MINISTRY OF THE ENVIRONMENT OF THE REPUBLIC OF ESTONIA

NATIONAL DEVELOPMENT PLAN FOR THE UTILIZATION OF OIL SHALE 2008–2015

Tallinn 2008

CONTENTS

INTRODUCTION

The basis of preparing the development plan ”Determining the developments in oil shale as a nationally strategic energy resource, incl. evaluation of the utility possibilities of shale oil and shale gas in implementing Approval of the National Long-Term Development Plan of the Fuel and Energy Sector up to 2015“ (hereinafter referred to as *Development plan for fuel and energy sector*), Table 4 of which provides that the function of the Government of the Republic is to determine the developments in oil shale as a nationally strategic energy resource [1].

According to the State Budget Act § 10 (2) and in accordance with the Government of the Republic's 13 December 2005 regulation No. 302 “Types of strategic development plans and the procedure for drawing up, amending, implementing and reporting on such plans”, the Government of the Republic with its 11 July 2006 order No. 384 approved preparation of the Oil shale development plan, appointed the Ministry of the Environment as the ministry responsible, and the Ministry of Economic Affairs and Communications and Ministry of Finance as ministries participating in the preparation process. According to the Earth's Crust Act § 34 (3) (amended by the Earth's Crust Act Amendment Act passed on 13 June 2007 and entered into force on 8. July 2007), the „ The implementation plan of the Oil shale development plan that has been prepared for the years 2008–2011 for the time being, shall be approved by the Government of the Republic.

Simultaneously with preparing the Oil shale development plan, the Minister of the Environment initiated strategic assessment of the environmental impact of the Oil shale development plan (hereinafter referred to as *EIA*) on the basis of the Environmental Impact Assessment and Environmental Management System Act § 33 (1) (1) and § 35 (2). The Minister of the Environment approved the EIA programme with 13 December 2006 directive No. 1369, and the EIA report with the 17 April 2007 directive No. 449.

The Oil shale development plan is guided by § 5 of the Constitution of the Republic of Estonia, according to which the natural wealth and resources of Estonia are national riches which shall be used economically. It has been guided by the requirement to use oil shale with maximum efficiency and with an objective to preserve the oil shale resources for as long as possible. Under the term of environment in the Oil shale development plan, the deeply intertwined wider natural-, economical and social environments are implied to.

The Oil shale development plan is a initial strategy document for developing the oil shale sector in the next eight years, providing the directions and principles for solving individual issues in this field. The objectives and methods presented in the Oil shale development plan act as a basis for planning state budget funds. The three most important strategic goals are as follows:

1) to guarantee Estonia's supply of oil shale energy and ensure energetic independence of Estonia;
2) to increase the efficiency of oil shale mining and use;
3) to decrease the environmental impact of oil shale mining and use.

The investments stipulated in the Oil shale development plan are necessary for realizing the state's interests in directing the use of oil shale. The activities fixed for that are related to the following fields:

1) legislation;
2) charges and fees on exploitation of the environment and taxes;
3) research for the optimum mining and use of oil shale;
4) harmonization and improvement of national development plans.

The main target groups the Oil shale development plan are:

1) businesses in the field of oil shale mining and use;
2) inhabitants in the areas of the Estonian oil shale deposit area, influenced by the relevant environmental and social issues;
3) the whole population of Estonia, consuming electricity and heat.

Estonian energy resources are based mostly on oil shale that ensures extremely important strategic independence of the state's power supply in the current international situation. In 2006, the oil shale percentage in electricity production was 90.2%. Using oil shale has two important positive aspects: the energetic security of supply and low level of dependence on the world market prices. The Oil shale development plan is guided by the fact that despite the planned energy savings measures, the consumption of energy in the Republic during the reference period does not decrease but increases. Establishing capacity based on other energy sources in Estonia or by cooperation with Latvia and Finland, as well as the impact and opportunities of the opening electricity market, are yet unclear. It would be unrealistic to rely on renewable energy resources for covering large-scale need for electric energy.

The coalition programme for 2007–2011 states that the coalition aims for the maximum oil shale mining capacity of 15 million tons a year. This coincides with the Oil shale development plan's objective to find ways to reduce the oil shale mining capacity, although initially, the maximum limit of oil shale mining is set to 20 million tons a year. The aim of this restriction is to ensure sustainable use of the oil shale resources, and in the long run, find ways to progressively reduce the annual use of oil shale in order to significantly reduce the negatiive environmental and social impact related to mining and using of oil shale. In implementing the Oil shale development plan, the objective is to achieve a maximum limit of oil shale mining of 15 million tons by the year 2015, for which a thorough analysis of the developments in the energy sector is necessary. If the allowed annual capacity would be lowered to 15 million tons immediately, there would be a serious problem with supplying Estonia with electrical energy. Considering the extraction permits issued to oil- and cement producers, only 9 million tons of oil shale would be left for producting electricity and heat, which is not enough for the period considered in the Oil shale development plan.

In relation to the fast development of Estonian economy and the resultant increase in consumption of electrical energy, the Government of the Republic appointed the Ministry of Economic Affairs and Communications to be responsible for preparing the "National development plan for the energy sector until 2020" by the 10.01.2008 order No. 13. The Development plan for energy sector is also the basis for the Oil shale development plan in addition to the Development plan of electricity economics and the Development plan for enhancing the use of biomass and bio energy. Pursuant to the electricity production strategy established in the process of preparing the development plans for energy sector and of electricity economics, different methods can be analysed for reducing the annual oil shale mining capacity to 15 million tons per year and to plan the implementation of alternative sources of energy.

1. CONNECTIONS TO STRATEGIES AND DEVELOPMENT PLANS OF OTHER AREAS, AND THE INSTITUTIONS PARTICIPATING IN THE PROCESS

The Oil shale development plan shall be prepared in consistency with other relevant development plans, i.e. the Development plan for fuel and energy sector [1], Development plan of the Estonian electricity economics 2005–2015 (hereinafter referred to as *Development plan of electricity economics*) [2] and several other development plans and strategy documents:

Estonian National Strategy on Sustainable Development "Sustainable Estonia 21" (SE 21) [3]. Since one objective of a knolwedge-based society is a general increase in well-being, according to ES 21, involving natural resources in creating the necessary economic base is inevitable. Sustainable administration of a natural resource is not merely protection, it means also using an ecologically balanced resource. Using a natural resource is accompanied by previously prepared justified and economically most profitable schemes of optimal use, and the mechanisms counterbalancing natural and social developments. All this can be considered only together with principles that ensure environmental protection. Sustainable consumption mechanisms shall be implemented on the criteria of public procurements, national investment programmes and other development plans. The Oil shale development plan is guided by these principles.

Estonian environmental strategy until 2030 [4]. The Oil shale development plan is very closely connected to the objective of the Estonian environmental strategy until 2031, which is environmentally friendly mining of mineral resources, saving water, landscapes and air, and using the mineral resources efficiently with minimal loss and waste. The measures of such strategy are said to be preparation and implementation of long-term national development plans of use of mineral resources (the basis of the development plans are the schemes for optimal use of the resource, promoting the use of the resources in accordance with the state's needs on scientific basis), and directing the activity of enterprises that extract and use mineral resources towards environmental safety by implementing a system of regulations and aids. Preparing the Oil shale development plan is one way of implementing the aforementioned measures.

Estonian Research and Development and Innovation Strategy 2007–2013 "Knowledge-Based Estonia"[5]. Estonian Research and Development and Innovation Strategy 2007–2013 "Knowledge-Based Estonia" (KBE II) is focused on the sustainable development of society through research and development activities and innovation. On the basis of this strategy, national research and development programmes shall be implemented to solve socio-economic problems and achieve the objectives in socio-economic fields that are important to all Estonians, i.e. energetics, national defence and security, healthcare and welfare services, environmental protection, information society. National reserarch- and development programme on energetics is closely connected to planning of scientific and applied research on oil shale, and preparation and training of the relevant specialists.

Long-term national development plan for fuel and energy sector until 2015 [1]. According to the development plan for fuel and energy sector, the relative importance of local energy sources in Estonian energy resources and primary energy balance will continue to be high for the next ten years, based to a large extent on oil shale. This ensures us a considerable strategic independence in electric supply (the relative importance of imported energy sources is ~1/3, whereas the average in the EU Member States is ~2/3). The main positive aspects of large-scale use of oil shale are the energetic security of supply of the country and low level of dependence on the world market price. As a negative side, heavy environmental damage accompanies both extracting and using oil shale, and the oil shale has low heat value. Therefore, we must preserve competitiveness in oil shale production in the open market conditions, and ensure the rise in effectiveness; however, on the other hand, we must preserve the environment. The main objective of the Oil shale development plan is also to ensure fuel and energy supply with proper quality and optimal prices, and to guarantee the necessary fuel supply to cover the domestic electric consumption load. A lot of attention has been turned to fulfilment of environmental protection requirements – therefore, the Oil shale development plan relates to the objectives set out in the Estonian development plan for fuel and enegy sector, which are ensuring preservation of competitiveness in oil shale production under the conditions of the open market, and increase in effectiveness by implementing modern technologies that reduce environmental impact, and to ensure the fulfilment of nationally established environmental requirements. The other objective is to ensure constant presence of modern know-how and specialists in all fields of the fuel and energy sector to encourage domestic technology development and to enable transfer of the modern energy technology. Indirectly, the Oil shale development plan is also related to establishing connections with Nordic and Middle-European energy systems, since the parallel work of Estonian energy system in a combined energy system also necessitates export of electrical energy and availablity of the corresponding fuel supply. The activities of the development plans are related to achieving the aforementioned objectives, but there are no overlaps in the funding of these development plans.

The Development plan for the Estonian electricity economy 2005–2015 [2]. The Development plan for electricity economy stresses the fact that shale oil is a strategic mineral resource and producing electricity from oil shale is our national speciality. In the financial year 2003 / 2004, AS Eesti Põlevkivi sold 14.35mn tons of shale oil, forming 92.7% of the total oil shale consumption. The relative importance of oil shale in Estonian electric economy fuel balance has demonstrated a small

falling trend in the last years. The biggest consumer of oil shale is AS Narva Elektrijaamad with ~12mn tons. Electricity and heat are produced from oil shale also in Ahtme, Kohtla-Järve and Sillamäe power plants. In addition to burning, oil shale is used to produce shale oil, and in the chemical industry; in 2003, it was 2.8mn tons. The same amount was used in 2005. Based on the technical and economic conditions of the power plants, the mineable reserve of oil shale would last for approximately 40 years provided the current rate of consumption. The mineable proved reserve of the currently used opencasts and pits of AS Eesti Põlevkivi would last until ~2020 at the current speed of consumption. If the consumption capacity does not decrease, new opencasts would have to be opened in 50 years; in case of increase in the consumption capacity, even sooner.

The most important objective is to guarantee the local generating power to cover the local consumption load, develop technologies that use energy resources more effecitvely, including combined heat and power, and to support the increase in effectiveness of production of electricity from oil shale as a local strategic resource in an open market, and to support the competitiveness of the domestic market. The Electricity economy development plan also stresses improved oil shale technologies as the domestic priority in energy development.

Proceeding from these aforementioned priorities, energy-related research and science programmes need to be developed in national educational and reasearch institutions, and these guidelines should be considered in directing and supporting research and development.

Estonian rural development plan for 2007–2013 [6] (hereinafter referred to as *Rural development plan*) is indirectly related to the Oil shale development plan through the priority axis No. 2 in the Rural development plan, discussing improvement of the environment and countryside, focusing on the less-favoured areas. In the future, the main focus would be afforestation of the areas left out of agricultural production, primarily of protective belts, to ensure good environmental condition. Indirectly, it also affects areas damaged by mineral industry. The Oil shale development plan can be connected to the priority axle No.3 of the rural development plan – quality of life in rural areas and diversification of the rural economy, treating the diversification of the economic activities in rural areas and renewal and development of villages. In order to improve the business situation, attention is focused on the development of operation of small businesses. Primarily, diversifying the activities of small agricultural holdings with other rural operations outside agriculture is encouraged. These activities do not much relate to the issues of the Oil shale development plan, since oil shale extration is mostly large-scale production. To some extent, restoring and reconditioning of the surface opencasts stated in the Oil shale development plan will foster emergence of new, mostly tourism-related areas of activity. The most preferred areas are non-agricultural production based on local resources, rural tourism, handicraft and provision of services directly related to improvement of the quality of life in rural areas. Due to that, employment in the secondary and tertiary sectors will increase and the jobs lost in agriculture shall be compensated.

Regional development plans. Regional development plans have been taken into consideration when preparing the Oil shale development plan. The subject under consideration has been quite thoroughly treated in the economic part [7] of the explanation letter to the Ida-Viru county plan (enacted on 22.01.1999). According to the Ida-Viru county thematic plan prepared in 2003 “Environmental conditions that influence settlement and land use“, the oil shale mining- and exploration fields are to a great extent located in the heartland of the green network being planned by the thematic plan. It means that if construction of an industrial object is necessary or unavoidable, a detailed plan has to be made to choose the location of the facilities, an environmental impact assessment (hereinafter referred to as EIA) carried out and measures taken to mitigate the negative environmental impact.

The Ida-Viru county thematic plan from 2002, ”Spatial planning of the Ida-Viru county oil shale mining areas“ makes provisions for continuation of oil shale mining and processing in that area. The Oil shale development plan is in accordance with the development plan of Ida-Viru county that provides for development of large-scale industry. According to the version [7] of the Ida-Viru county development plan (implemented on 21.09.2005), one of the visions guiding the business environment is worded as follows: "Ida-Viru county is an active business area (the entrepreneurial initiative has increased by more than 30% compared to 2004), with a large-scale industry based on

a modern technology ensuring its efficiency and competitiveness, and on the service-, logistics- and tourism sectors."

To achieve and support the objectives of the Ida-Virumaa waste management plan fees for mining rights and pollution charges need to be increased, annual amount of oil shale utilization must be limited and technological restrictions to extraction and utilization of oil shale established to ensure that the enterprises use technologies that produce little residue and enable to recycle them as much as possible.

The similar principles are carried and objectives in the field of environmental protection and development are set in the version 2006 of the Lääne-Virumaa development strategy 2007–2015[9], and the corresponding development plans of the rural municipalities in Lääne-Viru county. The SEA report addresses the connections between the development objectives of Lääne-Viru county and the current situation more thoroughly.

IX The National Environmental Action Plan of Estonia 2007–2013 [10] (hereinafter referred to as *Environmental Action Plan*) presents a series of principles that directly correspond to the Oil shale development plan. For example, achieveing control over waste streams and intensification of the control over waste management; in all sectors, preferring and implementing the best possible environmentally friendly technology and uses the material effectively; replacing the hydro transportation of oil shale coke with some other, more environmentally friendly technology; setting the optimal mining capacity in a certain time-frame (for up to 20 years), etc. The valid Environmental Action Plan aims to implement the Oil shale development plan, which implies all the objectives of the development plan would be implemented.

According to the **Sustainable Development Act** [11], the development of economy sectors and regions where pollution of the environment and use of natural resources may endanger the natural balance or biological diversity, shall be guided on the basis of a national development plan. The use of oil shale needs to be directed on the basis of a national development plan, to ensure the availability of the established resources for as long as possible, and to avoid polluting the environment as much as possible. Since there is inevitably an important economic impact to extracting and using oil shale, accrual of new negative environmental impact can be prevented on the basis of the Oil shale development plan, and the present negative effects in North-East Estonia mitigated. On the basis of this, the state can direct the extraction and use of oil shale more purposefully and usefully to the society.

In the Oil shale development plan, oil shale complex is taken as a whole, paying attention to the state's need to use oil shale as a strategic energy resource and taking account the growing need for oil shale as a raw material in oil and chemical industries. In planning the division of reseources and forming recommendations it has been presumed that national interests are of paramount importance. The Oil shale development plan determines the state's interests in processing extraction permits, and tries to take into consideration the plans and development plans of regional and local municipalities to an extent that does not prejudice the justified interests of the state and nation as a whole.

