



KESKKONNAMINISTEERIUM

*MINISTRY OF THE ENVIRONMENT*

*NATIONAL DEVELOPMENT PLAN FOR  
THE USE OF OIL SHALE 2016–2030*

# PÕLEVKIVI KASUTAMISE RIIKLIK ARENGUKAVA 2016-2030



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## Introduction

The Government of the Republic has approved the proposal for the preparation of the “National Development Plan for the Use of Oil Shale 2016–2030” (hereinafter “the oil shale development plan”, “the oil shale development plan 2016–2030”, or “the development plan”) with directive No. 138 of 4 April 2013.

The general objective of the oil shale sector is the enforcement of national interest, which means the effective and efficient use of oil shale as a nationally strategic resource, and ensuring the sustainable development of the oil shale sector. National interest is described in more detail in Chapter 4.1.

The oil shale development plan continues the strategic management of the oil shale sector, which was initiated with the “National Development Plan for the Use of Oil Shale 2008–2015”<sup>1</sup> (hereinafter “the oil shale development plan 2008–2015”), which was approved by the decision of 21 October 2008 of Riigikogu.

The Government of the Republic has appointed the Ministry of the Environment (ME) to be responsible for the preparation of the oil shale development plan — the Ministry of the Environment has developed the plan in collaboration with the Government Office, the Ministry of Economic Affairs and Communication (MEAC), the Ministry of Education and Research (MER), the Ministry of Finance (MF), the Ministry of the Interior (MI), and the Ministry of Social Affairs (MSA). The task of the Ministry of the Environment is to prepare, amend, execute, and assess the development plan and to coordinate the reporting thereof. The oil shale development plan is presented for approval to Riigikogu by the Government of the Republic.

The list and explanation of the definitions used in the oil shale development plan is provided in Annex 1 to the development plan. A summary of the main fields of activities handled in the oil shale development plan 2008–2015 is provided in Annex 2.

The oil shale development plan is prepared based on the State Budget Act and the necessity for the development plan arises directly from the Earth's Crust Act and the Sustainable Development Act. Pursuant to the Earth's Crust Act, the oil shale mining permit will not be granted in the absence of a national development plan that fixes oil shale utilisation trends (including the assessments of the utilisation of shale oil, oil shale retorting gas, and of the electricity and heat produced from oil shale). The national direction of the use of oil shale ensures the sustainable consumption of oil shale resources and limits, and controls the environmental load created by the oil shale industry. An overview of the legal requirements for the extraction and use of oil shale is provided in Annex 3 to the development plan.

The oil shale development plan is prepared in accordance with the “Estonian Environmental Strategy until 2030” (hereinafter “the Estonian environmental strategy”). An overview of the connections between the oil shale development plan and other strategic documents is provided in the first chapter of the development plan.

The strategic aims and measures for developing the oil shale sector are presented in the oil shale development plan. The action plan, which describes the measures together with the necessary

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<sup>1</sup> “National Development Plan for the Use of Oil Shale 2008–2015”

[http://www.envir.ee/sites/default/files/polevkivi\\_kasutamise\\_arengukava\\_2008\\_2015.pdf](http://www.envir.ee/sites/default/files/polevkivi_kasutamise_arengukava_2008_2015.pdf)

activities, serves as the document for implementing the development plan. A detailed financing plan for the measures has been prepared for 2016–2019.

The term *environment* in the oil shale development plan refers in a broader sense to the natural, economic, and social environment, all closely related. The development plan describes the current state of the extraction and use of oil shale, determines the strategic aims of the development and predicts the perspective, taking into consideration nature conservation and other restrictions.

According to the Environmental Impact Assessment and the Environmental Management System Act, oil shale extraction is an activity with significant environmental impact, which is why the strategic environmental assessment (SEA) was conducted simultaneously with the preparation of the oil shale development plan. Pursuant to clause 33 (1) 1) and subsection 35 (2) of the Environmental Impact Assessment and Environmental Management System Act, the SEA was initiated by the Minister of the Environment with regulation No. 557 of 30 May 2013. The SEA programme<sup>2</sup> was approved with the letter No. 6-8/14/8260-3 of 6 May 2014 of the Environmental Board. The SEA report was published in the Ministry of the Environment between 27 October 2014 and 19 November 2014. The Environmental Board approved the SEA report<sup>3</sup> with letter No. 6-8/14/26780-2 of 23 December 2014.

The study “Analysis of the Data Necessary for the Preparation of the ‘National Development Plan for the Use of Oil Shale 2016–2030’”<sup>4</sup> (hereinafter “the 2012 study”) was ordered in 2012 for the preparation of the oil shale development plan. The data on the Estonian oil shale deposit in the list of mineral deposits of the Environmental Registry and in the consolidated balance of the Republic of Estonia (hereinafter “the consolidated balance of the reserves of minerals”), as well as reports in the Estonian Geological Fund were used as the source materials for preparing the oil shale development plan. The data from the Environment Agency (KAUR) and Statistics Estonia, as well as the results of the inquiries conducted with the companies and organisations related with the extraction and use of oil shale were also used. The results of the studies conducted during the implementation of the oil shale development plan 2008–2015 and the annual reports about the execution of the development plan serve as a significant input. The data from Statistics Estonia is as at 2013 (the latest published data at the time of the preparation of the development plan), which is why the basic levels of the impact indicators for the performance of strategic objectives are presented based on the data of 2013.

Although the requirements for the geologic surveys and the extraction of minerals are not determined in the European Union (hereinafter “the EU”), there are still several restrictions (nature conservation, creation of waste, etc.) that have to be considered, as their legal basis lies in the legal acts of the EU and international agreements. Processing of oil shale into shale oil, fuel, chemical products, and using it for power generation is regulated by EU documents (an overview is provided in Annex 3 to the development plan).

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<sup>2</sup> Strategic environmental assessment (SEA) programme for the “National Development Plan for the Use of Oil Shale 2016–2030”

[http://www.envir.ee/sites/default/files/polevkivi\\_kasutamise\\_riikliku\\_arengukava\\_2016\\_2030\\_ksh\\_programm.pdf](http://www.envir.ee/sites/default/files/polevkivi_kasutamise_riikliku_arengukava_2016_2030_ksh_programm.pdf)

<sup>3</sup> Strategic environmental assessment (SEA) report of the “National Development Plan for the Use of Oil Shale 2016–2030”

[http://www.envir.ee/sites/default/files/polevkivi\\_kasutamise\\_riikliku\\_arengukava\\_2016\\_2030\\_ksh\\_programm.pdf](http://www.envir.ee/sites/default/files/polevkivi_kasutamise_riikliku_arengukava_2016_2030_ksh_programm.pdf)

<sup>4</sup> “Analysis of the Data Necessary for the Preparation of the ‘National Development Plan for the Use of Oil Shale 2016–2030’” <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

The preparation of the oil shale development plan has been a public process, where the representatives of relevant state institutions and companies, local governments, organisations and non-profit organisations, and other interested parties have been involved in. Experts were involved for getting the best data related with the oil shale sector and the analysis results.

## 1. Connections to the strategies and development plans of other areas

The oil shale development plan is prepared in accordance with the other development plans and strategic documents related with the oil shale sector.

**1. The Estonian national strategy on sustainable development “Sustainable Estonia 21”**<sup>5</sup> (hereinafter “SE 21”) handles four development objectives aimed at sustainability: the vitality of the Estonian cultural space, growth of well-being, cohesive society, and ecological balance. According to SE 21, natural resources have to be used in a way and in volumes that ensure ecological balance. The sustainable administration of a natural resource is not merely the protection of the resource; it is also the ecologically balanced use of this resource. Using a natural resource must be accompanied by previously prepared justified and economically the most profitable schemes of optimal use, and the mechanisms counterbalancing natural and social developments. SE 21 is targeted for the balanced management of resources and the natural environment in the interests of the society and local communities. The means for sustainable consumption will be implemented in determining the criteria for public procurements, national investment programmes, and other development plans. The oil shale development plan will also be based on the abovementioned principles.

**2. “Estonian Environmental Strategy until 2030”**<sup>6</sup>: the aim of the strategy is the environmentally friendly extraction of minerals, i.e. saving water, the landscape, and air, as well as using minerals efficiently with minimal loss and waste. The measures of the strategy are the preparation and implementation of long-term national development plans for the use of the mentioned minerals (the basis of the development plans are the schemes for the optimal use of the resource, promoting the use of the resources in accordance with national needs on a scientific basis), and directing the activity of enterprises that extract and use minerals towards environmental safety by implementing a system of regulations and aids. Therefore, the Environmental Strategy provides the objectives and courses of action for preparing an oil shale development plan that ensures that oil shale is extracted and used as sustainably and economically efficiently as possible, ensuring the supply of oil shale for the oil shale industry and taking into consideration the accompanying environmental impact.

**3. Competitiveness strategy “Estonia 2020”**<sup>7</sup> (hereinafter “Estonia 2020”) describes the main political directions and measures for enhancing the competitiveness of Estonia, and sets objectives for years 2015 and 2020 in accordance with the objectives of the European 2020 strategy agreed upon with EU member states. Pursuant to Estonia 2020, one of the main directions of the politics of the Government of the Republic is to enforce the long-term structural changes in the field of energy in accordance with the Estonian energy security and energy saving objectives. In order to achieve sustainable economic growth, the economic system of the state needs to become more resource efficient, environmentally friendly, and competitive. For the efficient and purposeful use of minerals, Estonia 2020 sees it essential to update the legal acts related with the earth's crust and to direct research and development activities (hereinafter also “the R&D activities”) to researching the potential minerals and technologies that have not been used so far. It is important to investigate new opportunities for recovering oil shale waste. The objective of the oil shale development plan

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<sup>5</sup> Estonian national strategy on sustainable development “Sustainable Estonia 21”

<https://www.riigiteataja.ee/akt/940717>

<sup>6</sup> “Estonian Environmental Strategy until 2030” <http://www.keskkonnainfo.ee/failid/viited/strateegia30.pdf>

<sup>7</sup> Competitiveness strategy “Estonia 2020” <https://riigikantselei.ee/et/konkurentsivoime-kava-eeesti-2020>



in accordance with the trends of Estonia 2020 is to economically efficiently extract and use oil shale.

**4. “Estonian National Development Plan for the Energy Sector until 2020”<sup>8</sup>** serves as the basis for the development plans for electricity economy, oil shale, biomass and bioenergy, and for the energy saving target programme that addresses energy saving issues. The “Development Plan for the Energy Sector until 2030” (hereinafter “DPES”<sup>9</sup>), which is currently under preparation, collects the future activities related with the electricity, heat, and fuel sector, as well as the energy use of the transport sector and housing sector. The relatively large energetic independence of Estonia is based on its domestic fuel economy, where oil shale covers approximately 65% of the primary energy supply of Estonia. Approximately 90% of the produced electricity comes from thermal power plants that use oil shale as fuel.

At least for the next 15 years, oil shale will remain the main raw material for producing electricity and shale oil. DPES handles oil shale industry as a part of the energy policy. The task of the oil shale development plan is to ensure the security of supply of oil shale resources for the oil shale industry by following the principles of sustainable extraction of oil shale, and reducing and mitigating the impact of extraction on the environment. In addition to extraction, the oil shale development plan also describes the impact, above all to the natural environment, resulting from the processing of oil shale and determines specific activities for reducing the impact of processing (development and implementation of BAT in the production of oil and electricity, analysis of the possibilities of prolonging the value chain of oil shale use, etc.). Therefore, DPES mainly handles the issues related with the production of energy from oil shale; the oil shale development plan, however, focuses on the possibilities of oil shale extraction and on the sustainability of the resource, as well as on the environmental impact resulting from the extraction and processing of oil shale. Both development plans provide measures for developing research activities for the field of oil shale.

**5. “Development Plan for the Estonian Electricity Sector until 2018”<sup>10</sup>** handles the requirements for rearranging the Estonian electricity production, where one of the determined necessity is a more sustainable use of oil shale resources, which corresponds to the strategic objective presented in the oil shale development plan to increase the efficiency of extraction and use of oil shale. Further development measures and activities of the electricity sector are presented in DPES, and a separate development plan for the electricity sector will not be prepared.

**6. “Nature Conservation Development Plan until 2020”<sup>11</sup>** (hereinafter “NCDP”) presents the most important development trends of the natural environment. These include the promotion of nature education, preservation of the diversity of nature, and a more sustainable use of natural resources. The oil shale development plan has a direct connection with the third strategic objective

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<sup>8</sup> “Estonian National Development Plan for the Energy Sector until 2020”

[https://valitsus.ee/UserFiles/valitsus/et/valitsus/arengukavad/majandus-ja-kommunikatsiooniministeerium/Energiamaajanduse\\_riiklik\\_arengukava\\_aastani\\_2020.pdf](https://valitsus.ee/UserFiles/valitsus/et/valitsus/arengukavad/majandus-ja-kommunikatsiooniministeerium/Energiamaajanduse_riiklik_arengukava_aastani_2020.pdf)

<sup>9</sup> Draft of the “Development Plan for the Energy Sector until 2030” (DPES)

[http://www.energiatalgud.ee/img\\_auth.php/2/25/ENMAK\\_2030\\_Eeln%C3%B5u\\_23.10.2014.pdf](http://www.energiatalgud.ee/img_auth.php/2/25/ENMAK_2030_Eeln%C3%B5u_23.10.2014.pdf)

<sup>10</sup> “Development Plan for the Estonian Electricity Sector until 2018”

[https://valitsus.ee/UserFiles/valitsus/et/valitsus/arengukavad/majandus-ja-kommunikatsiooniministeerium/Eesti\\_elektrimajanduse\\_arengukava.pdf](https://valitsus.ee/UserFiles/valitsus/et/valitsus/arengukavad/majandus-ja-kommunikatsiooniministeerium/Eesti_elektrimajanduse_arengukava.pdf)

<sup>11</sup> “Nature Conservation Development Plan until 2020” (NCDP)

[http://www.envir.ee/sites/default/files/lak\\_lop.pdf](http://www.envir.ee/sites/default/files/lak_lop.pdf)

of NCDP: the assurance of long-term perseverance of natural resources and the principles of the ecosystemic approach are considered in using those resources. Therefore, natural resources are used in an economical and sustainable manner that does not compromise the achievement of a favourable status of ecosystems. In using natural resources, the utilisation and conservation of nature will be integrated in a way that optimally uses the existing resources and does not considerably damage natural values. These principles coincide with the task of the oil shale development plan to ensure that oil shale is extracted and used as sustainably and economically efficiently as possible.

**7. “National Waste Management Plan 2014–2020”<sup>12</sup>** (hereinafter “the waste management plan”) also includes the waste prevention programme. One of the problems defined in the waste management plan that needs to be solved is the large amount of waste and oil shale waste rock created in the production of oil shale energy, and which have a low recovery rate. Although in the past few years, the Best Available Techniques (BAT) have been implemented increasingly more in the oil shale industry, and the recovery of oil shale waste rock and oil shale ash has also increased; new options for reducing waste and increasing the recovery rate will be continually sought for, which also serves as a prerequisite for implementing the oil shale development plan. Therefore, the waste management plan and the oil shale development plan are, above all, related with the development, advancement, and implementation of the BAT for handling extraction waste, mitigating the impact of residual pollution arising from oil shale extraction (assessment of the status of closed extraction waste repositories and reconditioning them), and expanding the possibilities of recovering oil shale waste rock.

**8. “Framework Plan for Environmental Charges 2016+”** is prepared as a preparatory document for the draft law amending the Environmental Charges Act, which will be valid as of 2016. The document presents the development trends that could be used to change the environmental charges regulation in a way that would ensure adherence to the objective to protect the environment.

**9. “National Transport Development Plan 2014–2020”<sup>13</sup>** (hereinafter “the transport development plan”) handles environmental friendliness and nature preservation, energy saving, safety, and universal design. In road construction, the oil shale waste rock from oil shale mining is one of the most important alternatives for natural building materials, and the maximum use of this waste is highly important for the oil shale development plan. Under normal circumstances, the usage of oil shale waste rock from oil shale extraction is currently 30% in a year and therefore, it is important to analyse whether the waste from oil shale extraction and processing (limestone of the caprock, enrichment waste, oil shale waste rock gravel, oil shale ash) can also be used as alternative construction materials.

**10. “National Health Plan 2009–2020”<sup>14</sup>** sets objectives for the vertical development plans and strategies in the field of health, binds them together and connects the already functioning strategic documents of other fields or documents under preparation. The health plan emphasises the production of electricity and heat from oil shale and chemical industry, which, although

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<sup>12</sup> “National Waste Management Plan 2014–2020”

[http://www.envir.ee/sites/default/files/riigi\\_jaاتمekava\\_2014-2020.pdf](http://www.envir.ee/sites/default/files/riigi_jaاتمekava_2014-2020.pdf)

<sup>13</sup> “National Transport Development Plan 2014–2020”

[https://www.mkm.ee/sites/default/files/transpordi\\_arengukava.pdf](https://www.mkm.ee/sites/default/files/transpordi_arengukava.pdf)

<sup>14</sup> “National Health Plan 2009–2020”

[https://valitsus.ee/UserFiles/valitsus/et/valitsus/arengukavad/sotsiaalministeerium/Rahvastiku%20tervise%20arengukava%202009-2020%20\(t%C3%A4iendatud%202012\).pdf](https://valitsus.ee/UserFiles/valitsus/et/valitsus/arengukavad/sotsiaalministeerium/Rahvastiku%20tervise%20arengukava%202009-2020%20(t%C3%A4iendatud%202012).pdf)



economically important, also serves as an important health risk in North-West Estonia. The objective common with the oil shale development plan is the continuous improvement of the health of humans who are affected by the extraction and use of oil shale.

**11. “Estonian Research and Development and Innovation Strategy 2014–2020”<sup>15</sup>** (hereinafter also “the R&D&I” or “R&D&I strategy”). Estonia has developed a functioning and developing R&D&I system and a business sector support structure. The objective of preparing a new strategy is to shape an R&D&I strategy in Estonia that considers the prerequisites, conditions, and needs that aim to achieve the goals of Estonia 2020, including the planning of main objectives, core values, and a management scheme. Connection with the oil shale development plan is expressed through the measures of the R&D&I strategy:

- Measure 2: increasing the social and economic benefit of R&D — the aim is to improve collaboration between research institutions and enterprises, and to increase the competence of the state as the body commissioning research and development works;
- Measure 3: smart specialisation is the basis for R&D&I changing the structure of economy — the aim is to significantly improve the share of employment and added value of the entrepreneurship of growth areas in economy and export.

**12. “Estonian Regional Development Strategy 2014–2020”<sup>16</sup>** sets the more capable use of regional specific resources of the state as one of its objectives. In the execution of the measures of the regional development strategy, areas larger than counties are handled as development regions. The strategy handles Ida-Viru County as a separate development region. The oil shale development plan helps to determine the specific prerequisites of the regional development of Ida-Viru and Lääne-Viru Counties, which should also be considered in the future when preparing development plans for different regions and making individual decisions that affect regional development.

**13. “East-Estonia River Basin Management Plan”<sup>17</sup>** highlights the action plan for improving the status of water bodies in poor and moderate condition, and the Ordovician groundwater body of the oil shale basin in Ida-Viru County, which is in poor condition. According to the diffuse pollution assessment, oil shale extraction and the production of electricity and shale oil serve as very important surface and groundwater pressure factors in East-Estonia. Semi-coke landfills (shale oil, phenols, aromatic hydrocarbons, including PAHs) in Kohtla-Järve (JRK-28) and Kiviõli (JRK-23) have a substantial negative environmental effect on the surface water and groundwater. The negative impact of semi-coke landfills is attempted to mitigate with the execution of closing projects funded by the Cohesion Fund.

The oil shale development plan will consider the environmental objectives set based on the Water Act and the Water Framework Directive. The East-Estonia River Basin Management Plan will be updated by the end of 2015. It is important for the entrepreneurs in the oil shale sector and the Minerals Department of the Ministry of the Environment and the Ministry of Economic Affairs and Communication to actively participate in the specification of the environmental objectives of the river basin management plan.

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<sup>15</sup> “Estonian Research and Development and Innovation Strategy 2014–2020”

<https://www.riigiteataja.ee/aktiisa/3290/1201/4002/strateegia.pdf>

<sup>16</sup> “Estonian Regional Development Strategy 2014–2020”

[https://www.siseministeerium.ee/sites/default/files/eesti\\_regionaalarengu\\_strateegia\\_2014-2020.pdf](https://www.siseministeerium.ee/sites/default/files/eesti_regionaalarengu_strateegia_2014-2020.pdf)

<sup>17</sup> East-Estonia River Basin Management Plan

[http://www.keskkonnaamet.ee/public/documents/trykised/Ida-Eesti\\_veemajanduskava.PDF](http://www.keskkonnaamet.ee/public/documents/trykised/Ida-Eesti_veemajanduskava.PDF)

**14. National plan “Estonia 2030+”<sup>18</sup>** determines, among other things, the principles and trends of the sustainable and balanced spatial development of the state. The national plan is an important strategic development document, which directs the state's land use at a general level.

**15. “Ida-Viru Action Plan 2015–2020”<sup>19</sup>** is a development document, which supports the development of Ida-Viru County as an economically and strategically important region. The action plan handles all fields of activities related with Ida-Viru County, and indicates the activities that are planned to be undertaken in order to mitigate or solve problems, or to better use the possibilities of the region. Among other things, the growth areas that are based on regional prerequisites are planned to be developed, primarily in the fields of energy, oil shale technologies and the chemical industry, and to comprehensively develop higher technical education, entrepreneurship, and workforce skills. It is considered practical to skilfully connect these growth areas also with other fields of activities, e.g. to develop aquaculture in order to exploit the cooling water from power plants. The abovementioned growth fields coincide with the activities presented in the oil shale development plan.

**16. “National Security Concept of the Republic of Estonia 2010”<sup>20</sup>** determines the principles of the security policy of Estonia, including energy security, objectives, principles, and courses of action. Estonian energy security is ensured by the security of supply, security of the infrastructure, connections with the energy networks of other European Union member states, and the variety of energy sources. The security of energy supply is also ensured by the maximum use of internal energy resources, which in the case of Estonia means as rational use of oil shale as possible. It is also essential to implement security and safety measures for ensuring the continuous functionality and protection of energy systems.

**Regional development plans.** Regional development plans have been taken into consideration in preparing the oil shale development plan. The objectives of the natural environment and resources section of “Ida-Viru County Development Plan 2014–2020” (approved on 6 November 2012)<sup>21</sup> include the reconditioning of mined and former industrial areas, and the efficient use of natural resources. In order to develop the economic environment, strong and international development of the oil shale sector is planned. Popularisation of the field of oil shale and technology among the youth and the whole population is emphasised in the provision of education at different levels. In order to raise the environmental awareness of the inhabitants of the county, oil shale related conferences and seminars are planned to be organised. These development trends coincide with the objectives set in the oil shale development plan.

From among the **thematic plans related with oil shale**, the “Spatial planning of the Ida-Viru County oil shale mining areas” (imposed on 1 January 2002) and the “Route determination for the location of the Ojamaa mine conveyor” (imposed in 2010) are the most important ones<sup>22</sup>.

