Calculation of the Energy Transition parameters when choosing Renewable Energy System according to economic criteria

Introduction

The **Ecological Goal** of the Energy Transition, as stated Adnan Z. Amin, Director-General of the International Renewable Energy Agency, is to reduce global greenhouse gas emissions and prevent the most serious effects of climate change. Replacing energy Fossil Fuel Systems (FFS) with Renewable Energy Systems (RES), as follows from this statement, is a way to achieve the **Ecological Goal**.

Economical Goal of the Energy Transition, as follows from a report commissioned at 2012 by the German government, is economic growth. The increase in the global market for environmentally friendly generation and storage of electricity from approximately 313 billion Euros in 2011 to more than 1 trillion Euros in 2025, as follows from this report, is a way to achieve the **Economical Goal**.

Modern energy uses many types of FFS and RES. FFS are called "environmentally dirty" because an emission of greenhouse gas is in places of their work. RES are called "environmentally friendly" because no an emission of greenhouse gas is in places of their work. This property has become a source of widespread belief that to improve the global ecology it is enough to start replacing all FFS with any RES of the corresponding power. Therefore, when discussing the Energy Transition, only economic criteria apply. We will show how this affects the efficiency of investments in the Energy Transition below.

The first thing that immediately attracts attention when familiarizing yourself with RES projects (see Fig. 2) for the Energy Transition is their large sizes and weight with relatively low power. Windmills with towers and blades hundreds of meters in size and weighing thousands of tons, solar panels with kilometer sizes and huge platforms at sea, which weigh thousands of tons at an installed capacity of up to 10 MW, are the RES prototypes for the Energy Transition.

Obviously, for the production of each kilogram of their structure, the energy received from the FFS was expended! That is, the production of each kilogram is accompanied by the emission of greenhouse gases from FFS. This is a lot of energy and greenhouse gas emissions in the aggregate, if you count them from mining to disposal of each RES.

For example, various manufacturers spend various amounts of energy to produce the same product. But **no one is interested in the exact amount of energy expended in their production**. The results of one of the studies show that this amount is approximately in manufacturing: of cement - from 0.917 to 1.389 kWh / kg, of steel - from 2.78 to 11.14 kWh / kg, of aluminum - from 48.33 to 48.61 kWh / kg, of electron silicon - from 583.33 to 694.44 kWh / kg, etc. The relative difference in energy costs is approximately: for cement (1.389 - 0.917) * 100% / 1.389 = 33.98%, for steel (11.14 - 2.78) * 100% / 11.14 = 74.24%, for aluminum (48.61 - 48.33) * 100% / 48.61 = 0.57%, electronic silicon (694.44 - 583.33) * 100% / 694.44 = 16%. Therefore, the average difference in relative energy costs is very approximately equal (48.61% + 74.24% + 0.57% + 16%) / 4 = 34.86%. When choosing RES according to economic or other criteria, this difference may be approximately half of the above calculated, that is, it will be approximately equal to 34.86% / 2 = 17.43%.

The Enercon E-126 wind turbine, installed near Hamburg in Germany, has a capacity of 18,000 MWh / year. Approximately 1,530 tons of cement was spent on the construction of a foundation weighing 2,500 tons and a supporting tower weighing 2,800 tons for this wind turbine. Consequently, approximately from 1,457.5 to 2,208.3 MWh of energy was expended in the production of this cement, according to the above studies. In addition, approximately from 1,944.4 to 7,797.2 MWh of energy were expended in the manufacture of steel for the generator nacelle and rotor with blades under a total weight of 700 tons of the same wind turbine, in accordance to the above studies.

The wind turbine Enerkon E-126 should work approximately from (1,457.5 + 1,944.4) / 18000 = 0.189 years to (2,208.3 +7,797.2) / 18000 = 0.556 years for the reproduction of energy spent on the manufacture of above cement and steel. Therefore, the maximum possible saving in the time of reproduction of the energy spent on the production of cement and steel will be approximately (0.556 - 0.189) = 0.367 years or (0.556 - 0.189) * 100% / 0.556 = 66% if energy efficiency will be used in their choice. This difference may be half of the maximum value calculated above and approximately equal to 0.367 / 2 = 0.184 years or 66% / 2 = 33% if choosing cement and steel at a price or other parameter, and not according to energy efficiency.

Consequently, our technology could shorten the time required to achieve the **Ecological Goal** of the Energy Transition by approximately at 17% to 33%. This corresponds to the effect of investments of 53 - 104 billion euro in 2011 and 170 - 330 billion euro in 2025, were been indicated in a report commissioned by the German government. In addition, additional investments and time will be required in the future to eliminate the results of harmful effects if the refusal to use our technology occurs.

