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IMPROVEMENTS IN LONGWALL TECHNOLOGY AND PERFORMANCE IN KUZBASS MINES OF SUEK

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ABSTRACT: SUEK operates ten longwalls in its Kuzbass mines. The area is highly gassy, with low gas permeability that effectively precludes pre-drainage, it has gradients from 5 to 25 degrees, weak roof and floor, and can suffer massive inflows of water into the longwall areas. SUEK has been steadily developing technological solutions, improving equipment, extending face lengths and developing longer panels over the last five years. This is now paying off with extremely high levels of output. In May 2017 one face produced 1.407 Mt saleable, and in July 2017 the same face produced 1.567 Mt. However, producing great volumes of coal is only half the problem.The mines are mostly located 5000-6000 km from the ocean, so transport is a major cost. Access to ports in Russia is also limited. SUEK has been forced to develop holistic solutions through the entire value chain in order to become the leading coal mining company in Russia, and to maintain high levels of output from gassy mines.

INTRODUCTION

Siberian Coal Energy Company (SUEK) produces approximately 105 Mt of coal per year. Most of this is export-quality bituminous thermal coal from large underground and opencast mines, plus a small number of coking and semi-soft coking mines.The company also produces sub-bituminous coal from large opencasts. This is sold unwashed for local markets. All bituminous (hard) coal is washed (if necessary) and exported, however several of the Kuzbass operations produce export quality coal without washing, from seams with 7% to 10% ash of high CV coal. The company operates 15 opencasts, with outputs ranging from 3 to 20 Mt/yr, and 12 underground mines with outputs of 3 to 7 Mt/yr, along with 9 washeries.

All washeries have been modernised and expanded in recent years so they now wash all ROM coal. In the past most Russian thermal coalmines washed only coarse coal, then blended this with unwashed fines and ultra-fines. SUEK's new washeries have been constructed using Australian designs, and all older plants that have been completely renovated and re-engineered to wash all coal sizes and to make a closed cycle, eliminating setting ponds. Quality of products is consistent and high.

SUEK exported approximately 52 Mt of low ash, low sulphur, high quality thermal coal in 2016. This comprised 32.1 Mt to Pacific users and 19.8 Mt to the Atlantic markets, and sold 51 Mt of brown coal (sub-bituminous), lower quality hard coal and washery middlings within Russia in 2016.

SUEK moves approximately 80 Mt of coal per year on the Russian Railways system, which is approximately 24% of all the total coal traffic in Russia. In order to get coal onto the rail network SUEK operates 190 locomotives, has constructed and operates 16 loading points and train assembly yards and operates 746 km of track. On average more than 48,000 railcars are dispatched from SUEK mines per month. Russian cars are 69-77 t capacity. Larger railcars are not feasible because of the huge numbers of bridges and tunnels on the main rail routes.

Coal is moved substantial distances to reach ports on the east and northwest coasts. The greatest volume of export coal is mined in Kemerovo province, in the Kuzbass coalfield. These mines are approximately 4800 km from the west coast ports and 5500 to 6000 km to the eastern ports, so rail transport is a major aspect of the business.

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Russia has very few ports that are suitable for export of coal. Established ports were limited to the Black Sea, Baltic, Barents Sea and the Pacific coast near Vladivostok, and this affects the available capacity and the port charges for coal exporters. In order to reduce these constraints SUEK has built its own coal loading port at Vanino on the east coast, and has acquired a controlling interest in Murmansk Commercial Seaport in the northwest. In 2016 we shipped 19.5 Mt through Vanino and 14.2 Mt through Murmansk. Vanino is a new port with ample space for stockpiles and it is equipped with stacker-reclaimers and ship loaders and its capacity is being increased to 24 Mt/yr. Murmansk is constrained for stockpile areas so it loads ships directly from railcars using cranes but its capacity is also being increased to 16 Mt/yr, and it has been deepened and equipped to handle Capesize vessels with rapid turn-around. All ports operate year-round, although Vanino is an ice port.

