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Environmental component in economic efficiency of renewable energy projects

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Abstract

Efficiency of renewable and alternative energy projects has recently been seen as an integral quantity, which includes economic, energetic, environmental, social and other components. With a lack of substantial financial support from federal, regional or municipal levels the determinant factor of renewable energy project implementation is still an economic efficiency. Economic efficiency can also be seen as a compound quantity, which includes, above others, environmental component. This paper attempts to formulate the definition of "environmental component of economic efficiency", and to distinguish that economic efficiency component of renewable energy projects. The authors expect the increase of environmental component contribution to the general economic efficiency of projects as a result of improvement of the Russian Federation environmental legislation and of consequent and strict control of its implementation. As an example we provide the project of biogas generation from livestock waste.
Keywords: renewable energy project, economic efficiency, environmental efficiency, government support, environmental legislation.

1 Introduction

The comparison of renewable energy project efficiency and conventional energy project efficiency might be the reason in favour of renewables.

It is particularly topical for Russia where the renewable energy development is slow. In 2015 the quantity of renewables used in power production was less than 1.4% (omitting the hydropower engineering). The goal is to increase this quantity to 2.5% by 2020 [1].

Objective factors that put renewable energy development in the Russian Federation on hold are low insolation and low wind speed in more than 65% or

country's area; significant conventional crude resources [2]; rapid growth and high technological level of nuclear energy; and dominant government support of conventional energy industry projects.

According to experts (Ural Federal University employees – experts in renewable energy or in energy-saving and practicians of implementing renewable energy projects, interviewed within this research), the main reason for making a decision in favour of renewable project implementation at all levels is their economic and financial efficiency (profitability).

It is worth noting that experts [3] consider economic efficiency of renewable project as one of the components of the general efficiency. There are also energetic, operational (performance), environmental and social components of efficiency. High value of these indicators is rarely the incentive for decision in favour of renewable project for their implementation. Although it is obvious that economic and financial efficiency of the project in many ways may be based on other types of efficiency, and their contribution can easily be shown in monetary form. For example, high operational (reserve) efficiency of the project that, above other, implicates low percentage of required generating capacity reservation for compensation of renewable energy objects' instability [3], substantially lowers capital expenditure for project implementation. Such compounds of social component as creating new jobs in villages and towns can be positive for local subsidiaries' wellness. Thereby the project might acquire support from local government that will be positive for economic efficiency and profitability.

Renewable or alternative project's environmental efficiency is often connected to lower emissions to environment. Economic result of such effect for a project in The Russian Federation is lower emission payments. But fees for emissions, waste dumping or disposal in The Russian Federation are still so low that it mostly doesn't affect economic parameters of the project (two decimal places of a percent from energy net cost). So, environmental efficiency of the project is rarely the reason in favour of project implementation. Telyashova and Kosmatov [4] also consider reduction of wastelands, improvement of produce' ecological properties as elements of environmental effect of energy-saving projects. Though, Telyashova and Kosmatov [4] don't give methodological approach for assessing such effects' real contribution in improving economic efficiency and profitability of the produce.

Purpose of this research was to reveal and assess environmental component of economic efficiency of renewable energy projects and to forecast increase of that component as a result of Russian legislation improvement and of state support for some renewable energy projects.

2 Economic efficiency of renewable energy projects

Assessment of economic feasibility (efficiency) of an energy project, according to conventional concepts [5], must include assessment of resource productivity and definition of unit cost of production (net cost of production).

Net cost (unit cost) of 1 kWh of energy, according to [5], may be considered as a summarizing factor of project's economic efficiency given in monetary form.

Objective factor of economic efficiency of power plants of different types, according to experts, is a levelized net cost of energy production (Levelized Energy Cost – LEC, Levelized Cost of Energy (LCOE), Levelized Cost of Electricity (LCOE)) [3,6]. This value is calculated by formula (1):

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \quad (1)$$

where t is lifetime of power plant, in years; n is counting year of lifetime; r is discount rate; I_t is investment cost per year, currency units; M_t is operational and repair cost per year, currency units; F_t is fuel cost per year, currency units; E_t is power production per year, MWh.

Estimated LCOE values for 17 types of power generation, including those using conventional fuel, nuclear energy and some types of renewables are given in [3, 6] ([3] gives minimum, average and maximum LCOE values for 2010 and projected values for 2018, [6] gives an LCOE estimation for 2020).

