

An aerial photograph of a vast, dense forest in Estonia. A straight road runs vertically through the center of the image, flanked by thick green trees. To the right of the road, a river flows through a valley, its water a striking turquoise color. The sky above is filled with large, white, fluffy clouds, and the overall scene is bathed in bright, natural light.

# ESTONIAN OIL SHALE INDUSTRY

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YEARBOOK  
2017



**The yearbook of the Estonian oil shale industry was issued by:**

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Cover

VKG's 12.5 kilometre above-ground oil shale conveyor (Arvo Juhkov)

p. 6

VKG Energia's production territory in Kohtla-Järve (Arvo Juhkov)

p. 12

Narva Quarry (Eesti Energia)

p. 24

Aseriaru wind farm (Aleksander Kaasik)

p. 34

2017 Miners' Day at Kohtla-Nõmme (Matti Kämära)

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# ESTONIAN OIL SHALE INDUSTRY

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YEARBOOK 2017

Statements from heads of companies and organizations in the oil shale industry. . . . . 4

**ROLE OF THE OIL SHALE INDUSTRY IN THE ECONOMY**

State revenue from the oil shale industry. . . . . 8

Competitiveness of the oil shale industry. . . . . 9

Operating framework in Estonia. . . . . 10

**OIL SHALE VALUE CHAIN: FROM MINING TO END PRODUCTS**

Mining permits and volumes. . . . . 14

Electricity . . . . . 17

Liquid fuels . . . . . 19

Heat . . . . . 22

Fine chemical industry . . . . . 23

**OIL SHALE INDUSTRY AND THE ENVIRONMENT**

Investments into the environment . . . . . 26

Restoring the landscape. . . . . 27

Emissions into ambient air . . . . . 28

Water in the oil shale industry . . . . . 30

Uses for by-products of the energy generation process . . . . . 31

**OIL SHALE AND ESTONIAN SOCIETY**

Oil shale industry’s contribution to society. . . . . 36

Supporting education . . . . . 37

Supporting innovation and knowledge export . . . . . 39

Giving back to the community . . . . . 43

## Estonian oil shale industry in 2017

Income  
into the state treasury

103

million

Total  
investments

70

million

Investments  
into the environment

31

million

Positions  
for

7387

people\*

Sales  
revenue

663

million

## Estonian oil shale industry in 2016

Income  
into the state treasury

103

million

Total  
investments

63

million

Investments  
into the environment

26

million

Positions  
for

6400

people

Sales  
revenue

606

million

## Estonian oil shale industry in 2015

Income  
into the state treasury

120

million

Total  
investments

199

million

Investments  
into the environment

82

million

Positions  
for

7411

people

Sales  
revenue

669

million

*\*As of 2017, Eesti Energia's jobs figures are calculated based on new principles, and the figure also includes the company's central services and Enefit Solutions*

## A competitive oil shale industry

At Eesti Energia, we have been moving for years toward more efficient and cleaner production, having invested into new technologies and modernized equipment.

In 2017, we adopted full use of the new and more efficient longwall mining method at Estonia Mine. We conducted successful trials for use of a currently environmentally problematic material – old tyres – as a raw ingredient for generating energy, and we launched equipment for refining shale petrol, which raised the quality and value of the petrol. One of the most important investments for large energy installations was related to the renovation of energy unit no. 8 of Estonia power plant, which helps to enhance oil shale, as less oil shale and more by-products of liquid fuel production – shale gas – are expended on generating electricity.



**Hando Sutter**  
*chairman of the  
management board  
of Eesti Energia*

We are proud that the Ministry of the Environment named Eesti Energia the company with the most environmentally friendly production process in 2017. We received recognition for using by-products of the oil shale industry in the circular economy and for establishing a clean and efficient sedimentation basin.

Yet the crowning achievement of 2017 was undoubtedly the Jordanian power project, which received USD 2.1 billion in funding. It shows that Estonia has unique competencies for processing oil shale and that the expertise is needed in the rest of the world. Our projects of yesterday, today and tomorrow are all aimed at making Estonia's R&D based energy sector better able to compete on the global market.