SUEK has a sophisticated marketing operation with sales offices in Russia and seven other countries, and more than 80% of sales are direct to end users. All coal is quality assured, with SUEK and independent contractors (SGS) sampling and analysing every wagon at mines and also at ports.

The strategy of the company is to mine high volumes from world class deposits, to sell high quality, finished products FOB or FCA to maximise added value and economies of scale, to control the rail transport and shipment of coal and, as far as possible, to sell direct to the end users.

In order to increase volumes mines and opencasts have been equipped with the best available equipment and with high capacity infrastructure for transport of coal, men and materials, gas drainage, ventilation, monitoring and safety.

SUEK is a major player in Russian industry, so it also has a major role in the communities and environment in mining areas. The company invested $15 M in community projects in 2016. Russian environmental law is similar to that of Australia and USA, and SUEK reaches or exceeds all standards for discharges, water quality and dust emissions .

SUEK operates a total of 27 mines and opencasts. These are located in the Kuzbass region in Siberia and the eastern parts of Russia, as shown in Figure 1. These are located along the main railway lines that cross Russia – the Trans-Siberian and the Baikal-Amur Main line (BAM). The figure also shows the main coal ports in Russia, including the three ports controlled by SUEK.

Figure 1: Location of SUEK mines, ports and Russian railways – Red = SUEK operational areas

The success of the company is highly dependent on maintaining a skilled and productive workforce. All coalmines in Russia are commercially operated and privately owned, so remuneration is competitive. Miners have decent standards of living and stable employment. SUEK has not suffered any layoffs or mine closures as a result of tightened markets, but has continued to develop, modernise and improve standards. Miners in SUEK mines work with the latest and most powerful mining equipment that is available. Most of the face equipment is imported from internationally respected suppliers, such as Komatsu Mining (Joy), Caterpillar (DBT), Sandvik and Famur. Safety standards are extremely good, and strictly regulated. For

example, all underground electrical equipment from the portals to the faces must be explosion proof or intrinsically safe, welding is not permitted underground, all major installations, including transferred longwalls must obtain State approval after commissioning, and mines are inspected almost daily by State inspectors.

In recent years SUEK has started to see the benefits from a period of sustained re-engineering and high investment, combined with technical innovation and sustained development of the workforce. This has culminated with record levels of production from two of the Kuzbass longwall mines:

- In 2015 Taldinskaya Zapadnaya No.1 mine produced over one million tonnes in one calendar month, breaking the previous monthly record for a Russian mine of 797,000 t.
- In May 2017 Yalevskovo Mine produced 1.407 Mt from the longwall in one calendar month. In July 2017 the same longwall produced 1.567 Mt.

In all cases coal quality was maintained within export specification by careful management of the cutting horizon and excellent roof control, so all the coal mined in these two months was sold for export. SUEK has not been able to identify any other instances of such high levels of production in any other country.

SUEK management recognises that monthly or annual records are not normal objectives of modern mining companies. However, there is a tradition of such records in Russia, and they are still a powerful way of motivating personnel. Russia was in a state of economic chaos only 15 years ago, and the changes made in mining are paralleled. Mines have transitioned from State owned, out of date and under-funded enterprises to advanced, modern, completely commercial and profitable businesses. In this environment Stakhanovite records still play a part – they still demonstrate that higher levels of technology can greatly increase production, and the earnings of the workforce. They are not sustainable and must be closely supervised to ensure safety and quality are maintained, but they do serve to drag up average performance in all the mines in the company. As a result, acceptable levels of output from similar longwalls have increased from 400,000 to 600,000 t in a month in recent years.

This paper focuses on the record-breaking longwall at Yalevskovo Mine and the strategies and actions taken by SUEK that have converted the company's Kuzbass assets from relics of the Soviet era to modern, highly productive, safe and extremely competitive mines – in a remarkably short time.

KUZBASS MINES

Mining conditions

Much of SUEK's export coal is sourced from underground mines in the Kuzbass region of Siberia, so these have been a major focus in increasing output and improving productivity.
SUEK operates nine underground mines, two opencasts and four washeries in Kuzbass, all mining hard coal (bituminous thermal coal, and high volatile semi-soft coking coal) with a total of 37.7 Mt ROM per year.

