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AN ENERGY EFFICIENCY PROJECT FOR A BROILERS FARM

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Abstract

Improving energy efficiency and reducing greenhouse gases is a central issue of the Europe energy strategy. The challenge of significant reduction in energy consumption is high. It can only be achieved if we all work together and share good experiences and practices. Recently in the livestock sector is highly relevant topic of the requirements for the breeding conditions of farm animals. These conditions are necessary for industrial methods of production and for poultry farming. They define health, ensure productivity and preserve the reproductive performance of farmed animals. The accumulation of products obtained in the process of birds breeding (heat, moisture, waste gases, etc.) in the premises may have a negative impact on the health of the birds. Correct determination of these products will result in the exact sizing of the ventilation and heating installations of poultry farms. This article identifies the incoming and outgoing heat flows from a broiler farm and proposes a methodology for determining the amount of energy required for heating the farm by providing the necessary zoo technical parameters for broilers breeding. The methodology has been developed on the basis of European and national regulations in the field of energy efficiency and in the field of veterinary medical requirements for livestock premises. The proposed methodology could be used for designing of heating and ventilation installations of poultry farms operating under different conditions.

***Key words**: agrarian buildings, microclimate, energy balance, energy consumption, poultry farming.*

INTRODUCTION

Europe's energy policy is part of the EU's overall economic policy. Three are the reference points of the energy policy: limiting climate change, encourage-vane for creating growth and jobs and limiting the EU's dependence on imports of natural gas and petroleum products.

European policy is aimed at ensuring the security of energy supplies and the introduction of an integrated approach to energy efficiency. Energy saving is the most direct and economically effective way to address these energy challenges (Rasheva V., 2011; htpp://www.seea.government.bg/).

That's why EU countries have agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. These targets aim to help the EU achieve a more competitive secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target.

The strategy sends a strong signal to the market, encouraging private investment in new low-carbon technologies and plants (https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2030-energy strategy).

That's why the Bulgarian national policy follows the priorities of European policy on sustainable energy development (Law of energetics, 2018; Law on energy efficiency, 2016; Regulation № E- RD-04-05, 2016; Regulation № E-RD-04-1, 2016; Regulation № E-RD-04-2, 2016; Regulation № RD-16-932, 2009). The main activities to improve energy efficiency are aimed at reducing the cost of production, transmission and distribution of energy, as well as in its final consumption.

Extensively current in the livestock sphere is recently the subject of the requirements for the conditions for rearing livestock. The agrarian buildings are one of the most important elements of modern technology used in agriculture. By properly designing of them largely depend on energy expenditure, the creation of suitable zoohygiene conditions for the cultivation of animals and their health and productivity, as well as the final economic results of production (Dinev D., 1999).

Managing the production environment is achieved by creating a good microclimate for the animals. It is necessary that the premises and conditions in them meet the physiological requirements of the animals kept (Hristev Hg., 2008).

A microclimate means the sum of the physical, chemical and biological properties of the air environment in a given room. The microclimate is determined by external climatic conditions, bird breeding technology, the type, shape and construction of the buildings. The factors of climate are: temperature, humidity, gas composition, movement of air masses, lighting, etc. (Spasov M., 1975).

The heating balance of the poultry farm is necessary to maintain these vital requirements. It is also in the design of the heating installation to take account of the specific conditions in keeping the birds in such a way as to meet the volume of production.

The purpose of this paper is to determine the proper amount of heat for heating the farm for industrial rearing of broiler chickens on the basis of normative documents in the field of energy efficiency.

MATERIALS AND METHODS

The heat balance of the poultry farm (Figure 1) includes all the heat inflows and heat losses of the poultry farm.

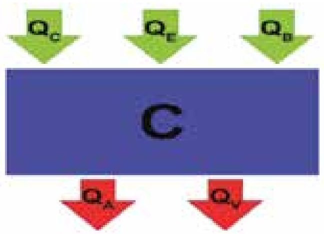

Figure 1. Heat exchange model of poultry farm:
C - premises of poultry farm; Q_C - heat released from the poultry; Q_E - heat delivered by electric power; Q_B - heat released from the poultry bed; Q_A - thermal losses from heat transfer; Q_V - heat losses from ventilation

The object of research is a modern building for industrial broilers grow thing.

