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E. F. Shamaeva¹, K. N. Shadrov²

¹Institute of Socio-Economic Population Problems of the Russian Academy of Sciences,
Moscow, Russia

¹E-mail: shamaeva.dubna@gmail.com

²Dubna State University, Moscow, Russia

²E-mail: shadrovkn@mail.ru

**ASSESSMENT OF GDP AND LIVING STANDARDS OF COUNTRIES
IN THE FOCUS OF INTERDISCIPLINARY STUDY**

For more than a hundred years, science has been applying physical laws to analyze social and economic systems. However, it must be admitted that in the management of social and economic systems there are no systemic connections with natural, economic and social phenomena, expressed in a consistently measurable form, which leads to incorrect estimates and gives rise to crises.

The current complex crisis situation in the world poses the task of the scientific community to develop theoretical and methodological provisions based on measured values or a meter that would be initially adequate for describing natural systems, and at the same time would be sufficiently applicable to assess socio-economic phenomena. For such assessments, it is necessary to rely on the law of nature and use the corresponding meter. Such a measure is proposed in the works of the International Scientific School of Sustainable Development named after P. G. Kuznetsova.

The socio-economic system, including the economy of the country and the world, can be represented as a generalized machine of a certain capacity. In this machine, useful energy is embodied, directly or indirectly, in all manufactured goods and services. Accordingly, some traditional macroeconomic indicators can be expressed in energy units. The article is devoted to the application of energy theory of cost to estimate Gross Domestic Product and living standards of the countries of the world in energy units, the results of calculations for the period 1992–2019 are given.

Keywords: cost, money, energy theory of value, standard of living, physical economy, exchange rate, energy-currency zone.

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Е. Ф. Шамаева¹, К. Н. Шадров²

¹Институт социально-экономических проблем народонаселения ФНИСЦ РАН,
г. Москва, Россия

¹E-mail: shamaeva.dubna@gmail.com

²Государственный университет «Дубна», г. Москва, Россия

²E-mail: shadrovkn@mail.ru

ОЦЕНКА ВВП И УРОВНЯ ЖИЗНИ СТРАН МИРА В ФОКУСЕ МЕЖДИСЦИПЛИНАРНОГО ИЗУЧЕНИЯ

На протяжении более ста лет в науке применяют физические законы для анализа социальных и экономических систем. Однако, необходимо признать, что в управлении социальными и экономическими системами отсутствуют системные связи с природными, экономическими и социальными явлениями, выраженные в устойчиво измеримой форме, что приводит к некорректным оценкам и порождает кризисы.

Сложившаяся в мире сложная кризисная ситуация ставит перед научным сообществом задачу разработки теоретических и методологических положений на основе измеряемых величин или измерителя, который был бы изначально адекватен для описания природных систем, и при этом был бы в достаточной степени применим для оценки социально-экономических явлений. Для таких оценок необходимо опереться на закон природы и использовать соответствующий ему измеритель. Такая мера предлагается в работах Международной научной школы устойчивого развития имени П. Г. Кузнецова.

Социально-экономическую систему, включая экономику страны и мира, можно представить, как обобщённую машину определённой мощности. В этой машине полезная энергия воплощается, прямо или косвенно, во все производимые товары и услуги. Соответственно, некоторые традиционные макроэкономические показатели могут быть выражены в единицах энергии. Статья посвящена применению энергетической теории стоимости для оценки валового внутреннего продукта и уровня жизни стран мира в энергетических единицах, приводятся результаты расчётов за период 1992–2019 гг.

Ключевые слова: стоимость, деньги, энергетическая теория стоимости, физическая экономика, валютный курс, энерго-валютная зона.

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Introduction. To date, there has been a continuous increase in the detachment of monetary circulation from the physical constraints of socio-economic life.

The instability of money as an integral measure and the reliance on dominant monetarist theories has been one of the reasons for the poor governance of countries and the world. Crisis phenomena are becoming more and more widespread every time, and their consequences are eliminated with more and more serious losses of time and resources. The current situation forces us to take a closer look at the energy theory of value, which offers a physical quantity as an integral measure of GDP, living standards and some other

traditional macroeconomic indicators. Reliance on adequate measures provides reliable information for planning and control in the management of large socio-economic systems. In more detail, the theoretical and methodological foundations of the article are described in several works listed in the list of used references [10; 11; 15; 18; 20 etc.] A few explanations are given during the presentation of the material, as well as in the corresponding section.

