Розглянуто питання спільного застосування енергії сонця і вітру в природних умовах Апшеронського півострова, на які такий багатий регіон, для цілей гарячого водопостачання. З цією метою було враховано розподіл швидкості вітру та сонячної радіації (в даний період швидкість вітру на Апшероні становить в середньому ~7,2÷8,5 м/с, а інтенсивність сонячної радіації становить в середньому ~650 Вт/м²)

Ключові слова: сонячний колектор, вітряної електричний агрегат, сонячна радіація, швидкість вітру

Рассмотрены вопросы совместного применения энергии солнца и ветра в природных условиях Апшеронского полуострова, которыми столь богат регион, для целей горячего водоснабжения. С этой целью было учтено распределение скорости ветра и интенсивность солнечной радиации (в данный период скорость ветра на Апшероне составляет в среднем ~7,2÷8,5 м/с, а интенсивность солнечной радиации составляет в среднем ~650 Вт/м²)

Ключевые слова: солнечный коллектор, ветряной электрический агрегат, солнечная радиация, скорость ветра

UDC 536.24,662.997
DOI: 10.15587/1729-4061.2016.72547

USAGE OF SOLAR AND WIND ENERGIES FOR HOT WATER-SUPPLY OF COUNTRY (COTTAGE) HOUSE IN NATURAL CONDITIONS OF ABSHERON

F. Salmanova
PhD, Senior Researcher*
E-mail: fs_rpi@mail.ru

P. Rzayev
Doctor of technical sciences, Professor*
E-mail: rzayev.1937@mail.ru

I. Yusubov
Engineer*
E-mail: iqoryusupov@yahoo.com

I. Velizade
Postgraduate Student*
E-mail: maa_1239@mail.ru

*Institute of Radiation Problems of Azerbaijan National Academy of Sciences
B. Vahabzadeh str., 9, Baku, Azerbaijan, AZ1143

1. Introduction

Presently, the Azerbaijan population is provided with energy by traditional methods due to the combustion of natural raw materials (natural gas, fuel oil) in thermal power plants (TPP) and the energy of rivers at hydro power plant. If on the one hand both these two essential brunches of power engineering provide high living standards but on the other hand they harm to the environment.

Azerbaijan is an advantageous region for the effective use of solar and wind energies thanks to its features of the geographical position and ecological infrastructure. Solar radiation intensity is usual 2200÷400 Vt hour/m^2 per year, and that time of sunshine duration is more than 2500 hours a year. The mean annual wind speed in Azerbaijan, especially at Absheron and in the coastal strip of the Caspian Sea equal to ~7,4 m/sec and 226 days a year, it exceeds 8–17 m/sec and much more up to ~30–35 m/sec.

Accordingly to the recommendation of The World Energy Council, the issue" The construction and development of wind power devices with limited power to energy supply of the "small autonomous" consumers" has a practical significance [1–3].

2. Analysis of published data and problem statement

Hot water-supply of a country (cottage) house is one of the well-known tasks of solar technology. SWH (Solar Water Heater) is the most popular device in the practical solar technology both in the former USSR and abroad.

However, combined usage of solar and wind energies for that purpose both in the former USSR and abroad is practically unknown to us from a reliable literature.

In view of the above, the system of hot water heating of country (cottage) house has been developed and created by us based on the use of the alternative Solar and wind energies sources.

To achieve the goal we have solved the following tasks: it is calculated and used SWH area of 4 m^2 based on solar radiation receiving equaled on the average 650 Vt/m^2.

The wind energy device (wind-powered engine) with capacity 2.5 kVt has been used by us in view of wind speeds distribution for the period months of March-October.

It is necessary to note that the energy produced in thermal power stations (TPS) is used at present widely in Azerbaijan to reach the above-mentioned goals but another part of electric energy is developed through hydro power plants (Mingachaur, Shamkir) and etc. [4, 5].

At present, the power developed in nuclear power plants which demanded significant resources as well as get worse ecology of environment uses to produce electric power in France, Germany, Hungary, Japan, Korea, etc.

We have developed and created the SWH+WED (wind power or energy device or wind turbine) on basis of combined use of solar and wind energies for this aim with consideration for the data of wind speed distribution and solar radiation receiving that are at the average 650÷860 Vt/m^2

for solar radiation and 7.2 m/sec for wind speed distribution (for the period months March-October of year considered). Through long-lasting experimental researches of the system SWH+WED (Picture) in natural Absheron conditions it was determined that hot water temperature is at the average 60÷70 °C and more(in case if solar radiation intensity is 650÷900 Vt/m^2 and wind speeds distribution is 7,2÷÷8.5 m/sec.) for the month of March.

Hot water temperature was at the average 70÷85 °C and more for the months of April and May.

In summer period of year the temperature of hot water was keeping firmly at the level of 80÷90 °C.

It is necessary to note that the energy produced in thermal power stations (TPS) is used at present to reach the above-mentioned goals but another part of electric energy is developed through hydro power plants (Mingachevir, Shamkir). As known, at present, the power developed in nuclear power plants demanded usually significant resources as well as get worse ecology of environment is used to produce electric power in France, Germany, Hungary, Japan, Korea, etc. [6, 7].