In the EU and in our country act the veterinary medicine requirements and requirements to animal buildings and requirements for the protection and humanitarian regards by growthing of farm animals, that provide optimal values and tolerances of the parameters of temperature-humidity regime and air quality in agricultural holdings (Regulation № 26, 2008; Regulation № 44, 2006). According to these requirements, the minimum bird density in the room should not exceed 33 kg/m^2. The intensity of the light in the rooms shall be at least 20 lux, measured at the bird's eye level, with at least 80% of the area illuminated. The concentration of ammonia (NH_3) should not exceed 20 ppm and the concentration of carbon dioxide (CO_2) should not exceed 3000 ppm measured at bird level.

The internal room temperature should not exceed the outside temperature by more than 3°C when the outside shade temperature is above 30°C. When measured for 48 hours, the average relative humidity in the room shall not exceed 70% when the outside temperature is below 10°C.

In other publications (Broileri, 2009; Dinkova V., 2013) are presented more specific data on the microclimate in the premises broiler management skills: in room should be supported with temperature-30-32^{0}C in the first 3 days. At the end of the first week the temperature at the level of the chickens should be with 30°C. In the after next week, it decrease by 2°C to 20°C, and is kept at the end of cultivation in the range of 18°C to 20°C. The relative air humidity is optimal in the range 60-70%. Ventilation must maintain an air velocity of 0.2 to 0.3 m/s.

The starting point for determining the heat flows imported or taken from the bird breeding building is the technical reference. It includes the following basic parameters:

1. Heated building - a poultry farm for 10 000 broilers. From them, 1000 broilers are with mass 0.2 kg, 4000 are with mass 1 kg, 3000 are with mass 2 kg and 2000 are with mass 3 kg. The rearing of birds is floor with separate broilers by mass;
2. The building is on the one floor with a total built up area of 564 m^2 and a heated area of 564 m^2;
3. The dimensions of the building are: height 2.7 m, width 12 m and length 47 m;
4. The built-up volume of the building is equal to the heated volume and is equal to 1522.8 m^3;
5. The walls and the roof are made of sandwich panels and the floor is made of reinforced concrete, located on land;

6. The yindows are with double glazed and structural considerations they are height 0.9 m, situated bilaterally along the entire length of the building. The area of windows is 84.6 m^2;
7. The poultry farm is located in the region of city Plovdiv. The average temperature of the outside air with the longer duration during the heating season is 2°C;
8. Room temperature and air humidity are respectively - 25°C and 70%.

Calculations made based on Regulation № 7, 2004.

RESULTS AND DISCUSSIONS

Initially, a check is made on the compliance of the area required for broiler breeding (equation 1):

$$A_n = N/a_n = 556\ m^2 \quad (1)$$

where:
- a_n is number of broilers/m^2; by hygienic norms $a_n = 18$;
- N - number of broilers in the poultry farm.

In the shown in Figure 1 model of the heat balance in the poultry farm, the heat input is represented by: the heat emitted by the birds Q_C, heat delivered by electric power Q_E and heat released from the poultry bed Q_B.

The separated heat from birds can be obvious and hidden. It is obvious this heat, which is expressed in the increase of the air temperature. Hidden heat is needed to evaporate moisture from birds. In this case, the total released heat from the birds is expressed as a sum of the other two. The heat flow value separated from the birds is derived from equation (2) (Spasov M., 1975):

$$Q_C = \Sigma q_C \,.\, N = 77.085\ kW \quad (2)$$

where:
- q_C is the heat flow separated from one bird depending on its mass (W);
- N - number of birds.

The heat flow separated by one broiler is plotted by (Hristev Hg., 2008) and depends on the bird mass (Table 1).