The underground mines extract two categories of seams - from 1.6 to 2.6 m thick, and 3.8 to 5.2 m thick. All mines contain multiple workable seams – typically from 6 to 15 seams per mine. Seams are normally worked in descending order, although alternatives have been used for particular reasons.

Seams are relatively free of minor faults, and there are no volcanic intrusives in the area. In most cases the roof of each seam is weak mudstones and shales. High levels of support are required during development and ahead of longwalls, and it is not possible to use place-changing in developments – by law and in practice it is essential to cut one cycle and then bolt immediately. Cycles are also limited to 0.9 m. The roof is normally bolted with six bolts of 2.4 to 2.6 m length, and each side is supported by two or three roofbolts of 1.8 m. Roof and sides are meshed. The width of roadways is limited to 5.2 m or less, due to difficult strata conditions and weak floor. Roads are driven at 2.6 to 2.8 m high in thinner seams and 4.0 to

4.5 m high in thicker seams. Major considerations are the height required to transport longwall shields and the area required to provide adequate ventilation.

All seams are gassy, with the gas content increasing from about 5-20 m^3/t of total gas content, with depth. There is a theoretical risk of gas outburst at depth, but no occurrences to date. The seam gas is mainly methane. The greatest problem with gas is the extremely low gas permeability of Kuzbass seams. It is exceptionally difficult to predrain the coal in the target seam, even with closely spaced holes on suction. There are also numerous seams above and below the mining horizon which release large volumes of gas into the face and goaf areas. The deposits are world class, with good to moderate mining conditions that are well suited to long, wide longwall panels, and contain high quality coal.

Longwall characteristics

SUEK operates a total of twelve longwalls, including ten in Kuzbass. All of these produce high quality steam coal for export. Five longwalls operate in seams of 3.6 to 5.2 m and the rest are in seams of 1.9 to 2.6 m. The five thick seam longwalls operate in low ash coal and produce 5900-6200 kcal coal mainly without washing, but the thin seam mines all have access to washeries.

The only system for mining is longwall. There is no room and pillar mining in SUEK mines, and no real potential. Most Kuzbass mines operate a single longwall, but Kirova Mine operates two longwalls simultaneously as this is a thin seam mine extracting large reserves of high quality coal. One set works in a seam of 1.9 m and the other is 2.6 m. In 2017 this mine produced more than 7 Mt ROM, and output is expected to increase because one longwall set is being replaced at the end of the year, and the second set should be replaced with new equipment in 2019.

Longwalls are conventional, using two gateroads and leaving pillars between walls, so layouts are very similar to Australian longwalls. All main roads and longwall gateroads are supported with bolts, but cross-measure drifts must be supported by arches under Russian law.

Caving conditions are relatively favourable. Even where sandstones occur above the seams they are relatively weak, jointed and easily caved, so supports are typically in the range of 800-1100 t.

Most deposits are synclinal with steep gradients near the outcrops. Deeper parts of the deposits generally have dips of 3 to 10^0 but the shallowest longwalls in each seam have gradients across the face of up to 26^0. All faces are driven generally along the strike, ideally with a small inclination along the gateroads so the faces retreat to the rise, causing water to flow back into the goaf rather than into the faceline and down the gate roads.

Face widths have been increased over the last 12 years, from initial widths of 180-240 m to 300 m and SUEK is currently increasing the width of all suitable longwalls to 400 m. The first 400 m face was extracted in 2017 and this established what is believed to be a world record during its third month of operation.

Panel lengths have also increased over time, partly as a consequence of deepening the mines, and partly due to investment in improved longwall equipment with increased working lives. Several of the Kuzbass mines are under major railway lines which cannot be undermined until a critical depth has been reached, so this has limited the extent of longwall panels. However, once the depth is adequate longwalls can be extracted below these features. A 400 m wide panel that is 5 km long, and 4.2 m thick is currently being developed. This panel will contain approximately 11 Mt ROM, most of which will be of saleable quality without washing.

