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DISCUSSION

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SOME PROBLEMS OF OIL SHALE RETORTING IN ESTONIA

Preface

The U.S. Government project led by the Agency for International Development (USAID) is carrying out a pre-feasibility study for an environmental investment project to address the environmental pollution problems of the Estonian oil shale chemical industry.

This paper presents an economical comparison of retorting development scenarios in Estonia using "Kiviter" retorts.

Introduction - Background of the Study

Oil shale in Estonia will be competitive in the long term as a primary resource for power generating. The price of energy of Estonian oil shale is at present approximately 4 times lower than that of coal: in 1994, US$ 1.5 and 6 per MWh, respectively. The forecasts on the long-term development indicate that this difference becomes smaller but by 2010 is still double - approximately US$ 3.6 and 7.2 per MWh, respectively.

The shale oil production at present is profitable. In spite of a deep declining of Estonian industry and energy output during the last three years (approx. 50 %) the production of shale oil has been raised. Shale crude oil production in Estonia was:

Year	1940	1991	1992	1993	1994 (forecast)
Tonnes	180,000	319,000	329,000	365,000	380,000-400,000

But the profitability of the production of shale oil has not been studied for a long-term run. The largest shale processing enterprise in Estonia whose development study will be the subject of the present investigation has on its four retorting plants (Nos. 3, 4, 5 & 6) three large retorts with a feed capacity of 1,000 TPD (Plant No. 6 and one single retort), 12 small retorts of 180 TPD (Plant No. 5), 20 (Plant No. 4) and 16 (Plant No. 3) very small retorts of 50 TPD. Their total capacity at present amounts to 6,200 TPD of shale rock. 237,000 t crude shale oil was produced from 1,556,000 t of shale in 1993.

There are also, but in stopped construction stage, four large retorts with a feed capacity of 4 × 1,400 TPD (Retorting Plant No. 7, Fig. 1). The total costs of reconstruction of retorting plants (including Plant No. 7) and investments for environmental protection are calculated on the basis of the installing budget from 1984 by raising the costs 100 times (Table 2).