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<sup>18</sup> National plan “Estonia 2030+” <https://eesti2030.files.wordpress.com/2014/07/eesti2030.pdf>

<sup>19</sup> “Ida-Viru Action Plan 2015–2020”

[https://www.siseministeerium.ee/sites/default/files/dokumendid/Arengukavad/ida-virumaa\\_tegevuskava\\_2015-2020\\_26.02.15.pdf](https://www.siseministeerium.ee/sites/default/files/dokumendid/Arengukavad/ida-virumaa_tegevuskava_2015-2020_26.02.15.pdf)

<sup>20</sup> “National Security Concept of the Republic of Estonia 2010” [http://vm.ee/sites/default/files/content-editors/JPA\\_2010.pdf](http://vm.ee/sites/default/files/content-editors/JPA_2010.pdf)

<sup>21</sup> “Ida-Viru County Development Plan 2014–2020” [http://axis.ivmv.ee/mv\\_kodulehe\\_failid/failid/204749/Ida-Viru%20maakonna%20arengukava%202014-2020.pdf](http://axis.ivmv.ee/mv_kodulehe_failid/failid/204749/Ida-Viru%20maakonna%20arengukava%202014-2020.pdf)

<sup>22</sup> Ida-Viru County thematic plans <http://ida-viru.maavalitsus.ee/et/teemaplaneeringud>

Similar principles and environmental protection and development objectives are also established in the Lääne-Viru County development strategy and county plan and the related thematic plans<sup>23</sup>. The connections of the development objectives of Ida-Viru and Lääne-Viru Counties with the oil shale development plan are discussed in more detail in the SEA report<sup>24</sup>.

**Connections with international agreements and EU documents.** International agreements include bilateral agreements, as well as conventions, i.e. multilateral agreements, which Estonia is a party to. Above all, the EU climate and energy package has to be considered when preparing the oil shale development plan, as the directives of the package impose restrictions on the use of oil shale with the aim of reducing the emission of greenhouse gases resulting from the manufacturing and consumption of oil shale. A more detailed overview of EU policy, directives, and international agreements is provided in Annex 3.

## 2. Analysis of the current situation

2016 symbolises the 100<sup>th</sup> anniversary of the industrial implementation of Estonian oil shale, or kukersite. At first, oil shale was used experimentally. The first large industrial consumer of oil shale was the Kunda cement plant in the 1920s, the rotary furnaces of which were adjusted to operate solely on oil shale in 1921<sup>25</sup>. Thereafter, oil shale was used as fuel in power plants, and in oil plants as raw material for shale oil production. These areas of use have been preserved to the present day; however, in the past 50 years especially, oil shale has been mostly used for producing electricity and heat.

An extensive oil shale industry has been developed, which has been and still is a strategically important industry for Estonian economy, comprising the production of electricity and heat, shale oil and cement, and involving several thousands of jobs. Oil shale is a local fuel and raw material for producing energy, shale oil, and cement. The production of these industries forms a considerable part of Estonian export, having a positive effect on the Estonian external trade balance. Oil shale as fuel for power plants has allowed ensuring the security of electricity supply, i.e. energy security for Estonia.

### 2.1. Summary of the implementation of the oil shale development plan 2008–2015<sup>26</sup>

The oil shale development plan 2008–2015 presents three strategic objectives for implementing the interests of the state.

1. Securing the sufficient supply of oil shale energy in Estonia and the energetic independence of Estonia.
2. Increasing the efficiency of oil shale mining and usage.
3. Decreasing the environmental impact of mining and use of oil shale.

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<sup>23</sup> Lääne-Viru County development strategy <http://laane-viru.maavalitsus.ee/documents/181101/0/L%C3%A4%C3%A4ne-Virumaa+arengustrateegia+2007-2015.pdf/937ad798-dd98-4f3c-b9f5-2ad89b1ce131>

<sup>24</sup> SEA report [http://www.envir.ee/sites/default/files/pak\\_ksh\\_lisa\\_1\\_heakskiitmiseks\\_meilimiseks.pdf](http://www.envir.ee/sites/default/files/pak_ksh_lisa_1_heakskiitmiseks_meilimiseks.pdf)

<sup>25</sup> “Põlevkivi põletustehnika,” Arvo Ots, Tallinn 2004

<sup>26</sup> “National Development Plan for the Use of Oil Shale 2008–2015” <http://www.envir.ee/et/polevkivi-kasutamise-riiklik-arengukava-2008-2015>

**According to the development plan, the maximum annual limit for oil shale mining is 20 m tons<sup>27</sup>.** A calculation of oil shale need for 2015 has been presented in Table 6 (page 23) of the oil shale development plan 2008–2015. Based on the development plan, the annual mining limit 20 m tons was stipulated in the Earth's Crust Act (adopted on 23 November 2008).

**Securing the sufficient supply of oil shale energy in Estonia and the energetic independence of Estonia.** The measures planned for the performance of the first strategic aim were used to improve the legal regulations of mining and use of oil shale, determining also the abovementioned annual mining limit of 20 m tons and activities for the sustainable use of oil shale. The part of the Industrial Emissions Directive (IED) that handles oil shale was transposed into Estonian environmental law, and ensuring the protection of the environment as a whole is foreseen through the introduction of the BAT. In order to codify the environmental law, Riigikogu adopted the General Part of the Environmental Code Act on 16 February 2011 and is finishing the coordination of the Earth's Crust Act with the General Part of the Environmental Code Act, i.e. has reviewed the terms and conditions for granting mining permits.

For the purpose of the energy security of the state, Estonia has managed to ensure the annual domestic electricity consumption, while continuously decreasing the share of oil shale in the electric energy balance. Due to the sufficient supply of oil shale energy, Estonia is capable of producing the necessary amount of electricity for the whole country. Pursuant to the Accession Agreement with the EU, Estonia opened its electricity market completely in 2013 and has been an electricity exporting country since.

**Increasing the efficiency of oil shale mining and usage.** The prerequisite for the performance of the second strategic objective is the further gradual reduction of the share of oil shale electricity and the increase in the production of shale oil. Considering the abovementioned, priorities for the use of oil shale and the optimal mining volume for 2016–2030 were determined in the 2012 study.<sup>28</sup> Increasing the efficiency of oil shale mining and use is possible as a result of the valorisation of oil shale, the main currently known prerequisite of which is the development of the oil industry and production of chemical products.

The main conditions for increasing the efficiency of oil shale mining is the reduction of the underground mining loss of oil shale reserves. One of the options is to implement mining without pillars in areas where the intentional subsidence of the ground is possible and acceptable from the perspective of environmental protection. Another technological solution is the backfilling of excavations (mines). Research for the implementation of this technology is under preparation but a usable result has not yet been achieved and the activities will be continued in 2016–2030.

The development of oil shale related R&D activities was mainly conducted through the framework programme “Estonian Energy Technology Programme” (hereinafter “ETP”), which is one of the implementation plans of the Estonian R&D activity and innovation (R&D&I) strategy “Knowledge-based Estonia 2007–2013”.

**Decreasing the environmental impact of mining and use of oil shale.** In describing the

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<sup>27</sup> “National Development Plan for the Use of Oil Shale 2008–2015”

[http://www.envir.ee/sites/default/files/polevkivi\\_kasutamise\\_arengukava\\_2008\\_2015.pdf](http://www.envir.ee/sites/default/files/polevkivi_kasutamise_arengukava_2008_2015.pdf)

<sup>28</sup> “Analysis of the Data Necessary for the Preparation of the ‘National Development Plan for the Use of Oil Shale 2016–2030’” <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

performance of the third strategic objective, the environmental impact of the mining and use of oil shale cannot be generally assessed based solely on the increase or decrease of certain indicators, but the volume of the produced products must also be taken into account and data per unit of production must be compared. Companies have made large investments and developed the technology used above all for the purpose of reducing the environmental impact (a surface miner has been put to use, the emission of pollutants into ambient air and the number of pollutant sources of ambient air have decreased, the recovery of oil shale waste rock and oil shale ash has increased, etc.).

A summary of the current environmental impact of the mining and use of oil shale has been provided in Chapter 2.5, and a more detailed description in Annex 6.

For the implementation of the oil shale development plan 2008–2015, implementation plans were prepared for years 2009–2012 and 2013–2015. The performance of the levels of accomplishment of the most important impact indicators of the implementation plan 2009–2012, compared with the basic levels in 2007, are listed below<sup>29</sup> (see also Annex 5 and Annex 6):

- 1) the amount of mined oil shale resources increased slightly, reaching 14.9 m tons in 2012 (in 2007, the amount was approximately 14 m tons), but was approximately 5.1 m tons less than the maximum annual oil shale mining limit (20 m tons);
- 2) the share of oil shale in electricity production decreased by 12.5% (93.6% in 2007 and 81.1% in 2012);
- 3) loss in the mining of oil shale resources increased by approximately one per cent (in 2007, the loss was about 3.4 m tons, i.e. approximately 12% and in 2012, 4.0 m tons, i.e. approximately 21% of mined resources);
- 4) the aggregate formation of semi-coke and bottom ash increased; however, the percentage of recovery has also increased:
  - in 2007, the amount of formed semi-coke was 0.981 m tons (0.262 m tons, or 26.7% of it was recovered) and in 2012, the amount was 1.077 m tons (0.694 m tons, or 64.5% of it was recovered<sup>30</sup>);
  - in 2007, the amount of formed bottom ash was 2.902 m tons (0.006 m tons, or 0.2% of it was recovered) and in 2012, the amount was 3.223 m tons (0.22 m tons, or 6.8% of it was recovered);
- 5) the total emissions of carbon dioxide (CO<sub>2</sub>) equiv., as well as the emissions that form during the energy production process have decreased to an extent (the total emission of greenhouse gases was 20.9 m tons of CO<sub>2</sub> equiv. in 2007 and 19.2 m tons in 2012; in the energy sector, the emission was 18.3 m tons of CO<sub>2</sub> equiv. in 2007 and 16.9 m tons in 2012); however, the share of the energy sector in the total emission of greenhouse gases has slightly increased.

Additionally, three impact indicators have been developed for measuring the efficiency of oil shale use:

- 1) CO<sub>2</sub>-specific emission value issued for electric power (CO<sub>2</sub> / issued electric power, in 2012, it was 1,211 tCO<sub>2</sub>/GWh<sub>e</sub>);
- 2) CO<sub>2</sub>-specific emission value issued for the cogeneration of electricity and heat (CO<sub>2</sub> / issued electricity and heat, in 2012, it was 1,188 tCO<sub>2</sub>/GWh<sub>e</sub>);

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<sup>29</sup> Performance report of the “National Development Plan for the Use of Oil Shale 2008–2015” for 2012 (report approved by the Government of the Republic on 6 November 2014)

[https://valitsus.ee/sites/default/files/content-editors/arengukavad/polevkivi\\_aruanne\\_2012.pdf](https://valitsus.ee/sites/default/files/content-editors/arengukavad/polevkivi_aruanne_2012.pdf)

<sup>30</sup> the much higher proportion than usual was due to the recovery during the closing works of the semi-coke landfill



3) the calculated energetic efficiency of the production of shale oil (71.0% in 2012).

The emissions of sulphur dioxide (SO<sub>2</sub>) have decreased more than twice, as the four oldest power units of the Estonian power plant have been equipped with SO<sub>2</sub> emission capture devices (hereinafter “deSO<sub>x</sub> equipment”). Therefore, the main positive result in the oil shale mining and usage sector is the reduction of emissions into air and the increased recovery of waste. The total annual amount of oil shale mining was less than 20 m tons, and the share of oil shale in electricity production also decreased. Enterprises are interested in oil shale industry and have made large investments for further development of the oil shale sector, above all, the production of shale oil.

**The main applied studies** (studies related with mining sensitivity and health) **planned in the oil shale development plan 2008–2015 are completed or will be completed in 2015.** Some less voluminous research works about the amendment of legal acts or setting additional requirements for environmental permits were not executed. These problems will be solved by bringing the earth's crust legislation in line with the General Part of the Environmental Code Act.

The most important activities conducted for the implementation of the oil shale development plan 2008–2015, including the studies conducted in 2008–2014, are listed in Annex 2 to the development plan.

## 2.2. Overview of oil shale mining

### 2.2.1. Estonian oil shale deposit

Oil shale is the most important mineral of Estonia and oil shale resources belong to the state. The Estonian oil shale deposit (with the surface area of 164,747.09 ha, Figure 1) is located in Ida-Viru and Lääne-Viru Counties<sup>31</sup> and is divided into 23 deposit parts, or mining and research fields.

The thickness of the yielding seam of oil shale (A–F<sub>1</sub>) is maximum in the northern and eastern part of the Estonian oil shale deposit (2.7–2.9 m) and thins towards the southern and western part of the deposit. The depth of the yielding seam is the smallest in the northern part of the deposit (1–10 m) and the deepest at the southern border of the deposit (80–90 m). The quality of the seam is higher at the central area of the deposit and lowers towards the periphery areas. Larger mining claims are located at the central and eastern part of the Estonian oil shale deposit.<sup>32</sup>

Oil shale mines and opencasts are mainly located in Ida-Viru County, only the old Ubja mine and the current Ubja opencast are located in Lääne-Viru County. By now, oil shale has been mined on the territories of 13 local governments (Iisaku, Illuka, Jõhvi, Kohtla, Kohtla-Nõmme, Lügānuse, Mäetaguse, Sonda, Sõmeru, Toila, and Vaivara rural municipalities, and the towns of Kiviõli and Kohtla-Järve). Of the listed local government units, oil shale has most been mined in Jõhvi rural municipality (60% of the territory), followed by Kiviõli town and Mäetaguse rural municipality (40%). A substantial part of the reserves with higher energy yield in Ida-Viru County is currently

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<sup>31</sup> on the territory of a total of 23 local governments: Alajõe, Iisaku, Illuka, Jõhvi, Kohtla, Kohtla-Nõmme, Lügānuse, Mäetaguse, Sonda, Toila, Tudulinna, and Vaivara rural municipalities, and the towns of Kiviõli and Kohtla-Järve in Ida-Viru County; Haljala, Kadrina, Rakvere, Rägavere, Sõmeru, Vihula, Vinni, and Viru-Nigula rural municipalities, and the town of Rakvere in Lääne-Viru County

<sup>32</sup> “Eesti põlevkivi geoloogia, ressurs, kaevandamistingimused”, V. Kattai *et al.*, 2000.

being mined or has already been mined. By today, mining has been finished in the area of 142 km<sup>2</sup> of the Estonian oil shale deposit.<sup>33</sup>

A large part of the reserve of the oil shale deposit is located in the restriction zone contingent on nature conservation and population. The areas under protection form 29% of the surface area of the Estonian oil shale deposit, whereas 38% thereof are in the areas that are not yet mined<sup>34</sup>.

The Estonian oil shale deposit is a complex deposit that completely or partly overlaps with the deposits of 44 incidental minerals: 19 sand, 17 peat, four gravel, two phosphorite, one clay, and one limestone deposit (as at 17 June 2015). Deposits of construction minerals and peat are geologically located above the oil shale seam, phosphorite deposits however 30–35 m below the oil shale seam.

In order to plan the long-term mining process of oil shale, mining options will be investigated and mining technology will be developed, taking into consideration the mining sensitivity category of the different regions of the deposit, as well as incidental minerals. In mining oil shale, incidental minerals will also be extracted, if the natural layout of this resource is destroyed in a way that it cannot be mined in the future. Additionally, the incidental minerals will be investigated as part of the geological study in equal detail with the main mineral (see Annex 4 to the development plan).

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<sup>33</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

<sup>34</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

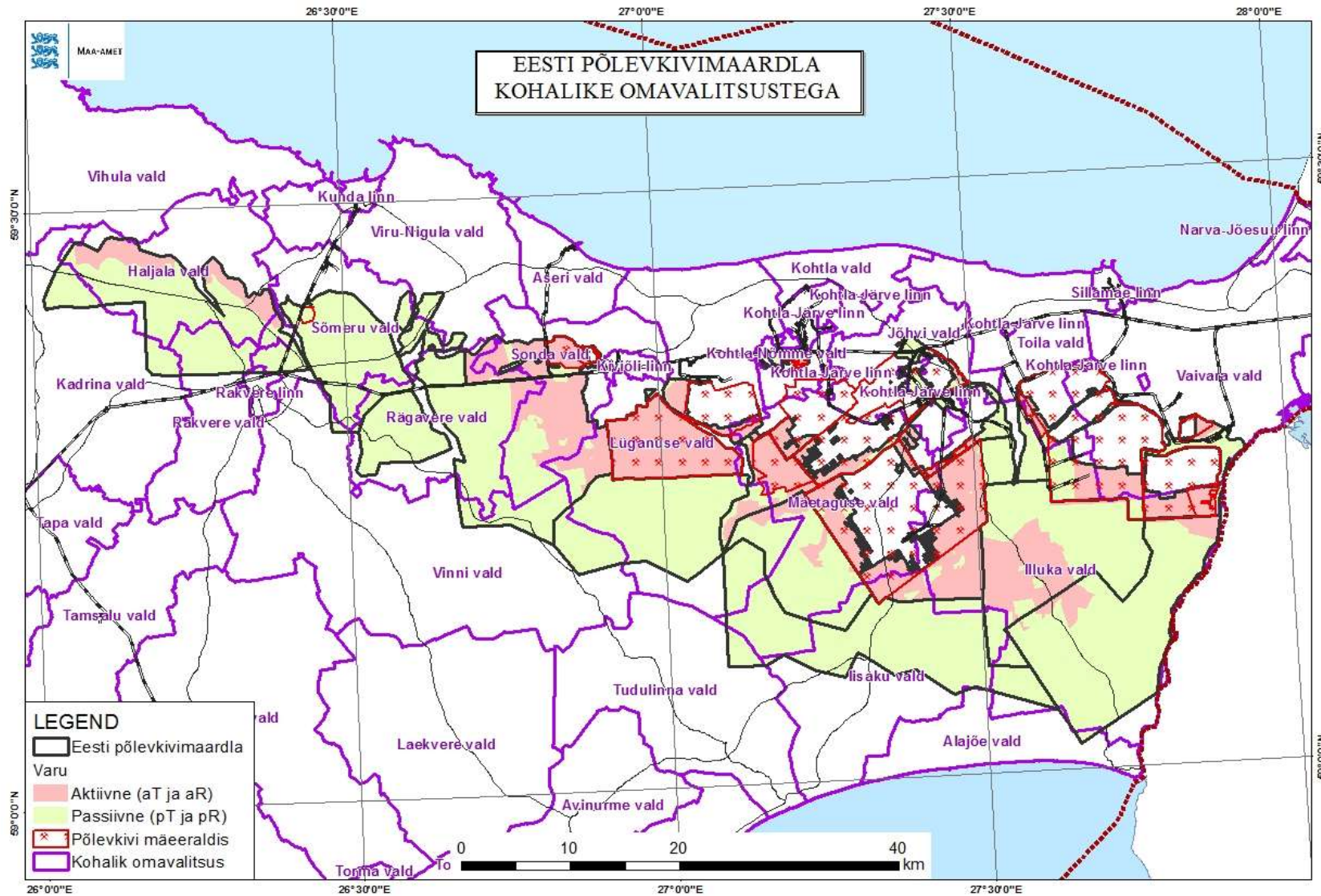


Figure 1. Estonian oil shale deposit (Land Board)

/table/:

***ESTONIAN OIL SHALE DEPOSIT TOGETHER WITH LOCAL GOVERNMENTS***

***LEGEND***

*Estonian oil shale deposit*

*Supply*

*Economic (economic consumption supply and economic proved reserve)*

*Potentially economic (potentially economic consumption supply and potentially economic proved reserve)*

*Oil shale mining claim*

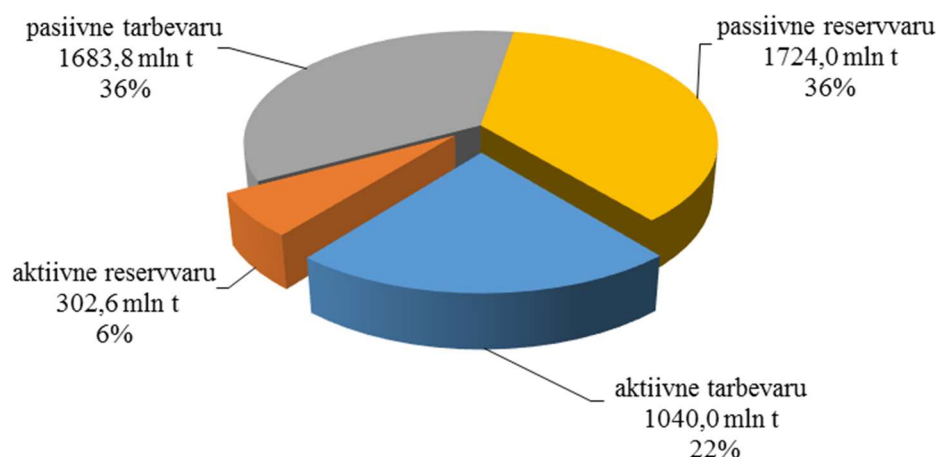
*Local government*

### 2.2.2. Reserve calculation and mining volume for 2007–2013

Calculation of the reserve of minerals is kept in the list of mineral deposits of the Environmental Registry, the responsible processor of which is the Ministry of the Environment and the authorised processor the Land Board. Based on the level of the geological exploration, the reserve of minerals has been divided into the proved reserve and probable reserve, and based on the economic importance; the reserves have been divided into economic and potentially economic.

The reserve of oil shale is calculated as the sum of oil shale layers, where the critical factors are the surface area of the spread of the oil shale seam, the total thickness of the oil shale layers of the seam (together with up to 5 cm thick limestone lenses and nodules) and the quality of oil shale, which is indicated by the calorific value of the dry mass and the volume weight in dry state.

According to the consolidated balance of the reserves of minerals as at 31 December 2013, the oil shale reserve of the Estonian oil shale deposit is 4,750.4 m tons, whereas the amount of economic proved reserve is 1,040.0 m tons, the amount of economic probable reserve is 302.6 m tons, the amount of potentially economic proved reserve is 1,683.8 m tons, and the amount of potentially economic probable reserve is 1,724.0 m tons<sup>35</sup> (Figure 2).