It may do conclusion summarizing above-stated that use of the native natural solar and wind energy sources in Azerbaijan for these goals is the given gift to residents of the Republic.

3. Purpose and objectives of the study

The purpose of the work consisted in developing the optimal hot water heating system for country (cottage) house based on the use of the alternative Solar and wind energies sources for the considered period of year.

To achieve the goal the following tasks were solved:

– The rational scheme of the system of hot water heating of country (cottage) house based on the use of the alternative Solar and wind energies sources was developed on the grounds of the long-term meteorological indicators of solar radiation entrance and wind velocity distribution.

– To achieving this aim the system of hot water heating of country (cottage) house has been developed and created with consideration of the long-term data of solar radiation entrance (approx. 800 Vt/m^2) and wind velocity distribution about 8,0 m/sec.

The system has been installed on laboratory house-top of the institute in where pilot researches were conducted during 2 years the results of those were expounded in the work.

4. Materials and Methods

As it is known, the solar radiation activity and wind velocity distribution in Absheron peninsula in where Baku city named as Sun city is situated are sufficiently high, and the combined usage of them to meet the sanitary-hygienic conditions of the population of the region is practically possible (solar radiation activity varies) within the limits of S=550÷650 Vt/m is the working wind speed for wind turbine and it varies within the limits of 7÷10 m/sec.

Long-lasting experimental researches of the system SWH+WED developed by us during 2013÷2015 years in natural conditions of Absheron confirmed the advisability of their use to meet the sanitary-hygienic conditions of the region population.

Development of an optimal hot water supply system for country house (cottage) that based on solar and wind energy, the alternative energy sources, in native condition of Absheron and the coastal strip of the Caspian Sea, and calculation of the gotten experimental data.

The developed system SWH+WED is based on use of methods and materials applying at the private housekeeping of the countrymen as use of methods and experience both of the formal USSR and foreign experience [8–10].

5. Results and discussion of the results

The experimental studies of the developed hot water-supply system of a country (cottage) house have been conducted on the roof of the 2nd laboratory division of the Institute of Radiation Problems of Azerbaijan Academy of Sciences.

The system has been supplied with the WED and SWH also appropriate apparatus and appliance.

The experiments were conducted daily for accepted year period (months March-October).

Advisability of combined use of solar and wind energies for the purposes of hot water-supply of the country cottage house has been assigned by experimental studies.

Mathematic and graphical development of the gotten results based to the prolonged experimental studies of the system solar water heater+wind electric unit (SWH+WEU) during March-November months (Table 1, 2) have been conducted by us. Calculations are taken average daily for each month, i. e. the meteorological indicators are taken for each hour of the month in the average value thus the average days are drawn up. All days during month are the same, values showed parameters per days change every hour.

Analysis of the obtained indicators shows that we get graphics of curvilinear trapezoids when constructing graphs of temperature t °C versus time τ_{hour} and Q_{total} radiation and etc.

In connection with it processing of the experimental data of the SWH+WEU system per the indicated period can be implemented by two methods used for the purposes [11–14]:

1. Simpson's Rule, area of the curvilinear trapezoid defined by a mathematical method is used for calculation of the experimental indicators obtained in a trapezoid form.

2. It can be used the method "Paletka" (palette) that is often used and approved in cartography, topography, as well as in solar technology reports.

Let's consider the 1st method.

We get a curve on the X–Y system The curve is a f (x) function. Because the function f (x) unknown, there is numerical calculating rule to find the area under this curve. We divide trapezoid into fragments which can be substituted by segments of straight lines to find the area of its curved side. Carrying out such a division will lead to dividing all of the experimental curves to trapezoids with sides one of which is higher than others [15, 16].

Thus, we divide axis of abscissa X on x coordinate to equal segments X_0, X_1, X_2...X_n, there is X_0=a (start time) aX_n=b (end time).

The given area is determined from this formula:

$$\int_a^b f(x)dx = s = \frac{b-a}{3n}\begin{pmatrix} y_0 + y_n + 4y_1 + 2y_2 + 4y_3 + 2y_4 + \\ +\ldots + 2y_{n-2} + 4y_{n-1} \end{pmatrix}.$$

Here x_0=a (beginning of the time calculated),

$x_1=a+h,\ x_2=a=2h,\ x_{n-1}=a+(n-1)\cdot h,\ x_n=b,$

here

$$h=\frac{b-a}{n}.$$

The method of "Parallel palette", the measure method of curve areas obtained in trapezoid form, is prevalent one in science and technology. It consist that the built palette is put on the area will be determined (for example, the trapezoid OABM in x-y coordinate system, then lines a_1 в$_1$ (trapezoid CABD), c, d (trapezoid ECDF) and e_1 f_1 (trapezoid OEFM) are determined by follow formula through the common height of trapezoid OABM:

$$a_1b_1=\frac{ab+cd}{2}h_1,\ \ c_1d_1=\frac{cd+ef}{2}h_2,\ \ e_1f_1=\frac{ef+km}{2}h_3,$$

here a_1, b_1, c_1d_1, e_1f_1 are middle lines of the trapezoids, we find area of the trapezoid having the common height $h=h_1+h_2+h_3$ by $F=h\ (a_1b_1+c_1d_1+e_1f_1)$.

