The potential of solar energy in Ukraine

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Abstract – In this paper the analysis of potential cumulative, direct, and diffuse solar radiation on the territory of Ukraine during to the period of one year and during the heating season is presented. It is shown that there is a change in these variables in Ukraine received empirical functional relationship to calculate the solar energy. The incoming solar energy in Ukraine has been analyzed according to its geographical position (i.e. latitudes). These research results may be used in the design and choice of location solar heating in Ukraine.

Key words – solar energy, direct and diffused solar radiation.

I. Introduction

"Thermal pollution" of the planet, "greenhouse effect," "anoxaemia", extensive contamination by toxic chemicals, etc. - are burning issues of today arising from the penalties of humanity for civilization comfort. Renewable sources of energy offer a possible alternative for setting the issues. Solar energy, as energy resources of the future, has a lot of benefits. It is mainly harmless for people and the environment. It does not distort the landscape. There is no point in exporting or importing it. As for the energy itself, it is both free and renewable, the latter benefit being the most important one.

II. Objectives the Formulation of the Problem

The overall effectiveness of solar installations is largely depends on the level of solar energy, which in its turn is strongly depends on the geographical position. The purpose of the research is to analyse the level of solar energy on the territory of Ukraine. In particular, it has evaluated the level of direct, diffuse and cumulative solar radiation seasonally adjusted and throughout the heating period.

III. The Analysis of Recent Research and Publications

A considerable number of scientific and practical works on energy efficiency have been published recently [1–4].

Although the monograph [5] considers the analytical and experimental researches of solar energy distribution during the daytime and throughout the year, it does not take into account the amount of incoming solar energy on the territory of Ukraine.

State building codes of Ukraine [6] is the source of climatic data used for the calculation and design of solar power installations plants. However, the codes don't have the calculation of the amount of seasonally adjusted solar energy depending on latitude.

IV. The Main Material

The evaluation of solar energy potential is regarded as the key factor in choosing the location of solar installations. The level of solar energy directly affects on the heliosystem efficiency, which in its turn depends on latitude. Thus the incoming solar energy on the territory of Ukraine has been analysed according to its geographical position (i.e. latitudes).

Annual monthly average total solar energy coming to the horizontal surface (Fig. 1) has a downward trend from south to north of Ukraine. The minimum monthly average total solar energy on the horizontal surface is 85 kW·h per $1m^2$, whereas the maximum is 103.5 kW·h per $1m^2$, which is 18 % more.

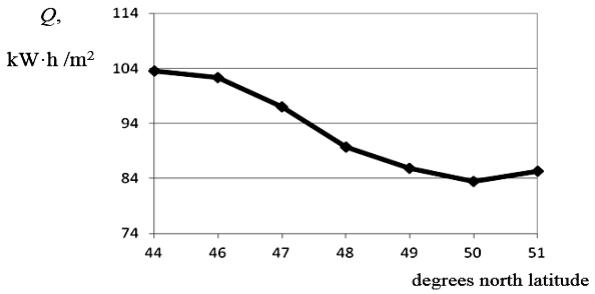

Fig.1 Annual monthly average total solar energy coming to the horizontal surface on the territory of Ukraine.

The empirical functional relationship $Q=f(\varphi)$ was based on Figure 1 data:

$$Q = 900 - 11.84 \cdot \varphi, \text{kW} \cdot \text{h per} 1\text{m}^2 \quad (1)$$

where Q is annual monthly average total solar energy, kW·h per $1m^2$; φ is a geographical latitude, in degrees of northern latitudes.

The daily average total density of solar energy in winter (December, January, February) and summer (June, July, August) has a downward character and gradually decreases from the south to north. In the south of Ukraine, the density rare in summer is higher than in winter by 73 %. As for the density rate in winter, it is lower by 8 % in the north of Ukraine compared to the south.

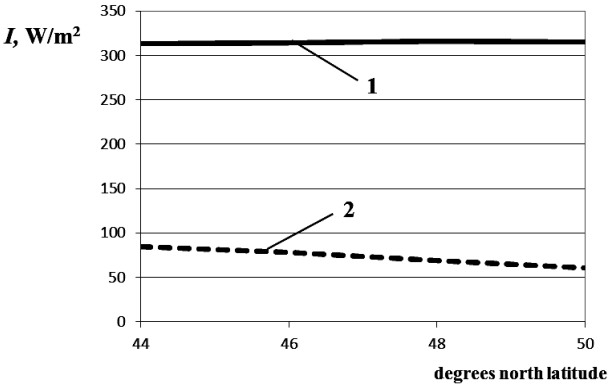

Fig.2. Daily average total solar energy density during the billing period coming to the horizontal surface on the territory of Ukraine: 1 - in summer, 2 - in winter

Empirical functional relationships $I=f(\varphi)$ in winter Eq. (2) and in summer Eq. (3) were based on Figure 2 data:

$$I = 295.7 + 0.4 \cdot \varphi, \text{W} / \text{m}^2 \quad (2)$$

$$I = 263.6 - 4.05 \cdot \varphi, \text{W} / \text{m}^2 \quad (3)$$

where I is daily average total solar energy density in winter or in summer, W/m^2; φ is geographical latitude, in degrees of northern latitudes.

According to the analysis of seasonal fluctuations of solar energy on the territory of Ukraine (Fig. 3), it could be argued that there is a reduction in solar energy depending on latitudes from the south to north. The potential of diffuse solar radiation is about twice less than that of direct one in all the latitudes of Ukraine only in winter, and in spring and autumn only on the northern territories. Compared with winter, direct solar radiation increases approximately in ten times in summer. As a result, there is greater efficiency in the use of flat solar collectors in that period of time.

