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Economic efficiency of application of solar window

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Abstract

Priority and qualitatively new direction in the fuel and energy sector is renewable energy. This paper describes a feasibility study of using solar window in the system of solar heat supply. The article presents literature data about the effectiveness of the use of solar systems in other countries. The results confirm a sufficient efficiency of solar heat supply with using solar Windows. Insights based on practical experience and mathematical calculations, which are aimed at a detailed explanation of economic efficiency of the proposed construction.

Key words: a solar window, economic efficiency, net present value, cost

1 Introduction

Alternative energy is becoming increasingly important for the world community, as the use of "fossil" energy resources leads to catastrophic climate change and reduce fossil fuels.
Thus, the transition to renewable energy sources gives an opportunity to solve the current geopolitical crisis in Eastern Europe to avoid further armed conflict associated with fossil fuel extraction and supply, as well as creating joint mechanisms of energy security. Ukraine can increase its political and energy independence by using domestic renewable energy sources. The degree of international cooperation necessary for this transition can act as a catalyst for cooperation in solving other regional problems. And finally, the phasing out of nuclear power will prevent potential threat of nuclear accidents and proliferation of radioactive materials in the region [1].

2 Analysis of main researches and publications

In the context of all the above, high priority acquire a western, in particular European, approaches to the introduction of alternative sources of energy [2, 3].
For example, a little-known government program called the Residential Renewable Energy Tax

Credit, coupled with massive evolution of solar technology has been consolidated. Because this program allowed the americans to install solar energy systems on their homes at shockingly low price and reduce their payments for electricity by an average of $1,560 per year (Fig. 1).

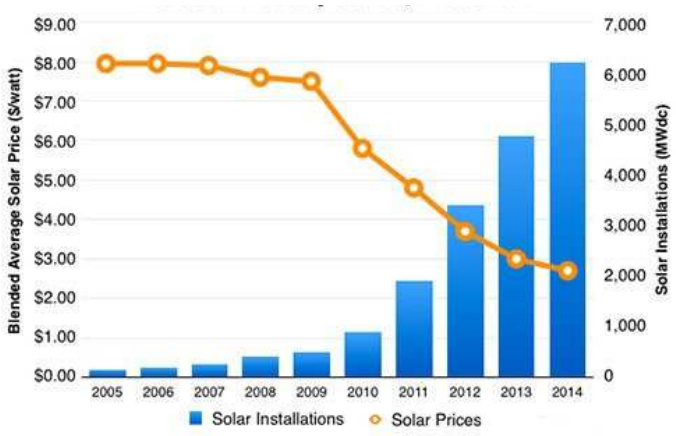

Figure 1: Industrial scale solar energy compared to the price scale in the United States

Energy innovation has recently published a very interesting article that provides an overview of equal energy costs for different technologies, both renewable and non-renewable.
One key asset is the use of standardized measures to compare different technologies (Fig. 2). In this case scale Lazard made by Lazard and an international financial advice, and management company assets. The following is a schedule of cost components sixteen diverse energy technologies, which is evaluated by Lazard's: 10 of them are alternative (comprising mainly low-carbon, renewable technologies) and 6 normal (including the sources of fossil fuels and nuclear energy) [4].
For example, onshore wind in this analysis has the lowest average cost per unit ($59 per megawatt-hour), solar PV technology is not far behind - 79$. For comparison, the lowest cost conventional technologies gas combat technology, an average of 74$ per megawatt and coal in an average of 109$ [5].

