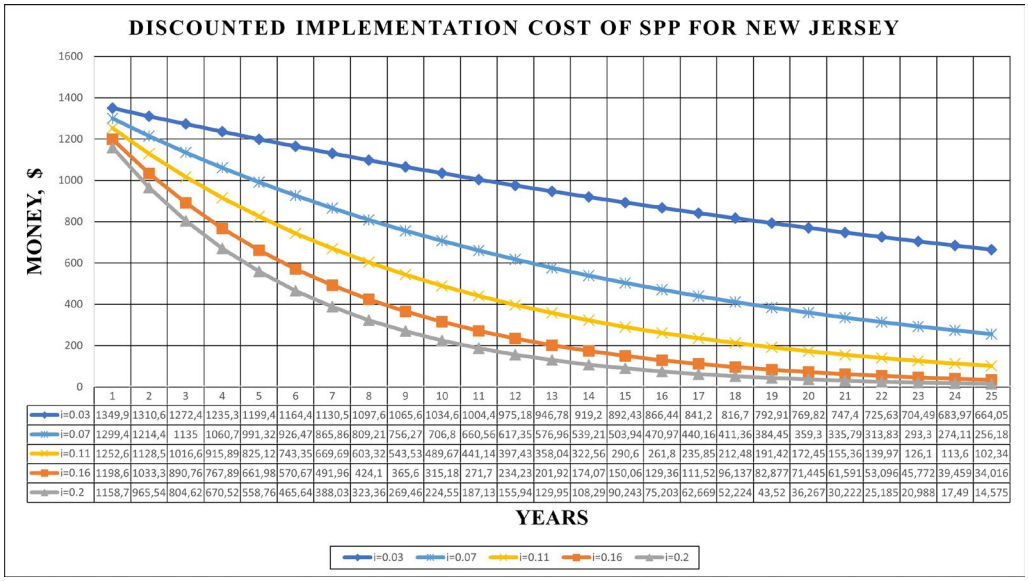
The results of calculations of the discounted costs for the implementation of SPPs for different states, depending on the value of money, are presented in Figures 2, 3, and 4 below.



	0,03	0,04	0,05	0,06	0,07	0,08	0,09	0,1	0,11	0,12	0,13	0,14	0,15	0,16	0,17	0,18	0,19	0,2
New Jersey	10227	8069,85	6229,4	4650,96	3290,29	2111,44	1085,07	187,162	-602,06	-1298,9	-1916,9	-2467,4	-2959,7	-3401,8	-3800,3	-4160,8	-4488,1	-4786,2
New Mexico	5540,94	3701,45	2132	785,977	-374,34	-1379,6	-2254,8	-3020,5	-3693,6	-4287,8	-4814,8	-5284,3	-5704,1	-6081,1	-6420,9	-6728,3	-7007,4	-7261,6
Michigan	10359,4	8074,53	6125,04	4453,09	3011,8	1763,11	675,941	-275,16	-1111,1	-1849,3	-2503,9	-3087	-3608,5	-4076,8	-4498,9	-4880,7	-5227,4	-5543,2

Fig. 1. Diagram of the discounted implementation cost of SPP for the states of New Jersey, New Mexico, and Michigan