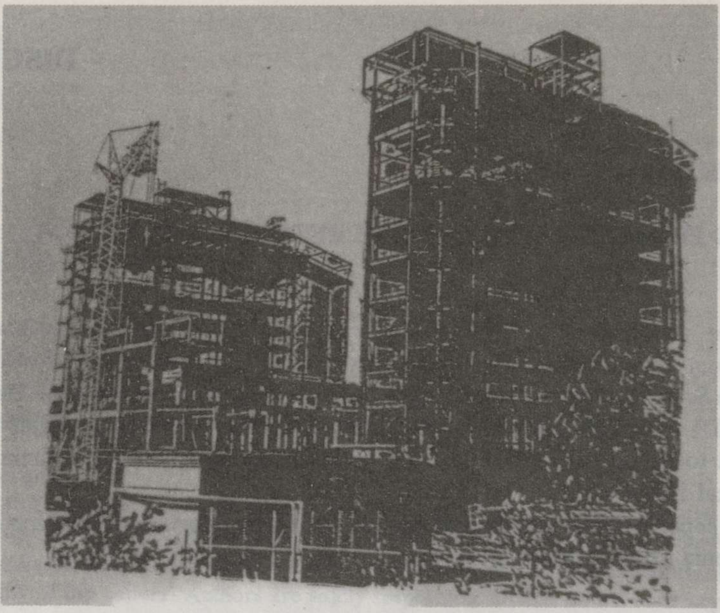

Fig. 1. The unfinished 4 x 1,400 TPD retorting plant

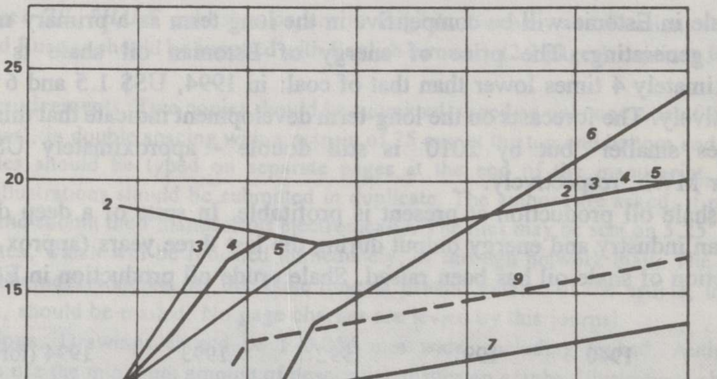

Fig. 2. Basis/rationale: *1* — mazout from Russia, US$/bbl; *2* — heavy fuel oil (HFO) transported from Rotterdam, US$/bbl; *3, 4, 5* — shale oil price scenarios, US$/bbl: *3* — optimistic, *4* — medium, *5* — pessimistic; *6* — level of wages, 1,000EEK/month, including social and medical costs and corporation overheads according to "worst case" scenario by A. D. Little, after 2003 60 % from J. Pöyrö scenario of mining wages; *7* — oil shale price, EEK/100 kg (J. P. forecast); *8* — electricity, 0.10EEK/kWh; *9* — oil shale feed price, EEK/100 kg, including quality premium and transportation costs (1 US$/bbl = 100 EEK/t)

Table 1. **Basis and Rationale for Development Scenarios of Kohtla-Järve Retorting Plants**

1.	The estimates are given in 1994 EEK with no inflation adjustment	
2.	Shale oil production, t/a:	
	Plant No. 3 which will be closed after the full run of the Plant No. 7	40,000
	Plants No. 4, 5 and 6, total	210,000
	Plant No. 7 (Fig. 1)	250,000
	The build-up of production by the year is assumed as follows:	
	from the 1st to the 3rd	construction
	the 4th	50 % production
	the 5th	100 % production
3.	Oil price scenarios, wage level, shale rock price and energy price forecasts	see Fig. 2
4.	Investment costs	see Table 2
5.	Employees (all scenarios) Year: 1994 1995 1996 1997 and later	 3000 2000 1000 800
6.	Oil yield from concentrated shale	18 %
7.	Quality premium and transportation costs	15% + 7 % = 22 %
8.	Power consumption	280 kWh per 1 t of oil
9.	Storage and other operation costs	100 EEK per 1 t of oil
10.	Depreciation	7 % per annum
11.	Interest rate (in real terms)	10 % per annum
12.	Income tax	26 %
13.	Rotterdam HFO price in Tallinn (1994): US$ 90 (average Rotterdam price) + 30 (transportation)	120 US$/t
14.	Russian mazut price in Estonia (1994): US$ 90 (average Rotterdam price) - 30 (trasnportation)	60 US$/t
15.	1 US$ = 14 EEK	
16.	1 US$/bbl = 100 EEK/t	

Table 2. **Evaluation of Distribution of Investment Costs since January 1994 and the Total Value of Investments Including Investments Made before 1994, %**

Line No.	Explanation	Investments for finishing the reconstruction (incl. Plant No. 7) since 1994	Budget value
1.	Field stripping (dismantelling etc.)	3	7
2.	4×1400 TPD Kiviter retorts with condensation system	16.5	23
3.	Shale handling, incl. two railway rotary dump-cars	15	16.5
4.	Solid residue handling* by hydraulic transport, incl. costs for a new pile for old and new retorts	8.5	16
5.	Gas handling and cleaning* for old and new retorts	7	7
6.	Oil and other production handling	5	7
7.	Tanks, networks and systems of internal railways	12	13
8.	Electric power station for shale gas utilization*	10.5	14.5
9.	Waste and fresh water handling*	6	9
10.	Infrastructure, incl. motor roads, drainage, installation fences, changing rooms and office buildings etc.	16.5	25
11.	Design work	?	6
	Total, % Mio EEK, ca	100 600	144 850
	*Environmental protection investments total, Mio EEK, ca	210	280