EQUIPMENT AND INFRASTRUCTURE

Most of the mines have been re-engineered and re-equipped in recent years and they are now modern mines that are comparable to successful longwall mines in Australia and the US. This has included twelve new main fan installations, five new longwall sets, two fully modernised longwall sets, plus major developments in gas management and mine safety. At the same time AFCs have been upgraded from a mix of Russian and imported machines to the latest imported models (PF4 and PF6 from Cat in thicker seams, Joy in thinner seams), shearers have been upgraded from Eickhoff SL500 to Joy 7LS6 and Eickhoff SL900, and development has been largely changed from light duty Russian roadheaders to Joy and Sandvik bolter miners. Belt conveyor systems have been upgraded and are commonly 3500-4500 tph, originally using imported VSD drives and controls, but recently with high quality Russian designed VSD drives and controls.

Several mines have been converted from vertical shaft winding by driving inclined drifts with belt conveyors. SUEK now has only one mine that winds coal in a shaft and even this has recently been upgraded to a fully automatic operation to maximise capacity.

TRANSPORT

Owing to the steep gradients and soft floor and frequently wet conditions in most mines the most common system for transport of men, materials and longwall equipment is roof-mounted monorail diesel locomotives. These are significantly less flexible and efficient than rubber tired diesels, but they can operate on gradients up to 26^0 or more, and they are not affected by floor conditions or water, and they are narrow so can operate alongside belt conveyors. They have improved longwall salvage operations compared to the former methods of dragging shields along the salvage chamber using low speed winches. After the face is bolted up a monorail is installed through the face, so diesels can drive along the face, pick up pans and supports and drive out the other end. However, they are a major constraint in transferring equipment to the next longwall.

A monorail diesel carrying a 28 t shield or a 90 t shearer can only move at 1-1.5 km/hr, and it stops frequently at corners, shunting points and changes of gradient. In this mode of operation availability is low due to frequent breakdowns of the locomotives. Upon reaching the installation chamber the diesel drives along the new faceline and lowers the shields at the required positions, and carries on through the face to exit. In many instances a loop is established to enable several diesels to work without interfering with each other. Beams are installed using roofbolts and heavy brackets. These bolts are in addition to the roof support system. It is rare for bolts to fail, even when carrying large shearers (7LS6, intact but minus the drums), because anchors are installed to high standards, in the knowledge that they will be carrying big loads. An additional limitation of this technology is damage to beams. When shields, pans, AFC drives and shearers are being transported they are drawn up close beneath the locomotive. Any swaying of the load translates into torque acting on the monorail beam, so the profile becomes twisted and damaged. To counteract this, it is necessary to set a steel beam against the roof, and then attach the monorail beam to this. Monorail beams have also been reduced in length in order to reduce bending and buckling damage.

VENTILATION

The system of ventilation in SUEK mines is forcing, or push-pull in the larger mines. Forcing main fan ventilation is necessary as the ventilation must be heated at every point where air enters the mine. In winter the atmospheric temperature is -25 to -40^0C, so air has to be heated or the intakes would be sealed with large accumulations of ice. At each fan site large boilers are installed, and by law these must be operational from September to May. They actually run at full power from October to April, and during this period they use approximately 10 MW of power to heat each 10,000 m^3/minute of ventilation flow. Most mines require 11-25,000 m^3/min of air to ventilate (~200-400 m^3/s) so this means 10-20 MW of heating power for each mine, 24 hours a day for about five months a year.

In recent years SUEK has constructed 12 main mine fan installations, each complete with a boiler, or large electrical heating arrangements. In recent years the designs have changed from conventional large concrete fan houses to compact, containerised units to reduce construction and installation time. Each unit produces 5000 m^3/min and banks of these modular fans are installed on top of short vertical shafts.

Standards of ventilation are very high, partly because the mines are gassy, and partly to satisfy Russian mining laws. In addition, areas that are accessed by diesel locomotives require 1000 m^3/min of airflow (>15m^3/s) to dilute fumes. This is a major constraint as mines require four to twelve development units, all of which have to be supplied by monorail diesels – a total of 60-180 m^3/s of air just for developments. Longwalls also require high flows of 1500 to 3000 m^3/minute (25-50 m^3/s). Gas emissions for the Kirova and Yalevskovo Seam 52 longwalls are 170 m^3/min and 130 m^3/min equivalent pure methane (2.83 and 2.16 m^3/s respectively). Without methane drainage the longwalls would require 283 and 216 m^3/s of air to dilute the methane to 1%, which clearly is an impossibility.