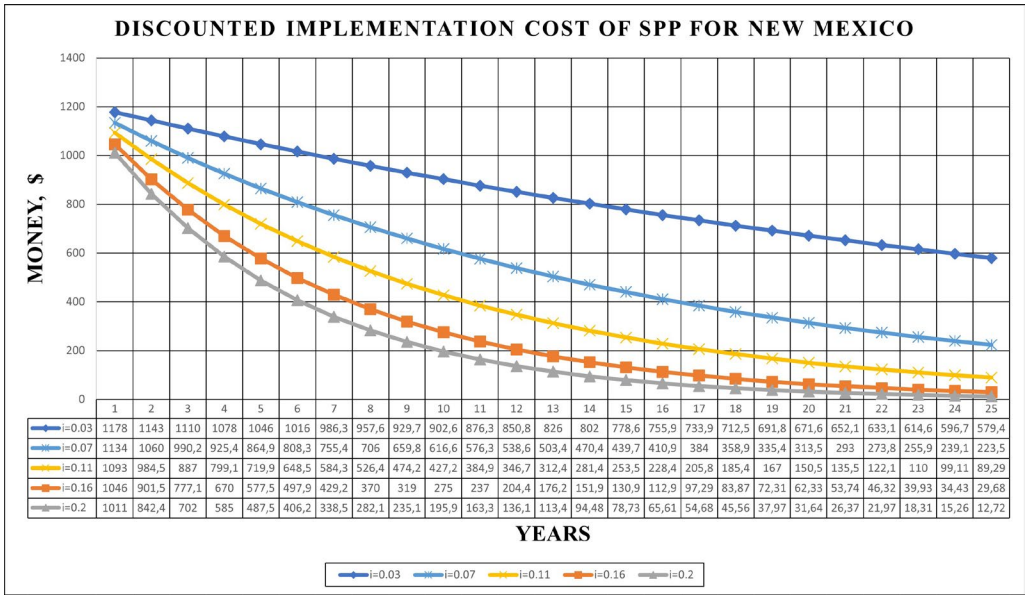
Rys. 1. Wykres zdyskontowanych kosztów wdrożenia SPP dla stanów New Jersey, Nowy Meksyk i Michigan



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
i=0.03	1349,9	1310,6	1272,4	1235,3	1199,4	1164,4	1130,5	1097,6	1065,6	1034,6	1004,4	975,18	946,78	919,2	892,43	866,44	841,2	816,7	792,91	769,82	747,4	725,63	704,49	683,97	664,05
i=0.07	1299,4	1214,4	1135	1060,7	991,32	926,47	865,86	809,21	756,27	706,8	660,56	617,35	576,96	539,21	503,94	470,97	440,16	411,36	384,45	359,3	335,79	313,83	293,3	274,11	256,18
i=0.11	1252,6	1128,5	1016,6	915,89	825,12	743,35	669,69	603,32	543,53	489,67	441,14	397,43	358,04	322,56	290,6	261,8	235,85	212,48	191,42	172,45	155,36	139,97	126,1	113,6	102,34
i=0.16	1198,6	1033,3	890,76	767,89	661,98	570,67	491,96	424,1	365,6	315,18	271,7	234,23	201,92	174,07	150,06	129,36	111,52	96,137	82,877	71,445	61,591	53,096	45,772	39,459	34,016
i=0.2	1158,7	965,54	804,62	670,52	558,76	465,64	388,03	323,36	269,46	224,55	187,13	155,94	129,95	108,29	90,243	75,203	62,669	52,224	43,52	36,267	30,222	25,185	20,988	17,49	14,575

