

Effect of georesource–consumer process flows on coal loss in energy supply of the Polar regions in Yakutia

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Abstract. It is shown that the process flows of mining, haulage and utilization of coal in the Polar regions in Yakutia feature high quantitative and qualitative loss. In case the process flows are considered as integrated systems aimed at the overall performance efficiency, it is possible to reduce the loss per each individual chain loop. The authors formulate approaches intended to lower total loss of coal in process flows. The geotechnical and organizational solutions are put forward to improve and stabilize quality of fuel used by local fuel and energy industry.

The scope of the social and economic development in the regions of Russian Arctic embraces [1, 2]: (1) optimization of the “northern supply” mechanisms, including local power sources; (2) application of resource-saving technologies and up-dated electric power installations; (3) expansion of product range and improvement of quality and competitive ability of products of the local mining industry; (4) maximum utilization of fuel and power resources (FPR) potential. These objectives imply that the current situation in some regions is disadvantageous, and relevant measures are to be undertaken to eliminate the shortcomings. The analyses of all process flows used to supply FPR in adverse and remote Yakutia’s Polar regions with the isolated infrastructure prove the statement.

Total 13 Polar municipal regions with an area more than 1.6 Mkm² with the population less than 76 thousand residents of 104 settlements consume unreasonably much diesel fuel, benzene, oil, gas condensate, coal and wood per man. At the same time, the federal budget (Yakutia subsidy) and the budget of the Republic of Sakha, which is another name of Yakutia (direct transfer of funds to municipal governments), spend much money to prove the so-called “northern supply.” The key producer of heat energy—company ZhKH RS(Ya)—alone consumed FPR in amount of 241.7 thou t, including 51.8% of coal, in 2014. The purchasing (including shipment) cost made Rub 3.77 billion, including 1.40 BRub to purchase coal [3]. The long-term and sometimes critical (up 100% in some areas) dependence on the external supply of FPR, by means of thousand kilometers long, multi-chain delivery schemes, with multiple re-loading stages, under condition of different times of beginning and closure of maritime navigation and winter roads exists so far.

Coal, solely, is partly of “local” origin. The Upper Kolyma district operates Zyryan Open Pit Coal Mine (Kolmar Co.) that supplies coal to population and industry in the basins of the Kolyma and Indigirka Rivers (95 thou t of coal, or 44% of overall coal supply in the Polar regions of Yakutia in 2014). Consumers at the lower reach of the Lena River and in the Yana River basin obtained coal from Dzhebariki-Khaya situated in the Tompon district (119 thou t coal, or 55%). Sakhaenergo company in Ust-Yana district consumed 37 thou t of solid fuel from SUEK’s open pit mines beyond the borders of



the Republic of Sakha (Yakutia). In 2014, according to the Republic's State Price Policy Committee, the price of coal to be delivered to the adverse northern areas made 5 to 10–12.7 Rub/t (Upper Yana, Ust-Yana, Abyi, Mom districts) and exceeded the world market prices by 2 times and Russian market prices by 3–5 times and above.

This paper addresses the issues of efficiency of process flows between a mineral deposit and a power consumer, where one of the key elements are the large companies listed above, from the viewpoint of loss in the quality and amount of coal in mining, handling and combustion, as well as in the context of assurance of such coal qualities that are required for rational combustion. With a view to ensuring better understanding of the relevancy and urgency of the discussed issues, some argumentation is given below in the paper.

Boiler-house plants in the municipal districts of the Polar zone of Yakutia are conventionally assumed the so-called “small-scale power generation system.” These boiler-house plants are the elements of the process flows, where coal produced and delivered from a distance of hundreds and thousands kilometers is converted into heat or, at its best, into electrical energy. These plants use mainly fuel-bed firing and impose higher standards on the quality of a coal product for the fuel-bed firing efficiency, as compared with powdered fuel firing, is to a higher degree dependent on grain-size composition of coal, uniformity of fuel composition, ash content and moisture content and to a lesser degree is dependent on coal grade.

The use of ROM coal with a high content of fine particles instead of standard quality coal product results in the drop of boiler efficiency from 64–73% to 23–35% and in the excess fuel flow by 50–100%. An increase in mine output costs 3–10 times higher than the enhancement of utilization efficiency of classified treated coal [4]. Capital costs of any fuel saving is 4–6 times lower than mining and transport of the fuel taken in the same quantity [5]. Loss due to fine coal combustion or due to its fall through fire bars reach 30% [6]. Moreover, unburned fine coal particles and ash are sent to dumps and continue burning there, which results in toxic emissions of combustion gases in air.