GAS MANAGEMENT

All mines in Kuzbass are gassy, however emissions on LW5003 were relatively low due to the shallow depth (to 260 m) and some degassing due to over-working in Seam 52. However, the unworked Seam 51 is 26 m above, and there are seams within the zone of influence below, so gas emissions are substantial. Gas permeability is extremely low (0.01 to 0.001 millidarcy) in this area, so most gas is released, by mining-induced destressing and by caving, directly into the mining area and the goaf just behind the face. Typically ranges of *in situ* gas content in this mine are 5 to 11 m^3/t. So even if gas emission during mining was only 3 m^3/t, this would require more than 250 m^3/s of ventilation to dilute it to 1% or less, which is the Russian maximum. Clearly it is not possible to pass this amount of air through a longwall face, so extraction of gas from the goaf at high concentrations is essential. This is achieved by drilling vertical boreholes of 156 mm diameter ahead of the face. These are cased to approximately 10 m above the seam as they pass through the goaf of the overlying seam.

For LW5003 two rows of boreholes were used, one row about 30 m from the bottom gate and the second, wider spaced row 120 m from the bottom gate. The direction of airflow through this face was top to bottom, so the bottom gate (Conveyor Road) is the return airway. The lowest pressure is at the junction of the Conveyor Road, so this is the direction of gas migration. In some faces the return airway is the uppermost road, so the gas wells are located near that road. These are shown in Figure 2, along with the general layout of the mine and the design of the longwall panels. The thin lines across the panels at right angles show the monthly retreats, and the angled, double lines across the panels are narrow roads which are needed under Russian law to provide escapeways.

Two boreholes are kept on suction at all times. The life of a borehole is short so the vacuum pumps are kept on the holes closest to the face. There is also a 700 mm diameter borehole located near the face start line which draws high concentration gas from deep in the goaf. All these systems extract methane at 80-90% concentration. There is also a system to drawn gas out of the goaf from behind the face, using inclined holes drilled through the sealed crosscuts.

Gas monitoring is local plus centralised and is maintained in all intakes, all returns and in every development and longwall working area. On a longwall face detectors are placed at the intake end of the face, return end, blind end (the collapsing roadway at the return end of the face, but outside the face airstream), and two detectors on the shearer. There are also airflow detectors, airborne dust detectors and carbon monoxide and smoke detectors. Under Russian law these must automatically trip electrical power at 1% methane. Within SUEK the detectors trip power at 0.8% and sound alarms at 0.6%.

All gas monitoring data is transmitted to the surface gas control room which is manned 24 hours a day by trained personnel. Their role is to detect rising trends, and monitor disruption of ventilation. These operators are adjacent to the Mine Dispatcher who monitors mining activity and directs activities in the event of any emergency. This ensures that in any

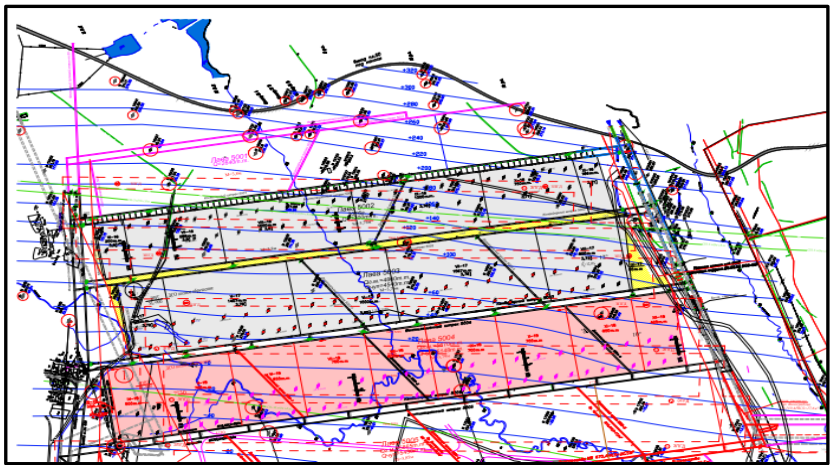

Figure 2: Seam plan for LW5003 area, showing gas drainage wells

emergency accurate information on ventilation and gas monitoring is immediately available. The mine dispatch office also gathers data on all main items of equipment, such as pumps, main fans, conveyors and longwall equipment, so this is a safety and production monitoring centre.