Fig. 2. Diagram of the discounted implementation cost of SPP for New Jersey

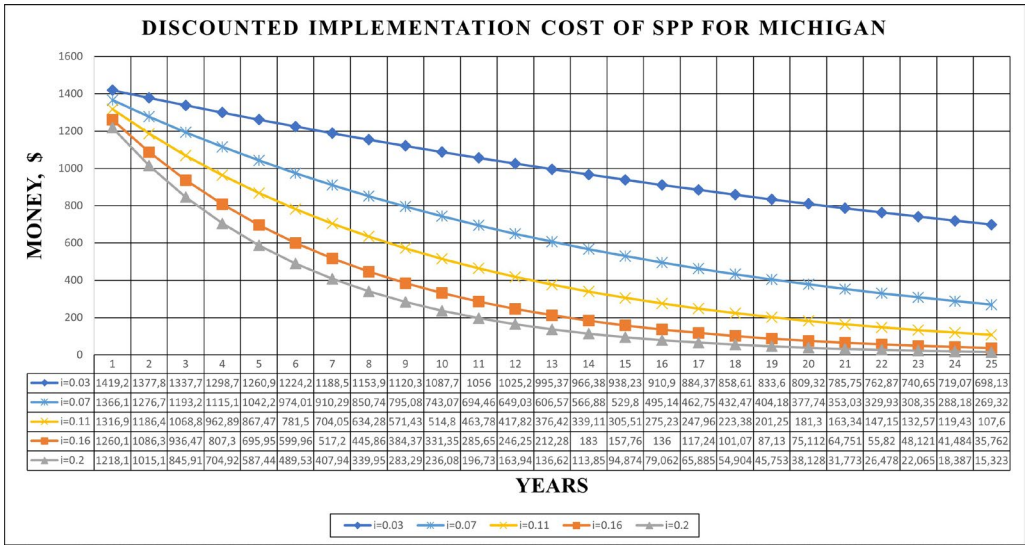
Rys. 2. Wykres zdyskontowanego kosztu wdrożenia SPP dla New Jersey



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
i=0.03	1178	1143	1110	1078	1046	1016	986,3	957,6	929,7	902,6	876,3	850,8	826	802	778,6	755,9	733,9	712,5	691,8	671,6	652,1	633,1	614,6	596,7	579,4
i=0.07	1134	1060	990,2	925,4	864,9	808,3	755,4	706	659,8	616,6	576,3	538,6	503,4	470,4	439,7	410,9	384	358,9	335,4	313,5	293	273,8	255,9	239,1	223,5
i=0.11	1093	984,5	887	799,1	719,9	648,5	584,3	526,4	474,2	427,2	384,9	346,7	312,4	281,4	253,5	228,4	205,8	185,4	167	150,5	135,5	122,1	110	99,11	89,29
i=0.16	1046	901,5	777,1	670	577,5	497,9	429,2	370	319	275	237	204,4	176,2	151,9	130,9	112,9	97,29	83,87	72,31	62,33	53,74	46,32	39,93	34,43	29,68
i=0.2	1011	842,4	702	585	487,5	406,2	338,5	282,1	235,1	195,9	163,3	136,1	113,4	94,48	78,73	65,61	54,68	45,56	37,97	31,64	26,37	21,97	18,31	15,26	12,72

Fig. 3. Diagram of the discounted implementation cost of SPP for New Mexico

Rys. 3. Wykres zdyskontowanego kosztu wdrożenia SPP dla Nowego Meksyku



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
i=0.03	1419,2	1377,8	1337,7	1298,7	1260,9	1224,2	1188,5	1153,9	1120,3	1087,7	1056	1025,2	995,37	966,38	938,23	910,9	884,37	858,61	833,6	809,32	785,75	762,87	740,65	719,07	698,13
i=0.07	1366,1	1276,7	1193,2	1115,1	1042,2	974,01	910,29	850,74	795,08	743,07	694,46	649,03	606,57	566,88	529,8	495,14	462,75	432,47	404,18	377,74	353,03	329,93	308,35	288,18	269,32
i=0.11	1316,9	1186,4	1068,8	962,89	867,47	781,5	704,05	634,28	571,43	514,8	463,78	417,82	376,42	339,11	305,51	275,23	247,96	223,38	201,25	181,3	163,34	147,15	132,57	119,43	107,6
i=0.16	1260,1	1086,3	936,47	807,3	695,95	599,96	517,2	445,86	384,37	331,35	285,65	246,25	212,28	183	157,76	136	117,24	101,07	87,13	75,112	64,751	55,82	48,121	41,484	35,762
i=0.2	1218,1	1015,1	845,91	704,92	587,44	489,53	407,94	339,95	283,29	236,08	196,73	163,94	136,62	113,85	94,874	79,062	65,885	54,904	45,753	38,128	31,773	26,478	22,065	18,387	15,323

Fig. 4. Diagram of the discounted implementation cost of SPP for Michigan

Rys. 4. Wykres zdyskontowanego kosztu wdrożenia SPP dla stanu Michigan

To create diagrams for three different US states (New Jersey, New Mexico, and Michigan), data from Table 1 was used. The trends of the diagrams are similar. The price of an SPP installation, the electricity tariff, and the volume of consumed electricity also have a significant impact on the diagrams.

