

ESTONIAN OIL SHALE INDUSTRY

YEARBOOK 2018



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ESTONIAN
OIL SHALE INDUSTRY

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Estonian oil shale industry in 2018:

Income into the state treasury	Total investments	Investments into the environment	Positions for	Sales revenue
122	116	55	7303	772
million euros	million euros	million euros	people	million euros

Estonian oil shale industry in 2017:

Income into the state treasury	Total investments	Investments into the environment	Positions for	Sales revenue
104	70	31	7387	663
million euros*	million euros	million euros	people**	million euros

Estonian oil shale industry in 2016:

Income into the state treasury	Total investments	Investments into the environment	Positions for	Sales revenue
103	63	26	6400	606
million euros	million euros	million euros	people	million euros

Estonian oil shale industry in 2015:

Income into the state treasury	Total investments	Investments into the environment	Positions for	Sales revenue
120	199	82	7411	669
million euros	million euros	million euros	people	million euros

Estonian oil shale industry in 2014:

Income into the state treasury	Total investments	Investments into the environment	Positions for	Sales revenue
174	266	42	6683	933
million euros	million euros	million euros	people	million euros

* Includes the adjusted total of KKT's natural resource and pollution charges

** Includes investments into Auvere Power Plant development

Witnessing rapid change in the Estonian energy sector

The oil shale energy sector is undergoing changes that are probably the biggest in history, and it is all happening faster than we are able to forecast.

In 2018, the development of the oil shale sector was dictated by the tripling of the market price of carbon dioxide emissions. This placed power generation under serious pressure, but provided motivation for taking faster steps toward even better valorization of oil shale.

The largest industrial investment in Estonian history – the completion of Auvere Power Plant – is a milestone on the road to making energy cleaner and more efficient. We completed a development project in Eesti Power Plant, quadrupling our capability to

use shale gas in an energy generating unit there. This will increase the flexibility and profitability of power generation and reduce environmental impact. We also boosted the efficiency of our proprietary Enefit technology even further and produced more shale oil than ever before. For Eesti Energia, this means a secure footing for the planned expansion of the oil industry.

The future of the sector depends largely on cooperation between market participants. Shale oil producers are setting the bar even higher and there are already a number of good examples of the synergy created. If the joint idea of a hydrogen processing plant is realised, this investment will guarantee export revenue for Estonia for a longer period.



Hando Sutter
*Chairman of the
Management Board
of Eesti Energia*

Smart development and automation are the keys to progress

Estonian oil shale is valuable today above all in the context of the global oil market, which is why the oil shale sector focuses mainly on production and valorization of shale oil. Thanks to our years of experience, our investments and constant development, we are capable of being competitive on a market forecasted to grow at an average of 1.2% per year over the next five years. To ensure competitiveness over the long term, it is important that we operate in a smart, clean and socially responsible manner. Energy conservation, waste-free production and a CO₂-neutral economy are just a few of the goals we strive toward every day.

VKG has embraced the changes successfully. We have optimized our production volumes and are focusing on raising the quality of our output. We see untapped potential in valorization of oils and retort gas and increasing the level of automation.

In 2019, we will mark the 95th anniversary of Estonian shale oil production, which started on VKG's current production territory. Our chemists, miners and energy researchers carry on the traditions, knowledge and experience developed over time, and have what it takes to maintain our natural resources as a competitive energy source on the global market.



Ahti Asmann
*Chairman of the
Management Board
of Viru Keemia Grupp*

Oil shale industry developing despite complicated conditions



Andreas Laane
*Chairman of the
Management Board
of Alexela Group*

The oil shale industry is adapting to a new reality characterised by ever more stringent environmental conditions, the dramatic increase in environmental charges, more costly resources, ageing of the workforce and shortage of young specialists. These factors have altered growth prospects for KKT and have forced us to look for new areas of activity.

We're constantly working to reduce the environmental impact of our activities. Last year as well, investments were aimed at developing the necessary technology for more environmentally friendly production and upgrading our equipment and vehicles.

Chemicals derived from oil shale are one of the largest export sectors in Estonia and companies in this field directly and indirectly provide work for tens of thousands of people in Ida-Viru County. It's a sector that has not received enough attention at the state level, and as a result it is difficult to find new qualified workforce. Today the average age of employees at KKT is over 50 and growing with each passing year. To retain existing employees and find new ones, we have reviewed our remuneration and bonus policies, improved work conditions for employees and increased cooperation with various academic and research institutions.

The key for industrial development is ensuring a future workforce



Kalle Pirk
*Director of the TalTech
Virumaa College's
Oil Shale Competence
Centre*

At the opening of the new Auvere Power Plant, members of the Estonian research community who contributed to the plant's completion were also recognised alongside the engineers. The list of research papers published this year confirms that science related to this sector is of a high calibre. At the same time, more than before, companies and research institutions are forced to devote attention to educating the next generation of specialists.

Digitalization of industry is leading to increasing automation. The introduction of robots should in theory reduce the need for workforce. In actuality, however, the changing situation is imposing greater demands on specialists. There is a greater need for

employees who have in-depth knowledge in at least one field and the skills to understand and integrate different disciplines and the people engaged in them.

Fundamental research and applied research are both important in scientific work. Success is ensured by the ability to cross-link them and use them in the interests of enterprise. The business sector is certainly not the only consumer of research. Various broad-based research studies and analyses are just as important for planning regulations and policies, because decisions concerning the investment-intensive oil shale sector must be high in quality. Only in this way can we ensure that businesses have certainty for a period comparable to the investment life cycle.



ROLE OF THE OIL SHALE

INDUSTRY IN THE ECONOMY

State revenue from the oil shale industry

Continued stable growth in the oil shale sector and record levels of oil production in 2018 showed that the industry has recovered successfully from a complicated period a few years ago. Similarly to the year before, the price level of liquid fuels rose significantly. The average price of Brent crude oil grew by one-third in spite of extraordinarily high volatility, and remained at 72 dollars per barrel.

As the market picked up, the company's output increased and state revenue from the oil shale industry returned to the pre-recession level. In 2018, the contribution made by Eesti Energia (EE), Viru Keemia Grupp (VKG), Kiviõli Keemiatööstuse (KKT) and Kunda Nordic Tsement (KNT) to the state revenue totalled over 122 million euros, which is 17% more than the year before. The principal part was made up of various environmental charges of more than 71 million euros and labour taxes of 42 million euros.

116 million into innovation and development

The improvement in the market situation encouraged the oil shale industry to initiate and continue large-scale development projects to adopt new technologies and make existing ones even more efficient and environmentally friendly. In 2018, four companies invested over 116 million euros into innovation and development, exceeding the 2017 investment volumes by 66%.

One-third of the investments comprised the last instalment into Eesti Energia's Auvere Power Plant. Balti Power Plant increased the capacity of its equipment and the establishment of a waste shredding and metal removal complex began. Construction work ended at unit no. 8 of the Eesti Power Plant for increasing the combustion efficiency of oil shale gas, and Eesti Energia invested 2 million euros for establishing a direct power line from unit no. 8 to Narva Quarry. In addition, Enefit Kaevandused purchased 48 new self-propelled pieces of equipment for Estonia Mine and Narva Quarry, for a total 17.5 million euros.

THE ESTONIAN OIL SHALE INDUSTRY IN FIGURES IN 2018

	Sales revenue (millions of EUR)	Average number of employees	Oil shale mined (thousands of tonnes)*	Energy content of used oil shale (MJ/kg)**	Tax footprint 2018 (millions of EUR)***
Companies related to Eesti Energia's oil shale industry	477 365 949	4 830	11 296	7,90	83 487 161
Companies related to Viru Keemia Grupp's oil shale industry	208 889 227	1 705	3 487	8,86	27 085 893
Kiviõli Keemiatööstus	37 210 685	582	1 088	8,90	7 314 332
Kunda Nordic Tsement	48 635 409	186	74	6,38	4 417 896
TOTAL	772 101 270	7 303	15 945		122 305 282

* Includes the company's central services and Enefit Solutions

** Calorific value of commercial oil shale

*** Workforce taxes, resource and pollution charges, corporate income tax, customs duty, land tax

VKG's largest investment in 2018 was made into continuing the circulation oil cleaning project to increase the production capacity of Petroter plants even further. The company also renovated its mining machinery, invested into making existing technology more efficient and carried out a 4-million-euro renovation of heating lines that had become superannuated. VKG contributed significantly to innovation as well, developing new software, creating interfaces for smart systems and carrying out a number of mining and digital projects in the field of energy efficiency.

KKT directed the lion's share of its development investments into installation of electric filters on solid heat carrier reactor smokestacks to improve local air quality and reduce the spread of nuisance odour. Also, investments were aimed at upgrading the company's equipment line-up.

Last year as well, investments were aimed at developing the necessary technology for more environmentally friendly production and upgrading our equipment and vehicles.

Oil shale products for export

According to Statistics Estonia, 14.4 billion euros of goods were exported from Estonia in 2018, which is 12% more than in 2017. This figure was supported by shale oil export, increasing balance in the transport fuels import market. In the last 20 years, the export of liquid fuels has grown close to twentyfold. In 2018, 99% of the record 1.1 million tonnes of shale oil produced in Estonia was sold to other countries.

Oil shale companies' electrical output in 2018 was 9.2 terawatt-hours out of 12.3 TWh of electricity generated in Estonia. Although the Estonia's total electricity output was 5.4% less than in 2017, close to 40% of Estonian power was exported. Today, Estonia sells seven times more electricity abroad than it did several decades ago.



The chemical industry can be called the cornerstone of the European economy, supplying modern products and materials to practically all sectors, while the oil shale industry can be considered Estonia's cornerstone. Estonia's most recent investments into technologically intensive production – 2.416 billion euros, the largest to date – were made by the oil shale industry companies in the years 2006–2016.

HALLAR MEYBAUM

*Executive director of the Estonian
Chemical Industry Association*



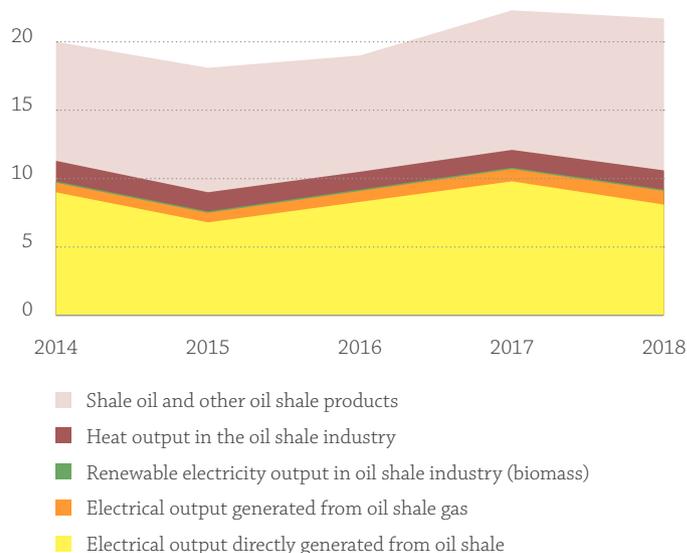
The competitiveness of the oil shale industry

Estonia is still the most energy-independent country in Europe

Oil shale ensures Estonia's energy independence, which is politically important. According to Eurostat data, Estonia has been the European Union's most energy-independent country in the last four years.

