Abstract
More and more conditions of mining are changing for the worse and more strict environmental requirements engender situation where mining companies have to apply new methods of mining. Methods in the result of which environment would be threatened as little as possible and high quality products could be got. One of such methods is high selective mining of oil shale by surface milling cutter Wirtgen 2500 SM.

Surface Miner 2500 SM allows to mine oil shale environmentally sustainable, to reduce losses, to improve oil shale calorific value as well as helps Power Stations to decrease the volumes of SO2, NOx, ash and CO2 by environmental requirements.

Keywords
Surface mining, Wirtgen 2500 SM, oil shale mining, high-selective mining

Introduction
The Estonian oil shale deposit stretches from the Russian border at the Narva River 130 km west along the Gulf of Finland. Oil shale is a yellowish-brown, relatively soft sedimentary rock of low density that contains a significant amount of organic matter and carbonate fossils. The thickness of the oil shale seam, without partings, ranges between 1.7 m and 2.3 m. The compressive strength is 20 MPa to 40 MPa compared to 40 MPa to 80 MPa for limestone. The density of oil shale is between 1.4 g/cm3 and 1.8 g/cm3 and that of limestone is between 2.2 g/cm3 and 2.6 g/cm3. The calorific value of oil shale deposit is fairly consistent across the deposit.

There is a slight decrease in quality from the north to the south, and from the west to the east across the area.

Oil-shale resources of Estonia are state-owned and lie in the Estonian deposit which is of national importance. State has issued mining licenses to the mines and pitches allowing them to perform mining works. About 98% of electric power and a large share of thermal power were produced from Estonian oil shale. Power stations can burn oil shale with net calorific values of around 2.050 kcal/kg or 8.4 MJ/kg. Net calorific values of oil shale used for retorting and chemical processing must be approximately 2.700 kcal/kg or 11.4 MJ/kg.

Mining conditions are degreasing continuously, therefore new technologies must take in use to increase output materials quality, to protect environment and to make mining more effective. One effective way is to use high selective mining method, such as mining with Surface Miner.

2. Technology overview
2.1. Current technology
Draglines are used for overburden removal (1) (Figure 1). After the overburden is drilled and blasted (2), stripping equipment excavates the overburden from the oil shale and handles it in the previous mined-out strip (3). The roof of the oil shale is first cleared by dozers to minimize dilution. The oil shale is then ripped by large dozers and loaded into trucks by shovel for transportation to the crusher stations located at the surface facilities. After crushing, the oil shale is loaded into railway cars and shipped to the Estonia Power Plant [4].

2.2. New technology
Surface Miner breaks, crushes and loads material in one operation. Productive oil shale seams and limestone interbeds are extracted layer by layer, oil shale is loaded directly to the dump trucks or is handled on to the extracting seam and then is loaded by bucket loaders into the dump trucks (Figure 2). Further, trucks to the Power Plant transport oil shale. Barren rock is removed by Surface Miner directly to the pit heap or is handled on to the limestone layer and then is rehandled by bulldozer or bucket loader into pit heap.
3. **Surface mining technology advantages compared with current technology**

Mining process carried out by Surface Miner is changed considerably in comparison with current technology. Number of the machines required for extraction of mineral resources is reduced. In addition to SM, bulldozers are used for overburden removal and dump trucks for extracted material transportation. Seismic vibrations available in blasting are absent during SM mining. Dust is emitted in minimum during cutting and loading, noise does not disturb. The SM has got high productivity (Wirtgen 2500 SM more than 1 million ton of oil shale per year), that reduces mining process impact on the environment and shortens duration of mining. Quick and comparatively noiseless and dustless mining gives possibility to extract mineral resources next to the settlements and to reclaim mined areas in acceptable way for population.

There are some opened and partially opened mine fields at the present mineral deposit (Ubja, North-Kiviõli, Kohila-Vanaküla, Kose-Tammiku). They are situated next to the populated areas where oil shale of a bit lower quality deposits under thin overburden and allows to use high-selective extraction.
3.1. Decreasing losses

The most perspective advantage of SM is high-selective mining. Surface Miner can cut limestone and oil-shale seams separately and more exactly than rippers (2...7 cm) with deviations about one centimeter. It is estimated that precise cutting enables Surface Miner to increase the output of oil shale up to 1 ton per square meter. It means, that oil-shale loosees in case of SM technology can be decreased from conventional 12 up to 5 percent.

The oil yield increase by 30%, up to 1 barrel per tone during the oil shale retorting, because of better quality. The same principle is valid for oil shale burning at Power Plants because of less limestone content in oil shale. It results to higher efficiency of boilers, because up to 30% of energy is wasted for limestone decomposition. Positive effect would result in lower carbon dioxide and ash emissions.