## The oil shale industry is looking to the future with high expectations

In 2017 the oil shale industry thrived thanks to a growing world economy. Heavy industry appears as if it is making slow progress, but in fact it is dynamic and undergoing rapid changes. The growth of environmental awareness is imposing additional frameworks on industries. Domestic growth in workforce expenses and the shrinking working-age population is leading companies to embrace robotics. Digitalization of industry is bringing more and more people from the IT and computerization fields to work for the oil shale companies, alongside the traditional industrial technologies.



**Ahti Asmann**  
*chairman of the mana-  
gement board of Viru  
Keemia Grupp (VKG)*

The day before yesterday, electricity and oil was produced from oil shale. Then it was yesterday, when oil and electricity were produced from oil shale. Today, we produce – in an environmentally clean manner – marine fuel and crude petrol for refineries, bitumen, coke, industrial steam, heating water and fine chemicals. Tomorrow is full of excitement and anticipation, big plans and new ideas that are still under wraps. 2018 will show which of them will become a reality.

## The oil shale industry awaits stability

For Estonia's oil shale industry, 2017 was still a complicated period. The price of shale oil did show signs of rising and was better than in a few past years. Yet the price level was under the profitability threshold and thus did not ensure the sustainability of the sector. The market was characterized by high volatility and prices fluctuated by a whole 33%. Oil shale companies tried to use future transactions to adjust to the situation, but the market's instability was expressed in the prices of those instruments as well.



**Andreas Laane**  
*chairman of the  
management board  
Alexela Group*

The current legislation also feeds uncertainty about the future. In 2018, it is not clear what will become of the taxes related to the shale oil industry. Since 2016, the state has significantly raised the price of inputs: fuel excise rates and the market prices of CO<sub>2</sub> allowances have risen. Thus, companies lost out on

the entire effect of the price rise due to the inputs rising in cost.

To cope with the situation and ensure survival of the industry, the entire oil shale sector has constantly sought to become more efficient. Every enterprise aims to reach better results with fewer resources. Over the last three years, Kiviõli Keemiatööstus has increased its production capacity by more than 20%.

In the years ahead, we expect stability in both the market price and taxation environment. The market has started showing signs of quieting, and we hope that our legislators will also move to ensure stability. This is a precondition for placing continuing investments and maximizing the value of Estonia's most important natural resource.

## Enhancement ensures competitiveness



**Kalle Pirk**  
*director of the Oil Shale  
Competence Centre at the  
Tallinn University of Tech-  
nology Virumaa College*

The most gratifying development for the oil shale sector in 2017 was the increase in market prices for shale oil. This is a primary factor for sustainability of the sector. Although companies cannot influence it, it has allowed them to increase investments in development activities related to production efficiency, product quality, and reducing environmental impacts.

In recent years, companies and scientists alike have focused on improving the quality of oil shale products,

developing new products and expanding the applications of by-products. These goals can be summed up with one word – enhancement, which is the cornerstone of the competitiveness of the industry.

Standardization plays an important role in the long-term development of the oil shale sector. Estonia's specialists have a key role in developing and updating standards by taking into account the special features of the sector.







ROLE OF THE OIL SHALE

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INDUSTRY IN THE ECONOMY

# State revenue from the oil shale industry

2017 brought some relief for the oil shale industry as the world economy enjoyed improved growth. After a low point in 2016, markets saw a return to a rising trend. The price level of electricity and liquid fuels improved significantly. The average price of Brent crude rose by 20% compared to 2016.

Similarly to 2016, oil shale companies paid EUR 103 million into the state treasury, of which the lion's share was in the form of resource and pollution charges and taxes on the workforce.

## 70 million euros into industry

As the market situation improved, industrial development projects gained momentum. In 2017, four oil shale companies invested close to EUR 70 million into innovation and new technologies.

## Oil shale products for export

The energy sector has a significant influence on economic growth and exerts a positive impact on Estonia's foreign trade balance. Statistics Estonia reported that the greatest influence on the export of goods came from export of chemicals and chemical products. The export of oil shale products has doubled in the last five years. In 2017, a total of EUR 100 million of light oils, fine chemical products, bitumen, coke, phenol resins and other products derived from oil shale were exported.