**Figure 2. Distribution of the reserve of the Estonian oil shale deposit as at 31 December 2013**

/figure/:

*Potentially economic proved reserve*  
1,683.8 m tons  
36%

*Potentially economic probable reserve*  
1,724.0 m tons  
36%

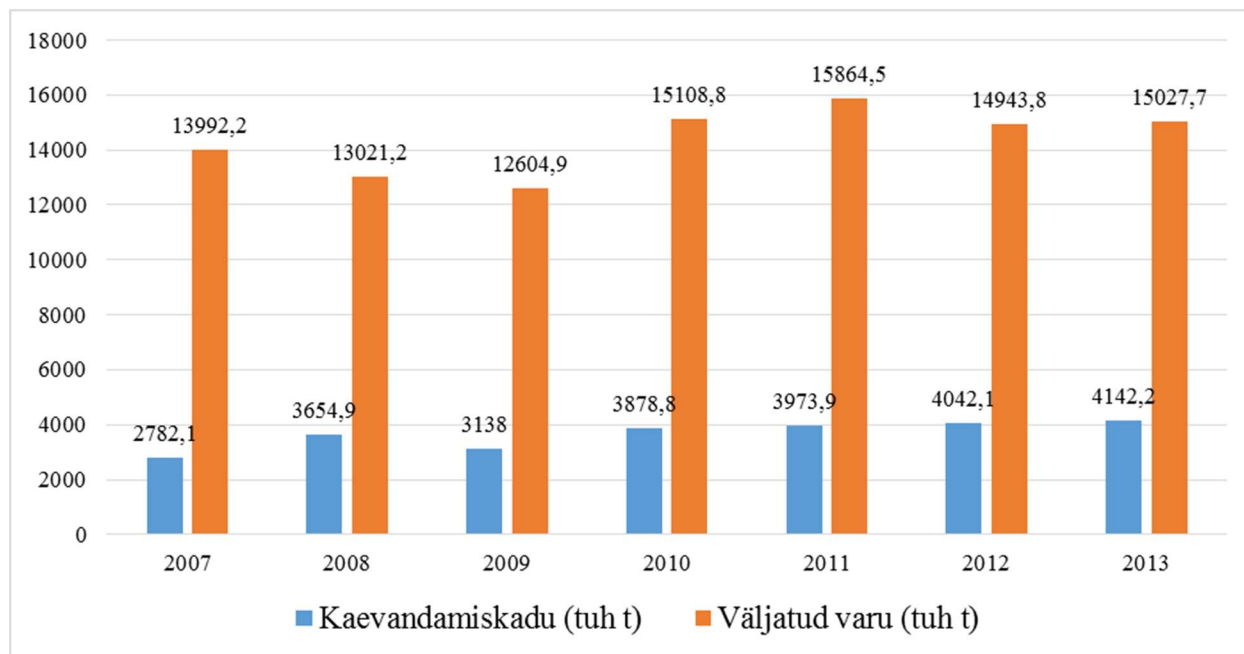
*Economic probable reserve*  
302.6 m tons  
6%

*Economic proved reserve*  
1,040.0 m tons  
22%

<sup>35</sup> Consolidated balance sheet of the reserve of minerals of the Republic of Estonia <http://www.envir.ee/et/ceesti-vabariigi-maavaravaru-koondbilansid>



In 2013, the amount of mined oil shale reserve was 15,027.7 thousand tons (to which the loss of 4,142.2 thousand tons were added). In 2007–2013, a total of 100,563.1 thousand tons of oil shale was mined (Figure 3).



/figure/: Mining loss (thousand t)

Extracted supply (thousand t)

18,000  
16,000  
14,000  
12,000  
10,000  
8,000  
6,000  
4,000  
2,000

2007: 2,782.1    2008: 3,654.9    2009: 3,138    2010: 3,878.8    2011: 3,973.9  
13,992.2    13,021.2    12,604.9    15,108.8    15,864.5  
2012: 4,042.1    2013: 4,142.2  
14,943.8    15,027.7

**Figure 3. Amount of oil shale mined in 2007–2013**

Pursuant to the Earth's Crust Act, the annual total oil shale mining limit based on all the permits is 20 m tons, i.e. the oil shale reserve registered in the Environmental Registry without the calculated mining losses (including the reserve left in the pillars).

In addition to the general annual mining limit of 20 m tons, the Secretary General of the Ministry of the Environment has established a maximum annual oil shale mining limit for each permit

holder with regulation No. 1319<sup>36</sup> of 10 August 2009<sup>37</sup>. Table 1 below lists the maximum currently allowed annual oil shale mining limits for all mining permit holders, the amount of oil shale mined in 2012 and 2013, and the percentage of the maximum annual mining limit.

**Table 1. The maximum currently allowed annual oil shale mining limit for mining permit holders**

Permit holder	Maximum annual mining limit (thousand t) (Regulation No. 1319)	Amount of mined oil shale in 2012 and 2013 (thousand t)	Share of the mined amount of oil shale out of the annual mining limit (%)
Eesti Energia Kaevandused AS	15,010	13,123.7 (2012) 11,830.0 (2013)	87 (2012) 79 (2013)
VKG Kaevandused OÜ	2,772	1,097.4 (2012) 2,344.4 (2013)	40 (2012) 85 (2013)
Kiviõli Keemia- tööstuse Varad OÜ	1,980	615.2 (2012) 755.4 (2013)	31 (2012) 38 (2013)
AS Kunda Nordic Tsement	238	107.2 (2012) 97.9 (2013)	45 (2012) 41 (2013)

Hitherto, i.e. 2015, none of the permit holders have completely mined their maximum annual amount of oil shale granted to them with the abovementioned regulation No. 1319.

On 15 June 2015, Riigikogu passed a law amending the Earth's Crust Act (draft law 43SE II), the objective of which is to allow companies to mine the oil shale reserve that they have not mined completely of the annual limit since 2009 (approximately 31 m tons) retrospectively in the next seven years. The amendment of the law ensures that in the accrual of additional volume, it is not possible to mine more than the annual limit stipulated in the permits, i.e. approximately 25 m tons, and the annual average amount of the mined oil shale will not exceed 20 m tons per year, as since 2009, the annual amount of mined oil shale has been approximately 15 m tons.

Excluding the areas of nature conservation restrictions with category I mining sensitivity, residential lands and other areas with terrestrial restrictions and reserve areas with a configuration unsuitable for mining, the 20 m tons annual mining limit allows mining the economic consumption supply for approximately 35–38 years, 48 years together with economic probable reserve. The loss in the forecast is calculated to be approximately 23%<sup>38</sup> and for the purpose of long-term sustainable use of the reserve, an increase of the loss should be avoided. The average loss in underground mining of oil shale in 2013 was 29.2% and in surface mining 6.3% (on average 21.6%)<sup>39</sup>. In conclusion, the share of loss will probably increase in the future, because the reserves are gradually exhausted in the parts of the deposit that allow surface mining, and because the share of supplies extracted from the mines will increase.

<sup>36</sup> Amendment of oil shale mining permits and the non-necessity of an environmental assessment

[http://dh2.envir.ee/atp/public/adr\\_upload/KK\\_1319.273611.pdf](http://dh2.envir.ee/atp/public/adr_upload/KK_1319.273611.pdf)

<sup>37</sup> Earth's Crust Act <https://www.riigiteataja.ee/akt/12894933?leiaKehtiv>

<sup>38</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

<sup>39</sup> Consolidated balance sheet of the reserve of minerals of the Republic of Estonia <http://www.envir.ee/et/eesti-vabariigi-maavaravaru-koondbilansid>

### 2.2.3. Technology used in mining

Estonia's accession to the EU has brought about new requirements and restrictions for oil shale mining, above all those related with impacts on the environment. This results in the need of faster development of oil shale mining technology; the main aspect to consider is the natural and social environment. The use of specific mining technology on mining claims is determined by the geological, hydrogeological, and environment protection requirements and settlement.

In **surface mining (opencasts)**, strip mining and transport mining technologies are used. Valid mining permits for surface mining have been granted to Aidu (the field is being reconditioned), Kohtla, Narva and Sirgala mining fields, and Kohala and Põhja-Kiviõli research fields. In surface mining, the loss may be up to 12% of the mined reserve.

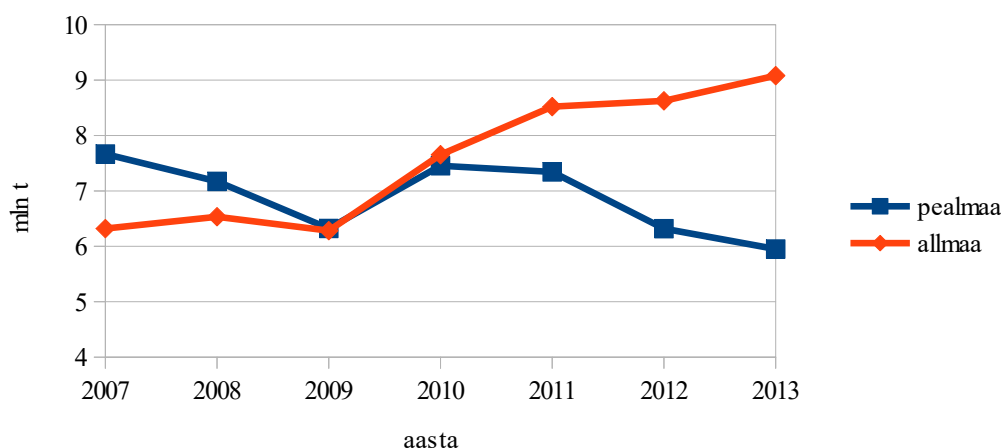
In **underground mining (mines)**, the technology currently used is chamber mining with holding the ceiling on pillars, the calculated load of which has deemed to be permanent (i.e. everlasting). Valid mining permits for underground mining have been granted for Ahtme, Estonia, Sompa, Tammiku and Viru mining fields, and Uus-Kiviõli and Ojamaa research fields.

A longer overview of oil shale mining methods is provided in Annex 4 and a more detailed overview of oil shale mining technology together with figures is presented in the 2012 study, pages 162–173<sup>40</sup>.

The oil shale mining face in the Estonian oil shale deposit moves gradually south, where the useful oil shale seam is located deeper in the ground. This is because the oil shale reserve has been exhausted in the northern and eastern part of the deposit and the restrictions related with environment protection and settlement. As at depths over 30 m it is generally economically more practical to mine oil shale in mines, the share of underground mining will increase and the share of surface mining will decrease in the future. The distribution of oil shale surface mining and underground mining is presented in Figure 4.

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<sup>40</sup> “Analysis of the Data Necessary for the Preparation of the ‘National Development Plan for the Use of Oil Shale 2016–2030’” <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>



/figure/:  
m tons  
year  
surface  
underground

**Figure 4. The distribution of extracted oil shale in surface and underground mining in 2007–2013**

The loss resulting from underground mining occurs due to the pillars that are left to support the ground, whereas the volume of the pillars may be, depending on the mining-technological conditions, up to 35% of the mined oil shale reserve. In the increase of the thickness of the overburden of the mine, the volume of the pillars supporting the ceiling of the mine also increases, therefore resulting in bigger losses. One of the main prerequisites for increasing the efficiency of oil shale mining is the reduction of losses occurring in underground mining. At the same time, if the volume of pillars is reduced, the risk of the subsidence of the ground occurs. If possible, mining without pillars in areas where the subsidence of the ground is possible and acceptable from the perspective of environmental protection will be implemented by using, for instance, the underground longwall miner (loss is two or three times smaller).

Research work for backfilling the excavation voids is conducted; however, a usable solution has not yet been found. In implementing the backfilling technology, investments will be made for arranging transport for the filling material, and solutions will be found for delivering it (ash, waste rock) underground. If the mining method is changed, new mining equipment will be used. The stability of artificial pillars and their leaching hazard in groundwater after the mining works are completed and the mining tunnels are flooded is also not yet clear. The solutions to the abovementioned problems are costly and, regardless of reducing the losses, increase the cost of oil shale mining. Therefore, the technological possibilities of intentional subsidence and backfilling of excavation voids will be continuously investigated.

In the Estonian geological structure, the Estonian oil shale deposit seam is partly located above the Rakvere and Toolse phosphorite deposit, approximately 30–35 m higher than the phosphorite layer. The Kabala research field of the Estonian oil shale deposit is located completely and the Sonda research field partly above the Rakvere phosphorite deposit, the Kohala and Pada research fields of the Estonian oil shale deposit remain partly above the Toolse phosphorite deposit. Oil

shale has been extracted from above the southern part of the Toolse deposit, and Kunda Nordic Tsement OÜ currently mines oil shale from Ubja opencast in the Kohtla research field.

If underground mining of oil shale is performed before the phosphorite is mined, the mining tunnels will be filled with water, and mining the phosphorite that lies 30–35 m below such a large underground body of water becomes dangerous due to the possible breakthrough of water located above the phosphorite mine. Hence, after the extraction of oil shale, mining the phosphorite located below oil shale becomes technically questionable, and entails large volumes of water to be pumped out from the oil shale excavation voids.

If phosphorite is mined before oil shale, the volume of natural pillars left in the excavation voids or artificial pillars will be calculated with extreme care in order to avoid the subsidence of rock layers located above the phosphorite. Therefore, it is very important to have support elements with sufficient strength, so that the layers of rock would not deform under the oil shale mine to be established. Otherwise, the mining of oil shale is dangerous and probably even impossible.

The best option technologically and economically would be the simultaneous mining of oil shale and phosphorite, establishing one two-storey mine. The main requirement for underground mining is that the pillars avoid the subsidence of land and that mining not change the land use requirements.

### Problems (Chapter 2.2)

1. For the purpose of planning long-term mining, the possibilities to use the oil shale resources of the Estonian oil shale deposit are not sufficiently investigated from the aspects of environment protection and economy.
2. Based on geologic surveys, the reserve of the deposit is divided into economic and potentially economic consumption and probable reserve; however, the priority areas where the environmental impact resulting from oil shale mining would be as low as possible, has not been distinguished by mining sensitivity.
3. No real breakthrough has been achieved in reducing oil shale mining loss, as the studies related with the extraction of the whole oil shale reserve and the backfill of excavation voids have not provided any useful solutions, especially from the perspective of economic cost-efficiency. The possibilities of intentional subsidence have not been studied at the necessary level.
4. Hitherto, the Estonian oil shale deposit has not always been handled as a complex mineral deposit, i.e. the necessary attention has not been given to the incidental minerals while granting permits for geological surveys and mining permits. The same applies to the research and mining of incidental minerals related with oil shale.

### 2.3. Overview of oil shale use

Due to the low calorific value and large mineral content, oil shale has no export potential as an energetic mineral and it is economically efficient only when used as raw material for industries established near oil shale mines and opencasts. However, products obtained from the processing of oil shale (shale oil, chemical products, and electricity) have good export potential.

Oil shale has specific characteristics, which is why different technologies and technical equipment have been developed for each area of use. The historical uses of oil shale in Estonia include the



production of electricity and heat, as well as the production of oil and cement. In the past decades, the production of electricity and heat has clearly been the most predominant.

In 2007–2013, the majority of trade oil shale<sup>41</sup> was used to produce electricity. At the same time, the use of trade oil shale for the production of shale oil shows a consistent upward trend. The different products (electricity, heat, oil, cement) from different areas of use of oil shale do not compete with each other in the market situation — the competitiveness of the area of use depends on the market situation of a comparable product. Therefore, liquid fuels produced from oil shale compete on the world market on equal grounds with other liquid fuels, and the electricity produced from oil shale competes on the open electricity market of the Northern Europe.

**Table 2. Use of trade oil shale based on areas of use in 2007–2013, thousand t**

	2007	2008	2009	2010	2011	2012	2013
Electricity	13,975	11,744	9,310	13,736	13,919	12,690	14,979
Heat	713	627	545	597	407	376	451
Shale oil	3,036	3,311	3,643	4,171	4,492	4,764	4,962
Cement	289	287	125	175	223	173	176
Other	6	0	0	0	0	0	0.0

While the currently valid oil shale development plan 2008–2015 focuses mostly on the oil shale reserve necessary for the production of electricity, then in relation to the complete opening of the electricity market in 2013 and the fact that compared to the production of electricity, the production of shale oil for export proves to be more beneficial, it is predicted that the share of oil shale used for the production of electricity will decrease in the oil shale development plan period of 2016–2030, and the share of oil shale used for the production of oil will increase accordingly. This can also be seen from the plans of the enterprises active in the oil shale industry — main investment will be made into shale oil production.

A more detailed overview of the volumes of use and deliveries of oil shale for producing electricity and heat, cement and shale oil, as well as the analysis of the criteria arising from different areas of oil shale use are provided in the 2012 study<sup>42</sup> and Annex 5.

### 2.3.1. Production of electricity and heat

There are several ways of using oil shale for producing electricity and heat in Estonia. Electricity is produced by directly combusting the oil shale and the retorting gas created in the processing of oil shale, by using either the oil shale or the gas or the combination thereof. The same methods are used for the cogeneration of electricity and heat. Direct combustion of oil shale is not used for producing only heat. Some of the smaller boiler plants that produce heat use combustion oil derived from oil shale.

<sup>41</sup> Trade oil shale is an oil shale rock mass with the real moisture content, which also includes a considerable amount of limestone (depending on the efficiency of the enrichment) and water. One ton of the oil shale reserve registered as mineral can be turned into 1.1–1.4 tons of trade oil shale, depending on the mining method and enrichment according to the wishes of the consumer.

<sup>42</sup> “Analysis of the Data Necessary for the Preparation of the ‘National Development Plan for the Use of Oil Shale 2016–2030’”

<http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

There are two combustion technologies used for the direct combustion of oil shale: pulverised firing and combustion in a circulating fluidised bed (CFB). In high-pressure steam boilers used in the pulverised firing technology, trade oil shale is burnt with the average calorific value of 84 MJ/kg, whereas the calorific value may vary in the range of 7.8–8.9 MJ/kg. Trade oil shale can be burnt in circulating fluidised bed boilers with the calorific value of 8.0–11.0 MJ/kg. Direct combustion of oil shale is mainly conducted by using the power units of the Narva Power Plants, which were put to use in the Baltic Power Plant in 1963–1965, and in the Estonian Power Plant in 1969–1973.

The currently used oil shale direct combustion technologies, pulverised firing, and combustion in a circulating fluidised bed differ greatly in terms of the efficiency of oil shale usage and environmental protection. The oil shale pulverised firing technology has been used for over 60 years, it has been thoroughly studied and improved; however, some of its deficiencies have remained. Hence, the pulverised firing boilers have a high concentration of SO<sub>2</sub> (approx. 2,400 mg/Nm<sup>3</sup>), the power units are with low efficiency (net efficiency approx. 30%), and a large volume of repair. In order to reduce the SO<sub>2</sub> emission, the boilers of the four old power units of the Estonian Power Plant have been equipped with the deSO<sub>x</sub> equipment, which limits the SO<sub>2</sub> emission level but also reduces the efficiency of the power units. For the remaining the old power units that are not equipped with the deSO<sub>x</sub> equipment, fuel with lower calorific value is used, i.e. limestone is added to the fuel during preparation (grinding). This may also limit the SO<sub>2</sub> emissions but at the expense of increasing CO<sub>2</sub> emissions and decreasing efficiency of the use of oil shale. However, the measures listed above have allowed meeting the SO<sub>2</sub> annual emission limit of 25 thousand tons per year imposed by the EU in 2012.

The CFB burning process implemented in 2004 does not involve the deficiencies of pulverised firing listed above. This has been confirmed by the operation of the equipment for over eight years. The concentration of SO<sub>2</sub> in flue gases is close to zero, the concentration of nitrogen compounds (NO<sub>x</sub>) has decreased by 2–3 times, the efficiency of the power units (net efficiency), compared with the existing pulverised firing blocks, has increased by approx. 6%. At the expense of the last indicator, the fuel consumption (approx. 20%) and therefore also the CO<sub>2</sub>-specific emission have decreased. The volume of repair of the boilers has also decreased. Practise has shown that in terms of efficiency and environmental protection, the CFB burning technology is the best solution for producing heat and energy from oil shale.

Together with oil shale, biofuel (wood, peat) can also be burned in the CFB burning process. This has already been successfully implemented in the CFB blocks of the Baltic and Estonian Power Plants. The share of biofuel in the new Auvere Power Plant is planned to be up to approx. 50%. As heat was used solely in a cogeneration mode in the direct combustion process of oil shale, the used oil shale originated from the same mining claims as the oil shale used for the production of electricity.

The volume of retorting gas used for the production of electricity and heat is determined by the shale oil production volume, as with the currently used production technologies, retorting gas is the by-product of oil shale retorting and is only used for producing energy by firing oil shale. The calorific value and amount of retorting gas depends on the shale oil production technology. In using the solid heat carrier method (hereinafter “SHC”) for producing shale oil, the by-product is semi-coke gas with high calorific value (higher than that of natural gas), but in using a gaseous heat carrier (hereinafter “GHC”), the by-product is generator gas with low calorific value.

In order to produce heat from oil shale, a cogeneration scheme with steam turbine solution is used. Thermal energy is mainly delivered to the adjoining district combustion networks (Narva, Kohtla-Järve, Ahtme, Sillamäe, Jõhvi, Kiviõli), but also as steam for technological purposes. Therefore, the waste heat and by-products (gases) created in the process of producing electricity and shale oil from oil shale is implemented in the CHP production process in case of on-site demand.

The determination of oil shale use efficiency indicators in the energy production process and their numerical values are provided in the description of the second strategic objective in Chapter 4.2.2. There is currently no common method developed and approved for calculating the numerical values of CO<sub>2</sub> emissions and collecting the source data.

### Problems (Chapter 2.3.1)

1. The majority of the electric capacity of AS Narva Elektriijaamad is from 1963–1973; their residual resource is limited and soon to be exhausted. There is currently a lack of clarity regarding the deadlines of investments and the necessity for new capacities.
2. Technologies used for reducing SO<sub>2</sub> emissions on old power units help limit the SO<sub>2</sub> emissions but also increase the amounts of CO<sub>2</sub> emissions and solid residue (oil shale ash), and reduce the efficiency of oil shale use.
3. There is no commonly developed and approved method for calculating the specific emission of CO<sub>2</sub> and for collecting source data.

### 2.3.2. Shale oil production

There are three companies in Estonia that produce shale oil: VKG Oil AS, KKT Oil OÜ (hereinafter “KKTO OÜ”), and Eesti Energia Õlitööstus AS (hereinafter “EE Õlitööstus AS”).

Two technologically different processes are used in Estonia for processing oil shale. These are: producing shale oil by using a gaseous heat carrier (GHC) (i.e. the generator process) or a solid heat carrier (SHC). These processes differ from each other technologically, as well as for the quality and characteristics of the oil shale used. A considerable amount of retort gas is also created as a by-product of the shale oil production process, the quality of which depends on the shale oil production technology.

The equipment based on the use of the GHC process is currently operating in Kohtla-Järve (VKG Oil AS) and Kiviõli (KKTO OÜ). The particle size of trade oil shale necessary for the GHC process is 25–125 mm and with the calorific value of 11–12 MJ/kg. Trade oil shale with this quality is only achieved by enriching the mountain mass or by using selective mining and filtering out the particles with the size of 0–25 mm. Therefore, the abovementioned companies could use trade oil shale originating solely from the Estonia and Viru mines, and the opencasts of Aidu and Põhja-Kiviõli.

The equipment operating based on the SHC process is currently operating at its nominal capacity in Narva (EE Õlitööstus AS) and Kohtla-Järve (VKG Oil AS). One device with a relatively small capacity is being tested in Kiviõli (KKTO OÜ). The SHC equipment uses fine oil shale with the particle size of 0–25 mm (including the dust created when mining and loading oil shale); however, pieces of oil shale can also be used if crushed to the necessary degree of fineness. Requirements for the calorific value are also considerably lower. Similarly to pulverised firing boilers, the SHC equipment uses low-calorific trade oil shale, but can also operate on enriched trade oil shale. This

way, EE Õlitööstus AS and the Estonian Power Plant share the fuel reception-feed system and oil shale warehouse. EE Õlitööstus AS used trade oil shale from the same mining claims as the Estonian Power Plant. Therefore, the SHC equipment has not had any limits arising from quality requirements related with the deliveries of trade oil shale from the mining claims located in Estonia. The determining factor here has been the availability of oil shale and a logistics solution.

