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ECONOMICAL ESTIMATION OF SOLAR AND WIND ENERGIES APPLICATION AS ALTERNATIVE OF FIRE WOOD

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Abstract- Presently, deficiency of both sources are actually all over the world and the main one is energy crises having the greatest role in solving the leading countries' tale in the field of policy. Now the independent country is considered that one who has no energy dependence. Development of energy sector branches of course directly serves progress in the life of the country. Beside energy, ecological and economical sides of the national economy should be taken into consideration. Ecological safety and economical support of the forest stocks are closely connected with energy demand supply, therefore alternative of the forest wood is to be utilized and both facets of these sources ought to be calculated. That is why the research was done on the basis of economical estimation of the Combined Solar Wind Energy Plant (CSWEP) application for protection of the woodlands' biodiversity. In order to economy, fire wood for saving forest lines and at the same time to solve the current energy demands, also ecological problems, renewable energy plant's economical proof are studied.

Keywords: Solar Energy, Wind Energy, Ecological Problems, Fire Wood, Reduction of Expenditures, Woodland Protection.

I. INTRODUCTION

The present state budget of the Republic of Azerbaijan has been established on the energy sector development including completely oil sector, partly gas sector. For improvement of nontraditional energy sector, President of Azerbaijan signed State Program on «Renewable and Alternative Energy Sources Application» on October 21, 2004. Increasing of this sector means not only to work out requirements dealing with energy potential diversity but also to reduce and at the same time to obstacle atmospheric, soil and alius pollutions.

As for renewable energy sources usage, among them the greatest reserves concern to solar and wind energy potentials in Azerbaijan. To use alternatives can't help to resolve ecological problems unless application of alternative energy sources change or reduce hazardous influences to the environment, then these reserves are not profitable from ecological and economical point of view. Sometimes alternative and renewable energy sources are confused; really they are not the same things.

Each energy source can be alternative for other one. Renewable energy potentials are the natural reserves which can resume periodically including solar, wind, thermal waters and so on. Azerbaijan's total solar and wind potentials give opportunity to realize this. Firstly solar [3, 4, 12, 14] energy application perspectives and possibilities have to be analyzed as follows:

❖ The average annual high intensity level of solar radiation in Azerbaijan Republic;
❖ Crises on the energy deficiency as in some countries;
❖ Unstable selling prices of natural energy resources, gas, oil and oil productions in internal/external markets;
❖ Considerable increasing of requirements to energy resources in the world;
❖ Extension of energy need for social and economical amelioration of the population and economical state of Azerbaijan;
❖ Protection of the environment such as; atmospheric air, soil and so on;
❖ Preference of independent (autonomous) energy application in the buildings;
❖ Reinforce of the ecological safety measurements for protection of the environment from being polluted;
❖ Prevention of woodlands' sawing.

Secondly wind energy [5, 7, 9, 10, 13] application perspectives/possibilities have to be analyzed as follows:

❖ The average annual high index of wind energy potential in Azerbaijan Republic depending on the zones;
❖ Balancing energy supply during rising in selling price of electricity to the population of Azerbaijan;
❖ Balancing energy supply during rising in selling price of natural gas to the population of Azerbaijan;
❖ Taking into consideration high taxes put for the black coal by customs and expensive cost;
❖ Realizing economy of fuel fossils such as; natural gas, oil, coal, oil productions and so on;
❖ Solving existing and further ecological hazardous problems;
❖ Supplying individually energy need of the population whose social economical state is not sufficient.

It must be taken into consideration that there are 250-270 sunny days [12] and 280-300 windy days [5, 9, 10, 11] in the Republic of Azerbaijan for a year. These potential index prove the possibility of the application of renewable energy sources (solar and wind) in Azerbaijan condition.

For solution of some ecological problems solar and wind energy are applied in several processes. In order to save environment and to protect forest strips [2], renewable energy sources' application is one of the main demand at present time. Total forest square consists of 11.2% of Azerbaijan and the forest area is 1213700 hectares. Due to the statistical information, total resource of the forest is 127440000 m3. The 0.12 hectare wood area and 17.5 m3 fire wood is considered for each person. Such showing is 2 or 3 times less than the international norms [3, 6, 8]. By this purpose, instead of fire woods from the forest, solar thermal and wind energy application is advisable, because as an alternative to fire wood, selection of these energy sources is protection of forest stripes with hectares.

