Energy Efficiency the Renewable Energy Sources
as an UNFCCC Process Tool

Introduction

The main stated goal of the UNFCCC process in the power engineering is to reduce greenhouse
gas emissions to the environment by phasing out the use of fossil fuel energy systems (FFS). Further, it
is called the Main Goal. The essence of the UNFCCC process is to replace FFSs with Renewable
Energy Sources (RES).

It is obvious that for the manufacture of renewable energy structures, their delivery to the place
of use, installation, commissioning and maintenance, a certain amount of energy, materials and labor
of people are always expended. All of these works are accompanied by environmental impacts at the
places of their implementation. Often, the above work is performed long before the start of the use
of RESs and several thousand kilometers from the place of their use. In addition, there is no accurate
and uniform end-to-end accounting of labor costs of people, energy, materials and harmful environmental
impacts when performing these works.

This time lag, remoteness and lack of end-to-end accounting break the causal link between
global environmental change and the use of RESs regardless of the total values of the above costs and
impacts due to the breakdown of this causal relationship. The illusion of the absolute “environmental
friendly” of RESs arose due to the breaking of this causal relationship and the absence of tangible
environmental impacts at the places of their use. Gradually, this illusion grew into a persistent
misconception about the absolute “environmental friendly” of RESs due to the media and the
involvement of many enthusiasts in the struggle to preserve the environment.

However, the published research results have clearly shown that RESs may be both
"environmentally friendly" and "environmentally dirty" – see
https://www.linkedin.com/pulse/choosing-best-systems-based-renewable-energy-process-valery-
matveev-1f and https://www.linkedin.com/pulse/calculation-energy-transition-parameters-when-
choosing-valery-matveev. Thus, it was proved that the postulate of the absolute "environmental
friendly" of RESs is a misconception.

The studies mentioned above have shown the decisive value of the energy efficiency of RESs
to accelerate the UNFCCC process when replacing FFS with ones. They allowed us to calculate that
the lack of control of RES energy efficiency by UNFCCC reduces about 2 times the environmental
effect of investments. Consequently, the mentioned studies reinforced the importance of energy
efficiency of RESs, which was already repeatedly emphasized in the UNFCCC documents (see, for
UNFCCC/TP/2015/4 and UNFCCC/TP/2016/5).

Studies have also shown that the documents of the UNFCCC process do not meet its Main
Goal. The reason for this discrepancy is the lack of a description of the criterion for evaluating the
energy efficiency of RESs, methods for its calculation; its minimum permitted value, methods for its
control, recommendations for providing, etc. This gives the right to replace FFSs with any RESs,
regardless of their energy efficiency. Thanks to this, the entire UNFCCC process is reduced to the
banal replacement of all FFSs with RESs. In other words, the entire UNFCCC process consists in the
global replacement the one equipment with another, which is a priori recognized as “environmentally
friendly”.

Accounting turned out to be the only type of end-to-end accounting that accompanies all types
of work related to the use of RESs. Under these conditions, the only criterion for choosing RES for the
UNFCCC process is economic efficiency. The UNFCCC process has thus evolved from a global
environmental project into a global economic project under an environmental pretext. Thanks to the
transformation described above, the energy efficiency of RESs was left without proper control of the
UNFCCC, and the main attention was paid to the volumes of investments.

The peculiarity of accounting is the lack of an exact relationship the amount of money and the
values of the above-mentioned labor costs of people, energy, materials and harmful environmental
effects that coincide with them in time and place. In particular, the increase energy volumes for the
implementation of the above works may coincide to a decrease the cost of money for them. Therefore,
it is unreasonable and dangerous for the global ecology to choose RESs on base the economic
efficiency for replacing FFS in the UNFCCC process.
The purpose of this article is to draw attention to:

- The obvious importance of the energy efficiency of RESs for the UNFCCC process, as indicated in its documents;
- The absence in UNFCCC documents of the criterion of energy efficiency, the technology of its calculation, the technology of its application, the maximum permitted values, etc;
- The fundamental possibility of the existence of "environmentally dirty" RESs;
- Great danger to the global ecology of the massive use of "environmentally dirty" RESs due to the delayed manifestation of its result and the high cost to eliminate it;
- The lack of reliable information on the real values of the energy efficiency of RESs used in the UNFCCC process, under its obvious importance;
- A real opportunity to use the RES energy efficiency as a tool to improve the UNFCCC process;

Relatively low cost of organizing control over the energy efficiency of renewable energy sources with the opportunity to obtain economic and environmental benefits of tens of percent.