Data analysis gives us reasons to suppose that in the near future LCOE of power plants using most of renewables' types will be close to energy cost of conventional power plants and even will be lower than coal stations' costs.

Assessment of LCOE decrease for geothermal and solar energy due to government subsidies, given in [6], is also worth mentioning.

It also worth noting that values given in [3] are calculated for energy industries of the USA, EU and China, and [6] gives projected values for US energy industry. LCOE calculation for different types of power plants in The Russian Federation is a topical issue. We may suppose that Russian renewable projects nowadays are not on such level of competitiveness.

LCOE allows us to compare economic efficiency of different types of power generation at macro level. In case if we need to assess profitability of a given renewable project for decision on its implementation it is appropriate to explicitly use standard values of project's economic efficiency.

3 The most economically efficient renewable energy projects in the Russian Federation at the moment

In the near future alternative energy projects are unlikely to compete with conventional energy industry in the Russian Federation. Although, there are certain economic opportunities of implementation of some renewable energy projects.

Experts think that renewable projects can be economically viable in Russia nowadays in such cases as:

- Solving the problem of energy supply to remote settlements isolated from the Unified Energy System of Russia [2, 3].
  About 20 million people [3] live in areas with unstable power supply. The most common source of power generation in such areas is diesel generators. Diesel fuel delivery costs for remote and hard-to-reach areas are very high. As a result, power cost is 5–10 times higher than in areas of centralized supply. Government subsidizes power bills for citizens, but local small- and medium-sized businesses can't develop and even exist with energy costs so high.
- Providing power to small- and medium-sized businesses in villages and towns [3].
  Fast (1–3 years in average) building of renewable energy facilities that doesn't require huge lump-sum capital investments encourages creation of new jobs in depressed areas. It may become the reason for acquiring additional funding from regional or local budget, acquiring subsidies for implementation of programs for energy-efficiency improvement and facilities' energy-saving.

Projects that have high economic opportunities in the Russian Federation are:

- Small-scale hydropower projects.
  Small-scale hydropower facilities' building is low-cost and pays off quickly. For example, cost of construction-and-installation works in building small scale hydropower plant is about 14.5–15.0 million roubles. Small-scale hydropower plant is brought into production within 15-18 months. Maximum net cost of power produced by plant is 0.45–0.5 roubles per 1 kWh [7].
- Biogas power projects.
  Strong interest of agricultural, food industry, water treatment facilities is caused by next reasons:
  - ✓ Usage of biogas units allows facility to become independent from power supply failures and rate hikes.
  - ✓ Usage of organic fertilizer-producing and biofuel-producing units may be very profitable for a facility.
  - ✓ The technology radically solves an agricultural and domestic waste problem, highly topical in Russia. This fact is more applicable to environmental efficiency of the project, but in some cases it may cause substantial increase of economic efficiency.

4 Government support for renewable energy projects

Fast pace of renewable energy capacities commissioning in the USA, EU, China and some other countries is mostly due to effectiveness of mechanisms of state support for renewables. Experts consider such most effective mechanisms as Guaranteed Feed-in-tariffs; Investment Tax Credit, Tradable Green Certificates (TGC), Renewables Obligation Certificates – ROCs (Great Britain), Renewable Energy Credits (the USA), New Energy Certificates (Japan), Renewable Energy Certificates (Australia).

Recently there were some attempts of shaping such mechanisms in Russia. Main documents that express economic support for renewable energy are given in Table 1.

Table 1: Normative legal documents, regulating state support for renewable energy projects in the Russian Federation.

Document	Type, year of approval
Package of Measures to Stimulate Production of Power by Facilities Run on Renewable Energy Sources	Government Executive Order of the Russian Federation № 4 of 4 October 2012
On the Stimulation Mechanism for Renewable Energy Sources Usage in the Wholesale Power Joint Market	Decree of the Government of the Russian Federation № 449 of 28 May 2013
On the Stimulation Mechanism for Renewable Energy Sources Usage in the Retail Power Joint Market	Decree of the Government of the Russian Federation № 47 of 23 January 2015

The stimulation mechanism for renewable energy sources usage in the wholesale power joint market is based on costs compensation for power selling arrangements (PSA) on wholesale power joint market. Selection of the projects on renewables PSA must be made on a competitive basis. One of the main criteria here is the extent of production localization (quantity of domestic equipment used).