Calculations made by methods of 1 and 2 show that findings on determining the area of the curvilinear trapezoid differ little from each other (approximately 10÷12 %) that naturally, it has no particular significance (it's of little import).

In this connection, using the graphical method of the practical findings processing we have found the mathematical processing taking into account the above and the time of useful work of the system for season (March-November months):

a) Water consumption passed SC SWH per hour;

b) Passing SC SWH specific water consumption per hour;

c) The specific quantity of water heated during a day;

d) The specific amount of heat transferred to water in the SC SWH during a day;

e) The specific amount of heat transmitted by the SC SWH during a day;

f) The average integral effectiveness of the heat-receiving plate of SC per day;

g) The coefficient of performance of the device per day;

h) the average temperature of heated water.

Definition of the relative error $\frac{E}{X}\cdot 100\ \%$ in the determination of the average integrated efficiency of the technological process of hot water supply is 14 percentage.

As you see, the given technological parameters of the system technological process of hot water supply in fact meet completely the given requirements of service, and satisfy hot water supply of the object.

On the other side, in this connection, it should be also noted that as experimental studies show functioning operability of the system WPU has been needed (for the given period) in fact for 7–12 days in March (2012–2013). Hot water supply of object has been implemented due to the solar radiation heat from the rest of the days in March till the end in October [17–21].

Because of decrease of solar radiation and temperature of environment in November the need has emerged for additional heating of system by WEU for 18–20 days, with short breaks to what also wind conditions favored well (the average wind speed per this period was 7.5 m/sec in the place of the system).

Naturally, the common COP of the system decreased from 48 % to 25–27 % for a shot period.

However, the need of the system SWH+WEU has not been on the power supply from the GEN.

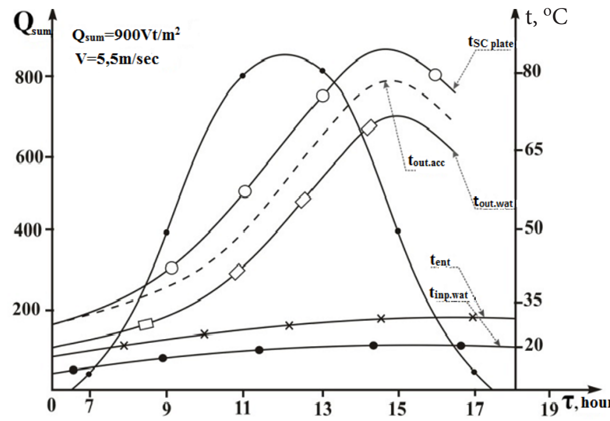

Fig. 1. Graphical dependence (at the average the months of June-August) temperature distribution t_{plate} SC, $t_{tank\ acc.}$ $t_{in.wat.}$ $t_{out.wat.}$ on the intensity of solar radiation $Q_{sum.}$, environmental temperature $t_{env.tem.}$ and the average wind velocity V≅5.5 m/sec

Analyses of the multilateral experimental data of nature tests of the SWH+WEU system of hot water supply of country house (cottage) developed for the function period the system in (March-November) 2013–2015 years shows that applying the work for the mentioned period in fact provides completely the required rational technological hot water supply mode of country (cottage) house, which characterizes sufficiently enough through the long-duration test, including the basic technological parameters of the process in the system (Table 1).

Table 1

The experimental indicators of the temperature distribution of the SC SWH system in dependence the summary solar radiation Q_{sum}, environmental temperature t env. tem. and wind velocity $V_{average}$ for the months May and September, 2013–2015 years

Time, hour	$Q_{sum.}$ Solar radiation Vt/m^2	Temperature, °C							The average wind speed $V_{ave.}$m/sec
		$t_{env.}$	$t_{in.wat.}$	t_{SC}	$t_{inter.air}$	$t_{isol.}$ and SC	TA $t_{wat.}$	TA $t_{out.\ wat.}$	
9.00	–	–	–	42.2	30.2	22.0	42.0	41.5	–
11.00	–	–		60.5	36.3	22.5	58.5	57.6	–
13.00	~650	25 °C	24.0	69.3	40.5	23.0	72.3	71.5	~7,4
15.00	–	–	–	72.5	39.3	22.0	70.0	68.5	–
17.00	–	–	–	65.3	38.5	21.5	65.4	64.0	–
...	–	–	–	–	–	–	–	–	–
...	–	–	–	–	–	–	–	–	–
9.00	~520	22.5	22.0	–	–	–	43.5	–	5.5

Table 2

For the periods 2013—2015 years (III—IV—V, VI—VII—VIII and IX—X—XI).
The experimental indicators of the SWH+WEU system function data on the processing

