Mining company as an effective element in coal supply to the regions of the Far North

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Abstract. The companies belonging to chains of mining, transportation and consumption of coal to the hard-to-reach regions use their own, often contradictory criteria for the assessment of their work efficiency. Because of that the possibilities to improve the processes of coal quality control in the interests of fuel-chain targets common to mining companies are not used rationally. This situation is more acute in the Far North, primarily in the northern regions of Yakutia. This is due to the extreme combination and negative effect of a number of geographic, climatic, mining-geological and logistical factors. The fulfillment of all operations here, from prospecting of deposits and ending with the distribution of energy received from coal, is complicated, which leads to a significant rise in price. Approaches to improving the work of open-pits as effective elements of coal supply chains, applied in practice, geotechnological and organizational solutions in the planning and management of mining operations can and should be adjusted on the basis of developed proposals, including additional coal preparation in the opencast mines for deliveries. Their realization allows increasing consumer properties of coal shipped to the market with a reduction in its total qualitative and quantitative losses.

1. Introduction
Various strategies and programs in Russia declare that every individual is guaranteed high-quality supply of energy resources and energy security, including hard-to-reach areas of the Fare East, Siberia and European North [1].

Actual monitoring informs of some adverse factors connected with the current supply of isolated territories of Russia with fuel and power resources (FPR). The costs of FPR purchase and shipment, heat and electricity generation and distribution tend to persistent growth. Fuel is delivered not always in time, there are periodic failures which result in force majeure. Total quantitative and qualitative loss of basic materials along the complex and often irrational supply chains is high. Available relatively inexpensive local coal, including high-grade products, is misused. Coal consumption drops at the concurrent degradation of useful quality of fuel. Mines are subject to closure, or decrease output with increasing cost per 1 t of production; economic performance worsens.

Aimed to improve the situation, by the Decree of the President of the Russian Federation (May 2018), the RF Government is entrusted to ensure stable energy supply to consumers in remote and isolate areas by 20204 based on distributed generation. Solution of this complex problem, despite special attention (market in a greater or lesser degree) renewable sources of energy, assumes wide use of coal alongside with hydrocarbons and for a long time. Coal is a relatively cheap type of fuel; it is produced on site or delivered from other regions in amount sufficient to meet the actual needs given efficient approaches to FPR supply.
For the Far North of Russia, including the comprehensively studied central and northern regions in Yalutia, solution of the said problem is of critical importance. As was shown earlier [1–3], this is connected with the impact of the unique combination of extreme natural, climatic, geological, infrastructural and economic factors which greatly complicate operation of the current and future chains of production, supply and use of coal. As case stands, an emphasis should be laid on the exposure of steady decline in the role of mines situated immediately in the regions of FPR consumption and having low and very low capacity, as a rule, as well as on the identification of background of higher attractiveness and sustainability of operating and new mining companies in the hard-to-reach areas based on development of the appropriate technological and organizational measures.

2. Underground and surface coal mines strategy

Approaches used to obtain relevant estimates can be reduced to some basic provisions included as the key components in the chains to coal supply to consumers in the analysis of performance of mining companies.

Underground and surface coal mines supplying FPR to the hard-to-reach regions operate in conditions of tough fuel competition. Interests of oil, gas condensate, diesel fuel and natural gas suppliers are lobbied by large and strong business. Regulatory bodies and corporate national giants are interested in a wide “innovative” use of more expensive and market-determined sources of energy (mini atomic power stations or plants driven by renewable energy of wind and sun are less reliable in the regions under discussion). The Greens accentuate ecological impact of coal combustion products. At the same time, they conceal littleness of this impact due to small coal consumption and low content of toxic elements in the majority of coal deposits in the region. Advanced technologies of solid fuel preparation and combustion, as well as waste management can ensure efficiency comparable with the other FPR types even on small-capacity plants.

Unlike large coal mining companies, small business is highly dependent on internal risks. For this reason, in order to preserve technological and economic sustainability, small companies have to invest considerable money in preventive control [4]. For example, according to the present regulatory documents, open pit mine planning and operation requirements are identical for all mines irrespective of the capacity. All check-list of design, exploration and various approvals is is subject to compulsory implementation [5]. As a consequence, the period starting from bidding documentation and mining license granting up to commissioning of a mine and its running at full capacity covers from three to five years and longer. In the conditions of the Far North, this period can extend to one–three years more in view of extremely complicated logistics connected with delivery of materials and equipment necessary for construction, modernization and normal performance of a mine. Over such a long period of time, it is highly probable that external difficult-to-predict conditions, under which the decision on mining was made, would change for the worse of the subsoil user.

Coal mining companies should be considered as the basic elements in the supply chain between a coal field and a consumer rather than as self-sustained, independent and exclusive economic market participants. It is expedient to implement vertical or horizontal integration of all chain components in the framework of a common system undergoing dynamic changes and using common approaches to evaluation of operating efficiency. A key figure in this case should the production quantity in the form of kilowatt-hours or mega joules consumed and paid by a final user, or even electric or thermal energy output rather than size of known reserves, or produced and conveyed coal. Local criteria for evaluation of small open pit mine performance should be synchronized with the common criteria for the whole system so that to eliminate and prevent current ore probable contradictions.

For revealing evident and hidden (actual and potential) capacities and risks of coal mining companies when incorporated in the regional market of FPR, it is wise to evaluate alternative, more efficient scenarios of operation under creation of common added value in supply chains. Companies engaged in mineral mining and processing obtain, as a rule, the lowest share in the total economic result of the chain operation [6]. In this situation, along with effectivization, it is a priority task to
improve performance of coal mining companies, not only for their convenience but also for the benefit of all participants in the coal supply chain.