Heat flow from electric light are taken into account for summer mode only when sunlight coincides with lighting. Heat flux, separated by the electrical power is only from light in the room for growing broiler chickens. It is the installed power for lighting and is determined by the dependence (equation 3) (Spasov M., 1975):

$$Q_E = nL.N_L = 1.06\ Kw \quad (3)$$

where:
- N_L the power from - one illuminant (W);
- n_L - the calculated numbers of illuminants.

Table 1. Heat flow separated from broilers Q_C

№	Mass of bird, kg	q_C for one bird, $x10^{-4}$ W	Number of birds	q_C for batch birds, kW	Heat separated from birds, kW
1	0,2	8.34	1000	0.83	42.11
2	1	27.8	4000	11.12	
3	2	54.77	3000	16.43	
4	3	68.67	2000	13.73	

For the poultry farm under consideration are selected energy-saving lamps of the brand "OSRAM" with power 20 W and light flow of 1300 lm. The number of illuminants is determined according to equation (4) and the required luminous flux for broiler breeding is related to the luminous flux of a luminaire (equation 5):

$$n_L = S_n/S_L = 52.3 \approx 53 \quad (4)$$

where:
- S_L is light flow of one illuminate (lm);
- S_n - necessary light flow (lm).

The necessary light flow S_n is evaluated from dependence (equation 5):

$$S_n = F_L.S_C = 68100\ lm \quad (5)$$

where:
- F_L is the total illuminated area of the luminaires (m^2). It includes areas of all walls, floor and roof;
- S_C - the necessary illumination for broiler breeding. According to the hygiene requirements for the breeding

of birds the required illumination is S_C = 50 lx.

According to the requirements of the assignment the height of the building is 2.7 m and the windows are on the long side and are 0.9 m high. Then the illuminated area of the illuminates is $F_L = 1362\ m^2$ and is presented in Table 2.

As mentioned, birds are growing on bed with straw. Bed due to processes of decay heat is evolved. This heat can be defined in the equation 6 (Spasov M., 1975):

$$Q_B = A_n.Q_B = 0.42\ kW \quad (6)$$

where:
- Q_B is heat separate from 1 m^2 bed (Wm^{-2}). According to the data on the straw bed and the selected internal room temperature it is 0.744 Wm^{-2} (Hristev Hg., 2008);
- A_n - floor area (m^2). In this case it is 564 m^2.

Table 2. Total illuminated area of the poultry farm

№	Name	Dimensions, m	Area, m^2	Total illuminated area, m^2
1	Wall	47x1.8	84.6	1362
2	Wall	12x2.7	32.4	
3	Wall	47x1.8	84.6	
4	Wall	12x2.7	32.4	
5	Floor	47x12	564	
6	Roof	47x12	564	

The sum of the incoming heat flows in the poultry rearing can be given by dependence (equation 7), and the results for the poultry farm under consideration are given in Table 3.

$$Q_I = Q_C + Q_B + Q_E \quad (7)$$

Table 3. Inflow heat power of the poultry farm

№	Heat energy	Quantity, kW	Total heat flow, kW
1	Heat flow separate from birds, Q_C	42.11	43.59
2	Heat flow from electric power, Q_E	1.06	
3	Heat flow from bed, Q_B	0.42	

During the heating period heat losses from heat transfer through the external enclosures of the building Q_A depend on the thermal properties of these elements.

The outer walls of the building are made of sandwich panels with a thickness of 0.15 m. The area of the outer walls is 212.40 m^2, and the area of the windows is 0.15 $W(m^2K)^{-1}$ (Monoroof_Agro_Metecno_Bulgaria_BG).

The area of the windows is 84.6 m^2. The joinery is aluminium with double glazing and interrupted thermal insulation. The coefficient of heat transmission of the windows is 1.7 $W(m^2K)^{-1}$.

The roof of the building is a warm roof without air space. The ceiling is made of 10 cm thick roof sandwich panels. The area of roof is 564 m^2, and its perimeter is 172 m. The coefficient of heat transmission of the roof is 0.21 W/m^2K (Monoroof_Agro_Metecno_Bulgaria_BG).