Date: month, year 2013–2015 III–XI	Time of useful SWH function	Water consumption passed SC SWH per hour	Passing SC SWH specific water consumption per hour	The specific quantity of water heated during a day	The specific amount of heat imparted to water from SC per a day	The specific amount of heat passed the SC SWH during a day	The average integral effectiveness of heat-receiver	COP of the device	The average temperature of heating water
	τ_n	G	$G_{spec.}$	G_{day}	q_n	q_E	$\overline{\eta}$	η	$\overline{t_{CIX}}$
	hour	kg/hour	kg/m²hour	kg/m² day	Vt·hour/m² day	Vt·hour/m²day	%	%	°C
March April May	8	29	8.8	70.4	3650	7450	49	43	60*
June July August	10	32	9.4	94.0	4420	8500	52	50	69
September October November	8	30	8.9	71.2	3810	7620	50	45	60*

*Note: * – subject to heating water in TA SWH by feeding WEU GEN*

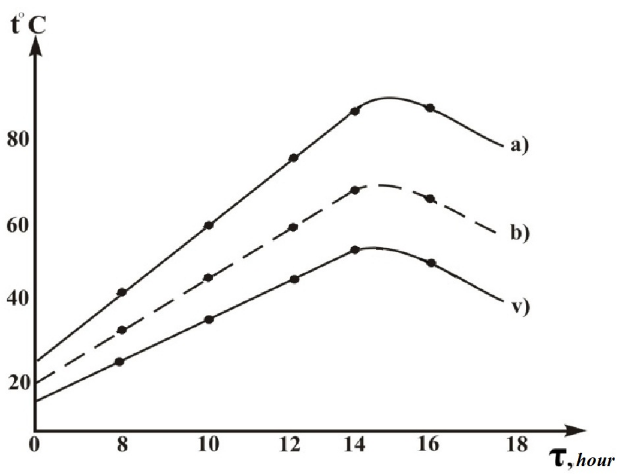

Fig. 2. $Q_{sum.}$ And temperature delivering of the SC SWH plate depending in $V_{wind\ speed}$: *a* — clear sky; *b* — cloudy sky; *c* — overcast sky

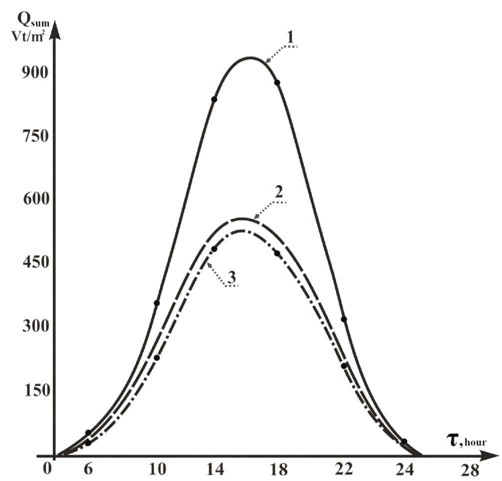

Fig. 4. Comparing the amount of SC SWH heat efficiently used on calculation and experimental parameters: 1 — the total solar radiation, 2 — efficiently used heat (calculation), 3 — efficiently used heat for experimental indicators

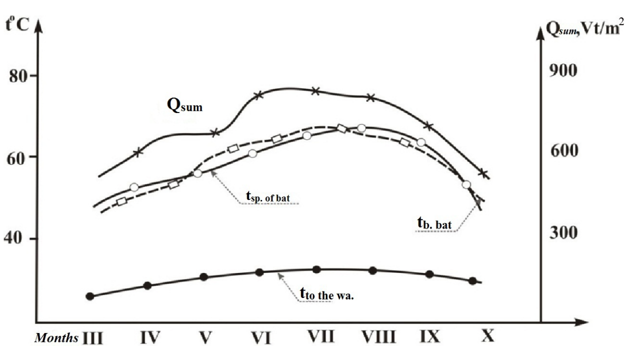

Fig. 3. $Q_{sum.}$ The average monthly distribution of hot water temperature $t_{tank.acc.eks.}$ depending on the intensity of solar radiation and temperature d $_{in.wat.}$

a) water consumption through SC SWH per hour G in the period months March-November approximately is ~30,3 kg/hour;

b) in this time the specific water consumption $G_{spec.}$ through SC SWH is equal to $\cong 9 \div 10$ kg/m²hour;

c) the specific amount of water heated during a day $G_{spec.}$=78 kg/m²;

d) the specific amount of heat passed to water during a day q_n=3960 Vt hour/m²;

e) the specific amount of heat reached SC SWH during a day q_E=7856Vt hour/m²;

f) the average integral effectiveness of the SC heat-receiver, 50,3 %;

g) COP η of the system – 46 %;

h) the average temperature of heated water $t_{out.}$=63 °C.