4. Oil shale quality, environmental impact, CO2 capture and storage technologies

Stratified structure of oil shale seam specifies that content and properties of the fuel supplied to the Power Plants largely depend upon the conditions of oil shale mining and enrichment. Limestone interbeds attending to saleable oil shale are the decisive factor. Estonian Power Plants are trying to upgrade calorific value of oil shale used as well as to reduce content of ash and CO2.

More and more strict environmental requirements produce new challenges to Power Plants to reduce emissions discharged into the environment. The main requirements for Power Plants are as follows:

- ash vehicles reconstruction should be executed by 16 July, 2009.
- overall limit amount of SO2 emitted by the oil shale burning plants should be about 25 000 t/per year since the 1st of January, 2012.
- ash disposal should be carried out according to Landfill Directive by January, 1st, 2014.
- all boilers should meet the requirements of LCP Directive by January, 1st, 2016.

This gave an impetus to Power Plants to research oil shale use of different calorific values.

When using oil shale of the above mentioned calorific value in the blocks of fluidized bed sulphur dioxide (SO2) emissions into atmosphere are very small. They make up some percent from 25 000 ton. In the mode of pulverized burning emissions of SO2 of four blocks make up maximum 13 000 ton. In addition to this it is necessary to install NOx equipment by 2016.

During burning carbon dioxide (CO2) is emitted into atmosphere too. During oil shale burning in addition to CO2 emerging from carbon burning there is surplus amount of CO2 arising from limestone decomposition. Under conditions where prices for CO2 quotas are high it is necessary to actuate all possibilities for CO2 reduction. Emitted CO2 has to be caught and stored.

In the world roughly 60% of the CO2 emissions takes place at large stationary source, such as electric power plants, refineries, gas processing plants and industrial plants. In the majority of these processes, the exhaust flue gas contains diluted CO2 (5% to 15%) One options is to separate the CO2 from other gases. Another option is to remove the carbon before combustion, as in the case where hydrogen and CO2 are produced from natural gas (CH4).

Captured CO2 can be either stored or reused (e.g. resource for producing soft drinks or in greenhouses to help plant growth). Because the market for CO2 reuse in currently limited, the majority of CO2 extracted needs to be stored. CO2 can be stored in geologic formations (including depleted gas reservoirs, deep saline aquifers and unminable coal seams). CO2 can also be fixed in the form of minerals.

In Estonian there are two ways of storage CO2. One is open-cast, ash field storage and another is open-cast storage or underground back filling.

I version: CO2 open-cast, ash field storage

Ash and minimal quantity of water is bumped into tank, which is next to pot. Ash and water are mixed and then CO2 is carried into the mixture. Unnecessary CO2 is lead to chimney. Dry pulp form mixture is transported to open-cast or ash fields.

II version: CO2 open-cast storage or underground back filling

Ash and water is bumped into tank, which is next to pot. Ash and water are mixed and then CO2 is carried into the mixture. Unnecessary CO2 is lead to chimney. As appropriate pulp and CO2 mixture is transported to open pit, ash field or underground mine. When pulp and CO2 mixture is transported to mine, then tails are added and the mixture becomes petrify fill. In such case it is possible to make new pillars in the mine and to extract more oil shale from pillars.
5. Conclusions

Mining conditions changing for the worse more and more make a claim for new and environment-friendly mining technologies. High selective mining by Surface Miner 2500 is one of such possibilities. Surface Miner 2500 allows to mine oil shale close to the towns and populated areas quickly and with small disturbance, to mine oil shale without blasting, to restore mined areas with suitable microrelief, to get higher productivity, to produce oil shale of higher quality. Calorific value of the raw material remains in the range of 8.4-11.4 MJ/kg. Surface Miner 2500 allows to use extracted oil shale without preparation and to generate electric energy in new fluidized bed boilers. Because of that emissions of CO2 are reduced by 20 % and ash amount is reduced up to 15 %.

Strict environmental standards gave an impetus to Power Plants to research oil shale use of different calorific value. Alternative solution is to study oil shale use of 10.5 or 11.5 MJ/kg.

Use of oil shale of that calorific value in fluidized bed blocks and pulverized burning boilers keeps sulphur dioxide (SO2) content in the permitted limits of 25 000 ton. In addition to that NOx emissions into the air should be reduced by 2016.

More and more attention is turned to decrease CO2 problems and to work out new solutions. In Estonian there are two ways of storage CO2. One is open-cast, ash field storage and another is open-cast storage or underground back filling.

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References

5. Karu. V. Kaevandivate ettevõtete põlevkivivaru inventuur. Estonia kaevanduse lõunaosas paikneva põlevkivivaru ümberhindamise põhjendus, Tallinn, 2004