In the past few years, the approximate annual amount of trade oil shale used in the SHC equipment has been 2,000–2,100 thousand tons, which means that no new generator equipment has been obtained and only the existing ones have been used. In recent years, the use of trade oil shale in the SHC equipment increased by approximately 2.4 times, from about 1,000 thousand tons to 2,400 thousand tons. The growth can be accounted for by the fact that EE Õlitööstus AS managed to make the existing SHC equipment more efficient and in 2010, VKG Oil AS and KKTO OÜ could also purchase SHC equipment.

A new SHC device (Enefit280) is in the start-up phase in EE Õlitööstus AS, the construction works of which began in October 2009. The plant was supposed to be ready in May 2012, but it is not yet operational. The constructed plant would annually consume 2.26 m tons of oil shale and would produce 290,000 t, i.e. 1.85 m barrels of shale oil. In 2012, VKG Oil AS started the construction of the second SHC device (Petroter II), which was ready and achieved its nominal capacity in September 2014. In 2013, the construction of a third Petroter device was launched.

Both Eesti Energia AS (hereinafter “Eesti Energia” or “EE”), as well as Viru Keemia Grupp AS (VKG) planned to establish an oil refinery for producing engine fuel from shale oil; however, the realisation of these plans has been suspended for the time being.

The description of the BAT of the Estonian shale oil industry has been prepared, which in the framework of the activity of Annex I, point 1.4 (b) of directive 2010/75/EU “gasification or liquefaction of other fuels in installations with a total rated thermal input of 20 MW or more” handles the technologies used in the crude oil production and determines the BAT for the use of these technologies. According to the conclusive document of the BAT of Estonian shale oil, all developed shale oil production technologies remain in the scope of the developed document.

The determination of the efficiency indicators of oil shale use and their numerical values are provided in the description of the second strategic objective in Chapter 4.2.2. There is currently no common method developed for calculating the efficiency indicator of the use of oil shale in shale oil production that would consider the energetic use of the by-products obtained in the oil shale retorting process.

### **Problems (Chapter 2.3.2)**

1. Experience in the implementation of new technological devices in shale oil production has indicated that the time planned for the implementation process often proves to be longer, which is why the need for oil shale for that period is unclear.
2. The previously planned decisions about the so-called post-processing of crude shale oil for the production of diesel fuel have been suspended as of July 2013. Therefore, the possibility of the planned further valuing of oil shale is unclear.
3. There is currently no common method developed for calculating the efficiency indicator of the use oil shale in oil production that would consider the energetic use of the by-products obtained in the oil shale retorting process.

4. The cost-efficiency and competitiveness of shale oil production depend on the environmental norms of the EU and the price of oil on the world market.

### 2.3.3. Cement production

Oil shale is used for cement production by AS Kunda Nordic Tsement (hereinafter “AS KNT”) whose main production include construction cements and a cement semi-product — clinker. For the production of cement, oil shale is used in clinker furnaces as a technological fuel. In order to ensure the quality of the cement, the characteristics of trade oil shale must correspond to the predetermined requirements. Hence, the calorific value of oil shale must be at least 10 MJ/kg and the MgO content in the mineral part less than 5%. Oil shale reserve corresponding to these requirements can be found in the Ubja oil shale opencast, and the oil shale from Põhja-Kiviõli II opencast may also prove suitable. Oil shale is selectively mined in the Ubja and Põhja-Kiviõli II opencasts. In the Põhja-Kiviõli II opencast, a mining permit has been issued for Kiviõli Keemiatööstuse Varad OÜ, which mines oil shale for the production of shale oil. In the Ubja oil shale opencast, a mining permit has been issued for AS KNT, and is valid until 2027. Pursuant to the oil shale continuity forecast, the reserves in the Ubja oil shale opencast, provided that the annual consumption by AS KNT remains at the current level, will be exhausted in approximately 2022. Oil shale reserves with the quality that is sufficient for the provision of supplies for the domestic cement industry are located in the Kohala research field.

AS KNT is one of the most important recyclers of the waste created in the oil shale combustion process (oil shale ash), and the company's annual need for ash would be up to 100 thousand tons. They could use the ash from the electric filters from the pulverised firing boilers of AS Narva Elektriijaamad. However, the implementation of the CFB burning process and the deSOx equipment on some of the pulverised firing boilers in the past few years has changed the characteristics of the oil shale ash, which makes the recovery of such ash in the cement industry questionable. This circumstance would considerably reduce further the already low oil shale ash recovery rate.

VKG has begun preparations for establishing a cement plant in Kohtla-Järve. As fuel for producing cement, they intend to use the retorting gas and semi-coke that are form as a result of the shale oil production process. The establishment of the plant depends on the price of oil on the world market, and is planned for 2015–2020; the start-up of the plant would allow reducing the volume of the stored hazardous waste.

### Problems (Chapter 2.3.3)

1. Characteristics of oil shale ash have changed due to new technologies implemented in oil shale combustion and to reducing the SO<sub>2</sub> content in flue gases. This makes the use of such ash in cement production questionable and also reduces the recovery rate of oil shale waste.

## 2.4. Education and research activities

The majority of the scientific research related with the use of oil shale, which are supported or financed by the foundations of MER, will be terminated in 2015 together with the oil shale development plan 2008–2015. Based on the R&D&I strategy of 2007–2013 “Knowledge-based Estonia” and its implementation plan, the ETP and an environmental protection and technology



programme was implemented, which are related with the use of oil shale and the reduction of the impacts of its use.

A project by the Tallinn University of Technology (hereinafter also “TUT”) will run until 2015 — with the project, the sustainable mining, processing, and usage criteria and technologies for oil shale will be developed based on geological, technological, and mining requirements (*Sustainable and environmentally acceptable oil shale mining*, National R&D programme “Energy”; framework project “Supporting the R&D of Energy Technology”). Research is conducted until the end of the same year for assessing the liquefying of the organic matter of dictyonema oil shale with supercritical solutions and reagents (ETF grant).

Until 2014, the TUT was conducting a project that aimed to reinforce the existing theoretical basic knowledge about the oil shale combustion process in a more oxygen-enriched combustion environment (ETP, financed by Foundation Archimedes). In the near future, a project studying the cogeneration of shale oil and electricity, and developing a cogeneration model (ETF grant) should be finished. Projects of the TUT handling the preparation of the strategy of the environmental use of solid oil shale waste and the new technologies of the thermochemical processing of oil shale and the mixtures of other fuels are also about to be finished. A study on the consequences of oil shale mining, where the focus was on the identification of mine collapses and the causes thereof, also came to an end in 2014 (ETF grant). Eesti Energia has provided additional financing for studying combustion processes.

It is difficult for the oil shale scientific research to compete on common grounds with other research areas (genetics, biotechnology, etc.) through foundation Estonian Research Council (hereinafter also “ERC”) of MER in different R&D financing competitions, because oil shale scientific research is a niche area specific for Estonia, and the international interest and response (for instance, to articles noted in the “Thomson Reuters Web of Science” database, their number, citations, etc.) is modest compared to many other research areas.

The new R&D&I strategy until 2020 determines more specifically the growth areas, one of which is the more efficient use of resources. One of the provided examples is the chemical industry (more efficient use of oil shale). Growth areas are developed based on a bottleneck analysis and they are based on the smart specialisation implemented therein. R&D&I must create added value in economy, especially in export, and solve the socio-economic issues important for society.

There are currently no curricula in any of the Estonian universities that would be specifically prepared for the field of oil shale. Applied research conducted in the framework of the national programme is directed to support entrepreneurship and market competence. Institutions of higher education in collaboration with ministries (especially MER and ME) review the curricula and, if necessary, complement the existing or create (common) curricula.

In the TUT, studies related with oil shale are to a smaller or a larger extent conducted in the framework of five curricula:

- 1) The Geotechnology Curriculum of the Department of Mining (Faculty of Power Engineering of the TUT) handles such oil shale related topics as geological surveys, mining, transport, processing, and use of oil shale. With the decision of the rector, the curriculum will be joined with the Curriculum of Earth Sciences (Faculty of Science) starting from the academic year 2015/2016 and from then on, mining engineers will be acquiring a degree in natural sciences; however, their specialisation corresponds to the engineering statute;



- 2) The connection between oil shale and the Curriculum of Chemical and Environmental Technology of the Department of Chemical Technology (Faculty of Chemicals and Material Technology of the TUT) is more modest, a base technology overview is given in the subject Chemical Technology;
- 3) The curriculum of the Department of Thermal Engineering (Faculty of Mechanical Engineering of the TUT) has subjects related with the production of electricity from oil shale (Thermal Power Plants, Boiler Equipment Special Course);
- 4) The TUT Virumaa College has relations with oil shale in two curricula: Fuel Technology (applied higher education studies) and Fuel Chemistry and Technology (master's studies);

The University of Tartu (hereinafter also “UT”) offers oil shale related studies in a total of seven curricula in the Institute of Ecology and Earth Sciences and in the Institute of Chemistry:

- 1) the bachelor's curriculum Geology and Environmental Technology and the master's curriculum Geology of the Department of Geology of the Institute of Ecology and Earth Sciences of the Faculty of Science and Technology of the UT handle the issues of the composition, formation, sediment composition, and age of oil shale in several lecture courses; additionally, the issues of oil shale as a combustible mineral, its research and mining technologies and environmental problems; the recultivation of mining areas and the legislation regulating the surveys and use of oil shale. The graduation papers of these levels have handled very different topics related with oil shale technology and oil shale use, from the stratigraphy of the sediment to the environmental impacts related with oil shale mining and the recovery of solid residue.
- 2) The master's curriculum Environmental Technology of the Faculty of Science and Technology of the UT handles the issues of oil shale composition, formation, and deposition; additionally, the issues of oil shale as a combustible mineral, its research and mining technologies, the recultivation of mining areas and the topic of oil shale in geological legislation. The master's theses have handled the chemical and mineralogical changes in semi-coke and oil shale ash, the movement of different elements in oil shale ash and the possibilities of fixing them;
- 3) The research work conducted in the framework of doctoral studies in the doctoral curricula Geology and Environmental Technology of the Faculty of Science and Technology has handled the underlying issues of oil shale geology; however, lately the environmental problems of the oil shale industry and the recovery of the waste created in the production processes have also become topical;
- 4) The bachelor's curriculum Chemistry of the Institute of Chemistry of the Faculty of Science and Technology handles, among other issues, the use of oil shale (courses Industrial Chemistry, Ecotoxicology, Water Technology Basics) and issues related with oil shale waste management (courses Handling of Hazardous Waste, Industrial Technologies and Environment).

#### **Problems (Chapter 2.4)**

1. It is difficult for the research works related with oil shale to compete with other fields of activity based on ERC financing assessment criteria. This partly results in insufficient financing of underlying studies related with oil shale. In order to maintain the continuity of oil shale scientific research, the state's attention should be directed to a more efficient use of oil shale as a national resource, to ensure R&D&I activities that create potentially high economic added value, and to ensure the state's support at the level of a special development programme.
2. There is no curriculum at Estonian universities, which concentrate specifically on knowing and using the technologies of the oil shale sector. Considering Estonia's historic leadership role

in oil shale knowledge worldwide, higher education institutions in collaboration with ministries discuss the creation of a common curriculum (in English) in Estonian universities, which concentrates on oil shale technology.

## 2.5. Summary of the environmental impact accompanying oil shale mining and use

Throughout almost a century, oil shale industry has substantially influenced the socio-economic and environmental condition of Ida-Viru County. The oil shale sector is an important employer in Ida-Viru County. Oil shale mining and use has a substantial environmental impact on landscape, soil, wildlife, ground and surface water, and ambient air. Many pressure factors caused by the oil shale industry originate from decades ago, but they influence the environmental status even today.

Oil shale mining (including flooded mines and opencasts) irrevocably changes the landscape (including water bodies) and the qualities of groundwater. The problems caused by the possible post-mining collapses of the ground and changes in the hydrological regime must be solved by local governments and the state, if mining activities were terminated more than 10 years ago (a total of 142 km<sup>2</sup>). Such mined areas are located in the Kiviõli town (the whole mined area), Kohtla (31%), Jõhvi (31%), and Kohtla-Nõmme (26%) rural municipalities, and the town of Kohtla-Järve (22%).<sup>43</sup>

Ten larger oil shale ash and semi-coke landfills have been established for the storage of waste created in the use of oil shale, the surface area of which totals at 21.5 km<sup>2</sup>; in addition to this area, land is also needed for the precipitation and leachate handling systems. Most of the landfills have been reconditioned by now, works are still performed on the Kohtla-Järve semi-coke landfill. As the volume of hazardous waste created as a result of oil shale use is large, it is important to deposit such waste by following environmental requirements. As the volume of the created waste depends on the amount of mined oil shale, the annual oil shale mining limit can also be handled as a factor limiting the creation of waste. For the surveys of the residual pollution objects of the oil shale sector and for making these objects safer for the environment, funds have been planned for the Kukruse waste rock hill and the Purtse river catchment area. Increase in the share of waste recovery in the past few years is worth noting.

In the mined area, the uppermost aquifer has become unusable as a source of drinking water and water from deeper aquifers have to be used for providing drinking water for the residents. The characteristics of the Lasnamäe-Kunda aquifer used at the time of mining will change after the end of mining and then it will become clear, if the aquifer is suitable for using as drinking water in the mined area. At the time of mining, bore wells for individual consumers have been established into this aquifer.

Bodies of surface water influenced by the oil shale industry are generally in a poor or bad condition. Tens of ditches have been dug in order to drain mining water, and riverbeds (e.g. Raudjõgi, Mustjõgi) have been altered. After the end of mining, several bodies of surface water have remained either partly or completely dry (the upper stream of the river of Kohtla, the Kose brook, the river of Hirmuse, etc.). An important positive change is the decrease in the amount of water pumped out from mines and opencasts. In addition, a new hydrologic landscape has been created as a result of closing the Aidu opencast.

<sup>43</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

Ambient air quality has so far been problematic in Kohtla-Järve, Sillamäe, Narva, and Kiviõli, where the possible pollution sources are VKG Oil AS, EE Õlitööstus AS, KKTV OÜ, the Kohtla-Järve regional treatment facility, the closing works of semi-coke hills and the fuel terminals of the Port of Sillamäe. The use of oil shale is accompanied by the emissions of SO<sub>2</sub>, NO<sub>x</sub>, and fine particles (PM<sub>10</sub> and PM<sub>2.5</sub>) and substances with a low odour threshold (e.g. dihydrogen sulphide H<sub>2</sub>S). For the purpose of reducing the negative environmental impact, it is essential that the emissions of SO<sub>2</sub> have decreased by more than twice, as the deSO<sub>x</sub> equipment has been installed on four older power units of the Estonian Power Plant.

Due to the measures implemented by companies and the state, the environmental status of Ida-Viru County has substantially improved. A more detailed overview of the environmental impact is provided in Annex 6. Environmental status requirements for water and ambient air have been described in the SEA report.<sup>44</sup>

In 2012, Ida-Viru County received aid in the sum of approximately 2.5 m euros (6%) from the environmental programme of the Environmental Investment Centre (EIC) (including proportionally from national projects), and approximately 30 m euros (17%) from the EU aid. Of the environmental charges, Ida-Viru County received 12 m euros<sup>45</sup> and therefore a total of 15% of all aid, which places Ida-Viru County second after Harju County in terms of aid. In 2009–2013, approximately 28 m euros has been allocated to Ida-Viru County for the removal of residual pollution, development of water infrastructure, and the rehabilitation of water bodies<sup>46</sup>. Annex 7 provides an extract of the projects financed by EIC in 2007–2013, which handle the environmental impact of the oil shale sector.

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<sup>44</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

<sup>45</sup> Data of the Ministry of Finance

<sup>46</sup> Data of the Ministry of the Environment

**Table 3. Summary of the environmental impact**

Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
<b>Impact on wildlife</b>	<p>The existing natural landscape is destroyed in surface mining, the variety of wildlife decreases. Water extraction due to mining causes changes in the hydrological regime, which influences the water-dependent biota. Mining water influences the surface water bodies acting as artificial recipients.</p> <p><b>Problems</b></p> <ol style="list-style-type: none"> <li>1. The possibilities for creating conditions for the recovery of more diverse wildlife in the recovered areas are not implemented sufficiently.</li> <li>2. The impact of underground mining is revealed in a longer period, the extent and impact on specific taxonomic groups is difficult to predict.</li> <li>3. The investigation of the impacts of underground mining is an expensive and long-term process and requires solving difficult problems.</li> </ol>	<p>The oil shale industry influences wildlife mainly through waste landfills and emissions into air and water.</p> <p><b>Problems</b></p> <ol style="list-style-type: none"> <li>1. The establishment of processing plants and communications, and waste landfills destroy original habitats, the extent of this impact is limited.</li> <li>2. Waste landfill areas have an extremely poor biota and need the planting of vegetation.</li> <li>3. Unsuitable species are used for planting (alien species).</li> </ol>	<ol style="list-style-type: none"> <li>1. The oil shale mining limit hinders the expansion rate of the area influenced by mining and limits the hazards on biota, but at the same time, the time of the impact of the operating company is prolonged.</li> <li>2. At the current level of research in Estonia and the used mining technology, underground mining of oil shale is not planned in areas under protection and areas with groundwater-dependant wildlife objects.</li> </ol>	<ol style="list-style-type: none"> <li>1. Analysis of the protection objectives of Kurtina Nature Reserve, the use of Vasavere groundwater reserve and the issues related with the mining of minerals.</li> <li>2. The step-by-step termination of mining in the Narva opencast reduces the oil shale mining impact on Kurtina Nature Reserve.</li> <li>3. The determination of priority areas reduces the possible conflict with environmental protection aims.</li> </ol>

<sup>47</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
<b>Impact on ambient air and climate</b>	<p>The separation of fine particles in a moderate amount and the creation of noise, which spreads into the environment in a limited extent.</p> <p><b>Problem</b> Compared with underground mining, surface mining has a greater impact on ambient air, disseminating dust on the surrounding areas, as well as the pollutants and noise related with blasting. However, it is positive that the share of surface mining will decrease in the future and therefore also the impact of surface mining on ambient air.</p>	<p>A remarkable volume of ambient air pollutants in Estonia originate from the oil shale industry, the most important ones of which are SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub> and fine particles; compounds with a strong smell are also created.</p> <p><b>Problems</b> 1. Compounds with a strong smell can be created in oil shale processing; odour pollution is a disturbance, which causes stress and irritation for the population. 2. Fine particles have adverse effects on the respiratory tract and may be carcinogenic.</p>	<p>The restriction arising from the annual mining limit of oil shale limits the expansion of production and therefore also air pollution.</p>	<p>Increase in the share of oil production creates prerequisites for the reduction of greenhouse gases in ambient air.</p>
<b>Impact on surface water</b>	<p>In mined areas, natural water bodies are replaced by heavily modified or artificial water bodies, the initial water habitats will disappear. The content of sulphate ion and suspension in the artificial recipients of mining water will increase. The achievement of a good condition or good ecological potential of many of the surface water bodies of the oil shale</p>	<p>The impact is caused by the load created by hazardous substances (including oil products, phenols, PAHs) (large share of residual pollution so far). The achievement of a good condition or good ecological potential of many of the surface water bodies of the oil shale industry region in the near future is questionable.</p>	<p>Prevention of the deterioration of the chemical status of surface water due to hazardous substances.</p>	<p>1. The specification of the emission of hazardous substances and the investigation of the impact of these substances on the aquatic environment, including the clarification of the load sources created by phenols. The assessments and the permitted emission loads of the conditions of surface water bodies arising from</p>

Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
	<p>deposit in the near future is questionable.</p> <p><b>Problems</b></p> <p>1. There is no general plan for designing the artificial water bodies established on the mined areas and those that will form after the end of the pumping process and water bodies that are heavily modified in the mining process as natural-looking as possible.</p> <p>2. In Kurtna Nature Reserve, the formation of a favourable water regime for surface water bodies affected by the oil shale mining process in the final stage and after the end of mining (Estonia mine and Narva opencast) is unclear.</p> <p>3. The mining water quality formation (similarly to groundwater) and its outflow to groundwater (including water quantities and emissions of hazardous substances) needs more efficient monitoring.</p>	<p><b>Problems</b></p> <p>1. The costs for controlling the polluted areas and limiting the emissions of hazardous substances made at the level of companies and the state may not be sufficient for the performance of the environmental quality requirements that are becoming more and more stringent.</p> <p>2. Cleaning works of the sectors of Purtse, Erra and Kohtla rivers, which were once polluted due to oil shale industry, have not been started. The contaminated soil (pitch) on the surface of Uhaku conservation unit on the banks of Erra River is hazardous to people and wildlife, the continuous emission of the polluted sediments to the groundwater is possible.</p>		<p>the content of hazardous substances will be specified.</p> <p>2. Pollution surveys of the polluted rivers in the Purtse river basin and the so-called phenol mire with the aim to make these areas safe for the environment.</p> <p>3. Inspection of the artificial recipients of mine drainages and the adjoining areas together with the measuring of drainage volumes of self-flowing mine waters, and the determination of requirements of environmental permits for reconditioning artificial recipients.</p> <p>4. Modelling of the artificial water bodies created in opencasts during the mining process into close-to-natural water bodies or water bodies, which can be used for general purposes.</p>
<b>Impact on groundwater</b>	<p>Lowering of the groundwater level, more intensive exchange of water. Increases the need for implementing deeper aquifers for water supply.</p>	<p>The main source of impact is the residual pollution that is still present in the production areas.</p>	<p>The restriction arising from the annual mining limit of oil shale hinders the expansion of the area influenced by mining activities.</p>	<p>1. Step-by-step mining.</p> <p>2. The reversal of water draining from flooded mines to the mines currently in use.</p>



Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
	<p>Increase in the area of the aquifer, which cannot be used as a source of drinking water. Deterioration of the quality of the Ordovician aquifer (sulphates, coarseness).</p> <p><b>Problems</b></p> <ol style="list-style-type: none"> <li>1. The water supply of upper aquifers (Ordovician) decreases and the quality of water deteriorates.</li> <li>2. Pressure for the use of lower aquifers (O-Cm and Cm-V) or the groundwater of Quaternary sediments increases; however, the water supplies of these resources are limited.</li> <li>3. The lowering of groundwater level influences the water-dependant ecosystems near the mining area, which in Ida-Viru County are mainly wetlands.</li> <li>4. In order to ensure the water supply of the population, new supplies of groundwater must be implemented and investments into establishing a common water system must be made.</li> <li>5. There is no up to date database about the use of the wells of the</li> </ol>	<p><b>Problems</b></p> <ol style="list-style-type: none"> <li>1. Residual pollution has been caused by the substantial impact of oil shale use.</li> <li>2. Pollution from modern industries can only be caused as a result of emergencies; however, this is not reflected by environmental monitoring, as oil industries are located in areas, the soil and groundwater of which were hazardously polluted in the past (areas with residual pollution).</li> </ol>		<ol style="list-style-type: none"> <li>3. Inventory of the condition of the wells of the Ordovician Lasnamäe-Kunda aquifer, which were established during mining and are currently in the areas of flooded excavation voids.</li> <li>4. Environmental audit of the mines where operation has been stopped or was terminated less than 10 years ago.</li> <li>5. The specification of the emission of hazardous substances and the investigation of the impact of these substances on the aquatic environment, including the clarification of the load sources created by phenols. Assessments of the conditions related with the content of the hazardous substances of aquifers will be specified.</li> </ol>

Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
	Lasnamäe-Kunda aquifer, which were established to replace the wells of individual consumers, which dried out due to mining activities, and about water quality (hazardous substances in water, including phenols, oil products and PAHs).			
<b>Impact on waste formation</b>	<p>Burnt waste rock hills are the source of residual pollution.</p> <p><b>Problems</b> Limited use of oil shale obtained after processing the waste rock into crushed stone. It is not known whether the long-term deposition of such oil shale is safe.</p>	<p>The impact arises from the formation of hazardous waste (oil shale ash, semi-coke, fussees) and their further processing.</p> <p><b>Problems</b> 1. The amount of created hazardous waste is large and increases together with the mined volumes. The formation of waste could be reduced by enriching the mountain mass; however, the share of extractive waste will then increase accordingly. 2. Waste must be predominantly deposited, their recovery rate is small.</p>	<p>1. Hazardous waste will be deposited in proper landfill areas. 2. The restriction arising from the annual mining limit of oil shale limits the formation of waste.</p>	<p>1. Making the repeatedly burnt Kukruse waste rock hill safer. 2. To implement the oil shale obtained as a result of processing waste rock.</p>

Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
<p><b>Impact on society and the socio-economic situation</b></p>	<p>The inhabitants of urban areas, especially the residents of Narva and Kohtla-Järve, who work in the mines located in the adjoining rural municipalities, are in a privileged position. A decrease in the accrual of environmental charges causes problems for rural municipalities where oil shale is mined.</p> <p><b>Problems</b></p> <ol style="list-style-type: none"> <li>1. There is no public information whatsoever about the excavation voids of the closed mines and the danger of collapse. They may be hazardous for human health and property, and complicate the construction and planning activities.</li> <li>2. Legal restrictions on land use arising from the existence of an oil shale deposit may hinder the development of alternative entrepreneurship.</li> <li>3. Hitherto, the state has not determined the priority areas for oil shale mining. Economic activities in regions with potentially economic oil shale reserve have too strict restrictions.</li> </ol>	<p>The inhabitants of urban areas, especially the residents of Narva and Kohtla-Järve, who work in the oil shale industry located in town. Reduction of the mining volume and the resulting reduction in the volume of oil shale industry causes problems primarily for towns.</p> <p><b>Problems</b></p> <ol style="list-style-type: none"> <li>1. In making decisions about the employment of oil shale companies (limiting the mining volume, increasing environmental charges, etc.), the possible impact on the employment of the region and the income of the people is not sufficiently considered. It must be ensured that the accompanying losses do not exceed the desirable benefits.</li> <li>2. In developing the living environment of Ida-Viru County, sufficient attention has not been given to making the region more attractive for</li> </ol>	<p>Aid has been allocated for the removal of residual pollution, development of infrastructure, and rehabilitation of water bodies.</p>	<p>Additional allocation of finances to Virumaa, accrued from the environmental charges used for the development of the living environment of the region.</p>

Environmental impact	Mining	Use	Mitigation measures implemented so far and still in operation	Mitigation measures offered in the SEA report <sup>47</sup> for 2016–2030
	4. The society has not been actively informed of the activities of the companies in the environmental impact mitigation process.	young top specialists whom the oil shale industry needs. 3. The residual pollution of the oil shale industry has not been fully removed and it hinders the development of the areas adjoining the residual pollution.		
	5. The possible external cost of oil shale mining and use are not known and there is no common method for calculating it, which is why the monetary cost of the external cost is not known.			Proposal of the SEA: additional allocation of finances to Virumaa, accrued from the environmental charges used for the development of the living environment of the region.
<b>Impact on human health</b>	Problems related with the external and working environment are created as a result of mining, and affect human health (noise, dust, emissions from mining machines, changes in water quality). The danger of the collapsing of the excavation voids of closed mines poses another health risk.  <b>Problems</b>	Problems related with the external and working environment are created as a result of mining, and affect human health (above all, emissions to air, residual pollution).  <b>Problems</b> 1. Hitherto, there were no health surveys conducted where	Health protection is ensured by the performance of environmental requirements and with mitigation measures listed above in the table. As mitigating measures the reduction of the emission load of hazardous substances in companies producing and processing oil shale and the implementation of newer, cleaner technology should be promoted. <sup>49</sup>	Hitherto, outside of the working environment, the impact of oil shale mining and use on human health was not specifically known (the results of the first study on the health impact of the oil shale sector were obtained as late as in 2015).

<sup>49</sup> “Research on the health impact of the oil shale sector” <http://www.tervisamet.ee/info/projektid/polevkivisektori-tervisemojude-uuring.html>

<b>Environmental impact</b>	<b>Mining</b>	<b>Use</b>	<b>Mitigation measures implemented so far and still in operation</b>	<b>Mitigation measures offered in the SEA report<sup>47</sup> for 2016–2030</b>
	Hitherto, there were no health surveys conducted where human health was investigated in direct relation with the impact of oil shale mining in the past 20 years. (In June 2015 a project “Research on the health impact of the oil shale sector” was completed) <sup>48</sup>	human health was investigated in direct relation with the impact of oil shale mining in the past 20 years. (In June 2015 a project “Research on the health impact of the oil shale sector” was completed) 2. Information about the integrated pollution of Ida-Viru County is not sufficient.	In the future, the studies on the health impact in the regions of the oil shale industry could be extended with specific biomonitoring. According to the World Health Organisation, toxic elements, such as arsenic, lead, cadmium, mercury, etc. are important biomarkers, the level of which in the population is associated with the pollution of the living environment and its impact on human health (WHO, 2012).	

<sup>48</sup> “Research on the health impact of the oil shale sector” <http://www.terviseamet.ee/info/projektid/polevkivisektori-tervisemojude-uuring.html>

### 3. Economic and social importance of the oil shale sector

In characterising the economic and social importance of the oil shale sector, it is reasonable to distinguish between its national and regional role.

At the national level, the universal indicator for determining the economic importance of the sector is its share in the gross domestic product of the country (hereinafter “GDP”). In determining the percentage of the oil shale sector, the direct, indirect, and induced impact of oil shale production must be distinguished. In the first instance, only the added value created by mining is taken into consideration. In the second instance, the whole added value created in the supply chain related with the use of oil shale (electricity-oil-chemical products) are taken into consideration. In the case of induced impact, which has a somewhat more hypothetical nature, the added value created as a result of oil shale use is added to the added value created in the oil shale supply chain.

When handled in the most narrow terms, oil shale mining provides a slightly less than 1% of Estonia's GDP (more precisely 0.9%). Its share has been constant since 2009 and it may increase, if the volume of oil shale mining increases (closer to 20 m tons). Added value from oil shale mining largely depends on the mining volume. The indirect impact of oil shale use as a contribution to the creation of other energy carriers is more than twice higher (almost 2% of the GDP; see Annex 9). By adding the calculation results of both the direct and indirect impact, the share of oil shale in GDP is approximately 2.9%. It should be taken into account, however, that the creation of added value by producing other energy carriers from oil shale depends on the level of sales prices of those energy carriers. In 2012, the price of shale oil was very favourable, approximately 110 dollars for a barrel. In 2015, it fell also below 50 dollars. Therefore, the added value is different over the years due to the fluctuations in electricity and oil prices, as well as according to the proportion of using oil shale for the production of oil or electricity.

In 2014, Ernst & Young Baltic AS conducted an analysis “Estonian oil shale mining and oil production: macroeconomic impacts study”<sup>50</sup> and added to its calculations the induced impact of the oil shale sector, which resulted in an approximately 4% share of the GDP.

The importance of the oil shale sector in national economy is, however, larger than its share in the creation of new value. So far, oil shale has been the main fuel for the production of electricity in Estonia, and continues to remain so in the near future. The electrical engineering based on oil shale has been a field ensuring the security of electricity supply for the state. With the establishment of international connections (Estlink 1 and 2), this role is reduced, but the supply of electricity for national economy and its export still balances the state's balance of payments. The continued use of oil shale as fuel for power plants provides an opportunity to avoid very large investments, which would be inevitable, if the country should forcedly switch to some other type of electrical energy in a very short period of time.

The current share of the sector of GDP is not the only important factor — its probable dynamics must also be considered. The latter must take into consideration both the changes in oil shale use, as well as growth forecasts for the Estonian economy. The share of oil shale in the electricity production in Estonia will probably decrease in time, however, this does not mean that the share

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<sup>50</sup> “Estonian oil shale mining and oil production: macroeconomic impacts study” [http://www.wec-estonia.ee/Estonian\\_oil\\_shale\\_mining\\_and\\_oil\\_production\\_macroeconomic\\_impacts\\_study.pdf](http://www.wec-estonia.ee/Estonian_oil_shale_mining_and_oil_production_macroeconomic_impacts_study.pdf)



of the oil shale sector of our GDP will decrease, which is above all increased by the export potential of shale oil production. Therefore, the share of the oil shale sector of the national economy of Estonia largely depends on how much of oil shale mined in Estonia can be marketed as shale oil and what is the price of that oil. The flexible reaction of the structure of oil shale use based on the created added value means an economically more efficient use of the strategic resource of the state.

Considering the scenarios of oil shale mining and use presented in Annex 8 to the oil shale development plan and the forecasts for the economic growth of Estonia, and if the conditions listed in the oil shale maximum scenario (PKmax) are realised, the share of the oil shale sector in Estonia may increase to reach up to 4.5% of GDP by 2030 (not considering the induced impacts). This requires conditions, which would allow developing all shale oil production capacities planned so far. A prerequisite for the scenario is the persistence of favourable price trends, where the price of heavy fuel oil is at the level similar to 2012 and the development trend in the use of alternative, above all renewable energy sources will continue in the current moderate pace. In the case of other scenarios, the share of oil shale use would remain at the level of 2–2.8% and would be at a level more or less the same in electricity production as now, despite the fact that the use of oil shale has decreased.

As a result of long-term use of oil shale, Estonia has acquired internationally remarkable experience and know-how in the oil shale industry, which is why the Estonian Entrepreneurship Growth Strategy recognises oil shale chemistry as one of the perspective and smart niches of economic growth.

Regionally, the fate of the oil shale sector largely influences the economic development and social well-being of the second largest county of the state — Ida-Viru County (population in 2013 was 151,909). Ida-Viru County also ranks second in terms of industrial production and is a strongly export-oriented region — 7% of the total export of goods of the country (2013).

A longer overview of the share of the oil shale industry in terms of salary and employment of local residents has been presented in Annex 6.13.

In addition to employment, the status of the oil shale sector has a significant impact on the revenue base of local governments. In the budgetary revenues of some of the so-called oil shale rural municipalities, the resource charges related with oil shale mining have an important role. Environmental charges make up the largest part of the budgetary revenues in Vaivara, Illuka, and Mäetaguse rural municipalities, reaching 45–60% of the revenues. The workforce of the sector mainly lives in the towns of Ida-Viru County, which is why the tax revenue of the towns is related with the personal income tax accrued from the oil shale sector. An analysis conducted by Praxis indicated that the impact of changes in the oil shale industry through the labour market is stronger and influences all of the larger towns in the Ida-Viru region. 80% of the population of the region lives in towns. The development of the oil shale sector has a broader impact on the labour markets of all of Estonia through direct, indirect, and accompanying changes in employment.<sup>51</sup>

#### 4. National strategy for oil shale mining and use

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<sup>51</sup> Oil Shale Industry's Impact on Demographic Development up to 2030; Praxis report <http://mottehommik.praxis.ee/wp-content/uploads/2014/08/P6levkivi-ja-demograafia.pdf>

The oil shale sector is important for the state for ensuring independent energy and security, obtaining tax revenues and providing employment. In the future, the production of shale oil and the share of its export will increase. At the same time, the production of electricity by using the oil shale direct combustion technologies based on the existing production capacities that correspond to the established environmental requirements will continue.

In the past 10 years, the environmental status of Virumaa has substantially improved due to the measures implemented by companies and the state; however, there are still regions where the indicators of soil, ambient air, and aquatic environment are not satisfactory. The achievement of a significant positive impact on the environmental status depends on the interaction of the residual pollution, water protection, and environmental protection measures, as well as the use of financial means in Virumaa.

The oil shale industry has strategic importance to the Republic of Estonia, and the know-how related with oil shale has potential in the international market. Therefore, the oil shale development plan includes the planned state-supported priority studies for the development of the oil shale sector. The state supports the studies related with the technologies of oil shale mining and use, as well as those related with the environmental impact caused by the oil shale sector.

#### 4.1. National interest and its realisation

**The general objective of the oil shale sector is the enforcement of national interest, which means the effective and efficient use of oil shale as a nationally strategic resource and in ensuring the sustainable development of the oil shale sector.**

**In implementing public interest, environmental protection, economic, security, social, and demographic (including regional) objectives and risks need to be considered.**

In making strategic choices, above all, the uncertainty of the internal and external market and the need to develop the technology to be more competitive have to be considered. The following topics have to be considered in making strategic choices:

- 1) the requests related with economy and energy security, which are planned for up to 2030, as well as longer objectives and risks (sustainable energy in Estonia, development of Virumaa);
- 2) the use of oil shale for the Estonian domestic economy and, if possible, for the export of products, and through that promoting the balancing of the Estonian balance of payments;
- 3) the possibilities for developing oil shale mining, as well as processing technology and increasing the efficiency and added value of resource use;
- 4) the need to adhere to more stringent environmental requirements, while ensuring normal working and development conditions for the oil shale sector.

The need for large investments and the long payback period of the investments is characteristic of the oil shale sector and the related branches of economy. Changing the created production capacities in this sector is costly and time-consuming. Adjusting regional employment to match the changing conditions also takes time. Therefore, the strategy has to be sufficiently flexible and convertible based on the conditions of the external environment.

The principles of oil shale mining and usage strategy of Estonia for 2016–2030 are the following:

- 1) to ensure conditions for switching to a more complex use of the resource, which is

economically more effective and provides more added value, and for decreasing the environmental impact, focusing on the needs and possibilities of the domestic, as well as the external market;

- 2) in a longer perspective, gain maximum revenue for society from the use of oil shale as a national non-renewable resource;
- 3) to ensure the necessary security of energy supply of Estonia, combining the production of oil shale based energy with renewable and other energy sources, and making oil shale use more environmentally friendly. To diversify and modernise oil shale energetics by using different modes of production;
- 4) to direct the mining and use of oil shale towards a more resource-efficient technology, taking into consideration the incidental minerals and other resources and by reducing the negative environmental impact, which has to be compensated for society, or for the limiting of which measures have to be implemented;
- 5) to promote the public education system and scientific studies in the field of oil shale in order to ensure the performance of the principles listed above.

Strategic choices are realised by the state by involving local government units and other parties. Suitable management means for that purpose are the following:

- 1) the annual oil shale mining limit is 20 m tons, which according to the Earth's Crust Act and for the purpose of economic efficiency is calculated as an average oil shale mining quantity of several years;
- 2) granting of mining permits for companies, taking into consideration the sustainability of the oil shale sector and the need to ensure the energy security of the state;
- 3) implementation of economic and environment protection regulatory measures, including the direction of the use of the state revenues from oil shale mining and use;
- 4) the direction of the use of mined areas;
- 5) specification of priority mining areas;
- 6) the control of the state as the owner of the strategic management of the companies of the oil shale sector;
- 7) the direction of R&D activities.

Oil shale mining and use has a substantial environmental impact on landscape, soil, wildlife, ground and surface water, and ambient air. This results in problems in using formed artificial landscapes, in the increasing amount of landfills, and the limited use of the ground above the underground mines due to possible collapses of the ground. The achievement of a good environmental condition of the region affected by the oil shale industry requires very large investments, the largest of which have so far been the reconditioning works of ash field No. 2 of the Baltic Power Plant and Kiviõli and Kohtla-Järve semi-coke landfills. At the same time, the impacted areas need sufficient time to recover.

The oil shale development plan determines the annual oil shale mining limit as 20 m tons, which is calculated as the average amount of several years. The annual oil shale mining limit is based on the SEA report prepared for the development plan, according to which the environmental condition of Ida-Viru County is improving, but according to the proposal made in the report, the changing of the annual oil shale mining limit established by the state would not be practical in the near future, as compared to the current condition, in the case of a mining limit of 20 m tons, the expected environmental impact of the oil shale sector would be at least neutral. If the annual mining limit of 20 m tons was exceeded without changing the technologies, it is probable that problems with ambient air and water quality, and waste landfills will increase. At the same time, the availability of oil shale supply compared to the operating period of the plants that use oil shale is uncertain in

the longer perspective.<sup>52</sup>

The oil shale development plan is reviewed every five years. The annual permitted mining limit can be changed, if the resulting negative impact of mining on the environment, socio-economic situation or public health does not increase, considering the levels of indicators related with the area and changes in technologies, the market situation, the companies' necessity of supplies, environmental requirements, and the environmental impacts, which have become evident. An increase in the annual permitted mining limit is possible only if the environmental load does not increase and the real market situation serves as a basis for this need.

If the annual mining limit of 20 m tons is adhered to, the oil shale supply given for mining on mining claims will be exhausted in 17–18 years. Therefore, during the oil shale development plan period of 2016–2030, at least one or two new mines have to be established. Annex 11 to the oil shale development plan presents the assessments for the necessity of trade oil shale in 2016–2030 of the companies using oil shale. The annual average oil shale need calculated based on the plans of the companies (by using the coefficient 1.2 for calculating the trade oil shale into the geological supply) indicates that the need exceeds the currently established annual mining limit. In 2016–2020, the planned oil shale use is close to the established annual mining limit; however, as early as in 2026–2030, it will be exceeded by 23%. The presented numerical data has to be treated as an assessment, especially in the field of oil production, where there are currently uncertainties in the schedule of constructing the production equipment, as well as in the financing decisions.

The determination of priority areas planned in the oil shale development plan allows assessing the status of natural values in these regions before the beginning of the mining process, and establishing the necessary conditions of environmental permits. In granting environmental permits, the rationality of oil shale use, efficiency of resource use, and the logistics of the use of the supply have to be considered.

By 2017, a remuneration model for the use of oil shale as a resource, based on the created value, is planned to be developed in order to better calculate the economic situation of the sector and to maximise the state revenue. The value of shale oil depends mostly on the crude oil world market price, but also on smaller components, such as the price of CO<sub>2</sub> on the EU emission market, the euro-dollar exchange rate, the so-called crack spread, etc. The volatility of the value created from oil shale results from these external impact factors. The price of electricity and therefore also the profitability of oil shale electricity depends on external conditions (electricity stock market price, prices of other resources, and the quota price in the CO<sub>2</sub> quota trade).

The environmental load of the oil shale industry is mostly directed by the restrictions originating from the Emissions Act, the annual oil shale mining limit of 20 m tons, and the ambient air pollution limits established for Estonia for 2020. Additionally, pollution charges have been implemented for the reduction of pollution, whereas the landfill charges form the largest share of these charges. In the upcoming years, the industry and the state have an important objective of finding application for waste and ensuring a suitable regulative situation and economic conditions for the recovery of waste. Here, the EIC is important, as the necessary applied research is carried out through this institution. In addition, the introduction of pollution charges has to reduce the emissions of hazardous substances into the air. Therefore, after a suitable transitional period, it is planned to establish a considerably higher charge rate (compared with the current rate) for carcinogenic, mutagenic, and reproductive toxic volatile organic compounds that are hazardous

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<sup>52</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

even in very small amounts.

The economic regulatory measures that affect the oil shale industry include the taxes imposed on the majority of the fields of activity, as well as the oil shale mining right charge used for taking state revenue. Based on the valid mining right charge, a fixed fee, irrespective of external conditions and the created value, for the mining of one ton of oil shale is requested. A regulation of the Government of the Republic establishes the oil shale mining charge rates for each upcoming year until 2025. The charge is based on the mined quantity and does not depend on the economic situation of the oil shale sector; however, depending on the situation of the sector, it is possible to lower the charge rate. At the same time, in case of favourable conditions, the state may demand a much lower charge for the society compared to the value of the resource, and in case of unfavourable conditions, the charge may be proportionally higher than the value. This system is clear, comprehensible and simple, and if the charge rates are determined for a longer period, companies are able to take into consideration the costs related with the charge rates. However, the system is not flexible regarding economic conditions and if instead of a forecasted single steady trend change, the factors affecting the value are very volatile, it will increase the risk that the state does not obtain sufficient revenue from the resource or that the industry is unnecessarily burdened at economically difficult times.<sup>53</sup>

In oil shale mining, the already open mines have to be exhausted first. The direction of the use of the mined areas starts with the granting of a mining permit by establishing the reconditioning requirements for the mined area in the future. The negative impact accompanying the mining process has to be planned to be minimum even before commencing mining, the impact on the natural values of the nearby areas has to be observed and negative impacts during the mining process have to be compensated.

The action programme of the Government of the Republic 2015–2019 sets a task for the Minister of the Environment to develop a long-term strategy for the implementation of the non-renewable minerals of Estonia and the functioning geology-related capacity for the performance of this strategy. ME has planned to present a proposal for the preparation of the earth's crust strategy to the Government of the Republic for approval in September 2015. Thereafter, the preparation of the earth's crust strategy will be started in the format of the fundamentals of the policy. The oil shale development plan serves as one of the inputs for the preparation of the earth's crust strategy as a strategic document of a higher level, and in the future, also as an inseparable part thereof.

## 4.2. Strategic objectives and measures

The oil shale development plan sets three strategic objectives arising from the necessity of implementing national interest.

1. Increasing the efficiency and reducing the environmental impact of oil shale mining.
2. Increasing the efficiency and reducing the environmental impact of oil shale use.
3. Developing education and research activities related with oil shale.

The implementation of the first two strategic objectives ensures an increase in the efficiency of the oil shale industry and the reduction of the accompanying negative environmental impact, and is supported by the third strategic objective – the development of education and research activities

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<sup>53</sup> Explanatory letter for the draft law amending the Environmental Charges Act and the Earth's Crust Act  
[http://www.envir.ee/sites/default/files/keskkonnatasud\\_seletuskiri\\_07112014\\_final.pdf](http://www.envir.ee/sites/default/files/keskkonnatasud_seletuskiri_07112014_final.pdf)

related with oil shale. Achieving the general objective of the field of oil shale depends on the implementation of national interest, which is confirmed by the fulfilment of the target level of the indicators set for achieving the strategic objectives.

A full overview of the activity necessary for fulfilling the measures together with the responsible executors and the estimated expenses will be submitted in the implementation plan and explanatory report attached to the oil shale development plan.

#### 4.2.1. The first strategic objective. Increasing the efficiency and reducing the environmental impact of oil shale mining

The main prerequisite for fulfilling the strategic objective is the reduction of the oil shale mining loss, and the maximum recovery of extractive waste.