The description of the possible use of energy efficiency of RESs as a tool of the UNFCCC process is given below. It shows the technology for calculating the criterion of energy efficiency, its availability, simplicity, low costs in comparison with the global environmental effect of its use, etc.

What is Energy Efficiency of RES

Any effectiveness is evaluated by comparing the value of the positive effect to the cost to obtain this effect. Accordingly, the energy efficiency of any RES is estimated by the ratio the amount of energy received from it during its entire operation and the amount of energy expended on it.

Energy sciences use an efficiency factor ($E_f$) to evaluate the energy efficiency of RES. It shows what part of the power of the flow of energy from the environment RES converts into usable power. It also shows how much of the total converts into useful energy amount of energy from the environment acting on it ($\sum E_n$). RES. $E_f$ takes into account all losses in all RES elements. The following are descriptions of $E_f$ of several types of RES, including:

The efficiency factor of RES with solar panels ($E_{fs}$) shows how much of the power of the flow of solar energy that has fallen onto the surface of the solar panel is converted into electricity. It takes into account the loss of direct conversion of light energy into electricity, as well as losses in wires, in energy storage, in a converter, etc.

The efficiency factor of RES with a wind turbine ($E_{fw}$) shows how much of the power of the air flow acting on the blades of its impeller is converted into electricity. It takes into account losses of direct conversion of wind energy into mechanical energy, mechanical energy into electricity, as well as losses in wires, in energy storage, in a converter, etc.

The efficiency factor of a RES with a water wheel ($E_{ft}$) shows how much of the power of the water flow acting on its impeller is converted into electricity. It takes into account losses of the direct conversion of the energy of the water flow into mechanical energy, mechanical energy into electricity, as well as losses in wires, in the energy storage, in the converter, etc.

The first thing that immediately attracts attention when familiarizing yourself with RES projects for the UNFCCC process is their gigantic size with relatively low power – see Fig. 1.
Windmills with towers more than 300 meters high and blades more than 100 meters long, kilometer-sized solar panels and huge platforms at sea that weigh hundreds and thousands of tons are the RES prototypes for the UNFCCC process. Obviously, for the manufacture of every gram of their design, energy was expended! However, the assessment of their energy efficiency remained in the background, as if they were still made in the garage. Therefore, the appearance of the prototypes raises several practical and theoretical issues related to the achievement of the Main Goal, including:

1 question: "Will there be enough energy is generated by this RES to the producing it itself?"
2 question: “Which RES is able to quickly compensate for the energy spent on its creation from several possible for use?”
3 question: "How to evaluate the energy cost efficiency of manufacturing RES?"
4 question: “How to evaluate the energy efficiency of converting energy received from the environment into usable energy?”

The above Ef does not give an answer to these questions because it does not take into account the energy expenditures on RESs itself.

The first of the efficiency criteria that we developed which we called the self-reproduction ratio (Ksr) of RES gives the answers to questions 1 and 2. The second of the efficiency criteria that we developed, which we called the energy efficiency ratio (Ke) of RES, is the answer to 3rd question. The third criterion of efficiency, which we called the total energy efficiency ratio (Kte) of RES, is the answer to 4th question.

The self-reproduction ratio of RES
Self-reproduction of RES is its ability to produce energy in an amount sufficient to produce a replacement for it itself. This ability is calculated through the self-reproduction ratio (Ksr). We calculate its value as the ratio of the amount of energy generated by RES during the entire service life to the amount of energy spent on its creation and functioning during the same period. When calculating the energy spent, the energy spent on the manufacture of equipment, materials, transportation and construction works, maintenance, repair, commissioning, routine maintenance, and also the energy of the fuel, including the energy spent on its transportation. To calculate the value of Ksr, the formula is applied:

\[ K_{sr} = \frac{\Sigma REn}{\Sigma PEn} \] - formula 1

Symbols in the formula 1:
\( \Sigma REn \) – the total amount of energy generated by RES during its service life;
\( \Sigma PEn \) – the total amount of energy spent on the creation and operation of this RES. The value of \( \Sigma PEn \) is calculated by the formula:

\[ \Sigma PEn = \Sigma PEn_1 + \Sigma PEn_2 + \Sigma PEn_3 + \ldots + \Sigma PEn_j + \ldots + \Sigma PEn_J \] - formula 2

Symbols in the formula 2:
\( \Sigma PEn_1, \Sigma PEn_2, \Sigma PEn_3, \ldots, \Sigma PEn_j, \ldots, \Sigma PEn_J \) – the total amount of energy spent on the creation and operation of this RES, including: the energy spent on the manufacture of equipment, materials, transportation and construction works, maintenance, repair, commissioning, routine maintenance, as well as fuel energy, including energy, spent on its transportation;

\( j \) – work type symbols: \( j = 1, 2, 3, \ldots, j, \ldots, J \).

