The Main Principles of Objective Evaluation of Cost-Efficiency of Investments into Alternative Energy Sources for Buildings Energy Supply

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Abstract. Energy-saving has become a part of the governmental policy in Russian Federation in recent years. Alternative energy sources usage, e.g. solar radiation usage, are considered to be one of the most urgent trends of power consumption reduction in housing and communal sector. The absence of sufficient and objective information about alternative energy source is a real usage in the process of heat energy providing to the particular consumer, usually, leads to technically and economically unpractical decisions. This paper presents calculation algorithm and modern methods of evaluation of investments profitability into alternative energy sources, which reflect the structure of determining factors interaction and the sequence of main calculations of technical and economic indicators, needed for the reasoned decision about feasibility of exact energy-saving measures implementation.

1. Introduction
The usage of alternative energy sources, including solar energy, is attractive, firstly, because of the fuel essential economy and energy resources in the process of providing customers with heating, hot water and electricity.

This is exactly the basis of producers and vendors supply in the sphere of energy-saving equipment and systems, which use alternative energy sources. However, they don’t provide objective information about its real cost-efficiency to potential customers in every particular case of usage.

Usually, conclusion about expediency of equipment and systems usage, which use nonconventional energy sources, is based on the results of rather simplified techno-economic calculations.

Meanwhile, regular payback period of investments into sale of energy-saving technology $T_0$ is used as main efficiency criteria. This is absolutely insufficient for making decisions about investments expediency in terms of market economic management. Market principles presuppose some several criteria usage, which can allow evaluating investments cost-efficiency more carefully and profoundly.

2. Control-flow Chart of evaluation of investments profitability into Alternative Energy Sources
The algorithm for calculations and evaluation of investments profitability into Alternative Energy Sources can be pictured as a flow chart, which shows the outline of determining factors interactions and sequence of main calculations of technical and economic indicators, needed for the reasoned decision about expediency of exact energy-saving measures implementation (see Fig. 1).
The size and structure of techno-economic analysis in each particular case depends on classifying indicators, which characterizes energy-saving technology belonging to any kind of group, moreover, it depends on project implementation conditions and investment background [1-5, 13, 5].

3. The Main Principles of evaluation of investments profitability Evaluation of Energy-Saving Technologies Investments' Cost-Efficiency

However, if consumers are located out of the zone with stable and sufficient sources and systems of central heating, there can appear economically valid preconditions for alternative energy sources usage.

While evaluating efficiency of investments to particular energy-saving technology, it is necessary to follow these essential positions: methodology of energy-saving project decisions usage should be based on the concept of an object as of united energy system; the leading role in procedures of selection, analysis and calculations should belong to the comparison of energy-saving technology relevance and conditions of traditional heating systems operation.

It is considered to be adequate if alternative energy source reflects the main characteristics of existing heating system: basic circuit of the system; flow chart, corresponding to the principle of operation of existing system; functional and technical characteristics of equipment, which vitally influence on energy sources consumption reduction. The following reasons can limit alternative energy sources based energy-saving technologies in operation, notably: size of energy-saving equipment; availability of free space for the equipment; location of the equipment against apartment buildings and social buildings.

Due to inability to provide needed power consumption of an object with alternative energy sources, we need information about external energy supply systems and its technical characteristics, including the following essential aspects: objects energy supply conditions, design parameters, operational modes, operation duration during a year, power reserve option, energy sources cost, etc.

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It should be assigned a special place for alternative energy sources equipment and systems in the whole structure of others, traditional systems of energy supply. While deciding, the object should be analyzed from the position of its readiness for installation of alternative energy sources, and the sequence of measures for this installation should be evaluated.

Size of costs for preliminaries depends on the object state: the new building (at the project stage); the new building (at the construction stage); existing or reconfigurable building.

The key point in choosing alternative energy source for buildings with different functions is heat consumption and electricity supply systems structure: just heating systems; heating and hot water supply systems; heating, hot water supply and electricity supply systems.

Alternative energy sources are mostly sufficient for the low-temperature heat consumption systems – low-ground and radiant panel heating systems, hot water supply systems in buildings of different functions, in low-temperature technological processes.

According to the source data, analysis of backbone factors and required measures, dedicated to provide object (system) energetic characteristics according to the energy-saving requirements of normative documents, there is a selection of competing alternatives to be held.

All in all, quantity of comparing alternatives depends on research limitations, which help to select competing alternatives intentionally. The minimum number of competing alternatives depends on the objects state.

For example, during the research for projecting or constructing the new building or reconstruction of the existing building, the minimum competing alternatives number is 2. The 1st alternative gives the project solution. The 2nd alternative, together with the project solution, offers alternative energy source usage.
1. Source data

- Climatological data and microclimate parameters
- Assumed heating and electricity load
- External power systems characteristics, possible restrictions
- Project realization conditions
- Reconstruction of existing object
- The new construction

2. Goals and objectives of energy-saving technology, characteristics

3. Selection of competing alternatives

- Main constructional and technical options, according to the competing alternatives
- Operational-energetic indicators of competing alternatives
  - Electricity consumption
  - Heat consumption
  - Repair-operational charge
  - Designed life of operation
- Necessary constructional calculations

4. Calculation of cost indicators

- Investments
- Operational charge

5. Deciding on methods of investments cost-efficiency evaluation

6. Calculation of investments cost-efficiency

- The 1st group projects:
  - Total reduced costs
  - Pay-back period
- The 2nd group projects (Cost-efficiency calculations):
  - Pay-back period
  - Net income
  - Profitability index

7. Techno-economic aggregates

- Results analysis
- Optimal conditions search

8. Conclusion

**Figure 1.** Flow chart of algorithm of evaluation of alternative energy sources investments’ cost-efficiency.

Working with existing object, with no need for reconstruction, it is usually reasonable to have 3 alternatives. The 1st alternative reflects up-to-day condition of the heat shield and microclimate organization systems of the building. The 2nd alternative includes additional heat shield measures and automation of microclimate organization systems of leading processes. The 3rd alternative, additionally to measures of the 2nd one, offers alternative energy sources usage.
All abovementioned factors influence not only on the choice of alternative energy source, but also on its power capability (heating efficiency) limitations in each particular case.