In addition, for the first time, production of shale oil topped one million tonnes in 2017. Of this, around 90% – a total of EUR 270.4 million – was exported. Production of electricity from oil shale, which showed signs of a declining trend in the last few years, is again on the ascendant, reaching the 2013 level (10 TWh). Although export of electricity has decreased somewhat in recent years, over one-half of the electricity generated in Estonia was sold to neighbouring countries in 2017.

## THE ESTONIAN OIL SHALE INDUSTRY

### IN FIGURES IN 2017

	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 2017 (millions of EUR)***
Companies related to Eesti Energia's oil shale industry	435,3	4 900*	11 157	7,9	72,0
Companies related to Viru Keemia Grupp's oil shale industry	148,6	1 700	3 239	8,7	21,3
Kiviõli Keemiatööstus	30,9	600	1 164	8,2	5,9
Kunda Nordic Tsement	48,3	187	74	8,1	4,1
<b>TOTAL</b>	<b>663,2</b>	<b>7 387</b>	<b>15 634</b>		<b>103,3</b>

\* 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

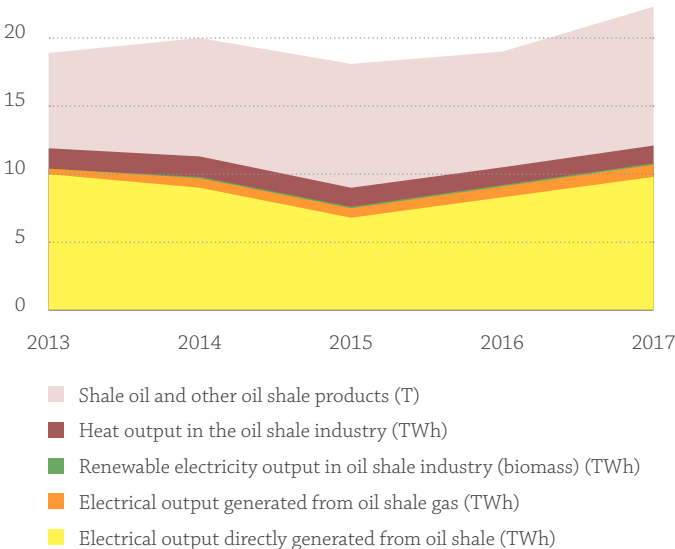
# Competitiveness of the oil shale industry

## Estonia is still the most energy-independent country in the world

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.

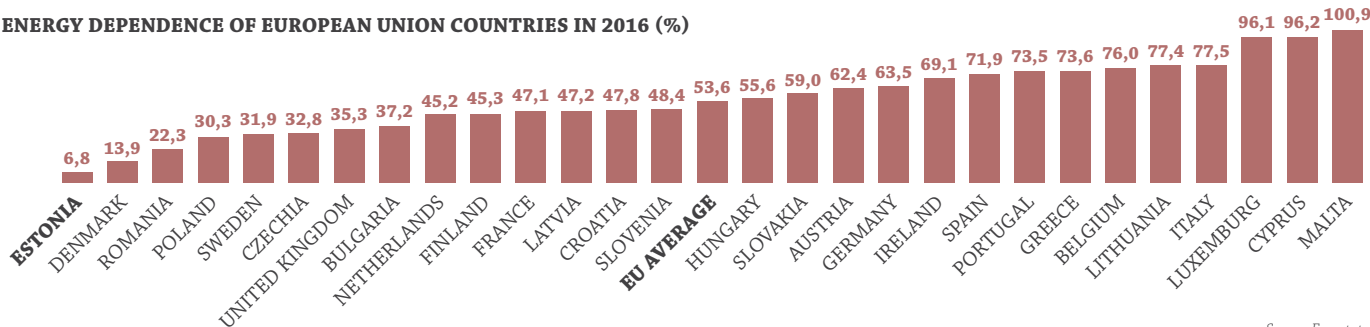
Estonia's energy independence has been growing year in and year out. In 2013, the state's energy dependence was approximately 12%, but had dropped below 7% by early 2017. This was made possible solely due to the strong domestic energy industry. Imported energy sources are consumed increasingly less. Compared to five years ago, the consumption of natural gas, on which Estonia is 100% energy-dependent, has fallen by close to 40%. The purchasing of electricity from foreign countries has decreased by close to 60% in the last few years.