The object of the research is the GDP and the standard of living of the countries of the world. The subject is the measurement of these parameters in units of energy. **The aim** of the work is to apply a physical approach to assess the GDP and living standards of the countries of the world.

Below is a summary of the calculations and results of the study.

1. Theoretical and methodological provisions. Back in the XIX century, S. A. Podolinsky showed that society is an open system that consumes a stream of total energy at the input, converts it and receives a stream of free energy at the output, which is embodied in the social product [16; 17] Nobel laureate F. Soddy demonstrated that the welfare of a society is determined by its physical capabilities, and not by debt-based “virtual wealth” [5; 6].

The diagram of S. A. Podolinsky is shown below.

Pic. 1. Schematic representation of energy turnover in the labor process in the socio-economic system, N — flow of full energy, G — losses, P — flow of useful energy

In the 1960s P. G. Kuznetsov proposed to consider any technological process as an energy converter, and the entire set of such converters as a “generalized machine” of the socio-economic system. For this “machine”, the researcher identified the generalized efficiency factor of all links of the technological chain from the moment of energy input to its implementation. He showed that GDP can be measured both in money and in energy, from the ratio of which the energy supply of the monetary unit is derived [13–15]. His

contemporary Nicholas Georgescu-Roegen characterized the second law of thermodynamics as the most economic of all laws of nature, since in the production of goods and services, humanity dissipates highly concentrated (low-entropy) free energy into low-concentrated (high-entropy) energy [3]. Similar considerations were expressed by R. Ayres [1].

A lot of works of specialists of different profiles (physicists, ecologists, economists, etc.) are devoted to the substantiation of the relationship between GDP and the energy potential of society. Therefore, in 1975, the physicist P. L. Kapitsa pointed out that "... the main factor determining the development of people's material culture is the creation and use of energy sources". He stated that the size of GDP is proportional to the total energy consumption [12]. Similar theses were set by ecologists G. Odum and E. Odum. They stated that the cash flow and the flow of useful energy embodied in goods and services move in the economic mechanism towards each other and identifying them as two ways of measuring the gross social product [4]. Economist R. Kostantsa showed that "in many sectors of the economy there is a close relationship between energy spent and the value in dollars" [2].

In the scientific literature, the interaction of the system and entropy is described through the tendency of the system to the lowest value of potential energy and the greatest disorder¹ (the second law of thermodynamics by Rudolf Clausius, the work of R. I. Prigogine).

Science's answer to this challenge, which was thrown after the discovery of the second law of thermodynamics by R. Clausius, was the work of S. A. Podolinsky, N. A. Umov, V. I. Vernadsky, E. S. Bauer.

Erwin Simonovich Bauer formulated the principle of the existence of living (in the natural scientific sense) systems, which include any socio-economic systems that have an input flow of resources (expressed in units of capacity) and two output flows (the total flow of goods and services produced, also expressed in units of power, and loss, which is a measure of entropy) (pic. 1).

The principle of stable non-equilibrium of E. S. Bauer states: "all and only living systems are never in a state of equilibrium and perform constant work against equilibrium at the expense of their free energy".

In projection onto socio-economic systems, it can be formulated: the share of the required time during the development of the system decreases, and the share of free time increases, which is the result of effective management. Two related processes can be distinguished here: active impact on the environment and the use by society of the flow of resources obtained because of this impact. These processes are united by the concept of "labor process". Spending the flow (power) P , the system over time receives a flow of resources, measured by the flow N . These resources are used by the system to produce goods. The ratio of P to N is a measure of the efficiency of using consumed resources and the life of the system (pic. 1). Thus, the development of the socio-economic system is associated with a decrease in the flow of entropy (G) and an increase in efficiency.

Comparing GDP, expressed in monetary and physical units, B. E. Bolshakov moved to assess the standard of living, the exchange rate and other economic categories in natural

¹ The works of I. R. Prigogine are built on the "order — chaos" alternative. While the applied aspect of the study of living systems is associated with the alternative "free energy — connected energy / power". A. N. Kolmogorov defined order as the existence of some rule under which the entire sequence can be reconstructed using fewer numbers than a given "random variable". The absence of such a rule is disorder / chaos. In the work, the principle of stable nonequilibrium of E. S. Bauer and the law of conservation of power in the applied aspect of the study of socio-economic systems act as such a rule (works by P. G. Kuznetsov, B. E. Bolshakov, etc.).

science measures [7–9]. Also, this scientist, using statistics from countries around the world (Russia, Kazakhstan, the USA, etc.), gave examples of the calculation of GDP, living standards and real exchange rates in physical measures. The scientist laid the developed prerequisites for assessing the equivalence of international exchanges. An interesting feature of the works of B. E. Bolshakov and several followers is the use of energy for estimates over a period, i. e., power, which allows, if necessary, to easily switch back to energy units. Certain aspects of the application of energy assessments are developed and specified in the description of socio-economic systems and the construction of forecasts of their development, including the level of the world, country, region [10; 11; 21].