Estonia's energy independence has been growing year in and year out, fluctuating between 7% and 12% during 2013–2017. The noteworthy achievement is possible only thanks to the strong domestic energy industry.

ENERGY OUTPUT OF OIL SHALE ENTERPRISES (TWH), 2014–2018



Source: Eesti Energia, Viru Keemia Grupp, Kiviõli Keemiatööstus, Kunda Nordic Tsement

In 2018, the contribution made by the oil shale industry to the state revenue totalled over 122 million euros, which is 17% more than the year before.

Operating framework

The operating framework affecting the oil shale sector was updated in 2018 at both the Estonian and European level, with the aim of reducing the environmental impact of the industry and create even better conditions for maximum valorization of oil shale.

Temporary fee levels for mining of oil shale become permanent

In January 2019, a new government regulation will establish new fee levels for mining of oil shale. It will also make the temporary system established in 2016, whereby the fees for the oil shale mining rights were linked to the world price of heavy fuel oil, permanent. The earlier oil shale extraction fee of 2.21 euros per tonne rose to 10 euros following the change. The oil shale resource fee will start growing when a tonne of fuel oil costs more than 241 euros per tonne and the maximum profit level is reached at a fuel oil price of 650 euros per tonne.

By knowing the state's plans farther ahead, companies can spread out their risks and more confidently plan investments and production. The current system supports the sustainability and development of the oil shale sector as it helps companies ride out challenging times.

The EU's strategic climate neutrality vision up to 2050

In November, the European Commission adopted a long-term strategic vision, "Clean Planet for All", aimed at moving toward carbon neutrality. Calculations indicate that this will require investments of up to 290 billion euros each year.

The vision document describes eight development scenarios, of which two require emissions to be cut by 100% and the others,

by 80–95%. This will be achieved mainly by giving up oil, natural gas and coal, as these are responsible for carbon dioxide emissions into the atmosphere. The reduction of greenhouse gases in agriculture and planting of new forests is also considered important.

According to the climate neutrality strategy, electricity will ensure over half of the EU's energy needs, which will be at least twice as much as today. The transition to electric cars has already begun, and heating of homes will continue to rely in part on electricity. Plans are for 80% of the needed electricity to come from renewable sources and 15% from nuclear power plants.

Trading against climate change

Close to 15 years ago, the European Union introduced its greenhouse gas trading system. In 2018, a **general framework** was laid down for the new trading period in 2021–2030. As a new feature, the quantity of units on the market will start decreasing more rapidly. Starting in 2021, the overall quantity of greenhouse gas units will be reduced by 2.2% per year instead of the current 1.74%. By 2030, the EU should be able to decrease CO₂ emissions in sectors covered by the trading system by 43% compared to the 2005 levels.

Companies on the Carbon Leakage List, including refining industry, are protected, in a decreasing extent until 2030, against carbon leakage, which is where competitors in the sector gain a competitive advantage by transferring their operations to outside the EU where there CO₂ emissions expenses are lower. The measures for equalizing differences in climate policies for the post-2030 period have not been designed yet.

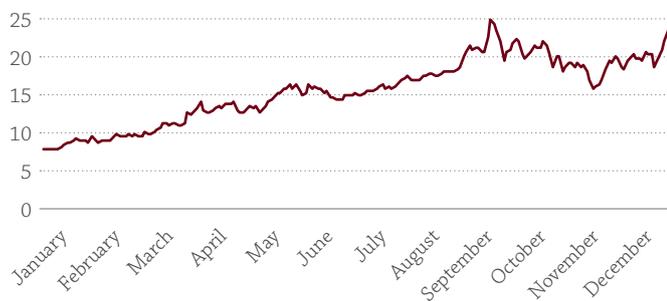
CO₂ price triples

The market price of carbon dioxide emissions in the European Union tripled in 2018, from 7.80 euros per tonne at the start of the year and reaching 23.40 euros per tonne by year's end. Such a price level was last seen in 2012. For the oil shale sector, a higher price of CO₂ allowances means increased costs, as production is a process that gives off carbon dioxide. At the same time, the higher price encourages energy sector companies and industries to invest more into making production more efficient and reducing gaseous emissions and spur researchers to find ways of capturing carbon.

Modern geology service launched

In 2018, the **Geological Survey** of Estonia was launched, tasked with representing the state in performing geological investigations and studies and preserving and making available information in the sector. The new service's function is to advise government institutions and notify the public on topics related to natural resources.

PRICE OF EUROPEAN UNION CO₂ EMISSIONS ALLOWANCES IN 2018 (EUR)



Source: Business Insider

Reshuffle at the Ministry of Environment

In 2018, an environmental technology department was set up at the **Ministry of the Environment**, which focuses on alleviating and reducing the impact of the mining industry. The new unit's field of responsibility is organising mining, industrial emissions and chemical policy and resolving emergencies in the ministry and its jurisdiction.

The restructuring was due to changes that have taken place over the last few years in the extractive industries. In 2017, the **Ministry of Economic Affairs and Communications** received a larger role with the approval of the mineral resources policy, allowing Estonian natural resources to be explored and used in a manner that generates greater value added for the economy. Processing of permits for mining of natural resources became the function of the **Environmental Board** and the **Land Board** became responsible for registration of natural resources reserves.

Price tag on external impacts

In the European Union, the external influences of the use of the environment have been assessed in monetary terms for several decades now. Estonia began using these methods only in 2018. With funding from the **Environmental Investments Centre**, the **Estonian, Latvian & Lithuanian Environment (ELLE)**, Inseneribüroo Steiger, **Praxis** and **Maves** analysed odour, noise, vibration, and pollutants into ambient air, soil and water, use of land and use of water and damming of bodies of water.

In the course of the **project**, a large part of Estonia's environmental data were analysed and a map application was developed to provide

an overview of different environmental indicators and statistics related to the population simultaneously. The project results give companies a clearer understanding of how state policy on environmental use is shaped and allow the environmental impact of the oil shale industry to be compared to that of other areas of activity.

Priority regions for mining of oil shale

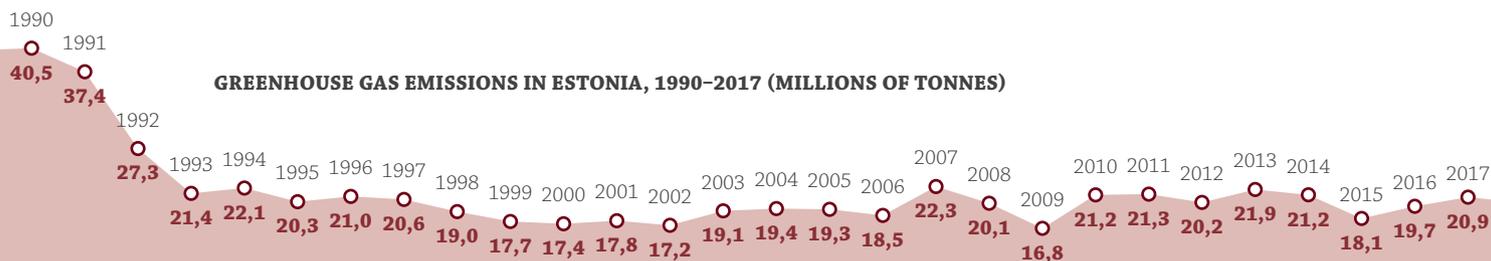
According to the environmental impact assessment report in the [national development plan for the use of oil shale 2016–2030](#), new mines will have to be opened in the near future in order to ensure security of supply. The opening of four mines is on the priority list of areas to be mined: Uus-Kiviõli, Sonda, Oandu and Estonia II. A study commissioned by the Ministry of the Environment and conducted by Praxis, Maves and the TalTech was released in 2018: “Determination of priority regions for oil shale mining on the basis of natural and economic conditions”. As a result, six priority areas for development of room and pillar mining and continuous mining were specified up to 2030. The four mines mentioned above were supplemented by Sonda II and Seli and Peipsi exploration areas located to the north of Iisaku in Alutaguse Municipality. The study results give valuable background information for issuing oil shale mining permits and for making other decisions related to use of oil shale.

More precise rules for registering natural resources

At the end of the year, the environment minister signed a regulation that further refines the conducting of natural resources exploration and accounting for natural resources. Compared to the previous version, the regulation’s requirements for registering oil shale as a natural resource have been amended and criteria for passive categorisation of oil shale from the economic aspect have been omitted.

SHEXIT

Environmental protection organisations have called for setting a fixed date for ending production of electricity from oil shale in Estonia. Oil shale companies maintain that this is not reasonable, as the reduction of electricity generation from oil shale is motivated by the European emissions trading system by way of economic measures. At the same time, when producing liquid fuels from shale it is essential to generate a small quantity of electricity as by-product. This is reflected in three of the country’s strategic documents: [the oil shale development plan](#), [the principles of climate policy](#) and [the energy sector development plan \(ENMAK\)](#). The most important change that can be highlighted in power generation is the replacement of Eesti Energia’s old energy generating units with Auvere power plant, and development of renewable energy and technologies for co-production of electricity and oil.





OIL SHALE
VALUE CHAIN:

FROM MINING
TO END PRODUCTS

Mining permits and volumes

Energy from oil shale for years

Over its more than a century of activity, the Estonian oil shale industry has mined close to one billion tonnes of oil shale. Of the 4.8 billion tonnes of oil shale reserves in Estonia, there is still left about another one billion tonnes of the mineral that can be mined without active restrictions.

The centre of Estonian oil shale mining operations is in north-eastern Estonia, where the two main deposits of the minerals are located. In the so-called “Eesti” deposit located between Rakvere and Narva, oil shale is mined using both underground and open-cast methods. The oil shale layer is thickest, up to 2.9 metres. The oil shale in the Tapa deposit between Ambla and Väike-Maarja is lower in quality and lies deeper in the earth’s crust. As a result, shale is not mined there today.

If oil shale continues to be used at the same rate and mined more efficiently, Estonia’s oil shale reserves are enough to last another half-century.

A record quantity of oil shale

In Estonia, four companies mine oil shale: Eesti Energia, Viru Keemia Grupp, Kiviõli Keemiatööstus and Kunda Nordic Tsement. In 2018, the companies extracted a record total of almost 16 million tonnes of oil shale, which is 80% of the annual 20 million tonnes allowed.

Thanks to noteworthy levels in stock, Eesti Energia mined 75% of the 15 million tonnes allowed by the company – 11.3 million tonnes. The overwhelming majority of this went for producing electricity, heat and shale oil. Similarly to 2017, VKG was the only company to use mining rights carried forward from previous periods. VKG extracted 3.5 million tonnes of shale compared to its annual 2.8 million tonnes – 126% of the allowed amount. The company produced chemical products and chemicals, oil derivatives and heat and power.



Estonian oil shale undoubtedly has a future, above all in the field of oil production and fine chemicals. Geologists and technologists can help the industry to expand the applications for recovery of by-products, develop solutions for rehabilitating and filling former mines and approach 100% resource use. The key to success lies in cooperation between industry and the academic sector.



ALVAR SOESOO

Director of Geological Survey of Estonia

As Eesti Energia is able to mine more efficiently than ever before thanks to the improved technology, the company's mining capability exceeds internal demand. Eesti Energia and VKG entered into a large-scale contract in 2018 under which Eesti Energia will sell VKG close to one million tonnes of oil shale over three years.