The Government of the Republic has appointed the Ministry of the Environment as the main executor of preparing the Oil shale development plan, and Ministry of Economic Affairs and Communications and Ministry of Finance as participants in the preparation process, but also including other ministries and offices. The participation of the Ministry of Social Affairs is particularly important, since many employment and social-demographic problems are related to extraction and use of oil shale. The Lääne- and Ida-Viru county governments and all relevant oil shale related local offices are also included. Numerous scientific research establishments have been related to the basic oil shale research, first and foremost Tallinn University of Technology [12-16] and University of Tartu. The specialists of AS Eesti Põlevkivi, AS Viru Keemia and OÜ Merko Kaevandused belong to the Oil Shale Committee. The representatives of the Estonian Fund for Nature, Estonian Green Movement, Estonian Society for Nature Conservation, Estonian

Council of Environmental Organisations and Estonian Women`s Associations were involed in the oil shale roundtable. Numerous different stakeholders were involved in the process of preparing the Oil shale development plan in drafting the EIA.

2. ANALYSIS OF THE CURRENT SITUATION

It is widely known that due to extraction and processing of oil shale, spoilt landscapes expand, natural water network is destroyed and the quality of ground water suffers. The territories under landfill expand. Depending on the production volume and strictness of environmental requirements, emissions of hazardous waste to air and water may increase. Former pollutions that have not been taken under complete control and the obligations of enterprises and several institutions to control the contamination have not been precisely determined yet.
The scenario of electric supply in the development plan of electricity economy is no longer practicable due to the rapid growth of the price of natural gas and the problems in supply security. At the same time, the state's need for electric energy will be rising quickly in the upcoming years (according to the estimation, 4–6% a year), although in the development plan of electricity economy, the increase was estimated to be 2–3.75% in case of rapid economic growth. Renewable energy cannot cover these growing needs. In 2005, Estonia needs production capacity of 2300–2500 MW to ensure electric supply, and the only way to cover that demand at the moment is to use oil shale in at least the same extent, continuing reconstruction of AS Narva Elektrijaamad, and establishing new fuel-based generation capacities, incl. increasing the use of renewable energy sources. Oil shale has to be extracted and processed in the most environmentally friendly and sustainable way, also considering the accompanying social impact.

One of the most effective ways of sustainable consumption of oil shale is energy saving. Since 2012, the energy market will be completely open and this may bring about some structural changes among energy enterprises. Currently, the same enterprise holds resource utilization, production of eletricity, transmission, and most of the distribution. Oil shale resource as a national treasures must stay under the management of the Republic of Estonia.

2.1. Main definitions in the field of oil shale use

Resource is earth's component used in economic activities, i.e. rock, mineral, deposit, etc.

Reserve is the amount of resources that is stated in the list of mineral deposits of the environmental register (thousand tons). Division into proved reserve, inferred reserve and possible reserve is done on the basis of the amount of geological research carried out. The most detailed research has been performed on proved reserve (Pr), the next is inferred reserve (I), and the least researched is the possible reserve. Proved and inferred reserves of mineral resources are divided into mineable reserves (M) and submarginal mineral resources (S) on the basis of their usability and economic importance. Mineral reserves are mineable when the technology and machinery used in extraction ensure the rational use of the crust and fulfilment of environmental requirements, do not bring about social changes that hinder sustainable development and worsen living conditions in that area, and using that mineral resource is economically beneficial. According to the Earth's Crust Act [17], a reserve can be considered submarginal if using it is not possible due to environment protection reasons, or there is no technology to extract it at the moment, but the reserve may become usable in the future. The other important criteria in determining the category of mineral reserves are objects and areas under nature protection. Oil shale reserve that is located in any kind of protected area, is generally considered submarginal or nonextractable. In many areas, reserves are submarginal due to economic criteria (low contents of organic substance in the rock) or nature conservation restrictions. Social criteria also need to be considered in determining whether a reserve is mineable or submarginal.

Estonian oil shale deposit includes 23 sections that are called mining- and exploration fields.

Mining- and exploration fields are sections of mineral deposit, the limits of which are defined in the course of work on the basis of different geological, geographical, historical and subjective conditions, divided into blocks.

Block is a three-dimensional part of earth, the mineability and reliability of which are considered to be constant. In blanket deposits like Estonian oil shale deposit is, blocks are considered as areas.

Energy rating (GJ/m^2) is the quality of oil shale determining it as a mineral resource, on the basis on which the mineability of a reserve is determined. According to the valid criteria, a reserve is mineable (profitable), when the energy rating is higher than 35 GJ/m^2, and submarginal, when the energy rating is between 25–35 GJ/m^2. To distinguish oil shale as an energy carrier, the term **trade oil shale** is used. The quality of trade oil shale is determined on the basis of Standard of the Republic of Estonia EVS 670:1998. This standard establishes the norms for quality criteria and the quality groups of extracted oil shale as a commodity that is used as fuel and raw material.

The **index of mineability** is a complex indicator that takes into consideration the econometric connections between the main characteristics of mining conditions and the economic results (extraction costs, capital consumption).

Mineability index	Mineability
<0.7	very low
0.7....0.9	low
0.9...1.1	average
1.1...1.3	high
>1.3	very high

Potential amount of energy in reserve block and on the field is energy rating multiplied by the surface area of the reserve block.

Mineral resource loss are mineral resources that have been accounted for but become unusable. Part of the mineral resources becomes unusable because of extraction and economic activities not related to mining. However, loss may also be induced by mistakes in taking inventory of the deposit, taking too much inventory or not in conformance with the requirements. General loss is resource that remains in the roadway pillars, barrier pillars left in the borders of allotment, protective pillars of the mining field's roads and other structures, etc. Mineral resource loss is divided into loss in the earth, loss of broken ground and loss by enrichment [13,14]. When 12mn tons of oil shale is extracted, the mineable reserve decreases by approximately 16mn tons.

The **workings** are divided into operating-, opening-, preparatory- and mine workings according to the regulation "requirements for mining and secondary use of a working" enacted on the basis of the Mining Act. An opening working is a working that is established to open a mining field and used during the mining process (a vertical or inclined shaft to transport oil shale, necessary equipment and people, a main haulage drift with the parallel workings (ventilation drift, conveyor drift, etc), and opening trench, cutting trench (a trench). A preparatory working is a working established to prepare for extraction of a mineral deposit (panel haulage, ventilation- and water drift, a collection drift, etc). A mine working is a working in which extraction takes place (mining trench, block chamber, winning of pillars, digging trench (cavity), stopes, lava, etc). An operating working is a chamber (a pump room, engine depot etc), storage (an explosives storage etc), a trench, inclining trench or other working necessary on the object.

Rock breaking is breaking mineral resource from a massif.

Closed dump is a mining term for a mass of accumulated mineral deposits.

A **condensing power plant** is a thermal power plant that produces only electric energy.

Semi-coke is a solid residue from oil shale retorting.

Separated products are oil shale processing residues that form from mechanical foreign matters in cleaning raw oil.

Longitudinal section mining is a form of underground mining, where mostly longitudinal section mining with double-unit faces has been used to win the oil shale, in the process of which the ceiling was also collapsed after winning of the oil shale.

Room-and-pillar mining is a form of underground mining where ground is held on the pillars left unmined.

Sink is setting of ground and a **ground sink** is sinking of a ground due to deformation, as a result of which a sunken area (subsidence trough) is formed.

Influence cone or **depression cone** is a depression cone of ground water forming around a working opencast (a cone-shaped depression of ground water open- or pressure surface).

Retorting gas is the gas that forms in the process of retorting, and **retorting** is dry distillation.

A working face is **an area in an opencast where mineral resources are extracted at the moment.**

2.2 Valid extraction permits and applications for extraction permits

In the period of 1999–2005, 18 oil shale extraction permits has been issued to four enterprises to mine in total up to 23.75mn tons of oil shale a year. An overview of the valid extraction permits is presented in Table 1.

Table 1. Valid extraction permits as at 01.01.2008.

Permit No.	Permit owner	Name of extract-ion permit area	Valid since	Valid until	Resource, thousand t	Max. annual product-ion, thousand t	Surface area, ha
KMIN- 017	Põlevkivi Kaevandamise AS	Vanaküla mining fields	18.08.1999/ 1 5.06.2006	11.07.2014	4260.4	1000	131.90
KMIN- 036	Põlevkivi Kaevandamise AS	Vanaküla mining fields II	22.07.2002	17.08.2012	2850	40	8.82
KMIN- 037	AS Kunda Nordic Tsement	Ubja oil shale opencast	15.08.2002	24.06.2027	3495	300	152.22
KMIN- 041	Põlevkivi Kaevandamise AS	Vanaküla mining fields III 1)*	06.05.2003	06.05.2013	132		4.09
KMIN- 045	Kiviõli Keemiatööstuse OÜ	Põhja-Kiviõli oil shale opencast	25.07.2003	18.07.2028	7603	1000	243.69
KMIN- 046	OÜ VKG	Narva	18.08.2003	15.08.2028	16653	1000	544.11

	Aidu Oil	oil shale opencast II					
KMIN- 052	Põlevkivi Kaevandamise AS	Vanaküla mining fields IV 1)*	22.07.2004	21.07.2014	200		6.18
KMIN- 053	Põlevkivi Kaevandamise AS	Viru opencast	22.07.2004	10.08.2019	45600	2500	4191.57
KMIN- 054	Põlevkivi Kaevandamise AS	Estonia opencast	22.07.2004	10.08.2019	281342	5000	14162.54
KMIN- 055	OÜ VKG Aidu Oil	Ojamaa oil shale opencast	27.09.2004	27.09.2029	58681	2500	1694.21
KMIN- 059	Põlevkivi Kaevandamise AS	Vanaküla V mining field [1)]*	25.10.2004	11.07.2014	53		1.65
KMIN- 062	Põlevkivi Kaevandamise AS	Vanaküla VI mining field [1)]*	31.03.2005	11.07.2014	370		11.44
KMIN- 066	Põlevkivi Kaevandamise AS	Sompa opencast	11.04.2005	31.12.2014	20044	700	3379.77
KMIN- 067	Põlevkivi Kaevandamise AS	Tammiku opencast	11.04.2005	10.08.2019	5557	1000	4014.05
KMIN- 073	Põlevkivi Kaevandamise AS	Narva mining field	20.06.2005	10.08.2019	39636	2200	4255.77
KMIN- 074	Põlevkivi Kaevandamise AS	Sirgala opencast	29.06.2005	03.05.2019	74011	3000	11296.60
KMIN- 075	Põlevkivi Kaevandamise AS	Aidu opencast	29.06.2005	03.05.2019	15157	3050	2555.01
KMIN- 087	Põlevkivi Kaevandamise AS	Sirgala	18.04.2006	07.03.2031	7503	500	233.75
TOTAL						23750	

1)* For Vanaküla mining fields, total annual production is presented

In 2005, 16 applications for oil shale extraction permits were submitted to the Ministry of the Environment, for some regions there were several applications. Applications have been submitted to extract a total of 26,315mn tons of oil shale per year, which means that in case all applications are accepted, the allowed amount of extractable oil shale would be 50,065mn t/year together with the extraction permits issued so far. An overview of the submitted and pending applications for extraction permits is given in Table 2. Processing of the applications has brought about numerous objections and court cases. The processing of all applications for oil shale extraction permits has been suspended in accordance with the amendment to the Earth's Crust Act passed in the Riigikogu until the general trends in the use of oil shale as a

nationally strategic source of energy have been determined in the Oil shale development plan.

Table 2. Valid extraction permits as at 01.01.2008.

Mining field, exploration field	Applicant	Resource to be extracted, th t	Maximum annual production, th t	Deadline
Uus-Kiviõli exploration field	OÜ Merko Kaevandused	207867	6000	25 years
	OÜ VKG Aidu Oil	207867	5000	25 years
	Põlevkivi Kaevandamise AS	207867	6000	25 years
Sonda exploration field	OÜ Merko Kaevandused	88207	4000	25 years
	OÜ VKG Aidu Oil	88207	2000	30 years
Seli exploration field	OÜ VKG Aidu Oil	135000	3700	30 years
Põhja-Kiviõli exploration field	Kiviõli Keemiatööstuse OÜ	21529	1500	25 years
Aidu mining field	OÜ Merko Kaevandused	16750	1500	
	Põlevkivi Kaevandamise AS	17175	1)*	15 years
	Põlevkivi Kaevandamise AS	8561	1)*	10 years
	OÜ VKG Aidu Oil	7114	1200	15 years
	Citizen Priit Piilmann	7114	1200	15 years
Narva mining field	OÜ Merko Kaevandused	2884	115	25 years
Oandu exploration field	OÜ VKG Aidu Oil	120000	4000	30 years
	OÜ Merko Kaevandused	133234	4500	30 years
Puhatu exploration field	OU Merko Kaevandused	147174	5000	30 years
TOTAL applications			26 315	

1)* Maximum production is related to the maximum permissible annual production of the currently working Aidu opencast, which is 3.050mn tons in total.

Problems and existing possibilities:

• The issued oil shale extraction permits with a total amount of 23.75mn tons together with the new applications with an annual amount of 26.315mn tons would enable to extract up to 50mn tons of oil shale per year, exceeding the limit of 2005 more than three times. Such a drastic

rise in extraction and use of oil shale would cause serious environmental and social and political problems.

- It is not possible to limit or refuse issuing extraction permits due to overly high annual capacity of extraction. The refusal criterion stated in the Earth's Crust Act, "mining is in conflict with national interests" would not be applicable since the interests of the state are not specifically stated.
- To enable national guiding of the use of oil shale, state's interests need to be determined and the requirements for issuing extraction permits changed.

2.3. Established trends of oil shale use in Estonia

The presented information has been obtained from Statistics Estonia [18] and larger enterprises engaged in the use of oil shale, like Eesti Energia AS, Viru Keemia Grupp AS, Kiviõli Keemiatööstuse OÜ, AS Kunda Nordic Tsement and OÜ Merko Kaevandused.

In 2006, 90 years passed since the beginning of an industrial mining and use of the oil shale. Mostly, two usage trends have developed: using oil shale as solid fuel, processing oil shale into shale oil, shale gas, and products of oil shale chemistry. In addition to these, cement is produced. Extraction of oil shale used in production of electricity and oil has been concentrated in Ida-Viru county, cement production takes place in Lääne-Viru county.

According to the energy balance [18] published by Statistics Estonia, oil shale was extracted and obtained in Estonia in 2005 and 2006 as follows, mn t:

	2005	2006
amount of oil shale in the beginning of the year (in store)	1.008	0.971
extracted	14.591	15.066
imported	0.180	0
Total energy resource	**15.779**	**15.066**

However, according to the energy balance, oil shale in 2005 was consumed as follows, mn t:

consumed to transform into other types of energy, incl.	14.454	13.810
production of electrical energy	10.892	10.096
to produce heat	0.754	0.724
to transform into other types of fuel	2.808	2.990
utilized as raw material	0.081	0.007
utilized in the production of other non-metal products	0.269	0.211
total domestic consumption	**14.804**	**14.028**
reserve at the end of year (in storage)	0.971	1.029
export	0.004	0.009

Below, an overview of the established ways of oil shale utilization in Estonia has been presented.

2.3.1. Use of oil shale as solid fuel

Today, most of Estonian electric energy is produced in the energy blocks of AS Narva Elektrijaamad, in which there are boilers equipped with dust burning devicesThe average calorific value of the oil shale burnt in these boilers is 8.37 MJ/kg, whereas calorific value can fluctuate from 7.8 to 8.9 MJ/kg.