The value of the self-reproduction ratio \( K_{sr} \) in practice varies from approximately 0.4 to 10. It is convenient to use in the UNFCCC process to compare the degree of environmental friendliness of
the RES in the process of choosing it to replace FFS, for example:

If the \( K_{sr} \) value of a real RES is less than 1 (i.e., \( K_{sr} < 1 \)), then for the entire service life up to its utilization, it produces less energy than is expended to it (i.e., \( \Sigma \text{REn} < \Sigma \text{PEn} \)). Obviously, taking such a RES for an UNFCCC process is unwise because it can never replace FFS. And the combined use of FFS and such RES will lead to more intense environmental degradation than when using only FFS.

If the \( K_{sr} \) value of a real RES is 1 (i.e., \( K_{sr} = 1 \)), then over the entire service life up to its utilization, it produces as much energy as it was spent to it (i.e., \( \Sigma \text{REn} = \Sigma \text{PEn} \)). Obviously, taking such a RES for an UNFCCC process is unwise too because it can never replace FFS. And the combined use of FFS and such RES will lead to more intense environmental degradation than when using only FFS too.

If the \( K_{sr} \) value of a real RES is greater than 1 (i.e., \( K_{sr} > 1 \)), then over the entire service life up to its utilization, it produces more energy than is expended to it (i.e., \( \Sigma \text{REn} > \Sigma \text{PEn} \)). Obviously, such a RES can to replace FFS. However, if the value of \( K_{sr} \) is not much more than 1, for example, equal to 1.001 (i.e., \( K_{sr} = 1.001 \)), then the entire Earth's surface will need to be used to install RES to globally replace all FFS. Obviously, such a replacement is energetically inefficient.

Consequently, there is a certain limit to \( K_{sr} \) value, less than which the use of RESs in the UNFCCC process becomes energetically ineffective. This limit is conditionally designated \( K_{sr\text{min}} \). A preliminary estimate shows that \( K_{sr\text{min}} \) may be equal to 2 (i.e., \( K_{sr\text{min}} = 2 \)).

Based on the foregoing, the following classification of RES by energy efficiency for the UNFCCC process is proposed:

RESs that have \( K_{sr} \leq 1.1 \) are "environmentally dirty";
RESs that have \( 1.1 < K_{sr} \leq 2 \) are energy inefficient;
RESs that have \( K_{sr} > 2 \) are energy efficient, that is, "environmentally friendly."

The energy efficiency ratio of RES

Energy efficiency of RES is its ability to rationally use the energy spent on its creation and functioning. This ability is determined through the value of the energy efficiency ratio \( (K_e) \). We define it as the quotient of dividing the difference between the amount of energy generated by RES during its service life and the amount of energy spent on the creation and functioning of this RES to the amount of energy spent on the creation and functioning of this RES. Thus, the calculation of \( K_e \) is based on the same values that were used above in formula 1 when calculating the value of \( K_{sr} \):

\[
K_e = (\Sigma \text{REn} - \Sigma \text{PEn}) / \Sigma \text{PEn}
\]

- formula 3

Symbols in the formula 3 - see above.

A strict mathematical relation for the quantities \( K_e \) and \( K_{sr} \) is represented by the formula:

\[
K_e = K_{sr} - 1
\]

- formula 4.

Conventions in the formula 4 - see above.

The value of \( K_e \) in practice varies from approximately -0.6 to 9. It is convenient to use in the UNFCCC process to compare the degree of environmental friendliness of the RES in the process of choosing it to replace FFS too, for example:

RESs that have \( K_e \leq 0.1 \) are "environmentally dirty";
RESs that have \( 0.1 < K_e \leq 1 \) are energy inefficient;
RESs that have \( K_e > 1 \) are energy efficient, that is, "environmentally friendly."

The total energy efficiency ratio of RES

The total energy efficiency of RES is its ability to efficiently convert the energy received from the environment into usable energy in combination with the rational use of the energy spent on its creation and functioning. This ability is calculated through the value of the total energy efficiency ratio \( (K_{te}) \). We calculate it as the ratio of \( \Sigma \text{REn} \) of the RES under consideration to the sum of its \( \Sigma \text{PEn} \) and \( \Sigma \text{En} \) (see all conventions above) by the formula:

\[
K_{te} = \Sigma \text{REn} / (\Sigma \text{PEn} + \Sigma \text{En})
\]

- formula 5

Conventions in the formula 5 - see above.