From the above calculations it follows that the maximum energy efficiency of RES projects selected to replace FFS can reduce the duration of achieving the **Ecological Goal** by tens of percent. This means that the duration of the environmental impact of FFS will also be reduced by tens of percent. Therefore, by the time FFS is completely replaced by RES, the environment will have better parameters than with any other choosing criteria.

However, reducing the duration of the Energy Transition through the efficient use of investments means reducing the duration of the associated economic growth. Below we will show how you can develop an economy for an infinitely long time by achieving an endlessly long achievement of the **Ecological Goal** of the Energy Transition.

Our technology gives answers to several questions which have rise due the obvious facts given above, including:

1 question: "How to accurately calculate the real energy costs at RES?"

2 question: "Is there enough energy that RES will generate for the entire time of its operation for its self-reproduction?"

A positive answer to this question ensures that the use of this RES does not degrade the environment. If the answer is no, the use of this RES will degrade the environment and should be justified by urgent need.

3 question: “Which RES is the best to achieve the **Ecological Goal** by energy parameters?”

4 question: “What is the effect of using the best RES to achieve the **Ecological Goal**?”

5 question: "How does the achievement of the **Economical Goal** affect the achievement of the **Ecological Goal**?"

The answers to these other possible questions are given below in the description of the technology, which we called "**Noologistic Choosing a Renewable Energy**" (NCRE). The word “Noologistic” in the NCRE name comes from the ancient Greek words νόος - noo (reasonable) and λογιτσιχη - logistics (the art of counting).

Noologistic Choosing a Renewable Energy

It was shown above that the environmental nature of the **Ecological Goal** of the Energy Transition and the chosen method of achieving it by replacing FFS with RES put energy efficiency of the choosing projects in first place. Therefore, the economic efficiency of the choose projects was in second place. It will be shown below that any attempt to put in the first place the economic efficiency of the project or any other criterion will negatively affect the achievement of the **Ecological Goal**.

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. 1. NCRE operations are described below.

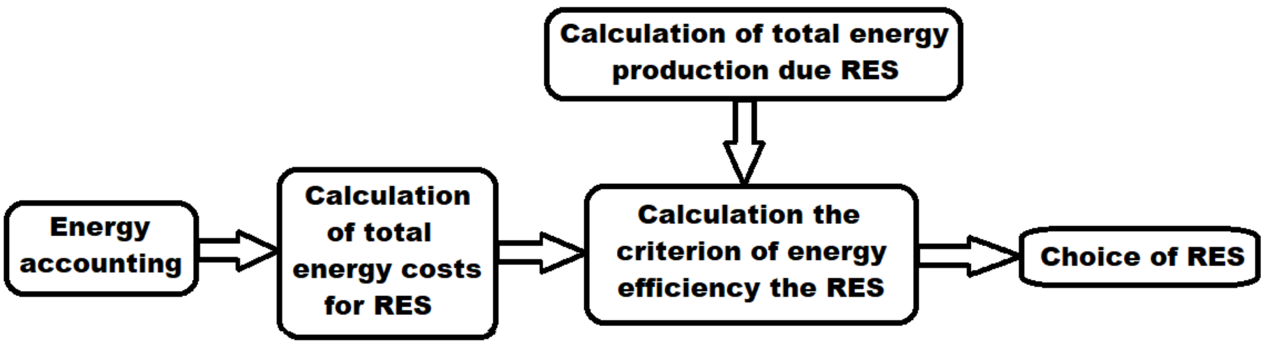

Fig. 1

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 ΣREn below. The rules for ΣREn calculation are established by the relevant regulatory documents.

Energy accounting

Energy accounting at NCRE is 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. Energy accounting will provide accurate information for calculating the energy efficiency of RES in real time.

The importance of energy accounting for the Energy Transition is as important as the importance of accounting for the economy. Its implementation will require worldwide unification, development on its basis of national and international 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 is performed similarly to the calculation of the total costs in the economy associated with their use for the entire duration of their work. It is labeled ΣPEn below. The basis of ΣPEn 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 ΣPEn 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 ΣREn to ΣPEn, may be used in NCRE to choose the best RES. We called one of these criteria the self-reproduction coefficient ($\mathbf{K_{cr}}$) to distinguish it from other energy efficiency coefficients. The value of $\mathbf{K_{cr}}$ is calculated by the formula:

$$\mathbf{K_{sr} = \Sigma REn / \Sigma PEn} \qquad \text{- formula 1}$$

Symbols in the formula 1 - see above.

The value of $\mathbf{K_{cr}}$ determines the property of self-reproduction of RES - this is its ability to produce energy in an amount sufficient to make a replacement for itself.

