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Energy Analysis of Agricultural Labor

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As is well known, sustainable development of agriculture depends on price parity between its products and various sectors of the economy. The basis of pricing must be the amount of useful human energy to produce goods and services. On the example of agriculture, we conducted an energy analysis of the labor and calculated the cost of energy for different categories of workers depending on gender, weight, age and physical activity. The results can be used to eliminate the disparity of prices in the economy.

1. Introduction

The relevance of the topic is determined by the fact that labor is the basis of pricing as the only power to create value. From the physical and physiological points of view it is energy transformation: the transformation of human energy into goods creates energy intensity of goods through the production process. The monetary value of this energy intensity, in our opinion, is the science-based price for a product or service. To calculate the energy intensity of 1 man-hour and knowing how many man-hours are spent on the production of various types of goods and services, we can correctly determine the energy intensity of total production for the creation of price parity between them, especially in the regulation of cross-sectoral exchange. But the problem is that subsistence expenses of the employee are not uniform and differ in intensity per unit time at the time of sleep, personal time and labor. In addition, there are inconsistencies in the regulations to determine the energy intensity of labor. According to GOST 51750-2001 of the Russian Federation "Methods for determination of energy intensity in the manufacture of products and provision of services in technological energy systems" the total energy intensity of the products is determined according to GOST R 51387: value of energy consumption and (or) fuel for manufacture of the product, including the cost of extraction, transportation, processing of minerals and the production of raw materials, materials, details with regard to the utilization of raw materials. In the energy intensity is associated with fuel and energy analysis. Belarusian colleagues consider that the total energy is the sum of direct and embodied energy per unit area or unit of output". Scientists of the Russian State Agrarian University – Moscow Agricultural Academy named K.A.Timiryazev (RSAU-MTAA) have focused on the assessment of the energy efficiency of agricultural technologies, without giving the definition of energy intensity of production.
In our opinion, the energy intensity is the total amount of anthropogenous energy for the production of goods and services.
Besides, the labor intensity is categorized as "very easy, easy, medium, heavy and very heavy." At the same time in the normative document physiological needs for energy and nutrients for different groups of the population of the Russian Federation, developed at the Institute of Nutrition and signed by the Chief Medical Officer of the Russian Federation December 18, 2008, the work is considered as a production and physical activity is divided into "very low, low, medium, high and very high ", with the corresponding coefficients of physical activity.
Secondly, the above sources provide different quantitative values of the intensity of labor, and therefore it is necessary to conduct special studies.

Calculate the total expenditure of human energy ($\sum E_H$) to work, in other words, the energy intensity of labor. For example, consider the energy cost of men aged 39 years, weight - 70 kg, physical activity work - very high, for example, the work of the miner). According to the article 91 of the Labor Code of the Russian

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Federation: "normal working hours may not exceed 40 hours in a week." Consequently, the average hours of work a five-day working week is 8 hours.

The total expenditure of human energy ($\sum E_H$) a day in intensity are divided into three parts: during sleep (E_S) (the cost of energy at this time is equal to the value of basal metabolism (E_{VBM}), during personal time (E_{PT}) (very low physical activity, I group physical activity) and labor energy (E_L).

Consider the expenditure of human energy during 24 hours.

Table 1: The average values of the basal metabolism of the adult population of Russia (kcal/day), Men (basal metabolic rate)

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	1450	1370	1280	1180
55	1520	1430	1350	1240
60	1590	1500	1410	1300
65	1670	1570	1480	1360
70	1750	1650	1550	1430
75	1830	1720	1620	1500
80	1920	1810	1700	1570
85	2010	1900	1780	1640
90	2110	1990	1870	1720

Table 2: The average values of the basal metabolism of the adult population of Russia (kcal/day), Women (basal metabolic rate)

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
40	1080	1050	1020	960
45	1150	1120	1080	1030
50	1230	1190	1160	1100
55	1300	1260	1220	1160
60	1380	1340	1300	1230
65	1450	1410	1370	1290
70	1530	1490	1440	1360
75	1600	1550	1510	1430
80	1680	1630	1580	1500

The results of labor intensity calculations for a specific employee with the use of normative documents are presented. The indicators of average energy intensity of labor calculated for all categories of workers, depending on sex, age, body weight and physical activity ratio are presented. According to the universal Declaration of human rights (1948) and the International Covenant on economic, social and cultural rights (1966), "the ideal of free human beings enjoying freedom from fear and want can only be implemented if there is a conditions whereby everyone may enjoy his economic, social and cultural rights, as well as their civil and political rights". Their effective implementation is necessary to observe the principle of equal pay for equal labor. However, the average wage level in rural areas is much lower than in other sectors of the economy, although the quantity and quality of labor is the same. This negative fact result in discrimination on a sectoral basis. For her (discrimination) eliminating us a method of energy analysis. Partially these issues were addressed by us in (Kasumov, 2014).