The mining volume for KKT was 1.1 million tonnes in 2018, which is 55% of the allowance. The company sold a noteworthy share of the mined oil shale to Eesti Energia, VKG and Sillamäe Soojus. KNT mined the least amount of oil shale; it uses oil shale as a fuel for cement production. Similarly to last year, the company extracted 74,000 tonnes of oil shale, which made up only 31% of the 238,000-tonne annual mining allowance.

Toward effectiveness and safety

The oil shale industry uses cleaner and more efficient technology than ever before. In spite of that, companies are making invest-

ments totalling tens of millions of euros to modernize their existing equipment and introduce innovative and even more environmentally friendly solutions.

For KKT, 2018 was a watershed year in the mining industry. The continually increasing volume in Põhja-Kiviõli II Quarry forced the company to look for alternatives for removal. To ensure the same volume of oil shale output as in the past, for the first time the company changed over from mechanical breaking to blasting of overburden. The new method has been effective and ensures that the works can continue at the desired volume. KKT's machinery also saw improvements. At the start of the year, the company bought a powerful XR82 Xcentric ripper, which will make the fragmentation operations in the quarry faster and more efficient. It also added cleaner and more powerful new-generation bulldozers, which have resulted in a 150% growth in efficiency of bulldozer operations.

OIL-SHALE MINING (2014–2018)

	Annual volume allotted, thousands of tonnes	Actual amount mined (thousands of tonnes)*, share of the allowance used (%)										Average % 2015–2018
		2014		2015		2016		2017		2018		
Eesti Energia	15 010	11 614	77%	11 083	74%	9 732	65%	11 157	74%	11 296	75%	73%
Viru Keemia Grupp	2 772	2 483	90%	2 637	95%	1 791	65%	3 239	117%	3 487	126%	98%
Kiviõli Keemiatööstus	1 980	750	38%	1 096	55%	1 169	59%	1 164	59%	1 088	55%	57%
AS Kunda Nordic Tsement	238	113	47%	92	39%	0	0%	74	31%	74	31%	30%
TOTAL	20 000	14 960	75%	14 908	75%	12 692	63%	15 634	78%	15 945	80%	74%

** Data for 2014-2016 are adjusted on the basis of consolidated balances for natural resources

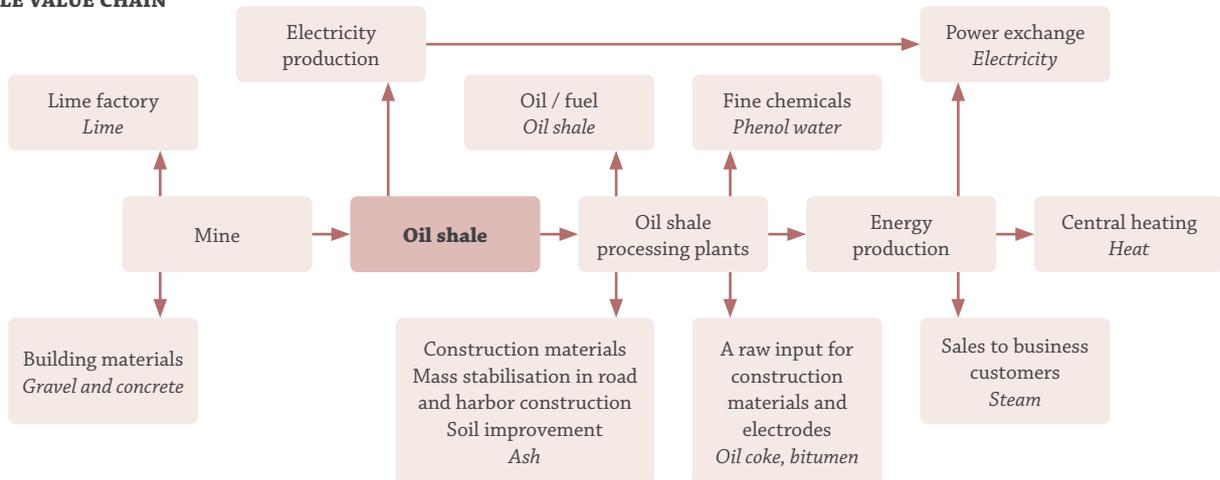
A safer working environment for miners

The first stage of a project designed to raise safety ended at VKG's Ojamaa Mine, the goal of which was to ensure higher safety for 300 mine workers. The company actively developed a web-based 24h air monitoring and control system in the mine. The most hazardous underground areas were fitted with new-generation smoke and CO detectors. Automatic alarm systems were also installed. They send an emergency signal to the mine supervision department if CO is detected and warn employees of danger. All underground workers at Ojamaa Mine were issued personal gas detectors that can be used to assess air quality and make sure on a running basis that the level of hazardous substances is within allowed limits.

An efficient underground repair shop in Estonia Mine

In 2018, the first underground repair shop was completed at Eesti Energia's Estonia Mine, allowing more complicated and larger repairs to be undertaken more efficiently and safely below the surface. The modern workshop covering 3,000 square metres – almost a football field – is used to perform more complicated welding work. Massive parts of large equipment can be replaced using hoist mechanisms and disassembly and assembly performed. The new option saves time, increases the efficiency of the mine and has a positive effect on the competitiveness of Eesti Energia's operations in this sector.

OIL SHALE VALUE CHAIN



Power

Power from oil shale in the majority

Since 2013, Estonia has been the least dependent on imported energy of any country in Europe, thanks largely to power from oil shale. In 2018, 12.3 terawatt-hours of electricity were generated in Estonia, which was 5.4% less than the year before. The largest share came from oil shale companies, which produced a total of about 9.2 TWh of power from shale and shale gas.

Oil shale energy does not only mean power generation based on burning of oil shale. Eesti Energia's energy generating operations use different fuels: waste wood, peat, shale gas and shale oil. In 2018, Eesti Energia received from the Ministry of the Environment and the European Commission documents needed to diversify fuel mixtures with shredded tyres as well.

2018 was the first year after 2015 that power generation in Estonia declined. Estonian electricity exports continued at around 5 TWh. Electricity imports increased by one-quarter in 2018, standing at 3 TWh. Estonia's electricity trading partners continued to be neighbouring countries Latvia and Finland.

ELECTRICITY OUTPUT IN ESTONIA, 2014–2018 (GWH, %)

	2014	2015	2016	2017	2018
Eesti Energia	9343	7312	8695	9363	8658
<i>of which oil shale electricity</i>	9003	6745	8203	8741	8074
Viru Keemia Grupp	217	311	352	416	466
Kiviõli Keemiatööstus	39	41	44	51	52
TOTAL POWER OUTPUT	9599	7664	9091	9830	9176
<i>of which oil shale electricity</i>	<i>9259</i>	<i>7097</i>	<i>8212</i>	<i>8747</i>	<i>8081</i>

Source: EE, VKG, KKT

Expansion to foreign markets

2018 was a year of expansion for electricity sales at Eesti Energia. In addition to the Latvian, Lithuanian and Polish markets already well established, sales of power under the Enefit brand started in Finland and Sweden. Along with Estonia, Eesti Energia's home markets now have a population of around 60 million and the annual power consumption is 420 TWh.

Electricity in excess of 40% more expensive

Estonia is part of one of the world's largest power exchanges, Nord Pool. In 2018, the average market price of electricity in all of Nord Pool's Baltic trading areas rose approximately 40%. The system price, which expresses the ideal price level for the market, rose to a seven-year high. The average price was 43.96 euros per megawatt-hour, which is 49.4% higher than in 2017.

The average price of power in the Estonian bidding area of Nord Pool underwent a big increase in 2018. The average power exchange price for the year rose to 47.04 euros/MWh, which is 41.6% higher. In Estonia, the hourly power price was lowest on 9 May (1.59 euros/MWh)

ELECTRICITY PRICES ON THE NORD POOL SPOT POWER EXCHANGE 2017–2018 (€/MWH)

Average price	2017	2018	Change
System price	29,43	43,96	▲ +49,4%
Finland	33,19	46,80	▲ +41,0%
Estonia	33,22	47,04	▲ +41,6%
Latvia	34,70	49,86	▲ +43,7%
Lithuania	35,15	49,96	▲ +42,1%

Source: Nord Pool

while the highest was 1 March, when the hourly price rose to 255.02. The average electricity price in Latvia and Lithuania remained around 49.9 euros/MWh, rising even more compared to 2017 than it did in Estonia – 42.1 and 43.7%, respectively.

The increase in the price of power was above all caused by changes in the CO₂ allowance market, the hydro balance remaining low year-round in the Nordics, and the general rise of energy prices in 2018.

The most modern Auvere power plant is completed

In September 2018, the operation of Auvere Power Plant was transferred from the builder to Eesti Energia's subsidiary Enefit Energiatootmine. Auvere Power Plant construction spanned nearly eight years. The most modern power plant in the region cost close to 640 million euros and is capable of generating 2.2 TWh of electricity every year, covering one quarter of Estonia's needs. Built by US industrial giant General Electric, the plant is capable of running on various domestic fuels: up to 100% on oil shale, 50% on biomass, 20% on peat and 10% on shale gas. The power plant

AVERAGE MONTHLY PRICES OF ELECTRICITY ON THE NORD POOL SPOT ESTONIA POWER MARKET (2014–2018, €/MWH)



Source: Nord Pool

is capable of generating close to 1 TWh of renewable energy each year. Auvere Power Plant's 300 MW power rating partially compensates for the operation of older generating units, as a result of which there will be 600 MW less electricity on the market. In the autumn the plant won the titles of business achievement and energy achievement of the year in Ida-Viru County.

A million euros in savings each year

In the autumn, another important project was completed at Eesti Energia, in the course of which a power line was established between the Eesti Power Plant's unit no. 8 and Narva Quarry. In addition, for 2 million euros, electrical connections were built, equipment at eight district substations at the quarry was taken over from Elektrilevi. Connecting consumers to electricity producers helps major energy industry companies save as much as 1 million euros per year on network fees.

Cleaner shale gas

Estonia produces its electricity from both oil shale and shale gas. In 2018, the oil shale industry produced a total of 967.5 GWh of electricity from shale gas, which makes up 10.5% of the power generation total.

In 2018, at Eesti Power Plant, Enefit Energiatootmine started using a greater share of the shale gas, which is given off as a by-product of oil production and has a high heating value. It can be used as a raw material for the energy generating units at a mixture of up to 50% in addition to oil shale. Thanks to renovations, the environmental impact will decrease and power generation will become more flexible.

Liquid fuels

Estonia has 95 years of experience in producing oil from oil shale. During this time, the technologies used have become many times more efficient and cleaner and the quality of the oil has improved significantly. The advantage of oil derived by retorting oil shale is that it is lower in sulphur than petroleum-based oil and it has low viscosity for its density – meaning that it does not have to be heated. Shale oil is used in the chemical industry as a raw ingredient and impregnating agent, for heating of boiler units and industrial furnaces, and as an additive in marine fuels. Today, Estonia is one of the world’s largest producers of shale oil.

A record year for shale oil

2018 was a record year in shale oil production. Three companies again produced a total of 1 million tonnes of shale oil. The annual total volume of the oil produced was 1.1 million tonnes, which is 8.7% more than the year before. Similarly to previous years, 90% of the output was sold on foreign markets.