**Table 4. Impact indicators of fulfilling the first strategic objective**

Impact indicator	Initial level	Target level 2020	Target level 2025	Target level 2030
1. The percentage of the underground mining loss from the oil shale reserves already mined and rendered unfit for use, % <sup>54</sup>	29.2 (2013) <sup>55</sup>	up to 29.2	up to 29.2 (will be specified in 2020)	up to 29.2 (will be specified in 2025)
2. Recovery of waste rock, %	40 <sup>56</sup>	not less than the initial level	not less than the initial level (will be specified in 2020)	not less than the initial level (will be specified in 2025)
3. The volume of water pumped out for each tonne of oil shale reserve extracted from the earth's crust	15 m <sup>3</sup>	14 m <sup>3</sup>	will be determined in 2020	will be determined in 2025

The indicator of the percentage of underground mining loss (Table 4 No. 1) in using the existing mining technology will increase in the future; however, the strategic objective is concerned with the increase in mining efficiency, the prerequisite of which, in turn, is to reduce oil shale mining loss<sup>57</sup>. Chapter 2.2 of the development plan highlights the problem involving the inability to reduce oil shale mining loss so far, as the research on the extraction of the oil shale reserves from the mines and the backfilling of excavation voids has not yielded any practicable results. In order to

<sup>54</sup> Because the existing chamber mining technology does not enable reducing loss, applied research in the field of mining technology must be conducted in the future, the results of which will then be used to set the target levels of the impact indicators as of 2020.

<sup>55</sup> Consolidated balance sheet of the minerals of the Republic of Estonia. <http://www.envir.ee/et/eesti-vabariigi-maavaravaru-koondbilansid>

<sup>56</sup> “National Development Plan for the Use of Construction Minerals 2011–2020”

[http://www.envir.ee/sites/default/files/ehitusmaavarade\\_kasutamise\\_riiklik\\_arengukava\\_2011-2020.pdf](http://www.envir.ee/sites/default/files/ehitusmaavarade_kasutamise_riiklik_arengukava_2011-2020.pdf)

<sup>57</sup> An explanation about the need of mining loss to support the ground with pillars and about the reasons of the increase in losses is presented in Chapter 2.2.3 of the development plan.



reduce underground mining loss, mining technology must be made resource-efficient to reduce negative environmental impact. At the same time, the cost of oil shale mining must enable the continued development of the oil shale sector. Consequently, scientific and applied research in the field of oil shale mining technology will continue to be necessary in the future in order to reduce losses.

The impact indicators of the efficiency of the oil shale sector include the percentage of waste rock recovery (Table 4 No. 2). The amount of waste rock incidental to oil shale mining cannot be reduced due to the geological structure of the Estonian oil shale deposit where the layers and nodules of calcareous rocks are interspersed with layers of oil shale. Waste rock is handled as waste if it has been extracted from a mine or an opencast together with oil shale and separated from oil shale during enrichment. The waste rock separated during selective mining (mainly slate in between layers of oil shale), which is left in the opencast or mine is not classified as waste according to the Waste Act and is not recognised in reporting (this is also not done with regards to the overburden of opencasts, which is used for clean-up after mining).

According to the definition of waste recovery stipulated in Waste Directive 2008/98/EC, it can be considered recovery only when the waste replaces “other materials that would otherwise have been used for the same purpose”. This refers to wider economic activity, e.g. the crushed stone manufactured from waste rock and used in construction replaces other types of crushed stone or gravel that would have otherwise been used for the same purpose even if the crushed stone manufactured from waste rock had not been available as an alternative. The term “by-product” is also provided in the EU waste directive and is already a product at the moment of creation, which means it is not classified as waste, thus, its processing cannot be considered recycling (but an important requirement for such a product is the market, or the demand).

Waste rock recovery includes adding it to power plant boilers (in order to bind the sulphur compounds, adjust the calorific value of fuel mixtures, etc.), manufacturing lime, using it for purifying flue gases, etc. – all new and developing recycling possibilities aside from the known use as mineral construction materials.

The “National Development Plan for the Use of Construction Minerals 2011–2020” forms the basis for determining 40% of the initial level of the impact indicator of waste rock recovery<sup>58</sup>, based on which crushed stone from waste rock can generally be used to construct certain elements on roads with a smaller traffic load; however, it is not suitable for the construction of motorways of high road classification. Thus, crushed stone from waste rock cannot be used as a replacement of quality construction crushed stone everywhere. At the same time, crushed stone from waste rock is good for manufacturing low class concrete. In 2011–2013, waste rock recovery amounted to over 50%; however, that was achieved due to several large construction works (Estonia motorsport hill, the covering of the Kiviõli semi-coke hill, reconditioning works in Narva and Aidu opencasts). Currently, constructions on such a large scale are not planned in the future.

The requirements for the new fluidised bed boilers and the SHC oil manufacturing equipment with regard to the calorific value of used raw material are lower than those of the old pulverised firing boilers and the GHC shale oil equipment. In the future, this could reduce the amount of waste rock deposited in extractive waste depositories, which is classified as non-hazardous waste, however, the amount of hazardous waste generated as a results of the use of oil shale will increase equally.

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<sup>58</sup> “National Development Plan for the Use of Construction Minerals 2011–2020”

[http://www.envir.ee/sites/default/files/chitusmaavarade\\_kasutamise\\_riiklik\\_arengukava\\_2011-2020.pdf](http://www.envir.ee/sites/default/files/chitusmaavarade_kasutamise_riiklik_arengukava_2011-2020.pdf)

The waste generated as a result of oil shale mining will be further described in Annex 6 to the development plan.

One of the impact indicators of the efficiency of oil shale mining is also the volume of water pumped out for each tonne of oil shale reserve extracted from the earth's crust (Table 4 No. 3), which in 2013, was approximately 15 m<sup>3</sup> (SEA Annex 1 p. 49–51, see chart 8)<sup>59</sup>. It is possible to reduce the amount of water pumped out down to the level of 14 m<sup>3</sup> if the mining intensity in mines and opencasts is increased. It is feasible to calculate the volume of water pumped out for each tonne of oil shale reserve extracted from the earth's crust as the average of a five-year-long period, then the precipitation variability of different years will even out.

The social impact of oil shale mining on society and human health is addressed together with the impact of the use of oil shale when describing measure 2.3. “Mitigation of the social impact (impact on human health and social impact) of the oil shale industry” of the second strategic objective.

### Measure 1.1. Promotion of sustainable oil shale mining

In chapter 2.2 of the oil shale development plan, a problem is raised with regard to the insufficient research in the field of environmental protection and economy of the Estonian oil shale deposit for the long-term planning of mining for 2016–2030. Thus, priority areas in the deposit must be determined where mining is economically justified and the negative impact on the natural environment is as low as possible.

**Table 5. Main activity and result of measure 1.1.**

Main activity	Result
Determining priority mining areas of the Estonian oil shale deposit	Priority areas will be determined based on the mining sensitivity and economic indicators, the result of which is a more sustainable mining of oil shale and a reduction of the accompanying negative environmental impact
Applied research in order to identify and implement the possibilities of reducing oil shale mining loss	As a result of modernising mining technology, the economic efficiency of oil shale mining and use increases, also, the percentage of directly used oil shale reserves from the oil shale reserves allocated for mining will increase (for example, intentional subsidence as a mining method will be reapplied)
Analysis of the possibilities of optimal charges of the oil shale resources	Earning maximum state revenues in the period of 2018–2050 and onwards until there are enough oil shale resources, and the development of the analysis model, which

<sup>59</sup> Strategic Environmental Assessment (SEA) Report (Annex 1)  
[http://www.envir.ee/sites/default/files/pak\\_ksh\\_lisa\\_1\\_heakskiitmiseks\\_meilimiseks.pdf](http://www.envir.ee/sites/default/files/pak_ksh_lisa_1_heakskiitmiseks_meilimiseks.pdf)

	would enable evaluating the maximisation of state revenues
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Research for 2016–2018 is intended to be commissioned for determining priority areas of oil shale mining. Determining these areas does not alter the permits issued for oil shale mining today. Priority areas are necessary for selecting the next mining areas in order to ensure investor certainty for companies until 2050.

Based on the natural environment, priority areas will be named, above all, in accordance with the results of the research on oil shale mining sensitivity (2010, 2014, 2015)<sup>60</sup>, which can then be used to draw conclusions on the impact of mining on species and habitats in need of protection, as well as on the functionality of natural ecosystems.

Assessment of the cost-efficiency of the oil shale reserves in the priority areas separated based on the nature protection conditions must be conducted, thus considering the possibilities of using the most efficient mining technology (intentional subsidence and other mining methods) and taking into consideration the mining-technological conditions in the areas of relevant minerals. Analysis needs to be conducted with regard to the criteria laid down in 2005 based on the Earth's Crust Act and which have been used to calculate the quality of the oil shale reserves and the determined reserves by drawing on the production of electricity as the primary method of oil shale application. As the direction of the energy management today is to increase the use of oil shale for oil manufacture, the existing criteria for oil shale reserves need to be evaluated and, if necessary, altered, and the reserves need to be classified.

In order to increase the efficiency of oil shale mining, a solution must be found in particular to reduce underground mining loss, which with the mining technology used today amounts to approximately 30%. The measurements of the pillars in chamber mining depend mostly on the depth of the mine and the height of the ceiling. As oil shale will be mined even deeper in the future, the percentage of loss will also increase. Thus, the objective of the research proposed in the implementation plan of the oil shale development plan is to modernise the technology used for the underground mining of oil shale.

One of the currently known possibilities is to mine oil shale by using the method of intentional subsidence, which ensures accessibility of the reserves of up to 90%. At the same time, land use and environmental protection conditions place restrictions on the scope of using this technology.

Another possibility is to continue research on the technology used for the backfilling of excavation voids, which could also potentially reduce mining loss in the distant future. Currently, the research has not yielded any significant results. In addition, the high cost of the oil shale mined by using backfilling poses a great challenge. The technology of backfilling can be used to reduce mining loss by approximately half. In surface mining, the rock mass in the overburden could possibly be used, in addition to reconditioning works, outside of the mining claim, such as in construction works as filling.

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<sup>60</sup> “Applied research for determining the categories of mining sensitivity and considering mining sensitivity for the use of the oil shale deposit” (2010, AS MAVES);  
[http://www.envir.ee/sites/default/files/rakendusuuuring\\_kaevandamistundlikkuse\\_kategoariate\\_maaramiseks\\_ja\\_lahtu\\_des\\_kaevandamistundlikkusest\\_polevkivimaardla\\_kasutamiseks.pdf](http://www.envir.ee/sites/default/files/rakendusuuuring_kaevandamistundlikkuse_kategoariate_maaramiseks_ja_lahtu_des_kaevandamistundlikkusest_polevkivimaardla_kasutamiseks.pdf)

In order to get an overview of the impact of the used mining technologies on the surface and to further develop mining technologies, it is necessary to analyse the stability of the pillars, which are being created or have been created in the process of chamber mining, after mining has ended and the mining tunnels have been flooded (map the areas where subsidence reaches the surface). The impact of underground mining areas is further addressed in the description of measure 1.3.

The objective of the state is to implement regulations with regard to oil shale mining, distribution, valorisation, and taxation, which would ensure the biggest income for the state during the period of 2018–2050 and onwards until there is enough oil shale, and which would make it attractive for companies to maximise the value of oil shale. This is why an analysis of the possibilities of optimal charge of the oil shale resources has been proposed in the action programme of the Government of the Republic for 2015–2019<sup>61</sup>. An analysis model enabling the evaluation of the maximisation of state revenues received from oil shale will be prepared for the analysis, which could then be used to evaluate, together with companies, the need for changing the ways and scope of distributing the risk and profit.

### **Measure 1.2. Reducing the negative impact of oil shale mining on the natural environment and water supply**

The use of natural resources brings about the risk of disrupting the balance of nature and biodiversity. The “Estonian Environmental Strategy 2030”<sup>62</sup> identifies the changes in the landscape and in land use, including the changes in many natural habitats, due to the mining of minerals and the depositing of waste as one of the primary concerns.

**Table 6. Main activity and result of measure 1.2.**

<b>Main activity</b>	<b>Result</b>
Developing a surface and ground water model for the area (and its buffers) impacted by mining	The surface and ground water model developed for public use primarily enables analysing the water regime and estimating the level and quality of ground water, thus improving the state of ground water in areas impacted by oil shale mining
Determining the mitigation measures of the negative impact caused by the change in the level of ground water in the mining area and analysing the possibility of their implementation (efficiency, environmental impact, cost)	The imposed mitigation measures reduce or prevent the negative environmental impact of mining, above all on the natural environment dependent on ground water
Ensuring water supply in mined areas	The residents of the area impacted by oil shale mining have proper supply of drinking water
Inventory of reconditioned opencast areas (including the analysis of the monitoring data)	Based on the state of the reconditioned opencasts revealed in the process of the inventory, it is possible to improve the

<sup>61</sup> Action programme of the Government of the Republic 2015–2019; <https://valitsus.ee/et/valitsuse-tegevusprogramm>

<sup>62</sup> “The Estonian Environmental Strategy 2030” <http://www.keskkonnainfo.ee/failid/viited/strateegia30.pdf>

	requirements of future reconditioning. This will increase the quality of the areas used for other purposes after mining
Development, advancement, and implementation of the BAT of extractive waste management	Oil shale extractive waste is managed in the best possible way, resources are used sustainably

The surface and ground water model generally deals with both ground and surface water (the post-mining state is also evaluated). Based on the data of the model, it is possible to analyse the mitigation measures of the lowering of the ground water level, including the step-by-step mining of large mines (a pillar is left in the areas between the so-called steps, artificial pillars are left in case of backfilling), and to develop more detailed models for smaller areas (such as mining claims) of oil shale deposits.

The model proves useful for different target groups (state authorities, local governments, non-profit associations, companies) in the areas impacted by oil shale mining and use when planning the activities that impact the environment (including construction, mining of minerals, land cultivation, etc.). The surface and ground water model developed for public use improves the availability of environmental information and contributes to the systematisation of environmental monitoring and the strengthening of supervision.

Pumping water out of opencasts and mines is incidental to oil shale mining, which is why separate mitigation measures that reduce to the maximum extent the changes in the level of ground water must be determined for each opencast and mine. The efficiency, environmental impact, and the cost of these measures must be explained. Mitigation measures include step-by-step mining in large mines, seepage barriers, underground sedimentary basins, infiltration basins, directing mining water into closed mines, etc. The step-by-step mining of large mines enables limiting the possible impact of the existing and potential pollution sources on ground and surface water. The efficiency, cost, and feasibility of each measure can be evaluated during the environmental impact assessment of the establishment of a particular mine.

In the oil shale mining area, 98% of the population has public water supply. The dry wells in single households in mined areas not linked with public water supply have been mostly replaced with the Lasnamäe-Kunda Ordovician aquifer wells or water pipelines have been installed therein. After the recovery of the Keila-Kukruse Ordovician aquifer, the quality of the Lasnamäe-Kunda Ordovician aquifer water in the wells in mined areas must be checked.

The current state of these wells must be inspected together with the quality of the water (in addition, the level of hazardous substances, such as phenol, petroleum products, and polycyclic aromatic hydrocarbons (PAHs) must be determined) in order to subsequently use or tampon the Lasnamäe-Kunda Ordovician aquifer wells established during mining and to optimally design the water supply of individual consumers in new mined areas. In planning the work, the results of the well research (50 wells are located in the area of the oil shale industry) conducted by the Health Board in 2014 must also be taken into consideration<sup>63</sup>. The results of the inspection of whether the drinking water sources of the Lasnamäe-Kuna aquifer comply with the requirements enable implementing measures that reduce the negative impact of closing the mine on individual wells.

<sup>63</sup> Research “Evaluation of the quality of the drinking water and health safety in dug wells and private water supply systems” (Health Board, 2014)

Reconditioning of the area altered by mining means that the area is made suitable for use for some other purpose on the basis of a reconditioning project. It is important to know the result of the reconditioning of a particular opencast area after the prescribed requirements and conditions are fulfilled. All the requirements arising from the Earth's Crust Act must be taken into consideration in the opencast reconditioning project. The reconditioned area must match the surrounding landscape (landforms must be natural, ground water regime must comply with the intended purpose of the use of the land, reconditioned area cannot be hazardous for humans). In the course of the inventory, the state of the reconditioned opencasts is identified, the fulfilment of the reconditioning requirements and the achieved result is evaluated, i.e. the compliance with the new intended purpose of the use of the land. If necessary, the requirements of the reconditioning of opencast areas must be amended and (or) improved in the future.

In 2010, research was started within the framework of the project “Commissioning of applied research for determining mining sensitivity” funded by<sup>64</sup> the Environmental Investment Centre (EIC). In 2014, the works described in the project were continued to explain the impact of oil shale mining on the protected and endangered species and their habitats, to gain knowledge on the existence of the favourable types of habitat for protected species that have formed in the reconditioned opencast areas, on the possibility of their formation, and to evaluate whether it is possible and necessary to implement additional measures for the formation of favourable habitats during the reconditioning of opencast areas. In order to do this, the habitats of the endangered and protected species and the habitats of the Nature Directive in reconditioned opencast areas will be inventoried.

After the conclusion of the research on mining sensitivity at the end of 2015 (where types of habitats dependent on water and the habitats of protected species are addressed), it will become clear whether it is necessary to specify the reconditioning technology used in the reconditioned opencast areas with additional research (to get fertile land for agriculture and (or) forestry, to (re)create protected natural values that are important from the point of view of mining sensitivity). Based on the results, an overview will be submitted with regard to the subsequent use of the reconditioned opencast areas, and suggestions will be made concerning the improvement of the conditions and requirements of the reconditioning, if necessary.

Currently, EU is preparing a reference (BREF) document of the BAT for the environmentally safe management of the extractive waste of minerals (including oil shale), which should be ready in 2016. This is why the development, advancement, and implementation of the BAT for the environmentally safe management of the oil shale extractive waste is proposed in the oil shale development plan, and it is carried out in accordance with the requirement stipulated in Article 21 (3) of the directive of 16 March 2006 of the European Parliament and Council. The European Commission organises the information exchange between the member states and relevant organisations with regard to the BAT, their supervision, and development, and discloses the results of the information exchange. Then the confirmation process of the BAT will take place. The advancement and implementation of the BAT for extractive waste is expected to begin no sooner than in 2017.

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<sup>64</sup> “Applied research for determining the categories of mining sensitivity and considering mining sensitivity for the use of the oil shale deposit” (2010, AS MAVES);  
[http://www.envir.ee/sites/default/files/rakendusuurung\\_kaevandamistundliikkuse\\_kategooriate\\_maaramiseks\\_ja\\_lahtu\\_des\\_kaevandamistundliikkusest\\_polevkivimaardla\\_kasutamiseks.pdf](http://www.envir.ee/sites/default/files/rakendusuurung_kaevandamistundliikkuse_kategooriate_maaramiseks_ja_lahtu_des_kaevandamistundliikkusest_polevkivimaardla_kasutamiseks.pdf)



### Measure 1.3. Mitigation of the impact of residual pollution and the legacy impact of oil shale mining

Hitherto, the impact of residual pollution of the previous use of oil shale is noticeable in nature: extensive areas where surface and ground water has been polluted, the environmental impact of which has been analysed in the SEA report<sup>65</sup>.

Residual pollution and the legacy impact of previous activities directly hinder the socio-economic development of the oil shale area and indirectly, the development of the entire oil shale sector. Using polluted areas is a great economic risk for companies, because the liability for making the previous pollution safer has not been determined in detail.

**Table 7. Main activity and result of measure 1.3.**

Main activity	Result
Evaluation and reconditioning of the condition of the closed extractive waste facilities	Level of hazardous substances in the air, water, and soil is reduced, and the conditions of the natural environment improve
Explanation of the location and scope of the legacy impact of underground mining areas and the mitigation of the impact	Inventory of underground mining areas, and the implementation of the mitigation measures developed as a result of the data, thus reducing the previous legacy impact of the oil shale sector

The sites with the largest residual pollution areas are located in Ida-Viru County. The main reason for the condition of the surface not complying with the environmental requirements is residual pollution, which has formed as a result of the previous activities of the oil shale sector. Hazardous substances in the polluted soil spread into the aquatic environment and ambient air.

The prerequisite for reducing residual pollution is to make the inspection of the spread of hazardous substances more efficient. According to the SEA report, the objective is to remove the residual pollution formed due to previous oil shale mining in the area of the Estonian oil shale deposit, starting from the catchment of the Purtse river and the burned waste rock hill of Kukruse. As a result of this, the level of hazardous substances in the soil, air, and ground water will be reduced, and the state of the environment will improve, thus improving the entire living environment.

In order to mitigate the legacy impact of underground mining areas, the stability of the surface above the mines must first be determined, i.e. map the known cave-ins and subsidence areas. It is also necessary to examine the impact of previous mining technologies to advance mining technology.

An analysis of the impact of underground mining areas on subsequent land use (construction activities, construction of infrastructure, land cultivation, etc.) must be prepared, and the expectations of the local population to the reconditioning of mined areas must be identified. The result gives an overview of the condition and possibilities of use of the underground mining areas

<sup>65</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

after mining has ended, and if necessary, suggestions can be submitted with regard to the changing of the requirements set for underground mining.

The results of the impact analysis described above assist in evaluating oil shale loss, planning the subsequent use of the land, evaluating the stability of land, analysing and removing the cave-ins formed as a result of mining. The project “The digitalisation of the plotting boards of oil shale underground mining areas and the evaluation of stability” funded by the Environmental Investment Centre (EIC) is currently in the works (estimated time of completion 31 December 2015). Within the framework of the project, the stability of the mined areas is evaluated depending on the used mining technology. As a result of the work, a map layer is developed, which will be linked with the application of the deposits of the environmental register and is publicly available to everyone.

#### 4.2.2. Second strategic objective. Increasing the efficiency and reducing the environmental impact of oil shale use

The main prerequisite for achieving the objective is a significant increase in the added value from oil shale – the valorisation of oil shale, restricting the emissions incidental to the use of oil shale into air and water, increasing the recovery of processing waste, and the continued assurance of the development of the oil shale industry.

**Table 8. Impact indicators of fulfilling the second strategic objective**

<b>Impact indicator</b>	<b>Initial level 2013</b>	<b>Target level 2020</b>	<b>Target level 2025</b>	<b>Target level 2030</b>
1. Energy efficiency of shale oil production, %	76	over 76	over 76 (will be specified in 2020)	over 76 (will be specified in 2025)
2. CO <sub>2</sub> -specific emissions emitted in relation to total electricity and thermal energy in the case of cogeneration, t <sub>CO2</sub> /GWh <sub>e+th</sub>	1,186	below 1,186	below 1,186 (will be specified in 2020)	below 1,186 (will be specified in 2025)
3. Percentage of recovered oil shale ash from the total formation, %	4.5	at least 4.5	over 5 (will be specified in 2020)	over 5 (will be specified in 2025)
4. Indicator of economic efficiency of producing energy from oil shale, €/t per trade oil shale	34.55 <sup>*66</sup>	no degradation of value (compared to the initial level)	no degradation of value (compared to the initial level, will be specified in 2020)	no degradation of value (compared to the initial level, will be specified in 2025)
5. Added value created by producing energy from oil shale in relation to the oil shale reserve mined and made unusable, €/t	29.78*	no degradation of value	no degradation of value	no degradation of value

<sup>66</sup> Indicators 4-6 are descriptive (the price of the product is of great importance)

		(compared to the initial level)	(compared to the initial level, will be specified in 2020)	(compared to the initial level, will be specified in 2025)
6. Added value created by producing energy from oil shale in relation to the deposited waste, €/t	71.04*	no degradation of value (compared to the initial level)	no degradation of value (compared to the initial level, will be specified in 2020)	no degradation of value (compared to the initial level, will be specified in 2025)

The ratio of the sum of useful energy received from the produced shale oil, the gases and flue gases formed as by-products, and ash cooling to the energy of oil shale as fuel used as raw material has been selected as the efficiency indicator of shale oil production in percentages (Table 8 No. 1).