From the thesis on the identification of GDP and the energy potential of society, a number of monetary circulation rules are derived, including the need to comply with the standard of energy support of the monetary unit (not by analogy with the reserves of gold-foreign exchange reserves of central banks, but as a calculation parameter), control of monetary aggregates taking into account the dynamics of the energy potential of society, management of exchange rates with an orientation towards the provision of useful energy of quoted currencies. The methodology for assessing the energy supply of currencies, setting exchange rates, measuring the equivalence of international exchange rates as an alternative to the estimates proposed in the theory of purchasing power parity of currencies is being improved; estimates are made in energy and monetary units of GDP, living standards, exchange rates, equivalence of international trade. [19; 20, etc.]

2. Data used and methods of working with them. An important feature of modern socio-economic statistics is the focus on solving problems of science and practice within the framework of the dominant approaches. For this reason, for the tasks of this work, it is necessary to refer to different databases formed according to different methods, and then make a lot of intermediate recalculations to bring all the data to a uniform form. Despite the difficulties, the authors managed to collect and process complete data.

Due to the presence of losses for calculating GDP and living standards, not the flow of total energy — N , but the flow of useful energy — P should be taken into account (see Equation). In this work, the total energy is understood as the consumption of energy goods before transformation, and the useful energy is the volume of total energy, taken taking into account the conversion efficiency and losses during transmission and distribution. In all of the results below, energy refers to useful energy.

The total GDP of the country consists of domestic consumption of energy goods and the results of the exchange of energy and non-energy goods with the external environment.

1) The volume of domestic consumption of energy products.

The volume of domestic consumption of energy products P_{EI} is calculated taking into account conversion efficiency and transmission and distribution losses. In other words, all domestic production comes to the transformation of energy by a “generalized machine” into the final product.

The equation for calculating GDP is given below

$$P_{EI} = \sum_{i=1}^n X_i * k_i * \varphi \quad (1)$$

X_i — type of energy product (oil, gas, etc.), k_i — efficiency of transformation of the i -type of energy product, φ — transmission and distribution losses (parameter value from 0 to 1, no losses is taken as 1).

In fact, in view of the available data, $\phi < 1$ only for electricity, for other energy products ϕ is taken as 1.

The conversion efficiency of conventional fuels k_i is taken as ranging from 0.360 to 0.404 depending on the year according to British Petroleum's Statistical Review of World Energy. The same sources are used for oil, gas and coal consumption and production; electricity generation including generation by source (oil, gas, coal, nuclear, hydro, renewables, and others); oil, gas and coal export/import balance; and oil, gas and coal prices. Transmission and distribution losses are considered according to US Energy Commission statistics².

Note that to avoid double counting, the amount of fossil fuels used to generate electricity must be subtracted from the total energy consumption.

2) International exchanges.

Since the contribution of exchange of energy goods is already accounted for in the P_{EI} calculation, it remains to measure the non-energy export-import as well as the trade balance. In order to solve this problem it is necessary to convert monetary units into energy units, for which the following equation is used:

$$E_{cur} = P_{EI} / P_I \quad (2)$$

where E_{cur} — energy supply of a unit of currency, P_{EI} — GDP excluding export-import, P_I — GDP excluding export-import, expressed in the currency of the country.

GDP of the countries of the world in monetary units is taken from the IMF's World Economic Outlook.³ Export-import of oil, gas, coal and electricity according to statistics from the US Energy Commission.⁴

For each type of energy product, the calculation of exports and imports is carried out separately at average annual prices. Coal, oil and gas prices are from British Petroleum statistics, electricity prices are from the UK Department for Business,⁵ Energy and Industrial Strategy database, and total exports and imports are from the World Bank database.⁶ Due to the lack of data and the complexity of indirect calculations, it is assumed that all world trade is carried out in US dollars.⁷

To improve the accuracy of calculations within the group of non-energy goods, a separate accounting of energy-intensive goods (aluminum, fertilizers, etc.) is advisable. However, this calculation was not made due to the lack of statistical data and the difficulty of indirect calculations.