The value of the total energy efficiency ratio \( K_{te} \) in practice varies from approximately 0.1 to 0.22. It is convenient to use to compare the degree of technical excellence of RES in the process of their design.

The use of \( K_{te} \) may provide a more accurate choice of the most energy-efficient renewable
energy compared with the use of $K_{cr}$ or $K_e$. However, its technical application requires the installation of additional equipment to automatically register the energy flow from the environment affecting RESs. This may create additional difficulties for their economic justification due to lack of sufficient information.

In other words, using $K_{cr}$ and $K_e$ as criteria for choosing the best RES when replacing FFS in the UNFCCC process will reduce the total greenhouse gas emissions by tens of percent. And the rationale for their use is extremely simple and obvious. It contains only three arithmetic operations and one logical function, does not require additional equipment, and is already formally stated in the UNFCCC documents. Applying $K_{te}$ as a criterion will add a few more percentages to the effect of $K_{cr}$ and $K_e$, is a little harder to justify, and take more time to adopt and implement. Therefore, the use of $K_{cr}$ and $K_e$ as energy efficiency criteria for the UNFCCC process is considered below.

Reducing the duration of the UNFCCC process by increasing the energy efficiency of RES

The duration of the period for replacing all FFS with RES should be minimal for a given volume of commissioning of RES capacities and other conditions being equal. This will minimize the duration of the harmful impacts of FFS to the environment until they are completely replaced. The formulas for calculating the duration reduction of the replacement period for all FFSs with RESs due to their increased energy efficiency are below:

$$N_T = K_{cr} \times (K_{cr} - 1) / K_{cr} \times K_{cr} - 1$$

- formula 6

Symbols in formula 6:
- $N_T$ – coefficient for reducing the duration of the replacement period of all FFS with RES due increasing their energy efficiency;
- $K_{cr}$ – the value of the RES self-replication ratio before increasing energy efficiency;
- $K_{crx}$ – the value of the RES self-replication ratio after increasing energy efficiency;

$$N_T = K_e \times (K_{ex} + 1) / K_{ex} \times K_e + 1$$

- formula 7

Symbols in formula 7:
- $K_{ex}$ – the value of the RES energy efficiency ratio before increasing energy efficiency;
- $K_{ex}$ – the value of the RES energy efficiency ratio after increasing energy efficiency;

$$T_{chx} = N_T \times T_{ch}$$

- formula 8

Symbols in formula 8:
- $T_{chx}$ – duration of the FFS replacement period after increasing energy efficiency;
- $T_{ch}$ – duration of the FFS replacement period before increasing energy efficiency;
- the rest – see above.

The dependence of $N_T$ on the combination of $K_{cr}$ and $K_{crx}$ is shown in Fig. 2. The area of energy inefficient RES (see above) is highlighted in red in Fig. 2. The area of energy efficient RES is highlighted in green in Fig. 2.

Calculations show that for some combinations of $K_{cr}$ and $K_{crx}$, the $N_T$ value may be very small. For example, with $K_{cr} = 1.01$ and $K_{crx} = 10$, the value $N_T = 0.011$. Consequently, the $N_T$ duration for these variants differs by $1 / N_T = 1 / 0.011 = 90.9$ times! The mistake may be such scale at present when choosing RES without using energy efficiency, because it is impossible to calculate the value of the energy efficiency criterion according to the rules of the UNFCCC process.
An example of calculating the duration decrease of the FFS replacement period due increasing energy efficiency is below.

EXAMPLE 1

Initial data:

$T_{ch} = 5$ years – the duration of the period of replacing FFSs with RESs until energy efficiency increases;

$K_{cr} = 2.65$ – the value of the self-reproduction ratio of RESs before increasing energy efficiency;

$K_{crx} = 10$ – the value of the self-reproduction ratio of RESs after increasing energy efficiency;

$K_{e} = 1.65$ – the value of the energy efficiency ratio of RESs before increasing energy efficiency;

$K_{ex} = 9$ – the value of the energy efficiency ratio of RESs after increasing energy efficiency.

The task:
Calculate the duration of replacing FFSs with RESs after increasing energy efficiency.