As can be seen from the diagrams shown in Figures 2, 3 and 4, regarding the discounted implementation cost of SPP for 3 states of the US for 25 years, the minimum implementation cost is USD 6,001.62 in the state of New Mexico at i = 0.2. The maximum is USD 25,453.32 in the state of Michigan at i = 0.03 (see also Table 2).

It is necessary to subtract the costs for the construction and maintenance of the SPP from the received implementation cost.

According to Table 1, the construction of a 6 kW SPP in New Jersey, New Mexico, and Michigan averages USD 10,745, USD 12,343, and USD 11,855, respectively (see Table 1).

According to research by the National Renewable Energy Laboratory (NREL), the annual operation and maintenance cost of home solar systems is around USD 31 per kilowatt (kW) of installed capacity (The Cost of…), which means that the approximate cost of operating a 6 kW SPP is USD 186 per year (USD 31 × 6 kW). This value must be multiplied by 25 years of operation of the solar power plant. The result will be USD 4,650. The results of calculations taking into account the cost of construction and operation of the SPP are presented in Table 3.

As seen from Table 3, after subtracting the costs of construction and operation, the implementation cost for SPPs not only significantly decreased but even became unprofitable in many cases. For example, with i = 0.2, the profit in the state of New Mexico is now –USD 10,991.38. SPP in the state of New Mexico is the most unprofitable because the cost of

Table 2. Implementation cost without taking into account the costs of construction and operation

Tabela 2. Koszt realizacji bez uwzględnienia kosztów budowy i eksploatacji

	0.03	0.07	0.11	0.16	0.2
New Jersey	24,210.89	16,202.91	11,709.43	8,477.28	6,879.03
New Mexico	21,122.84	14,136.26	10,215.91	7,396.02	6,001.62
Michigan	25,453.32	17,034.39	12,310.32	8,912.30	7,232.04

Table 3. Implementation costs, including the costs of construction and operation

Tabela 3. Koszty realizacji, w tym koszty budowy i eksploatacji

	0.03	0.07	0.11	0.16	0.2
New Jersey	8,815.89	807.91	–3,685.57	–6,917.72	–8,515.97
New Mexico	4,129.84	–2,856.74	–6,777.09	–9,596.98	–10,991.38
Michigan	8,498.32	529.39	–4,194.68	–7,592.7	–9,272.966

electricity in this state is the lowest, and the cost of SPP installation is the highest among the states considered.

However, it is also necessary to take into account the dynamics of changes in electricity tariffs (see Table 4 (Average energy prices…) and Figure 5 (Electricity per KWH…)).

Table 4. Average energy prices for the states of New Jersey, New Mexico, and Michigan according to the U.S. Bureau of Labor Statistics in USD (Average energy prices…)

Tabela 4. Średnie ceny energii dla stanów New Jersey, Nowy Meksyk i Michigan według US Bureau of Labor Statistics w USD

	June 2022	May 2023	June 2023
New Jersey	0.186	0.179	0.191
New Mexico	0.138	0.150	0.150
Michigan	0.154	0.161	0.165

Another US government agency, namely the Energy Information Administration, provides slightly different tariff values (see Table 5 (Table 5.6.A. Average Price of Electricity…)).

According to information from the U.S. Bureau of Labor Statistics presented in Figure 5, Tables 4 and 5, the price of electricity is constantly changing. Analyzing the above statistics, the cost of electricity has increased significantly in recent years and will continue to increase in the future.

According to the data presented in Table 6, most of the US's electricity is produced using hydrocarbons (coal and gas). Therefore, the change in the cost of these resources will affect the cost of electricity.