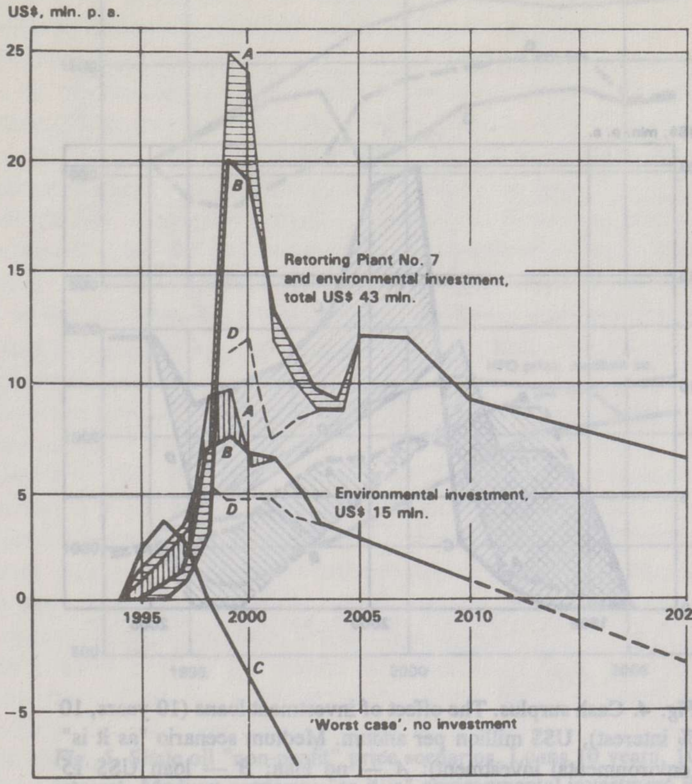

Fig. 3. Cash surplus, US$ million P. A. Shale oil minimum price: *A* — 100 % Western heavy fuel oil price up from 1999 (optimistic scenario); *B* — 100 % Western heavy fuel oil price up from 2001 (medium scenario); *C* — 100 % Russian mazut price ("worst case" scenario); *D* — 100 % Western heavy fuel oil price up from 2003 (pessimistic scenario)

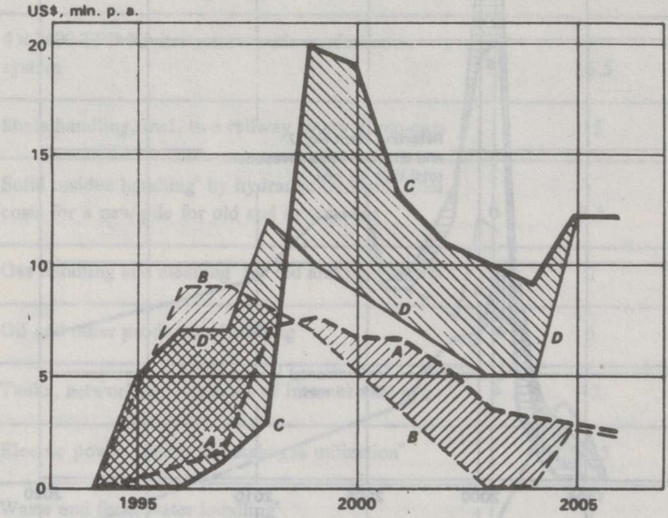

Fig. 4. Cash surplus. The effect of investment loans (10 years, 10 % interest), US$ million per annum. Medium scenario "as it is" (environmental investment): *A* — no loan; *B* — loan US$ 15 million. Medium scenario — investments for environmental protection and increasing production: *C* — loan US$ 11.4 million; *D* — loan US$ 43 million