At the same time, gas emission's amount in atmosphere may be reduced that formed at the result of natural gas, coal and other fossil fuels' ignition which are used instead of fire wood. The gas emission leads directly to the greenhouse effect in atmosphere that causes the global warming. But ecological and economical facets, utilization of the local solar and wind potentials is cheaper and more profitable than traditional sources. This showing proves possibility of CSWEP application [12] for solution of ecological problems and protection of environment. Utilization of solar thermal and wind energy is economy of fossil fuels. By this purpose CSWEP was developed and built in Pirgulu of Shamakhi region with 4,274 hectares area. It was determined that at the result of CSWEP's application, the following questions' solution is possible:

• Prevention of forest strips' destroying by energy purpose;
• Reduction of gas emissions formed at the result of fossil fuels' ignition;
• Economy of the traditional fuels being used instead of the fire wood;
• Decreasing of the additional financial expenditures from ecological problems made by traditional fuels' usage.

II. MATERIAL AND METHOD

Especially for the protection of forest fire wood, application of solar and wind energy potentials in mountainous and foothills have been projected. The first possibility for increasing CSWEP utilization by only solar and wind energies is the erection of new, rural energy network. This is usually the core of «bio-energy village or region» project indeed. One example of this type of efficient bio-energy project has been developed in the settlement of Pirgulu in Shamakhi region on the south-east part of the Big Caucasus Mountain. Pirgulu makes use of a CSWEP on the outskirt of the village where woodchip-fired boiler and biodiesel-fired peak load boiler are being used. All these were altered into a new district heating combined plant. Of course the plant was applied at one house but for the erection of the latter in all villages of the natural region, there are two ways: the first is individual mounting of CSWEP in each houses; the second is development of the central bio-energy energy network from renewable energy sources. In this case approximately 70% of the inhabitants of Pirgulu natural zone including all villages [12, 13] and a district located here must agree to change their energy supply from their own boilers to one of systems as above mentioned ways. Although recent studies have revealed that in rural regions individual CSWEP or district central heating networks based on the CSWEP can be used not only for ecological considerations but also for economic benefits, considerable efforts had to be taken to reach such a high willingness from inhabitants to connect the new heat supply. Beside ecological and energy advantages, solar and wind energy application has great economical benefit [1, 3, 4, 5, 6, 7, 9, 11].

Another example of using of the very energy plant from solar and wind energy sources, currently gaining more importance in Azerbaijan regions settled on the mountainous and foothills is the protection of the woodlands. This means that Azerbaijan great solar and wind energy potentials are satisfy in economy of bio-fuels for reducing additional expenses from the personal budget of the population. Because fossil fuels' transportation or carrying, purchase and sale demand is much more expenses from economical point of view. Such CSWEP was first applied in Absheron Peninsula in Badamdar settlement located more than 200 m above from the sea level. Here wind both potentials are sufficient, sometimes more than ever. In this region location of wind energy plants in the Caspian Sea can give excellent effect in electricity supply of all Absheron Peninsula. In comparison with these projects there is no great deed realized in the Caspian Sea but lately one project (2-3 MW) is being planned to accomplish in Chilov Island in the Caspian Sea by the Ministry of Industry and Energy. There is no wind turbine mounting practice in the offshore in the Azerbaijan [5].

Also Solar Power Station mounting or development in the peninsular may lead to the solution of the energy demand of all Absheron. Separately usage of both potential gives effect but no more, combined utilization causes twice or trice efficiency in energy provision of the population. The second way of the CSWEP application is greater suitable for Absheron Peninsula condition. In Pirgulu zone individual CSWEP usage may be easier than the central heating network, at the same time for increasing energy efficiency and economy of woodchip-fire and bio-fuels, the mounting of the CSWEP being centrally controlled has productivity on a large scale. At the same time ecological damages made by the traditional energy sources causes the additional expenses during the solution of these problems. From time to time such ecological damages can't be resolved on account of demanding long term restoration of the natural complex (woodland) on the mountainous zones.

While carrying out ecological monitoring in Pirgulu so environmental defects or determents around the Pirgulu forest is one of the ecological disadvantages has been shown in Figures 1, 2 and 3.

Figure 1. Destruction of the foothill woodlands

Figure 2. Soil erosion on the foothills

Figure 3. Dangerous situation in woodless zone in river basin

From the photos taken in Pirgulu forest, clearly the present state of the woodland is seen including soil erosion, soil slide, destruction of the mountain soil, washing of the mountain slopes by river, exhausting forest woods on the foothill of the mountain, poverty of biovarieties, overflow during spring and autumn by the abundant river and so on. The appeared ecological problems encourage the researchers on energy to think the reliable source to save woodland and environment by changing energy need supply of the inhabitants from woodchip-fired one into renewable energy sources (solar and wind energy potentials).