The total amount of oil produced at VKG crossed the 600,000-tonne mark for the first time history in 2018. The company pro-

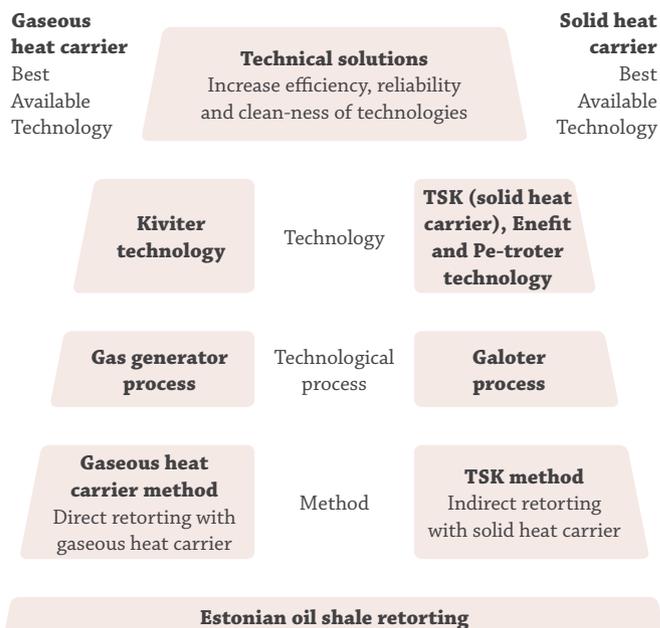
THE ESTONIAN OIL SHALE INDUSTRY’S LIQUID FUEL OUTPUT, 2014–2018 (THOUSANDS OF TONNES)

	2014	2015	2016	2017	2018
Eesti Energia	265	337	318	395	410
Viru Keemia Grupp	433	506	451	536	607
Kiviõli Keemiatööstus	62	72	83	89	92
TOTAL	760	915	852	1 020	1 109

Source: EE, VKG, KKT

cessed oil shale at three plants using the Petroter technology and at three Kiviter oil shale plants, of which one was re-launched midyear. Due to a deficit in oil shale, one plant remains closed. The Petroter plants operated a total of 905 days and the average net efficiency indicator for processing of oil shale was 90.5% In addition to record production levels, VKG managed to increase the effectiveness of oil shale valorization, which is important for maintaining competitiveness.

TECHNOLOGY USED TO PRODUCE SHALE OIL IN ESTONIA



Source: AF-Consulting

At Eesti Energia as well, a record quantity of shale oil was produced in 2018 – 411,000 tonnes. The company has increased the annual total each year and found more efficacious ways of achieving its goals. Although the productivity of Eefit280 was on par with 2017, oil shale consumption decreased by 27,000 tonnes. Enefit140's actual levels were 102% of budget and in 2018 it produced 224,000 tonnes of shale oil that was the highest result in 38 years of operation. In 2017, yield was 13.1% and in 2018, 13.4%.

Unpredictable crude oil prices

2018 was an unpredictable year for the oil shale industry due to the wide fluctuation of crude oil prices. In May and October, the price of Brent crude rose to over 80 USD per barrel but in spite of an OPEC agreement to continue cutting back production, the price dropped dramatically to 50 USD by the end of the year. The main reasons for the drop in oil price are the lower than expected economic figures from China and the major oil reserves in the US. The average price of Brent crude for the year was 71.7 USD per barrel, which is 31% higher than in 2017.

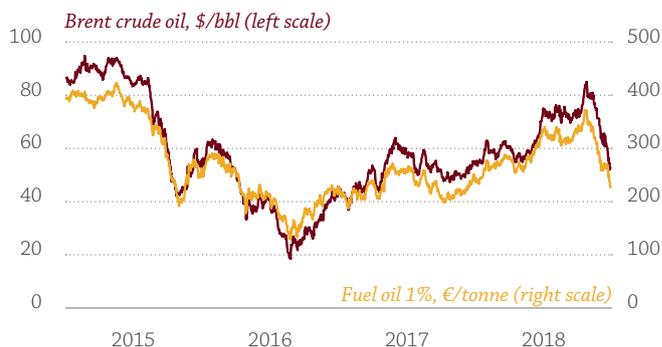
In 2018, three companies produced a total of 1,1 million tonnes of shale oil, setting a new record.

The market price of 1% sulphur fuel oil, which is the reference product for oil shale, achieved its peak for 2018 at the beginning of October – 425 euros per tonne. The lowest level was recorded in February at 285.7 euros per tonne, and the average for the year was 338 euros per tonne (+23%)

Trend toward reduced marine pollution

The primary component for producing marine fuels is 3.5% sulphur heavy fuel oil. Under the new rules introduced by the international convention for the prevention of pollution from ships MARPOL set to enter into force in 2020, the ceiling for sulphur in bunkers will be set at 0.5%. The sulphur content of shale oil from the Estonian producers is an average of 0.8%, which meets criteria for low-sulphur fuel. As the first priority, companies will focus on lowering sulphur content in petrol, but in future it is also planned to reduce sulphur in all oils to 0.5% by volume, and in the distant future to under 0.1%.

PRICES OF LIQUID FUELS (\$/BBL, €/TONNE)



Source: Thomson Reuters

Oil from old tyres

Estonia generates an annual average of about 10,000 tonnes of end-of-life tyres; Europe as a whole, over 3,000,000 tonnes. In autumn 2018, Eesti Energia received permission from the European Commission to diversify fuel mixtures used in the production to produce shale oil, allowing shredded tyres to be used as well. The use of tyres in oil production will resolve a significant environmental problem in Estonia and possibly in neighbouring countries as well. End-of-life tyres at Raadi Air Base and in Estonian forests will be turned from waste to valuable raw material, increasing the range of fuels that can be used in production.

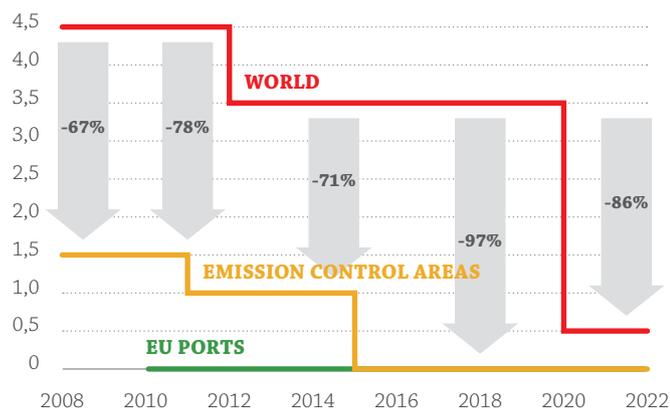
Experiments carried out at Enefit oil plant in 2017 confirmed that the combined use of oil shale and shredded tyres in a pyrolysis process works when the shredded tyres make up to 10% of the

fuel mixture. The quality of the oil produced from a combination of shredded tyres and oil shale remains the same and the environmental impact does not increase. Eesti Energia plans to launch manufacturing of oil from end-of-life tyres in the coming years. Enefit oil plants would be able to use the annual quantity of old tyres generated in Estonia over the space of a couple months.



The oil shale sector has produced many renowned chemists such as Paul Kogerman, who is considered the father of Estonian oil shale chemistry. Even today, the field of oil shale valorization provides plenty of work for Estonian chemists. One example is a project for producing dicarboxylic acids from kerogen, the organic matter in shale. In this way, Estonian oil shale will be turned into valuable materials that will start improving people's quality of life.

CHANGES IN MARINE FUEL SULPHUR LIMITS 2008–2022



HALLAR MEYBAUM

Executive director of the
Estonian Chemical Industry Association



Heat

Cheaper residential heat from oil shale

Production of heat from oil shale has remained on par with the level of the last four years – 1.4 TWh – making up one-fifth of the district heat consumed. Residential heat in Estonia is largely produced from heat and power co-generation plants. In 2018, the limit price of heat for end consumers approved by the Competition Authority averaged 61.68 euros per MWh across Estonia. Consumers whose heat is generated as a by-product of the oil shale industry continued to enjoy lower prices.

The lowest price for residential heat was enjoyed in 2018 by close to 60,000 Narva residents who paid Narva Soojusvõrk 35.33 euros per MWh for heat produced from oil shale and biomass at Eesti Energia's Balti Power Plant. A total of 692 sites are heated in the district and the total capacity of consumers ranges up to 333 MW. In addition, industrial consumers in the near vicinity are supplied with steam at 15 atm pressure. In 2018, Narva Soojusvõrk received the Efficient District Heating label, recognizing the company for developing the Narva district heating system and its use of renewable energy.

Co-generation of heat and power at KKT covers the needs of Kiviõli and the company's own needs. In Kiviõli, consumers paid Kiviõli Soojus, the pipeline system operator, 48.69 euros per MWh.

VKG Soojus supplies heat to 30,000 consumers in the Kohtla-Järve and Ahtme-Jõhvi area. Last year the company lowered its rates by 5% and starting in November, consumers are paying 52.66 euros per MWh for heat. For the last five years, the company has been producing heat in a more environmentally friendly manner, using gas generated through the processing of oil shale.

New heating lines for over 4 million euros

VKG Soojus started an extensive renovation project in 2018 to replace an outdated heating pipeline. The renovations of the 10-km-long heating line cost 4.4 million euros, of which one-third will be covered by the Centre for Environmental Investments.

Narva Soojusvõrk, part of the Eesti Energia Group, administers around 77 km of heating pipeline in Narva. Today nearly half of the entire network has been renovated and over the last few years, the relative heating losses have dropped from 18% to 12%. With the decrease in losses, the environmental impact and the fuel expenditure per MWh of heat generated also drop.

In 2018, Narva Soojusvõrk received 150,000 euros in support from the Centre for Environmental Investments for renovating nine segments of line. Also, it is planned to digitalize data transmission and install remote-read sensors in the city of Narva.

OIL SHALE COMPANIES' HEAT OUTPUT IN ESTONIA, 2014–2018 (GWH)

	2014	2015	2016	2017	2018
Enefit Energiatootmine	603	614	596	564	582
Viru Keemia Grupp	581	532	506	452	454
Kiviõli Keemiatööstus	107	108	123	125	139
Kunda Nordic Tsement	191	97	104	219	188
TOTAL	1482	1351	1329	1360	1363

Source: EE, VKG, KKT, KNT

Chemicals from oil shale

Besides power, heat and fuel, various chemical products are also produced from oil shale. VKG remains the only Estonian company that extracts fine chemicals from the phenol water given off in Kiviter plants in the oil production process.

Oil shale chemicals are various grades of alkylresorcinols, which are widely used in making moulds and as epoxy adhesives in rubber, plywood and the petroleum industry. Phenols produced in Estonia - Honeyol 80, Honeyol and Rezol – are used in Lexus and Toyota automotive parts and they are used to make highly durable tyres.

The fine chemicals obtained from oil shale – anhydrates of 2-methylresorcinol and monohydroates of 5-methylresorcinol – are used in perfumery, cosmetics and the electronics industry. Products with high – over 99% – purity can be found in pharmaceuticals and hair dyes. LCD monitors' liquid crystals are also made from them. Fine chemicals with a high level of purity are expensive; the price of one kilogram in euros can range well into the double digits.

EXPORT OF FINE OIL SHALE CHEMICALS AND PHENOLS, 2014–2018 (IN EUROS)

	2014	2015	2016	2017	2018
Phenol products (including fine chemicals)	719168	1034909	730309	968059	2767446
Total phenols	41849	39596	6212	4411	0
TOTAL	761017	1074505	736521	972470	2767446

Source: Statistics Estonia

An important export article

In 2018, VKG produced 1,911 tonnes of fine chemicals and phenol products, which the company sold to clients within Estonia as well on British, Indian, Belgian and US markets. The company's biggest challenge today is to expand its customer base for marketing standardised fine chemical products.