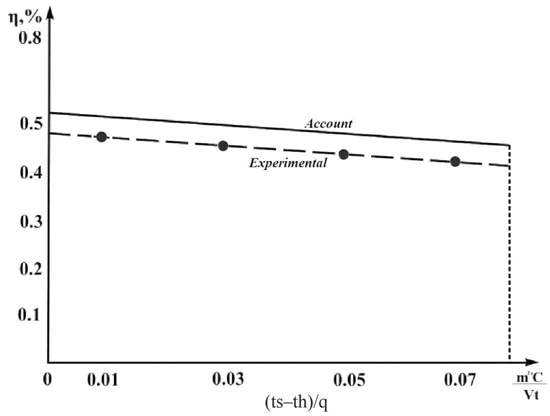

Fig. 5. The dependence of COP on the difference temperature of water and environment by difference intensity q η of solar radiation fallen on SC ($t_{wat.}-t_{env.}$)

Error definition has been found to assess the average integral effectiveness of SC SWH experimental studies:

1. The evaluation of the average mathematic value of the measured quantity:

$$\bar{x}=\frac{\sum x_i}{n}. \quad (1)$$

2. The absolute errors of the separate measures have been found:

$$\Delta x_i=\bar{x}-x_i. \quad (2)$$

3. The mean second root error of the separate measures has been determined:

$$\bar{\xi}=1.253\Delta\bar{X}. \quad (3)$$

4. The mean second root error of the average value has been determined:

$$\bar{S}=\frac{1,253\sum(x_i)}{n\sqrt{n}}=\frac{1,253\Delta\bar{x}}{\sqrt{n}}. \quad (4)$$

5. The Student constant – $\bar{t_S}$ has been determinated on probability p chosen in Student's Table and by the number of observations.

6. Confidence interval quantity was obtained from the average value of the measured quantity:

$$E=t_S\cdot S. \quad (5)$$

7. Results of measures was noted:

$$X=\bar{X}\mp E \quad (6)$$

and defined the relative error:

$$\frac{E}{\bar{X}}\cdot 100\,\%\cong 14\,\%.$$

The sample numerical Table 1, 2 of the experimental indicators for SWH obtained in 2013–2015 is followed below.

Scheme of accepted numerical calculation:

1. Water consumption through heat-absorbing surface situated on SC tube per hour (experimental indicators).

G=32kg/hour.

2. Specific water consumption through SC per hour (experimental indicators)

$$G_{spec.}=\frac{32}{3.5}=9.1\ \text{kg/m}^2\cdot\text{hour}.$$

3. Time of SWH useful function

τ_n=10 hours (for June).

4. Specific weight of obtained heated water per day (experimental indicators)

$G_{day}=9.1\cdot10=91$ kg/m^{2}day.

5. The average temperature of heated water (is taken on the processing of experimental curves): (τ – more t °C), E – from τ

$$\bar{t}_{out.}=\frac{Ft}{\tau n}=\frac{650}{10}=65\ ^{o}C,$$

where Ft=650 hour (is obtained using the method The Template Method pattern).

6. The specific amount of heat passed to water during a day

$q_n=c\cdot G_{spec.}\cdot F_n=1,16\cdot9,1\cdot400$ Vt·hour/m^2=
=4220 Vt·hour/m^{2}day.

where F_n=400 hour (is obtained using the method "Paletka", The Template Method pattern).

7. Specific weight of the heat reached to device per day:

q_E=7600 Vt hour/m^2 day

is obtained using the method The Template Method pattern.

8. The average integral effectiveness of the SC

$$\bar{\eta}_{ave.}=\frac{q_n}{q_E}=\frac{1.16\cdot9.1\cdot250}{5680}\cdot100\cong 46.4\,\%.$$

9. COP SC

$$\eta=\frac{q_{nst}}{q_{Est}}=\frac{1.16\cdot9.1\cdot250}{5680}\cdot100\cong 46,4\,\%.$$

Here q_{nst} – the specific amount of heat passed to water during stationary function of the heat-receiver.

Here q_{est} – the specific amount of heat is reached to the heat-receiver during its function at steady-state regime.

The area under the curve appropriately described the changes of outgoing heat-receiver water temperature, and summary solar radiation $Q_{sum.}$ during stationary function of heat-receiver – F_{nst}, F_{est} is determinated by The Template Method pattern.

Let's consider the moment of beginning of the constant temperature of the water flowing out of the SC the star timing of the stationary function τ_{stn} of the heat-receiver.

The end timing of the stationary function of the SC τ_{stn} is considered the completing moment of a stable level of total solar radiation Q_{sum}.

To improve the social-hygienic condition of the Absheron population the expediency of calculation of the system SWH+WEU applying is conducted approximately in accordance with recommendations BR and N52-86 accepted in solar engineering.

The calculation, naturally, is conducted for a one family as accepted in the technical-economical assessment then the indicators are used for 10, 100 and more families with areas of the SC SWH 4 m^2 and 400 m^2 respectively.

To provide the calculation the expediency of the sun and wind energy sharing, it is necessary, the first, to determine of the amount of heat received in the technological process per season $Q_{seas.}$, the given indicators of η_{COP} that is submitted Chapter 2 of this thesis.

The calculations is carried out for following relation: the technical and economic calculation to saving the SWH+WEU energy is determined by formula below:

$$Q_{sav.fuel} = 0{,}034 \frac{F_{SX} \cdot \sum q_{iseas} \cdot 30 \cdot 9}{0 \cdot 6},$$

here

$$F_{SC} = 4.0 m^2;$$

$$\eta_{SEAS.} = 0.442;$$

$$\sum q_{iSEAS} = 54000 \frac{VT \cdot hour}{day};$$

$$\eta_{equiv.heat sour.} = 0.60$$

from it, $Q_{sav.fuel}$=9,35445845 G.