The calculation of **living standards** is carried out in the traditional way — there is a ratio of GDP to the average annual permanent population. Since 2015, Rosstat data⁸, have

² U. S. Energy Information Administration. URL: <https://www.eia.gov> (accessed 25.04.2021).

³ World Economic Outlook, April 2019, International Monetary Fund. URL: <https://www.imf.org/en/Publications/WEO/weo-database/2020/October> (accessed 25.04.2021).

⁴ U. S. Energy Information Administration. URL: <https://www.eia.gov> (accessed 25.04.2021).

⁵ U. K. Department for Business, Energy & Industrial Strategy. URL: <https://www.gov.uk> (accessed 25.04.2021).

⁶ The World Bank. URL: Available at: <https://www.worldbank.org> (accessed 25.04.2021).

⁷ Presumably, this gave underestimated GDP indicators for some energy-dependent countries and regions with large volumes of foreign trade in their own currencies (Japanese yen, euro).

⁸ The size and composition of the population. Federal State Statistics Service of Russia. URL: <https://www.gks.ru/folder/12781> (accessed 25.04.2021).

been used for the population of Russia, for the period until 2015 and for all other countries for the entire period under review — World Bank data.⁹

In the absence of data for a certain year, the last known values are used. The estimates obtained may differ from those described in earlier published works due to the further improvement of the methodology and the involvement of more complete data. The values of some parameters do not converge slightly with each other due to inaccuracies and insufficiency of the original statistics, as well as rounding errors.

3. Research results. The critical importance of energy for modern technogenic civilization has made the task of managing energy flows particularly urgent. The key mechanism for managing the flow of useful energy internationally is the setting of exchange rates.

Table 1 shows the exchange rates of some countries to the US dollar, considering their energy supply.

Table 1

Exchange rates of national currencies against the US dollar in terms of energy supply, 1992–2019

№	Country	1992	1997	2002	2007	2012	2017	2018	2019
1	Australia	0.58	0.50	0.43	0.41	0.46	0.42	0.43	0.43
2	Algeria	2.36	4.08	4.32	6.27	12.60	12.30	13.95	14.97
3	The UK	0.83	0.69	0.68	0.97	1.63	1.70	1.76	1.86
4	Germany	2.61	2.78	2.58	2.24	2.62	2.95	3.17	3.47
5	India	11.07	14.76	17.72	19.90	31.79	46.89	50.77	54.95
6	Indonesia	584.60	842.02	1 474.74	1 899.81	2 642.72	3 489.16	3 448.44	3 551.23
7	Iraq	—	—	47.87	106.73	167.37	98.16	115.24	116.08
8	Iran	82.21	269.03	597.15	1 090.14	2 406.56	3 339.42	4 230.39	6 688.50
9	Kazakhstan	0.01	4.96	6.00	10.86	21.52	33.09	37.54	43.35
10	Canada	0.52	0.42	0.40	0.37	0.41	0.38	0.40	0.42
11	Qatar	0.18	0.15	0.15	0.25	0.32	0.25	0.29	0.28
12	China	0.87	1.63	1.65	1.62	2.39	3.32	3.61	3.80
13	Colombia	238.03	394.41	495.19	500.86	529.51	683.51	782.64	867.44
14	Kuwait	0.02	0.01	0.02	0.02	0.03	0.02	0.03	0.03
15	Mexico	1.57	3.49	4.84	5.34	8.19	13.45	15.57	17.31
16	Norway	1.21	0.95	0.90	1.09	1.43	1.41	1.62	1.78
17	United Arab Emirates	0.32	0.34	0.39	0.53	0.70	0.59	0.67	0.66
18	Russia	0.0043	0.50	1.59	3.08	5.55	6.43	7.31	7.77
19	Saudi Arabia	0.25	0.24	0.23	0.29	0.45	0.38	0.43	0.46
20	Turkey	0.02	0.41	3.76	5.53	7.03	11.48	12.28	11.50
21	Ukraine	0.0001	0.29	0.50	1.10	2.00	6.08	7.45	8.63
22	France	2.96	2.34	2.04	1.91	2.10	2.31	2.29	2.48
23	South Korea	3 392.83	5 282.62	4 046.67	3 628.56	4 396.76	4 987.14	5 744.83	5 405.47
24	Japan	1 680.88	1 043.67	826.07	719.15	2 353.18	1 219.82	1 085.52	1 031.48

A measure of the non-equivalence of international trade can be introduced — this is the difference between nominal exchange rates and energy supply rates (table 2).