The solution:

1. Calculation the coefficient value of reducing the duration of the replacement period of FFSs with RESs due to the increase in their energy efficiency.

$$N_T = \frac{K_{crx} \times (K_{cr} - 1)}{K_{cr} \times (K_{crx} - 1)} = \frac{10 \times (2.65 - 1)}{2.65 \times (10 - 1)} = 0.692$$

$$N_T = \frac{K_{ex} \times (K_{ex} + 1)}{K_{ex} \times (K_{ex} + 1)} = \frac{1.65 \times (9 + 1)}{9 \times (1.65 + 1)} = 0.692$$

2. Calculation of the duration of the period for replacing FFSs with RESs after increasing energy efficiency.

$$T_{chx} = N_T \times T_{ch} = 0.692 \times 5 = 3.46 \text{ years}$$

The calculation has showed that the use of either $K_{cr}$ or $K_{e}$ does not affect the duration of the UNFCCC process. Therefore, only the application of $K_{cr}$ is briefly considered below in the technology, which we called the “Noologistic Choosing a Renewable Energy” (NCRE). The word “Noologistic” in the NCRE name comes from the ancient Greek words νόος - noo (reasonable) and λογιστική - logistics (the art of counting). Learn more about NCRE – see [https://www.linkedin.com/pulse/calculation-energy-transition-parameters-when-choosing-valery-matveev](https://www.linkedin.com/pulse/calculation-energy-transition-parameters-when-choosing-valery-matveev).

**Technology for choosing the best RES for the UNFCCC process**

The essence of NCRE is to choose RES of maximum energy efficiency. It consists in performing operations, the scheme of which is presented in Fig. 3. NCRE operations are described below.
Calculation of total energy production due RES

The total energy production through RES is calculated by the project developer as the sum of the total energy amount that it will generate for the entire time it works. It is labeled $\Sigma REn$ (see above). The rules for $\Sigma REn$ calculation are established by the relevant regulatory documents.

Energy accounting

Energy accounting in NCRE is end-to-end and similar to accounting in economics. Its basis is the accounting of fuel costs - energy resources, which already exists in the accounting records, for example, for settlements to suppliers. Mankind’s 500 years of accounting experience and many years of experience in creating automated accounting are the basis for its quick implementation. End-to-end energy accounting will provide accurate information for calculating the energy efficiency of RESs.

The importance of end-to-end energy accounting to the UNFCCC process is as important as the importance of accounting to the economy. Its implementation will require worldwide unification, development on its basis of national and international end-to-end energy accounting rules, as well as organization of control over their implementation.

Calculation of total energy costs at RES

Calculation of total energy costs at RES ($\Sigma PEn$) is performed similarly to the calculation of the total costs in the economy associated with their use for the entire duration of their work. The basis of $\Sigma PEn$ calculation is the energy accounting described above and the rules that should be unified throughout the world and enshrined in the regulatory documents of states. All costs of energy spent on equipment manufacturing, materials, transportation and construction works, maintenance, repair, commissioning, routine maintenance, and also fuel energy, including energy spent on its transportation and storage, are taken into account when calculating the $\Sigma PEn$ value.

Calculation the criterion of energy efficiency the RES

Any of the energy efficiency criteria used in the energy sector, which establishes the mathematical relationship the $\Sigma REn$ to $\Sigma PEn$, may be used in NCRE to choose the best RES. We called one of these criteria the self-reproduction ratio ($K_{sr}$) to distinguish it from other energy efficiency ratios. The value of $K_{sr}$ is calculated by the formula 1 – see above:

Choice of RES

According to NCRE, the best RES for the UNFCCC process is the one with the highest $K_{sr}$. The rules for choosing the RESs by $K_{sr}$ value should be established by the relevant regulatory documents and globally unified in the UNFCCC documents.

In addition, the massive production of RESs that have a $K_{sr}$ value less than the minimum allowed $K_{srmin}$ value (see above) should be globally prohibited.

The effectiveness of ongoing investments in the UNFCCC process

The mistake when choosing of RESs without taking into account energy efficiency

When calculating the reduction in the duration of the replacement period FFSs with RESs, it was shown that, in theory, an error of 90 times is possible - see Fig. 2. It follows from formula 1 that the value of $K_{sr}$ is the greater, the lower the value of the total costs $\Sigma PEn$ for RESs. It is known that different manufacturers spend different amounts of energy to produce the same product. But an accurate end-to-end accounting of the energy expended for their production is not provided in the
UNFCCC process. Therefore, it is currently impossible to choose RESs by the maximum $K_{ar}$ for replacing FFSs in the UNFCCC process.

The results of the studies show that the amount of energy spent on manufacturing products is approximately equal to:
- cement - from 0.92 to 1.39 kWh / kg;
- steel - from 2.78 to 11.14 kWh / kg;
- aluminum - from 48.33 to 48.67 kWh / kg;
- electron silicon - from 583.33 to 694.44 kWh / kg, etc.