Under combustion of coal from Khabarovsk deposit (Transbaikalia) in boiler-houses and domestic furnaces equipped with 8–15 mm grates, coal particles smaller than 8 fall into ash boxes. On the average, this loss makes 25% in the overall loss of 36%. Also, quality characteristics of this coal (ash content, moisture content, calorific capacity, grain-size composition) have wide ranges, which complicates its combustion in furnaces [7].

By the data obtained at the Skochinsky Institute of Mining, efficiency of a domestic furnace when burning coarse grade anthracite is 64.3%, and when burning anthracite with coal dust, its is 40–31.8%. One of the main causes for dust to appear in a coal product is coal overgrinding. Dust yield makes 35–40% in mine plowing and 45–60% in modern cutting–loading with rotating drum heads. Scraper conveying to distance of 100 m increases the fine size yield by 10% [8], and this is added with 15% by bulldozers commonly employed in open pit mines and coal-storage yards of underground mines [6].

Another problem is connected with the loss of high quality and high energy coal in multi-stage reloading, storage, combustion and distribution of heat and electrical energy. Standard coal loss in transportation within mineral deposit–consumer process flows in the Polar areas is not higher than 8.4–11.3%. However, actual loss, considering the decrease of the energy value, is not less than 10–20%, for instance, in the chain between Dzhebariki-Khaya Mine and Deputat heat power plant, the mentioned loss makes 19.2% [9].

At the same time, sorting plants installed at reloading stations, e.g. Kharanor Open Pit Mine, enable production of standard quality coal, and combustion of such coal improves furnace efficiency to 90% owing to more complete burning. Fine coal particles are recommended for briquetting [7]. The whole-sale prices of coarse standard-quality coal in the Soviet Union were 2–3 times higher than of fine coal, and this remains the same in recent Russia. So, production of coarse coal (at the same output) will essentially enhance profitability of a mine.

The control over generation and yield of coal of various size (together with ash content, calorific effect and moisture content) in the course of mining and primary dressing on-site, with maximum reduction in overgrinding of coal when transported, reloaded and prepared for firing, can improve the

performance of the process flows on the whole by means of better and sound utilization of coal potential. Sometimes technical, technological, organizational and economical measures and means require no expensive and high-tech procedures to be implemented, which is of importance for remote areas with underdeveloped infrastructure. The increased yield of fine sizes in underground mining of coal is a complementary argument in favor of open pit mines. Owing to higher efficiency of furnaces when burning standard quality coal, coal shipment volume is reduced and, accordingly, shipment cost is cut-down. The wanted production output of coal can be decreased too.

In this connection, it seems quite logical to introduce notions of theoretical, technical and operating costs of coal, and absolute and relative cost of lost quality of coal in mining and economics [9]. Given an uncertainty of economical and mathematical considerations presented in [9], justification of standard quality coal to be used for fuel-bed firing is acceptable.

Assumable as monopolists, extremely few coal suppliers in the Polar areas of Yakutia pay little attention to coal quality control. This is valid both for mines, which is to a certain degree understandable and explainable, and for the main buyer that is a state represented by authorized consumers of solid fuel, which seems incompletely reasoned.

In Yakutia, coal quality test, with regard to the interests of a producing mine, is executed by the technical services of this mine. This test is a formal procedure, and no receive inspection is performed by a consumer, except for Deputat heat power plant. Quality of supplied coal can “adapt” to changing terms and conditions with time, either because of objective or subjective causes. The former are causes connected with unpredictable aggravation of ground conditions or impoverishment of coal quality in some localized areas (oxidation zones, jointing, thinning of beds, etc). The latter causes are associated with managerial blunder and misdeed, for instance, when “effective” managers validate cutting of expenditures for additional operation exploration. Lack of knowledge on georesource can and results dirt rock cutting in roadway roof and floor due to disagreement of specifications of mining machines and sizes of roadways (e.g. Dzhebariki-Khaya Mine). Overall ash content of produced coal and atle are increased as a consequence. Wide-spaced surveying net and insufficient geological information add to that long-term and current mine planning is performed with no regard to variability of some quality characteristics of coal beds. As a consequence, produced coal has fluctuating quality per different batches.