⁹ The World Bank. URL: <https://www.worldbank.org> (accessed 25.04.2021).

Table 2

Ratio of the official annual average exchange rate of the US dollar to the energy exchange rate, 1992–2019

№	Country	1992	1997	2002	2007	2012	2017	2018	2019
1	Australia	2.36	2.67	4.24	2.89	2.08	3.09	3.12	3.33
2	Algeria	9.24	14.15	18.45	11.05	6.15	9.02	8.36	7.97
3	UK	0.69	0.89	0.98	0.51	0.39	0.46	0.43	0.42
4	Germany	0.60	0.62	—	—	—	—	—	—
5	India	2.34	2.46	2.74	2.08	1.68	1.39	1.35	1.28
6	Indonesia	3.47	3.46	6.31	4.81	3.55	3.83	4.13	3.98
7	Iraq	—	—	0.01	11.75	6.97	—	—	10.18
8	Iran	0.80	6.52	11.57	8.51	5.06	9.95	9.66	6.28
9	Kazakhstan	—	15.20	25.54	11.28	6.93	9.85	9.18	8.83
10	Canada	2.32	3.30	3.93	2.93	2.43	3.41	3.28	3.17
11	Qatar	20.79	24.69	23.56	14.31	11.47	14.45	12.64	12.94
12	China	6.31	5.10	5.02	4.69	2.64	2.03	1.83	—
13	Colombia	3.19	2.89	5.06	4.15	3.39	4.32	3.78	3.78
14	Kuwait	12.28	20.48	20.04	11.73	9.37	13.84	11.62	11.78
15	Mexico	1.97	2.27	2.00	2.05	1.61	1.41	1.24	1.11
16	Norway	5.13	7.41	8.89	5.36	4.08	5.86	5.01	4.95
17	United Arab Emirates	11.32	10.67	9.52	6.94	5.25	6.27	5.51	5.54
18	Russia	—	11.47	19.72	8.31	5.55	9.07	8.57	8.33
19	Saudi Arabia	15.04	15.64	16.65	12.79	8.38	9.97	8.68	8.19
20	Turkey	0.31	0.37	0.40	0.24	0.26	0.32	0.39	0.49
21	Ukraine	—	6.44	10.60	4.61	3.99	4.38	3.65	3.00
22	France	1.79	2.49	—	—	—	—	—	—
23	South Korea	0.23	0.18	0.31	0.26	0.26	0.23	0.19	0.22
24	Japan	0.08	0.12	0.15	0.16	0.03	0.09	0.10	0.11

Table 2 shows that there is significant non-equivalence in international trade due to differences in the energy supply of currencies. So, for Russia in 2019, the official ruble exchange rate was understated by 8.33 times compared to the energy supply rate, even though back in 2014 the difference was only 5.55 times.

There are about 200 countries in the world. However, few of them can independently meet their energy needs in the conditions of modern technogenic civilization. The total volume of world trade (in useful energy) in 2019 reached 33 % of world GDP (table 3).

Table 3

The volume of world trade in useful energy

№	Source	Quantity, TWh	Share in world GDP, %
1	Oil	12 731	20.18
2	Gas	4 968	7.88
3	Coal	3 555	5.64
4	Electricity	526	0.83
Total:		21 780	34.53

Approximately 25.7 % of world consumption of usable energy is donated.

Table 4 shows the net exports of useful energy by the main donor countries.

Table 4

Main Donor Countries, TWh of Useful Energy

№	Country	1992	1997	2002	2007	2012	2017	2018	2019	Accumulated total
1	Russia	1 296	1 513	1 819	2 583	2 607	3 424	3 613	3 699	63 212
2	Saudi Arabia	1 659	1 618	1 365	1 783	1 907	1 966	2 034	1 980	48 686
3	Norway	499	767	879	804	772	852	837	324	21 444
4	Canada	380	547	671	771	817	1 127	1 172	1 189	20 623
5	Australia	327	389	554	670	876	1 334	1 412	1 472	17 959
6	Indonesia	299	355	416	634	1 020	990	1 029	998	16 800
7	United Arab Emirates	444	448	380	518	565	562	568	627	13 624
8	Iran	541	507	431	525	335	479	493	441	12 834
9	Venezuela	286	503	413	421	374	403	398	401	11 522
10	Iraq	13	158	325	357	529	822	805	799	10 714
11	Qatar	75	103	195	334	674	691	689	129	10 207
12	Algeria	205	276	360	477	370	369	358	324	9 734
13	Kuwait	144	243	212	364	474	475	479	495	9 518
14	Mexico	281	364	367	360	169	48	37	23	7 390
15	Colombia	74	138	153	226	397	432	425	390	6 602
16	Kazakhstan	17	100	216	295	334	348	357	304	6 517