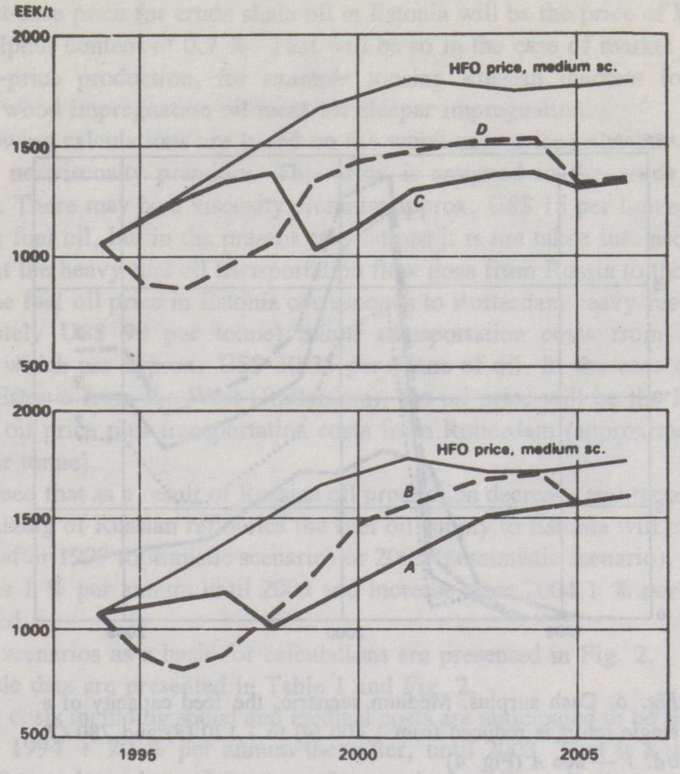

Fig. 5. Shale oil "non-profit" price scenarios. Loans 10 years, 10 % interest. Medium scenarios "as it is" environmental investment EEK 210 million: *A* — no loan; *B* — loan US$ 15 million. Medium, investment EEK 600 million for environment protection and raising production from 250,000 to 460,000 t/a shale oil: *C* — minimum loan US$ 11.4 million; *D* — loan US$ 43 million

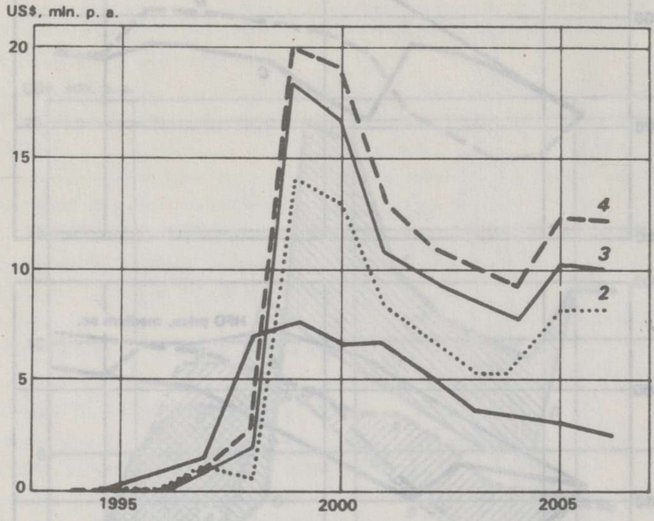

Fig. 6. Cash surplus. Medium scenario, the feed capacity of a single retort is reduced from 1,400 (*4*) to 1,120 (*3*) and 780 (*2*) t/d. *1* — see *A* (Fig. 4)

Shale Oil Price and Other Basic Data

The shale retorting and shale oil refining products are presently sold as middle and heavy fuel oil, wood impregnation oil, road oil, rubber softener, electrode coke for aluminium industry and phenols of resorcinol type.

The worst-case price for crude shale oil in Estonia will be the price of heavy fuel oil with sulphur content of 0.7 %. That will be so in the case of market losses for the higher-price production, for example loosing Russian markets for phenol-containing wood impregnation oil ment for sleeper impregnation.