4. Deciding on Methods of Investments Cost-Efficiency Evaluation

The size and structure of techno-economic analysis in each particular case depends on classifying indicators, which characterize energy-saving technology belonging to any of the existing groups, together with investments conditions and project implementation.

All energy-saving technologies are usually divided on two groups. The first group includes technologies, which should be implemented according to the requirements of relevant directive and normative documents, and “expensive” projects, which are not aimed at profit making. The second group includes technologies, which should be implemented due to the relevant techno-economic calculations.

According to the modern methodology [1-3, 10-11], economic indicators are recommended to be determined for two possible variants of usage of the intermediate income coming from implementation of the investment project: in case of income augmentation (capitalization), if investment project temporary income is used as portfolio investment; in case of income discounting, if investment project temporary income is used as current assets.

For the first group projects it is economically expediency to choose the alternative of investment project with the minimum level of reduced costs.

The range of use of this reduces costs method extends to different “expensive” projects, which are not aimed at profit gaining and are implemented in terms of limited budget sources.

These “expensive” projects include also projects, which implementation and investment is provided by several individuals of juridical entities (recipients), and which are aimed at reduction of current costs in the process of heating systems operation in objects, owned by the participant of the investment project.

The cost-efficiency of energy-saving technologies, implemented and sponsored by particular individuals or juridical entities from their own budgets, is usually evaluated from the position of a “consumer”.

In this case energy-saving technologies efficiency is evaluated for two possible ways of reduced costs calculations: by estimated expenditures, without taking into account the time factor; by reduced costs, with augmentation of temporary income because of temporary costs reduction.

This method of investments efficiency evaluation for particular recipients is more preferable, as far as they need fast recoupment of their expenditures at the expense of economy in current costs (operational costs).

Cost-efficiency evaluation from the position of discounting for the majority of individual investors, which are positioned as “consumers”, doesn’t possess actuality, because implementation of energy-saving technologies is not considered to be an alternative for any other kind of financial investments.

The cost-efficiency evaluation for energy-saving technologies of the 1st group and “expensive” projects may be implemented according to the discounting scheme, from the position of a “reasonable” investor, who can analyze up-today cost of one monetary unit of the future, which will be circulating in the business sphere several periods after the moment of making calculations.

5. Evaluating Cost-Efficiency of “Expensive” Projects with Income Augmentation

The main indicators of “expensive” investment projects cost-efficiency, implemented by unprofitable enterprises and organizations, or by particular individuals or judicial entities, who uses received from investments temporary income as portfolio investment, include [2, 14]:

1. common payback period and non-discounted reduced costs – at the first stage of comparing different alternatives of investment projects;
2. reduced payback period and total reduced costs with income augmentation (capitalization) – at the second stage of comparison.
Common payback period and non-discounted reduced costs calculation is done for the cost-efficiency preliminary evaluation of compared alternatives.

At the 2nd stage the evaluation of “expensive” projects, aimed at energy and resources saving, and temporary income usage, received as a result of investments, portfolio investments with the condition of its augmentation, is conducted according to two criteria – reduced payback period and total reduced costs with the condition of income augmentation. Meanwhile, rated current costs (operational costs) are increasing, according to compared alternatives by the years of payback period, for saving the required profitability, in conditions of inflation and macroeconomic background negative influence.

Usually, investments into alternative energy sources are additional one-time costs to basic variant, but it explains option costs reduce in energy-saving variant, comparing with the basic variant.

6. “Expensive” Projects Cost-Efficiency Evaluation in Conditions of Income Discounting

Cost-efficiency evaluation of “expensive” projects of the 1st group by discounting is done from the position of “wise” investor, who considers income as one of the variants of investments into energy-saving project, as an alternative way of receiving temporary income, used as current assets [2]. In case of several alternatives of “expensive” investments projects the main goal of techno-economic basis is to choose such a variant, which will be connected with the minimal total discounted costs for a payback period.

The comparison of different alternatives of “expensive” investments projects in conditions of discounting is made at the basis of calculation and comparison of the following cost-efficiency criteria: investments payback period, due to the discounting increase indicators of the project, for example, income at the expense of current costs reduction; annual total discounting costs.

At the stage of choosing the alternative, taken for the objective comparison, its cost-efficiency evaluation is done at the basis of calculation of common payback period and non-discounted reduced costs.

While calculating discounted reduced costs in compared alternatives of “expensive” projects, the condition of constant rated current costs (operation costs) is usually accepted, by years of rated period.

Usually, the method of reduced costs is used only when evaluating investments cost-efficiency of energy-saving technologies of the 1st group and “expensive” projects.

While evaluating the commercial efficiency, projects, providing for alternative energy sources usage, are evaluated from the position of its profitability and are included into the 2nd group. In this case different variants of investments resources usage are recommended to be considered in conditions of income discounting. In case of income discounting the alternative of investments into energy-saving technology is evaluated by the investor (budgets of different levels, entrepreneurs, enterprises, etc.) from the commercial point of view, as an alternative way of receiving temporary income, used as current assets.

The commercial efficiency of investments into energy-saving technology is evaluated by criteria of cost-efficiency: net income, net discounted income, profitability index, investments payback period and others.

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