At the same time, AS Narva Elektrijaam has implemented a modern direct burning technology – burning in circulating fluidized bed (CFB). For now, two boilers operating on that technology have been installed in two energy blocks. Introduction of the new boilers has shown that implementing CFB-technology on the basis of Estonian oil shale is well justified: unit capacity of the energy blocks has increased, atmospheric emissions decreased significantly (especially as to SO2) and generation effectiveness has also increased. It is safe to say that the CFB technology is the best possible technology of direct burning of Estonian oil shale at the moment. AS Narva Elektrijaamad has planned to expand this technology to the next energy blocks.

When in the old dust burning boilers oil shale with calorific value between 7.8–8.9 MJ/kg could be used, the new ones can accommodate a significantly broader range – 8.0–11.0 MJ/kg. It means that enriched oil shale can also be used in the CFB boilers. AS Narva Elektrijaamad has started an analysis on the use of oil shale with higher calorific value in the new CFB boilers, to find out its impact on the technical-economic indicators and emissions of the energy blocks, and to optimize fuel preparation (level of enrichment, calorific value) on the basis of the whole value added chain of oil shale use.

To ensure continuing modernisation of the oil shale processing plant on the basis of CFB technology, landfilling of oil shale dust in accordance with the Council's Directive 1999/13/EC on landfills (ELT L 182, 16.07.1999, pp 1-19; L 282, 05.11.1999, p 16) needs to be solved by July 15, 2009, for which a new technology has to be introduced. AS Narva Elektrijaamad has done a series of voluminous studies and tests, including on test devices in the actual conditions of a processing plant. Concept and technological requirements have been developed and approved with the Ministry of the Environment. Building of industrial test devices has started.

The main energy production by direct burning of oil shale takes place in AS Narva Elektrijaamad, which has produced more than 90% of Estonian electric energy in the last years. To a smaller extent, direct burning of oil shale for energy production is also used in Kohtla-Järve VKG Energia Põhja power station and Ahtme power station, Sillamäe thermal power station and in Kiviõli Keemiatööstuse OÜ.

In 2005, oil shale as a solid fuel was used in the amount of 11.646mn tons.

According to the Development plan of electricity economy [2], oil shale will continue to be the primary fuel of energy production in 2005–2015. At the moment, ~91% of Estonian electric energy is produced by direct burning of oil shale, the main share of it by AS Narva Elektrijaamad. Installment of wind generators has increased and combined heat and power plants working on bio fuel are planned, but for the moment, their capacity is still relatively low and not able to ensure the growth in energy consumption in Estonia, and the necessary capacity. In 2010, 5.1% and in 2015, 8% of gross consumption of electric energy has been planned from renewable sources. Even assuming that the pace of creating generation capacity from renewable sources may increase, the relative importance of oil shale electricity in the Oil shale development plan in the period of time under consideration would remain prevalent. Therefore, it is important to continue using direct burning of oil shale to produce electricity, implementing the new circulating fluidized bed technology in the existing energy blocks, and building new ones. The prerequisite for that is reconstruction of the ash disposal system to meet the requirements.

According to the estimation in the Oil shale development plan, gross consumption of electricity in 2007–2015 would grow by 2–3.75% on average per year, but the actual growth in consumption in these years has been somewhat higher due to rapid economic growth.In 2005, gross consumption was 7494 GWh, which coincides with the growth scenario of the Development plan of electricity economy [2].Export formed 1953 GWh and the losses 1103 GWh. At the same time, growth of domestic consumption in 2006 has been significantly faster than estimated due to entry into

market of energy – consuming industries wherefore the capacity and relative importance of oil shale electricity increased compared to the estimation.Such a trend is estimated to continue in the near future, and therefore it is feasible to estimate the relative importance of oil shale electricity in the Oil shale development plan in the period under consideration as is the level in domestic consumption instead of the ~90% used so far.
The oil shale reserve needed to produce oil shale electricity according to the estimation of Eesti Energia AS has been presented in Table 3 (these are the ambitions of Eesti Energia AS, not the capacities planned in the Oil shale development plan).

Table 3. Oil shale reserves for production of oil shale electricity according to the estimation of Eesti Energia AS, mn t

Year	2008	2009	2010	2011	2012	2013	2014	2015
Total	17.244	14.755	16.273	18.947	14.605	14.159	13.925	14.720
incl. for domestic consumption of electricity	11.590	12.195	12.799	12.969	13.238	11.656	12.398	12.904
for export	5.654	2.560	3.474	5.978	1.367	2.503	1.527	1.816

2.3.1.1. Combined heat and power production based on direct burning of oil shale

Kohtla-Järve VKG Energia northern power station and Ahtme power station, Sillamäe and Kiviõli Keemiatööstuse OÜ thermal power stations and Balti Power Plant in Narva are currently combined heat and power production plants using the method of direct burning of oil shale. Among these, manufacturing operations based on direct burning have to be ended in Ahtme in 2010 and VKG Energia northern power station in 2015, unless ash disposal systems are brought into accordance with requirements, sulphur trapping devices are implemented or burning technology changed. Construction of new combined heat and power production plants using direct burning of oil shale has not been planned. Building new power plants on the basis of direct burning of oil shale is more expensive compared to renovation of the existing power plants, since it would mean finding a new location, building an infrastructure, opening a new ash field to landfill the ash, etc. Building new combined heat and power production plants is feasible on the basis of shale oil or other fuels that are covered in Subsection 2.3.3 of the Oil shale development plan. To produce thermal energy in combined heat and power production plants by direct burning of oil shale in the current level, 0.5mn tons of oil shale per year are needed. According to the estimations, this amount is will not increase, however, it may decrease.

2.3.2. Production of shale oil and -gas. Oil shale chemistry

For a long time, mostly so-called Kiviter generators have been used to obtain shale oil, gas and other chemical products from oil shale. The process (hereinafter referred to as *generator process*) consists of retorting oil shale in generators (in vertical retorts), where oil, water and generator gas are produced by thermal decomposition of oil shale. The processing residues are semi-coke and separated products. Since 2007, VKG Oil AS processes oil shale separated products into a solid filter cakes and then markets them to the cement industry. The generators need enriched oil shale with dimensions of 25–125 mm. The average calorific value of the oil shale used is 12 MJ/kg. Devices based on generator process are currently in use in Kohtla-Järve VKG Oil AS and Kiviõli in Kiviõli Keemiatööstuse OÜ. The produced shale oil and chemical products are sold and retorting gas with a low caloricity is burnt in energetic boilers.

The generator-process's chemical efficiency, characterizing the effectiveness of the process, is between 69–75% [19, 20]. The content of organic carbon in semi-coke is up to 12%, and the enterprises plan to reduce it to 8%.

AS Narva Elektrijaamad has industrially introduced devices with solid heat carrier (hereinafter referred to as SHC) that are able to acheve higher unit capacity and recycle fine oil shale with low calorific value, i.e. unenriched fine oil shale. The idea of the SHC process is to transmit the heat necessary for thermal decomposition of oil shale by a solid heat carrier – circulating heated oil shale dust. Energy-engineering processing of oil shale with a solid heat carrier gives an opportunity to use fine-grain oil shale (including dust) that occurring in the extraction process of oil shale.Oil shale will be thermally processed and the results are oil products and gas with a high calorific value of 9,8–46,8 MJ/Nm^3.The products will be used as energy carriers, and the more valuable chemical components will be an additional raw material for the chemical industry.The last option is not used by AS Narva Oil Plant, since this plant was only built to supply the adjacent Estonian Power Plant with liquid fuel.

AS Narva Elektrijaamad marked these devices in 2006 with a marking TSK-140. Both of these TSK-140 devices are processing 3000 tons of fine oil shale each per day in Narva Elektrijaamad Oil Plant. These devices produce one third of Estonian oil production. The raw material used is oil shale with low calorific value (8,37 MJ/kg) and unlimited piece size. In addition to that, this technology enables to process rubber crumb and organic residues or petroleum and oil, which could be considered as alternative raw materials. The amount of rubber crumb and oil residues may comprise up to 10% of the amount of oil shale being processed. However, it is important to stress that processing residues in oil shale retorting device requests compliance with the strict environmental requirements laid down by the Directive 2000/76/EC of the European Parliament on the incineration of waste (implemented in Estonia by the regulation enacted on the basis of the Waste Act § 33 (1)), which means additional measures need be taken.

The following products are produced at the oil plant:

1) shale fuel oils widely used in larger and smaller boilers;
2) road bitumen that is used domestically in road building, and retort gas that is used as an additional fuel in electricity production in Eesti Power Plant.

The process chemical efficiency of the TSK-140 devices is between 80–85% [21, 22] and the content of organic carbon in the ash is less than 1%.

Shale oil is used as a supplement to ship fuel and in heating boilers and industrial furnaces. The advantage of oil over black oil lies in its low viscosity and sulphur contents, and its low pour point. The range of chemical products produced from oil shale is diverse and it can be expanded if the market demand would rise.

In 2005, 2.804mn tons of oil shale was used in Estonia to produce shale oil and gas, and manufacture other chemical products. In 2005, 345 thousand tons of shale oil was produced and 342 thousand tons of it was used. In domestic consumption 120 thousand tons or 35% was used in total, and 222 thousand tons or 65% was exported.

At the moment, shale oil and gas are produced by Viru Keemia Grupp AS, AS Narva Elektrijaamad and Kiviõli Keemiatööstuse OÜ. Viru Keemia Grupp AS uses generator-process based devices that processed 1.4mn tons of oil shale in 2005. The enterprise produces shale oil and gas, and several chemical products. Viru Keemia Grupp AS is planning to expand its activities by introducing TSK-based devices to process 2.7mn tons of oil shale, but still using the old generators as well. AS Narva Elektrijaamad uses only TSK-based devices TSK-140 to process oil shale. It is planning to expand its production on the basis of similar TSK-140 devices. In the financial year 2005/2006, 1.0mn tons of oil shale was processed. Kiviõli Keemiatööstuse OÜ uses generator-process based devices that processed 0.4mn tons of oil shale in 2005. The enterprise produces shale oil and gas and several chemical products. The plant has started to expand its production on the basis of TSK-based devices.

The need for oil shale on the basis of estimations by these businesses is presented in Table 4.

These are the estimates of the businesses, not the amounts planned for in the Oil shale development plan.

Table 4. Need for oil shale for processing, on the basis of the business estimations, mn tons

Year	VKG	EE-NEJ	Kiviõli	Total*
2014	5.75	3.85	1.09	**14.69**
2008	2.00	1.43	1.09	**4.52**
2009	2.20	1.60	1.09	**4.89**
2010	2.75	3.85	1.09	7**.69**
2011	3.30	3.85	1.09	**10.68**
2012	4.05	3.85	1.09	**11.43**
2013	4.80	3.85	1.09	**13.74**

Note*: in the final column besides the estimates of OÜ VKG Aidu Oil, AS Eesti Energia and Kiviõli Keemiatööstuse OÜ, the estimates of OÜ Merko Kaevandused for the years 2011–2015 have been taken into consideration, but since the extraction permit of OÜ Merko Kaevandused was registered to OÜ VKG Aidu Oil in January 2008, their figures are not indicated separately. In the summary, all estimates reported to the compilers of the Oil shale development plan before 2008 by the businesses were taken into account.

2.3.3. Production on the basis of shale oil and gas. Dispersed energy production

Using shale oil and gas in energy production is most economical in combined heat and power production plants. Combined heat and power production is limited by heat consumption. According to the Development plan of electricity economy [2], heat consumption of the central heating networks of the biggest settlements is estimated to be 150 MW in total, based on the electrical capacity of the potential new combined heat and power plants. The later estimates [23] present a somewhat lower estimation of ~100 MW as the potential of combined heat and power production. These combined heat and power capacities would be located in 12 towns, incl. Tallinn, Tartu, Pärnu, Viljandi, Valga and Haapsalu, therefore all over Estonia. These estimations do not take into consideration the potential combined heat and power production of the large power-intensive businesses that use electricity and heat, since due to the relatively low price of electric energy today, these businesses lack motivation to start their own electricity production, and buy the electricity they need from traders. The current oil plants for producing shale oil and gas are located near oil shale opencasts and power plants. It is feasible to build the new oil and gas production capacities also near oil shale opencasts and power plants. This is due to the fact that transportation of oil shale over long distances is not economical and it is practical to burn retort gas together with oil shale in the oil shale boilers because of hydrogen sulphide it contains.

If the current economic conditions prevail, only shale oil would be left as a fuel for the new combined heat and power plants in the cities, as using shale oil gas in boilers heated with gas and black oil to purify gas from hydrogen sulphide and to transport it over long distances in order to establish transport infrastructure is related to large additional costs.

The most feasible way to use shale oil gas is in energy production in a combined heat and power plant in close proximity of an oil plant. The oil plant itself would be the consumer of heat and electrical energy, and the electricity remaining from their needs would be sold to other consumers. At the same time, it would facilitate utilization of the oil shale gas from oil production, if it is not intended to be used in production of other chemical products. At the same time, research is needed for finding technical solutions for utilization of shale oil in both combined heat and power plant by an oil plant, and in a combined cycle power plant, for example, to rule out negative impact of hydrogen sulphide to the equipment and the environment.

2.3.4. Using oil shale in production of cement

Oil shale is used in the production of cement by AS Kunda Nordic Tsement, a 135-year-old business, the main products of which are construction cements. Oil shale is used in clincker furnaces as technological fuel. In 2005, 0.225mn tons of oil shale was used in production of cement. In addition to oil shale, oil shale ash from power plants is used as a component in cements (See also Ch. 2.3.5).

AS Kunda Nordic Cement presented an estimation according to which the annual need of oil shale of the business in 2008–2015 is 0.35mn tons for fulfilling its production plans.The calorific value of oil shale has to be more than 7.53 MJ/kg (1800 kcal/kg) and magnesium contents (MgO) in the mineral part of oil shale below 2.8%. During basic research [14] the contents of MgO in the shale oil of Estonian oil shale reserve have been examined. Oil shale reserve with a suitable MgO content is located in Aidu mining field and Ubja oil shale opencast. Research revealed that based on the MgO content, AS Kunda Nordic Cement must pay attention to the oil shale in Ubja opencast, on which an extraction permit has been issued and extraction process began in 2005.

2.3.5. Use of the mining residues and waste

In oil shale mining in pits, the rock material of oil shale bed's overburden is used as a filling material of closed dumps. To a smaller extent, overburden rock has been used on consturction sites as a filling under buildings, and in landscape design. Separating limestone layers from the overburden to produce crushed stone is not feasible at the moment – the process is laborious and hinders (slows down) oil shale extraction significantly, as a result of which production costs of crushed stone are high.

~40% of the industrial oil shale bed is formed of limestone beds. Rock material forming in the enrichment process of broken oil shale is deposited in open spoil dumps near the opencasts. With today's production output (~7mn tons of trade oil shale per year), ~4.5mn tons of spoil is deposited to open dumps annually.

Through times, hundreds of millions of tons of different quality spoil (percentage of oil shale is approx. 3–20%) have been deposited in the open dumps near the opencasts. An additional ~200mn tons of spoil (percentage of oil shale is approx. 3–5%) will be produced by the end of working life of the Estonia and Viru opencasts.

Limestone retrieved in selective mining (Narva opencast) and enrichment of oil shale (Aidu opencast) are mostly used as a filling of closed dumps and in landscape design, also partly for building roads inside the opencasts (the rock material formed during selective mining of the industrial bed of the Narva opencast and deposited in the closed dump is not considered to be spoil). Avoiding of depositing spoil in closed dumps would decrease the height of the dumps only by approximately 20–30 centimeters, thus the change compared to what was stated in the reclamation design is insignificant.

Due to growing construction activity and the resultant demand for crushed stone and filling material, oil shale tailings are used to make crushed stone. The consumers use crushed spoil as a filling material on construction sites, and crushed stone made from spoil as a construction material and in concrete mixes. In 2005, 22% (1.3mn tons) of spoil was recycled.

In relation to shortage of crushed stone in Estonia, it can be estimated that oil shale tailings (fractionation, i.e. crushing and sieving), its use and sale would be valued significantly more in the future. Part of spoil-based crushed stone that is of higher quality, can be used in production of concrete.

