SC C3 Power system environmental performance
PS2 Environmental impact of energy transition

The impact of distributed generation intensive development on ecological performance of remote power supply centers

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The presented study is interdisciplinary and addresses the preferential subjects of Study Committee C3 “System Environmental Performance” and Study Committee C6 “Active distribution systems and distributed energy resources”. The paper presents the results of the assessment of distributed generation systems impact on the environmental performance of remote energy districts. The focus is on cumulative environmental damage arising from the manufacturing, construction and operation of power supply systems in remote energy districts within the lifecycle of energy assets.

Implementation of distributed energy resources, including renewable and non-conventional energy sources, is one of the priorities to reduce power supply shortages and diversify fuel balance, which makes it possible to provide remote and hard-to-reach areas with thermal and electrical energy. Often the problem of meeting the energy needs of the population in remote areas is solved by the construction of long-distance power transmission lines. However, this leads to the higher investment costs and big concerns regarding land allocation issues. The construction and operation of long-distance distribution feeders can often take place in terrain with difficult access, which leads to additional increase in operating costs and, subsequently, dramatic increase of environmental damage.

In order to provide uninterruptable power supply for remote customers, excluding the option of centralized grid expansion, the following alternatives can be considered:

- distributed generation based on fossil-fuels, mainly natural gas, diesel fuel;
- distributed generation based on local fuels, including peat, waste from logging industry, etc.;
- distributed generation based on renewable energy sources;
- hybrid systems that operate depending on the availability of primary energy resources, including fossil fuels, renewable energy resources, and, as a rule, electrical energy storage.

The task of life cycle assessment addresses all possible environmental aspects and potential environmental impacts from the acquisition of raw materials, production of

generation equipment, installation and commissioning of power supply systems, the operation of power equipment, decommissioning, dismantling and disposal.

In this paper, the lifecycle assessment of technical systems is performed in accordance with the requirements of the international standards ISO 14040 and ISO 14044. It is important to note that the task of life cycle assessment involves consideration of all qualitative and quantitative characteristics and factors of the natural environment, human health, resources, as well as all technical and technological features of power supply systems operation.

For example, an essential factor for ensuring the reliability of a lifecycle assessment is the intended operation mode of generation units and power grid equipment, which are evaluated depending on the electrical load of the energy district under consideration, the season, averaged climate indicators and other parameters, which are taken into account in this work by simulating various operation conditions for the power supply system under consideration.

Practical part of the study focuses on the problem of power supply system implementation for a remote community located in the Far North region, which characterizes the corresponding geographical and climatic conditions. At the moment, the power supply of the community is carried out by 10 kV overhead power transmission line with a total length of 56 km. The line route passes through inaccessible territories, all the way through the forest belt, which makes it difficult to maintain and repair. The total number of towers is 1056 pcs., which makes it possible to evaluate the required land allocation, and, as a result, environmental damage of the existing potion. In order to make the more accurate estimation of the lifecycle of existing and alternative options, the measurements of electrical load curves were carried out and electrical energy losses were estimated. A visual inspection of the energy infrastructure facilities of the community under consideration allowed determining the main characteristics of the natural environment of the adjacent territory.

As a result of the calculations, based on the method of indicator analysis, a final assessment of power supply system alternatives in terms of environmental damage was made taking into account the criteria and factors determining either ecological impact or technical performance of the system. Comparison of different alternatives, considering hybrid, fossil-fuel and renewable generation, was carried out relative to the existing power supply option - the overhead 10 kV power transmission line. Additionally, the paper analyzes the dependence of the assessment results on the variability of the initial data.