In other words, energy donation for 2019 means:

- 15.6 TWh useful energy, (the equivalent of almost all gas production), *or*
- 36.5 TWh of primary energy (by comparison, global electricity production is about 27 TWh), *or*
- 1.48 of US GDP, *or*
- 4.73 of Russia GDP.

The largest energy donors in the world over the 28 years considered are Russia (76 % of average GDP per year or 21.4 average GDP per period) and Saudi Arabia (219 % of average GDP per year or 61.2 average GDP per period). During the indicated period, only these two countries transferred to the external environment 1135 % of the US average GDP in terms of useful energy.

Useful energy from donor countries to the world socio-economic system is available for consumption by participants in international exchanges, depending on their financial, technical, and other capabilities.

Table 5 shows net imports of useful energy by main recipient countries.

Table 5

Countries — main recipients, TWh of useful energy

№	Country	1992	1997	2002	2007	2012	2017	2018	2019	Accumulated total
1	USA	1 458	2 093	2 806	3 308	1 868	1 046	618	141	60 161
2	Japan	1 542	1 806	1 775	1 929	2 055	1 989	1 924	1 894	50 203
3	China	–98	29	106	672	2 121	3 194	3 540	3 820	30 548
4	South Korea	398	712	742	889	1 091	1 296	1 330	1 339	23 746
5	India	144	279	455	819	1 347	1 840	1 934	2 042	23 704
6	Germany	674	720	786	748	705	786	769	785	20 714
7	Italy	532	523	667	777	653	623	616	599	17 392
8	France	428	456	483	547	455	472	452	452	13 330
9	Spain	309	314	405	489	419	477	469	449	11 076

№	Country	1992	1997	2002	2007	2012	2017	2018	2019	Accumulated total
10	Turkey	119	177	203	320	371	481	443	435	7 551
11	Ukraine	421	274	307	308	149	121	114	47	6 539
12	UK	61	-86	-46	254	413	249	276	266	3 713

Note: negative values indicate energy donation.

According to Table 5 main energy recipients are Western countries (USA, Germany, Italy, France, etc.) and their closest allies (Japan, South Korea, Turkey). We can talk about the existence of an energy-currency zone (ECZ) of the West. The competition for it is significantly weaker ECZ of China and Russia — as applicants for an independent role on a global scale, as well as India and Iran — as influential regional players.

Accounting for international exchanges allows us to move on to estimating GDP and living standards. Table 6 shows the GDP of the G20 countries as well as Iran, Belarus, Kazakhstan, Ukraine and the Total World.

Table 6

GDP of some countries of the world, usable energy, TWh

№	Country	1992	1997	2002	2007	2012	2017	2018	2019
1	China	3 123	3 835	4 796	8 995	12 066	14 032	14 638	15 354
2	USA	8 011	8 921	9 515	9 985	9 451	10 151	10 606	10 581
3	India	851	1 066	1 253	1 779	2 466	3 203	3 414	3 512
4	Russia	3 302	2 437	2 557	2 902	3 114	3 163	3 308	3 300
5	Japan	1 767	2 079	2 098	2 144	2 020	2 024	2 027	2 019
7	Canada	1 041	1 151	1 231	1 378	1 441	1 521	1 583	1 571
8	Iran	374	441	586	844	997	1 234	1 307	1 372
9	South Korea	478	744	854	981	1 149	1 292	1 301	1 309
10	Germany	1 428	1 412	1 385	1 273	1 256	1 328	1 295	1 277
11	Saudi Arabia	398	445	546	775	1 105	1 249	1 241	1 268
12	Brazil	533	722	766	923	1 168	1 193	1 197	1 229
13	Indonesia	263	365	459	576	791	823	910	972
14	France	911	908	985	1 031	998	987	988	972
15	UK	916	931	974	983	904	887	892	879
16	Mexico	493	516	593	727	819	855	872	853
17	Australia	376	433	481	567	604	654	679	710
18	Italy	675	673	772	801	707	693	703	687
19	Turkey	208	278	283	412	517	677	658	675
20	South Africa	352	397	409	489	527	557	564	578
21	Ukraine	880	545	521	564	522	365	376	366
22	Argentina	197	234	220	306	346	384	379	363
23	Kazakhstan	309	163	156	237	289	313	344	344
24	Belarus	148	96	93	106	117	104	106	109
25	Total World	33 692	36 310	39 845	48 719	54 256	59 903	61 939	63 080