If $\mathbf{K_{sr}} < 1$, then such a RES cannot be used for the Energy Transition because it produces less energy than was spent on its creation and operation. Therefore, the use of only such RES requires the install the additional FFS and eliminates the possibility of achieving the **Ecological Goal**.

If $\mathbf{K_{sr}} = 1$, then such a RES produces exactly the same amount of energy that was spent at it. Therefore, its use does not make sense - it is impossible to replace the FFS and achieve the **Ecological Goal** through its use.

If $\mathbf{K_{sr}} > 1$, then such a RES may be used for the Energy Transition because it produces more energy than was spent at it. The larger the $\mathbf{K_{sr}}$ value, the more efficient the replacement and the **Ecological Goal** is achieved faster. For example, if $\mathbf{K_{sr}} = 6$, then for the whole time it is able to generate enough energy to produce 6 the self like RES, and if $\mathbf{K_{sr}} = 1.5$, then 4 times less. Accordingly, the duration of the Energy Transition at $\mathbf{K_{sr}} = 6$ will be shorter than at $\mathbf{K_{sr}} = 1.5$.

The value of $\mathbf{K_{sr}}$ has approximate ranges from 0.4 to 9 in practice. This means that in practice there are cases of using environmentally "dirty" RES with $\mathbf{K_{sr}} < 1$, environmentally neutral, with $\mathbf{K_{sr}} = 1$, and environmentally inefficient, with $\mathbf{K_{sr}} < 1.5$.

In fig. 2 shows for comparison projects of 25 various RES_i and their approximate values K_{sri}, which were calculated by formula 1. Presented in Fig. 1 $\mathbf{K_{sri}}$ values are extremely inaccurate and are intended only to demonstrate the technology of choosing. The use of these values for practical comparison of RES will become possible only after the organization of the energy accounting mentioned above.

Fig. 2

Methods of generating Renewable Energy, shown in Fig. 2:
RES_1, RES_2, RES_3, RES_4 and RES_5 - use the energy of sunlight;
RES_6, RES_7, RES_8, RES_9 and RES_{10} - use wind energy;
RES_{11}, RES_{12}, RES_{13}, RES_{14} and RES_{15} - use the energy of water flows;
RES_{16} and RES_{17} - use dissipated thermal energy;
RES_{18} and RES_{19} - use geothermal energy;
RES_{20}, RES_{21}, RES_{22} and RES_{23} - use the energy of the tides;
RES_{24} and RES_{25} - use the energy of sea waves.

Choice of RES

The best project for the **Ecological Goal** of the ones shown in Fig. 2 according to NCRE is a RES_{16} project. It has the largest value of $\mathbf{K_{sr16}}$ = 8.792.
The worst project for the **Ecological Goal** is RES_5: it has $\mathbf{K_{sr5}}$ = 1.182.

Calculation the effect of using the NCRE

For the calculation, it is accepted that:

- An Energy Transition to achieve the **Ecological Goal** will be carried out over a period of TET_{16} = 5 years by replacing all FFS with RES_{16}.
- Organizational, economic and technical barriers to replacing all FFS with RES_{16} for 5 years do not exist.

Obviously, any other RES_i, for example RES_5 or RES_{18} may be the best for the **Economic Goal**. Therefore, we compare them to RES_{16} under the same amount of annual increase in renewable energy power and other conditions being equal. To do this, we calculate the absolute duration of the Energy Transition TET_5 and TET_{18} in years, as well as their relative duration increase $\Delta T_{\%5}$ and $\Delta T_{\%18}$ in % compared to TET_{16} using the formulas:

$T_{ET18} = T_{ET16} * \mathbf{K_{sr18}} *(\mathbf{K_{sr16}} – 1) / \mathbf{K_{sr16}} *(\mathbf{K_{sr18}} – 1) = 4.987 * (8.792 – 1) / 8.792 * (4.987 -1) = 5.54$ years. - formula 2

$\Delta T_{\%18} = (T_{ET18} - T_{ET16}) * 100\% / T_{ET16} = (5.54 - 5) * 100\% / 5 = 10.85\%$ - formula 3

$T_{ET5} = T_{ET16} * \mathbf{K_{sr5}} *(\mathbf{K_{sr16}} – 1) / \mathbf{K_{sr16}} *(\mathbf{K_{sr5}} – 1) = 1.182 * (8.792 – 1) / 8.792 * (1.182 -1) = 28.78$ years. - formula 4

$\Delta T_{\%5} = (T_{ET5} - T_{ET16}) * 100\% / T_{ET16} = (28.78 - 5) * 100\% / 5 = 475.58\%.$ - formula 5

Symbols in the formulas 2, 3, 4 and 5 - see above.
Similar calculations were performed for all other RES shown in Fig. 2, the calculation results are shown in table 1 and in Fig. 3.