**Table 9. Energy efficiency of oil shale production in Estonia in 2011–2013<sup>67</sup>**

	2011	2012	2013
Energy value of used oil shale, TJ	42,556.8	48,522.6	49,557.0
Energy value of shale oil, TJ	24,627.5	26,130.8	27,302.1
Total energy value of by-products, TJ	6,727.7	7,933.4	10,331.0
Energy efficiency of shale oil production, %	73.7	71.0	75.9

A common methodology must be developed and confirmed for the gathering of primary data and for calculating the efficiency indicator of oil shale use when producing oil, which would take into consideration the energetic use of the by-products of oil shale retorting. The initial level of the indicator has been determined based on expert opinion.

The quantity of the CO<sub>2</sub>-specific emission that formed during the combustion of oil shale, i.e. the weight ratio of the CO<sub>2</sub> emission to the total quantity of the emitted electricity and the thermal energy emitted in the cogeneration regime ( $t_{CO_2}/GWh_{e+th}$ ) has been selected as the efficiency indicator of the production of oil shale electricity (Table 8 No. 2).

**Table 10. The values of the CO<sub>2</sub>-specific emission relating to the cogeneration of total electricity and thermal energy emitted in Estonia in 2011–2013<sup>68</sup>**

Produced and emitted from oil shale	2011	2012	2013
Emitted electricity, GWh <sub>e</sub>	9,650	8,544	10,037
Emitted thermal energy, GWh <sub>e</sub>	293	257	430
Total emitted energy, GWh <sub>e</sub>	9,943	8,801	10,468
Emitted CO <sub>2</sub> , tons	11,949,779	10,454,001	12,417,489
CO <sub>2</sub> / emitted energy, $t_{CO_2}/GWh_{e+th}$	1,201	1,188	1,186

<sup>67</sup> Calculated based on the data of companies

<sup>68</sup> Calculated based on the data of companies

In order to ensure the comparability of data in time, a methodology for gathering primary data and calculating the numerical quantity value of the CO<sub>2</sub>-specific emission must be developed and confirmed. The initial level of the indicator has been determined based on expert opinion.

The weight quantity ratio of the recovered oil shale ash to the total formation (in percentages) has been selected as the indicator of the level of the use of oil shale resource (Table 8 No. 3).

**Table 11. Formation and recovery of oil shale ash in Estonia in 2011–2013<sup>69</sup>**

Code	Waste	Quantity, thousand t		
		2011	2012	2013
Formation				
10.01.97*	Oil shale bottom ash	3,238.4	3,224.0	3,791.2
10.01.98*	Oil shale fly ash	4,375.9	4,279.0	4,964.9
Total formation		7,614.2	7,503.0	8,756.1
Recovered				
10.01.97*	Oil shale bottom ash	28.1	220.9	268.7
10.01.98*	Oil shale fly ash	183.6	207.0	125.9
Total recovered		211.7	428.0	394.5
Percentage of recovered oil shale ash, %		2.8	5.7	4.5

The added value of oil shale mining and the added values of oil production and producing electricity from oil shale (Annex 9) have been calculated in order to identify the economic contribution of oil shale mining and use. Economic contribution is expressed as the direct and indirect added value of the use of oil shale in the total added value created in Estonia. The greater the created value, the more is contributed to the development of the economy, and the use of a national resource helps increase the well-being of the society.

In order to measure the economic efficiency, the total added value created can be used to compare its change in time, calculate its relative importance from the total Estonian added value, or to evaluate the added value in relation to the resource unit connected with production. As the total added value depends significantly on the price of the energy carriers and the volume of mining, this would not express the economic efficiency of the sector. Its importance in the total Estonian added value also depends on the added values created by other sectors, thus, it does not independently express efficiency either.

Consequently, the added value created must be evaluated in relation to a resource unit connected with production, taking into account the extent to which the efficiency indicator is influenced by other companies, and then the indicator can be used to measure the contribution of the companies to making their activity more efficient. Three possible quantity indicators have been presented in Table 8:

- indicator No. 4 – shows how much added value was created in relation to the used trade oil shale;
- indicator No. 5 – shows how much added value was created in relation to the oil shale mined and made unusable;
- indicator No. 6 – shows how much added value was created in relation to the deposited waste;

<sup>69</sup> Raw data from KAUR

All of the impact indicators express different aspects of economic efficiency. Their objective and calculation has been described in more detail below.

The economic efficiency indicator (Table 8 No. 4) is calculated as the ratio of the added value created by oil shale mining in 2012 and the production of energy carriers to the trade oil shale used for the production of energy carriers. The ratio has been calculated by dividing the added value created in oil shale mining with the trade oil shale used in the production of the energy carriers in 2012. The added value of the production of energy carriers in relation to trade oil shale has been calculated as the weighted average from the added value of oil and electricity production in relation to trade oil shale, where the weight is the quantity of the trade oil shale used in the production of oil or electricity from the total trade oil shale used. By adding the added values of mining and the production of energy carriers, we get the added value created by the oil shale industry in relation to the trade oil shale used.

The indicator depends mostly on the differences in the volumes of the mining and use of oil shale and on the world market prices of energy carriers. Presuming that oil shale is mined according to the estimated demand, which depends on the quantity of the amount of energy planned to be produced and a certain quantity of trade oil shale is needed for that, then the mined and used oil shale should move in correlation with minor fluctuations. World market prices, however, depend on external factors.

Given the above, indicator No. 4 mainly describes the price level of the energy carriers created from used trade oil shale, as the rest of the factors, which a company could optimise to increase efficiency (the quantity of trade oil shale for producing one product unit, labour costs, etc.), have already been fixed. The price level of oil was very high in 2012 (approximately 111 dollars per barrel); however, in 2015, it had already fallen to 50 dollars per barrel, which also illustrates the descriptive value of the indicator – in 2015, the value created for the society was at a much lower price level. The economic efficiency of the sector can also be influenced, to a certain extent, through identifying the proportions of oil shale used by the oil industry and the electricity production and by changing it in accordance with the value created with the resource. At the same time, there should be sufficient flexibility for producing different energy carriers and production volumes, which Eesti Energia has to a certain extent in producing electricity, however, no decision can be made between oil and electricity production of other companies.

Indicator No. 5 – “Added value created by producing energy from oil shale in relation to the oil shale reserve mined and made unusable” – the ratio of the created direct and indirect value of oil shale in relation to one tonne of oil shale reserve mined and made unusable in the same year is calculated. The change of the indicator in time expresses, similar to the previous indicator, the price trends indirectly affecting the oil shale industry but also the value created for the society in relation to the so-called state reserve unit used.

When the price level of oil or electricity is high and the efficiency in relation to trade oil shale is also high, then regarding great losses, a significant amount of natural resources is still used, and we must also examine the contribution to added value in relation to the total use of the natural resource and the quantity made unusable. If the losses can be reduced, the indicator will show an increase even when the price level remains the same – state assets are used more economically efficiently. Thus, with a very low price level but an increasing loss of oil shale reserves, the indicator would financially express the fact that the natural resource, which could be used significantly more economically efficiently at some other time, will stay as a loss in large quantities underground.

Indicator No. 6 – “Added value created by producing energy from oil shale in relation to the deposited waste” – the ratio of the created direct and indirect value of oil shale in relation to the quantity of waste of the oil shale sector deposited in the same year is calculated. The indicator indirectly expresses the resource efficiency: the extent to which the resource used to create added value is managed to be used. As one of the objectives of the oil shale development plan is the reduction of the quantity of the deposited waste, then the calculation of added value expresses better the size of the income of the activities that have led to the formation of waste, irrespective of the large quantity of deposited waste; however, efficiency also increases when waste recovery is increased – even when the prices remain the same, it is possible to increase economic efficiency through a more complete valorisation of the resource.

### **Measure 2.1. Increasing the efficiency of oil shale use**

Increasing the percentage of oil production in oil shale use provides a bigger added value. The initiative of the companies to advance the complex use of oil shale for the production of shale oil, electricity, and thermal energy is worthy of support; however, a situation must be avoided where the total oil shale volume is used for oil production and electricity is produced only from the by-products of oil production. In producing energy by using the direct combustion of oil shale, it must be taken into consideration that the environmental impact may transfer from one environmental element to another if companies reduce one type of emission (for example the emission of sulphur compounds), due to which the efficiency of equipment decreases and the specific cost of fuel increases, and also, the quantity of industrial waste (for example ash) increases, as well as the environmental impact thereof. An increase in the issues of waste recovery cannot be excluded either, as the characteristics of ash change in the processing operation.

**Table 12. Main activity and result of measure 2.1.**

<b>Main activity</b>	<b>Result</b>
The advancement and implementation of the BAT in the production of electricity	Restricting the emission of pollutants, increasing resource efficiency, reducing the quantity of waste, and promoting waste recovery
The advancement and implementation of the BAT in the production of oil	Restricting the emission of pollutants, increasing resource economy, reducing waste, and increasing recovery
The analysis of the possibilities of extending the value chain of oil shale use (including the recovery of waste heat and waste)	The maximum use of the oil shale resource: the use of the resource has been analysed and the possibilities of extending the value chain of oil shale use that are economically and technologically efficient and acceptable from the perspective of environmental protection have been identified. The results of the analysis will be used in the subsequent R&D activity in the field of oil shale



Oil shale will remain the primary raw material for producing electricity and shale oil in Estonia in the next 15 years at least. This ensures the security of electricity supply in Estonia and helps to increase product export by helping to move towards balancing the foreign trade balance. According to the principles of sustainable development, the implementation of the BAT is the most efficient tool for increasing the environmental sustainability of production. Above all, the BAT descriptions according to the areas of activity mentioned must be prepared for the implementation of the BAT in oil shale energy. The preparation of the BAT descriptions is a part of the first stage of the development activity. The final result of that is a survey report or document, a part of which is the draft of the BAT conclusions. The BAT conclusions can be made legally binding. In Table 12 of the oil shale development plan, the first two activities include the organisation of the first stage of the development plan by the ME in collaboration with the MEAC as the institution maintaining a favourable business environment, and with the main producers of electricity and shale oil in Estonia. The research activity is planned to be financed from the programme of environment management of the EIC. The implementation works are financed and organised by the companies producing oil shale electricity and shale oil.

Currently, retorting gas, which forms in oil production with both the GHC and SHC equipment, is the only by-product of shale oil production that is utilised completely. Oil shale industry inevitably produces large quantities of waste (oil shale ash from the production of electricity and oil production with the SHC equipment, and oil shale semi-coke from oil production with the GHC equipment). Waste formation is proportional in quantity to the quantity of the used oil shale. In recent years, the percentage of the recovered oil shale ash from the total formation has been small (Table 11). Surveys must be conducted and technologies implemented that would enable preserving the already existing recovery areas and introducing new ones. Permanent areas of use that would ensure consistent recovery should be preferred.

By adhering to the requirements of the valid BAT reference document<sup>70</sup> that applies to large combustion equipment, a more efficient use of energy must be focused on. The efficiency achieved in energy production is a significant indicator of CO<sub>2</sub> emission. In order to reduce the total CO<sub>2</sub> emission in energy production, companies need to employ the BAT with the relevant requirements described in the environmental permits issued to the companies. The implementation of these requirements presupposes the following:

- 1) power units with the most efficient steam turbine cycles must be used in producing new oil shale blocks;
- 2) the cogeneration of electricity and thermal energy must be used in the case of sufficient heat consumption;
- 3) combustion in a circulating fluidised bed must be used as the firing technology, and if possible, oil shale and biofuel should be fired together;
- 4) the combustion of oil shale by using oxy-fuel combustion must be examined.

The following measures increasing the energetic efficiency of shale oil production are described in the BAT description<sup>71</sup> of shale oil production:

- 1) the use of retorting gas as fuel inside and outside of the plant;
- 2) the reversal of liquid and solid substance flows, which have energetic value, into the retorting process or their use as fuel both inside and outside of the plant;

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<sup>70</sup> <http://www.ippc.envir.ee/estonian/bat.htm>

<sup>71</sup> Directive No. 1-2/13/1200 of the Minister of the Environment of 17 December 1999

[http://www.ippc.envir.ee/docs/PVT/Uuendused/Eesti\\_p%C5%levkivi%F5li\\_tootmise\\_PVT\\_K%E4skkirja\\_lisa.pdf](http://www.ippc.envir.ee/docs/PVT/Uuendused/Eesti_p%C5%levkivi%F5li_tootmise_PVT_K%E4skkirja_lisa.pdf)

- 3) the use of the residual heat of the gaseous, liquid, and solid substance flows in order to produce energy.

If the technical possibilities exist, the abovementioned, as well as additional measures, separately or combined, must be implemented to more fully use the energy emitted in the retorting process, including the production of low-pressure steam.

The analysis of the possibilities of extending the value chain of oil shale use means that a way of use is found for the rock mass formed during mining which results in minimum loss and quantity of deposited waste. **Minimum** here refers to the result of an activity that is technically possible and economically feasible and acceptable from the perspective of environmental protection, i.e. in accordance with the BAT definition. The responsibility of the state is to provide conditions for the extension of the value chain of the use of oil shale by using benefits, means of environmental legislation, or justified taxation. The following applied research must be conducted within the framework of this activity: identify the possibilities of use of crushed stone (or filling material) and oil shale produced from the processing of the waste rock formed during mining; identify the possibility of a wider and more permanent use of the oil shale ash of power plants; find a use for the semi-coke formed in the GHC equipment during shale oil production (i.e. for manufacturing cement) and for the oil shale ash and waste heat formed in the SHC equipment; find solutions for producing motor fuels in order to better valorise shale oil; advance the production of oil shale-based chemical products; conduct scientific research to develop and implement new and more efficient technologies for processing oil shale. The need for conducting the abovementioned research has been taken into consideration in developing the areas supporting the promotion of the R&D activity addressed in the third objective.

## Measure 2.2. Reducing the environmental impact of oil shale use

When the volume of oil shale use is increased, there is a risk that the quantity of emissions and waste will increase, as well as the risk of environmental accidents. An extensive residual pollution, the removal of which is costly and time-consuming, still hinders the achievement of a good environmental condition of the oil shale industry area.

**Table 13. Main activity and result of measure 2.2.**

Main activity	Result
The inspection and enhanced checking of the sources of substances hazardous for the aquatic environment, identifying the impact of the emission of hazardous substances on the aquatic environment, and the specification of environmental requirements and measures	Based on the research results, the possibilities of limiting the environmental load can be analysed (the interaction of pollution sources and loads) in order to ensure an environmental condition that is in accordance with the limit values of environmental quality by specifying environmental permits, and to reduce the risk to human health and wildlife
Developing a calculation method for the emission quantity of odorant and improving environmental permits in that area	A calculation method is developed for the emission quantity of the odorant emitted into ambient air from the activity causing odour disturbances (including from oil shale industry) which enables adjusting the odour

	emission in the environmental permit and to request additional measures from the operator in justified cases in the future
The inventory, analysis, and reduction of the negative impact of the residual pollution of oil shale use (the sources of residual pollution are made safer)	Making residual pollution safer reduces the spread of hazardous substances into surface and ground water. Thus, the state of the soil, the quality of the water, and the state of the natural environment will improve as a whole; the negative impact on human health and wildlife is reduced
Identifying the content and hazard of deposited waste	Prerequisites are developed for the environmentally safe depositing and wider recovery of waste

It is possible to prevent the reduction in ambient air quality by fulfilling the established environmental requirements. Issues with ambient air quality have been detected in Kohtla-Järve, Sillamäe, Narva, and Kiviõli, where the potential sources of pollution include VKG Oil AS, a regional purification plant, closing works of semi-coke hills, Kiviõli Keemiatööstuse Varad OÜ, the Port of Sillamäe together with fuel terminals, and EE Õlitööstus AS. The emission of SO<sub>2</sub>, NO<sub>x</sub>, fine particles, and substances with low odour threshold (such as H<sub>2</sub>S, odour pollution) is an important aspect related with the use of oil shale.<sup>72</sup>

Making the inspection of the spread of odour disturbance more efficient helps to improve the psychosocial environmental condition and to prevent the possible negative impact on human health and well-being by reducing disturbing environmental factors, which, in turn, reduce the state of stress.

The inspection of the emission of hazardous substances enables specifying the sources of pollution and the pollution load incidental to the oil shale industry and their combined impact on the aquatic environment. Based on the research results, a decision can be made to develop mitigation measures and limit the emission load. Above all, attention must be paid to the surface and ground water bodies that are in poor condition and under the influence of the oil shale sector. Detailed research must be conducted in order to identify the sources of phenols entering the aquatic environment. Identifying the load from the sources of hazardous substances enables evaluating the chemical condition of water bodies.

In order to ensure the quality of ground water, the state must continue the coordination of the removal of residual pollution. The sources of residual pollution entered into the inventory (industrial territories, waste disposal sites) must be made safer for the environment in collaboration with the state, local governments, and companies. In 2015, works will be launched to make the sources of residual pollution in the catchment of the Purtse river and the burned waste rock hill of Kukruse safer for the environment. Other territories polluted by the companies of the oil shale sector must be made safer to the extent that they would not pollute the surrounding areas. As a result of the measure, the spread of hazardous substances from the sources of residual pollution into ambient air and surface and ground water is restricted, the condition of the soil improves, and the negative impact on wildlife and human health is reduced.

<sup>72</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

Due to the development of the oil shale industry, the content and properties of the deposited waste change. The increase in the quantity of the oil shale ash with little-researched properties is incidental to the reduction of the use of ash burning and to the increase in the percentage of fluidised beds and the oil production process with GHC. It is necessary to safely deposit the ash waste and to fully analyse the possibilities of recovery. As a result of the research, the environmental requirements of the waste management of oil shale ash formed in different production units are specified, including the requirements of the safe depositing and monitoring of waste.

### **Measure 2.3. Mitigation of the impact (impact on human health and social impact) of the oil shale industry on society**

In making decisions impacting oil shale companies (restricting the mining volume, increasing environmental charges, etc.), their possible impact on the employment of the area and on the income of the people must be taken into consideration, and it must be ensured that the resulting loss does not exceed the desired gain. The population must be notified in advance of the activity of companies with regard to mining and the mitigation of the created environmental damage, and of the reconditioning plans of the mined areas.

**Table 14. Main activity and result of measure 2.3.**

<b>Main activity</b>	<b>Result</b>
The monitoring of health indicators in Ida- and Lääne-Viru County	Based on the results of the monitoring of the health indicators of the population, the state can plan supranational developments of the health system (including the implementation of health-promoting measures), if necessary. In addition to that, local governments plan local activity according to their possibilities
Evaluation of the negative social impact (including the impact on human health) caused by the mining and processing of oil shale, and the analysis of the possibilities of reduction	Based on the results of the analysis, environmental measures will be implemented, if necessary, which will reduce the negative impact of the oil shale industry on the living environment; the health and well-being of the residents of the oil shale area will improve

In 2014–2015, a survey on the health impact related with the mining and processing of oil shale was conducted<sup>73</sup> (party who ordered: Health Board, also involved: UT, MSA, ME). The results of the survey on the health impact of the oil shale sector illustrate that several indicators of the health of the residents of Ida-Viru County are worse from those in other parts of Estonia. One of the reasons for this is most likely the polluted environment resulting from the activity of the oil shale sector. At the same time, the monitored area is plagued by complex problems (such as industrial pollution, legacy pollution, complicated socio-economic situation, risk behaviour, etc.) which also impact the health of the residents. Although the environmental condition of Ida-Viru County has significantly improved over the years, the data of Statistics Estonia illustrates that the life

<sup>73</sup> Research on the health impact of the oil shale sector <http://www.terviseamet.ee/info/projektid/polevkivisektori-tervisemojude-uuring.html>

expectancy of a child born in Ida-Viru County is still approximately five years less than that of a child born in Tartu or Tallinn. Similarly, children in Ida-Viru County are diagnosed with more respiratory diseases and there are more deaths from diseases of circulatory system than in other parts of Estonia. The current survey confirmed the concern of the residents of Ida-Viru County regarding their health and the environment. The survey conducted among adults illustrated that more than 10% of the residents consider the air pollution unbearably disturbing, and half of the respondents consider the air pollution a big threat to their own health, as well as to their family and loved ones. In implementing the oil shale development plan, the health indicators must be monitored through periodic surveys, for example after every 10 years, if necessary.

Approximately 6,650 people in Ida-Viru County are involved daily in the mining and processing of oil shale. The direct negative impact of the oil shale industry on the population of Ida-Viru County was mainly revealed in the 1990s and at the beginning of the last decade when the population in Ida-Viru County decreased faster than anywhere else in Estonia. According to the data of Statistics Estonia, the population of Estonia decreased by 14.4% in 1989–2006 while the corresponding number for Ida-Viru County was 22.1%. One of the direct causes of this process is the shrinking of the oil shale industry, the reduction of mining volume, and the closing of mines. In municipalities where active mining is currently in operation, the population has been decreasing more slowly in the past ten years. In the following years, Eesti Energia and VKG are planning to invest in the expansion of shale oil production, which will bring along new jobs in the industry, as well as in service areas, such as logistics and construction. Thus, the number of jobs and the income of the employees is estimated to increase in the following years.<sup>74</sup>

The oil shale industry is in need of young specialists. In order to mitigate the negative population trends, attention should definitely be given to making the living environment of Ida-Viru County more attractive to young top specialists. In order to do this, possibilities for reconciling family and work life must be provided, new residential areas established, local public services developed, including recreational possibilities, the quality of roads improved, and work must be done to promote the image of the area. Kindergartens and childcare places must be established. This is supported by the report of the analysis of the possibilities for reconciling work and family life of people belonging to an ethnic minority (2013) which stresses that people are upset about the absence of kindergarten places, especially if they work in production where flexible working hours cannot be implemented.

The activity necessary for analysing and developing the functioning of the business and living environment of the oil shale industry area has been described in the development document “Ida-Viru Action Plan 2015–2020”<sup>75</sup>, for the execution of which the Minister of the Interior will assume responsibility. This is why the area of business and labour market is not discussed further in the oil shale development plan.

#### 4.2.3. Third strategic objective. Developing education and research activities in the field of oil shale

The main objective of developing education and research activities in the field of oil shale is to

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<sup>74</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>

<sup>75</sup> “Ida-Viru Action Plan 2015–2020”

[https://www.siseministeerium.ee/sites/default/files/dokumendid/Arengukavad/ida-virumaa\\_tegevuskava\\_2015-2020\\_26.02.15.pdf](https://www.siseministeerium.ee/sites/default/files/dokumendid/Arengukavad/ida-virumaa_tegevuskava_2015-2020_26.02.15.pdf)

support the development of technology for a more efficient and environmentally sustainable use of oil shale, make the collaboration between the private sector, government institutions, and universities more efficient, and to ensure an emergence of new experts in the field. In addition, it is important to ensure the consistency of the R&D activities in the field of oil shale historically specific to Estonia and to make sure that Estonian knowledge of oil shale remains on a sufficient worldwide.