Table 7 shows living standards in the G20 countries, as well as Iran, Belarus, Kazakhstan, Ukraine and the Total World.

Table 7

The standard of living of some countries, useful energy, kWh/person

№	Country	1992	1997	2002	2007	2012	2017	2018	2019
1	Canada	36 686	38 483	39 248	41 888	41 519	41 618	42 705	41 784
2	Saudi Arabia	23 051	22 917	25 027	30 759	37 885	37 721	36 837	37 009
3	USA	31 231	32 720	33 083	33 147	30 112	31 220	32 419	32 237
4	Australia	21 470	23 373	24 479	27 226	26 559	26 563	27 160	27 986
5	South Korea	10 925	16 198	17 919	20 152	22 886	25 112	25 196	25 313
6	Russia	22 209	16 475	17 597	20 319	21 746	21 539	22 529	22 488
7	Kazakhstan	18 812	10 609	10 481	15 302	17 185	17 339	18 828	18 554
8	Iran	6 362	6 984	8 706	11 836	13 201	15 294	15 979	16 553
9	Japan	14 226	16 491	16 459	16 749	15 831	15 966	16 018	15 987
10	Germany	17 714	17 206	16 787	15 477	15 621	16 072	15 616	15 358
11	France	15 483	15 143	15 931	16 108	15 195	14 758	14 743	14 489
12	UK	15 905	15 969	16 408	16 027	14 190	13 432	13 420	13 155
13	Belarus	14 517	9 521	9 397	11 100	12 376	10 960	11 216	11 549
14	Italy	11 893	11 838	13 537	13 701	11 882	11 445	11 627	11 385
15	China	2 681	3 118	3 746	6 825	8 933	10 121	10 511	10 985
16	South Africa	9 106	9 240	8 856	9 949	9 974	9 767	9 769	9 874
17	Ukraine	16 869	10 766	10 809	12 135	11 454	8 149	8 432	8 236
18	Turkey	3 725	4 601	4 348	5 928	6 925	8 342	7 987	8 088
19	Argentina	5 869	6 570	5 841	7 713	8 289	8 727	8 526	8 072
20	Mexico	5 658	5 455	5 829	6 662	6 984	6 849	6 910	6 688
21	Brazil	3 455	4 317	4 268	4 855	5 863	5 738	5 716	5 822
22	Indonesia	1 399	1 802	2 112	2 480	3 183	3 110	3 398	3 590
23	India	936	1 065	1 146	1 503	1 948	2 393	2 524	2 570
24	Total World	6 178	6 182	6 351	7 299	7 656	7 975	8 156	8 220

Expressing GDP and living standards in a stable physical measure instead of unstable monetary measures gives a picture of socio-economic development more adequate to the natural scientific constraints of the real world than unstable monetary measures.

The conducted research does not contradict the concept and method of energy production cycles proposed by N. N. Kolosovsky and developed in the works of A. T. Khrushchev (1979), T. M. Kalashnikova (1970), M. D. Sharygin (1975) and others.

The energy production cycle was determined by N. N. Kolosovsky as a set of production processes that are consistently developing in the socio-economic system based on a combination of types of energy and raw materials, from the primary forms of extraction and upgrading of raw materials and energy and the rational use of all components of raw materials and energy resources.

Thus, it is possible to fix the statement: it is impossible to produce a single good, product, service without spending energy and time, that is, the flow of energy or power. On this basis, the assessment of the total flow of produced goods, products, services is carried out in units of capacity based on the methodological premises and methodological works of P. G. Kuznetsov, B. E. Bolshakov. In the works of A. E. Petrov considered the method of interindustry balances on the power invariant.

In addition, in the practice of international assessment of the countries of the world, it is customary to calculate the human development index (UN global indicator). At the same time, the methodology for calculating the index assumes the aggregation of disproportion-

ate data (life expectancy, average and expected duration of schooling, gross national income per capita). The use of disproportionate data leads to a loss of meaning, ambiguity in the interpretation of the dynamics of the development of regional socio-economic systems.