They indicate the possibility of increasing $\sum P_{En}$ in comparison with the minimum possible from about 15.71% to 46.52%. This averages 31.12%. This mistake in choosing the best RES arises due to the lack of end-to-end energy accounting. These values do not contradict the accuracy adopted above for calculation the total energy consumption in the absence of end-to-end energy accounting and are adopted for further calculations. It is obvious that all further calculations are approximate precisely because there is no accurate end-to-end energy accounting.

An analysis of the investment efficient in the UNFCCC process from $500 billion in 2018 to $1200 billion in 2030 is shown below. The purpose of the analysis is to show the importance of applying the energy efficiency criterion for the global environment. It shows the approximate scale of the annual and daily global investment in the UNFCCC process. It also shows the approximate scale of investments that are useless and harmful in achieving the Main Goal of the process. The calculation was made on the basis of approximate initial information because there is no accurate end-to-end energy accounting. It consists of simple arithmetic operations. Therefore, calculation examples are not given to reduce the volume.

**Calculation of the inefficient investments**

When calculating the annual investment in the UNFCCC process, it is assumed that the amount of investment increases linearly. The calculation results were recorded in column 2 of Table 1.

The daily investment is calculated by dividing the annual investment by the number of days per year. The calculation results were recorded in column 3 of Table 1.

The minimum annual ineffective investment is approximately 15.71% of the annual investment from column 2 of Table 1. The calculated values were recorded in column 4 of Table 1.

The maximum annual inefficient investment is approximately 46.52% of the annual investment from column 2 of Table 1. The calculated values were recorded in column 5 of Table 1.

Average annual ineffective investment is approximately 31.12% of the annual investment from column 2 of Table 1. The calculated values were recorded in column 6 of Table 1.

Daily approximate minimum, maximum and average ineffective investments are calculated by dividing the respective annual investments (see columns 4, 5 and 6 of Table 1) by the number of days in a year. The calculated values were recorded accordingly in columns 7, 8 and 9, respectively, of Table 1.

<table>
<thead>
<tr>
<th>Years</th>
<th>Investments, $ billiard</th>
<th>Approximate ineffective investments, $ billiard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>annual</td>
<td>daily</td>
</tr>
<tr>
<td></td>
<td>min. 15.71%</td>
<td>max. 46.52%</td>
</tr>
<tr>
<td>1</td>
<td>2018</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>558.33</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>616.67</td>
</tr>
<tr>
<td></td>
<td>2021</td>
<td>675.00</td>
</tr>
<tr>
<td></td>
<td>2022</td>
<td>733.33</td>
</tr>
<tr>
<td></td>
<td>2023</td>
<td>791.67</td>
</tr>
<tr>
<td></td>
<td>2024</td>
<td>850.00</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>908.33</td>
</tr>
</tbody>
</table>
The results of calculating the approximate annual inefficient investment in comparison to all annual investments from Table 1 are presented graphically in Fig. 4.

### Calculation of annual efficient, harmful and useful investments

Annual maximum efficient investment is calculated by subtracting the annual minimum inefficient investment (see column 4 of Table 1) from the annual investment (see column 2 of Table 1). The calculation results are recorded in column 2 of Table 2.

The annual minimum effective investment is calculated by subtracting the annual maximum ineffective investment (see column 5 of Table 1) from the annual investment (see column 2 of Table 1). The calculation results are recorded in column 3 of Table 2.

Annual average efficient investment is calculated by subtracting the annual average inefficient investment (see column 6 of Table 1) from the annual investment (see column 2 of Table 1). The calculation results are recorded in column 4 of Table 2.

When analyzing investments, it is assumed that about half of inefficient investments are harmful because they degrade the environment. They are caused by the misconception of people about the absolute ecological purity of all RESs. The values of the annual minimum, maximum and average harmful investments are calculated by dividing by two the values of the annual minimum, maximum and average ineffective investments (see columns accordingly 4, 5 and 6 of Table 1). The calculation results are recorded accordingly in columns 5, 6 and 7 of Table 2.

The values of annual the maximum, minimum and average useful investments are calculated by subtracting the values of the minimum, maximum and average harmful investments (see columns accordingly 5, 6 and 7 of Table 2) from the values of the maximum, minimum and average investments (see columns accordingly 2, 3 and 4 of Table 2). The calculation results are recorded accordingly in columns 8, 9 and 10 of Table 2.

### Table 2

<table>
<thead>
<tr>
<th>Years</th>
<th>Approximate effective investments, $ billion</th>
<th>Approximate harmful investments, $ billion</th>
<th>Approximate useful investments, $ billion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>max.</td>
<td>min.</td>
<td>av.</td>
</tr>
<tr>
<td>1</td>
<td>84.29%</td>
<td>53.48%</td>
<td>68.88%</td>
</tr>
</tbody>
</table>
The results of calculating the approximately annual effective, harmful and useful investments from Table 2 in comparison to all annual investments from Table 1 are presented graphically in Fig. 5.