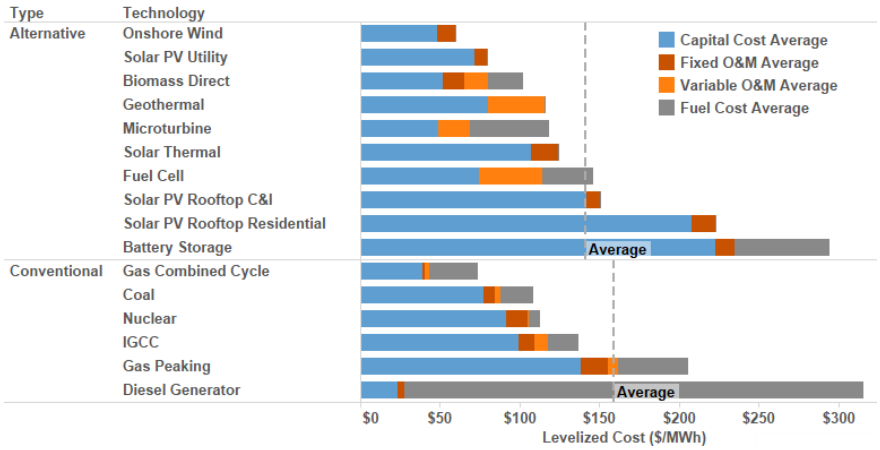

Figure 2: Components of levelized cost of energy

The following Figure 3 from the Massachusetts Institute of Technology illustrates the decline in revenue for the solar farm owner to reduce average wholesale prices in the market [6].

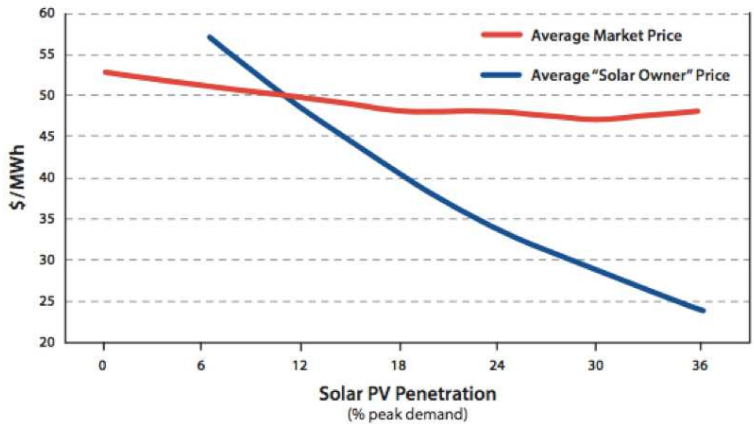

Figure 3: Average market prices and average prices as perceived by owners of solar generation

3 The objective of the article

Arranging the system of heat supply to the apartment or house, we are all pursuing the goal of achieving maximum comfort, while trying of course to spend minimal funds.
In practice, the understanding of the role of natural gas in our daily lives helps to find optimal ways of using material and financial resources. There is a clear trend – the exhaustion of the world reserves of natural gas and the increasing production on the one hand and growing consumption on the other lead to the growth of each year, the price of natural gas, which in turn increases the share of expenditures in the balance of both the state and houses the energy source, and makes increasingly to raise the question of its efficiency.
For an economic justification of expediency of application of solar windows, it is advisable to compare the importance and cost of installing alternative energy and energy savings. Economic positive "profit" the calculation will be its native push for mainstreaming in the direction of use additional sources (trust funds energy thrift), additional investment and internal funds of business entities.

4 The Main Material

Analyzed the market of flat solar collectors, their brand, the efficiency, calculated based prices of flat solar collectors.
The calculation was performed for a two-storey house located in the city.
For the original data was taken:
- living area of 120 [m^2];
- accommodation in a room of 4 people;
- hot water consumption by one person 89,25 [*l*/day];
- the presence of a gas meter;
- the retail price of natural gas, provided that the amount of natural gas consumption does not exceed 2500 [m^3 per year] according to The National Commission for State Regulation of

Energy and Public Utilities resolution No. 420 dated 3.04.2014 year 1,089 [UAN per 1 m^3].
A universal criterion of economic evaluation of projects is Net Present Value (NPV) based on discounting the cash flow.
The essence of the criterion is to compare the present value of future net cash flows from the project with the investment costs required for its implementation.
Consequently, the Net Present Value is the difference between the total present value of net cash flows and the present value of the investment, discounted at cost of capital.
Basically the net present value can be transferred to products, but to summarize the performance of products and considering for 1 year.
In general, the value NPV is determined by the following formula (1):