In view of this, based on the stated concept and methods, a method is proposed for calculating the aggregate quality of life in units of power per person as the product of the normalized average life expectancy by the aggregate standard of living and the quality of the environment¹⁰.

Normalized life expectancy is the average life span divided by 100 (years). Expressed in dimensionless units.

The aggregate standard of living in a country (region) is the ratio of the useful power to the population of the country. Expressed in units of power per person (kW / person).

The quality of the environment is the ratio of the power losses of the previous period to the power losses of the current period. Expressed in dimensionless units.

The equation for calculating the quality of life is given below:

$$QL = T_H \times U \times q \quad (1)$$

where QL — the quality of life, T_H — normalized life expectancy, U — standard of living, q — environmental quality.

The proposed methodology is a methodological attempt to take into account the standard of living, health and quality of the environment, while the standard of living is taken into account on the basis of physically measurable stable values, and taking into account the quality of the natural environment directly links humanity and its habitat.

4. Conclusions. Based on the above, theoretical conclusions can be drawn:

1. Interdisciplinary studies of socio-economic processes based on natural science principles and the “power” measure make it possible to formulate a fundamental basis for calculating the cost of goods and services.

2. Presented in applied socio-economic aspects by P. G. Kuznetsov, the law of conservation of power (Pic. 1, $N = P + G$), based on the discoveries of the Russian scientific school and the works of S. A. Podolinsky, V. I. Vernadsky, E. S. Bauer and others, plays an important role in interdisciplinary research, being the first law of open systems, which include all known phenomena of life, including social life.

3. Power is the ability to act in time or performance per unit of time or the performance of a system that determines the viability of a socio-economic system.

4. A number of countries, including Russia, are donors to the external environment, primarily the energy-currency zone of the US dollar.

5. Management of useful energy flows is carried out through the establishment of unequal exchange rates, which ensures its predominant consumption by Western countries and their most important partners.

6. At the same time, ECZ of Russia, China, India and Iran are being formed in the world.

7. Given data on GDP and living standards for a number of countries, measured in energy units, provide a more reliable picture of reality due to the use of sustainable physical measures instead of unsustainable financial ones.

¹⁰ URL: <http://www.yrazvitie.ru/?p=396>

5. Recommendations. The results obtained provide clear guidelines for the further improvement of Russia's socio-economic policy. Our **recommendations** are the following:

1. Introduce into state planning the priority of increasing the efficiency of the socio-economic system as a generalized machine through the introduction of more efficient technologies, as well as establish appropriate benchmarks.

2. To reduce the unequal exchange of energy with the external environment by investing in the development of our own processing industries that produce products with a high level of redistribution, paying special attention to energy-intensive goods.

3. Stimulate the transition to foreign trade for Russian rubles, while trading in energy products is carried out exclusively in the national currency.

4. Move to purposeful maintenance, expansion and accelerated development of its energy-currency zone by building through — from a natural resource to a final product — technological chains that use mainly or completely the Russian ruble for mutual settlements.

The earliest possible implementation of the proposed measures will allow directing additional amounts of energy to the benefit of Russia and its citizens.

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Сведения об авторах

Шамаева Екатерина Федоровна — кандидат технических наук, доцент, ведущий научный сотрудник лаборатории проблем уровня и качества жизни Института социально-экономических проблем народонаселения ФНИСЦ РАН, г. Москва, Россия.

E-mail: shamaeva.dubna@gmail.com

ORCID: 0000-0002-1070-8550

Web of Science ResearcherID: O-1031-2016

Шадров Константин Николаевич, аспирант государственного университета «Дубна», г. Москва, Россия.

E-mail: shadrovkn@mail.ru

ORCID: 0000-0002-9662-7240

About the authors

Dr Ekaterina Shamaeva, Associate Professor, Leading Researcher of the Laboratory of Level and Quality of Life Problems, Institute of Socio-Economic Population Problems of the Russian Academy of Sciences, Moscow, Russia.

E-mail: shamaeva.dubna@gmail.com

ORCID: 0000-0002-1070-8550

Web of Science ResearcherID: O-1031-2016

Konstantin Shadrov, Dubna State University, expert JSC Media KST, Moscow, Russia.

E-mail: shadrovkn@mail.ru

ORCID: 0000-0002-9662-7240

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