Calculation of cumulative investment

Cumulative annual investments at the end of each year are calculated by adding the annual investments (see column 2 of table 1) to the calculated cumulative investments of the previous year (see column 2 of table 3). The results of this calculation are recorded in the corresponding cells of column 2 of table 3.

The annual average cumulative effective investments at the end of each year are calculated by adding the annual average effective investments (see column 4 of table 1) to the calculated average effective investments with a cumulative total of the previous year (see column 3 of table 3). The results of this calculation are recorded in the corresponding cells of column 3 of table 3.

The annual average cumulative harmful investments at the end of each year are calculated by adding the annual average harmful investments (see column 7 of table 2) to the calculated average harmful investments with a cumulative total of the previous year (see column 4 of table 3). The results of this calculation are recorded in the corresponding cells of column 4 of table 3.

The annual average cumulative useful investment at the end of each year is calculated by adding the annual average useful investment (see column 10 of table 2) to the calculated average useful investment with a cumulative total of the previous year (see column 5 of table 3). The results of this calculation are recorded in the corresponding cells of column 5 of table 3.

To calculate the average annual investment on a cumulative basis at the end of any day in the interval from January 01, 2018 to December 31, 2030, Table 3 shows the average daily investment.

Average daily investments have been rewritten to column 6 of table 3 from column 3 of table 1 for ease of reference.

Average daily effective investments are calculated by dividing the average annual effective investments (see column 4 of Table 2) by the number of days per year. The results of this calculation

<table>
<thead>
<tr>
<th>Year</th>
<th>Effective Investments</th>
<th>Harmful Investments</th>
<th>Useful Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>421.45</td>
<td>267.40</td>
<td>344.43</td>
</tr>
<tr>
<td>2019</td>
<td>470.62</td>
<td>298.60</td>
<td>384.61</td>
</tr>
<tr>
<td>2020</td>
<td>519.79</td>
<td>329.79</td>
<td>424.79</td>
</tr>
<tr>
<td>2021</td>
<td>568.96</td>
<td>360.99</td>
<td>464.97</td>
</tr>
<tr>
<td>2022</td>
<td>618.13</td>
<td>392.19</td>
<td>505.16</td>
</tr>
<tr>
<td>2023</td>
<td>667.30</td>
<td>423.38</td>
<td>545.34</td>
</tr>
<tr>
<td>2024</td>
<td>716.47</td>
<td>454.58</td>
<td>585.52</td>
</tr>
<tr>
<td>2025</td>
<td>765.63</td>
<td>485.78</td>
<td>625.71</td>
</tr>
<tr>
<td>2026</td>
<td>814.80</td>
<td>516.97</td>
<td>665.89</td>
</tr>
<tr>
<td>2027</td>
<td>863.97</td>
<td>548.17</td>
<td>706.07</td>
</tr>
<tr>
<td>2028</td>
<td>913.14</td>
<td>579.37</td>
<td>746.25</td>
</tr>
<tr>
<td>2029</td>
<td>962.31</td>
<td>610.56</td>
<td>786.44</td>
</tr>
<tr>
<td>2030</td>
<td>1011.48</td>
<td>641.76</td>
<td>826.62</td>
</tr>
<tr>
<td>Total</td>
<td>9,314.05</td>
<td>5,909.54</td>
<td>7,611.79</td>
</tr>
</tbody>
</table>
are recorded in the corresponding cells of column 7 of table 3.

Average daily harmful investments are calculated by dividing the average annual harmful investments (see column 7 of Table 2) by the number of days per year. The results of this calculation are recorded in the corresponding cells of column 8 of table 3.

Average daily useful investment is calculated by dividing the average annual useful investment (see column 10 of Table 2) by the number of days in a year. The results of this calculation are recorded in the corresponding cells of column 9 of table 3.