Oil shale spoil and/or crushed stone made from it are marketed by the businesses of Põlevkivi Kaevandamise AS, OÜ Ahtme killustik, AS Floccosa and Kiviõli Keemiatööstuse OÜ.

Põlevkivi Kaevandamise AS is using or building crushed stone production facilities. In the crushed stone production facilities of Aidu opencast belonging to Põlevkivi Kaevandamise AS up to 400 000 tons of crushed stone per year can be produced. The crushed stone fractions being produced are 4–16, 16–32 and 32–40 mm. The crushed stone has passed tests in an accredited

laboratory and meets the standards of quality grade IV. Besides crushed stone, Aidu opencast also sells spoil as a filling material.

In Estonia opencast of Põlevkivi Kaevandamise AS, a low-productivity crushed stone unit is currently working, producing crushed stone in fractions of 4–20 and 16–63 mm from spoil. Construction of the new crushed stone complex of Estonia opencast is in the stage of procurement. After the first stage is ready, up to 600 000 tons of crushed stone in fractions of 4–16, 16–32 and 32–64 can be produced annually, in the second stage, the amount of crushed stone produced would rise to 1.2mn tons per year. According to the pre-tests, crushed stone also corresponds to the requirements of quality grade IV. Besides crushed stone, Estonia opencast also sells spoil.

Viru opencast of Põlevkivi Kaevandamise AS sells spoil as a filling material. A mobile crushed stone complex has been put into operation, enabling to recycle the whole amount of spoil formed in the process of enriching the broken oil shale, and also spoil already deposited in the dump.

Shale ash that is formed in the process of direct burning of oil shale is also re-usable. It is a valuable binder and filling material that can be used in building material industry, as a cement additive, in road construction, in agriculture to neutralize acid soil, as a filling material, etc. At the moment, mostly fly-ash trapped in cyclones and electric filters is used.

The coarse-grained fraction of fly-ash can be used:

- in production of autoclaved cellular concrete blocks;
- to lime fields;
- as an additive in production of granulated mineral fertilizers;
- in road construtions for building monolithic bases.
-

There are also standards governing the shale ash used in production of the abovementioned products:

1) Burnt oil shale for producing gas concrete products. Standard EE 01003682 ST 2:97;
2) Burnt oil shale (oil shale dust) for use in agriculture. Standard EE 01003682 ST 3:97.

The fine fraction of oil shale fly-ash can be used:

- as a component in producing special kinds of portland cement;
- as a filling material in producing rubber and plastic products;
- as a binder to partially replace cement in producing reinforced concrete products.

There is a standard on the fine fraction of shale dust:
Burnt oil shale for production of portland oil shale cement, portland composite cement and masonary cement.
Standard EVS 636:2002.

According to research, using shale dust is also profitable in:

- production of synthetic detergents;
- production of heat insulating materials;
- production of finishing materials containing phosphor -gypsum;
- production of sanitary ceramics.

Despite the numerous ways of use described above, only a small amount of oil shale ash is currently recycled, a little more than 2% of the annual amount produced. Only OÜ Silbeti Plokk uses oil shale ash in producing building blocks, and AS Kunda Nordic Cement in production of cement. Both establishments have stated their intent to increase the use of oil shale ash in the future. It would be feasible in the long run to granulate oil shale ash and make products of it, or o utilize granulated oil shale ash as a filling material in buildings and other facilities.

In order to encourage the increased recycling of oil shale ash and spoil being formed in the process of extracting and using oil shale, economic measures need to be taken (by increasing environmental charges on natural resources), studies for finding ways to recycle spoil must be supported, and investment aid given to establish the necessary production capacities. Balancing of the aforementioned mining residues and spoils needs to be discussed under a separate section of the national waste management plan [24] that is currently prepared.

2.3.6. Comparison of usage trends

In evaluating the usage trends of oil shale, the strategic objectives and plans provided in the Development plan for fuel and energy sector are used [1]. These are:

- to ensure fuel and energy supply with proper quality and optimal prizes;
- to ensure local generative power needed to cover domestic electricity consumption, and the reserve of liquid fuel as provided by law;
- to preserve competitiveness in oil shale production in the open market conditions, and ensure improved effectiveness; using modern technologies that reduce environmenal impact.

In the time period under consideration the Development plan for fuel and energy sector specifies oil shale as the dominant form of electricity production. This must be done more sparingly, in an environmentally friendlier manner and using the best available technology and equipment. In electricity production, direct burning using the circulating fluidized bed technology (CFB) has to be preferred. Compared to shale oil and gas that emerge in the process of processing oil shale, direct burning has a number of advantages in electricity production in condensing power plants, e.g.:

- higher efficiency [15];
- smaller investments;
- using residues (oil shale ash) in production of building materials and in agriculture.

In addition to basic research [14], we shall now compare electricity production from direct burning of oil shale and from shale oil and gas. The comparison is based on the use of unenriched oil shale on the basis of the CFB and SHC technology accordingly.

Net efficiency of an energy block with a 200–250 MW steam turbine cycle:

1) on direct burning:
   - NEJ CFB energy block (factual) – 36%
   - with an energy block based on modern CFB technology (calculated) – 38.5%
2) on burning shale oil and -gas:
   - energetic efficiency of recycling oil shale – 85–88%
   - net efficiency of an energy block with a modern steam turbine cycle – 40%
   - the same on modern SHC- and energy block (calculated) 0.85x0.4=0.34 – 34%
     or 0.88x0.4=0.352 35.2%

Therefore, factual net efficiency on direct burning (CFB) is 36%.

The same on modern devices (calculated):

1) on direct burning – 38.5%
2) on burning shale oil and -gas – 34–35.2%.

The comparison confirms the clear advantage of direct burning of oil shale in electricity production.

Using shale oil and gas to produce energy is the most economically feasible in combined heat and power plants and therefore the potential of combined prodution needs to be developed and utilized better, taking additional measures to develop combined heat and power production. Since the potential of combined heat and power production is limited, in the period of time under consideration, producing electricity by direct burning of oil shale shall still remain a priority in Estonia, using the modern circulating fluidized bed technology.

We need to preserve and develop Estonia's longstanding unique experience in producing oil, gas and chemical products from oil shale. According to Subsection 2.3.2, the preferred retorting process of the two processess currently used – generator and SHC process, is the latter, since SHC devices have higher efficiency and smaller environmental impact. On the basis of tests carried out in AS Narva Elektrijaamad Oil Plant, provided the oil shale used is with comparable quality, the devices based on the SHC process also have higher oil yield. Although no CO2 emissions occur with the generator process and they do occur in some extent in the SHC process, the higher efficiency of the latter compensates for it. In addition, the quality of oil shale required for the SHC process are considerably more flexible, enabling to use both fine and lump oil shale, as well a soil shale with low and high calorific value. Further use of the generator devices is possible only in case of improvement of the method, by reducing the high contents of organic carbon in solid residue or semi-coke with an objective to use oil shale more efficiently. However, SHC devices also need improvement, primarily in reliability and ash disposal. Environmental requirements need to be significantly stricter in order to decrease the negative environmental impact of oil shale production,. Oil shale is a potential raw material for producing motor fuel and several other chemistry products that would significantly increase the additional value of using oil shale. Possibilities to refine shale oil to produce motor fuel need to be examined. Before building new oil shale production devices, research and tests need to be taken on semi-industrial devices to ensure proper valuation of oil shale on new industrial devices, and thus its economic use. For that, accounting criteria must be developed. New extraction permits on processing oil shale should not be issued until proper valuation of oil shale has been ensured.

Estonia has produced electricity from oil shale for years, both for domestic use and export. In the last years, our export partners have been Latvia and Lithuania. With Latvia, we have had a longstanding cooperation in optimizing capacity charts in different consumption modes. At the end of 2006, a sea cable between Estonia and Finland was completed, significantly increasing the security of supply of the Estonian energy system and broadening the opportunities in the electricity market. We also need to consider the need to participate in balancing the united power system that would also affect the stability of Estonian energy system. The latest developments in petroleum products and electricity market show that proceeds from the export of shale oil and electricity may be similar. Electricity can only be exported in an amount that does not exceed the allowed limit of emissions resulting from its generation, and does not threaten fulfilment of international environmental obligations taken.

The state needs to contribute into energy saving measures in a greater extent, to reduce the need to build new condensing power plants, and apply additional measures to establish more dispersed generation capacity based on alternative fuels that would help to reduce the relative importance of oil shale in the energy balance.

.Using oil shale is a priority also in cement production. The demand for oil shale in this field is not high, yet oil shale is one of the most important components of domestic cement production

Table 5. Ambitions of enterprises as to the use of oil shale in 2008–2015

Year	**Oil shale, mn tons**					**per year**		
	EE **electricity**	**EE heat**	**EE oil**	**EE total**	**VKG**	**Kiviõli**	**Kunda**	**Total**
2008	17.244	0.375	1.429	**19.048**	2	1.145	0.35	**22.543**
2009	14.755	0.375	1.597	**16.727**	2.2	1.145	0.35	**20.422**
2010	16.273	0.375	3.85	**20.498**	2.75	1.145	0.35	**24.743**
2011	18.947	0.375	3.85	**23.172**	3.3	1.145	0.35	**27.967**
2012	14.605	0.375	3.85	**18.83**	4.05	1.145	0.35	**24.375**
2013	14.159	0.375	3.85	**18.384**	4.8	1.145	0.35	**24.679**
2014	13.925	0.375	3.85	**18.15**	5.75	1.145	0.35	**25.395**

2015	14.72	0.375	3.85	**18.945**	6.7	1.145	0.35	**27.14**

Table 5 shows that the businesses' applications for use of oil shale exceed the recommended volumes in the Oil shale development plan by 20mn tons per year, and amount up to 31.24mn tons per year. Considering national interests (Sections 3.1.1 and 3.1.2) and the restrictions established to oil shale extraction (Section 3.2.1), the maximum extraction amount of oil shale may not exceed 20mn tons annually (the calculation is shown in Table 6, page 23). Therefore, issuing new extraction permits must be restricted and, if necessary, the already issued permits must be changed (see also Section 3.2.2).

The priorities in the use of oil shale in the period under consideration (2008–2015) are:

1) production of electricity and shale oil to cover domestic consumption;
2) using oil shale in further valuation of oil shale (motor fuels, chemical products, etc), using the best available technology;
3) fulfilling the needs of domestic cement production.

Using oil shale in production of electricity and shale oil for export is allowed in a limited amount, based on the state's interests. It can be indirectly regulated by issuing extraction permits, and detemining the mining capacity of AS Eesti Põlevkivi.

The maximum limit of oil shale extraction (up to 20mn tons/year) has been determined on the basis of the following calculations and data:

1) the maximum annual need for oil shale in the period under consideration (2008–2015) needs to be estimated;
2) the main priorities are supplying Estonia with energy, i.e. ensuring energy and heat supply, and supplying concrete production with oil shale;
3) the scenario of fast increase in energy consumption in the Development plan of electricity economics has been taken as a basis for these estimations;
4) the relative importance of electricity produced from renewable energy and other sources in Estonian gross consumption has beed estimated to be 10%; the corresponding proportion of oil shale electricity is 90%;
5) producing electricity from oil shale in condensing power plants os more effective and environmentally friendlier by direct burning;
6) all the necessary technological measures are applied in order to ensure fulfilment of environmental requirements;
7) according to estimations, 20% of the electricity produced will be exported; while the need to participate in balancing the united power system that in turn will also affect the stability of Estonian energy system, has been taken into account;
8) the export volume of oil shale has been estimated to be approximately at the same level as at the moment; export is necessary for balancing external trade balance of the country.

In Table 6, the calculation of oil shale needs for the year 2015 has been presented, as the year with the highest annual domestic consumption of electricity in the period of 2008–2015.

Table 6. Calculation of the oil shale need for 2015

No.	Indicator	Unit	Amount	Source/equation
1.	Gross consumption of electric energy in Estonia in 2015 – scenario of rapid growth	TWh	10.077	[2]
2.	Relative importance of electricity from renewable- and other sources in gross consumption		0.1	Oil shale development plan [1)*]
3.	Amount of electricity from renewable- and other sources in gross consumption	TWh	1.008	(1) x (2.)
4.	Relative importance of oil shale electricity in domestic consumption		0.9	Oil shale development plan
5.	Amount of oil shale electricity in domestic consumption	TWh	9.069	(1.) x (4.)
6.	Oil shale consumption to produce 1 TWh	mn tpk /TWh	1.26	[25;26] [2)]*
7.	Need for oil shale to produce electricity for domestic consumption	mn t	11.5	(5.) x 1.26
8.	Oil shale reserve for unforeseen needs in electricity production	mn t	1.0	Oil shale development plan
9.	Need for oil shale for domestic consumption (at the level of 2005)	mn t	0.12	[18]
10.	Need for domestic production of oil shale for producing oil	mn t	1.0	(9.) x 8.3 [3)]*
11.	Need for oil shale to produce heat in combined heat and power plants	mn t	0,5	Oil shale development plan
12.	Need for oil shale in cement production	mn t	0,4	KNC [4)]*
13.	**Total need for oil shale domestic consumption**	**mn t**	**14.4**	**(7.)+(8.)+(10.) +(11)+(12.)**
14.	Need for oil shale for export of electricity	mn t	2.8	Oil shale development plan
15.	Need for oil shale for export of shale oil and chemical products	mn t	2.8	Oil shale development plan
16.	**Total need for export of oil shale products**	mn t	**5.6**	**(14.)+(15.)**
17.	**Total need for oil shale**	mn t	**20.0**	**(13.)+(16.)**

1) * Here and hereinafter according to estimations.

2)* 1.26mn tons of oil shale is needed to produce 1 TWh of electric energy (t_{pk}), calculated on the basis of [25, 26] data, taking into consideration the percentage of energy blocks with CFB and dust burning technology in electricity production.

3)* To produce 1 ton of shale oil, 8.3 tons of oil shale is needed.

4)* On the data by AS Kunda Nordic Cement.

In using oil shale for production of electricity, complying with the limitations on atmospheric waste (SO2, NOx and fly-ash) laid down in the large combustion plant directive (Directive 2001/80/EC of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from large combustion plants (hereinafter referred to as LCP – ELT L 309, 27.11.2001, LCP directive)) will be of great importance to Estonia from 2016, as well as the obligation fixed in the EU Accession Treaty to limit SO2 emissions to 25 000 tons per year from 2012. Since AS Narva Elektrijaamad remains the main producer of oil shale electricity in the period under consideration in the Oil shale development plan, the planned measures of that enterprise for fulfilling these requirements are extremely important. As the main measure, AS

Narva Elektijaamad plans to continue implementing the CFB technology in new energy blocks. In addition to the two energy blocks already working, implementation of another two 300 MW energy blocks is planned in 2011 and 2012 accordingly, and start-up of two additional 250 MW energy blocks until year 2015. The most critical year will be 2012, when the limit of SO2 emissions of 25,000 tons per year will enter into force. For that, installation of purification devices to some older blocks to trap SO2 from flue gas (deSO2) is being prepared. The control calculations show that upon implementing these measures, the requirements for SO2 emissions would be fulfulled, given that the electricity output corresponds to the estimation (see calculations in Table 7). That way, special emissions of SO2 for one unit of production (GWh) in 2006 reduced by 7% compared to 2005. In relation to implementation of the new energy blocks and deSO2 devices, special emissions will be reduced even more, constituting 37% of the year 2005 level in 2012, and 29% of that level in 2015. Energy blocks using the new CFB technology correspond to the requirements of the LCP directive and shall remain in operation after 2015 as well; the old energy blocks operating on dust burning technology would have to be removed from operation then.