If we take into consideration all of the economical, ecological and energy expenditures, building of renewable energy plants is economically cheaper than the non renewable ones [1]. There are some methods to calculate economical benefits of CSWEPs. Depending on the exploitation term of the manufactured plants, one of the main methods is for determination of its economical payback period. Generally payback period of CSWEP is determined on the formula

$$T = \frac{S_v}{Q \cdot S_t} \tag{1}$$

Where S_v is specific value of CSWEP, USD/W; Q is annual heating amount, manufactured CSWEP, W·hour; S_t is heat cost from traditional energy sources, USD/W. Calculation of payback period on equation (1) is not objective, as well as it doesn't take into consideration energy comparability of the comparative variants. The last one has role when quantity of thermal energy of the manufactured CSWEP for estimated service life is compared with the energy consumption to the material production of solar collectors, equipment and construction of CSWEP. Then energy payback period of CSWEP may be determined from the equation (2).

$$T = \frac{\sum(m_g \cdot E_g) + \sum(m_p \cdot E_p)}{(Q_p \cdot n)} \tag{2}$$

where $\sum(m_g \cdot E_g)$ is sum of mass products and materials energy intensity according to CSWEP; $\sum(m_p \cdot E_p)$ is sum of auxiliary construction and equipments of CSWEP; Q_p is quantity of thermal energy, manufactured CSWEP for a year and n is projected exploitative life of CSWEP. The analysis of present calculation method on economical expediency of CSWEP's building is carried out and application basis is given for determining the economical payback period of CSWEP with thermal alternative by equation (3).

$$T = (K_p - K_t)/(QC_t) \tag{3}$$

where Q is the annual (seasonal) quantity of the thermal energy, manufactured CSWEP; K_p and K_t are capital investment to the CSWEP and substitute of the traditional energy sources and C_t is cost of alternative energy. For CSWEP objects which don't demand higher temperature maintenance of the hot water and corresponding to the alternative variant of the traditional energy sources, economical payback period may be defined from equation (4).

$$T = K_t /(QC_t) \tag{4}$$

Result of the economical calculation CSWEP was properly shown [3, 5, 12, 13, 14] to add to the energy payback period calculation, when energy amount is compared, manufactured CSWEP and expenditure to the materials and the building of the combined plant. Equations (3) and (4) are used for lack condition of the percentage rate for bank credit, in the presence of the equation (4) acquires to equation (5).

$$T=\frac{\ln\left[\frac{1}{1-(K_2/QC_t)(P/100)}\right]}{\ln(1+P/100)} \quad (5)$$

where P is annual percentage rate for credit. Due to the payback period calculation alternative thermal energy has great advantage.

III. RESULTS AND DISCUSSIONS

Finally the results from the ecological and environmental monitoring completed in Pirgulu settled in Shamakhi region [2] on the south-east part of the Big Caucasus Mountain prove that to revive and solve these problems take much more financial support or expenditures. Therefore, preventive measurements are to be worked, the energy source of the inhabitants in Pirgulu should be changed into other one.

According to our economical calculations, production of solar and wind plants in local condition is cheaper than their importation from the world countries where the income-generating production is being realized, because automatically the sale price becomes higher than the original one. The imported manufactures are added auxiliary expenses whilst being sold including taxes, transportation expenditures and so on.

Cost of thermal energy and electricity in all regions of Azerbaijan appreciably is lower than in the world that determines the economical perspectives of CSWEP. So, economical benefits of CSWEP are characterized as follows [3]:

• For a family with six persons, CSWEP, 4000 W = 14000 USD;
• Payback period is 4.8 years;
• Exploitation period is 20 years;
• Annual income (due to the increasing of the fuels' cost) is 20-30%;
• Pure income is 12500 USD.

So the pure benefit got from the investment project proposed is 12500 USD. If a family realizes the project about 14000 USD after 4.8 years the very family will be able to gain both 14000 USD spent to the project and 12500 USD as the additional benefit. These showings (cost) are considered to the local production for internal market.

The research territory (Pirgulu) has not natural gas supply, in the villages fire-wood is used, if the woodchip is altered into bio-(fossil)-fuels, there will appear other additional economical expenditures for the inhabitants living socially under bad condition. So a family with four members seasonally must minimally pay energy bills because of electricity and natural gas utilization. In summer for each month for electricity 50 USD, for gas 60 USD and for three months these bills will be 50×3=150 USD and 60×3=180 USD; in spring for each month electricity 60 USD and for gas 80 USD and for three months these bills will be 60×3=180 USD and 80×3=240 USD; in autumn for each month for electricity 60 USD, for gas 90 USD and for three months these bills will be 60×3=180 USD and 90×3=270 USD; in winter for each month for electricity 100 USD, for gas 150 USD and for three months these bills will be 100×3=300 USD and 150×3=450 USD.