The production of fine chemicals contributes to the development of the circular economy in the oil shale industry, as they were produced from by-products of the oil shale processing.

In 2018, Estonia exported 2,8 million euro's worth of oil shale based fine chemicals per year, which is 186% more than the year before.



OIL SHALE INDUSTRY

AND THE ENVIRONMENT

Investments into the environment

55 million euros into reducing the environmental footprint

In 2018, oil shale companies' direct and indirect investments into the environment totalled 55 million euros, which is nearly twice as much as a year before. Investments were made into upgrading the existing technology, modernizing production processes and speeding up the adoption of innovative solutions. All in order to reduce the environmental footprint and improve the quality of ambient air.

In addition to environmental investments, 71.4 million euros in environmental charges were received in the state treasury from the oil shale sector. Of this, pollution charges on waste, emissions and deposition of waste related to mining and processing made up 40.4 million euros. Resource fees for mining of oil shale and use of water amounted to 31 million euros.

Praise for environmental efforts

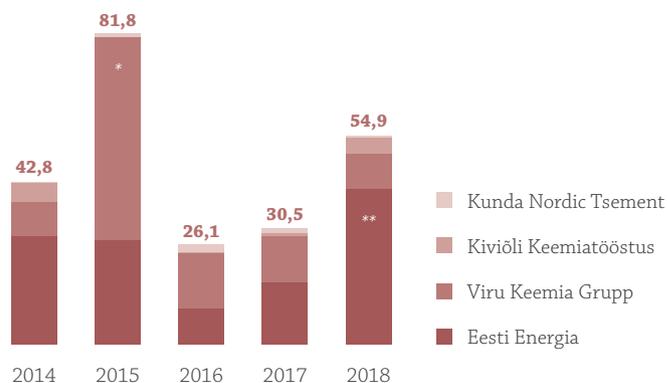
The consistent work of oil shale enterprises to make their industry cleaner and eliminate legacy pollution has not gone unrecognized. The Responsible Business Forum recognized Eesti Energia by awarding it a responsible business certificate and a gold-level quality label. Viru Keemia Grupp, similarly to the year before, received a bronze level quality label. The label is awarded to companies that took part in the responsible business evaluation, which contribute strategically to the development of a sustainable social and natural environment.

In 2018, Eesti Energia, KKT and VKG again passed an ISO 14001 environmental management system audit conducted by Bureau

Veritas Estonia. Receiving the certificate certifies that the companies are dedicated to ensuring sustainability, that they put emphasis on constantly improving the environmental sector and that their activity complies with legal acts on protection of the environment.

Sustinere, a consultancy that promotes the concept of sustainability, analysed the annual reports of Estonia's 100 most influential companies to study their corporate social responsibility. The attitude of the companies toward people, the environment and society as a whole was studied. Eesti Energia and VKG both were included among the 15 most open companies.

ESTONIAN OIL SHALE COMPANIES' DIRECT AND INDIRECT ENVIRONMENTAL INVESTMENTS IN 2014-2018 (MILLIONS OF EUROS)



* Includes indirect environmental investments in connection with expanded production volumes and the establishment of the Petroter III shale oil plant

** Includes investments into Auvere Power Plant development

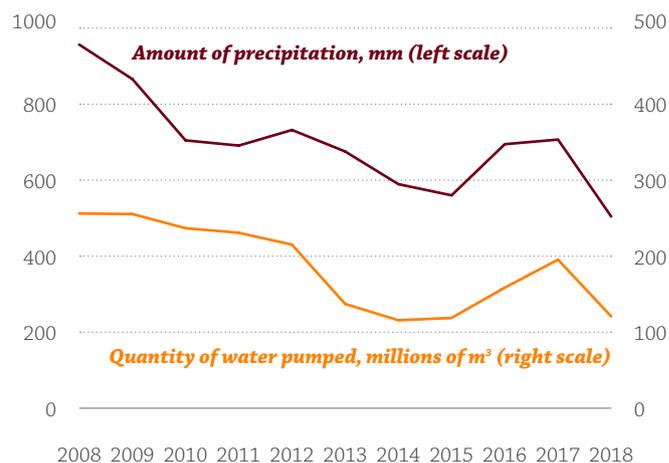
Water and the oil shale industry

Over the years, the impact of the oil shale industry on aquatic environments has decreased. Mines and quarries have to be kept dry during mining and the water is pumped into sedimentation pools for suspended solids to settle. Companies recover a majority of the water in the technological process or re-introduce it into nature. Compared to other mines elsewhere in the world, oil shale mining waters are significantly cleaner because the local water is not acidic and does not contain hazardous substances such as heavy metals.

Tax burden that increases with rain

The main source of mining water is rainwater and snowmelt. Rainwater accounts for about 80% of the water in opencast mines and 50% in underground mines. The rest of the water seeps in from groundwater and closed mines in the vicinity. As the mining water volumes depend directly on the amount of precipitation, companies have a hard time forecasting the amount of taxes they will have to pay the state for pumping the water out.

AMOUNT OF PRECIPITATION VS. AMOUNT OF WATER PUMPED IN THE OIL SHALE INDUSTRY



Source: National Weather Service, Environmental Board, oil shale companies



The undisputed tourism magnets in Ida-Viru County are the former oil shale industry features that are now successfully re-used by the Estonian Mining Museum, the Kiviõli Adventure Park and Aidu Veemaa water park. These key attractions were launched in cooperation between local activists and industry and there are no developments on a similar scale in neighbouring countries. We have already noticed the noteworthy growth of private sector investments into regional tourism and with support from the EU and public sector the attraction of the former “brown gold” mines for tourism will increase even further.

KADRI JALONEN

Tourism coordinator at the Ida-Viru Business Centre



According to the weather service, 2018 was the fourth driest year since 1961. This reduced the amount of water pumped out of mines significantly. During the year, a total of 122.4 million cubic metres of water was pumped out, which was 27.2% less than the year before. Pursuant to the corresponding Government of the Republic regulation, the fee for pumping water out of quarries was 19.87 euros and for mines, 55.41 euros per 1,000 m³. Thus, oil shale companies paid slightly less than 6.2 million euros in fees for the special use of water in 2018.

The most environmentally friendly use of water

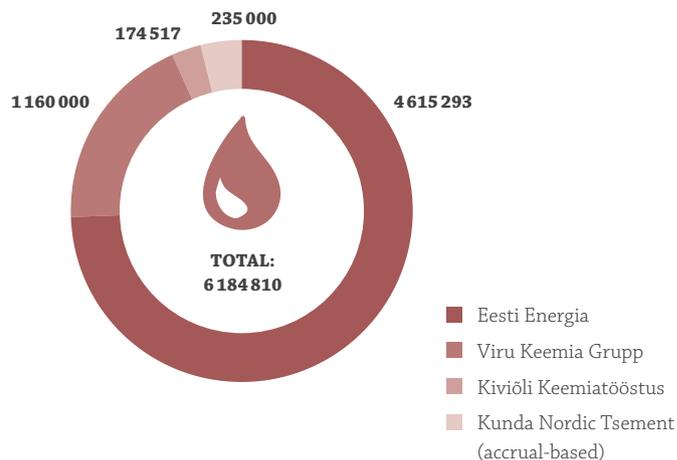
In 2018, Alutaguse Rural Municipality Council gave Eesti Energia permission to initiate a detailed plan for establishing a 50-mega-

watt pump hydroelectric plant at Estonia Mine. In what will be Estonia's first plant of its kind, one water reservoir will be built atop a hill and the other at a depth of at least 70 metres below ground. At times when the price of electricity is low, the hydroelectric plant will pump water from the mine uphill and the water will be allowed to flow back to the lower water reservoir when the price is higher. This unique plant works like a giant battery that stores potential energy in the upper reservoir. The construction works on the hydroelectric plant are expected to start a few years from now.

One focus for environmental investments by KKT in 2018 was prevention of water removal problems. The company renovated the

In 2018, oil shale enterprises paid 6.2 million euros into the state treasury for pumping out the mining water.

FEES FOR THE SPECIAL USE OF WATER PAID BY OIL SHALE COMPANIES IN 2018 (EUROS)



Sonda-Satsu road crossing, and built a new culvert underneath it. New mobile pumps will also ensure smooth removal of water when mining operations expand to the southern part of the quarry and during high water in spring, as the pumps can be easily relocated. Modern metering equipment installed will help maintain more precise account of the water that is pumped out.

A major project for cleaning the River Purtse

In 2018, the Ministry of the Environment kicked off a four-year-long environmental project, in the course of which one of Estonia's most polluted bodies of water will be cleaned of legacy pollution from the oil shale industry: the most polluted stretch of the River Purtse and the intake area of the river. About 14 hectares of phe-

nol-contaminated marshland will be cleaned up – the contaminated water will be collected and a new ditch system established. About 87,000 m³ of mud and soil contaminated with oil residues will be removed from Purtse and Kohtla rivers, Vahtsepa ditch and Püssi artificial lake. After they are cleaned up, the areas will be returned to a natural appearance. A 3-km stretch of the River Kohtla will also get a new riverbed.

Estonia's biggest project to clean up residual pollution up to 2022 will cost 21 million euros, which will be funded by the European Cohesion Fund, the Centre for Environmental Investments and the Estonian state.

The volumes of pumped-out water are directly proportional to the amount of precipitation, as rainwater makes up 80% of mining water in quarries and close to 50% in underground mines.

Emissions into ambient air

The goal of the European Union is to reduce by 2030 greenhouse gas emissions by 40% compared to the 1990 level. Today the European Union is halfway there, with emissions down by 22%. Improving the quality of ambient air has for years been one of the most important aims and challenges for oil shale enterprises.

The cleanest industry in history

Thanks to large-scale investments and setting of priorities, the emissions into the atmosphere from the oil shale industry have decreased despite increasing production volumes. In 2018, the oil shale industry was cleaner than ever before. Compared to five years ago, one-third less SO₂, one-fourth less NO₂ and 74% less solid particles enter the atmosphere. CO₂ emissions have dropped by 9% in five years.

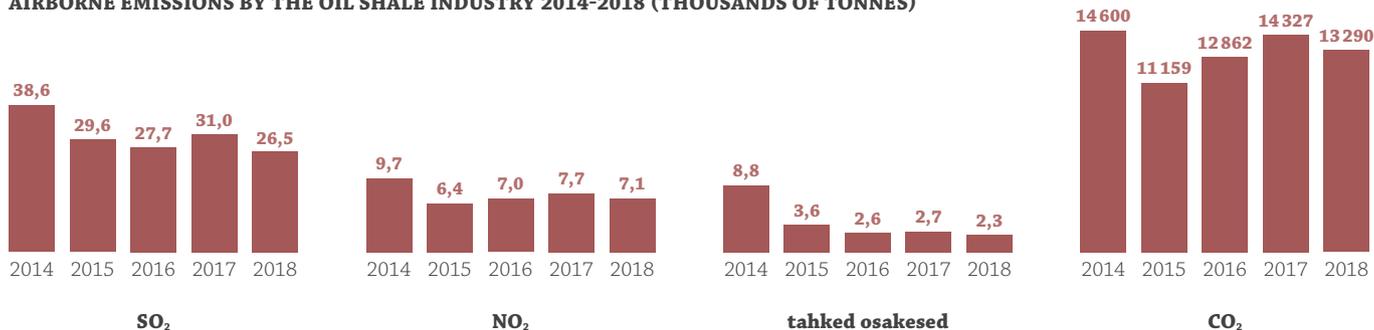
Millions allocated to improving air quality

In spring 2018, a 1.8-million-euro electrical filter was installed on solid-heat-carrier reactor smokestacks at KKT. The modern filter

significantly improves air quality in the Kiviõli area, as it reduces the fine particle and hydrogen sulphide content in smoke gases.