In our opinion, the labor is a conscious energy to create goods and is the basis of value and pricing. On the basis of equality of people, the socially necessary equal work should be paid equally regardless of industry sector worker. Therefore, the development of standards for the energy equivalent of 1 man-hour is an urgent task.

2. Material and methods

To determine the energy intensity (energy equivalent) of labor of various categories of workers we used the "Norms of physiological needs for energy and nutrients for different groups of population of the Russian Federation. Guidelines" (2008) and the obtained data are compared with materials GOST R 51750-2001. Method of determining energy consumption during the production of goods and rendering of services in technological energy systems (2001).

As noted above, total energy expenditure ($\sum E_H$) per day according to intensity can be divided into three parts: during sleep (E_S) (cost of energy at this time is equal to the value of basal metabolism (E_{VBM}), during personal time (E_{PT}) (very low physical activity, I group physical activity) and to labor (E_L):

$$\sum E_H = E_S + E_{PT} + E_L \quad (1)$$

$$E_S = \frac{E_{VBM}}{3} \quad (2)$$

$$E_{PT} = \frac{(E_{VBM}\, x1.4) - E_S}{2} \quad (3)$$

$$E_L = (E_{VBM}\, xC_{PhA}) - E_S - E_{PT} \quad (4)$$

where, C_{PhA} - the coefficient of physical activity.

Using these formulas, we calculate the average values of the energy intensity of labor all categories of workers, depending on physical activity, body mass, gender and age. Note that the entire adult population, depending on the magnitude of energy expenditure is divided into 5 groups for men and 4 groups for women, taking into account the production of physical activity and other expenditure.

3. Results and discussion

The result of the calculation according to the above procedure, we obtained the following values of energy intensity or the energy equivalent of labour between different types of workers depending on the ratio of physical activity. The unit is MJ/hour.

Group I (**very low physical activity; men and women**) workers mainly mental work, physical activity coefficient of **1.4** (civil servants of administrative organs and institutions, researchers, teachers of universities, colleges, secondary school teachers, students, medical professionals, psychologists, managers, operators including equipment maintenance of computers and computer software, programmers, employees of financial-economic, legal and administrative services, employees of design bureaus and divisions, advertising and information services, architects and engineers in industrial and civil construction, tax officers, employees of museums, archives, librarians, specialists, graphic designers, travel Desk, reference services and other related activities).

Table 3: The average values of energy intensity of labor adult population for the I group physical activity (MJ/h), Men

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	0.405	0.382	0.357	0.329
55	0.424	0.399	0.377	0.346
60	0.444	0.419	0.394	0.363
65	0.466	0.438	0.413	0.380
70	0.488	0.461	0.432	0.399
75	0.511	0.480	0.452	0.419
80	0.536	0.505	0.475	0.438
85	0.561	0.530	0.497	0.458
90	0.589	0.555	0.522	0.480

Table 4: The average values of energy intensity of labor adult population for the I group physical activity (MJ/h), Women

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
40	0.302	0.293	0.285	0.268
45	0.321	0.313	0.301	0.287
50	0.343	0.332	0.324	0.307
55	0.363	0.352	0.341	0.324
60	0.385	0.374	0.363	0.343
65	0.405	0.394	0.382	0.360
70	0.427	0.416	0.402	0.380
75	0.447	0.433	0.422	0.399
80	0.469	0.455	0.441	0.419

Group II (low physical activity; men and women) - workers engaged in light labour, the physical activity coefficient is **1.6** (drivers of urban transport, workers food processing, textile, garment, electronic industry, operators of pipelines, packers, drivers of railway transport, local doctors, surgeons, nurses, salespeople, employees of enterprises of public catering, hairdressers, workers housing and maintenance services, restorers of art products, guides, photographers, technicians and operators of radio and television broadcasting, customs inspector, workers police and highway patrol officers and other related activities).