According to the outlook of the Energy Information Administration (on September 10, 2023) (SHORT-TERM ENERGY OUTLOOK), the electric power sector plans to add 27 gigawatts

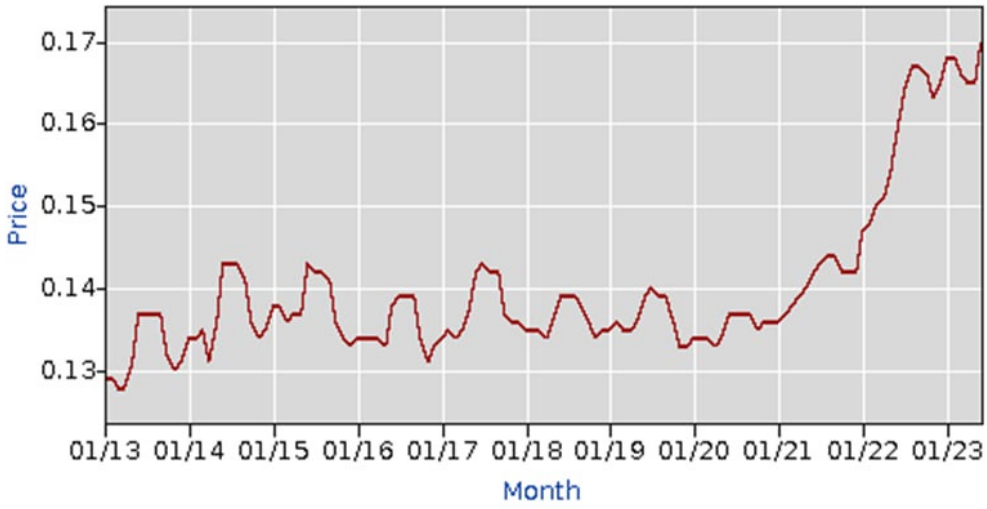


Fig. 5. Average price of electricity per kW·h in U.S. city, not seasonally adjusted, from 2013 to 2023 (Electricity per KWH…)

Rys. 5. Średnia cena energii elektrycznej za kW·h w mieście w USA, niewyrównana sezonowo, w latach 2013–2023

Table 5. The average price of electricity for the states of New Jersey, New Mexico, and Michigan, according to the U.S. Energy Information Administration in USD (Table 5.6.A. Average Price of Electricity…)

Tabela 5. Średnia cena energii elektrycznej dla stanów New Jersey, Nowy Meksyk i Michigan, według amerykańskiej Agencji Informacji o Energii, w USD

	May 2022	May 2023
New Jersey	16.98	17.18
New Mexico	12.94	13.30
Michigan	17.83	18.56

(GW) of new solar generating capacity by the end of 2023 and a further 31 GW in 2024. This new capacity leads to the forecast that renewables, other than hydropower, will account for a 16% share of total U.S. generation in 2023, up from 15% in 2022. That share grows to 18% in 2024.

In contrast, about 15 GW of coal-fired capacity is scheduled to retire by the end of 2023, so the Energy Information Administration forecasts that coal's share will fall to 16% of total U.S. generation in 2023 and 15% in 2024 (well below its generation share of 20% in 2022). The forecast natural gas generation share rises from 39% in 2022 to 42% in 2023 due to low natural gas prices and net natural gas-fired generating capacity additions of 3 GW. As a result, coal production is expected to decline 3% from 597 million short tons (MMst) in 2022 to 578 MMst in 2023. Coal production will fall by 18% in 2024 to 472 MMst.

Table 6. U.S. utility-scale electricity generation by source, amount, and share of the total in 2022, according to the U.S. Energy Information Administration (What is U.S. electricity…)

Tabela 6. Według amerykańskiej Agencji Informacji o Energii produkcja energii elektrycznej na skalę przemysłową w USA według źródła, ilości i udziału w całości w 2022 r.