VKG became the first Estonian industrial enterprise to introduce an innovative solution for transport of by-products, directing semi-coke and ash from oil shale plants and factories to a landfill site using a special pipe conveyor. VKG transported ash to the landfill starting from the addition of the third Petroter plant in 2015, the semi-coke from Kiviter-process factories began to be transported starting in March 2018. The technology, which cost 1.5 million euros, will reduce the amount of dust and emissions and the result will be lower atmospheric pollution and a cleaner production territory and environment. The weatherproof conveyor system has a positive economic impact as well, as it reduces the need for trucks and will save as much as 583 litres of fuel per day. The pipe conveyor is narrower than an open conveyor, takes up less space and it can handle shaper curves and steeper grades.

AIRBORNE EMISSIONS BY THE OIL SHALE INDUSTRY 2014-2018 (THOUSANDS OF TONNES)



Kunda Nordic Tsement's data include all of the company's ambient air emissions, of which most are from combustion of WTE fuels.

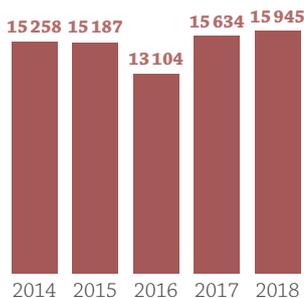
Major investment into cleaner air

In autumn 2018, the Environmental Board and the city of Kohtla-Järve approved VKG's action plan for reducing odorants. The company will invest 1.1 million euros into improving the quality of ambient air. As a result of the investments in 2018-2019, the odour emissions from production territory will be reduced by a planned 12%.

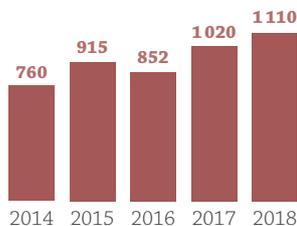
The approved plan has five measures. Three of them are geared at recovering emissions in various production equipment, as a result of which three sources of emission causing unpleasant nuisance odours will be completely eliminated. The fourth measure envisions making the hermetic seal tighter in regard to tanker truck loading equipment. This will help to reduce potential emissions during the loading process and make the loading process more environmentally friendly. As the fifth measure, a major project

will continue for improving the quality of ambient air in VKG's landfills. The supply of air will be cut off to smouldering areas and the exothermic process will thereby be halted.

In 2018, Enefit Energiatootmine fulfilled the oil industry nuisance odours action plan. To implement the goals of the action plan approved by the Environmental Board, the company invested over 4 million euros over four years. In the framework of the action plan, Enefit140 oil shale and heat carrier feeder equipment were renovated, gas flares were renovated, oxygen sensors were installed on electrical filters and a steam returner device for hydrocarbons was installed in oil products tank farm. In addition, a petrol purification device was built that will remove mercaptans and hydrogen sulphide, which have an unpleasant odour, from petrol and the ambient air monitoring station in the Auvere-Vaivara segment was launched.



kaevandatud põlevkivi



toodetud põlevkiviõli

Every year the oil shale industry invests millions of euros into improving the quality of ambient air.

Source: oil shale companies

Use of by-products of the energy generation process

The processing and valorization of oil shale generates limestone filler material (crushed limestone), and oil and electricity production generates ash. These are not worthless by-products but rather potential inputs for production for a second go-round. For years now, oil shale companies have dedicated themselves to finding new uses for crushed limestone and ash. This will reduce the environmental impact of the sector, besides being economically beneficial.

Modern recovery

The circular economy remains a focus topic of the oil shale industry. In the oil shale industry, it is seen as having great potential from the standpoint of environmental conservation and economic advantages. To this point, the use of fly ash in agriculture, construction material industry or polymer production, and in production of cement and cleaning of phenol-contaminated water has been noted as potential developments.

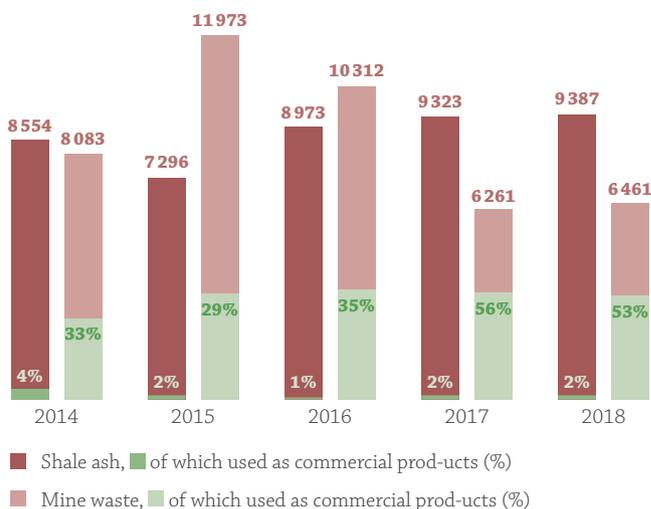
Introducing limestone into the circular economy

Oil-shale mining generates mine waste that is used for produc-

ing crushed limestone. Crushed limestone consists mainly of that mineral itself with a small quantity of oil shale. In 2018, the oil shale industry generated 6.46 million tonnes of crushed limestone, of which over one-half found a use in other fields. Through re-use, companies make a substantial contribution to reaching the target level for crushed limestone specified in the National Development Plan for the Use of Oil Shale 2016–2030.

VKG recovered a whopping 95% of the 2.3 million tonnes of crushed limestone generated from mining and valorization of oil shale in 2018. The overwhelming majority of this went to road construction and as filler material.

BY-PRODUCTS GENERATED BY THE OIL SHALE INDUSTRY (THOUSANDS OF TONNES) AND THEIR USE AS COMMERCIAL PRODUCTS (%)



PROPERTIES OF FLY ASH, CHALK AND TALC AS FILLER

	Fly ash	Chalk (CaCO ₃)	Talc
Needs drying	No	Yes	Yes
Needs processing	No	Yes	Yes
Needs to be made finer	To some degree	Yes	Yes
Density	2,4 g/cm ³	2,7 g/cm ³	2,7 g/cm ³
Percentage granular	85%	84%	50%

Source: Estonian Plastics Association

In 2018, Eesti Energia sent 300,000 tonnes of mine waste to the circular economy. In cooperation with the railway enterprise EVR Cargo, limestone was transported to different regions of Estonia. One-third of it reached Pärnu County for the Granite Centre, which supplies material for road construction. In future, Eesti Energia intends to recover a larger and larger share of the 5 million tonnes of limestone it generates each year. Limestone gravel is suitable for roads, large plazas, causeways and other massive sites as well as for resurfacing forest roads.

Eesti Energia supplied oil shale ash and crushed limestone produced from mine waste for the works along marshy areas of the eastern state border of Estonia.

Oil shale ash makes organic crops thrive

Fly ash is a by-product of the production of electricity from oil shale. It has high calcium content and it is harmless for the environment. In 2018, a total of 9.4 million tonnes of ash was generated by oil shale power plants of which only 1.9% – 175 000 tonnes – was recovered for a use in the construction and agricultural sectors and as a special cement for closing exhausted oil and gas fields in Siberia.

Each year, Eesti Energia's boilers generate a total of close to 7,000,000 tonnes of ash. In March 2018, the company set a

FLY ASH

Fly ash is a by-product of the filtering of smoke gases from the generation of electricity from oil shale. Special filters capable of collecting incredibly fine ash particles are installed in power plants to catch the high-calcium by-product.

monthly sales record – over 20,000 tonnes of ash. Of this amount, slightly over one-half was used in agriculture and the rest in the construction sector. To expand the applications of oil shale ash, Eesti Energia launched studies that will analyse the possibilities of using ash in plastic composites for increasing heat resistance and durability.

In 2018, Eesti Energia completed trials of its Enefix soil amendment, made from fly ash, on conventional and organic fields. The tests confirmed that fly ash had a positive impact on soil pH neutralisation and that it was good for use on organic fields as well.



Today we know how valuable a raw material fired oil shale is for the plastic industry and we know how to produce the material profitably – a complicated but entirely feasible process. What is required is for regulations and the attitudes in our heads to be changed. That is even harder to accomplish, but it is an essential prerequisite for starting production.

IVAR VIIRA

Managing director of ATI Profil





Energia

OIL SHALE

AND ESTONIAN SOCIETY

Oil shale industry's contribution to society

As the oil shale industry's operating environment improved, the companies began making a greater contribution to state revenue. In 2018, over 122 million euros in tax revenue flowed in from four companies in the sector, which is 18 million more than the year before. Over the year, oil shale industry companies contributed time and resources to continue and initiate new education, research and environmental projects and support community activities in Ida-Viru County.

Jobs for over 7,303 people

The oil shale sector continues to be one of Estonia's biggest employers. In 2018, the companies in the sector employed 7,303 people, which is 84 employees less than a year before. The sector's workforce taxes reached 42 million euros and the average gross wages rose by 3.6% to 1,576 euros. This is one-fifth more than the Estonian average and 50% more than the average gross wage in Ida-Viru County.

EMPLOYMENT IN THE ESTONIAN OIL SHALE SECTOR (2018)

Total employees	7 303
Average number of years worked	16
Average gross monthly wage (EUR)	1 576
Change in gross wage compared to 2017 (%)	+3,6%

In the annual survey conducted by the job site cvkeskus.ee, which drew 8,000 respondents, Eesti Energia was selected for the second year in a row as Estonia's most attractive employer. Respondents say the company offers good career opportunities, work with a high level of responsibility and competitive wages. They also gave good marks to the company's fairness, good reputation and possibility to pursue an important mission.



Ida-Viru County and oil shale are so intertwined that sometimes they see synonymous. Local government units have been connected to the oil shale industry both directly and indirectly. Where does mining take place and what are environmental charges used for? Where are the major employers located and where is personal income tax received? What are the places where you can smell and see smoke but tax receipts are meagre? Often one person's blessing is another person's misfortune. Undoubtedly, oil shale mining and valorization have an extremely important role in shaping Ida-Viru County's socioeconomic environment.

VEIKKO LUHALAID

Managing director of the Union of Ida-Viru County Municipalities



Contribution to education

Bright minds in energy

One of the missions of oil shale companies is to get young people interested in science and energy to ensure that the industry remains sustainable and growing years down the road.

In 2018, Eesti Energia rekindled cooperation with the civic initiative project “Tagasi Kooli“ (**Back to School**) and called on all employees to teach as guest lectures at schools. The goal of the company is to supplement the school curriculum with energy sector knowledge, skills and values to ensure a supply of future workforce. The company’s management members and specialists shared their experience with students in a total of 55 guest lecturers in Tallinn, Võru, Narva and Kohtla-Järve.

Nothing better than seeing with one’s own eyes

To introduce future generations to the allure of the energy world, VKG launched a project that opens the doors of the company to employees’ children and grandchildren. Twenty-five basic school students received a thorough initiation to the company’s work and took part in workshops and an exciting tour of the Petroter oil shale plant.