The floor slab is reinforced concrete with a thickness of 0.16 m and is located on the ground. The individual layers of the floor slab with their respective parameters are presented in Table 4. The floor area is 564 m^2 and its perimeter is 172 m. The coefficient of heat transfer from the heated area to the outside air is determined according to Regulation № 7, 2004. The spatial characteristic of floor B' is determined by equation (8):

$$B' = A/(0.5P) = 6.56\ m \quad (8)$$

where:
- A is floor area (m^2);
- P - floor perimeter (m).

The equivalent thickness of the floor d_t is determined by the equation (9):

$$d_t = w + \lambda*(R_{si} + R_f + R_{se}) = 4.342\ m \quad (9)$$

where:
- w is the thickness of the overhead part of the vertical wall above the level of the terrain (m);
- λ is the coefficient of thermal conductivity of the Earth. Assume that $\lambda = 2\ W(m^2K)^{-1}$;
- R_{si} - heat transfer resistance from the inner surface, $R_{si} = 0.17\ m^2KW^{-1}$;

- R_f - heat conductivity coefficient of the floor plate (Table 4), $R_f = \Sigma(\delta i/\lambda i) = 1.881\ m^2KW^{-1}$;
- R_{se} - thermal resistance of the outer surface, $R_{se} = 0.04\ m^2KW^{-1}$.

Table 4. Evaluating of floor heat transfer coefficient

Floor layers	Layer thinkness, δi	Coefficient of thermal conductivity, Λi	Layer resistance Ri
-	m	$W(m^2K)^{-1}$	m^2KW^{-1}
Straw bed	0.10	0.07	1.429
Concrete slab	0.16	1.63	0.098
Rubble	0.2	1.1	0.182
Thick finger	0.2	1.16	0.172

At $d_t < B'$ the heat transfer coefficient throwght floor is evaluating with dependece (equation 10):

$$U = [(2\lambda)/(\pi B'+d_t)]\ \ln(\pi B'/d_t+1)=0.28\ W.(m^2K)^{-1} \quad (10)$$

The coefficient of heat transfer through heat transfer is determined by the H_{tr} equation (11):

$$H_{tr} = H_D + H_g + H_U + H_A \quad (11)$$

where:

- H_D is the coefficient of heat transfer by heat transfer through the enclosing elements, bordering the outside air (WK^{-1});
- H_g - coefficient of heat transfer by heat transfer through the Earth in the stationary regime (WK^{-1});
- H_U - coefficient of heat transfer through heat transfer through the elements, bordering on non-heated or non-cooled areas (WK^{-1});
- H_A - coefficient of heat transfer by heat transfer through the elements, bordering clinging buildings (WK^{-1}).

The coefficient of heat transfer by heat transfer through the enclosing structures bordering the outside air, H_D is given by the formula 12:

$$H_D = \Sigma_i(U_i.A_i) + \Sigma_k(l_k.\psi_k) + \Sigma_j\chi_j \quad (12)$$

where:

- i, j, k are numbers of element, of linear heated bridge and of point heated bridge;
- U_i - coefficient of heat transfer of i-th enclosing element, bordering the outside air $[W(m^2K)^{-1}]$;
- A_i - the surface area of the i-th enclosing element (m^2);
- l_k - the length of the k-th linear thermal bridge (m);
- ψ_k - linear coefficient of k-th linear thermal bridge $[W(mK)^{-1}]$;
- χ_j - coefficient of heat transfer in thermal j-point bridge (WK^{-1}).