Table 7. SO2 emissions from oil shale power plants (NEJ) by years

Seq. No.	Name	Unit	Orig. source	2006 (1)	2012	2015
1.	Gross consumption of electricity in Estonia	GWh	[2]		9297	10077
2.	Electricity production in Estonia	GWh	calc.		10227	11085
3.	Estonian electricity export (20% of electricity production)	GWh	"		2045	2217
4.	Relative importance of oil shale electricity in gross consumption		Oil shale develop-ment plan		0.9	0.9
5.	Gross production of oil shale electricity for domestic consumption	GWh	calc.		8367	9069
6.	Total net production of oil shale electricity	GWh	"	7965	10413	11286
7.	Relative importance of CFB blocks in net production		11	0.32	0.63	0.7
8.	Net production of CFB blocks	GWh	11	2549	6560	7900
9.	Specific fuel consumption of CFB blocks	tpk/MWh	[25;26]	1.206	1.206	1.206
10.	Fuel consumption of CFB blocks	mn t	calc.	3.07	7.91	9.53
11.	Relative importance of old blocks in net production		(t	0.68	0.37	0.3

12.	Net production of old blocks	GWh	(t	5416	3853	3386
13.	Specific fuel consumption of old blocks	tpk/MWh	[25;26]	1.394	1.394	1.394
14.	Fuel consumption of old blocks	mn t	calc.	7.55	5.37	4.72
15.	Special SO2 emissions of CFB blocks	tso2/tpk	"	0.0000642	0.0000642	0.0000642
16.	SO2 emissions of CFB blocks	t	"	197	508	612
17.	Special SO2 emissions of old blocks	tso2/tpk	"	0.006328	0.006328	0.006328
18.	SO2 emissions of old blocks	t	"	47778	33985	29868
19.	Total SO2 emissions	t	"	47975	34493	30479
20.	SO2 emissions on an old block if deSO2 is installed	t	"		3020	3020
21.	The same, if an old block does not have a deSO2	t	"		7939	7939
22.	Difference of SO2 emissions on an old block if deSO2 is installed	t	"		4919	4919
23.	Total SO2 emissions in case of 1 deSO2	t	"		29575	25561
24.	Difference of SO2 emissions if two blocks have deSO2	t	"		9837	9837
25.	**Total SO2 emissions in case of 2 deSO2**	t	"		**24656**	**20642**
26.	**Average special emissions**	**tso2/tpk**		**0.0045157**	**0.0018564**	**0.0014488**
27.	Total oil shale consumption	mn t	"	10.62	13.28	14.25
28.	**SO2 emissions in the NEJ 2006 report**	t		**47975**		

[1)] For 2006, a control calculation has been made to evaluate special SO2 emissions of CFB and old blocks. The calculation has been made on the basis of the following NEJ data:
- net production (p 6)
- relative importance of CFB and old blocks in net production (p 7 and 11)
- total SO2 emissions of NEJ without the Oil Plant emissions (p 28)

NB! In 2012 and 2015, the following CFB blocks and deSO2 devices have been taken into account:

New energy blocks:
in 2006, operating 2x215MW or 430 MW
in 2012, additional 2x300MW or 600 MW
in 2015, additional 1x250MW or 250 MW
deSO2 devices:
will be installed to two old energy blocks in 2012
Device's SO2 emissions < 800 mg/Nm^3 (in the given calculation, 750 mg/Nm^3)

In order to use the oil shale resources better, we need to review the fees for the mining rights, taking into consideration the quality of the oil shale.

Problems and opportunities:

- Most of the oil shale electricity is produced by devices that use obsolete technology, which means a relatively low effectiveness of oil shale use and higher pollution of the environment;

- Recycling of oil shale also takes place with devices mostly based on obsolete technology, bringing about significant losses and pollution of the environment;

- Obsolete devices and technologies in both electricity and shale oil production need to be replaced during the period under consideration in the Oil shale development plan, to bring them into accordance with the environmental requirements of Estonia and the EU, demanding large investments;

- Production of shale oil has been the focus of oil shale recycling; other possibilites of valuing oil shale, i.e. production of motor oil, etc., have not been examined or implemented;

- The level of recycling of mining residues and residues forming in the use of oil shale is low;

- There is no clearly formulated and justified alternative for significant reduction of oil shale power industry in the energy supply of the republic;

- To ensure energy supply of Estonia and fulfil the environmental requirements, a significant acceleration of the speed of implementetion of modern technologies in the use of oil shale for production of energy and in recycling is necessary. We already have first experineces in implementing the circulating fluidized bed technology in the burning process and solid heat carrier methods in recycling, whereas they still need improving and optimising.

2.4. Criteria of estimating the oil shale resources in accordance with the usage trends, and long-term resource planning

The supply of mineral raw material is determined by the technology used and the economic activities influencing its consumption. On the basis of this, criteria are laid down, determining that the deposit inside the earth's crust is a mineral resource. One of the most important criteria are

boundary conditions of the reserve. The other most important criteria are distance to the consumer and different mining restrictions.

According to the valid criteria of oil shale reserves in Estonia, a reserve is mineable when the energy rating of the bed is higher than 35 GJ/m^2, and conditionally mineable when the energy rating is between 25–35 GJ/m^2. Boundary conditions do not take into account the distance to the consumer. These conditions have been established based on electricity energetics. By now, the development opportunities of energetics- and oil industries in Estonia are starting to become clear. According to this, there is not only a need for distinguishing boundary conditions of oil shale reserve based on electricity and oil industries, but to also for dividing Estonian oil shale deposit into districts according to the location of the industry. The proposal to carry out the research has been added to the implementation plan of the Oil shale development plan.

The Department of Mining in TUT has made control calculations on the suitability of energy output as a criterion of mineability to estimate oil shale reserves, taking into consideration the changes in economic situation [14]. On the basis of these calculations, the recommended activity limit of oil shale reserve is 30 GJ/m^2, leaving the limit of submarginality to 25 GJ/m^2. This means that on the basis of energy output, higher quality blocks of Oandu, Pada, Permisküla, Puhatu, Seli, Sonda and Uljaste fields would become mineable. However, this suggestion may not be implemented without prior thorough environmental and economic research.

Upon lowering the limit of mineability, mineable reserve increases. Since activity of a reserve is not determined merely by economic conditions, but environmental restrictions need to be considered as well, it is not possible to express the exact volume of reserves without a thorough evaluation that takes into consideration the environmental restrictions on the basis of which the reserve on an area of natural value is considered submarginal.

The mineability of a mineral resource can be best estimated on the basis of a feasibility study on the specific project. Therefore, with every field and block, the business plan based on the follow-up inspection of the geological data should be used as a basis for issuing the extraction permit. In the fundamental research, the loss of energetic potential of an oil shale bed in winning, and the combined impact of the effectiveness of oil shale winning and utilization is estimated [14]. It can be concluded from the results that better utilization of the energetic resource of oil shale is ensured by devices that are able to process rock with low calorific value.

From the viewpoint of utilizing the oil share resources it is important that in case fuel consumption of energy production does not decrease in the period under consideration in the Oil shale development plan, it is not reasonable to restrict the development of electric power stations and mining enterprises connected to railroads.

Currently, AS Narva Elektrijaamad Eesti and Balti Elektrijaam are supplied with oil shale from the Estonia and Viru opencasts of the subsidiary undertaking of AS Eesti Põlevkivi, Põlevkivi Kaevandamise AS, and by the railroad from Narva and Aidu oil shale opencasts. The biggest consumer of oil shale, Eesti Elektrijaam, is connected to the opencasts of Estonia and Viru, and Narva oil shale opencast directly by AS Põlevkiviraudtee, not using the rails of AS Eesti Raudtee. The mineable reserves of the aforementioned opencasts and pits belonging to Põlevkivi Kaevandamise AS are presented in Table 8.

Table 8. Mineable reserves of oil shale in the allotments supplying AS Narva Elektrijaamad, as at 01.01.2006.

Opencast/pit	**Mineable reserve, mn t**	
	Proved reserve	Inferred reserve
Estonia opencast [1)]*	267.2	15.8
Viru opencast [2)]*	47.2	16.3

Narva pit	37.2	-
Sirgala pit	68.9	-
Aidu pit [3)*]	16.6	1.2

1) * incl. Ahtme mining field
2) * incl. Sompa and Tammiku opencasts
3) * incl. Kohtla and Vanaküla mining fields

The biggest reserve is in Estonia opencast that is sufficient for more than 30 years. Considering current output, the reserves in Narva and Sirgala will last for 17 years in total. The fastest decreasing Aidu opencast will be depleted very quickly, already during the next 4–5 years.

Problems and existing opportunities:
- The boundary conditions to the oil shale reserve are established in accordance with electricity energetics. By now, the development potential of Estonia's energetics and oil industries is starting to emerge, wherefore it is necessary to review the boundary conditions.

2.5. Environmental condition of the oil shale deposit area

Oil shale sector is the largest water consumer in Estonia. In 2005, 1.5846bn m^3 of water in total was taken from all water sources of the country, i.e. 188mn m^3 less than in the previous year. The energy sector enterprises in total used 1.258bn m^3 of water from surface water bodies, mostly used as cooling water for power plants.

In total, 273.7mn m^3 of ground water was used. 223.36mn m^3 was pumped out of opencasts, 6–73% of it was ground water [27]. Compared to year 2004, the amount of water pumped out decreased by 37mn m^3. Although the amount of nutrients (N, P) and organic waste in production of energy is relatively low, negative impact on the environment comes from the alkalinity of the water used in ash transport from oil shale power plants. The excess water of ash fields caused by heavy rains has been directed to the Narva reservoir from time to time, whereas the ash water from power plants is diluted to an allowable level (pH < 9.0) before releasing it into the environment. Water level is decreased due to mining in the mining area and a temporary increase of sulphates in the ground water and in water being pumped out of opencasts up to 500 mg/l (the usual concentration is 20 mg/l). Water pumped out of opencasts is cleaned from suspended solids in sedimentation basins. From there, water is directed through ditches and rivers mostly to the Gulf of Finland, and partially to the lake Peipsi. Cooling water used in power plants does not need cleaning. Ida-Viru county is the firm leader among the counties in water consumption.

As to the air pollution from stationary sources the weight of Ida-Viru county is significantly higher compared to other counties. According to the SEA report of the Oil shale development plan, in 2005 Ida-Viru county was responsible for 66% of the total particulates, 94.6% of sulphur dioxide, 68.4% of nitrogen oxides, 62.2% of carbon oxide, 82.6% of carbon dioxide, 32.5% of flammable organic matter and 89.6% of other atmospheric emissions in Estonia.

Oil shale industry is the largest consumer of natural resources and producer of waste in Estonia. Since oil shale opencasts and enterprises using oil shale are mostly located in Ida- and Lääne-Viru counties, emissions from oil shale processing and use of natural resources has the most negative impact on the environmental condition and health of the people living in these counties. Since the Estonian economy is growing and the current environmental protection and economic measures have not been able to harmonize the economic growth and the pace of using our natural resources, the economic growth may bring about a regrettable increase of waste and environmental pressure compared to improvement in our environmental condition that took place in the last decade.

Mining, especially quarries, changes landscapes. The areas mined in accordance with the Earth's Crust Act will be restored and new landscape elements will be added (water bodies, hills, etc). Although the recreational value of these landscapes may be higher than previously and the site quality of reforested areas may be better due to change in the water regime compared to the previous swampy and wet areas, restoration of the natural appearance of these areas takes decades and sometimes causes displeasure in the local community. Numerous mined areas are not recoverable or usable in their previous form. It is especially true for former agricultural land.

In the SEA report, additional measures have been foreseen which should contribute to realization of environmental objectives set out in the Oil shale development plan and other valid national development plans.

The health indicators of residents of Ida-Viru county, i.e. the frequency of respiratory, haematopoietic and cardiovascular diseases, cancer and other diseases prone to environmental impacts is somewhat higher than in the regions where no oil shale is mined. Since the health of population largely depends on the quality of environment, every measure needs to be taken to avoid its deterioration and to reduce the waste resulting from oil shale mining and use.

Problems and existing opportunities:

- Oil shale sector is the largest water consumer in Estonia. Alkalinity of the water used in ash transport from oil shale power plants has had a negative impact on the environment.

- As to the emissions from stationary source of pollution, the relative importance of Ida-Viru county is significantly higher than in the other regions of Estonia.

- Oil shale based energy production is very wasteful.

- Mining, especially quarrying, changes landscapes.

- Health indicators of residents of Ida-Viru county, i.e. the frequency of respiratory, haematopoietic and cardiovascular diseases, cancer and other diseases prone to environmental impacts is somewhat higher than in the regions where no oil shale is mined.

- The basis for laying down limits of emissions for businesses in different spheres of production is different.

- In order to reduce environmental impact, implementation of modern technologies in oil shale mining and use, and recycling of residues needs to be accelerated, and new rates of environmental charges for use of oil shale and ground water laid down, while first assessing the impact of the new rates on business activity and the price of electricity.

- In order to evaluate and improve the environmental condition and quality of life of the population, advanced studies need to be carried out and the relevant recommendations implemented.

2.6. Limitations due to international requirements

Estonia has joined 55 international environmental conventions and bi- or multilateral agreements that impose certain environmental restrictions to the state and the establishments using oil shale. The most important of these documents are the following:

1) UN Convention on Biological Diversity (entered into force in Estonia in 1994) and the EC Directives 79/409/EEC on the conservation of wild birds (OJ L 103, 25.04.1979) and 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.07.1992), pursuant to which the national programme "Estonian NATURA 2000" for the years 2000–2007 was approved.

2) The aforementioned convention and the directives establish a requirement to take endangered species under national protection and to ensure preservation of these species and their habitat. Each protected area has protection rules that prescribe allowed and forbidden activities, incl. carrying out geological research and mining of mineral resources.

3) UN Convention on long-range transboundary air pollution (LTRAP, Geneva 1979) and the European Parliament and Council Directive 2001/81/EEC on national upper level of certain air pollutants.

The aforementioned convention and directives set the limits of total annual emissions (from sources of pollution) on several discharges. For the use of oil shale, the most important is the

total annual limit of 100 000 tons of carbon dioxide emissions applicable from 2010. The Republic of Estonia has taken an additional obligation upon joining the EU, according to which the amount of carbon dioxide emissions from large combustion plants using oil shale would not exceed 25 000 tons/per year from 2012.

Considering tightening of the obligations to limit the emissions of particulates, NOx and SO2 in the EU Member States on the basis of the aforementioned directive 2001/81/EC, it can be presumed that significant restrictions shall also be implemented in 2010 and 2020 for the total sulphur dioxide emissions of the enterprises using oil shale in Ida-Viru county.

Estonian-Finnish bilateral agreement to reduce atmospheric emissions:

Agreement between the Government of the Republic of Estonia and the Government of the Republic of Finland on air protection, July 02, 1993, provides for the obligations to reduce atmospheric emissions by 80% by 2005 compared to 1980. The Riigikogu ratified this agreement on September 14, 1994. Unfortunately, Estonia has not been able to fulfil the obligation taken for 2005 – in that year, stationary sources of pollution in Estonia emitted 73.9 thousand tons of SO2. Total estimated emissions of carbon dioxide from stationary and diffuse sources of pollution were 116.3 thousand tons.

LCP directive 2001/80/EC:

- The directive provides certain limit values of atmospheric emissions that enter into force for businesses on 01.01.2008. Estonia applied for a transitional period on the existing oil shale burning devices in Section A (solid fuels) of Annex III (limit values of SO2 emissions) of the Directive in accordance with the level of sulphur capture stated in Article 4 (3) of the Directive. The transitional period was applied for until 2025, but it was granted until 31.12.2015.