ENERGY OUTPUT OF OIL SHALE ENTERPRISES, 2013–2017



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

ENERGY DEPENDENCE OF EUROPEAN UNION COUNTRIES IN 2016 (%)



Source: Eurostat



# Operating framework in Estonia

In 2017, various important changes took place in the operating framework of the oil shale industry with the aim of supporting the maximum enhancement of the country's most essential natural resource and a reduction in the accompanying environmental impacts.

## **Fundamental principles of the subsurface mineral resources policy up to 2050**

In June 2017, Parliament adopted the fundamental principles of the subsurface resources policy. The document seeks to ensure the sustainable use of mineral resources and maximum value for society, taking into account socioeconomic, security, geological and environmental impacts at the same time.

The strategy document declares that investigations into the volumes and quality of Estonia's potential mineral resources have been insufficient. There is a need to continue research activity that gives an overview of existing resources, possibilities of enhancing them, the geo-risks and potential impacts on the environment and health. On the basis of the information received, we can plan the introduction of new natural resources, water supply, waste management and establishment of infrastructure and environmental impact assessments.

The document prioritizes the forging of a close bond between R&D and the needs of the state. This requires appropriate infrastructure at universities for study and research.

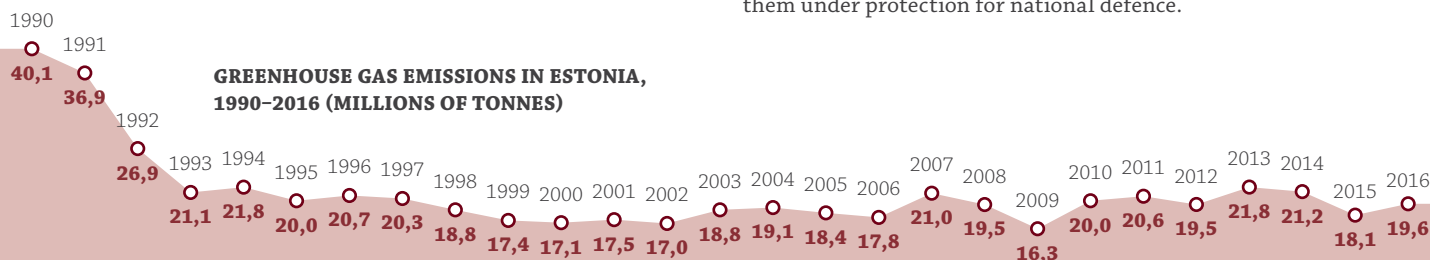
## **The new Earth's Crust Act**

In 2017, a new Earth's Crust Act entered into force in Estonia. It aims to ensure the sustainable and economically expedient use of natural resources, while reducing significant adverse effects for the environment.

The newly enforced Earth's Crust Act has left unchanged the oil shale mining allowance of 20 million tonnes per year as well as the right to extract the oil shale retroactively within seven years following the year when the quantity failed to be extracted.

Under the new legislation, the Environmental Board takes over from the Ministry of the Environment as the issuer of exploration and mining permits. When applying for a mining permit, the company must set out an analysis of the socioeconomic impact of activities related to oil shale.

The legislation also provides for an additional possibility of establishing roads and railways on top of mineral deposits or place them under protection for national defence.



### **Fundamental principles of Estonian climate policy up to 2050**

In April 2017, Parliament adopted a document outlining the vision of the fundamental principles of climate policy up to 2050. Estonia's long-term objective is to make the transition to a low-carbon-emission economy, which means gradually transforming the economic and energy system into a more resource-efficient, productive and environmentally cleaner one.

By 2050, Estonia aims to reduce greenhouse gas emissions by close to 80% compared to the 1990 level. By 2050, the amount of emissions would drop by close to 8 million tonnes from the current 21 million tonnes in CO<sub>2</sub> equivalent. Impact assessment from a few years ago showed that the goal is feasible and that it will have a likely positive impact on the economy and energy security.