In this time 1 kg equivalent fuel

$$7000 \text{ kkal} = 7 \cdot 10^6 \text{ kal} = 7 \cdot 10^6 \text{ kal} \cdot 4.2 = 7 \cdot 42 \cdot 10^5 \text{ G} =$$
$$= 294 \cdot 10^5 \text{ G} = 29.4 \cdot 10^6 \text{ G} = 29.4 \text{ MG} = 0.029.$$

So, $Q_{sav.fuel}$=9,35 HG; 1 kg equivalent fuel – 0.29HG; X – 9.35 HG.

There by

$$X = \frac{9.35}{0.029} \cong 320 \text{ kg}.$$

Thus, a saving fuel from SWH will be

$F_{\text{with the area SC}}$=4.0 m^2×320 kg,

$F_{\text{with the areaSC}}$=$40^2$×3.2 (ton),

$F_{\text{with the area SC}}$ =400 m^2×32 (ton).

We should note that the combustion of 1 kg of fuel oil is cause to releasing 3.18 kg of CO_2 , thus saving 400 kg of fuel is prevented the allocation of 1.3 tons of CO_2 into the environment, including preventing of diffusion of "greenhouse gas" – 13 and 130 tonnes to 10 families and 100 families, respectively. We have conducted the approximate technical-economical assessment of the energy consumption (natural gas) for meeting of requirements the social-hygienic conditions of the region people. It was found that the energy consumption reduces (10–12 %) when our proposed method have been used.

Also, a saving fuel for March, April and November months has been determined the average due using solar energy to supply hot water by this formula.

So, the amount of the heat for heating water 1250 and 2500 kg from 20 °C to 50 °C and time spent with these aims to use WEU with a capacity 12 and 16 kVt, respectively will be (for 5 and 10 families with members 20 and 40 respectively):

Q_1=cm×Δt=4.2×kG/kg×0C×1250 kg×
×1250 kg×30 °C=157,5 MG,

Q_2=cm×Δ t=4.2×kG/ kg×0C ×1250 kg×
×2500 kg×30 °C=315 MG.

To WEU with power 12 kVt:

12 kVt×3.7 hour=12 kG×3.5 hour×3600 sec≅157.5 MG.

And to WEU with power 16 kVt:

16 kVt×5.5 hour=16 kG×5.5 hour×3600 sec≅315 MG.

Based on the above, we can conclude that the WEU with a capacity of 12 and 16 kW, respectively (In this case the number of residents to 10 families and 5 has been taken 20 and 40 respectively) will be sufficient for heating water in 1250 and 2500 kg from 20 °C to 50 °C.

As the long-duration experimental studies shown, the need of the under study SWH+WEU system to heating by wind in fact appeared mainly in the months of March, November. The percentage of water heating by wind averaged 10–15 % of total heat output (Fig. 6–8).

In some cases not provided for work (the end of December) the energy consumption from GEN was 35 % when wind is absent and temperature is –1.5÷2.5 °C.

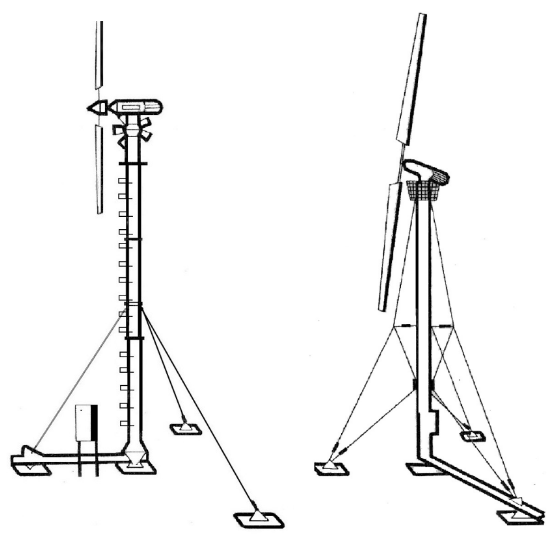

Fig. 6. Wind-powered engine:
a — АВЭУ-12 kVt, *b* — АВЭУ-16 kVt

The wind-powered engines have been manufactured in the plant "Vetroenergomash" of Astrakhan city (Russia).