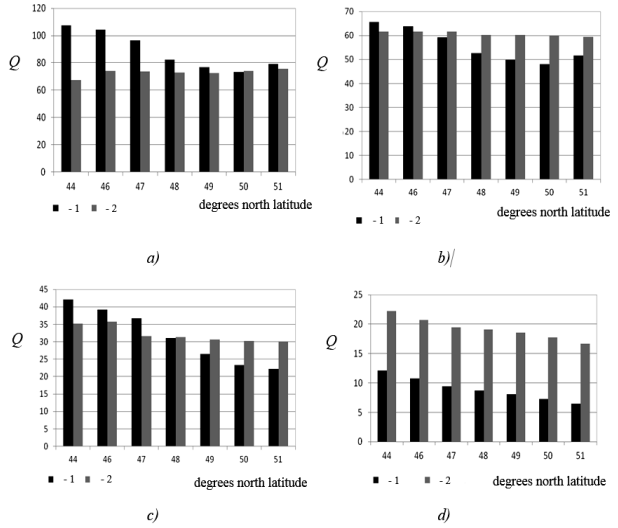

Fig. 3. Seasonally fluctuations of direct and diffuse solar energy *Q*, kW·h/1m^2 on the territory of Ukraine: 1 - direct solar radiation, 2 - diffuse solar radiation; a) the summer season; b) the spring season; c) the autumn season; d)the winter season

The amount of incoming solar energy on the territory of Ukraine during the heating period serves as an important indicator of effective implementation of heliotechnologies in industry and housing. The installation of solar collectors requires additional research of the required amount of solar energy for its possible use during the heating period.

Monthly average total solar energy coming to the horizontal surface during the heating period has a downward trend (Fig. 4). Compared with the south of Ukraine, it is minimal (45.5 kW·h/m^2) in the northern regions. Monthly average diffuse during the heating period (Fig. 5) is higher than the direct one 1.2-1.6 times.

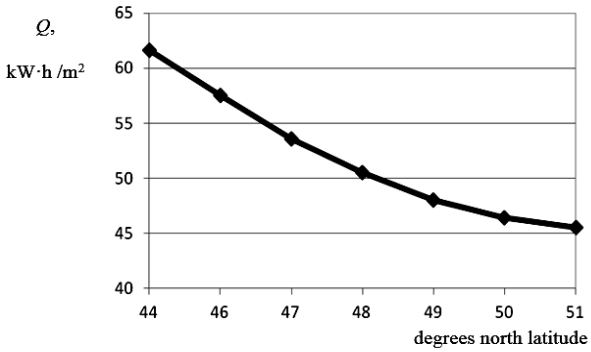

Fig. 4. Monthly average total solar energy coming to the horizontal surface during the heating period on the territory of Ukraine

The graphs depicting total solar energy, direct and diffuse during the heating period, show that the level of solar insolation for household energy needs of population is sufficient for the introduction of solar power plants in the energy sector of Ukraine.

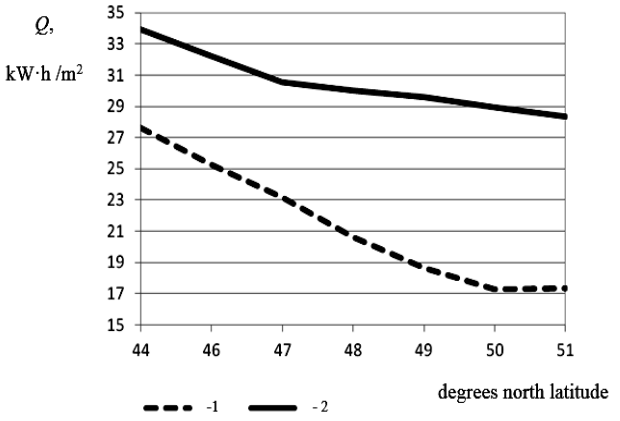

Fig.5. Monthly average direct and diffused solar radiation coming to the horizontal surface during the heating period on the territory of Ukraine: 1,2 - diffuse and direct solar radiation

Conclusion

Summarizing the above-mentioned data, it could be argued that there is enough incoming solar energy on the territory of Ukraine for energy-dependent needs. Therefore, the term traditional energy industry will gradually reduce its potential, while the potential of renewable energy, particularly solar energy industry will grow.

The use of solar energy in the energy industry will definitely make it less dependent on fluctuations in prices on conventional fuels.

Taking into account considerations that territorial and climatic conditions in Ukraine are favourable for that alternative source of energy, to solar energy should be given priority in the modernization of the basic platform in the productive-economic sphere of all the branches in the state infrastructure.

References

[1] Analytical report [Electronic resources] // National Institute for Strategic Studies under the President of Ukraine. – Access mode: www.niss.gov.ua/articles/1174.

[2] Analysis of the contemporary state of the alternative energy sector and recommendations on making the Ukrainian fuel – energy complex ecologically - sound [Electronic resources] // Industrial ecology. - Access mode: www.eco.com.ua.

[3] Solar energy. Why it is beneficial for Ukraine? [Electronic resources] // – Access mode: http://teplovam.com/index.php/opalennya/4-soniachni-systemy?showall=&start

[4] Solar radiation and radiation balance. [Electronic resources] // – Access mode: http://geografica.net.ua/publ/galuzi_geografiji/meteorologija/.

[5] Y. Mysak. Solar energy: theory and practice: monograph / Y. Mysak, O. Vozniak, O. Datsko, S. Shapoval. – L: Lviv Politechnic Publishing House. - 2014. – 340 pp.

[6] Building climatology. ISO - NBV. 1.1 - 27:2010.- К.: Ministry of Regional Development. - 2011 - 123 pp.