**Table 15. Impact indicators of fulfilling the third strategic objective**

<b>Impact indicator</b>	<b>Initial level 2013</b>	<b>Target level 2020</b>	<b>Target level 2025</b>	<b>Target level 2030</b>
1. Number of doctorate degrees concerning oil shale mining or use or research on the environmental impact incidental to them obtained in a year	3	Not less than the initial level	Not less than the initial level (will be specified in 2020)	Not less than the initial level (will be specified in 2025)
2. The cost of applied research in the field of oil shale in relation to the cost of all of the research and development activities in the field of oil shale, % (€) <sup>76</sup>	41% (€521,721)	At least 41%	At least 41%	At least 41%

The development of the education and research activities in the field of oil shale mining and use is based on the objectives of the Estonian research and development activities and innovation strategy 2014-2020 “Knowledge-based Estonia” and on the measures and activities implemented to achieve them, all the while considering the measures of the oil shale development plan.

### **Measure 3.1. Research and development work in the field of oil shale**

If fulfilling the first two strategic objectives is directly related with the oil shale industry and the research necessary for developing it, then the fulfilling of the third strategic objective depends on the basic research necessary for the R&D activity. The line between basic and applied research is relative; however, applied research can only be based on basic research.

In order to ensure the consistency of the R&D activities in the field of oil shale historically specific to Estonia and to preserve the international leading role in the knowledge of oil shale, the R&D activity in the field of oil shale will be taken on a programmatic basis.

**Table 16. Main activity and result of measure 3.1.**

<b>Main activity</b>	<b>Result</b>
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<sup>76</sup> Estonian Science Portal <https://www.etis.ee/portaal/projektiAndmed.aspx?VID=ee84d814-c07a-4acd-863a-930fdf5c7326&PersonVID=36745&lang=&FromUrl0=isikuProjektid.aspx>



Developing a substantive programme integrated into the different programmes of R&D in the field of oil shale in accordance with the four thematic focuses of the areas of research topics mentioned below	Oil shale research is addressed in at least the following programmes and development plans: ENMAK, the resource efficiency programme of ME, a programme of applied research of smart specialisation. The research has financial contributions
The development and analysis of the methodology of calculating the external cost of the field of oil shale. Identifying the ecological footprint of the field of oil shale	The methodologies for considering the external impact of environmental use and the calculation of their financial value have been implemented, and the ecological footprint has been described

The objective of the national research and development plan of oil shale is to support the development of the technology for a more efficient and environmentally sustainable use of oil shale as a national resource. The research topics address the mining of oil shale and the entire chain of oil shale use in all the areas of use (energy, oil, and cement production; oil shale chemistry), as well as the environmental impact related with the mining and use of oil shale.

**The research topics must focus on the following areas.**

1. The development of oil shale technologies, basic and applied research concerning environmentally sustainable energetics and the chemical and construction material industry. Works regarding the reduction of pollutant emissions, including greenhouse gases: the development of firing technologies in a fluidised bed of oil shale and in the area where oxygen, oil shale, and other fuels (biomass, oil shale gases, coal, etc.) are burned together. The works with regard to achieving resource efficiency in order to expand the recovery of solid residue with changing properties as raw material to use it as congealed mixtures in backfilling mining areas, as a stabiliser in road construction, in the production of construction ceramics and cement, as soil modifiers, as new sorbents.
2. The development of environmentally and resource sustainable methods of the thermochemical processing of oil shale and the production of valorised products. Works concerning the maximum transformation of the liquid product of organic carbon: the developments of the existing SHC and GHC pyrolytic processes with the fluidised bed and fast pyrolysis methods; the co-pyrolysis of biomass and polymer waste. Researching and developing the implementation possibilities of the new worldwide-developed processing technologies of solid fuels with high resource efficiency and environmental sustainability (direct and indirect liquefaction, etc.) in oil shale processing, also valorising the liquid product and gas formed in processing in order to produce oil, phenols, bitumen, liquid fuel, and chemicals. Research on the properties of the products of oil shale processing based on the practical production technological and environmental technical aspects.
3. The development of oil shale mining technology Future technologies of oil shale mining and returning the mined areas to the society in the best possible way. Selective extraction, combined outcropping, opencast boring, etc. Research on reducing mining loss, including increasing the efficiency of initial enrichment: the development of the technologies regarding mining under wetlands, lava mining, short face longwall mining, fast boring, selective extraction, and combined outcropping. The increasing of the yield in the processes of dry and fine enrichment. Research works in the field of resource efficiency:

water treatment or use in mining and after mining. The developments regarding the digital management of ores and machines. Research regarding the feasible use of mined areas.

4. Research regarding the human health and environmental condition related with the first three research areas listed above, and the research on the expression of the environmental impact.

The need for calculating external cost has been acknowledged since 2006. In order to calculate external cost, the significant environmental and social impact is mapped and agreed upon, and in order to develop the financial value thereof, a methodology will be developed for evaluating external cost. A methodology will be developed for each impact area in collaboration with the state, local governments, research institutes, and industrial companies which will then be used to evaluate the external cost related with this area. Once the external cost is calculated, measures will be developed to enter the external cost into the product prices through the policy of environmental charges or to compensate the external cost through other financial measures. The objective has been achieved once the external cost has been identified, and the compensation measures taking into account the impact of the environmental policy, as well as the economic impact have been implemented.

The implementation of the research topics is coordinated by the Ministry of the Environment in collaboration with MER, MSA, and MEAC. The research topics are mainly funded from the means of the 2014–2020 cohesion policy funds and the EIC environmental programme, as well as from the state budget and the contribution of companies.

**The funding of the research in the field of oil shale can be applied for through three programmes that do not coincide substantially with each other.**

1. **The resource efficiency programme of the Ministry of the Environment:** funded from two sources: from the sub-measure of MER “The support of the R&D activity and programmes of sectoral ministries” (structural funds), and from the budgetary resources of ME (state budget, EIC, other external assistance, for example, from Norway). Funding consists of up to 50% of the money from structural funds and at least 50% of the contribution of ME. The programme objectives and action plan are fixed with the conditions of the negotiations between ministries and of the granting of aid. The programme is carried out based on the conditions of granting aid of the sub-measure directive, which is approved by the Minister of Education and Research. The estimated cost of the applied research of oil shale could amount to 100,000 euros per year. The objective of the applied research is to start using or adapt new technology to make better use of the resource or oil shale waste. The programme is carried out by ETAG. The programme launches in 2015 and ends in 2020, and is directed at promoting collaboration between companies and universities.
2. **A programme of applied research of smart specialisation:** is funded through the sub-measure “Increasing the local socio-economic impact of the R&D and innovation system, and smart specialisation”. The budget amounts to 41.5 million euros. The objective of the programme of applied research of smart specialisation is to increase the motivation of universities and R&D institutions to conduct applied research necessary for business and to promote collaboration between universities and companies. The applied research carried out in the growth areas of smart specialisation in universities and R&D institutions, which are based on the needs and initiative of companies. The financial contribution of the private sector will also be necessary (40%).

### 3. The R&D programme of ENMAK<sup>77</sup>.

The funding necessary for the programme is at the planning stage.

It is also possible to apply for competition-based funding (funding dependent on scientific level). Funding for applied research related with oil shale can also be applied for from the programme of EIC. The sub-programme, from which aid is applied for and funded from depends on the research topic. For example, funding from the environmental management programme can be applied for projects directed at resource efficiency, developing new technologies, preventing or reducing pollution, reducing waste formation, or waste recovery.

#### Measure 3.2. Education in the field of oil shale

**Table 17. Main activity and result of measure 3.2.**

Main activity	Result
The amendment and updating of the curricula of universities and institutions of professional higher education	The curricula which have been reviewed annually, updated, and amended, when necessary, with the thematic of oil shale
Developing a specific oil shale study module, including formal education	A developed and approved elective subjects module between universities, which addresses the subjects of the master's programme specifically related with oil shale
Making collaboration between universities, institutions of professional higher education, government institutions, local governments, and the private sector more efficient	Collaboration takes place based on the collaboration memorandum, joint seminars are organised where universities introduce the results of their research and government institutions and the private sector introduce their needs, practical training possibilities, etc.

Estonia is one of the few countries with existing oil shale mining and processing, universities which offer studies in this area, and experienced engineers. The companies active in the area of oil shale mining and use have made and are planning to make major investments in the near future, based on which the activities of the next decades are continued. The Estonian working environment and the technologies used have become known internationally, and the trend is obviously growing. In order to ensure the rational and sustainable mining and use of oil shale, specialists and top specialists competent in the area must be continuously trained.

In order to do this, specific subjects dealing with the mining and use of oil shale and their environmental impact must be gradually added to the updated curricula of universities and institutions of professional higher education. Hereby, reference is being made to the curricula that

<sup>77</sup> ENMAK [http://www.energiatalgud.ee/img\\_auth.php/2/25/ENMAK\\_2030\\_Eeln%C3%B5u\\_23.10.2014.pdf](http://www.energiatalgud.ee/img_auth.php/2/25/ENMAK_2030_Eeln%C3%B5u_23.10.2014.pdf)

include, to a greater or lesser extent, the thematic of oil shale. The improvements and updates of the curricula must follow the directions of the change in the working environment and technology. The improvement and update of the curricula presupposes the cooperation between universities, companies, and government institutions (promotion of cooperation).

It is important to create a special oil shale study module. It would include subjects related with the mining and use of oil shale and their environmental impact, which could be used in the relevant curricula. The acquisition of the module subjects prepares the students for the work in a position requiring the qualification of oil shale technology, including a systematic overview and extensive knowledge of fuels, the concepts of oil shale technology, theories and research methods, the theoretical development trends of oil shale technology, current problems, and implementation possibilities. The student who have acquired the module subjects are capable of continuing studies or participate in research activities, work as a specialist and developer of oil shale technology, including on an international level.

## **5. Implementation of the oil shale development plan**

### **5.1. Management structure for the implementation of the oil shale development plan**

Pursuant to section 2 “Strategic development documents” of the State Budget Act, the procedure of the implementation, accounting, evaluation, and amendment of the development plan is established with the regulation of the Government of the Republic. The oil shale development plan is an area development plan and has been developed according to regulation No. 302 of 13 December 2005 of the Government of the Republic “Types of strategic development plans and the procedure for their development, amendment, evaluation of their implementation, and accounting”.

With order No. 138 of 4 April 2013, the Government of the Republic has appointed the Ministry of the Environment (ME) to be responsible for the preparation of the oil shale development plan, and their task is to develop, amend, implement, and coordinate the evaluation and accounting in collaboration with the Government Office, the Ministry of Economic Affairs and Communication (MEAC), the Ministry of Education and Research (MER), the Ministry of Finance (MF), the Ministry of the Interior (MI), and the Ministry of Social Affairs (MSA). Pursuant to the Earth's Crust Act, the oil shale development plan is approved by Riigikogu.

The document of the implementation of the oil shale development plan is an implementation plan that states the measures and activity necessary for fulfilling the strategic objectives and the parties liable. The forecast for the funding of the measures is prepared until 2030 (see Chapter 5.2), a more detailed cost is planned in the implementation plan for 2016–2019. The implementation plan is approved by the Government of the Republic. The Minister of the Environment annually submits to the Government of the Republic a report with regard to the fulfilment of the oil shale development plan, the achievement of the objectives and the effectiveness of the measures described in the development and implementation plans in concert with the other ministries participating in the collaboration. Annual accounting forms a basis for the decision to amend or terminate the oil shale development plan.

The implementation of the oil shale development plan lasts for 15 years. In addition to the analysis of the accounting of the implementation plan, the results of the impact indicators of the oil shale

development plan are analysed every five years in order to acknowledge the changes in technologies, market situation, environmental requirements, and the apparent environmental impact. Considering the changed situation, it is possible that the activity necessary for achieving the objectives set in the development plan are adjusted in the implementation plan.

The Minister of the Environment initiates the amendment of the oil shale development plan if it becomes necessary during the implementation of the development plan to redefine the interest of the state, change the existing or set new objectives and measures. Relevant interested persons and institutions will be included in the amendment of the area development plan. In deciding on the amendment or termination of the development plan, the relevance of the objectives, the effectiveness of the implemented measures, and the changes taken place or planned to take place in financing and in the environment of the activity are taken into consideration above everything else. The amended development plan is coordinated with the Government Office and the Ministry of Finance and, if necessary, with the relevant ministries.

The assignments and obligations necessary for the implementation of the oil shale development plan have been discussed in the course of the development of the development and implementation plans, so that all of the relevant ministries could take into consideration the resources necessary for implementing the oil shale development plan in their area development plans and budget money applications. The ME needs information on the different areas of the oil shale sector in order to ensure the implementation of the development plan. In order to do this, the Minister of the Environment will form a support group for the oil shale development plan, which will include people with extensive knowledge of the field of oil shale, who will counsel the fulfilment of the measures described in the development plan and take part in the accounting of the activity. The support group includes experts, scientists, SEA developers, representatives of local governments and of the relevant ministries, and mining operators.

## 5.2. Estimated cost of the oil shale development plan

The cost of the implementation of the development plan and the sources of financing, which are periodically updated based on the State Budget Act, are included in the implementation plan of the oil shale development plan.

The estimated cost of the oil shale development plan for 2016–2030 amounts to approximately 20 million euros. A more detailed overview of the funding of the activities for each year is presented in the implementation plan for the period of 2016–2019, and approximately 4.4 million euros have been planned for this. The cost and income of the implementation of measures is evaluated in the implementation plan for each period based on the state budget. In addition to the state budget, the implementation of the development plan is also funded from the means of the EIC and EU.

The state receives over 80% of the environmental charges received from the oil shale industry. This is the portion that can be channelled back to supporting the industry in transitioning to a more environmentally sustainable activity and researching environmentally sustainable solutions, as well as directed to research and development activity in order to research the possibilities of oil shale use, so the owner of the oil shale as a mineral could get the biggest added value from their assets. Such contribution from the state helps to achieve the critical level for the funding of research, so that the issues are dealt with consistently and progress is sustainable. 5% of the environmental charges received annually by the state from the oil shale industry can ensure this kind of level.

There are activities in the oil shale development plan, which are funded through other previously approved development plans or other strategic documents; that cost is not reflected in the implementation plan.

## Summary

Oil shale is the Estonian national treasure that must be valued as an important strategic resource. The function of the oil shale development plan is to direct the mining and use of oil shale in the 2016–2030 – i.e. over the course of 15 years. In order to do this, national interest has been identified and three strategic objectives have been established in the development plan, which will be implemented through an implementation plan of measures and activities until 2030. The annual rate of oil shale mining continues to be 20 m tons, which is calculated as a multi-annual average. The results of the impact indicators set in the development plan are analysed every five years.

Three measures are described in the development plan for increasing the efficiency and reducing the environmental impact of oil shale mining. For the sustainable development of oil shale, priority areas of the Estonian oil shale deposit, where mining impacts the environment the least, must be identified in the first years of the development plan. In addition, the search for solutions must be continued with regard to reducing the oil shale loss incidental to underground mining and mitigating the negative environmental impact thereof, especially to reducing the legacy impact of residual waste and the impact formed as a result of the previous activity of the oil shale sector.

The increase in the efficiency of oil shale use presupposes the development of the technology and the implementation of the BAT in the production of oil shale electricity and shale oil. The research planned for the reduction of the negative environmental impact of the oil shale industry is necessary for restricting the environmental load and for ensuring an environmental condition that complies with the limit values of the environmental quality. As a result of this, the negative impact of the industrial area on human health is reduced. The investments of the companies into oil shale energetics, especially into oil production, which increase employment in Ida-Viru County, are of great importance.

Developing the education and research activity in the field of oil shale helps to solve the issues described in chapter 2.4 and supports the development of a more efficient and environmentally sustainable technology for the use of oil shale. It is also important to improve comprehensive collaboration in conducting basic and applied research and to ensure an emergence of new experts in the field for the continued R&D activity in the field of oil shale.

Simultaneously with the preparation of the oil shale development plan, the Minister of the Environment initiated with directive No. 557 of 30 May 2013 the SEA accompanying the development plan, the report<sup>78</sup> of which includes significant suggestions for the implementation of the development plan, which the developers of the oil shale development plan have taken into consideration. The environmental impact is addressed in the development plan with regard to the negative impact of the mining and use of oil shale, which enables to better understand the sources and issues of the environmental impact. In addition, at the suggestion of SEA, the impact on both the surface and ground water has been described, and a more detailed summary of the environmental impact as a whole has been presented in Annex 6 to the development plan.

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<sup>78</sup> SEA report <http://www.envir.ee/et/polevkivi-kasutamise-riikliku-arengukava-2016-2030-koostamine>





## Annex 1. Main concepts

The following main concepts are used in the oil shale development plan:

**waste rock** – residue or waste (overburden is not considered waste rock) which has been separated from the yielding seam extracted during underground or surface mining of oil shale;

**economic reserve** – the reserve of minerals is active when the technology and technique used in mining ensure the rational use of the earth's crust and fulfilment of environmental requirements, and when the use of the mineral is economically feasible;

**underground mining** – the mining of oil shale from a mine (without removing the overburden from the earth's crust, oil shale lies generally at the depth of 30 m);

**face** – a place (element of working) where mining is proceeding, the mineral is extracted, the overburden is removed, or tunnelling is carried out;<sup>79</sup>

**power unit** – a set of equipment, which consists of one or two steam boilers, a turbine generator, and a block transformer at thermal power stations;

**fussees (sludge from oil production process)** – hazardous semi-liquid waste that contains polycyclic aromatic compounds (PAHs), hydrocarbons, phenols, oils, etc.;

**retorting process with a gaseous heat carrier (GHC)** – a retorting process where the heat carrier is a hot mixture of retorting and flue gases formed when the reversed part of the generator gas formed during the retorting of oil shale is burned;

**generator gas** – a retorting gas that is formed during the retorting with a gaseous heat carrier (GHC);

**residual pollution** – a polluted area in a land and aquatic environment (surface and ground water) formed as a result of human activity in the past or a set of unused hazardous substances left in the environment, which endanger the health of the residents and wildlife of the surrounding area (Annex to Riigi Teataja (RTL) 2009, 19, 235);

**waste disposal site** – a waste disposal site is any building or site that is used for collecting or depositing extractive waste in the form of solid matter, liquid, solution, or suspension:

- for an indefinite period of time in category A waste disposal sites and in the hazardous waste disposal sites described in the extractive waste management plan;
- for more than six months in suddenly formed hazardous waste disposal sites;
- for more than a year in non-hazardous waste, which is not inert waste, disposal sites;
- for more than three years in disposal sites for unpolluted surface, non-hazardous waste formed in the course of research, waste that forms as a result of the mining, enriching, and depositing of peat, and for inert waste;

**waste prevention** – is the implementation of measures preceding the formation of an object into waste in order to reduce the quantity and the environmental and health hazards of the formed waste;

**extractive waste** – waste that has formed as result of the research, mining, enrichment, and depositing of minerals;

**mining sensitivity** – shows the possibility of mining based on the value of nature protection (the categories of mining sensitivity);

**mine** – a place where the underground mining of oil shale takes place;

**rock mass** (also mountain mass in mining) – any rock or solid component of a sediment that has been extracted from its natural state;

**opencast** – a place where the surface mining of oil shale takes place;

**overburden** – sediments covering the mineral reserve (the removal of which is necessary in surface mining);

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<sup>79</sup> Mining textbook <http://maeopik.blogspot.com/2008/12/kaevente-clemendid.html>

**trade oil shale** – the mined oil shale as goods that are used as raw material for fuel and oil (Estonian standard EVS 670:1998);

**environment** – the interaction of the natural, economic, and social environment;

**complex deposit** – a deposit with two or more different minerals (main and associated mineral) which can be mined together or in the case of the mining of one mineral, the others are preserved in natural bedding conditions;

**cogeneration** – a process where two types of energy, both heat and electricity, is released from one and the same device;

**mining claim** – the part of the earth's crust assigned for the mining of a mineral with a mining permit;

**direct combustion** – the immediate combustion of oil shale in the combustion chamber of the steam boiler;

**best available technique (BAT)** the most efficient and well-developed level of technical development and the work methods implemented therein;

**potentially economic reserve** – mineral reserve is potentially economic when the use of it is not possible from the perspective of environmental protection or when there is no proper technology for it; however, it could become suitable for use in the future;

**surface mining** – the mining of oil shale in open earth's crust or an opencast (oil shale lies generally at the depth of less than 30 m);

**semi-coke** – solid residue formed in the process of oil shale retorting or semi-coking (the heating of oil shale up to 500 °C);

**semi-coke gas** – a retorting gas that is formed during the retorting with a solid heat carrier (SHC);

**combustion in a circulating fluidised bed** – combustion in a fluidised bed is a firing technology where the fuel is not pulverised but only crushed before it is sent to the combustion chamber. The fluidised bed is a two-phase system of pulsating solid particles in the gas flow of the combustion chamber. The solid particles in the circulating fluidised bed, which are carried out of the combustion chamber, pass the cyclone and are then partly directed back to the combustion chamber, thus creating circulation. The combustion temperatures in the circulating fluidised bed are significantly lower compared to pulverised firing;

**mining of oil shale** – the work performed in order to prepare for the removal of oil shale from its natural state, extraction from the earth's crust, technological transport in the place of mining, and initial processing;

**use of oil shale** – production of electricity and heat from oil shale; the use of oil shale as fuel in the manufacture of cement; the processing of oil shale in order to produce and consume oil, fuel, and chemical products;

**oil shale retorting or semi-coking** – a process where oil shale is heated up to 500 °C without adding any air in order to produce shale oil and its by-products;

**oil shale reserve** – a reserve (of minerals) that has been identified as a result of geological exploration of oil shale and which has been entered into the list of deposits of the environmental register (the consolidated balance sheet of the minerals of the Republic of Estonia);

**legacy impact** – the environmental impact of oil shale mining: subsidence (destroying the stability of surface), undemolished buildings, artificial water bodies, ground water that has been made unsuitable as a source of drinking water in flooded mines (hard ground water full of sulphate) and the load of such mining water on artificial recipients, etc. (the impact after the maintenance period following the end of 10 years of mining which does not fall under the definition of residual pollution);

**probable reserve** – is a reserve of mineral, the geological exploration volume of which enables obtaining the necessary data for the evaluation of the perspective of the mineral reserve and for the direction of further geological exploration. Probable reserve is classified based on the geological investigation or geological exploration. The Minister of the Environment can declare

the probable reserve a mineral reserve suitable for mining and use if the probable reserve directly borders with the proved reserve or is located in the base or lap seam of the proved reserve;

**retorting process with a solid heat carrier (SHC)** – a retorting process where the heat carrier is the hot ash partly reversed into the reactor and formed during the burning of semi-coke formed as a result of oil shale retorting;

**proved reserve** – is a reserve of mineral, the geological exploration volume of which enables obtaining the necessary data for the mining and use of the reserve of mineral. Proved reserve is classified based on geological exploration;

**pillar** – mineral or some other material (artificial pillar) not extracted from and left in the mine in order to support the surface;

**pulverised firing** – a combustion technology where fuel is pulverised or powdered before being sent to the combustion chamber;

**retorting gas** – a gas with a sufficient calorific value for burning, which is formed in the pyrolytic process of oil shale.