### **Geological Survey of Estonia focuses on research**

In April 2017, the Geological Survey of Estonia (Eesti Geoloogia-teenistus) was established. The function of this government department is to study what natural resource reserves Estonia has and where they can be mined most expediently in light of environmental protection and economic considerations. The findings allow the Geological Survey to make proposals for officially recognizing reserves and issuing resource use permits.

### **Oil shale and the Estonian economy**

E&Y Baltic conducted a study commissioned by the Government Office and the Ministry of Finance on the optimum fees charged on oil shale. The study was published at the beginning of 2017. The

purpose of the study was to determine: what should government intervention be like in 2018–2050 to allow the Estonian economy to gain the maximum benefit from the oil shale resources.

Although the study concluded that above all, the sector was impacted by the price of heavy fuel oil, electricity and CO<sub>2</sub> emissions rights on the world market, much does depend on owner's fees – i.e. how the state taxes resources and environmental impact.

The analysis found that keeping the charges on oil shale low will help to maximize the state's revenue from the oil shale sector as a whole. Also, the price of oil shale needs to be linked to the price of electricity and heavy fuel oil. The same scheme applies to companies now as well and will continue until 2019 when the new pricing model for oil shale will be completed.

### **OECD wants a greener Estonia**

In March 2017, the Organisation for Economic Cooperation and Development (OECD) published an overview of the performance of Estonian environmental policy. The OECD praised Estonia for making noteworthy progress toward decoupling economic growth from air pollution and energy consumption. At the same time, the Estonian economy is still carbon- and energy-intensive due to the dependence on oil shale.

The OECD recommended that Estonia speed up its transition to a low-carbon economy, and make its goals connected to the productivity and environmental impact of oil shale mining more ambitious.





OIL SHALE  
VALUE CHAIN:

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FROM MINING  
TO END PRODUCTS

# Mining permits and volumes

## A half century of oil shale

Oil shale exploration and mining has spanned an entire century. During this time, slightly over a billion tonnes of oil shale have been mined in Estonia. Of the current 4.8 billion tonnes in oil shale reserves, there is 1.3 billion tonnes of active oil shale remaining that can be mined without restrictions. If oil shale continues to be consumed at current rates and is mined efficiently, Estonia will have enough reserves to last yet another half a century. Estonia's "brown gold" can be a source of energy for even longer if new technologies are introduced to enable mining of oil shale deposits that are currently inaccessible due to geological conditions and restrictions.

Estonia's two main oil shale deposits are located in north-eastern Estonia. The thickest oil shale strata lie in an area between Rakvere and Narva, in the so-called "Eesti" site, where industries have established both underground and opencast mines to access the up to 2.9-metre-thick oil shale layer. To extract the oil shale layer that is up to 2.9 metres thick, companies have developed both underground mines and strip mines. Because the oil shale in the so-called Tapa site between Väike-Maarja and Ambla is of low quality and lies deep, no oil shale is currently being mined there.

## Mining volumes highest in years

In Estonia, four companies have a permit to mine oil shale: Eesti Energia (EE), Viru Keemia Grupp (VKG), Kiviõli Keemiatööstus (KKT) and Kunda Nordic Tsement (KNT). In total, these companies mined 15,6 million tonnes of oil shale in 2017, which is a six-year high. It makes up 78% of the 20 million tonne annual mining level permitted by the state. Eesti Energia is allowed to

mine 15 million tonnes of geological reserves a year, VKG 2.8 million tonnes, KKT, close to 2 million tonnes and KNT, 0.2 million tonnes.

In 2017, Eesti Energia used its existing oil shale stock in production and mined 11.2 million tonnes of oil shale, which is 74% of the company's annual rate. Most of it was used to produce heat, power and shale oil. As the first and only company to do so, VKG used the oil shale allowances carried forward from previous years. In 2017, the company extracted 3.2 million tonnes of oil shale, which was 117% of the annual allowance. VKG produced oil products, chemicals, various chemical products and heat and power. KKT, which produces shale oil products, mined 1.2 million tonnes of oil shale, which is 59% of the annual allowance. The company with the lowest mining volume is Kunda Nordic Tsement, which used oil shale mainly as a fuel in the cement production process. In 2017, the company mined 74,000 tonnes of oil shale.