Data from all the SUEK underground mines is then transmitted to the Regional Office which is also manned 24 hours a day. This provides an over-view of all activities and the status of production equipment. It also shows every warning and alarm from the gas monitoring system.

A similar dispatch room is maintained in the Moscow headquarters so that in the event of any emergency the specialists in Moscow can be fully informed, with access to all data coming from a mine and able to assist and support staff in the region and at the mine. This is partly due to the vast distances in Russia. Kuzbass mines are 4.5 hours east of Moscow by commercial plane. The most remote mines are 9 hours away from Moscow. In addition to these constantly monitored systems every gas alarm triggers an automatic system of SMS messages that ensures all senior managers are aware of a problem, and can commence monitoring it if necessary.

The seam plan also shows a common mining practice in Russian mines. “Diagonal roads” are driven right across the longwall panel in order to meet the requirement for escape on foot within the 90-minute life of the standard oxygen generating self-rescuers. No longwall will be approved to commence extraction unless these are in place. The longwall simply mines back through them. The monthly retreats shown on this plan demonstrate that there is no loss of output during this crossing. These roads are driven narrow and about 2.6 m wide (or seam height if less), and heavily bolted. Weak areas are cable bolted and steel beams are bolted on the roof across the road. They are driven on an angle so that when the longwall crosses the road only three or four supports are in the roadway at any time. Occasionally longwalls also cross multiple roads, which are parallel to the face, but these have to be heavily supported with bolts, cables and cribs.

At the top of the seam plan is a short longwall numbered LW5001, that contains 2.64 Mt of reserves. The depth of cover to the top gate on this face is only 20-40 m and about 80 m at the bottom gate. It is not economic to use opencast for this small area, so it will be extracted by the longwall. SUEK has successfully worked several such panels in recent years, and salvaged the equipment with difficulty, but without incident.

RUSSIAN MINING LEGISLATION

Mining legislation is extensive, and the State plays a major role in approval and administration of most aspects of coal mining, from vetting of annual mining plans to approval of all equipment that goes into a mine, continual inspection of operations, and occasional enforced

stoppage of mines. Licensing of reserves is very stringent and mining companies are forced to drill at close to 150 m centres before any longwall panel will be approved for extraction. Part of the reason is to accurately quantify all reserves, to enforce high levels of recovery. If coal is lost without good cause and prior approval then mining companies are fined several times the normal royalty. However, mining companies are not forced to extract coal that is uneconomic, but the process of detailed checks and approvals is designed to ensure best usage of the nation's mineral wealth.

Labour legislation has remained largely unchanged since the replacement of the Soviet system. Despite replacement of limited mechanisation and severe underground working conditions with the most modern mining technology an underground miner is limited to approximately 30 hours at the face peer week. It has taken many years to obtain the right to work 8 hour shifts, rather than 6 hours, but this has not increased the permissible total working hours per man per week or per month. Working time is further reduced by miners being awarded approximately 8 weeks holiday per year. The result is that in order to keep one man on a machine, one shift a day, seven days a week, 52 weeks a year, Russian mining companies must employ 2.383 men – each working limited time with consequential limits to earnings potential.

SUEK'S STRATEGY

SUEK has developed a large and successful coal mining company based on the following strategies:

- Main focus is steaming coal
- High volumes
- Low sulphur, high CV, washed and sized and quality assured products.
- Control costs whilst increasing volumes.
- Control the full product chain – from mining, processing, rail transport, ship loading and marketing – in order to add maximum value and retain it.
- Apply best international technology, and develop innovative engineering solutions.
- Constant pressure for improvement in every aspect of the business.

