Efficiency evaluation of sustainable energy development financing mechanism

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Abstract. Transition to the sustainable energy development and modernization model requires adequate financing, and, consequently, generation of specific mechanisms, instruments, institutions, and sources of financing. All this predetermines the need to study methodological approaches to development and optimal implementation of financing mechanisms for sustainable energy development, and approaches to evaluation of their efficiency. This article clarifies the concept of the sustainable energy development financing mechanism (SEDFM), defines its specificities, proposes a system of indicators and methodology for efficiency evaluation of sustainable energy development financing mechanisms.

1. Introduction
Being a fundamental and life-supporting industry closely interconnected with all sectors of the economy and social sphere, the power industry plays an essential role in achieving the country's sustainable development goals. The power sector’s contribution to the country's economy exceeds 3% of GDP [1]. Federal budget expenditures in 2018-2020 on the Energy Efficiency and Development Program amount almost to RUB 31 bln [2], investments in the domestic power sector are growing on the whole [3] and energy efficiency in the fuel and energy complex, energy saving, energy consumption efficiency is increasing [4].

Studies have shown that, in the presence of many papers by foreign and domestic scientists dedicated to sustainable development financing, there are only few studies investigating the issues of SEDFM use efficiency evaluation and there is no unified approach to SEDFM efficiency evaluation. As aggregate efficiency data, the efficiency level is most often used as compared to incurred expenditures determining the result that various approaches and methods of strategic analysis, ratio analysis etc. are applied to SEDFM evaluation. Despite their high theoretic and practical value, in terms of SEDFM efficiency evaluation, some of them require improvement, and often omit power industry peculiarities.

2. Results and Discussion

2.1. Peculiarities of SEDFM Efficiency Evaluation
Socio-economic, organizational and managerial, information- and communication-related, technical and technological, and other peculiarities of the power industry significantly impact the formation of mechanisms for its sustainable development financing and determine the specifics of their functional efficiency evaluation.

In addition, the financing of power sector enterprises has a number of peculiarities:
- Need for large investments;
- Diversified model for the industry’s financial support;
- High capital intensity of power facilities;
- Long payback period of capital investments (normally, over 10-15 years);
- Presence of a natural monopoly;
- Continued government regulation;
- Diversification of investment risks by the industry’s sectors.
These specifics were taken into account by the authors in forming a system of indicators for SEDFM efficiency evaluation.

2.2. Integrated Approach to SEDFM Efficiency Evaluation
For the comprehensive evaluation of SEDFM efficiency, the authors suggest using an integrated approach characterized by: consistency; availability of background information; simplicity and low labor intensity; practical orientation; consideration of internal/external environment factors and current situation, available resources; consideration of industry specifics of SEDFM. The integrated approach unites systemic, structural, process-related, factorial, situational, resource and reframing approaches. In this approach there are several methodological approaches to SEDFM efficiency evaluation: general evaluation of SEDFM efficiency; efficiency evaluation of individual SEDFM elements; evaluation of the relationship between individual SEDFM elements, evaluation of SEDFM implementation results; evaluation of SEDFM implementation implications; SEDFM efficiency evaluation in relation to each project participant.

Here we should dwell on the methodology for general SEDFM efficiency evaluation, without division into subsystems (figure 1).

In the said approach, the following provisions are essential.
1. The authors consider SEDFM as a system of economic, organizational and other forms, methods, tools, legislative norms, principles and methods for organization of financial relations, through which financial resources are generated, raised, transformed, accumulated, distributed and applied in order to achieve the power industry’s sustainable development and competitiveness. SEDFM consists of three subsystems: the subsystem of financing tools and technologies, support systems and the ideological subsystem, each of them including a package of elements. In addition to financial benefits, SEDFM should deliver social and environmental benefits.
2. SEDFM efficiency should be evaluated taking into account national and industry characteristics, the specifics of each particular organization and particular project. One should take into account the level, at which SEDFM itself is generated and implemented (global, regional, national (federal, sub-federal, local), industry, organization or household), the type of SEDFM, the system of financial tools serving the basis for financing technology. The evaluation process must factor in the interests of all internal and external stakeholders (government, owners, investors, consumers, etc).
3. For evaluation purposes, the authors take into account 17 new global sustainable development goals (SDGs) [5], four sustainable development components: economic growth, environmental sustainability, social sustainability, digitalization. Peculiarities of the power sector and increased attention to the problems of introduction of new science-intensive digital technologies, environmental safety and social responsibility of business predetermine the need to include not only three classical SD components (economic growth, environment and society), but also a fourth one – digitalization – into the sustainable development model. The SEDFM system of indicators is relevant, maximally informative, measurable and compliant with SDGs, it is generated taking into account the principles of balance and reasonably limited evaluation.

4. The following factors are taken into account: the package of 244 global SDG indicators approved by the UN General Assembly; indicators laid down in 2035 Russian Federation Energy Strategy; indicators of national projects, the system of economic and energy indicators, and efficiency indicators.

