Oil Shale, Vol. 15, No. 3
pp. 295-301

ISSN 0208-189X

https://doi.org/10.3176/oil.1998.3.06

DISCUSSION

FUTURE OF THE ESTONIAN OIL SHALE ENERGY SECTOR

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Current Situation in the Oil Shale Energy Sector

In 1997, twenty two million tonnes of oil shale of 43 TWh of effective energy was extracted from the six mines and three opencasts in Estonia, of which 14.4 million tonnes, of 30 TWh of total energy, was sold after enrichment at the average price of 98 EEK/t, and at the price of energy of 4 sents/kWh. This was used to generate a little less than 8 TWh of electricity in two large power plants, ca 5 TWh of oil shale oil and gas in three oil shale oil plants and slightly more than 2 TWh of thermal energy in Kunda, Narva, Kohtla-Järve and Jõhvi region. According to these figures, the efficiency of the oil shale energy conversion system with regard to the extracted oil shale was close to 37 %.

The oil shale and energy complex employing a total of 15,000 employees is located in Ida-Virumaa, where the production of oil shale and electricity can be characterised by failure to use up the capacity of production facilities. Although the oil shale oil plants are operating at maximum load, the rising prices of oil shale are about to drive them into economic difficulties. Ida-Virumaa is haunted by unemployment, which has tied the economic policies of the region up with social policies. The latter makes the realisation of the long-term national fuel and energy sector development plan obviously more complex. According to this plan the share of oil shale as the primary energy used in Estonia has to be reduced from the current 62 % a year to 52-54 % by the year 2005 and 47-50 % by the year 2010.

Power Plants

In 1998, two power plants in Narva will generate 5 TWh of electricity in the winter period (1st and 4th quarters) and 3 TWh of electricity in the

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summer period (2nd and 3rd quarters). By taking also into account the less fluctuating seasonal consumption of oil shale by the oil shale oil plants, the Estonian Oil Shale Company expects to extract 8 million tonnes of oil shale in the winter season and 6 million tonnes in the summer season.

It is probable that the economical combined natural gas- and peat-fuelled plants to be built in Tallinn, Kunda and elsewhere, may reduce the difference in winter and summer generation volumes of the Narva oil shale-fuelled power plants. Thus, the year-round loads in both the power plants and oil shale extraction are going to be levelled out.

The *NRG Energy* Business Plan of June 1997, submitted for creating by AS *Narva Power*, offers a rational development plan for renovating the oil shale based power plants. Over the period of approximately 8-10 years 500 million USD (half from loan and half from equity) is to be invested in refurbishing 1000 MW of power. The efficiency will be considerably increased (from the current 29 % to 34-35 %). The worn-out existing boilers are planned to be replaced with CFBs, which have been sufficiently studied by *Eesti Energia* and the scientists of the Tallinn Technical University in co-operation with the world's leading boiler construction companies, e.g. LBB, ABB, and *Foster Wheeler*. The 1000 MW capacity to be refurbished would be sufficient to generate 6 TWh of energy at an even load all round the year. Improved efficiency would reduce fuel consumption by 17-24 % and only 14-18 TWh of oil shale energy would be required to generate 6 TWh per year.

Electricity from Oil Shale

Most of Estonia's geological oil shale resources are found in deeper layers than economically justified for opencasts, i.e. deeper than 30 meters. The oil shale resources that the newly refurbished boilers would be using are located in the central part of the oil shale field, in the depth of 40-70 meters. However, the right to use these resources belongs to the *Estonia* mine, which is the largest in Estonia and whose cost price is also the highest. Similar resources are also found east of the Kurtna Nature Reserve, with centers in the *Sirgala* and *Narva* opencasts. These oil shale layers are found in the depth of 20-40 meters. As the production grows, these opencasts will inevitably have to switch to underground mining.

The average cost price of a tonne of oil shale produced in 1997 in the *Sirgala* and *Narva* opencasts constituted 63.5-70 % of the cost price of the *Estonia* mine. The difference in the average calorific value, 9.0 GJ/t in *Estonia*, 8.7 GJ/t in *Sirgala* and 8.3 GJ/t in *Narva*, had only a minor effect here, resulting in 64-73 %. The difference in cost price of this magnitude, supporting surface mining rather than underground mining, would be a very bad perspective for the use of oil shale, if there were no possibilities to considerably cut the price of oil shale.

Oil shale is being enriched in five out of the six mines. Only the relatively small *Kohtla* mine produces unenriched oil shale (ca 0.6-0.7 million t/a). Usually the enrichment process is carried out in two parts: for lumps of the size exceeding 100 mm and for the lump size of 25-100 mm. Lumps of less than 25 mm in size are not enriched. In this process 20 % of the extracted energy is lost as unusable for generation. The energy loss would be reduced to 5-6 % if only lumps of +100 mm in size were enriched.