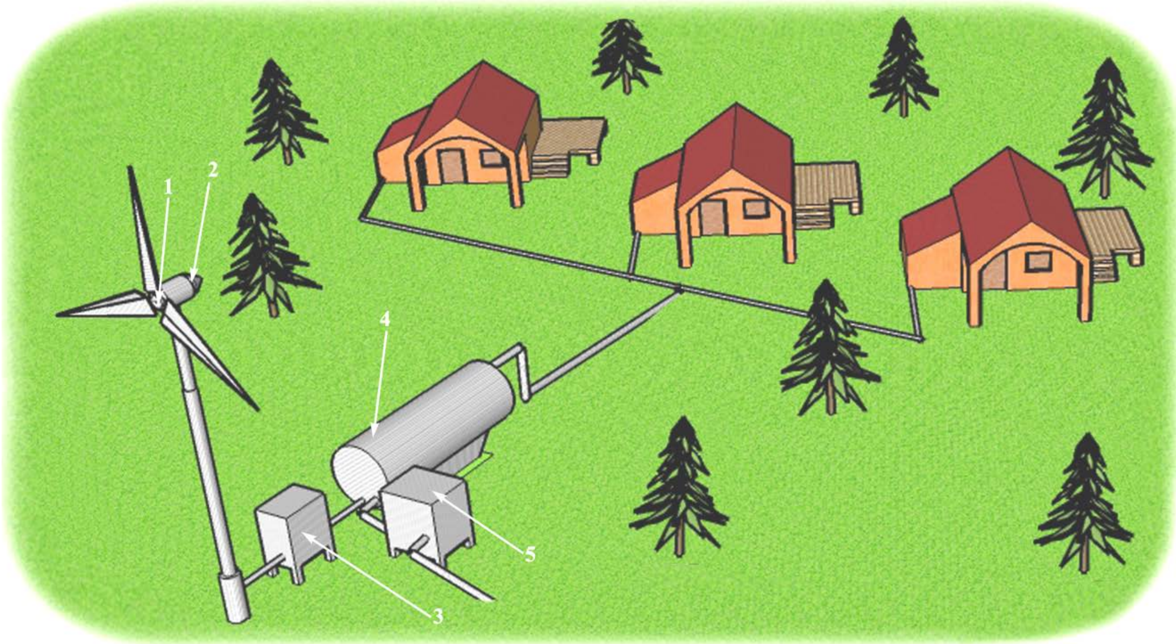

Fig. 7. The offered system of house heating based on use of WED only: 1 — WED, 2 — Generator, 3 — the managed system unit, 4 — Water tank, 5 — Pump

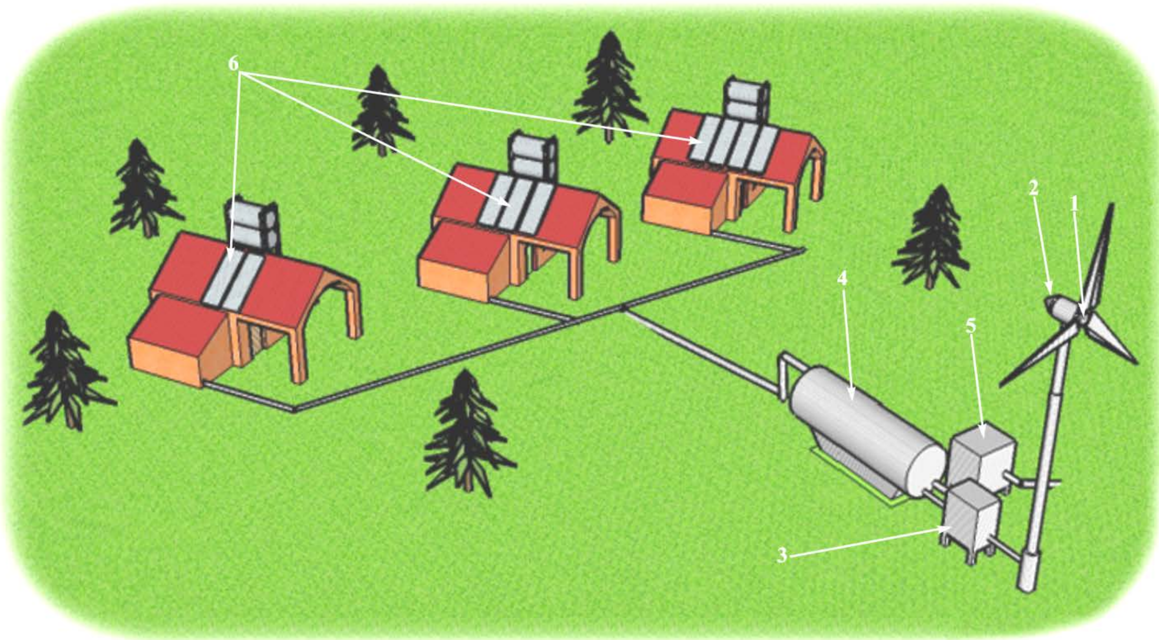

Fig. 8. The offered system of heating includes solar water heater besides WED:
1 — WED, 2 — Generator, 3 — the managed system unit, 4 — Water tank, 5 — Pump, 6 — SWH

Analyses of the long-duration experimental and calculation data shown that the combined use of the solar and wind energy is a real implementable question in natural and economic conditions of Absheron and the Caspian Sea coastal strip.

6. Conclusions

The offered SWH+WED system has the heating feature of house that is realized through solar energy – SWH and wind one – WED which may support heating mode of hot water preparing and house heating on enough high level.

The SWH + WED system in Absheron functions sufficiently for the period of months March-October in case of ~400–600 Vt/m solar radiation intensity and wind speed ~8–10 m/sec.