- In the Accession Agreement with the EU, transitional period was agreed until December 31, 2015 in AS Narva Elektrijaamad Balti and Eesti power plants, and VKG Energia Põhja power plant. In the Accession Agreement the plan of Estonia to bring energy production with other burning devices in accordance with the requirements since the moment of accession is stipulated. The agreement also comprises the promise made by Estonia regarding interim deadlines to achieve gradual accordance as follows: to introduce fluidized bed technology in four boilers of AS Narva Elektrijaamad by December 31, 2004, and in another four by December 31, 2010. The Accession Agreement also establishes the intention of Estonia to close the old TP-17 type boilers in Balti Elektrijaam by 2010 at the latest. It also states that the burning devices used in transitional period must have a sulphur capture level of 65% and the emissions of particulates may not exceed the limit value of 200 mg/Nm^3.

EC directive 1999/31/EU of 26 April 1999 on the landfill of waste:

- stipulates the requirements for landfill building, operating and closing. For currently used landfills of oil shale residues (ash, semi-coke) that do not meet the requirements of the directive, a transitional period until July 16, 2009 was granted. According to the EU directive requirements, no liquid waste may be stored in landfills.

UN Convention on Climate Change:

- - On May 9, 1992, the representative of Estonia signed the United Nations Framework Convention on Climate Change (UNFCC) in New York, ratified by Estonia in 1994. The objective of this convention was to stabilize greenhouse gas emissions (CO2, N2O,

CH4, HFC, PFC and SF6) to the level of 1990 by 2000. In December 1997, the so-called Kyoto Protocol was adopted, and Estonia acceded to it;

- - On November 17, 1998, and ratified by Estonia on September 3, 2002. The countries who acceded to the Protocol agreed to reduce their greenhouse gas emissions compared to the base year of 1990 by a set percentage by the years 2008–2012. Estonia assumed an obligation to reduce its greenhouse gas emissions by 8%. The Kyoto Protocol entered into force in 2005.

- In 2002, Estonian emission of greenhouse gases compared to the base year (37,494 t CO2 equiv.) was considerably smaller (2002 emissions – capture = 10,411 t CO2 equiv). By the amount of CO2 emissions per person, Estonia belongs to the top 20 countries in the world. With the Kyoto Protocol, Estonia has assumed an obligation to keep the CO2 equiv. emissions in 2008–2012 below 34.2mn tons/year.

In order to reduce greenhouse gas emissions the CO2 Emissions Trading Scheme has been established by the European Parliament and Council directive 2003/87/EC (laying down the system for trading with greenhouse gas emission allowances of the Union), binding to all enterprises that emit the most greenhouse gases. Estonia has transposed these rules to its own legislation. For the enterprises involved in this scheme, the state shall allocate an allowed amount of CO2 emissions for the trading periods of 2005–2007, and 2008–2012 (in tons). If the establishments reduce their emissions, they will have a right to trade their unused CO2 quotas. If an establishment exceeds its total allowed annual CO2 emissions, it has to purchase a necessary amount of emissions from the market in advance, or pay a fine (in the period of 2008–2012, 100 euros for every ton that exceeds the allowed limit). Participation in the EU ETS and allocation of quotas is covered in detail in the SEA report.

Problems and existing opportunities:

- In the period discussed in the Oil shale development plan, the most important aspect in oil shale use is the total limit value of sulphur dioxide emissions that need large-scale investments in order to be met.

- On landfilling of oil shale residues that do not meet the requirements stated in the 26. April 1999 Directive 1999/31/EC on landfills, a transitional period applies until July 16, 2009, the deadline for which is tight.

- In order to fulfil the limitations from international requirements, introduction of modern technologies needs to be accelerated in the use of oil shale, and legislation made stricter to ensure that these requirements are met.

2.7. Population problems in the oil shale deposit area in the view of social and demographic sustainability

Oil shale industry is the largest consumer of natural resources and producer of waste in Estonia. Oil shale opencasts and enterprises that use oil shale are mostly located in Ida- and Lääne-Viru county, therefore the negative effects of oil shale industry can mostly be seen in the environmental condition and population well-being of these counties.

Well-being is defined as the satisfaction of people's material, social and cultural needs, accompanied by opportunities to maintain and improve their health, realise their ambitions and goals, and actualize oneself. The concept of well-being also has a broader meaning as an indicator of a society or territory, because an increase in well-being enables to increase evaluation of

people's working and living environments and self-actualization. The concept of social well-being and sustainable development comprises the principle that one generation may not lessen the opportunities of another generation with its aspiration for well-being. The impact of ecological balance to people's well-being results from the idea that people's living environment – air, water, landscapes etc, are also central factors in people's well-being.

An overview of the population problems and social and demographic sustainability has been presented in the Oil shale development plan on the basis of data analysis of population and social statistics and the results of two sociological studies:

1. Data analysis of population- and social statistics of Ida- and Lääne-Viru counties covers the population, employment and well-being problems (related to people's health, income and wages, real estate prices and viability of the area) in the Estonian oil shale reserve area. The analysis is based on the data by Statistics Estonia, and on the results of social researches carried out in Lääne-Viru county. It is natural that it was not possible to make a comprehensive analysis during the time of research, but the results obtained were relatively explicit and should be reliable enough.

Sociological studies based on qualitative method were carried out among the population of the oil shale deposit area in Ida- and Lääne-Viru counties. The sociologist involved in the workgroup of the Oil shale development plan carried out 16 interviews and 4 focus group studies involving the leaders of rural municipalities of Ida- and Lääne-Viru counties (4 respondents), officials of state authorities of Ida- and Lääne-Viru counties (2), employment- and vocational education specialists (2), specialists from enterprises involved in oil shale mining and processing (5) and representatives of the third sector organisations (3). In the four focus group studies, residents of Maidla, Mäetaguse, Rägavere and Ubja villages were questioned (43 persons in total). The ethics rule of sociological studies guarantee the anonymity of the participants and do not allow associating the results with any certain respondent. A profound or unstandardized interview (without response options) is a conversation with open questions held between the respondent and the interviewer in relaxed environment. The objective of the interviewer is to find information on the phenomena under question through interpretation of the issues by the respondents. Focus group studies are usually held as a conversation between 10–12 participants, in which the issues under examination are discussed through questions asked. Interactive relations forming between the participants increase the amount and diversity of the exploratory information. Profound interviews and focus group studies organized on the basis of qualitative method provide more immediate and deeper knowledge on the problems under consideration than the qualitative research (a large-scale sample study with options). Information gathered by profound interviews and focus groups increases the validity of the topic under consideration and the problems are surveyed more precisely. The results of a qualitative study are not presented as a percentage distribution, instead they are systematized and presented as a thorough description of the problems under consideration.

3. AS Saar Poll carried out a telephone survey based on qualitative method in October 2006 in Ida-Viru county. 1811 respondents, selected randomly, were involved. A questionnaire with given response options was used. The study showed that 83% of the respondents consider oil shale mining important in the view of region development. It was also considered important not to only produce electric energy, but also liquid fuel and chemical products from oil shale (78% of the respondents). 39% even considered it purposeful to expand oil shale industry, but 41% thought it would be reasonable to keep its current scope. Very few people supported reduction of production (5–8%). The opinions of the residents of the "oil shale municipalities", suffering most from oil shale mining, were divided as follows: 13% of the residents found that oil shale industry should be expanded, and 16% had the same view on electricity production. 12% of the respondents from these rural municipalities supported reduction of oil shale industry, and 21% of the electricity production. It is important to add that most of the respondents considered it important cover mostly the needs of Estonia and did not find large-scale export of electric energy and shale oil

justifiable. Since large percentage of the respondents do not live directly in the area of the oil shale deposit, the results of this quantitative study cannot be adequately compared to the aforementioned qualitative studies.

Problems and existing opportunities:

- The conclusions of analysis of health- and social statistics of Ida- and Lääne-Viru counties and the results of sociological studies of the population of Estonian oil shale deposit area reveal lower than average health- and well-being indicators. Pollution (chemicals and dust) arising from oil shale mining and production of oil shale chemicals influences people's health on direct contact, as well as through air and water. These pollutants may cause a rise in the occurrence of respiratory, haematopoietic and cardiovascular diseases, also malignant tumours, mutations, and fertility problems.

- At the same time, oil shale and energetics industry is the most important employment sector of the country. The unemployment rate of the Ida-Viru county population has remained steadily high in the last decade, compared to the average rate of unemployment in Estonia.

- Studies on the health and well-being of the population of the oil shale area have been rare and episodic.

In order to minimise the harmful effects of oil shale industry to the living environment a complex monitoring system should be created, systematically observing the influence of oil shale mining and use to health indicators of both the employees in the oil shale sector, and the general population of the oil shale area.

3. NATIONAL INTERESTS, OBJECTIVES AND MEASURES

Following the national priorities of the Republic of Estonia, which have been established as valid sectoral and multi-sectoral strategies and stemming from the responsibilities assumed by international environmental protection, the following main goals are set regarding the usage of oil shale and indicators are determined required forachieve the aforementioned objectives. The estimates of the financial means needed to achieve the objectives is presented in Table 9, Chapter 4.2.

Strategic goal No. 1. Securing sufficient reserves of oil shale energy in Estonia and its energetic independence

Impact indicator	Base rate
The dependancy rate of Estonian electric energy (imported electricity ratio in domestic electric energy consumption)	3.1% (2006)
Share of oil shale in the balance of Estonian electric energy	90.2 % (2006)
Annual volume of oil shale mining (does not exceed 20mn t)	17.1mn t (2007)

Measures:

1.1. Determining national interests and the changes in the conditions of issuing extraction permits

The state's interest is to provide Estonian consumers with electricity and heat energy without interruptions as well as agglomeration of oil shale products, by implementing the best possible technologies in the mining and processing of oil shale, using oil shale and associated natural resources efficiently and with the lowest possible negative environmental and social influence in a way that would maintain the reserves of oil shale as long as possible and grant the state's security and its sustainable development.

Activity:

1) determining national interest in the Earth's Crust Act and all relevant implementing provisions;
2) determining the conditions of the Earth's Crust Act, which would form the basis for the decisions regarding issuing of extraction permits (usage of the best possible technology, etc.).

1.2. Implementing the legal regulations needed to decrease the use of oil shale

The reserves of oil shale are sufficient to satisfy the current as well as increased energy demands in the future, but oil shale is a non-renewable natural resource and that is why Estonia needs to decrease the annual mining volume of oil shale to 20 million tons and take measures to secure continuing decrease of the share of oil shale in Estonia's energy balance, in order to secure the long-term security of supply. Keeping in mind the Development plan for energy sector until 2020 and the strategy of electricity production fixed in the development plan of electricity economy, we can analyze different measures to bring down the annual mining volume of oil shale to 15 million tons and plan the development of alternative energy sources. The decrease of mining volume to 15 million tons will be set as a goal for the year 2015. The Development plan for energy sector is the basis of the Oil shale development plan in addition to the Development plan of electricity economy and the Development plan for enhancing the use of biomass and bio energy.
In order to achieve the goals set in the Oil shale development plan and meet the obligations taken to limit air pollution, it may become necessary to limit the production of electricity based on oil shale for export and the export of shale oil. In order to guarantee the sufficient reserves of energy for Estonian consumers, the utilization of oil shale for the production of shale oils needs to be limited in the amount that would cover the needs of Estonian heat and electricity producers.

Activity:

1) changing the conditions of the Earth's Crust Act and issuing of extraction permits (the maximum allowed annual volume of oil shale up to 20 million tons with a goal to decrease the mining volume to 15 million tons);
2) changing the Environmental Fees Act providing effective measures to avoid exceeding of the annual limit of oil shale mining.

1.3. Ensuring the sustainability of oil shale usage

In order to ensure the sustainability of oil shale usage, the restrictions related to economy, technology, social sphere and the environment concerning international requirements and the local conditions of Estonia are implemented in the mining of oil shale.
The restrictions will be based on laws, and the restrictions and requirements on the technologies of oil shale mining and use, the efficiency of the usage of natural resources, release of waste into the environment and the ways of waste processing will be determined both by legal acts and

environmental permits. Under the conditions of liberal market economy, the more efficient implementation of fiscal measures (environmental fees, fuel excise) plays an important role in the achievement of the efficiency of oil shale use.
Innovative activities as well as the development and implementation of new efficient and environmentally safe technologies need to be supported.

Activity:

1) amendment to the Waste Act by setting a restriction on the content of organic substance in the solid waste of oil production;
2) studies to determine the usage trends of oil shale:
Stage I – to work out the criteria to evaluate the reserves of oil shale on the basis of quality;
Stage II – the assessment of the oil shale reserves based on the new criteria.

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Strategic goal No. 2. Increasing the efficiency of oil shale mining and its usage

Impact indicator	Base rate
Indicator(s) reflecting the usage of oil shale in the production of shale oils and their base rate will be determined in the study conducted within the framework of activity 2 of the measure 2.1.	
Indicator(s) reflecting the efficiency of oil shale usage in the production of electricity and their base rate will be determined in the study conducted within the framework of the activity 2 of the measure 2.1.	
Loss of oil shale reserves in underground mining	28% (2007)
Loss of oil shale reserves in quarry mining	8% (2007)

Measures:

2.1. Optimization of mining volume

Despite the increase of energy consumption and the fact that the extraction permits have been issued in the maximum annual volume of up to 23.75 million tons, the mining volume of oil shale needs to be restricted, setting the upper limit to 20 million tons per year. The establishment of the maximum limit is necessary to avoid the excess damage to the natural environment and social pressure to the area and to guarantee the sustainability of oil shale mining. The reasoning for the optimum mining volume has been presented in subchapter 2.3.
The Energetics Board of Estonian Academy of Sciences notes in its decision of December 19th, 2006 that since the consumption of electricity is increasing in Estonia, the demand of oil shale does not decrease in the next few years, but would rather increase. In order to determine the future production volumes and optimum solutions, the Energetics Board recommends to analyse the entire mining and usage chain of oil shale, keeping in mind the economic efficiency, environmental protection and sustainability and the energy strategy and needs of the state as a whole. This task needs to be solved in the next stage of the implementation of the Oil shale development plan for the years 2016–2030.
Environmental restrictions limit the excess mining and consumption of oil shale that have been mentioned in the environmental impact assessment report. Exceeding of the annual production of up to 20 million tons would threaten fulfilment of the environmental obligations taken by the Republic of Estonia.
According to the index of mineablility, the areas with high and very high mining value are Uljaste, Narva, Uus-Kiviõli, Ojamaa, Aidu, Viru, Sirgala, Sompa, Ahtme, Kohtla and Tammiku.

The fields with the **best energy productivity in terms of the bedding** are Narva, Uus-Kiviõli, Puhatu, Ojamaa, Estonia, Aidu, Sirgala, Sompa, Viru, Ahtme, Kohtla and Tammiku.

Of the aforementioned mining and exploration fields, the ones that will have been mostly exhaused by 2015 are Narva, Sompa, Ahtme, Kohtla (incl. Aidu) and Tammiku. Ojamaa deposit has already received an extraction permit and the opencast is being mined. The exploration field of Uus-Kiviõli has applied for an extraction permit. Mining is complicated at the Uljaste exploration field due to environmental restrictions. In order to secure the national energy supplies (to diffuse the energy) beyond the year 2015 and develop chemical industry, the future use of Uus-Kiviõli and Puhatu is possible.
The more perspective fields in terms of **potential energy** volume are Peipsi, Rakvere, Estonia, Permisküla, Puhatu, Sonda, Tudu and Oandu. Therefore, 78% of energetic resources of Estonian oil shale deposits is located in fields that have a lower than the average mining value. The average value is based on the deposits of the Estonia opencast.
Once the open oil shale opencasts in the eastern part of Estonian oil shale deposits are exhausted, mining of oil shale in the central and western parts needs to be considered, but the oil shale reserves there are located deeper in the ground. In connection to that, the share of underground mining will increase, which, on the one hand, will mean the increase of investments and the rise in oil shale prices, but on the other hand, will decrease the impact on the environment and the social disturbance. Taking into account of the mining value, energy productivity of the bedding and potential energy volume as well as the environmental restrictions, it is practical to start mining in the prospecting fields of Uus-Kiviõli and Puhatu in the future, that have not been used so far.
Despite the sufficient oil shale resources, we need to start shaping Estonian energy economy so that the importance of oil shale energetics decreases, considering the environmental and social factors and public pressure. In Estonia, in the provision of domestic energy, the situation will become tense at the end of 2015, when all the present oil shale production volumes based on burning of oil shale dust will be shut down. The alternative is to invest in nuclear energetics or diffused energy production, but the alternatives have not been discussed in the Government of the Republic of Estonia, among specialists or in public.
In order to achieve the goals set in the oil shale and fuels and energy economy development plans, more efficient measures need to be taken to further the development of the electricity production capacity based on alternative fuels and the production of renewable fuels.