5. Significant efficiency components to be included in calculation of the overall efficiency indicator, their content and evaluation are selected by experts, taking into account SEDFM specifics. It is proposed to evaluate overall SEDFM efficiency, its components and indicators using a 10-score scale (due to size variations of indicators): 10 – highly efficient SEDFM, 9 – very good SEDFM, 8 – good SEDFM efficiency, 7 – SEDFM efficiency above average, 6 – average SEDFM efficiency, 5 – low SEDFM efficiency, 4 – very low SEDFM efficiency, 3 – very low SEDFM efficiency, 2 – insignificant SEDFM efficiency, 1 – inefficient SEDFM, 0 – extremely inefficient SEDFM.

6. As the main criteria for comprehensive evaluation of overall SEDFM efficiency, the authors propose to take into account 7 efficiency components being the most significant for adequate presentation of SEDFM functioning efficiency at the country level: economic, environmental, social, technical and technological, organizational and managerial, risk-related, marketing and a package of indicators corresponding thereto.

7. SEDFM efficiency calculation comprises the following stages: 1) selection of SEDFM indicators; 2) rating evaluation of SEDFM indicators; each of selected indicators (K) is assigned certain points; 3) evaluation of each SD component based on individual SEDFM indicators (K, K, K, K); 4) calculation of particular integrated indicators of efficiency components evaluation (K, K, K, K, K, K, K); 5) generation of comprehensive and aggregate indicator of SEDFM efficiency evaluation (K) (table 1).

| Table 1. Indicator System for SEDFM Efficiency Evaluation. |
|-------------------------------------------------------------|
| Efficiency | Sustainable development components |
| Economic | Share of energy products in GDP (K) |
| | Energy export in total energy consumption (K) |
| | Energy efficiency (K) |
| | Organizations’ debt on credits received from banks and granted loans (K) |
| | Amounts owed by buyers and to organizations’ suppliers (K) |
| | Amount of budget subsidies (K) |
| Environmental | GDP energy intensity (K) |
| | Volume of investments by energy organizations aimed at environmental protection and rational use of natural resources (K) |
| | Specific fuel consumption for electricity supply (K) |
| | APG utilization rate (K) |
| | Share of renewable energy resources’ consumption (K) |
| Social | GDP per capita (K) |
| | Energy consumption per capita (K) |
| | Number of people employed in the power sector (K) |
| | Organizations’ wage arrears to employees (K) |
| | Organizations’ arrears of payments to the national budget and national extra-budgetary funds (K) |
| Digitalization | Industry-specific research and development expenditure as a percentage of GDP (K) |
| | Financing of science from the federal budget (K) |
| | Internal R&D costs (K) |
| | Grants, subsidies, competitive financing (K) |
| | Research and development in the sphere of energy (K) |
| | Rate of gasification with natural gas (K) |

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| Efficiency | Sustainable development components |
|------------|-----------------------------------|
| | Economic growth | Environmental sustainability | Social sustainability | Digitalization |
| | $I_1$ | $I_{21}$ | $I_{22}$ | $I_4$ | $I_{51}$ |
| | $= (I_{12} \times I_{13})^{1/n}$ | $= (K_{a12} \times K_{a13} \times K_{a14} \times \ldots \times K_{a1n})^{1/n}$ | $= (K_{a21} \times K_{a22} \times K_{a23} \times \ldots \times K_{a2n})^{1/n}$ | $I_2$ | $= (K_{a41} \times K_{a42} \times K_{a43} \times \ldots \times K_{a4n})^{1/n}$ |

3. Social

| | Average monetary income per capita (K<sub>s1</sub>) | Environmental costs (K<sub>s2</sub>) | Real accrued wages of employees (K<sub>s3</sub>) | Share of youth (adults) having information and communication technology (ICT) skills (K<sub>s4</sub>) |
| | Average cash expenditures per capita (K<sub>s5</sub>) | Expenses for energy organizations’ participation in social and charitable initiatives (K<sub>s6</sub>) | Active life expectancy (K<sub>s7</sub>) | Share of population using the Internet (K<sub>s8</sub>) |
| | Profitability of sold goods, of the industry’s products (works, services) (K<sub>s9</sub>) | Share of fines in energy organizations’ profits (K<sub>s10</sub>) | Level of support to implementation of constitutional rights and freedoms (K<sub>s11</sub>) | Investments in modernization (K<sub>s12</sub>) |
| | Organizations’ return on assets (K<sub>s13</sub>) | | Number of reported crimes in the industry (K<sub>s14</sub>) | Innovation activity level (K<sub>s15</sub>) |