### MINING METHODS

- **Opencast mining** – in places where the oil shale layer lies up to 30 metres deep, the oil shale is mined in opencast mines, after removal of the overburden.
- **Underground mining** – if the oil shale layer lies deeper than 30 metres, an underground mine has to be built – mine shafts have to be established, reinforced and the necessary systems for extracting the rock put in place.

For several years, KKT and VKG have worked toward opening a new joint oil shale mine in Sonda. In 2017, the companies submitted amendment proposals for evaluating environmental impact and meetings took place with government officials, developers and experts. The opening of joint mines is a more reasonable proposition based on economic considerations as well as from the standpoint of mining technology and environmental protection.

### More effective technology

In spite of the complicated market situation, oil shale enterprises continued investing into technologies to make mining more efficient and cleaner for the environment. Early in the year, Eesti Energia introduced a unique improved longwall mining technology, which increases the production capacity by almost 800,000 tonnes a year.

In the North-Kiviõli II oil shale opencast, KKT is moving into an area where the deposit is thicker. Thus, there is a need for more efficient equipment and methods. In 2017, the company launched tests to find the most suitable out of various rock-breaking methods. The effectiveness of bore demolition and its appropriateness for opencast conditions was tested. The significantly more powerful XR82 Xcentric ripper was also tested. The trials were successful and the new-generation ripper will soon be added to KKT's equipment line-up.

In 2017, VKG invested over EUR 10 million into modernizing technology and improving production processes. Around mid-year, extensive works were carried out for upgrading VKG Oil's oil plants based on the Petroter technology. Along with the new VKG Energy boiler, these projects will allow the effectiveness of production throughout the group to be increased, allowing maximum output per oil shale unit.

### OIL-SHALE MINING (2013–2017)

	Annual volume allotted, thousands of tonnes	Actual amount mined (thousands of tonnes)*, share of the allowance used (%)										Average % 2013–2017
		2013		2014		2015		2016		2017		
Eesti Energia	15 010	11 830	79%	11 614	77%	11 083	74%	9 732	65%	11 157	74%	74%
Viru Keemia Grupp	2 772	2 344	85%	2 483	90%	2 637	95%	1 791	65%	3 239	117%	90%
Kiviõli Keemiatööstus	1 980	755	38%	1 058	53%	1 350	68%	1 581	80%	1 164	59%	60%
AS Kunda Nordic Tsement	238	98	41%	103	43%	117	49%	0	0%	74	31%	33%
<b>TOTAL</b>	<b>20 000</b>	<b>15 027</b>	<b>75%</b>	<b>15 258</b>	<b>76%</b>	<b>15 187</b>	<b>76%</b>	<b>13 104</b>	<b>66%</b>	<b>15 634</b>	<b>78%</b>	<b>74%</b>



## Smarter industry

Modern industry is increasingly based on digital and telecommunications solutions that make the process of mining oil shale and production more efficient, secure and faster.