Development authors summarizing above-stated consider it advisable of wide implantation of the system SWH+WED to natural conditions of Absheron to meet sanitary and hygienic conditions of the region population.

The developed system SWH+WED would certainly be optimized and improved subsequently.

References

1. Beckman, W. A. The calculation of solar heating system [Text] / W. A. Beckman, S. A. Klein, D. S. Duffy. – Moscow: “Energoizdat”, 1982. – 250 p.
2. Rzaev, P. F. Solar cadastre and ITS practical use [Text] / P. F. Rzaev, F. A. Salmanova, E. N. Movsumov // Proceedings of the eighth Baku International Congress ‘Energy, Ecology, Economy’, 2005. – P. 99–100.
3. Covalev, O. P. The solar combined water heating installation of hot water supply [Text] / O. P. Covalev, A. V. Volkov // Electronic magazine of an energy service company “Ecological systems”. – 2003. – Vol. 5. – P. 15.
4. Avezov, R. R. Solar Systems for Heating and Hot Water Supplying [Text] / R. R. Avezov, A. Yu. Orlov. – Tsh. FAN, 1988. – 250 p.
5. Carbonell, D. Simulations of combined solar thermal and heat pump systems for domestic hot water and space heating [Text] / D. Carbonell, Y. Michel, P. Daniel, F. Elimar // Energy Procedia. – 2014. – Vol. 48. – P. 524–534. doi: 10.1016/j.egypro.2014.02.062
6. Shershnev, V. The solar heating system [Text] / V. Shershnev, N. Dudarev. – Construction engineering, 2006.
7. Rzaev, P. F. Some Characteristics of Solar Radiation Entry Through the Transparent Enclosures of South-Facing Homes in the winter [Text] / P. F. Rzaev, F. A. Salmanova, A. B. Babaev // Applied Solar Energy. – 2007. – Vol. 43, Issue 1. – P. 43–44. doi: 10.3103/s0003701x07010148
8. Jungbauer, A. Windenergienutzung in einem regenerative Energiesystem, Analyse der Windkraftanlagen Eberschwang und Laussa [Text] / A. Jungbauer. – Diplomarbeit Technischen Universitat Graz, Institut fur Hochspannungstechnik, Elektrotechnik – Wirtschaft und Energiennovation. Craz, 1998.
9. Kharchenko, N. V. Individual Solar Applications [Text] / N. V. Kharchenko. – Energoatomizdat, 1991.
10. Panjiyev, A. Prospects for the use of renewable energy sources in Turkmenistan [Text] / A. Panjiyev // Alternative Energy and Ecology. – 2007. – Vol. 9, Issue 53. – P. 65–69.
11. Abdelmoneym, A. Thermal modes of heat accumulators with a phase transition to solar heaters [Text]: Doctoral Dissertation of the candidate of technical sciences / A. Abdelmoneym. – Moscow, 1988.
12. Bekman, U. Raschet system solnechnogo teplosnabjenija [Calculation of Solar Heating Systems] [Text] / U. Bekman, S. Kleyn, J. Daffi. – Moscow: Energoizdat, 1982.
13. Movsumov, E. A. About general characteristics of the receiving of solar radiation in Azerbaijan [Text] / E. A. Movsumov, V. I. Yesman // Journal of “Geliotekhnika”. – 1969. – Vol. 4. –P. 43–46.
14. Ignatiev, S. G. Razvitie metodov ocenki vetroenergeticeskogo potenciala i rasceta go-dovoj proizvoditelnosti vetroustanovok [Text] / S. G. Ignatiev, S. V. Kiseleva // International Scientific Journal for Alternative Energy and Ecology (ISJAEE). – 2010. – Vol. 10. – P. 10–35.
15. Sun & Wind Energy [Text] // Booming market without subsidy. – 2014. – Vol. 3. – P. 34–35.
16. Ushakova, A. Combined solar installation to heat and cold of the experimental residential building of the Institute of Solar Energy [Text] / A. Ushakova. – The test results. Ashkhabad: Turkmenniinti, 1986.
17. Rekomendacii po opredeleniu klimaticeskih harakteristik vetroenergeticeskih resursov [Text]. – GGO. NPO “Vetroen”. Leningrad: Gidrometeoizdat Publ., 1989.
18. Grinevich, G. A. Collection “Study of the characterictics of the renewing sources of energy” [Text] / G. A. Grinevich. – Publishing House of the Academy of Sciences of Uzbekistan SSR, Tashkent, 1963. – 150 p.
19. Romanovskiy, V. I. Implementation of the mathematical statistics experiences [Text] / V. I. Romanovskiy. – Moscow-Leningrad, Gostoptekhizdat, 1987. – 410 p.
20. Salmanova, F. A. Calculation of the Repetition Rate and the Provision of Daily Amounts of Solar Radiation: Cadastre Parameters [Text] / F. A. Salmanova, I. M. Kulieva // Applied Solar Energy. – 2007. – Vol. 43, Issue 4. – P. 243–246. doi: 10.3103/s0003701x07040123