4. Organizational and managerial

| | Integrated indicator of efficiency of labor resources use (K<sub>o1</sub>) | Share of organizations using an environment pollution control system (K<sub>o2</sub>) | HR stability level (K<sub>o3</sub>) | Number of energy organizations involved in research and development (K<sub>o4</sub>) |
| | Energy unit generation cost (K<sub>o5</sub>) | Integrated cost efficiency indicator (K<sub>o6</sub>) | | Organizational culture level (K<sub>o7</sub>) |
| | Investment activity level (K<sub>o8</sub>) | Share of environmental financing in total investments (K<sub>o9</sub>) | Number of staff engaged in research and development (K<sub>o10</sub>) | ICT Development Index (K<sub>o11</sub>) |

5. Technological

| | Availability of fixed assets (K<sub>t1</sub>) | Depreciation of fixed assets (K<sub>t2</sub>) | Level of energy organizations’ technical and technological infrastructure (K<sub>t3</sub>) | Number of developed advanced manufacturing technologies (K<sub>t4</sub>) |
| | Investment in fixed assets (K<sub>t5</sub>) | Fixed assets renewal ratio (K<sub>t6</sub>) | Industrial injuries per 100,000 employees (K<sub>t7</sub>) | Number of employed advanced manufacturing technologies (K<sub>t8</sub>) |
| | Project payback period (K<sub>t9</sub>) | Installed capacity of power plants (K<sub>t10</sub>) | Obtained patents (K<sub>t11</sub>) | Investments in gasification (K<sub>t12</sub>) |

6. Marketing

| | Availability of financial services (K<sub>m1</sub>) | Customer satisfaction level (K<sub>m2</sub>) | Employee satisfaction level (K<sub>m3</sub>) | Digital consumption index (K<sub>m4</sub>) |
| | State satisfaction level (K<sub>m5</sub>) | Compliance with the system of international and national standards (K<sub>m6</sub>) | Counterparties satisfaction level (K<sub>m7</sub>) | Volume of organizations’ innovative goods, works and services (K<sub>m8</sub>) |
| | Owner satisfaction level (K<sub>m9</sub>) | Public organizations’ satisfaction level (K<sub>m10</sub>) | Infrastructure development level (K<sub>m11</sub>) | Technology trading with foreign countries (K<sub>m12</sub>) |
| | Investor satisfaction level (K<sub>m13</sub>) | | | |

7. Risk-related

| | Risk resistance coefficient (K<sub>r1</sub>) | Environmental risk manageability level (K<sub>r2</sub>) | Risk management efficiency (K<sub>r3</sub>) | Share of risk management-related innovative technologies (K<sub>r4</sub>) |
| | Risk intensity (K<sub>r5</sub>) | Level of risk management system implementation (K<sub>r6</sub>) | Risk management stability level (K<sub>r7</sub>) | Share of organizations implementing innovations that ensure increased environmental safety during production of goods, works, services (K<sub>r8</sub>) |
| | Risk ratio (K<sub>r9</sub>) | Risk management process continuity ratio (K<sub>r10</sub>) | Digital security index (K<sub>r11</sub>) | Share of organizations implementing innovations that ensure increased environmental safety as a result of consumers’ use of innovative goods, works, services (K<sub>r12</sub>) |
| | Autonomy ratio (K<sub>r13</sub>) | | | |
One can set the following intervals of the values of particular integral indicators for component efficiency evaluation and the aggregate efficiency indicator: 1-4; 4-7; 7-10, which correspond to the low, medium and high levels of SEDFM efficiency.

It should be noted that SEDFM efficiency is limited by a number of factors. They include lack of own financial resources, investment risks, high percentage of commercial loans, complex mechanism for obtaining loans for investment project implementation, price fluctuations in the global energy market, imperfect legal and regulatory framework governing investment processes, and existing tax treatment of investment activities [6].

The system of indicators should be regularly revised in connection with changes of priorities, emergence of new goals, tools, technologies, sources, financing institutions, and environmental changes.

The proposed methodology allows for an adequate evaluation of SEDFM efficiency level, to obtain a comprehensive and accurate picture of SEDFM condition, to reduce time and increase the efficiency of managerial decision-making and optimize risks, and can serve as an information basis for selection of the most promising ways to increase SEDFM efficiency. The methodology’s distinctive feature is that it allows to use any number of the most significant indicators available, compare the achieved level of SEDFM efficiency with the expected one, dynamically, with other countries’ indicators, and develop a step-by-step system for SEDFM adjustment to improve SDG implementation.

3. Conclusion
Thus, the goal of the study which is to develop an integrated approach, the system of indicators and the methodology for SEDFM efficiency evaluation has been achieved. Unlike the existing methodologies, the proposed one assumes an integrated, systematic and comprehensive evaluation of SEDFM efficiency by calculating a composite integral indicator based on particular integrated indicators of seven efficiency components, taking into account four components of sustainable development, power industry specifics and stakeholders’ expectations. The practical application of the presented approach allows improving monitoring process efficiency, strengthening SEDFM control, identifying functional problems and directions for improvement of SEDFM, the industry and country economy as a whole, and also opens up great prospects for finding competitive advantages and new solutions to strategic issues.

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