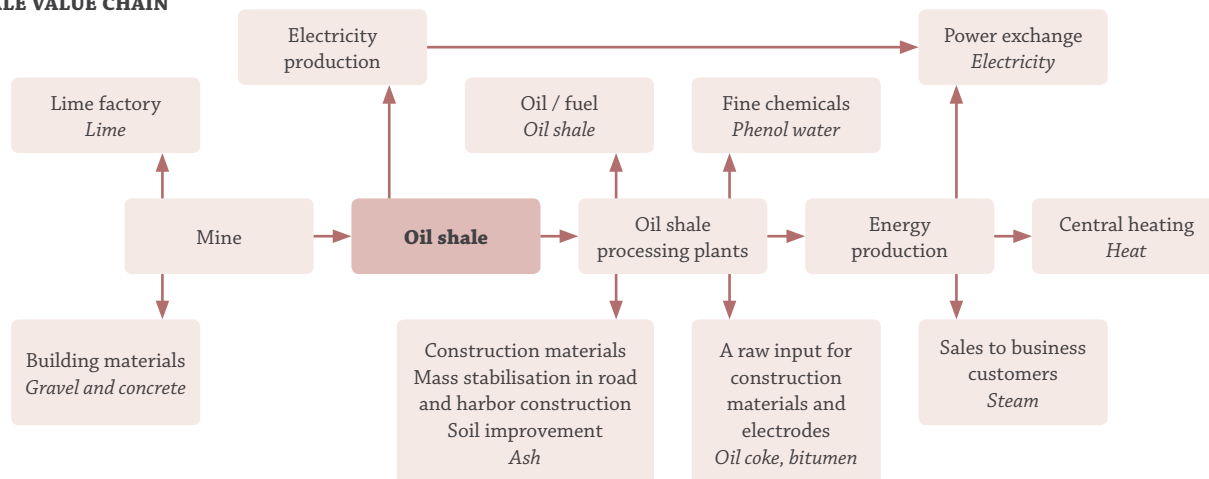
In 2017, Eesti Energia's power plants, oil production facilities and mines introduced equipment that use special software to measure the caloric value and moisture of oil shale on a moving conveyor and send the results in real time to a console. Digitalization of industry makes data analysis more effective and helps to make the production process more flexible, efficient and better for the environment. Oil shale quality can now be verified starting from its mining and enrichment to transport and use in generation of electricity and oil production.

The Narva Quarry, owned by Enefit Kaevandused, tested a drone for evaluation of mining volumes and visual inspections of walking draglines.

## Cell phones in mines

VKG's Ojamaa mine has had cell phone communications and Internet for the last five years, but wireless coverage reached Eesti Energia's Estonia mine only in 2017. Enefit Kaevandused installed 45 km of fibre-optic cables, allowing voice and data communications to be used and employees and equipment to be positioned. Since all of the equipment is mobile, underground wireless connectivity remains available while the mining front is in motion.

## OIL SHALE VALUE CHAIN



# Electricity

In recent years, Estonia has been the most energy-independent country in the EU, which is largely due to oil shale energy.

## Power output on the rise

In 2016, a total of 13.3 TWh of power was generated in Estonia – 7.5% more than a year earlier. Three-fourths of it came from oil shale companies' output. Of this, 90% was produced by Eesti Energia in its power plants by direct combustion of oil shale.

In the first half of 2017, electricity output grew by nearly a quarter, but in the second half of the year, power production was more modest due to unfavourable price competition.

According to Statistics Estonia, Estonian net power output in 2017 was 11.23 TWh. Domestic electricity consumption made up 7.72 TWh, which is on par with 2016. Power generation exceeded power consumption by 31%. Estonia exported 5.02 TWh through the Nord Pool power market – i.e. close to half of its power output. Compared to 2016, power exports dropped by 10.7% and import fell by 13%. Estonia's power trading partners continued to be its neighbours Latvia and Finland. Estonia's southern neighbours bought 78% of the electricity exported from Estonia, and the rest was sold to Finland. Of total imports, 80% came from Finland and 20% from Latvia.

In 2017, 767 GWh was generated from renewable sources, which is 18% more than a year earlier. In 2017, 736.7 GWh was generated from wind, which is 20% more than a year earlier. Hydroelectric energy volumes dropped 15% to 30.3 GWh.

## ELECTRICITY OUTPUT AND ELECTRICITY CONSUMPTION IN ESTONIA, 2013–2017 (GWH, %)

	2013	2014	2015	2016	2017
Eesti Energia	10278	9343	7312	8695	9175
<i>of which oil shale electricity</i>	9965	9003	6745	8203	8747
Viru Keemia Grupp	190	217	311	352	416
Kiviõli Keemiatööstus	38	39	41	44	51
<b>TOTAL POWER OUTPUT</b>	<b>10506</b>	<b>9599</b>	<b>7664</b>	<b>9091</b>	<b>9640</b>
<i>of which oil shale electricity</i>	<i>10193</i>	<i>9259</i>	<i>6754</i>	<i>8212</i>	<i>8747</i>
Consumption of electricity in Estonia	7332	7417	7440	7672	7721
<i>"Share of oil shale electricity of total consumption of electricity in Estonia"</i>	139%	125%	95%	107%	113%