In autumn, a traditional VKG work shadow day took place, with upper secondary school students seeing what it was like for specialists to do their everyday work. The goal of the programme is to stimulate interest in teens about the economy and enterprise, demonstrate the connections between education and future career opportunities and help youths decide what educational goals to pursue and career to choose.

STEM

For the third year in a row, experts from different fields at VKG, Eesti Energia and Eastman offer a STEM elective programme for the 11th grade at Jõhvi Gymnasium. The course consists of lectures and tours of companies. Interest in the elective is growing with each year. In the first academic year, eight students opted for STEM but the next years there were 12 students and in 2018, 16 students were enrolled in the STEM programme.

Smarter than the smartest

In 2018, the most academically gifted upper secondary school students in Ida-Viru County again took part in a science-themed academic Olympics, the Five Schools competition held for the 53rd time. This year, the Ida-Viru dream team included students from various schools in Ahtme, Jõhvi, and Kohtla-Järve, who went head to head with other students in mathematics, chemistry and physics.

Recognition for the best

Oil shale companies continued the tradition of recognizing the most diligent students in the field by handing out scholarships. The Talented Youth Energy Fund established by Eesti Energia and Union of Ida-Viru County Municipalities awarded a scholarship to 50 outstanding young people from the region, totalling 9,950 euros. Besides the usual grants, Eesti Energia awarded a special scholarship in the fund’s anniversary call observed in spring 2018 for outstanding results in the science and technology field.

For 15 years now, VKG has provided scholarships to motivate the brightest students at TalTech to pursue careers that the group will need. In 2018, through the **TalTech Development Fund**, VKG

handed out scholarships to tech, chemistry and energy students worth a total of 10,600 euros. The VKG scholarship is available for TalTech and TalTech Virumaa College students in professional higher education, bachelor's and master's degree programmes.

With the support of Enefit Kaevandused, six diligent mining sector workers are studying at **Ida-Viru County Vocational Education Centre** in 2018. The company has supported the younger generation's studies for 10 years now to popularise the mining speciality and ensure a supply of future workforce.

The KKT scholarship was awarded to a fuel technology student at the TalTech Virumaa College.

Cooperation leads closer to the goal

In spring 2018, a cooperation project between VKG Kaevandused and Ida-Viru County Vocational Educational Centre completed developing a mining studies programme spanning 18 months. In the course of the project, the course was completed by 16 young specialists from Ojamaa Mine, who received, along with their graduation diploma, professional qualification as a mine worker.

During the year, KKT worked closely with both TalTech's Geology Institute and Kiviõli Secondary School No. 1. As part of various courses, students familiarised themselves with everyday life at the company and mining and received material for performing experiments. KKT also mined oil shale for the university project.

KKT specialists visited Ida-Viru County schools to introduce workforce needs and career opportunities. In cooperation with

the blasting company Voglers Eesti, students at Secondary School No. 1 in Kiviõli were taken to the quarry on a field trip where they could observe blasting work and learn about mining of oil shale and future trends.

In the autumn, a new lecture series started at TalTech's Virumaa College – “Strategic development in energy” – where a number of leading Eesti Energia employees shared their knowledge and experience of the development of energy, the role of the state, challenges for electricity and oil production, digitalization and renewable energy. The lecture series was also held in 2017 for TalTech students.

Enefit Idea Hub

To maintain competitiveness, Eesti Energia is always on the lookout for new ideas, which it collects in the **Enefit Idea Hub**. The platform gathers exciting and innovative ideas from employees, research institutes and start-ups. Experts from the company's different units sift out the best suggestions and the ideas that create the most value are developed into projects and receive support for their implementation. By the end of the year, the Idea Hub had received 791 ideas. The value of the projects initiated and implemented is now over 50 million euros.

Each year, the Ministry of Education and Research thanks education professionals and supporters whose work over the last three years has been a role model when it comes to supporting the development of students. For its longstanding contribution to developing the education sector, VKG advanced to the final round in the category “Friend of education”.

Supporting innovation and knowledge export

Estonia is one of the most important competence centres in the world in the area of oil shale. That is because of experience from a century of oil shale mining and valorization – know-how that is now exported successfully to other countries. Their unique know-how is the product of long-term cooperation with local top researchers and experts, investing millions into the energy sector for conducting research.

From CO₂ capture to natural resource exploration

The State Research and Development Support programme (RITA) continued with research in 2018 to identify the most expedient and innovative ways of using Estonia's natural resources and to give the state an input for planning future developments.

The Estonian Research Agency announced a competition in 2018 as part of the RITA program to study ways of capturing and using carbon dioxide to ease climate change. A TalTech led consortium won the competition and in the next two years will provide an answer as to whether CO₂ can be used as an input for Estonian industry or whether it is good economic sense to export it for

MORE THAN 60 YEARS OF OIL SHALE RESEARCH

Oil shale has been systematically studied in Ida-Viru County since 1958, when the Institute for the Scientific Study of Oil Shale was founded in Kohtla-Järve. The successor of research at the onetime Kohtla-Järve Oil Shale Institute is the fuels technology research and testing laboratory at TalTech's Virumaa College. In 2011, the Oil Shale Competence Centre was established here as a unit of the Virumaa College. It provides oil shale and chemistry services to companies and the public sector.

use in other countries' industrial sectors. The results of research costing close to 1 million euros yield valuable input for planning government institutions' activities as well as for the sector's companies, universities and research institutes for further research.

A consortium led by the Estonian Research Agency and the University of Tartu (UT, TalTech and the Estonian Geology Centre) continued a research project with a 1.26 million euro budget as part of RITA to study more efficient and cleaner and more sustainable ways of using natural mineral resources. Four oil shale-related topics are being studied as part of the consortium's research:

- the positive impact of Estonia's primary natural resources on economic growth as well as their negative impact on the natural and living environment;
- forecasts regarding future mines and their environmental impact; suggestions are mooted as to how to make mines more environmentally and resource efficient to comply with tighter environmental protection conditions;
- changes in the composition of solid fuels resulting from the adoption of new technologies, along with their impact on waste handling upon landfilling and recovery and re-use;
- the possibilities of bioleaching in terms of extraction of metals from the graptolitic argillite widespread in northern Estonia.

The research results should be published in 2020.

Researchers in the science and technology fields at TalTech and the University of Tartu launched a new RITA programme cooperation project in 2018 to study the potential for applying innovative technologies for sustainable use of oil shale for production

of gas and oil. The goal of the study, which spans three years and has a budget of 243,000 euros, is to analyse the properties of the industry's by-products and potential for valorization to increase the environmental friendliness and economic cost-benefit of the technologies and assess the impact on the environment.

Smart decisions with models

In 2018, researchers in two working groups at the University of Tartu completed environmental geology models that correspond to the actual geological situation of Viru County. The models can be used to assess the environmental impact of mining based on the scope of mining and to test the effectiveness of remedial measures. The report notes that by closing mines one part at a time, they can be divided into smaller segments that are hydraulically separated from each other. It is important from the standpoint of reducing environmental impact both during mining and after mine closure. The isolated parts allow groundwater to rise to different levels, reducing sulphate formation in the area being drained and preventing flooding problems in lower-lying areas.

Introducing more by-products into the circular economy

The Estonian oil shale industry generates about 9.4 million tonnes of oil shale ash per year, of which only a small fraction is re-used. Current rules classify fly ash as a hazardous waste, which imposes major restrictions on its use. Yet there are several different categories of ash, as it is generated by different processes – circulating fluidized bed and the older dust-fired technology, as well as in production of shale oil using different methods. The TalTech and the University of Tartu have been commissioned by the Ministry of the Environment to study the properties of different kinds of



Over the four years of activity, the technical committee EVS/TK 57 has invested into preparation of transposition of international standards to Estonian environment and updating original standards in the field. The adoption of four international standards in Estonia and the process of drafting of two original standards have been successfully completed. Even now, new Estonian standards are being compiled and preparations being made for transposition of international standards. EVS/TK 57 keeps up to date with the oil shale field and general principles and processes of standardisation and serves as a liaison and resource for anyone interested in standards in this field.

MARTIN MERIMAA

*Head of standardisation department
at the Estonian Centre for Standardisation*



shale ash to determine which of them, if any, should be classified as hazardous waste.

Eesti Energia, Rail Baltic Estonia and the TalTech entered into an agreement on cooperation for studying the potential for re-use of crushed limestone and ash generated at Estonia Mine. Researchers at the TalTech institutes of construction and architecture and geology and business affairs institutes will start studying the suitability of oil shale by products, economic expedience and potential volumes of use in important projects for Estonia such as the construction of the Rail Baltic project.

Organised and up-to-date standards

Since 2015, the Oil Shale Competence Centre at TalTech's Virumaa College is coordinating the technical committee on processing of oil shale and oil shale products (EVS/TK 57) set up at the **Estonian Centre for Standardisation**. It includes VKG, Eesti Energia, KKT, the Estonian Centre for Environmental Studies, the Estonian Mining Society and TalTech together with the Oil Shale Competence Centre.

The purpose of the standards is to organise and harmonise the principles for activities in the oil shale sector and support development in labs. Today, five standards have appeared in print, among them new developments of original Estonian standards and adapted versions of international ISO standards with Estonian comments.

Three standards were drafted and published in 2018 in the oil shale sector and the development of three additional standards was launched.

STANDARDS PUBLISHED IN 2018

EVS-ISO 587:2018 Solid mineral fuels. Determination of chlorine using Eschka mixture.

Revision of the international standard ISO 587 that deals with determination of chlorine content in oil shale, coal, brown coal, lignite, and coke, using the Eschka method. The standard includes addenda corrigenda that allow chlorine content to be determined also in oil shale and semi-coke.

EVS-ISO 562:2018 Hard coal, coke and oil shale. Determination of volatile matter.

Revision of international standard ISO 562:2010 that includes addenda and Estonian comments that allow the volatile compound content in oil shale to be determined on the basis of the standard. Modified edition of the standard in the context of oil shale is necessary for better organising the work of research labs.

EVS 668:2018 Oil shale. Determination of moisture.

Revision of an original Estonian standard describing the determination of total moisture in oil shale using the two-stage and single-stage method, the analytical moisture determination method and the procedure for preparing samples. Moisture can be determined both in a commercial oil shale sample and in layer samples taken for the purpose of natural resource and technological study, drill cores, valorization residue and other oil shale samples taken and prepared in conformity with the standard applicable to the samples. The standard is valid for oil shale regardless of the location of the deposit of origin.