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+k)^t} - IC \quad (1)$$

where: CF_t – the annual net cash flows; IC – outbound investment; k – the discount rate; n – the lifetime of the project.
Obviously, when NPV > 0 – the project should take; when NPV < 0 – the project should be rejected; when NPV = 0 – project accuracy to ensure a given rate of return, and it is also taken.
To accept fixed assets equipment (solar collector) with a minimum useful life of 5 years in accordance with the new Tax Code, which provides for a new classification of groups of fixed assets and other fixed assets.
The cost of the solar collector (SC) – 1592 [UAN/m^2] (he required area for a dwelling house of 4 people - 4,28 [m^2]), accordingly 1592*4,28≈6850[UAN].
The value of SC with the recommended technological equipment is 15500 [UAN]. Costs one-off (in the first year of project): construction-installation – 1550 [UAN]. Costs annual maintenance – 500 [UAN], other – 100 [UAN].
In line with this, we expect depreciation expense (straight-line method) (2):

$$A = 15500/5=3100 \text{ [UAN]} \quad (2)$$

The cost is one of the most important General economic indicators. Connected with the performance of construction and installation works, that is, with the use of machines, mechanisms, equipment, material, labor and other production resources. The costs included in the cost of construction and installation works, include the costs provided for in national Provisions (standards) of accounting approved by orders of the Ministry of Finance of Ukraine.
The cost of the SC will be 1550 [UAN] +500 [UAN] +100 [UAN] =2150 [UAN] in the first year, and in the next 4 years 2400 [UAN].
Revenue is determined on the basis of the method of "over-spending", which will result in the amount of money will be saved when installing this type of SC. Income from the SC (in terms of gas, at the rate of 27.32 [$]) is 5348 [UAN/year].
Taxes on the use of wind energy or solar in Ukraine. Under current law, the fee for special use of natural resources shall be paid only for usage of earth entrails, forest and water resources. However, to heat the water required cold water, in accordance with the current Legislation of Ukraine on water supply and water drain is set to a value added tax. Take a tax of 20%.
The discount rate adopted is also 20%, due to the risk of changing the intensity of the solar energy and use this energy a solar collector.
Look at the investment side of this project, namely the return on investment for the consumer.
22.09.2016 year the Supreme Council adopted in first reading bill No.4334 "On amendments

to the law of Ukraine 'On heat supply' concerning incentives for production of thermal energy from alternative energy sources". Now a bill is being prepared for the second reading.
The bill addresses two existing problems. Today when setting the tariffs for heat from alternative sources by controller (The National Commission for State Regulation of Energy and Public Utilities), the principle of "cost +6%". The principle passed to us in the inheritance from the Soviet era and does not correspond to the principles of a market economy in which we now live. He "encourages" manufacturers of thermal energy to inflate in all possible ways its costs, as its margin is equal to 6% of the cost. The more the cost the more income. And to pay for the increased cost to consumers.
For example, in Lithuania for more than 5 years working model of the competitive market of thermal energy and the heat energy tariff for independent producers is not set by the regulator, and is defined as the monthly auction.
To achieve this in the conditions of Ukraine is possible by running a full-fledged competitive market of thermal energy.
This bill has a number of advantages, but the consumer is guaranteed to receive the alternative heat for 10% cheaper gas. This will gradually reduce the overall cost of thermal energy for final consumers.
Therefore, based on calculations by the method of " over-spending", namely the amount of gas saved, which for the classical scheme, for comparison, selected Vitosol 200 F. Thus, the retail price of natural gas per month according to the resolution The National Commission for State Regulation of Energy and Public Utilities) № 583 from 03.03.2015 year 7,188 [UAN per 1 m^3], then on 1m^3 the user can save 0,72 [UAN]. That is, when a joint installation of the solar collector, the consumer will save 7,91 [UAN per 1m^3] of gas, that was not used to heat hot water (Fig. 4).
Namely, when the load on the hot water supply 89,25 [*l*/day] when using a gas boiler with a capacity of 83% that uses natural gas LL 8,15 [m^3/h] and capacity of the boiler is 60[kW], the consumer can save some of 7.91 [UAN] when heated up to 0.46 [*l* per hour] using the proposed solar collector.
Nominal gas consumption by the device is determined (3):