Table 3

<table>
<thead>
<tr>
<th>Years</th>
<th>Annual investments, $ billion</th>
<th>Approximate average annual investments, $ billion</th>
<th>Average daily investment, $ billion</th>
<th>Approximate average daily investments, $ billion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>effective</td>
<td>harmful</td>
<td>useful</td>
</tr>
<tr>
<td>2018</td>
<td>500.00</td>
<td>344.43</td>
<td>77.79</td>
<td>266.64</td>
</tr>
<tr>
<td>2019</td>
<td>1058.33</td>
<td>729.03</td>
<td>164.65</td>
<td>564.38</td>
</tr>
<tr>
<td>2020</td>
<td>1675.00</td>
<td>1153.82</td>
<td>260.59</td>
<td>893.24</td>
</tr>
<tr>
<td>2021</td>
<td>2350.00</td>
<td>1618.80</td>
<td>365.60</td>
<td>1253.20</td>
</tr>
<tr>
<td>2022</td>
<td>3083.33</td>
<td>2123.95</td>
<td>479.69</td>
<td>1644.26</td>
</tr>
<tr>
<td>2023</td>
<td>3875.00</td>
<td>2669.29</td>
<td>602.85</td>
<td>2066.44</td>
</tr>
<tr>
<td>2024</td>
<td>4725.00</td>
<td>3254.82</td>
<td>735.09</td>
<td>2519.72</td>
</tr>
<tr>
<td>2025</td>
<td>5633.33</td>
<td>3880.52</td>
<td>876.41</td>
<td>3004.12</td>
</tr>
<tr>
<td>2026</td>
<td>6600.00</td>
<td>4546.41</td>
<td>1026.80</td>
<td>3519.62</td>
</tr>
<tr>
<td>2027</td>
<td>7625.00</td>
<td>5252.48</td>
<td>1186.26</td>
<td>4066.22</td>
</tr>
<tr>
<td>2028</td>
<td>8708.33</td>
<td>5998.74</td>
<td>1354.80</td>
<td>4643.94</td>
</tr>
<tr>
<td>2029</td>
<td>9850.00</td>
<td>6785.17</td>
<td>1532.41</td>
<td>5252.76</td>
</tr>
<tr>
<td>2030</td>
<td>11050.00</td>
<td>7611.79</td>
<td>1719.10</td>
<td>5892.69</td>
</tr>
</tbody>
</table>

The calculation results with the cumulative total of the annual approximate effective, harmful and useful investments in comparison to the cumulative total of all annual investments from Table 3 are presented graphically in Fig. 6.

Table 3 makes it possible to calculate the several types of global investments on a cumulative basis for any period of time from January 01, 2018 to December 31, 2030. For example, the sums of all types of global investments from 01/01/2018 to 05/29/2020 (i.e., for 2 years and 150 days) are approximately equal:

Total investment - 1058.33 + 1.685 * 150 = $ 1311.08 billion;
Effective investments - 729.03 + 1.161 * 150 = $ 903.18 billion;
Harmful investments - 164.65 + 0.262 * 150 = $ 203.95 billion;
Useful investment - $564.38 + 0.899 \times 150 = 699.23$ billion.

The amounts of the same types of global investments from 05/29/2020 to 07/23/2020 (i.e., 54 days after the first publication on the application of energy efficiency) are approximately:

- Total investment - $1.685 \times 54 = 90.99$ billion;
- Effective investments - $1.161 \times 54 = 62.694$ billion;
- Harmful investments - $0.262 \times 54 = 14.148$ billion;
- Useful investment - $0.899 \times 54 = 48.546$ billion.

The above investment values in $ billions in practice mean the involvement of billions of tons of various material resources and labor of billions of people in the UNFCCC process over the next 10 years. It also means a corresponding global impact on the environment in the form of terrain changes, billions of tons of waste, greenhouse gas emissions, etc. They also show that about half of these resources are involved in the UNFCCC process inappropriately in terms of achieving its stated Main Goal. In other words, about half of the material resources, human labor and time in the UNFCCC process are spent on irreversible changes in the environment for the sake of the so-called "economic growth".

The investment inefficiencies described above were justified as long as the importance of applying the energy efficiency criterion in the UNFCCC process was unknown and there was no other choice. It is possible now to apply the energy efficiency criterion, increase the efficiency of investments and thereby accelerate the replacement of FFSs with RESs. And to provide "economic growth" by investments in increasing the energy efficiency of RESs.

**Conclusions**

1. The documents of the UNFCCC declare the importance of the energy efficiency of RESs, but do not provide its application.
2. Not all RESs are "environmentally friendly", there are also "environmentally dirty" ones.
3. It is impossible to distinguish "environmentally friendly" RESs from "environmentally dirty" ones without calculating their energy efficiency.
4. Mass production of "environmentally dirty" RESs must be banned.
5. There are no theoretical and technical barriers to applying energy efficiency in the UNFCCC process.
6. The costs of applying energy efficiency in the UNFCCC process will be disproportionately less than the environmental and economic bonuses of its implementation.
7. There is an urgent need to start using energy efficiency as soon as possible in the UNFCCC process.

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