Table 5: The average values of energy intensity of labor adult population for the II group physical activity (MJ/h), Men

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	0.556	0.526	0.491	0.453
55	0.583	0.549	0.518	0.476
60	0.610	0.576	0.541	0.499
65	0.641	0.602	0.568	0.522
70	0.672	0.633	0.595	0.549
75	0.702	0.660	0.622	0.576
80	0.737	0.695	0.652	0.603
85	0.771	0.729	0.683	0.629
90	0.810	0.764	0.718	0.660

Table 6: The average values of energy intensity of labor adult population for the II group physical activity (MJ/h), Women

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
40	0.414	0.403	0.391	0.368
45	0.441	0.430	0.414	0.395
50	0.472	0.457	0.445	0.422
55	0.499	0.484	0.468	0.445
60	0.530	0.514	0.499	0.472
65	0.556	0.541	0.526	0.495
70	0.587	0.572	0.553	0.522
75	0.614	0.595	0.580	0.549
80	0.645	0.626	0.606	0.576

Group III (medium physical activity; men and women) - workers average weight of labour, the physical activity coefficient is **1.9** (machinists, operators, machine operators, drillers, drivers of electric vehicles,

excavators, bulldozers and other heavy equipment, workers greenhouses, growers, gardeners, fisheries and other related activities).

Table 7: The average values of energy intensity of labor adult population for the III group physical activity (MJ/h), Men

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	0.784	0.741	0.692	0.638
55	0.822	0.773	0.730	0.671
60	0.860	0.811	0.763	0.703
65	0.903	0.849	0.800	0.735
70	0.946	0.892	0.838	0.773
75	0.990	0.930	0.876	0.811
80	1.038	0.979	0.919	0.849
85	1.087	1.028	0.963	0.887
90	1.141	1.076	1.011	0.930

Table 8: The average values of energy intensity of labor adult population for the III group physical activity (MJ/h), Women

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
40	0.584	0.568	0.552	0.519
45	0.622	0.606	0.584	0.557
50	0.665	0.644	0.627	0.595
55	0.703	0.681	0.660	0.627
60	0.746	0.725	0.703	0.665
65	0.784	0.763	0.741	0.698
70	0.827	0.806	0.779	0.735
75	0.865	0.838	0.817	0.773
80	0.909	0.881	0.854	0.811

Group IV (high physical activity; men and women) workers in heavy physical labour, the physical activity coefficient is **2.2** (construction workers, porters, working on maintenance of railway tracks and repair of roads, forestry, hunting and agriculture, woodworkers, athletes, blast furnace steelmakers-casters and other related activities);

Table 9: The average values of energy intensity of labor adult population for the IV group physical activity (MJ/h), Men

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	1.012	0.956	0.893	0.823
55	1.061	0.998	0.942	0.865
60	1.110	1.047	0.984	0.907
65	1.165	1.096	1.033	0.949
70	1.221	1.151	1.082	0.998
75	1.277	1.200	1.130	1.047
80	1.340	1.263	1.186	1.096
85	1.403	1.326	1.242	1.144
90	1.472	1.389	1.305	1.200

Table 10: The average values of energy intensity of labor adult population for the IV group physical activity (MJ/h), Women

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
40	0.754	0.733	0.712	0.670
45	0.802	0.782	0.754	0.719
50	0.858	0.830	0.809	0.768
55	0.907	0.879	0.851	0.809
60	0.963	0.935	0.907	0.858
65	1.012	0.984	0.956	0.900
70	1.068	1.040	1.005	0.949
75	1.116	1.082	1.054	0.998
80	1.172	1.137	1.103	1.047

Group V (very high physical activity; men) workers particularly hard physical labor, the coefficient of physical activity - **2,5** (machine operators and agricultural workers in the sowing and the harvest period, herders and other related activities).

Table 11: The average values of energy intensity of labor adult population for the V group physical activity (MJ/h), Men

Body weight, kg	18-29 years	30-39 years	40-59 years	Over 60 years
50	1.239	1.171	1.094	1.009
55	1.299	1.222	1.154	1.060
60	1.359	1.282	1.205	1.111
65	1.428	1.342	1.265	1.163
70	1.496	1.410	1.325	1.222
75	1.564	1.470	1.385	1.282
80	1.641	1.547	1.453	1.342
85	1.718	1.624	1.522	1.402
90	1.804	1.701	1.598	1.470

4. Conclusions

The indicators were calculated on the basis of the state of [2] and can be used in the development of federal and municipal rules and regulations, as well as in the economic activity of enterprises, organizations and institutions of all forms of ownership.

The use of the average values of energy intensity of workers in economic practice, reduce social tension in labor relations, lead wages in line with the level of labor costs by sectors of the economy, optimizing the structure of the economy and the proportional, the dynamic development of the real sector economy.

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