Due to the three monthly showings for electricity and gas bills we calculated the average annual electricity and gas bills for a family with 4 persons as followings:

• For average annual electricity bill has been determined on sum of three month bills of all 4 seasons are ((150$+180$+180$+300$)/4seasons)$\times$12 months=2430 USD average annual bill;
• For average annual gas bill has been determined as the above mention based on sum of three month bills of all 4 seasons are ((180$+240$+270$+450$)/4seasons)$\times$12 months=3420 USD average annual bill.

After having calculated all bills for a family whose members' minimum salary can't give opportunity economically to solve the energy need problem, in this case production and utilization of CSWEP working from solar and wind energy potentials is necessary on the mountainous zones.

IV. CONCLUSIONS

Due to the results obtained from the carried research, we have come to the following conclusions that if the above mentioned CSWEP is applied, then it is possible:

- To save 150-200 USD expenditure for electricity in summer months;
- To save 180-250 USD expenses for natural gas in summer months;
- To save 180-200 USD expenditures for electricity in spring months;
- To save 240-300 USD expenses for natural gas in spring months;
- To save 180-200 USD expenditure for electricity in autumn months;
- To save 270-300 USD expenses for natural gas in autumn months;
- To save 300-350 USD expenditures for electricity in winter months;
- To save 450-500 USD expenses for natural gas in winter months;
- To save 3000-3600 USD annual expenditures for natural gas utilization can be realized;
- To save 1800-2400 USD annual expenses for electricity usage;
- To economy 5000-6000 USD in the budget of a family with more than 6 members, nevertheless the minimum salary of a working member of a family is 80 USD.
- To apply individually CSWEP with 20 years exploitation period, because it is economically more profitable for the population living in houses.

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BIOGRAPHIES

Qarib Sh. Mammadov received the higher education degree in 1970 at geography and biology faculties. He received the Ph.D. degree in 1979 on soil science and ecology at the Institute of Soil Science and Agrochemistry of Azerbaijan National Academy of Sciences. Then he received the degree of Doctor of Science in 1992 on soil science and ecology. He was selected as the academician of Azerbaijan National Academy of Sciences in 2007. He has published more than 400 papers, half of the publications concerns to the international journals and conferences including more than 20 books and 4 atlases. His research interest are multilateral such as; soil ecology, soil evaluation, soil mapping, soil cadastre, renewable energy ecology, topography and so on. Presently, he is the head of the State Committee of Land and Cartography of Azerbaijan Republic.

Ulviyya F. Samadova received the bachelor degree in 2001 and the master degree in 2007 at Azerbaijan Language University. Since 2004 she has done researches on ecological, technical and economical estimation of solar, wind and biomass energy potentials. Amount of her publications are more than 30 in the international journals including 3 certifications of authorship and a book (Solar Power Engineering Terms) in seven languages (Azerbaijani, Russian, English, German, French, Spanish, Italian). Her research interest is technical, ecological and economical estimation of renewable energy sources, solar, wind and other renewables' application to protect forest wood being used to supply energy demand of the local population living around the forest strips. Presently, she is a candidate for Ph.D. at the Institute of Soil Science and Agrochemistry of Azerbaijan National Academy of Sciences (ANAS) and is working at the State Committee of Land and Cartography of Azerbaijan Republic.

Fuad F. Mammadov was born in Baku, Azerbaijan Republic in 1981. He received the bachelor degree in 2001 and the master degree in 2003 at Azerbaijan Technical University on the profession of Thermal Transfer, Nontraditional and Renewable Energy Sources and Plants. He received the Ph.D. degree in 2007 on theme of Parabolic trough Solar Energy Plant for Solar Energy Application in Crude Oil Treatment. Amount of his publications are more than 50 in the international journals including 7 certifications of authorship and a book (Solar Power Engineering Terms) in seven languages (Azerbaijani, Russian, English, German, French, Spanish, Italian). His research interest is technical, ecological and economical estimation of renewable energy sources, solar, wind and other renewables' application in different technological processes, and constructing and building solar, wind and other renewable energy plants. Since 2008 he has been selected as a member of The International Steering Committee of WREC (World Renewable Energy Congress) is being held by WREN (World Renewable Energy Network). Presently, he is an associate professor and leads the research direction on solar and wind energy application in oil industry in several processes.