The Table illustrates the approximate economic results of giving up enrichment either fully or partly in the leading *Estonia* mine in the center of the oil shale fields.

The Cost Price of Oil Shale, Impact of Enrichment and Transportation Costs to Estonian Power Plant - EPP (on the basis of the *Estonia* mine example)

Elements of formation of cost price and sales price	Formation of cost price and sales price on their basis					
1. Oil shale mined (Pk), mill t/a	5			9		
2. Calorific value of oil shale mined, GJ/t	6.7					
3. Enrichment, mm	no	>100	>25	no	>100	>25
Volume of oil shale to be enriched (Pr), mill t/a	0	1.2	3.3	0	2.2	6
4. Marketing (Pt), mill t/a	5	4	3	9	7.2	5.4
• Average calorific value, GJ/t	6.7	7.9	9	6.7	7.9	9
• Energy sales, TWh/a	9.3	8.8	7.5	16.7	15.8	13.5
5. Electricity generated in EPP, TWh/a						
• At the current efficiency of 0.29	no	2.6	2.2	no	4.6	3.9
• Same at the efficiency of 0.35	3.3	3.1	2.6	5.8	5.5	4.7
6. Production: 148.5 + 36.3 Pk, mill EEK/a	330	330	330	475	475	475
7. Enrichment: 9 Pr, mill EEK/a	0	11	30	0	20	54
8. Railway transportation, mill EEK/a						
• Version A using state railways: (3 + 20.6) Pt	118	94	71	212	170	127
• Version B using only internal railways: 5 Pt	25	20	15	45	36	27
9. Prices in EPP, transport						
Version A						
• Oil shale, EEK/t	90	109	144	76	92	127
• Energy with oil shale, EEK/GJ	13.4	13.7	16	11.3	11.6	14.1
• Fuel component in EPP, efficiency 0.35, sents/kWh	13.8	14.1	16.5	11.7	12	14.4
Version B						
• Oil shale, EEK/t	71	90	125	58	74	103
• Energy with oil shale, EEK/GJ	10.6	11.4	13.9	8.6	9.3	11.4
• Fuel component in EPP, efficiency 0.35, sents/kWh	10.9	11.7	14.3	8.8	9.5	11.7

Note: The approximate calculations are based on 1997 prices.

The Table has considered two versions for rail transport of oil shale from the central part of the oil shale fields around the Kurtna-Lakes to the east and the power plants. Version A constitutes the current route, using the expensive (20.6 EEK/t) line between Kohtla-Vaivara. According to version B the route would be shorter by ca 50 km and only the company railway between the mines and opencasts would be used. To use that version the unfinished 14.2 km Ahtme-Sirgala railroad should be completed.

The Table also reveals that the installed capacity of just one mine (i.e. 9 million tonnes of unenriched oil shale or 17 TWh per year) would be sufficient to meet the needs of the 1000 MW refurbished capacity of the power plant if the latter did not have seasonal fluctuations. At the oil shale energy price of 8.6 EEK/GJ the price of the fuel component to Estonian Power Plant (EPP), when using transportation version B, would drop from the current 20 sents/kWh to 8.8 sents/kWh. In this manner the production costs of the 1000 MW power plant at the production level of 6 TWh/a would be reduced by approximately 650 million EEK!

Circulating Fluidized-Bed Boiler

The above figures demonstrate how important it is to combine together the technologies of the consumer and producer of oil shale, but also measures that have nothing to do with technology. The **circulating fluidized-bed (CFB) boiler**, which is able to burn unenriched oil shale with calorific value of 6.7 GJ/t, and the **completion of the Ahtme-Sirgala mine railway** are of crucial importance here. The latter would help avoid the main railway line when transporting oil shale from the mine to EPP. The former has to be definitely taken into account when designing the test boiler in EPP, which is scheduled for this year.

CFB boilers for 1000 MW capacity will be placed into operation gradually - by 200 MW blocks, probably at the interval of 1-1.5 years. The next measure that ought to be of interest is the reduction of the enrichment level of the old boilers that continue operating during the period of transition. For example if the lump size of the enriched oil shale were to be increased from 25 mm to 100 mm the calorific value would increase to 7.9 GJ/t, which is comparable to the oil shale from Russia. Combining this measure with the effect of new boilers would allow the fuel component in the price to be reduced to 9.5-14 sents/kWh in the power plant. Even without the new boilers the fuel component could be lowered to 11.5-17 sents/kWh, depending on the volume of production and transportation conditions.

In addition to the fuel price and transportation costs there are other factors of smaller economic effect that depend on the calorific value. Therefore the first CFB boiler module to be installed in EPP must assist us in choosing the enrichment level for fuel we are going to burn in the future.