Purposes of stimulation of renewable energy sources usage in the retail power joint market are efficient usage in regions of local fuel types and power; solving environmental and social problems.

Support mechanisms for renewable energy sources usage in the retail market also apply to generating facilities using biogas, biomass, and landfill gas.

Support for renewable energy sources usage assigns grid companies buying power from qualified renewable energy-generating facilities by regulated rates. After competitive selection of renewable energy projects, admissible level of capital and operational costs is set. Usage of maximum level of capital and operational costs is not applicable for selection in areas not connected to the Unified Energy System.

5 Environmental efficiency of renewable energy projects in Russia

By “environmental efficiency of renewable energy” [3], basing on a worldwide-spread approach [8], understands the value of “lifetime emission”. Lifetime emission is the volume of waste produced in all the life stages of the project from acquiring materials and parts to operation and units’ utilization. At most of the renewable energy projects this value is significantly (tens and even hundreds times) lower than emissions of fuel energy facilities.

Environmental efficiency isn't always shown in monetary units. For example, decrease of emissions during the renewable energy project's lifetime can be assessed in monetary form only applying to greenhouse gases (carbon dioxide above all) [9], incremental cost of which may be assessed with market mechanisms of Kyoto Protocol [10]. In Russia such an assessment always had only scientific value and didn't impact project's economic parameters. Considering that Russia didn't enter the second round of Kyoto Protocol, usage of emissions' market assessment becomes even more problematic.

There are two legislative economic mechanisms of environmental damage assessment in the Russian Federation: *environmental damage* evaluation and, tangentially related to the above, *emission fees* evaluation.

Environmental damage evaluated by current methods usually exceeds emission payments hundredfold. Legal entities and individuals that significantly harm the environment must pay rather high fees if the fact of damage is found and assessed. But due to lack of state control of companies' activities and to financial insolvency of companies-polluters real cases of damage compensation are very rare. Actually, the mechanism doesn't work. It is possible that more gradual control of pollution by special units of state departments responsible for natural resources usage management and protection may bring actual results that might improve environmental and economic efficiency of some renewable energy technologies. Currently it is impossible to quantitatively evaluate contribution of prevented environmental damage (due to lack of significant fines) to economic efficiency of the project.

Emission fees that are defined by Decree of the Government of the Russian Federation № 344 of 12 July 2003 are still so small that don't encourage implementation of technologies to lower emissions. Although, it should change soon. Changes to Russian legislation considering payment for environmental damage suppose significant increase of emission fees rate [11]. As soon as in 2016 fees must rise hundredfold and their contribution to produce net cost will be counted not as two decimal places of a percent, but as few percent and even dozens percent. Since 2020 there shall be an increase of adjustment factors of fees rates for pollution volumes exceeding threshold limit values (within limited values – from 5 to 25, above limited values – from 25 to 100 respectively). According to experts' forecasts, these measures should encourage production and energy facilities to solve emissions problem. That will bring renewable energy facilities in a fortunate position because they are likely to be considered as the best technologies available and are to be free from emission fees.

An increase of fee rates was supposed to come into effect at 1 January 2016, but actually it didn't happen then.

Technically we may consider increase of environmental friendliness of commercial product, acquired along with energy generation, as environmental efficiency of the renewable energy project. Principally we are talking about bioenergy projects that often produce organic fertilizers along with biogas. Marketing profit from such produce might easily be considered as environmental component of economic effect.

Environmental component of economic efficiency (ECEE) of a renewable energy project can be defined as decrease of power net cost due to decreasing environmental damage as one of the results of project implementation.

We may also define cost of spared mineral and energy sources as ECEE. But this value is more often considered as a component of economic effect of resource-saving from renewable energy project implementation.

6 Assessing efficiency of a bioenergy project that uses livestock waste

We used figures of a biogas plant that recycles organic cattle stock waste from several farms in Alapaevsk district of the Sverdlovsk region for assessing economic efficiency of a bioenergy project.

Main technical equipment of the projected plant is a biogas unit (BGU). Proposed equipment supplier is "Dzeta-Service" engineering company. This company also provides installation and check-out services.

While assessing investment project we defined sources of income:

1) Biofuel sales,
2) Dry and wet biofertilizer sales, depending on the season.