$$q_{nom} = Q_{nom} \cdot 3.6 / Q_l^c \text{ , [m}^3\text{ /h]} \quad (3)$$

where: Q_{nom} - nominal thermal load of gas appliance, [kW]; Q_l^c - accept the lowest regulated in Ukraine, the heat of combustion of natural gas 31,8 [m^3/h].

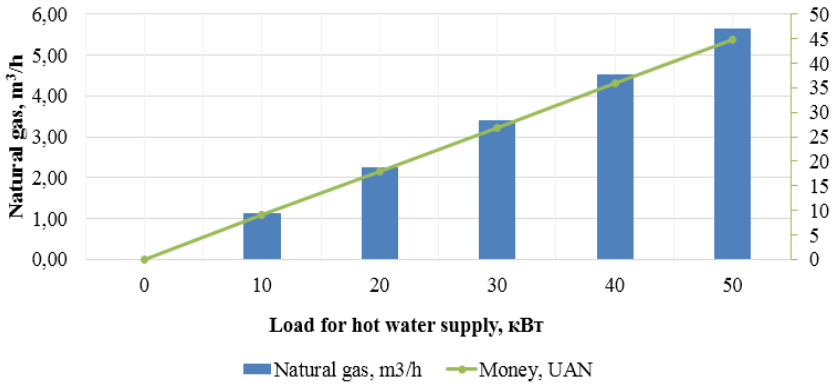

Figure 4: Return on investment (ROI) for the consumer

In practice, calculating such consolidated indicator NPV, the investment is variable and multifactorial for the small consumer than firm. Therefore, in the shorter term, investing in this project will be variable and will depend on the capabilities of the consumer that should be reflected in a three-dimensional graph.
For this purpose we have chosen the variables for a 5 year term.
Factors were elected:
- x_1 – investment, *I,* [UAN];
- x_2 – depreciation deductions, *A,* [UAN];

Table 1 presents data on the levels of factors and variation intervals.

Table 1

The name of the factor	Encoded marking	The levels of factors			Interval variation
		–1	0	+1	
Investment, *I*	x_1	0	2500	5000	2500
Depreciation deductions , *A*	x_2	0	1550	3100	1550

For visualization of net present value for the investment accounting and depreciation proposed Figure 5.