The coefficient of heat transfer through heat transfer through the enclosing walls adjacent to the outside air H_{D1} is determined by equation 13. The impact of thermal bridges has been taken into account when calculating the heat transfer coefficient through the walls. For this reason, the second and third member of the equation are ignored.

$$H_{D1} = U_W A_W = 0.15*\ 212.40 = 31.86\ WK^{-1} \quad (13)$$

The heat transfer coefficient by heat transfer through the windows H_{D2} is determined according to equation 14.

$$H_{D2} = UA = 1.7*\ 84.6 = 143.82\ WK^{-1} \quad (14)$$

The coefficient of heat transfer by heat transfer through the roof H_{D3} is calculated by equation (15):

$$H_{D3} = UA = 0.21*564 = 118.44\ WK^{-1} \quad (15)$$

The coefficient of heat transfer through the floor plate is H_g is calculated by equation (16).

$$H_g = UA = 0.28*564 = 157.92\ WK^{-1} \quad (16)$$

Therefore, the coefficient of heat transfer through heat transfer calculated in (11) is:

$$H_{tr} = H_{D1} + H_{D2} + H_{D3} + H_g = 452.04\ WK^{-1}$$

Heat transfer heat losses are calculated by Q_{tr} for the duration of the heating for each area and for each month in a formula 17 and are shown in the Table 5.

$$Q_{tr} = 1/1000*[(H_{tr} + \Phi_g)*(\theta_{i,H} - \theta_e)]*t \quad (17)$$

where:

- H_{tr} - coefficient of heat transfer in the surrounding area elements when temperature difference 1 K, WK^{-1};
- Φg - heat flow through the Earth at temperature difference 1 K, caused by the thermal inertia of the Earth, WK^{-1};
- $\theta_{i,H}$, - zone temperature in winter mode (^0C). Midle volume temperature of internal air is 25^0C;
- θ_e- the average monthly value of the ambient temperature (^0C);
- t - months duration (h).

Heat losses from heat transfer through the building envelope are reduced by heat gains from sunshine through transparent enclosures.

Table 5. Heat losses from heat transfer

Month	Days	$\theta_{t,H}$	θe	$\theta_{t,H}$-θe	Htr	Qtr
	numbers	°C	°C	K	WK^{-1}	kWh
1	31	25	0.2	24.8	452.04	8340.680
2	28	25	1.8	23.2	452.04	7047.484
3	31	25	6.9	18.1	452.04	6087.351
4	6	25	12.4	12.6	452.04	820.181
10	8	25	12.8	12.2	452.04	1058.858
11	30	25	7.4	17.6	452.04	5728.251
12	31	25	1.9	23.1	452.04	7768.940
Total						36851.747

Heat flow $\Phi_{sol,k}$ of sunshine through the building enclosing element k is given by the equation (18):

$$\Phi_{sol,k} = F_{sh,ob,k} * A_{sol,k} * I_{sol,k} - F_{r,k} * \Phi_{r,k}, \text{ W} \quad (18)$$

where:

- $F_{sh,ob,k}$ is the shading of the host solar energy from external causes;
- $A_{sol,k}$ - effective area of the host solar energy surface (m);
- $I_{sol,k}$ - midle daily intensity of sunshine on the host surface (Wm^{-2});
- $F_{r,k}$ - angular coefficient between element k and heaven, there are values as follows F_r=1 horizontal surface, F_r = 0.5 for no shading vertical surface;
- $\Phi_{r,k}$ - heat flow as a result of the elemena k to heaven (W).

The effective receiving surface of a transparent envelope (for example a window) A_{sol} is determined by the formula (19) and the values obtained are shown in Table 6.

$$A_{sol} = F_{sh,gl} * g_{gl} * (1-F_F) * A_{w,p} \quad (19)$$

where:

- $F_{sh,gl}$ is the shading factor (from moving shadows);
- g_{gl} - the total throughput of the transparent part of the element;
- F_F - the frame factor of the element k (the part occupying the frame);
- $A_{w,p}$ - the total area of element k(m^2).

When the sun's rays do not fall perpendicular to the surface, the value of g_{gl} is determined by formula (20):

$$g_{gl} = F_W * g_{gl,n}, \quad (20)$$

where:

- F_W is the correction factor for no perpendicular radiation. F_W = 0.90;
- $g_{gl,n}$ - the actual ratio of total solar energy transmittance at normal radiation, account of Regulation № 7, 2004.