STANDARDS BEING DRAFTED:

EVS-ISO 334:2019 Solid mineral fuels. Determination of total sulphur using Eschka method, which is a revision of international standard ISO 334:2010

EVS 668:2018 Oil shale. Determination of moisture (English-language translation of the original Estonian standard)

EVS 664:2017 Solid fuels. Sulphur content. Determination of total sulphur and its bonding forms (English-language translation of the original Estonian standard)

SELECTION OF SPECIFIC OIL SHALE STUDIES

Research and development ac-tivity	Performed by	Funding source
Turning fly ash into valuable raw material	TalTech	EIT (Raw Materials)
Principles for handling multi-component mineral organic systems: chemistry, modelling and sustainable use	TalTech	Estonian Research Agency
Applied research into microbiological processing of oil shale and semi-coke	TalTech	European Regional Development Fund
Study of the hazardousness of oil shale ash types	TalTech	Ministry of the Environment
Use of the calcium cycle for pro-duction of CO ₂ free cement clinker	TalTech	European Commission
New technological platform for oil shale kerogen valorization. partial oxidation into dicarboxyl acids and further transformation into valua-ble derivates of dicarboxyl acids	OÜ Kerogen, performed by TalTech	Archimedes
Novel sulphur-tolerant electrodes with invertible functionality for solid oxide fuel cells	University of Tartu	Estonian Research Agency
Novel laser absorp-tion ionization high resolution mass spectrometry approaches for study of complex samples	University of Tartu	Estonian Research Agency
Division of oil-shale region swamps and bogs	University of Tartu	Centre for Environmental Investments
Carrying out biomonitoring among the population pertaining to the oil shale sector (employees and residents), preliminary study – identi-fi-cation of biomarkers	University of Tartu	Health Board
Developing and implementing methodology for finding correla-tions between ambient air state and childhood asthma and other allergy diseases in areas affected by oil shale industry	University of Tartu	Health Board
Determination of preferred areas for oil shale mining on the basis of the natural environment and economic conditions	SA Poliitikauringute Keskus Praxis, AS Maves	Centre for Environmental Investments
Acquisition, installation and con-figuration of a continuous smoke gas measurement system for KKT oil production equipment for relia-bly measuring carbon dioxide, sol-id particles and hydrogen sulphide	KKT Oil	Centre for Environmental Investments
Aerial supervision of mining activity	Land Board	Centre for Environmental Investments
Raising awareness in the field of mineral resources	Ministry of the Environment	Centre for Environmental Investments
Handling of leachate and polluted rainwater in Kohtla-Järve industri-al waste and semi-coke landfill 2018–2019	Ministry of the Environment	Centre for Environmental Investments
Post-monitoring and maintenance of the Kohtla-Järve industrial waste and semi-coke landfill 2018–2019	Ministry of the Environment	Centre for Environmental Investments
Recovery of oil shale fly ash as a hydraulic binder for strengthening soft soils	IPT Projektijuhtimine OÜ	Centre for Environmental Investments
Environmental impacts of possible mining of Virumaa natural resources on groundwater and surface water and the landscape analysed with environmental and geological models together with alternative alleviatory measures	University of Tartu	Centre for Environmental Investments

Giving back to the community

For years, oil shale companies have sought to life better in Ida-Viru County and preserving local traditions. What is particularly impressive is the ever increasing personal contributions made by employees in the sector to improving the community through participating in forest planting actions, helping with yard work at nursery schools and supplementing the blood bank as donors.

New life for industrial buildings

Together with the Estonian Academy of Arts and TalTech, KKT initiated the project “Abandoned landscapes” to find a new life for valuable historical industrial buildings on KKT’s territory. University students suggested ideas for giving intriguing buildings new life. A lecture day and workshops were held for art university students and as a result, students came up with four conceptual designs. KKT also dedicated to the project the traditional chemists’ day celebrations where students of Academy of Arts presented their original ideas to the public.

ONE HUNDRED YEARS OF OIL SHALE INDUSTRY

The first written record of “burning earth or rock” found in Estonia can be found in annals of history in 1788, but it was soon forgotten due to the existence of cheaper alternatives. The topic came up again because of the fuel crisis of the First World War and in the post-war years, the industry began to be developed.

One hundred years ago, on 25 November 1918, the Estonian Provisional Government under the future State Oil Shale Industries director Märt Raud established state control of the Kohtla oil shale mine from German occupation forces. Up until the Second World War, the date is considered the birth date of the Estonian oil shale industry. This laid the preconditions for Estonia to develop from an agrarian to an industrialised country, along with all the problems and possibilities this meant.

The project that was selected as the most successful was Priit Ingver’s and Kaja Sepper’s project “Kuidas Kalevipoeg kivist õli välja pigistas!” (How epic hero Kalevipoeg squeezed oil out of a rock) focusing on creating a public area for locals. A former industrial area with long disused factory buildings will be turned into a modern urban park with clubhouse, story wall, conference centre, outdoor café, a handcar track and military-style adventure course.

Thanks to miners and chemists

At the end of the summer, one of the most beloved and oldest events in Ida-Viru County took place under the leadership of Eesti Energia and VKG, which each year draws thousands of regional inhabitants who have been or are currently tied to the oil shale industry. The community festival recognized miners, and there was a cultural programme for both young and old with the public squaring off in a number of sport events.

VKG held a traditional chemists’ day in Kohtla-Järve’s park. This time there was a charity run and a big public celebration.

Maidla Manor Park was the venue for Lügänuuse Day, which started with a grand procession and was sponsored by VKG. At this key community event, owners of the most attractive homes in the area were awarded prizes and several ensembles performed. The day culminated with a major lottery, the prizes for which were sponsored by KKT’s parent Alexela Group.

Sports and health hand in hand

In June, over 4,000 sportsmen and -women from all counties in Estonia and 14 foreign countries gathered for Ida-Viru County’s

largest public sports event, the running event **Narva Energiajooks**. Eesti Energia offered an exclusive track through the historic Kreenholm textile mill. The top men's finisher was Kenyan Dominic Kiptarus, who set a new course record for the half-marathon, 1:03:55. The top woman was Estonian Olympian Leila Luik. Narva Energiajooks is an event started by Eesti Energia, the Narva City Government, the Ministry of Culture, and the Sports Events Organisation Club, aimed at encouraging people to get active in sports and raise Ida-Viru County's importance on Estonia's cultural and sports landscape.

KKT continues to make a special point to support young footballers in Ida-Viru County. For years, the company has helped young footballers to take part in games abroad. With support from KKT, the Kiviõli football club Irbis was able to travel to Germany for the Munich Summer Cup 2018, which was contested by 83 teams from 14 countries. In 2018, KKT's became the sponsor of 14-year-old running sensation Luna-Aleksandra Lagoda.

For several years now, VKG works with the blood service of Ida-Viru County central hospital VKG in organising a blood drive for the company's employees. In 2018, VKG employees donated 42 litres of blood – which is 35% more than a year before. VKG contributed even more to the healthcare sector – instead of making corporate gifts to partners, it supported Ida-Viru Central Hospital's paediatric ward in acquiring a vital piece of equipment.

Together, we can do even more

As part of **Let's Do It Estonia**, 71 KKT employees with their children planted 7,000 young pine trees at Põhja-Kiviõli I oil shale opencast and tidied up the area's parkland.

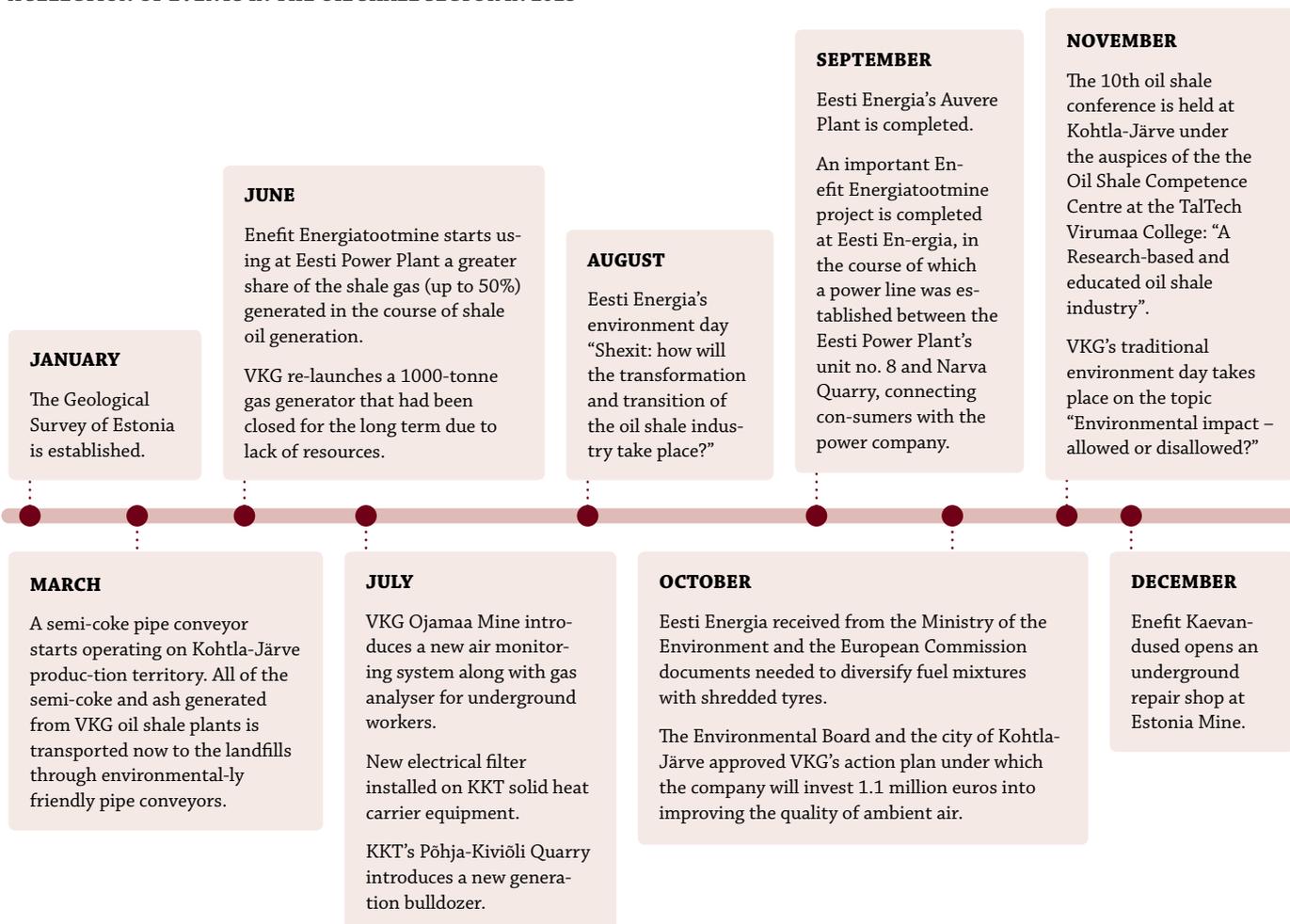
At Eesti Energia employees' traditional community work day at Äkkeküla, Narva, recreational trails and stretching and climbing equipment at Pähklimäe were cleaned up. Also, 200 young trees were planted.

At VKG's traditional community service days, the company staff cleaned up their own grounds and helped Kiikla children's home perform spring yard work. Gardens were established, potatoes were planted and the yard and manor park were cleaned up.

“Põnekvivikaevandus” at the adventure park

In summer 2018, Kiviõli Adventure Centre opened a new family adventure park where one attraction is called Põnekvivikaevandus (a play on the Estonian word for oil shale). Six excavators and an information wall that tells the story of the large ash hill can be viewed. The adventure centre won the best tourism attraction in northern Estonia in 2018 and was picked as the favourite adventure for people in Ida-Viru County.

A SELECTION OF EVENTS IN THE OIL SHALE SECTOR IN 2018



Estonian oil shale industry in 2018:

Income
into the state treasury

122

million euros

Total
investments

116

million euros

Investments
into the environment

55

million euros

Positions
for

7303

people

Sales
revenue

772

million euros

In comparison with 2017:

The average
oil price

+31%

Income into
the state treasury

+17%

Production
of shale oil

+9%