Activity:

1) ordering applied studies to draw up the development plan for oil shale use, including: a complex study for the determination of optimum oil shale mining volume for the years 2016–2030, taking into account the gradual decrease of the share of the oil shale energetics in the future and the more precise interest of the state in relation with the previous;
-studies to set the priorities for the use of oil shale for the years 2016–2030, taking into account the economic criteria and the determination of the best possible technology;
2) ordering of analyses needed for the strategic planning of energy and electricity economy (finding alternative energy sources for the decrease of the share of oil shale and the usage of the alternative energy sources to secure a sufficient production volume).

2.2. Furthering oil shale implementation studies and product development

Determination of the usage trends is based on Development plan for fuel and energy sector [1], Development plan of electricity economy [2] and basic research ordered by the Ministry of Economic Affairs and Communications and conducted by the department of mining and the institute of oil shale of Tallinn University of Technology [12-16]. Data has also come from the bigger companies connected with utilization of oil shale (Eesti Energia AS, Viru Keemia Grupp AS, Kiviõli Keemiatööstuse OÜ, AS Kunda Nordic Tsement).
The time span described in the Oil shale development plan is a very short one, only two years, and that is why it is clear that the usage of oil shale has to be continued according to the old trends and based

on the technologies used now. The question lies mainly in the volume of oil shale to be used and the proportions of different usage trends. On the other hand, we need to start the development of new potential oil shale development trends already today. This requires the planning and support of studies targeted at finding new development trends and technologies (*the best possible technology, PBT*) as well as optimizing the present ones, the increase of the efficiency of oil shale usage and the decrease of the environmental impact. The strategy of development activities and innovation for the years 2007–2013, known as "Knowledge based Estonia II" sees the development of certain fields in conjunction with the realisation of national research and development programs. One of the key areas includes the planning of compilation of national program for R&D of energy, and one of the trends is the development of oil shale technologies (activities for the development and growth in efficiency of the entire oil shale production cycle, including the further increase in value of oil shale). The financing of basic research (targeted and grant-based financing in the field of energy technologies as a whole) depends on the success of the applications made.

Activity:

1) compiling the national program of energy R&D, with one trend being the development of oil shale technologies (activities for the development of the entire production cycle and growth of efficiency of oil shale are planned, including the further increase in value of oil shale);
2) helping in the planning of the establishment of the develpment centre of oil shale technology;
3) studies in the field of research and development of oil shale and creating prerequisites to start international co-operation projects.

2.3. Review of the principles of the environmental fees related to oil shale mining and utilization

It is increasingly necessary to take into account the external costs associated with the mining of oil shale and the use of oil shale products, while setting the rates of environmental fees. In the implementation of the mining rights fee, quality of the oil shale needs to be considered as well.

Activity:

1) Applied research to calculate the external costs in the environmental fee rates objectively in a way that would improve the efficiency of oil shale usage and the value of oil shale products, and by advance assessment of the impact of possible changes of environmental fees on the price of electricity and entrepreneurship. The increase in the share of the equalisation fund of the so called oil shale municipalities was considered.

2.4. Furthering education and research

The subjects related to oil shale need to be popularized more with the young, both on the level of vocational and higher education.

Activity:

1) Improvements in education and research activities in institutions of professional higher education as well as universities and popularization of fields related to oil shale;
2) Compiling and publishing of Estonian language study materials (within the general project for developing Estonian study materials).

Strategic goal No. 3. Increasing the environmental impact of mining and use of oil shale

The state can decrease the environmental impact of oil shale mining and utilization by taking regulative and fiscal measures simultaneously, supporting the establishment of the environmental infrastructure and the conducting of environmental research and the spread of the environmental

knowledge. Since the environmental impact of oil shale mining and use is largely related to the volumes of mining and the technologies used, the maximum annual mining limits have to be set on oil shale mining and set limitations decreasing the environmental impact on both the mining of oil shale as well as the technologies used. In order to decrease the negative impact on the social welfare of the area and the traditional survival ways, we need to limit the number of new pits, ensure faster exhaustion of pits and the quicker reusing of the mined areas. It is important to take measures to avoid pollution of the environment and harmonize these measures with the local governements.

Impact indicator	Base level
The ratio of reused areas to pit areas to be opened	50%:50% (2007)
The amount of semi-coke from processing of oil shale	0.846mn tons (2005)
The amount of clinker from the processing of oil shale	2.352mn tons (2005)
CO2 emission on the production of energy	16.3mn tons (2006)
The indicator(s) reflecting the health impacts to the population, and their base level is determined in a study conducted as part of the action 2 of measure 3.4.	

Measures:

3.1. Implementation of special environmental measures

The special environmental measures need to be implemented while mining in the former Pandivere water protection area and the bordering areas and in the influence area of the natural objects under protection according to the local natural conditions and the conditions determined by the management plans of the species and living environments.
The Ministry of the Environment coordinates the compilation of water management plans of river basins and sub-basins. The maintenance plan for Pandivere sub-basin was approved by the Minister of the Environment on March 10, 2005, with Order No. 253. The information is available on the website of the Ministry of the Environment at http://www.envir.ee/204372. A nitrate sensitive area in Pandivere has been determined, and this is protected by a ruling Nö. 17 of the Government of the Republic of Estonia from January 21, 2003.
According to the assessment report of environmental impact, the requirements decreasing the harmful impact of mining to people's health, property and the environment can be set immediately as established in the Earth's Crust Act.

Activity:

1) mapping the negative environmental and health impacts related to oil shale mining and providing alleviating measures to decrease the impact;
2) studies to assess the ground water supplies at oil shale field that have to ensure a true overview of the ground water supplies and their movement in the planned mining area, specification of the hydrogeological models that help to determine the span of depression areas and the quality of water that is pumped out;
3) supplementing the Earth's Crust Act so that on the basis of the results of the advanced studies (activity No. 1), maximum possible decrease of harmful impact of mining to people's health and property, as well as the environment, is ensured.

3.2. Usage of oil shale fields considering mining sensitivity

Mining is forbidden or restricted in areas under natural and environmental protection or in socially sensitive areas. Mining at natural conservation areas and the areas influencing these has to be forbidden if possible. In case an application is made, it has to be preceded by a very thorough

environmental assessment. In the foundation studies made in 2005 as part of the compilation of the Oil shale development plan compiled in the the department of mining of Tallinn University of Technology, the conditions of the usage of mining fields take into account the categories of the areas' mining sensitivity [15]. The proposition that was made distinguishes between 4 categories, taking into account the technological, economic and environmental requirements set on the mining areas.

Activity:
1) ordering applied studies so that it would be possible to take into account the category of mining sensitivity while handling the extraction permit applications and starting to use the mining fields.

3.3. Optimization of reusing of the mined areas

Concerns of the population in connection with the reuse of mined areas are mainly based on the Soviet experience – maintenance was done without sufficient care and without consulting the locals. The situation in the present Estonia has improved considerably, the mined areas are generally reforested and will be reused with a higher quality than it previously had. Various large mammals and bird species under protection, including eagles have settled down in the forests. There are no depressions in the ground above the new opencasts, because the room-and-pillar type of mining reserves wholes large enough. The areas with depressions have undergone maintenance work and the more dangerous depressions have been filled with spoil and covered in earth. The closed mining territories are mainly used as business land, the unused territories are maintained and given back to the state (Ahtme opencast). Opencast waste deposits are redesigned into multipurpose recreational areas (Ahtme, Kohtla and others).
At the same time, people have high expectations on the reusable land and as a rule, they wish that the mined areas were restored to the landscapes at least comparable to the ones that existed previously. In order to meet these expectations, the world's best known environmental practices need to be implemented, based on the entire environmental cycle, from the activity before the mining until the returning of the land to its owner. Including the local governments and population in all the cycles is necessary. We have to secure a complete material and environmental responsibility and involve landscape architects who would issue from the specificity of the mining landscape. In case of the protected objects on the ground, maintained wholes need to be preserved.

Activity:

1) foundation studies with a goal to regulate oil shale mining in separated areas based on the Earth's Crust Act and other legal acts and extraction permits and to start reusing the mined areas as quickly as possible, in order to keep the disturbing effects as short-term as possible and turn the landscape after mining into a usable one.

3.4. Decreasing the negative social and demographic impact in oil shale basin and the impacted areas

The local population has noted disruptions in the provision of clean drinking water, low quality of ambient air, noise and smell produced by the companies, damaged real estate and the drawbacks in the compensatory system as negative effects relating to oil shale mining.
The quality of ambient air at the oil shale mining area definitely needs improvement. In order to achieve that, air pollution that accompanies oil shale production needs to be decreased considerably. This is achieved by the considerable modernisation of the entire electricity and oil shale production, especially the improvements in generator-based production facilities. Since the situation in Kohtla-Järve is critical due to the high background air pollution, it is not practical to build new shale oil production plants here.

Of the types of negative influence that accompany the oil shale mining and processing, the local inhabitants are considerably distracted by the impediments in the usage of the present infrastructure. Noise is a significant factor in areas where the production facilities or the roads which are used to deliver the raw materials and products are located close to people's homes.
In order to alleviate social pressures, especially those stemming from the expansion of production and the use of transport, the location of the production facilities used for new oil shale opencasts needs to be better planned and the transport flows need to be diffused both in space and time.
The companies need to contribute more into the implementation of the social alleviation measures, including into the founding of support funds and programs. Representatives of local governments and stakeholders need to be involved in the management of these and their means should be used to finance the measures needed to decrease the negative impact of the companies in the interests of the local inhabitants.

Activity:

1) fixing the mining business'es social, economic and environmental responsibilities on issuing of an extraction permit. In order to provide the local inhabitants with quality drinking water, the waterworks need to be fully built before mining is started in the areas where the disruptions in the provision of water are likely to occur due to the mining activity (to specify the Earth's Crust Act);
2) setting a compensatory mechanism that would take into account the health of the locals and other social aspects better while amending the law of environmental fees;
3) working out and implementing the ways of compensation of damages to the inhabitants and local governments in the area of oil shale mining;
4) improving exchange of information regarding the new activities planned by the enterprises and regarding the environmental impact stemming from the activities of the enterprises, to alleviate the social disruption of the locals and social tensions. Introducing the environmental measures and their effectiveness.

3.5. Setting conditions that take into account the environmental and social requirements in issuing of the extraction permits

The governing coalition's program for the years 2007–2011 establishes the obligation to maximise the use of the mineral deposits and the depositing of the soil and dirt in a way that would enable their reuse, and such requirements are to be added to the Earth's Crust Act and extraction permits. The analysis shows how it is possible to implement technologies that minimize the negative impact of mining in the granting of new mining areas, to use the resources in an economical way, minimize the losses of mineral deposits (by giving up the unreasonably big deposit wholes, filling of the mined areas, using the method of longitudinal section mining under wetlands). Technogenic environmental impact needs to be minimized: avoidance of seismic impact, noise, dust and change in the condition of ground water (for instance by mechanical extraction). It is important to get a quality end product from the oil shale, in the farther future also including fuels and chemical products. In above ground mining of oil shale (natural landscape is destroyed, the layered rocks will be removed and reset, the layer of oil shale will be removed completely, and the rain and ground water will be removed from the water in the pit, and after that, the exhausted mining field will be reused) or in underground mining (the layers of oil shale will be broken, leaving the pillars keeping the ground stable, and carried out without removing the layer of soil; rain and ground water that has entered the pit water will be directed away), the impact that disrupts the environment and the inhabitants is different. When an extraction permit is issued, it is important to assess the impact on the environment and the wellbeing of the inhabitants in the mining area, both during the mining activity as well as after it.
When an extraction permit application is assessed for its impact on the environment and the permit is issued, the following aspects need to be taken into account:

1) Impact on ground and surface water. It is important to describe and explain the influence of the technology used (and the speed of mining) on ground water: the span of the depression

area and that (on maps, by layers of ground water); the volume of water that is pumped out (m^3/per year m^3/t per the mined oil shale volume) and measures to decrease the amount of ground water would enter the pit; the quality of water that is pumped out (the content of BOD, COD, particles in the water, sulfates, phenols) and the technological measures implemented to maintain the quality of water;

2) Impact on the quality of life of the local inhabitants. It is necessary to describe the technologies of mining, processing, storing and delivering of oil shale and their impact: location and extent of the built infrastructure (maps); the spread of noise and dust that accompanies the building, mining and processing activity, and the relevant zones (maps); the oil shale transportation options, delivery routes (maps) and volumes and estimates on the residues (CO2, solid particles, SO2, NOx waste per t/year and kg/t per volume of mined oil shale) and energy cost (support/ton per volume of mined oil shale); description of other possible disruptive factors and their alleviation measures;

3) The social impact and the extent of the implementation of alleviation measures. If possible, to assess how many households are going to suffer from the deterioration in the quality of social services (presence of roads, water supply, access to postal service and other social infrastructure and services) and to describe the compensatory measures that can be implemented; further measures to support the social infrastructure and people's quality of life in the area that is related to the planned activities, and calculation of their cost (EEK/year);

4) Closing of the opencasts. It is necessary to describe the technologies of maintaining the exhaused pits and the ways of closing the pit as well as the methods and cost of restoring the natural condition of the area (EEK/hectare), also the restoration of the natural condition (restoration time in years).

Activity:

1) applied studies to completement the Earth's Crust Act with a list of options to change and invalidate the extraction permits, taking into account the level of non-compliance with the legal acts;

2) complementing the Earth's Crust Act with a list of possibilities of changing and invalidating the extraction permits, taking into account the level of non-compliance with the legal acts.

4. IMPLEMENTATION OF THE OIL SHALE DEVELOPMENT PLAN

4.1. Management structure for implementation of the Oil shale development plan

Description of the Oil shale development plan management structure was prepared pursuant to Regulation No. 302 of the Government of the Republic of 13 December 2005 "Types of Strategic Development Plans, the Procedure for their Preparation, Amendment, Implementation and Evaluation and the Reporting Procedure".

The Government of the Republic has given the Ministry of the Environment the responsibility of preparing the Oil shale development plan. The Ministry of the Environment is responsible for coordination of preparation, amendment, implementation, assessment and reporting of the Development Plan. On the basis of the Amendment Act to the Earth's Crust Act, passed on 13 June 2007 by the Riigikogu (entered into force on 8 July 2007), the Oil shale development plan is approved by the Riigikogu. The Oil shale development plan is accompanied by an implementation plan that is prepared for the years 2008–2011 for the time being, and will be presented to the Government of the Republic together with the Oil shale development plan by the Minister of the Environment.

On the basis of Regulation No. 302 of the Government of the Republic, the Minister of the Environment shall provide the Government of the Republic an annual report on implementation of the Oil shale development plan, achievement of the objectives set out in the development and implementation plans, and efficiency of the measures on the basis of which amendment or termination of the development plan will be decided. If necessary, the implementation plan will also be amended in the course of annual reporting.

The Oil share development plan will be implemented by periods on the basis of the updated implementation plan envisaging the cost and financial sources of implementing the Oil shale development plan, initially according to the measures planned for the first four years. The Ministry of Environment has involved the Ministry of Economic Affairs and Communication, the Ministry of Finance, the Ministry of Education and Research, and the Ministry of Social Affairs in the introduction process of the implementation plan. The main tasks and obligations set for the implementation of the Oil shale development plan for Oil Shale were been discussed in the process of the preparation of the development plan in order to give all the relevant ministries a chance to take the Oil shale development plan into consideration during the preparation of the development plans for their own areas and budget applications.