Table 1

Parameter	RES$_1$	RES$_2$	RES$_3$	RES$_4$	**RES$_5$**	RES$_6$	RES$_7$	RES$_8$	RES$_9$	RES$_{10}$	RES$_{11}$	RES$_{12}$	RES$_{13}$
K$_{sri}$	4.353	1.499	5.304	5.621	**1.182**	7.207	2.133	6.572	2.767	4.036	2.45	8.158	4.67
T$_{ETi}$, years.	5.75	13.31	5.46	5.39	**28.78**	5.15	8.34	5.23	6.94	5.89	7.49	5.05	5.64
$\Delta T_{\%i}$, %	15.06	166.23	9.22	7.8	**475.58**	2.9	66.85	4.53	38.78	17.82	49.75	1.01	12.77

Continuation of table 1

Parameter	RES$_{14}$	RES$_{15}$	**RES$_{16}$**	RES$_{17}$	RES$_{18}$	RES$_{19}$	RES$_{20}$	RES$_{21}$	RES$_{22}$	RES$_{23}$	RES$_{24}$	RES$_{25}$
K$_{sri}$	1.816	5.938	**8.792**	3.085	4.987	7.524	6.255	3.402	6.89	7.841	8.485	3.719
T$_{ETi}$, years.	9.86	5.33	**5**	6.56	5.54	5.11	5.27	6.26	5.18	5.08	5.02	6.06
$\Delta T_{\%i}$, %	97.24	6.57	**0**	31.13	10.85	2.21	5.49	25.52	3.67	1.58	0.48	21.22

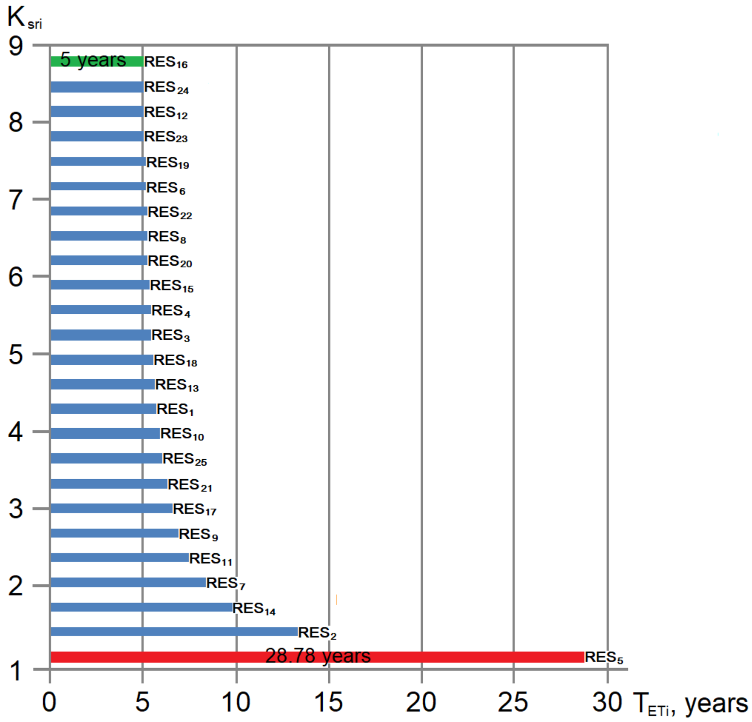

Fig. 3

Obvious and simple calculations showed that any replacement of the **Ecological Goal** with an **Economic Goal** or any other goal, ceteris paribus, increases the duration of the Energy Transition. Moreover, the “Energy Transition” may continue indefinitely with an infinitely long environmental degradation if, instead of the most energy-efficient projects, projects with a self-reproduction coefficient **K$_{sr}$** of one or less than one are adopted.

1. There are no theoretical and technical obstacles to the implementation of NCRE.
2. The use of NCRE by tens of percent increases the efficiency of investments in the Energy Transition. This corresponds to hundreds of billions of euro of economic benefit per year worldwide.
3. Adherents of other goals for whom the achievement of the **Ecological Goal** is an advertising ploy will oppose the implementation of NCRE. Therefore, the project needs the support of international, state and public organizations.

Ending

The project has obvious global environmental importance, and all of humanity will use its results. Therefore, we presented it to the public and are ready to give details if we have not set forth in sufficient detail. The scale of the project requires the participation of many partners. We invite all interested in improving the environment international, state and public organizations to support the project and take part in it.

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