Mines usually ship ROM coal: 0–300 mm in sizes (Zyryan Open Pit Mine) or 0–200 mm (Dzhebariki-Khaya Mne). Control of quality and the required grain-size composition for boil-house plants is nearly disregarded. Primary dressing (sorting, removal of rock, washing) is absent. Key useful quality (ash content and calorific effect) is low and variable in different batches shipped. Grain-size composition is predominantly represented by fine and very fine sizes, especially in underground mine coal, fuel-bed combustion of which is extremely inefficient. Gross open-pit or underground mining of complex-structure coal beds and impurity of coal with roof and floor dirt rocks lower factual average ash-content of coal down to a minimum allowable level and even beneath it in some product batches. End-to-end monitoring of coal quality variation along the shipment chains is absent.

The causes of that situation are different, including:

- rigid thinking on fuel supply of the remote and power-isolated areas since Soviet period of the state-controlled economy with low, adjustable and state-supported domestic prices of energy sources;
- interest of the parties to preserve the situation as it entails annual, not always rational and transparent budget and off-budget outlays to maintain the “northern supply;”
- possible asking for greater finance in case of various circumstances beyond control, for instance, shallow waters in some rivers;
- traditional approach to coal-driven heat and power engineering, when introduction of internationally and domestically approved, high-efficient and energy-saving technologies, including cogeneration, is obstructed by close-mindedness of a decision-maker;
- absence of real economical incentives and preferences both for consumers and suppliers;

—long-lived money stringency to upgrade all chains in a process flow, for energy-saving activities and improvement of technologies connected with maintenance and enhancement of produced and delivered coal quality.

Complete preservation of current “northern supply” circuits when fuel is delivered to consumers to distances of thousands kilometers, with numerous stages of re-loading, with high cost and loss in the presence of many coal deposits in the Polar regions is inexpedient. This paper authors have reviewed and discussed some scenarios that seem viable, for instance:

—exploration and selection of coal deposits with the best and most attractive characteristics of quality;

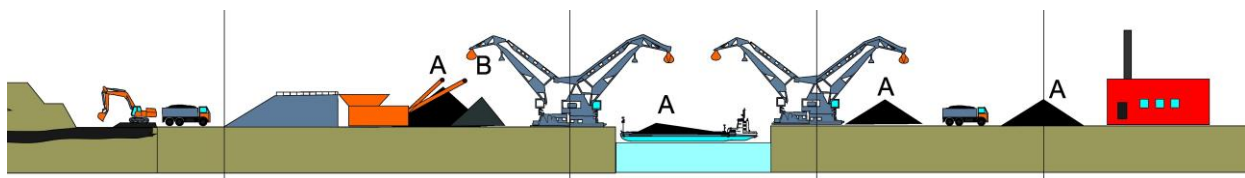
—construction of new mini open-pit mines in remote areas of Yakutia, closer to a potential consumer;

—generation of control over coal quality and process flows to ensure efficiency of the entire georesource–consumer system;

—vertical and/or horizontal integration of all mines (process flows) in a single system of efficient coal production and utilization [10];

—introduction of new processes to prepare coal for use, including: mine planning with regard to quality of produced coal, selective cutting; blending, sorting, separate packing of ROM and standard quality coal.

One of the consequences of implementing the put forward scenarios can be new coal supply chains (see the figure) based on mini open-pit mining [3] of the most promising coal deposits [11], for instance, Krasnorechensk field in the Indigirka River basin. As a result, some labor-consuming stages of coal re-loading will be eliminated (e.g. loading from a river vessel to a marine vessel and vice versa); transportation distances will reduce (to 1500 km) and delivery terms will shorten (from 2–2.5 years to a few months); energy preparedness of remote areas in Yakutia will improve.



Coal production and delivery flow chain

Introduction of new processes in mines to generate flows of coal of pre-set quality in conformity with the standards of different consumers and to produce standard size ROM coal will greatly decrease considerable total quantitative and qualitative loss of coal, especially in the flow chains connected with logistics and coal combustion. Coarse standard quality coal can be shipped to the most remote consumers in bulk or in bags of 1–2.5 t. Fine size coal is for nearby consumers and/or for dust firing.

Conclusion

The process flow chains in coal supply of the Polar areas in Yakutia feature anomalously high quantitative and qualitative loss of solid fuel, which impairs efficiency of the mining industry and decreases utilization factor of produced coal.

Assuming various process flows as integrated systems aimed to meet a common objective enables reduction in coal loss per individual chains in a process flow. Considerable capabilities in this respect are concentrated in mines—in process flows of mine planning, coal extraction and preparation.

The proposed geotechnical and managerial solutions are aimed to reduce coal loss as well as to improve and stabilize its quality, and are useful in improvement of efficiency of local power generation systems.

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