Energy source	Billion kWh	Share of total [%]
Total – all sources	4,243	
Fossil fuels (total)	2,554	60.20
Natural gas	1,689	39.80
Coal	828	19.50
Petroleum (total)	23	0.60
Petroleum liquids	16	0.40
Petroleum coke	7	0.20
Other gases	12	0.30
Nuclear	772	18.20
Renewables (total)	913	21.50
Wind	435	10.20
Hydropower	262	6.20
Solar (total)	146	3.40
Photovoltaic	143	3.40
Solar thermal	3	0.10
Biomass (total)	53	1.30
Wood	37	0.90
Landfill gas	9	0.20
Municipal solid waste (biogenic)	6	0.10
Other biomass waste	2	0.10
Geothermal	17	0.40
Pumped storage hydropower	–6	–0.10
Other sources	11	0.30

It should be taken into account that the cost of installing an SPP is constantly falling due to the introduction of new technologies and the popularization of the solar energy market. This is confirmed by the diagram in Figure 6 (Solar Industry Research Data).

According to Figure 6, the total capacity of SPPs installed during the year is steadily increasing, while the installation price, on the contrary, is falling. However, over the last two years, shipping constraints and other supply chain challenges stemming from the global pandemic and trade instability have led to price increases across the U.S. solar industry (Solar Industry Research Data) and even a drop in the total capacity of installed SPPs in 2022.

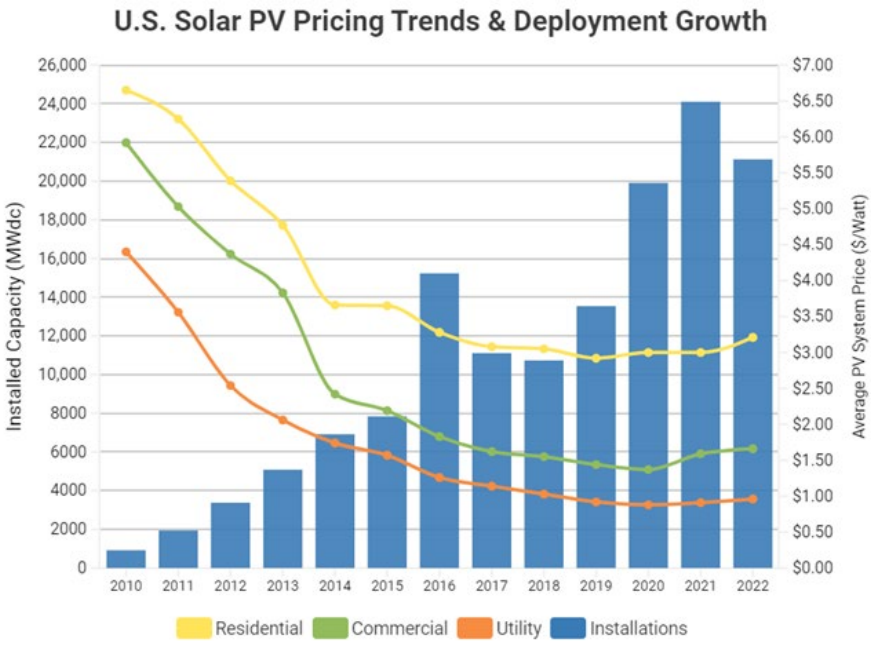


Fig. 6. Changes in the cost of installing SPPs in the US and the number of new stations (columns reflect the capacity of the installed stations per year in MWh, curves – installation cost in USD per Watt) (Solar Industry Research Data)

Rys. 6. Zmiany kosztów instalacji SPP w USA oraz liczby nowych stacji (kolumny odzwierciedlają roczną moc zainstalowanych stacji w MWh, krzywe – koszt instalacji w USD za wat)

According to the Solar Energy Industries Association (SEIA), the cost to install solar has dropped by more than 50% over the last decade, leading the industry to expand into new markets and deploy thousands of systems nationwide. An average-sized residential system has dropped from a pre-incentive price of USD 40,000 in 2010 to roughly USD 25,000 today (Solar Industry Research Data).