This strategy has enabled SUEK to compete with Australian mines in export markets for thermal coal, despite the harsh climate, the need to transport coal thousands of kilometres to port, and the limited capacity and high cost of ship loading.

The company is still growing and increasing output. Several new mines are being developed to continue the increased production of high quality, high value coal. In order to sustain growth and continue to develop the most favourable deposits, additional reserve areas are being procured, explored and approved for mining. SUEK currently has 5.4 billion tonnes of JORC Reserves, with a substantial pool of resources that can readily be upgraded to reserves as required.
The core business is steam coal for Russian power stations and for export. Thermal deposits are structurally simpler than coking coal deposits so production is more constant and demand is also less cyclical. These factors create opportunities to achieve economies of scale. High volumes are essential in order to influence transport and port costs.

Cost have been tightly controlled, even in periods of strong demand and high prices. Increase in labour costs is directly linked to better productivity. Material costs are controlled by manufacturing all roofbolts, mesh, plates, monorail beam, conveyor structure and similar items in-house in SUEK owned factories. Miners' earnings are lower than Australia, but there have been no redundancies in SUEK operations, and the company has increased production from 90.9 Mt in 2007 to an estimated 106 Mt by the end of 2017.

SUEK is in the value-added business. All coal is processed and blended, to maximise sale value and minimise transport costs per unit of energy, and sold directly to end users in order to retain value. Most of SUEK's mines are in Kuzbass, far from the ports, so are highly dependent on efficient and competitively costed railway services. At the time SUEK was founded the Russian rail system had serious capacity limitations due to years of inadequate

investment, so it was impossible to ship high tonnages, and there were seasonal shortages of wagons. SUEK has addressed this by:

- Building new loading points to match the increasing output of mines.
- Building large marshalling yards to make up trains ready for dispatch onto the Trans-Siberian rail network.
- Purchasing large numbers of railway wagons, including larger, better wagons. The company now has a fleet of more than 30,000 railcars.
- SUEK works closely with the national rail company to increase the capacity of bottle necks in the system.

These measures mean that rail capacity is not normally a constraint to production. However, some mines have access quotas on competitors' rail systems, and this occasionally necessitates trucking coal substantial distances to another SUEK train loading point, or creating large stockpiles, especially during periods of exceptional performance of mines.

SUEK is a major buyer of mining equipment and infrastructure. In the last three years the company has bought three new longwalls and extended two thick seam sets to 400 m, upgraded most AFCs, upgraded complete conveyor networks in several mines, purchased six new shearers and 12 new bolter miners. All of this is world-class, high capacity equipment from US and European suppliers. The only exception is belt conveyors – here SUEK has worked with Russian companies to develop systems that suit local conditions and operate with software that has local support. As new equipment is introduced, changes in work practices and organisation are introduced to maximise performance and continue the drive for more output with higher margins.

PERFORMANCE OF YALEVSKOVO LW5003

The recent record performances were achieved by the team working on Longwall 5003. This was the second longwall panel in this recently developed seam. Seam 50 is approximately 45 m below Seam 52, which has been worked over the last 15 years with longwalls extracting approximately 5 m of coal. This new seam is 3.6 m thick, but with no significant stone bands, so ROM ash is less than10% and the coal is suitable for export markets without washing. Seam 50 was developed by new inclines driven in seam from the outcrop at 14^{o}, reducing to 9^{0} as the seam flattens out. The full dip of the seams in the initial panels is approximately 8-12^{0}, with the Conveyor Road of the longwalls approximately 70 m lower that the Ventilation Road (TG). These gradients present no operational difficulties. Table 1 shows the monthly output and LW5003 retreat.

