Solar Energy Resources of Uzbekistan and Peculiarities of Their Mapping

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Abstract — The desert and semi-desert areas of Uzbekistan emerge at present as zones of intensive economic activity that is closely connected to economic progress of the country. The following priority areas of the development should be emphasized. First, the bulk of this territory is occupied with Karakul sheep pastures, where 5 million heads of Karakul sheep. Second, mining industry (gold, uranium, marble etc. excavation) is expanding there, and broad scale geological prospecting is underway there. Third, ecotourism and some kinds of health care activities are capable of being developed in the territories.

In the arid areas in absence of natural sources of potable water, all the above kinds of activities, including people living and working in arid conditions experience acute need in water supply. Life such territories intended for development can be secured such non-traditional sources of energy as the solar and wind power installations. With this regard, work has been done on estimation of solar energy resources of Uzbekistan and the methodology of their mapping has been developed as well.

Keywords — solar energy, solar energy resources, methodology of solar energy mapping.

I. INTRODUCTION

Present development of civilization requires expansion of power generation. Use of traditional methods of power generation (coal, oil, and shale) yet in the nearest future will not allow for generation of necessary amount of energy, it means that crisis is threatening. This is a solid argument in favour of non-traditional power generation. Many experts in power generation reckon that the only way to overcome this crisis is large scale utilization on renewable sources of energy (solar, wind, ocean, or non-traditional, as they are termed) [2, 4]. Besides, it should be born in mind that employment of traditional energy resources besides consuming oxygen leads to significant pollution of the environment, which is one more reason for developing non-traditional energy sources.

At present, the problem of utilization of the solar energy moves from the sphere of scientific research to area of practical application the broad spectrum: from solar cell batteries to solar power plants (SPP) [6]. In 2016, it is planned to put commission of the first SPP in Samarkand Region with rated power 100 MW. Annual power generation is capable of raising to 220 million KW per hour [5]. In total, according to the opinion of experts equals approximately 50 million tons in oil equivalent, which makes 99% on all the renewable of all the renewable energy source in Uzbekistan.

Purpose of the work: first to provide estimation of solar energy resources in the territory, to provide estimation of the solar resources in the territory Uzbekistan.

II. SOLAR ENERGY RESOURCES

The number of clear and cloudy days allows us to estimate the efficiency og utilization of the solar energy in the territory of Uzbekistan. While counting clear and cloudy days, common methodology has been applied: the days when relative duration of sun shining (RDSS) exceeds 80%, and cloudy were the days when RDSS was less than 20% of maximum possible duration of sun shine (DSS) in the particular day. The interval between these two indices characterizes average conditions of cloudiness. As RDSS has been defined on records from heliograph the obtained data on quantity of clear and cloudy days should be considered more objective as compared with number obtained as a result of normal climatic processing of cloudiness.

According to the data from actinometric measurements in the territory and border areas of the neighbouring countries (Kazakhstan, Turkmenistan, and Kyrgyzstan) the map of territorial distribution of number of clear days had been constructed, fig. 1. As it is seen from the Figure that the number of clear days in maximal in the southern areas of the country (207 days), minimal on the Ustyurt Plateau and Fergana Valley (142-148 days), and 170-190 days in the rest of territory. The maximum number of completely cloudy days is observed on Ustyurt and Fergana Valley (70-75 days), minimum is in the southern areas – 51 days, and that in the rest of territory it is – 60-70 days.

The DSS has its maximum in the period of May to September (300-350 hours a month), which makes 64-69% of the annual amount. The maximum number of DSS is observed in the desert zone and the South of the country (over 3000
as on elevation of the point over the sea level [1]. We have the horizon that is defined by the longitude of the point as well as observation, i.e. on its transparency, elevation of the Sun over the surface, i.e. for those stations, for which the anthropogenic pollution could be considered negligibly small. To this category of stations, we have drawn for the points characterizing the background transparency of the atmosphere, i.e. as estimation of the solar radiation weakening by means of energy have on essential fault it is they do not take into account location of the actinometric stations. In the lower half-kilometer layer of the atmosphere at equal other conditions, input of direct insolation on the upper border of this layer increases by 10-12% [1]. As actinometric stations of Uzbekistan are located within the range: from 75 m (Takhyatash) to 2000 m (Qyzylcha) at mapping altitudinal change of radiation flux of the solar energy. In this respect, a new methodology of solar radiation record depending on altitude of the points of actinometric observation has been developed. As it is known, the flux of solar radiation in clear days depends on optic condition of atmosphere in the point of observation, i.e. on its transparency, elevation of the Sun over the horizon that is defined by the longitude of the point as well as on elevation of the point over the sea level [1]. We have used these patterns for development of methodology of mapping monthly, seasonal, and annual sums of direct insolation in clear days.

The diagrams have been drown where sums of solar radiation of all the actinometric stations or Uzbekistan as well as the adjacent territories of Turkmenistan, Kazakhstan, and Tajikistan have been plotted with consideration of elevation of these spots over sea level. The total of 15 stations have been chosen.

Inter-seasonal variations of the sums of direct radiation has allowed to identify four typical periods: winter (XI-II), summer (V-VIII), and two transitional (III, IV), and (IX, X) ones. With respect of longitudes, the data from all the stations have been summarized for intervals 37.5-41°, 41-44° north latitude. The curves of vertical distribution of direct radiation have been drawn for the points characterizing the background transparency of the atmosphere, i.e. for those stations, for which the anthropogenic pollution could be considered negligibly small. To this category of stations, we have attributes Karakalpakstan, Takhyatash, Tandm, Akmolla, Akkum, and Kyzylycha. While constructing the profiles, the patterns of vertical variations of direct insolation in unpolluted atmosphere obtained as a result of experimental sensing of the lower layers of atmosphere with aid of air-balloons and specially equipped plane [1, 3].