Oil Shale Oil

Due to competition with the heavy fuel oil price imported from Russia (which in its turn depends on the world market oil price), the cost of oil shale to produce 1 tonne of crude oil has been kept down to 450-550 EEK. Given the fact that the 1999 cost price of oil shale in different enterprises ranges from 90 to 139 EEK/t, none of the mines or opencasts of the Estonian Oil Shale Company can get this price, since their oil shale produces only 12-15.5 % of oil. The cost of producing one tonne of oil shale oil by using enriched oil shale (11 GJ/t) would be lowest in the *Viru* mine - 760 EEK/t. There is a questionable possibility to reduce the price down to 640 EEK per a tonne of oil shale oil, if the volume of production were increased.

The oil shale costs would be the lowest (710 EEK per a tonne of oil shale oil) when using the selectively mined oil shale in the *Sirgala* opencast, which is used in the solid heat carrier (SHC) retorts in EPP. If Estonian Power Plant starts burning the unenriched oil shale from the *Estonia* mine, yielding ca 10 % of oil, the cost of oil shale could go down to 600 EEK/t. However, such raw material is only usable in SHC retorts.

In the interests of the oil industry, it is crucial to study the characteristics of selectively produced oil shale for both the oil yield and lump size classes, particularly in the case of classes of lump size over 15, 20 and 25 mm, as well as the possibilities for adjusting the Kiviter-type retorts to use leaner oil shale of lesser lump size. Another problem resulting from the increased use of oil shale for the oil processing plants from the western regions of the oil shale fields arises from the fact that large amounts of oil shale slack have to be transported via the main railway line, which adds more than 20 EEK to the price of a tonne of oil shale.

There have been no calculations to show that it is possible to produce oil shale at the price that enables a tonne of crude oil shale oil to be extracted at a cost of less than 600 EEK. It leads from here that it is necessary for the state to subsidise oil shale oil as a strategic product on account of the 90 security reserve of fuel oil. Namely, each tonne of oil shale oil replaces a tonne of imported fuel oil, which has to be kept as a 90 day security reserve and the cost of which is 200-250 EEK per tonne. This cost can be taken as a target in computing the compensation payable by the state to the producers of oil shale oil.

Eesti Energia has calculated the following fuel prices for 1999:

- Heavy fuel oil 1255 EEK/t (31.5 EEK/GJ)
- Natural gas 1120 EEK/1000 m^3 (33.2 EEK/GJ)
- Oil shale oil 1029 EEK/t (26.2 EEK/GJ)

These figures demonstrate that oil shale oil can compete with heavy fuel oil but only to the extent that oil prices do not exceed 20 USD/barrel.

Another factor that has increased preference to heavy fuel oil is the unproportionally low pollution charge on its sulfur content. Therefore one of the advantages of the Estonian oil shale oil - low sulfur content - is not made full use of.

Mining Industry

The oil shale industry lacks a development plan that would take into account the possible changes on the oil shale market. To date the longer term development plans of the Estonian mining industry have been built on maintaining the current production volumes, which the Estonian Oil Shale Company regards as a basis for oil shale policy. There are no concrete real time budgetary calculations and time schedules for restructuring the whole sector in case the production levels drop and production itself becomes more efficient.

It has not been decided **who is going to cover the direct and indirect costs of closing the opencasts or mines,** particularly in the event that the Estonian Oil Shale Company is divided into different organisational structures or the oil processing industry is closed or the oil shale consumption of power plants is reduced.

Until there are no plans for closing oil processing plants and mines, the problem of **supplying oil processing plants with oil shale** in the medium term needs to be resolved rapidly. In order to maintain the sales volumes of the Estonian Oil Shale Company during the few transition years, the oil shale price could be made to meet the proportional cost of the Estonian Oil Shale Company without causing much harm to anybody. The latter forms about 55-56 % of the average of the mines, or 72-73 EEK/t in 1999. It is not realistic to enhance oil shale sales volumes for generating electricity through special prices, especially if this occurred during the summer season. The reason lies in the lack of the relevant electricity market.

Different options are being considered for supplying the oil processing industry with cheap oil shale. Retorts with solid heat carrier have the best chances, since they do not need enriched oil shale. The production capacity of the two SHC retorts is considerably higher than their current oil production of 65 000-70 000 t/a.

The Kiviter-type retorts are unsuitable for the use of unenriched oil shale, whose lump size exceeds 25 mm, and which yields 8-9 % of oil. A rational solution has to be found by using selective mining of oil shale from opencast mines, whose transportation to EPP would become easier as the new railway connection between Ahtme-Sirgala is completed.

Future

The Estonian oil shale energy sector develops in accordance with the long-term fuel and energy sector development plan. If the oil processing industry does not disappear and if the energy blocks in the power plants are refurbished, the share of oil shale as primary energy could be expected to drop from the current level of 36 TWh/a to 27 TWh/a by the year 2010. The change also causes the efficiency of energy conversion of oil shale to increase from 35 % to 45%.

Received March 8, 1998