Table 1: Monthly Output and LW5003 face retreat

Period	Output (kt ROM)	Retreat (m)
April 14-30	428	203
May	1407	560
June	1001	424
July	1567	699
Aug	850	364
Sept 1-15	56	24
Total	**5310**	**2274**

The longwall was commissioned mid-April 2017. The longwall gate conveyor has to elevate the coal 100 m from the face start line to the junction with the main inclines, and was 2.0 km long. The longwalls are laid out in this manner deliberately, in order to ensure that all water drains back into the goaf. This mine can be extremely wet. On a previous face in Seam 52 water inflows of 400 m^3/hr were experienced on the face and the AFC was running more than 1 m below water at times. The resultant wet coal had to be dried on the conveyors to prevent it sliding back once it reached the main inclined conveyors. This included a tripper with a grizzly. Coarse coal went across the grizzly and right back onto the belt, and the fine, fluid material was collected in a tank, taken into a crosscut where it was treated using hydro-cyclones. Ultra-fines that passed through the hydro-cyclones were collected by settling and

mechanical elevators and the fine solids were fed back onto the belt, on top of the bed of coarse coal at the next crosscut. This was successful, but experience has shown that longwalls must retreat to the rise in this part of the deposit so that any periodic inflows of water that occur will not inundate the working area and run down the conveyor gateroad.

This is the second panel in Seam 50. The first panel was 300 m wide and operated with a PF6 AFC and an Eickhoff SL500 shearer. It achieved more than 1 Mt for two months in the middle of the run, but the under-powered shearer was a constraint. The second panel was developed for 400 m width, and the AFC was extended and additional power added. An Eickhoff SL900 was procured to provide additional cutting power to enable high cutting speeds to be maintained and to allow the face to operate bi-di, producing up to 3500 tph. The web on this face (and most longwalls in SUEK) is only 0.8 m, due to the limited stand-up time of the roof, so the production is 1575-1700 t per shear, depending on seam thickness. Output of 1 Mt/month requires an average of 21 shears per day, or an average of 57 minutes per shear, 20 hours per day, every day. The peak monthly retreat was 699 m – over 20 m every day. The most impressive aspect of this performance was the consistency of output. It is an average of 1.072 Mt/month for the 4.5 months of production, and 1.325 Mt/month for the three full months of highest output, and equivalent to an average of 1.13 Mt per month from commissioning to bolt-up.

It was also noteworthy that very high levels of safety were maintained throughout the full period. There were no reportable injuries, no infringement notices issued and no reduction in standards. The operation was closely monitored by continuous gas monitoring systems, which would trip the power at 0.8% methane, and frequently inspected by senior staff and the State inspectors. No cutting of corners was permitted.

SUEK's miners are paid a substantial productivity bonus from an agreed scale, subject to meeting quality specifications and complying with safety regulations. In this case the productivity bonus payments were substantial, and the key personnel were recognised and given personal awards. This serves to motivate other teams to emulate the success.

CONCLUSIONS

SUEK is achieving world-class levels of production, productivity and safety in underground mines. Similar progress has been made in washeries, opencasts, transport operations and the company's export ports. The company follows bold strategies, is not affected by short-term consideration of share prices, and has continued to invest in holistic improvements even during the worst years. There is still considerable improvement under way, with two new underground mines being developed at present, and several longwalls planned to be upgraded and extended to 400 m. There are still problems to be overcome, including the constraints imposed by monorail transport and a major challenge to substantially increase development rates in order to replace longwalls. However, these are being actively addressed, and solutions will be developed. The company is profitable. In 2016 the EBITDA was US$965 million, or 24% on total revenue. Output increased by 8% overall with all of the increase being from underground mines - which produce premium quality products. Productivity increased by 12% in the year to 498 t/man month, and the amount of coal that was washed increased by 4 Mt, or 12% as a result of upgrading existing washeries and commissioning of a new 3 Mt/yr plant.

Technical improvement of mines is essential but improved equipment and operations alone are not adequate. It is essential that this is combined with clear and sound strategies for operational efficiency and commercial optimisation. In Russia mining and processing is only half of the equation, and transport and ship loading are of equal importance and complexity. Only a large company that can develop holistic solutions can be truly successful on the world scale.

SUEK is positioned to remain one of the lowest cost, long term coal producers in the market. The future of coal mining is not rosy, but if seaborne markets do contract then it is likely that the lowest cost suppliers will outlast the others, so SUEK can afford to plan and invest for the long term.