Based on the obtained vertical profiles, the smoothed profiles of direct insolation sums have been built for separate seasons and the year as whole. Based on these profiles, a table of monthly mean sums of direct solar radiation has been built depending on altitude and longitude of the territory, table 1. The data of the table has been used for mapping the monthly, seasonal, and annual sums of direct radiation on the perpendicular surface by means of their putting on hypsographic map of Uzbekistan. We have used a similar methodology as the basis for constructing maps of sums of the direct insolation on horizontal surface, fig. 3.

The maps of distribution of the scattered and sum solar radiation show the inhomogeneity of input of these kinds of radiation in the territory of Uzbekistan depending of lay-off-the-land. We point out as well that in the conditions of heavy dustiness of the lower layers of atmosphere in the warm half year the sums of scattered radiation increase that entails the comparable order of magnitude with direct insolation on the perpendicular surface.

IV. ESTIMATION OF HUMAN-CAUSED POLLUTION ON SOLAR ENERGY RESOURCES

The mapping methodology we offer of the direct and sum solar radiation on clear days allows to estimate to what extent human-caused exhausts into atmosphere entail weakening of the solar radiation. Deviations of sums of direct insolation on the perpendicular surface as compared with its values in the winter time show that in winter time weakening of sums of the direct radiation reach 32% (Fergana) in south-eastern part of Fergana Valley, 20% in its western part (Kayrakkum). In Tashkent, weakening of direct insolation makes 18%. The least weakening of the direct radiation is observed at the points, first, fairly open and, second, with smaller industrial production capacity. These include Termez and Charjou, where weakening of the direct radiation in winter season makes 5-6%.

In the transition seasons in the south-eastern part of Fergana Valley, weakening of the direct radiation makes 23-25%, that in Termez is 13% and in Tashkent it is 14%.

In the summer season, these indices tend to diminishing over all the listed periods.

V. CONCLUSION

The developed mapping methodology of sums of the direct and sum solar radiation allows to estimate potential values of the solar energy resources of the individual areas of Uzbekistan. From this point of view, these resources are the most significant in the following territories of Uzbekistan: the South Aral Sea area, the desert part of Bukhara and Navoi Regions, Karshi, Surkhan-Sherabad, and Mirzachol regions.

Based on climatic and statistical and trend analysis as well as estimation of the solar radiation weakening by means of calculation, it has been shown that close to large industry centres of Uzbekistan conditions for operating solar installation worsen as a result of weakening of the solar energy resources.
radiation by human-caused exhausts into atmosphere as well as the temporal variability of the radiation characteristics. With this regard, utilization of the solar installations capable of transforming scattered and sum radiation is more expedient in such areas.

For efficient deployment of the natural resources in the desert areas of Uzbekistan, it is reasonable building of SPP of small capacity.

REFERENCES
Table 1: Monthly Average Sums of Direct insolation on Perpendicular Surface in Clear Days Depending on the Altitude and Longitude (MJ/m²).

<table>
<thead>
<tr>
<th>Longitude, φ°</th>
<th>XI-II</th>
<th>III-IV</th>
<th>V-VIII</th>
<th>IX-X</th>
<th>roa</th>
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<tbody>
<tr>
<td></td>
<td>MJ/m²</td>
<td>h, m</td>
<td>MJ/m²</td>
<td>h, m</td>
<td>MJ/m²</td>
</tr>
<tr>
<td>41.44 &lt;750</td>
<td>0-100</td>
<td>&lt;100</td>
<td>0-200</td>
<td>&lt;1100</td>
<td>0-100</td>
</tr>
<tr>
<td>37.41 &lt;750</td>
<td>0-100</td>
<td>&lt;100</td>
<td>0-200</td>
<td>&lt;1100</td>
<td>0-100</td>
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<tr>
<td>41.44 700-750</td>
<td>100-300</td>
<td>1000-1050</td>
<td>200-400</td>
<td>1100-1150</td>
<td>300-350</td>
</tr>
<tr>
<td>37.41 700-750</td>
<td>100-300</td>
<td>1050-1100</td>
<td>400-850</td>
<td>1150-1200</td>
<td>350-900</td>
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<td>41.44 750-800</td>
<td>300-600</td>
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<td>37.41 750-800</td>
<td>300-600</td>
<td>1100-1150</td>
<td>850-1600</td>
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<td>900-2000</td>
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<td>41.44 800-850</td>
<td>600-1200</td>
<td>1100-1150</td>
<td>850-1600</td>
<td>1200-1250</td>
<td>900-2000</td>
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<tr>
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<td>600-1200</td>
<td>1150-1200</td>
<td>1600-2400</td>
<td>1250-13000</td>
<td>&gt;2000</td>
</tr>
</tbody>
</table>

Figure 1: Geographic Distribution of the Number of Clear Days in Uzbekistan (days).

Figure 2: Geographic Distribution of the Yearly Sums of Duration of Solar Shine in Uzbekistan (hours).
Figure 3: Geographic Distribution of the Yearly Sums of Direct Insolation on Horizontal Surface on Clear Days in Uzbekistan (MJ/m²).