Table 6. Effective host surface of transparent enclosing element

$A_{w,p}$	$1-F_F$	$F_{sh,gl}$	$g_{gl,n}$	Fw	A_{sol}
84.6	0.85	1	0.75	0.9	48.54

Needed energy for heating for each month of the heating period and for each area of the building is calculated according to equation (21):

$$Q_A = Q_{H,Ht} - \eta_{H,gn} * Q_{H,gn} \quad (21)$$

where:

- Q_A is needed energy for heating zone (kW);
- $Q_{H,Ht}$ - full heat losses of the month (kWh);
- $Q_{H,gn}$ - heat gains in the area for months (are presented in Table 7) (kWh);
- $\eta_{H,gn}$ - dimensionless factor of utilization of heat gains in the area for months.

Table 7. Heat gains in the area

Month	Days, numbers	$A_{sol,k}$ m^2	$I_{sol,k}$ kWm^{-2}	Coefficient 24/1000	$Q_{H,gn}$ kWh
1	31	48.54	63.55	0.024	2295.029
2	28	48.54	75.13	0.024	2450.656
3	31	48.54	83.43	0.024	3012.971
4	6	48.54	90.30	0.024	631.175
10	8	48.54	80.35	0.024	748.836
11	30	48.54	60.75	0.024	2123.140
12	31	48.54	51.50	0.024	1859.859
Total					13121.67

Q_A = 36851.747– 0.5*13121.67 = 30290.912 kWh for the year.

It is necessary to turn the energy power through division and of the heated days of the year (they are 165) and for a period of 24-hour security. Thus, heat losses from the poultry farm result in Q_A = 2.78 kW.

In determining the heat losses from ventilation Q_V, it is necessary to determine the amount of air taken in CO_2 and moisture. After, setting for subsequent calculations into the greater value.

To determine the amount of respiration required depending on the maximum allowable amount of carbon dioxide, a dependence (22) is used:

$$V_{CO2} = \Sigma CO_2/(k_{max} - k_a) = 8688.88\ m^3h^{-1} \quad (22)$$

where:

- ΣCO_2 is quantity CO_2, accumulated in the premises as a result of metabolic processes in organisms of the birds. The calculated value of CO_2 is 38593 ($g.h^{-1}$), k_{max} - maximum permissible concentration of CO_2 in the room. According to hygienic norms it is 3 lm^{-3} (Hristev Hg., 2008);
- k_a - CO_2 content in the ambient air. It is constant and equal to 0.3 lm^{-3}.

The value of the carbon dioxide of the birds is determined by the subject (2), provided that the q_C is replaced by the concentration of CO_2, separated from a bird k_{CO2}. The value varies between: for 0.2 kg - 2.7 $l.h^{-1}$; for 1 kg - 1.31 $l.h^{-1}$; for 2 kg - 2.74 $l.h^{-1}$; for 3 kg - 3.65 $l.h^{-1}$ (Hristev Hg., 2008).

Determination of the necessary quantity of air in order to maintain a certain relative humidity shall be carried out in the relation (23) (Spasov M., 1975):

$$V_W = W/(d_i - d_0) = 3665.89\ m^3/h \quad (23)$$

where:

- W is separated moisture from the birds. The computed value of the moisture, separated from broiler chickens is 47400 $g.h^{-1}$;
- d_i - moisture content of the air in the room at a temperature of 25°C and a relative humidity of 70% (d_i = 9.55 $g.m^{-3}$) (Kimenov G., 1995);
- d_a - the moisture content of the ambient air at a temperature of 2^0C and a relative humidity of 85% (d_a = 4.74 $g.m^{-3}$) (Kimenov G., 1995).

The separated moisture in the rearing of broiler chickens is determined in dependence (2), as in the formula instead of using the q_C separated moisture from a broiler w_C. The value varies between 0.2 kg - 1.1 $g.h^{-1}$, for 1 kg - 3.2 $g.h^{-1}$, for 2 kg - 6.1 $g.h^{-1}$ and for 3 kg - 7.6 $g.h^{-1}$ (Hristev Hg., 2008).