In conclusion, taking into account the decrease in the price of installing SPPs, the significant increase in electricity tariffs in recent years, and their further growth, the expenditures saved with the help of SPPs will increase.

Conclusions

The article provides calculations and feasibility study of solar power plants implementation for the states of New Jersey, New Mexico and Michigan, since households in these states have almost equal electricity consumption per month which gives an opportunity to see the difference

between the profits from a solar power plant depending on the state (based on electricity rates, installation costs and other factors). At the same time, the average cost for grid power, average household kwh use per month and average cost for 6-kw system with 26% federal tax credit applied were taken into account. The approach outlined in this article proposes to take into account changes in the value of money which allows to convert future cash flows into their present value. This gives an opportunity to evaluate possible options for the development of events and their effects on the SPP project economic efficiency throughout the entire operation service. There are also other parameters included, such as tariffs and SPP's period of service.

The conducted research shows that the construction of solar power plants in the USA can be profitable in the conditions of constant growth in prices for electricity produced using traditional energy sources. However, with the stability of electricity prices, the use of solar energy is far from the most profitable investment.

There is necessary to focus on the research of the latest technologies for the storage and production of electricity in order to reduce the impact of the instability of production from renewable energy sources on the stability of power grids in the future. Further development of SPPs can help increase their availability and competitiveness, which will contribute to the creation of a sustainable and green energy infrastructure. The development of technologies in this area will also lead to a decrease in installation prices and an increase in the efficiency of the panels.

The main limitation of solar power plants is the need for a large area for the installation of panels in order to achieve the level of industrial electricity production. Therefore, now the centralized production of electricity using the sun is possible only in areas that are unsuitable for life and economic activity.

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Studium wykonalności wdrożenia elektrowni słonecznych w USA

Streszczenie

W artykule przedstawiono obliczenia i studium wykonalności wdrożenia elektrowni słonecznych dla stanów New Jersey, Nowy Meksyk i Michigan. Pod uwagę wzięto średni koszt energii sieciowej, średnie miesięczne zużycie kWh w gospodarstwie domowym oraz średni koszt systemu o mocy 6 kW z zastosowaną 26% federalną ulgą podatkową. Podejście przedstawione w tym artykule proponuje uwzględnienie zmian wartości pieniądza, taryf i okresu eksploatacji elektrowni słonecznej.

Z przeprowadzonych badań wynika, że budowa SPP w USA może być opłacalna w warunkach stałego wzrostu cen energii elektrycznej wytwarzanej w tradycyjnych źródłach energii. Jednak przy stabilności cen energii elektrycznej wykorzystanie energii słonecznej nie jest najbardziej opłacalną inwestycją.

Udowodniono, że istnieje potrzeba skupienia się na badaniach nad najnowszymi technologiami magazynowania i wytwarzania energii, aby w przyszłości ograniczyć wpływ niestabilności produkcji energii odnawialnej na stabilność sieci elektroenergetycznych. Dalszy rozwój SPP może pomóc w zwiększeniu ich dostępności i konkurencyjności, co przyczyni się do stworzenia zrównoważonej i zielonej infrastruktury energetycznej. Rozwój technologii w tym obszarze doprowadzi także do spadku cen instalacji i wzrostu wydajności paneli.

Głównym ograniczeniem elektrowni słonecznych jest konieczność posiadania dużej powierzchni pod montaż paneli, aby osiągnąć poziom przemysłowej produkcji energii elektrycznej. Dlatego obecnie scentralizowana produkcja energii elektrycznej za pomocą słońca jest możliwa tylko na obszarach nienadających się do życia i działalności gospodarczej.

Słowa kluczowe: wdrożenie, odnawialne źródła energii, elektrownie słoneczne, studium wykonalności, obliczenia, metodologia