The following calculations are based on the worst-case price - the heavy fuel oil price with no viscosity premium. This price is assigned to the crude shale oil production. There may be a viscosity premium approx. US$ 15 per tonne for crude shale oil as fuel oil, but in the present calculations it is not taken into account.

At present the heavy fuel oil transportation flow goes from Russia to the West. In this case the fuel oil price in Estonia corresponds to Rotterdam heavy fuel oil price (approximately US$ 90 per tonne) minus transportation costs from Russia to Rotterdam which are approx. US$ 30-35 per tonne of oil. In the case of fuel oil import to Estonia from the West (Rotterdam), the oil price will be the Rotterdam heavy fuel oil price plus transportation costs from Rotterdam (approximately US$ 120-125 per tonne).

It is assumed that as a result of Russian oil production decrease and reconstruction for modernizing of Russian refineries the fuel oil supply to Estonia will come from Rotterdam after 1999 (optimistic scenario) or 2003 (pessimistic scenario). A decline in oil prices 1 % per annum until 2003 and increase after 2004 1 % per annum is also assumed.

Oil price scenarios as a basis for calculations are presented in Fig. 2.

Other basic data are presented in Table 1 and Fig. 2.

The wage costs including social and medical costs are anticipated to be EEK 2,500 a month in 1994 + 20 % per annum thereafter, until 2003. That is a wage level optimistic for workers, but a "worst case" scenario for oil production.

After 2003, the wage cost development is anticipated to be more moderate, up to EEK 24,000/month by the year 2020.

The oil shale price is calculated by Jaakko Pöyry Consulting Oy on the basis of wage cost in 1997 10,000/month, in 2000 20,000/month and in 2020 40,000/month and considering a new LHD (loading-hauling-dumping) technology in underground oil shale mines.

It is anticipated that there will be a restructuring of the Kiviter Ltd. and decrease in the number of employees from 3,000 in 1993 to 800 in 1997. It is anticipated that after the full run of the plant No. 7, the plant No. 3 will be closed and there are no changes in the number of employees at the enterprise. The oil yield from shale feed is anticipated to be 18 % (or 15.8 % with no quality premium), the quality premium of concentrated shale feed - 15 %, transportation costs are anticipated to be 7 % from oil shale price.

The price of electricity is anticipated to grow up to EEK 1.0/kWh in the year 2020. The electricity price EEK 0.2/kWh at present in Estonia does not include capital costs needed for refurbishing of Estonian oil-shale-consuming power stations between the years 2000-2010.

While all the prices and calculations of the enterprise are presented with no inflation adjustment, the other operation costs of oil shale retorting are anticipated for the prognosed period to remain at the present level: power consumption kWh 280/t of crude oils and other operation costs (excluding labour, raw material and power consumption) EEK 100/t of oil.

Results, Discussion and Conclusions

The results of the study are presented in Figs. 3, 4, 5 and 6.

1. There is no perspective for environmental protection and production sphere investments if the shale oil price will stay at the level of the present Russian heavy fuel oil price (Fig. 3).

2. The shale oil production with "Kiviter" retorts is profitable for a long run and may be expanded if the shale oil price stays at the level of the price of imported Rotterdam heavy fuel oil.

3. It is recommended to study the possibility to rise the total feed capacity of "Kiviter" retorts in Estonia to a full utilization of the mined lumpy (over 25 mm size) resource, approximately 4-5 million tonnes per annum.

4. The optimum 10-year, 10 % interest p.a. loan for environmental investments only is between US$ 5-15 million, for simultaneous investments both for environment protection and raising production is US$ 20-43 million.

5. The dependence of the oil shale processing economy from the shale feed quality is moderate taking into account a correction of the quality premium of the shale. For example, a decrease of oil yield 20 % (approximately from 18 to 15 %, on feed shale basis) calls forth a rise of operation costs about 5 %.

6. The profitableness of the new plant can stand a risk of a loss amounting to 50 % of the planned capacity of a single retort (1,400 TPD) and of corresponding decrease in oil production.