The cost items are all the current expenditures of the project, including personnel expenses, building maintenance costs, office operations costs etc. The biggest part of the investment project costs is main technical equipment costs – 39%. Overall volume of investments required for the project implementation is 180 million roubles (borrowed funds). The project is designed for 5.5 years at discount rate of 7%.

Calculated integrated indicators (Table 2) prove that project has high economic efficiency.

Table 2: Integrated indicators of project's economic efficiency.

Project indicators	Indicator value
1. Simple pay-back period, yrs	3.1
2. Discounted pay-back period, yrs	3.3
3. Net Present Value, ths. rbl.	221190
4. Internal rate of return, %	42.3
5. Profitability index	2.1

On the basis of efficiency assessment of similar project in the Orenburg region, author [12] showed that usage of BGU at cattle farms is economically viable. It causes 30% average decrease of energy costs' share in the net cost of farm's products. In given conditions minimum net cost of energy produced from biofuel is 2.74–3.23 rbl/kWh.

The crude net cost estimate for biogas unit of projected plant calculated by Formula (1) was 2.7 rbl/kWh.

Market analysis showed that the project is vital for the Sverdlovsk region. The region is among regions with the most advanced livestock breeding in the Russian Federation. The Sverdlovsk region produced 2.5 million tons of waste in 2014. Organic fertilizer consumption was 1.6 million tons in 2014.

The expected results of project implementation in volume terms are given in Table 3.

Table 3: Projected results of livestock waste recycling plant operations.

Operation	Quantitative value, ths. t/yr	Region's needs satisfaction degree
Organic fertilizer production	23.6	1.5%
Livestock waste recycling	50.4	1.8%

In order to drastically solve the problem of livestock waste recycling in the Sverdlovsk region and the problem of providing the region with quality organic fertilizers it is rational to create similar plants in all major livestock-breeding complexes of the region.

It is well-known that copying a well-proven renewable energy project is widespread in the countries-leaders of renewable energy and leads to decrease of net costs per capacity unit. Therefore, the examined renewable project may be assessed as quite promising.

Initially we may consider these below as project's *environmental component* of economic efficiency:

1) Profit from environment-friendly produce (organic fertilizers) sales;
2) Possibility of accelerated capital allowances due to operations with waste.

Accelerated capital allowances will help to increase cash flows from project implementation and to acquire funds for technical modernization as soon as possible.

If the project will be integrated into the livestock complex, which is seen as the most reasonable choice, the ECEE of the project might also include:

1) Fuel cost decrease, if before the project implementation farms acquired heating from their own boiler-houses;
2) Decrease or total lack of emission fees for the livestock complex;
3) No threat of fines for environmental damage due to improper waste storage;
4) Project implementation funding (or compensation of main equipment costs) from federal, regional budgets and from non-budgetary sources, if the project is considered as the best technology available (since 2020).

Industry of waste treatment, so as some branches of livestock breeding were referred to the industries of the best technology available (BTA) implementation by Decree of the Government of the Russian Federation № 2674-p of 24 December 2014. The technology acknowledged as the BTA may have a substantial effect on financial results of the project.

Main technical equipment cost is (as for 2012 prices) about 70 million roubles. If the technology of organic fertilizer and biogas production will be acknowledged as the BTA, the government may subsidize these costs. It will substantially

decrease current and investment costs of the plant and may lead to economic efficiency components' growth, particularly, NPV would increase 5–10%, and payback period will be cut by 0.3 years approximately.

The exact quantitative assessment of project's environmental component of economic efficiency on the current development stage is impossible. But ECEE can be assessed for active and launching renewable energy projects. It will be especially topical when economic stimulation mechanisms of environmental activities will come in force due to environmental legislation changes.

7 Conclusion

Economic efficiency has a pivotal role in decision-making on the renewable energy project implementation. While assessing it we should consider that economic efficiency may include components of other types of efficiency. Environmental component nowadays doesn't contribute much to the economic results of the most renewable energy projects in the Russian Federation. But in the nearest future environmental legislation changes should cause the substantial growth of that contribution. It may probably increase economic strength of renewable energy projects' implementation that will result, above all, in decrease of anthropogenic influence on environment. It is necessary to work out methodological approaches to the accurate assessment of projects' environmental component of economic efficiency.

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