The implementation plan also identifies developments in oil shale use for the next few years, also considering relevant developments in the world.

4.2. Estimation on the cost of the Oil shale development plan

Table 9. Cost of measures in kroons

Strategic goal No.1. Ensuring Estonia's supply of oil shale energy and securing Estonia's energetic independence							
MEASURE 1.1. Defining the national interest and changing the conditions of issuing mining permits							
	Time of implementation	Cost by years					
	2008–2009	2008	2009	2010	2011	2012–2015	Funder/source
Cost of measure	300,000	0	300,000	0	0	0	ME/SB
MEASURE 1.2: Implementing the necessary legal regulations for reducing the usage of oil shale							
	Time of implementation	Cost by years					
	2008–2009	2008	2009	2010	2011	2012–2015	Funder/source
Cost of measure	70,000	0	70,000	0	0	0	ME/SB

MEASURE 1.3. Ensuring sustainability of oil shale use							
	Time of implementation	Cost by years					
	2008–2010	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	1,000,000	0	500,000	500,000	0	0	MEAC/SB
Strategic goal No.2. Increasing the effectiveness of oil shale mining and use							
MEASURE 2.1. Optimising mining capacity							
	Time of implementation	Cost by years					
	2008–2015	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	5,700,000	1,700,000	1,000,000	1,000,000	1,000,000	10,000,000	ME, MEAC/RE
MEASURE 2.2. Promoting process-oriented research and development and product development related to the subject field of oil shale							
	Time of implementation	Cost by years					
	2008–2015	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	9,250,000	1,000,000	2,250,000	1,000,000	1,000,000	40,000,000	ME, MEAC, MER/RE
MEASURE 2.3. Reviewing the principles of environmental charges of mining and oil shale use							
	Time of implementation	Cost by years					
	2008–2009	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	500,000	0	500,000	0	0	0	ME/SB
MEASURE 2.4. Promoting education and research							
	Time of implementation	Cost by years					
	2008–2012	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	7,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	MER/SB
Strategic goal No.3. Reducing the environmental impact of oil shale mining and use							
MEASURE 3.1. Applying specific measures on environmental protection							
	Time of implementation	Cost by years					
	2008–2015	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	1,200,000	500,000	0	0	0	700,000	MSA, ME/SB
MEASURE 3.2. Use of oil shale deposit based on mining sensitivity							
	Time of implementation	Cost by years					

	2008–2015	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	5,000,000	250,000	750,000	1,000,000	600,000	2,400,000	ME/SB

MEASURE 3.3. Optimising the reclamation of mined areas							
	Time of implementation	Cost by years					
	2008–2010	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	1,250,000	0	625,000	625,000	0	0	ME/SB

MEASURE 3.4. Decreasing the negative socio-demographic influence in an oil shale basin and its area of influence							
	Time of implemen-tation	Cost by years					
	2008–2015	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	500,000	0	0	0	500,000	0	ME/SB

MEASURE 3.5. Setting the conditions that consider environmental and social life requirements in issuing extraction permits							
	Time of implemen-tation	Cost by years					
	2008–2009	2008	2009	2010	2011	2012–2015	Funder/ source
Cost of measure	350,000	0	350,000	0	0	0	ME/SB
Total development plan	**2008–2015**	**2008**	**2009**	**2010**	**2011**	**2012–2015**	
Total cost	**32,620,000**	**4,950,000**	**7,845,000**	**5,625,000**	**4,600,000**	**9,600,000**	**SB**

The Ministry of Economic Affairs and Communications has initiated a consortium for establishing a development centre of oil shale technologies (TAK).

SUMMARY

Oil shale is a national treasure that must be used economically and valued as an important strategic resource that provides Estonia with a political, economic and energetic independence. Oil shale has to be mined in an environmentally friendly manner, saving water, landscapes, air, the animal- and plant kingdom and various people inhabitating the area. Environmentally friendly mining involves quick explotation of the deposit, quick winning of the resource, minimal affecting of the groundwater and biota, avoiding noise-, dust- and seismic effects, and restoration of the mining area quickly and in line in accordance with the Europe's best standards approved by local governments.

The Earth's Crust Act that was passed on December 23, 2004 by the Riigikogu entered into force on April 1, 2005. The provisions of this act are insufficient for efficient directing of the usage of oil shale on the national level, although in the § 34 (1) 14) of this Act, refusal to issue an extraction permit is allowed if "extraction is contrary to the national interests". Until now, national interest had not been clearly defined. In the Oil shale development plan, national interest in using the oil shale resource is properly defined and needs an approval of the regulator. **National interest includes providing a steady supply of electricity, heat and agglomerated oil shale products by implementing the best possible technology in mining and processing of oil shale, using the oil shale and the accompanying natural resources effectively and with minimal negative environmental and social impact in order to ensure the presence of oil shale for as long as possible and to ensure national security and sustainable development.**

1. To use the oil share resources economically, the limit of 20mn tons/year on oil shale mining needs to be set immediately and find long-term possibilities to gradually reduce the annual usage capacity of oil shale. The mining capacity shall be determined by national demand, environmental protection restrictions, and social endurance of the population.
2. Since more than 20mn tons/year worth of extraction permits have already been issued, new applications or applications submitted before the adoption of the Oil shale development plan, but yet unissued, cannot be satisfied, with the exception of applications that had received the EIA before suspencion of procedure on the basis of § 75 (6) of the Earth's Crust Act. Pursuant to the Earth's Crust Act, new extraction permits will not be issued until the resources of the existing opencasts would be depleted in up to 5 years. On the basis of the quality of the resource and technological, environmental protection and social conditions, the best possible options for constructing new opencasts are the Uus-Kiviõli and Puhatu mining or exploration fields.
3. More attention sould be paid to residual reserves (Ahtme, Kose Tammiku, etc.); ruined landscapes can be reshaped into areas suitable for management and recreational purposes.
4. Oil shale is a strategically important resource, so mining this resource needs to be directed in a more efficient way on the national level; this means that in the case of several applicants, an auction does not need to be held; mining rights should rather be given to a company that implements more environmentally friendly technologies and better measures for improving the status of the environment.
5. In order to use the energetic resource of oil shale in a better way, preferably the technologies that can also process ore with a low calorific value should be used.
6. With a view of agglomeration of shale oil, including in processing it into motor fuels, the government and the private sector need to carry out additional scientific research and tests of industrial processing devices. Before this no new permits should be issued for expanding shale oil production. Accounting criteria for assessing the agglomeration of shale oil need to be determined.
7. Usage trends of oil shale in 2008–2015 are the following:
   - using oil shale for the production of electricity and shale oil to cover Estonia's national consumption, as a priority;
   - using oil shale for its additional agglomeration (motor fuels, chemical products, etc.) with the best possible technologies, as a priority;
   - for the needs of domestic cement production, as a priority;
   - using oil shale for the production of electricity and shale oil for export is only allowed in a limited scope on the basis of national interest; this is regulated with extraction permits and mining capacities set for AS Eesti Põlevkivi.

8. Since oil shale power plants produce most of the electricity in the period under consideration, it is not feasible to restrict the development of the mining companies that are connected to power plants and already have an existing transport infrastructure (principally, a railway). It is advisable to reserve the blocks of mineable reserve bordering with the mining fields of these mining companies to the same mining companies, providing a relevant legal basis for such an action.
9. In order to raise the effectiveness of using oil shale, recycle residues from oil shale mining and use, exploit the accompanying natural resources and reduce the proportion of oil shale in the energy balance, the concept of determining the rates of environmental charges needs to be reviewed, taking into consideration the quality of the mineral resource and, increasingly, the external costs of mining and using oil shale and oil shale products included in the rates. To this end, the rates of the right of use of natural resources and the rates of pollutants need to be increased.
10. Mined areas have to be taken into usage according to the best known practice, keeping in mind the optimal expenditure and the specific character of the nature of the area. Local inhabitants and governments need to be more involved in the process.
11. Preparation of the second stage of the Oil shale development plan (until 2030) has to begin as soon as possible. The purposefulness of establishing new opencasts and pits has to be deliberated and their possible new locations considered, keeping in mind the social impact of these new structures and their impact on nature, including the socio-demographic sustainability of the population and the viability of local governments of the oil shale basin, employment, and training of skilled labourers and specialists. Conditions for a better infrastructure need to be provided.
12. In the short run, the Government and the Riigikogu need to make a quick strategic decision on which alternative energy sources to use to reduce the proportion of using oil shale. A decision needs to be made whether to contribute to nuclear energy or distributed energy production that considers the real technical and economic opportunities. The decision needs to be made in cooperation with impartial foreign experts and the general public by means of a broad discussion and, if necessary, a referendum.
13. Various vocations in the field of oil shale need to be increasingly promoted among young people, both at vocational and higher education levels. For this purpose, vocational guidance should be provided in general education schools in Ida-Virumaa as a pilot project, with an emphasis on ensuring a large enough volume of workers in the oil shale industry.

Used literature / sources

1. Long-Term Development Plan for Estonian Fuel and Energy Sector 2015. The Appendix to the State Gazette, 23.12.2004, 88, 601; *Internet:* https://www.riigiteataja.ee/ert/act.jsp?id=829062 (4. 02.2007)
2. Development plan of the Estonian electricity economics 2005–2015. The Appendix to the State Gazette, 18.01.2006, 7, 134. *Internet:* https://www.riigiteataja.ee/ert/get-attachment.j sp? id=984718 (4.02.2007).
3. Estonian National Strategy on Sustainable Development "Sustainable Estonia 21". Ministry of the Environment of the Republic of Estonia. Tallinn 2005.
4. Estonian Environmental Strategy 2030. Ministry of the Environment. Internet: http://www.envir.ee/orb.aw/class=file/action=preview/id=328494/Keskkonnastrateegia+2030+ %28eeln%F5u%29.pdf (04.02.2007).
5. Estonian Research and Development and Innovation Strategy 2007–2013 "Knowledge-Based Estonia". Ministry of Education and Research. *Internet:* http://www.hm.ee/index.php?popup =download&id=4808 (04.02.2007.
6. Estonian rural development plan for 2007–2013. Ministry of Agriculture. *Internet:* http://www.agri.ee/link.php?id=13792&filename=MAK_2007_2013_25_01_2007.pdf (04.02.2007).
7. Development plan of Ida-Viru county. *Internet:* http://www.ida-virumaa.ee/rightSections.php? sectio =topMenu/maakond/arengutegevus. (04.02.2007)
8. Waste management plan of Ida-Viru county. *Internet:* http://www.envir.ee/237051 (04.02.2007).
9. Development strategy of Lääne-Viru county 2007–2015, version 2006. *Internet:* http://zoomserv.mls.ee/lvirumv/?id=3255 (07.02.2007).
10. Environmental Action Plan. Ministry of the Environment. *Internet:* http://www.envir.ee/2851 (04.02.2007).
11. Sustainable Development Act. The State Gazette I 1995, 31, 384; 1997, 48, 772; 1999, 29, 398; 2000, 54, 348; 2005, 15, 87. *Internet:* https://www.riigiteataja.ee/ert/act.jsp?id=874359 (04.02.2007).
12. Adamson, A jt. 2006. Eesti põlevkiviressursi kasutamissuundade riikliku strateegia aastani 2020 alusuuringud. Ettepanekud Eesti põlevkivitööstuse 2006…2010 arendusuuringuteks (Basic research of the national strategy on the utilization trends of the Estonian oil shale resource until 2020. Suggestions on the development research of Estonian oil shale industry 2006…2010). Manuscript in the Department of Mining TUT, Tallinn.
13. Adamson, A jt. 2005. Eesti põlevkiviressursi kasutamissuundade riikliku strateegia aastani 2020 alusuuringud. Põlevkivi kaevandamise tehnoloogilise struktuuri optimeerimine. (Basic research of the national strategy on the utilization trends of the Estonian oil shale resource until 2020. Optimization of the technological structure of oil mining). Manuscript in the Department of Mining TUT, Tallinn.
14. Adamson, A jt 2005. Eesti põlevkiviressursi kasutamissuundade riikliku strateegia aastani 2020 alusuuringud. Kasutamissuundadele vastava põlevkivi varu hindamise kriteeriumite loomine ja koguse hindamine vastavalt arenevale kütuse ja energiamajandusele, ressursi pikaajaline planeerimine. (Basic research of the national strategy on the utilization trends of the Estonian oil shale resource until 2020. Establishing the criteria on estimation of the oil shale resource in accordance with the utilization trends and estimating the capacity in accordance with the developing fuel- and energy economy. Long-term resource planning). Manuscript in the Department of Mining TUT, Tallinn.
15. Adamson, A jt. 2005. Eesti põlevkiviressursi kasutamissuundade riikliku strateegia aastani 2020 alusuuringud. Eesti põlevkivimaardla tehnoloogiline, majanduslik ja keskkonnakaitseline rajoneerimine" (Basic research of the national strategy on the utilization trends of the Estonian

oil shale resource until 2020. Technological, economical and environmental division of Estonian oil shale deposit). Manuscript in the Department of Mining TUT, Tallinn.
16. Soone, J jt. 2005. Kasutamissuundadele vastava põlevkivi varu hindamise kriteeriumite loomine ja koguse hindamine vastavalt arenevale kütuse ja energiamajandusele, ressursi pikaajaline planeerimine. Varude hindamise kriteeriumid põlevkivi kui kütuste ja kemikaalide lähtetoorainele. Manuscript in the Department of Mining TUT, Tallinn.
17. Bowels of the Earth Act. The State Gazette I 2005, 15, 87; 67, 512; 2006, 14, 109,; 58, 439. *Internet:* https://www.riigiteataja.ee/ert/act.jsp?id=12766617 (04.02.2007).
18. Statistics Estonia. Energy Balance 2005, 2006. *Internet:* http://pub.stat.ee/px-web.2001/Dialog/varval.asp?ma=KE023&ti=ENERGIABILANSS+K%DCTUSE+V%D5I+ENERGIA+LIIGI+J%C4RGI&path=../Database/Majandus/02Energeetika/&lang=2 (04.02.2007).
19. *Soone, J. Doilov, S. 2003.* Resources and comparison of contemporary technologies used for oil shale processing. Oil Shale, *20, 3S. 311-323*
20. Soone, J, Riisalu, H. Kekisheva, L., Doilov, S. 2006. *Environmentally Sustainable Use of Energy and Chemical Potential of Oil Shale.* Tallinn University of Technology, International Oil Shale Conference 2006, Amman, Jordan.
21. *Petersen, I. 2006.* The Unique Experience of Oil Shale Utilization at Narva Power Plants (NPP). AS Narva Elektrijaamad, WEC, Executive Assembly 2006, *September 07, Tallinn.*
22. *"The Unique Experience of Oil Shale Utilization".* Ilmar Petersen, Narva Power Plant, Oil Shale Conference 2006, Amman.
23. Pirksaar, R. 2006. Eesti Energia AS ja soojuse-elektri koostootmine. Seminar presentation of the Ministry of Economic Affairs and Communications and Eesti Energia, Tallinn.
24. National waste management plan. RTI, 23.12.2002, 104, 609. *Internet:* https://www.riigiteataja.ee/ert/act.jsp?id=232285 (04.02.2007).
25. *Arro, H., Prikk, A., Pihu, T. 2005.* Combustion of Estonian oil shale in fluidized bed boilers, heating value of fuel, boiler efficiency and CO2 emissions. Oil Shale, *22, 4S.*
26. *Arro, H., Prikk, A., Pihu, T., 2006.* Calculation of CO2 emission from CFB-boilers of oil shale powerplants". Oil Shale, *23, 4.*
27. *Perens, R., Punning, J.-M., Reinsalu, E. 2006.* Water problems connected with oil shale mining in North East Estonia. Oil Shale, *23, 3, 228-235.*.