A critical backup are the integrated systems of management of coal quality and energy generated from coal. Such systems should target at full-scale improvement of useful qualities of produced and shipped coal, production of grade and calibration fuel, as well as at reduction of total quantitative and qualitative energy loss along the supply chain. Such systems should start with in-depth analysis of mineral potential in the fields under operation or planned for development and finish with distribution of cogenerated thermal and electric energy to a final, including retail, consumer.

With intent to evaluate actual and future role of coal mining companies in FPR supply to the hard-to-reach areas, review positive and negative experience as well as to reveal present difficulties and shortcomings, information on trends in performance of most small open pit mines in the Far East, Siberia and other regions of Russia has been collected from various sources and analyzed (Figure 1). The list of selected mines includes round 50 operating or recently closed coal mining companies (mostly open pits with ROM coal capacity up to 0.3 Mt/yr, situated in localities with undeveloped transport infrastructure and supplying products first all to local markets.

![Figure 1. Main small coal mines in Russia.](image)

| Table 1. Coal production in central and northern Yakutia, thousand tons. |
|-----------------|---|---|---|---|---|---|---|
|                | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| **Open pit mine** |       |       |       |       |       |       |       |
| Bituminous coal |       |       |       |       |       |       |       |
| Dzhebariki-Khaya (underground mine up to 2017) | 367 | 381 | 559 | 320 | 542 | 398 | 157 |
| Zyraynsky       | 243 | 200 | 171 | 160 | 124 | 151 | 148 |
| Kharbalakh      | 85  | 108 | 116 | 132 | 129 | 134 | 162 |
| Lignite         |       |       |       |       |       |       |       |
| Kangalass       | 126 | 134 | 141 | 131 | 145 | 170 | 160 |
| Kirov           | 18  | 18  | 19  | 20  | 23  | 25  | 23  |
| Kempendyai      | 15  | 16  | 21  | 21  | 25  | 26  | 25  |
| **Total**       | 854 | 857 | 1027 | 784 | 988 | 904 | 675 |

Open pit coal mines in Yakituia are reviewed in more detail. Out of 11 6 mines run in the late size years and produced 0.7–1.0 Mt of coal yearly (table). ROM coal was meant for shipment, with numerous rehandling points and long-term delivery periods (to 2–2.5 years), huge unavoidable
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quantitative and qualitative loss much higher than standards allowed. Percent of logistics and transportation expenditures in the structure of coal cost was and still is very high (to 70–85%). The open pit mines under analysis feature also high committed fixed cost per one produced ton of coal.

Based on the analysis of operation of coal mining companies as components in the fuel supply chain, some basic conclusions have been drawn and are presented below.

The optimistic forecasts made in view of available potential background of sustainable performance and anticipated increase in the number and role of small coal mines in Russia [7, 8] and its separate regions [9, 10] failed on some reasons, including those of subjective nature.

There is high dependence of capacity of open pit mines on demand for coal, which is crucially governed by the government buying. Produced coal output, given indirect cost control, is insufficient to support sustainable operation. Companies persistently run short of assets renewal and technical upgrading to increase labor productivity.

When determining annual regimes of overburden removal and coal extraction, open pit mines should take into account periodicity of demand for coal due to winter and summer seasons. Furthermore, in view of remoteness of many consumers and underdeveloped infrastructure, the impact exerted on annual coal outputs by haulage distance between open pits and users is very high. Schedules of river and ocean shipping, as well as motor roads (winter roads) mismatch, which greatly complicates coal logistics. In coal seasons, periods of extremely low air temperature take place rather often, and operation of modern mining machines, especially hydraulically driven, having wide technological capabilities, is complicated.

Lack of care towards coal quality control results in the nonconformance between coal properties, consumer expectations and process characteristics of combustion equipment. It concerns, for the first turn, the purpose, uniformity and preservation of fuel. Possibilities for improvement in operation of open pit coal mines in terms of delivery are used inefficiently. At stages of mine planning and operation, the features of formation and alteration of quantitative and qualitative characteristics of coal produced are nearly neglected. As a result, efficiency of coal utilization in boiler installations exercising mostly fuel-bed firing, drops [2]. Supply chains suffer appreciable, much higher than standard, total loss in terms if coal quality and quantity, while this loss can be considerably reduced given coordinated interests of all participants. One of the variants of solution to this problem can be introduction of auxiliary process circuits at open pit mines to prepare coal for further use. For instance, production of graded coal and its delivery in flexible containers to very remote regions.

3. Conclusions
1. Review of small coal mining companies as the elements of fuel delivery to hard-to-reach areas has offered the time history of their technological and economic changes. The obtained information is intended to be used to adjust operating conditions so that the mines can be efficient and sustainable for a long time, at expanded limits of production and use of coal as common and relatively inexpensive type of FPR.

2. Low-capacity open pit coal mines running for the benefit of users in hard-to-reach and energetically isolate regions should be considered as the main but not unique links in supply chains which, in their turn, should function with regard to harmonization of interests of all participants.

3. The significant source for improving efficiency of supply chains is shaping and application of special systems of coal quality control. These systems must ensure useful qualities of coal for boiler houses such that to find compromise between mineral potential of coal fields, capabilities of modern efficient mining technologies and admissible economic and ecological consequences.

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