Of dependencies (22) and (23) shows that the air quantity depending on the maximum level of carbon dioxide (V_{CO2}) is greater than the air required for the maintenance of a specific relative humidity (V_W). As mentioned in the calculations, the higher value is taken and the required amount of heat for ventilation is determined by the dependence (24) (Spasov M., 1975):

$$Q_V = V_{CO2} * C_P * (\theta_{i,H} - \theta_e) = 84.13\ kW \quad (24)$$

where:

- C_P is the specific heat capacity of the air and is 1 kJ $(kg.K)^{-1}$ (Kimenov G., 1995).

The heat losses from the farm can be expressed with formula (25). Heat flow consumed to overcome the losses of heat transfer and ventilation is:

$$Q_{EX} = Q_A + Q_V = 86.91\ kW \quad (25)$$

According to the heat balance (Figure 1) its necessary energy for heating on the farm can be expressed by the subject (26):

$$Q = Q_{EX} - Q_I = 86.91 - 43.59 = 43.32\ kW \quad (26)$$

CONCLUSIONS

It is developed a methodology to determine the necessary quantity of thermal energy for heating poultry farm, in providing the necessary zootechnical parameters for growing birds.

The calculations are made on the basis of European and national normative documents in the field of energy efficiency, so that power consumption and consequently CO_2 emissions allocated to be minimized.

The methodology may be used in the design of poultry farms with parameters other than those specified in the publication.

REFERENCES

Broileri (2009). Rakovodstvo, Ross. http://pt.aviagen.com/assets/Uploads/Ross-Broiler-Manual-bg.pdf.

Dinev, D., Delchev, N. (1999). Tehnologchno proektirane na agrarni sgradi. Universe, Stara Zagora.

Dinkova, V. (2013). Ventilation, cooling and heating of ANIMAL farms, Agro biotechnika, year I, broi 3. http://agrobio.elmedia.net/bg/2013-3/editorials/

Hristev, Hg. (2008). Rakovodstvo za uprazhnenia po zoohigiena. AU-Plovdiv.

https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2030-energy-strategy

htpp://www.seea.government.bg/

Kimenov, G. (1995). Termodinamichni I toplofizichni svoistva na veshtestvata. Spravochnik, Tehnika, Sofia.

Spasov, M., Grozev, G. (1975). Ventilatsia I otoplenie v zhivotnovadni fermi. Zemizdat, Sofia.

Law of energetics, 2018. https://www.me.government.bg/bg/library/zakon-za-energetikata-256-c25-m258-1.html.

Law on energy efficiency (2016). http://www.seea.government.bg/documents/ZEE_30.12.2016.pdf.

Monoroof_Agro_Metecno_Bulgaria_BG. https://metecno.bg/index.php/bg/products-and-services/pur-roof-panels/monoroof-agro.

Rasheva, V. (2011). *Energy technological analyses of industrial systems*. Academic Publishing House of UFT, Plovdiv (in Bulgarian).

Regulation № E-RD-04-1 of 22.01.2016 on energy efficiency audits, certification and assessment of energy savings of buildings.

Regulation № E-RD-04-2 from 22.01.2016 on the indicators for energy consumption and energy performance of buildings.

Regulation № E- RD-04-05 of September 8, 2016 for the determination of energy consumption indicators, energy performance of enterprises, industrial systems and external lighting systems, as well as for setting the terms and conditions for conducting energy efficiency audits and preparation of energy savings assessment.

Regulation № RD-16-932 of 23 October 2009 on terms and conditions for carrying out the verification of energy efficiency for hot water boilers and air conditioning installations under article 27, al. 1 and article 28, al.1 of the law on energy efficiency and for establishing, maintenance and use of the basis data about them.

Regulation № 7 of 2004 on Energy Efficiency of Buildings.

Regulation № 26 of 05.08.2008 laying down minimum welfare and protection requirements for broiler breeding. Ministry of Agriculture and Food.

Regulation № 44 of 20 April 2006 for veterinary medical requirements for animal sites.