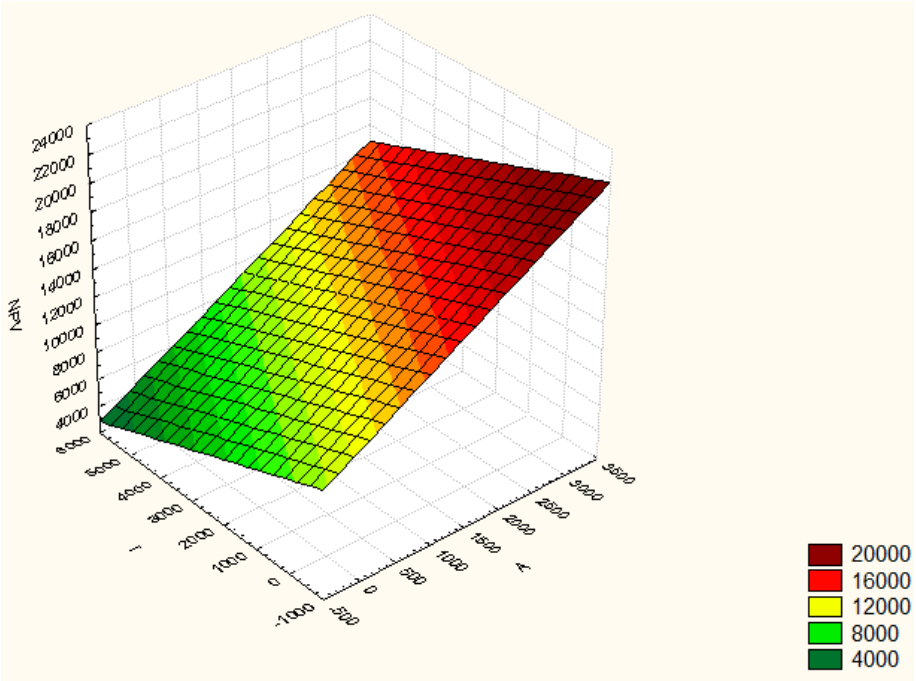

Figure 5: The dependence of the net present value gelousy from varying the investment and depreciation costs

Further solar window NPV calculated without installation and construction costs, and for the period minimum allowable residual life of the project when the area of solar windows and depreciation costs (Fig. 6).

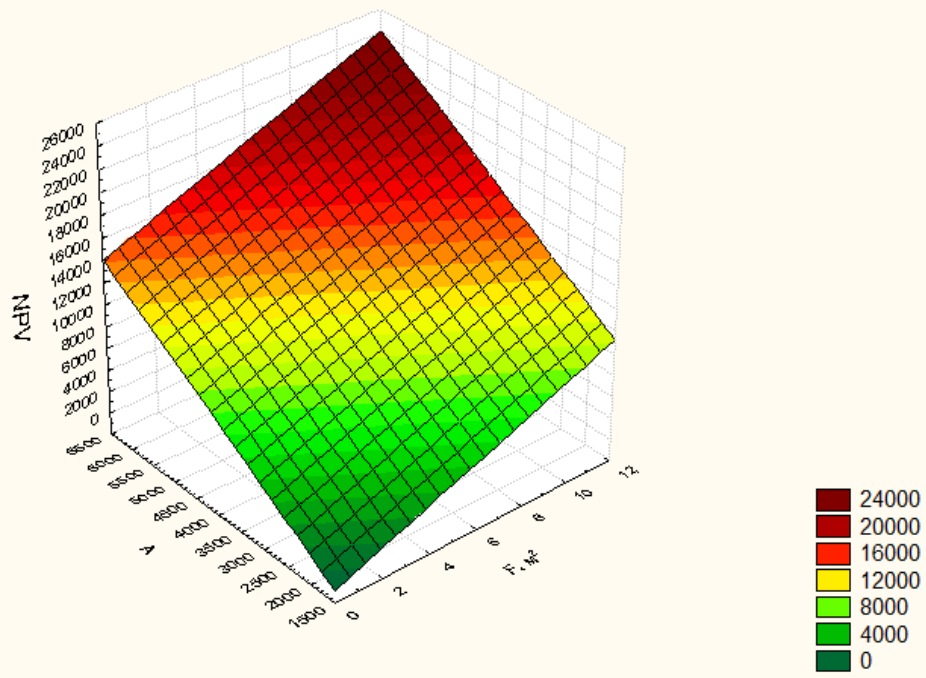

Figure 6: The dependence of the net present value of the solar windows of the variation of the area of solar windows and depreciation costs

5 Conclusion

The use of windows as solar systems of heat supply is economically advantageous in technical and economic aspect. Since optimization of solar windows is due to the combination of the existing system. Also in mathematical calculations in verhoven net present value result was positive or 0, which is the background of understanding-making projects on the proposed solar window system of heat supply of the building. The results of a study of the economic efficiency of solar windows can be the impetus for mainstreaming in the direction of use additional sources (trust funds energy frugality), additional investment and internal funds of business entities alternative sources of energy.

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