Source: EE, VKG, KKT, Statistics Estonia

## ELECTRICITY PRICES ON THE NORD POOL SPOT POWER EXCHANGE 2016–2017 (€/MWH)

Average price	2016	2017	Change
System price	26,9	29,4	▲ +2,5%
Finland	32,5	33,2	▲ +0,7%
Estonia	33,1	33,2	▲ +0,1%
Latvia	36,1	34,7	▼ -1,4%
Lithuania	36,5	35,1	▼ -1,4%

Source: Nord Pool

**90% of electricity was produced from oil shale in Estonia in 2017.**

## Electricity in high demand

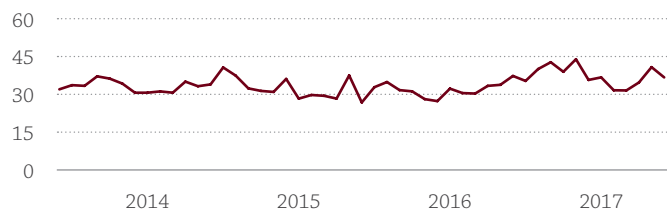
Estonia is part of the Nordics' single open power market, Nord Pool. Nord Pool is a trading venue for electricity generated in the Baltic Sea region's largest hydro, wind and nuclear power plants and Estonian oil shale plants, the Iru plant's waste-to-energy units and various renewable energy production units.

2017 saw declining prices in Latvia and Lithuania, at the same time as prices in other Nord Pool bidding areas rose.

The system price, which expresses the ideal price level for the market, rose 9.5% from 2016, and the average price for the year was 29-41 €/MWh. The power exchange in the Estonia bidding area stayed at 33.2 €/MWh – the same as last year – while Latvian and Lithuanian prices fell 4%.

In 2017, the average monthly prices of electricity in the Nord Pool Spot Estonia bidding area ranged between 30-38 €/MWh. The

### AVERAGE MONTHLY PRICES OF ELECTRICITY ON THE NORD POOL SPOT ESTONIA POWER MARKET (STARTING 1 APRIL 2010), €/MWh



Source: Nord Pool

power market price of electricity in 49% of the hours during the year was lower than 30.70 €/MWh – in other words, less than the regulated price in effect up to the end of 2012. The lowest and highest hourly price was in October, when the lowest price was 2.99 €/MWh on 30 October and the highest was 130.05 €/MWh on 11 October.

The price of emissions allowances nearly doubled in the year, ranging between EUR 4.26–7.91 per tonne.

On the open market, the prices are impacted by the existence of sufficient production capacities and connections for ensuring transmission of electricity within Estonia and to other countries. The price of electricity also depends on air temperature, price of coal and maintenance of the power plants in the near vicinity.

## Shale gas preferred

Estonia produces its electricity primarily from oil shale, but also generates it from shale gas. In 2017, Eesti Energia, VKG and KKT generated a total of 893.5 GWh from shale gas, which makes up 9% of the total volume of power generated by oil shale enterprises.

One of the most important development projects of 2017 was the renovation of energy unit no. 8 at the Eesti power plant operated by Enefit. The introduction of a new fluidized-bed boiler in 2018 will increase the company's shale gas usage capacity from 13 to 50 per cent. This will do much to help decrease emissions into the environment, as a greater amount of shale gas will be used to generate power. In 2017, Eesti Energia invested EUR 10 million, and the total budget on the renovations is EUR 14.7 million.

# Liquid fuels

The oil from oil shale is essentially synthetic petroleum. The oil shale is heated to obtain it. Estonia is one of the world’s biggest producers of shale oil. Shale oil has lower viscosity, a lower pour point and lower sulphur content than heavy fuel oil derived from petroleum. Oil produced from shale is mainly used as an input in the chemical industry, an impregnation oil, a fuel for boilers and industrial furnaces and a marine fuel additive.

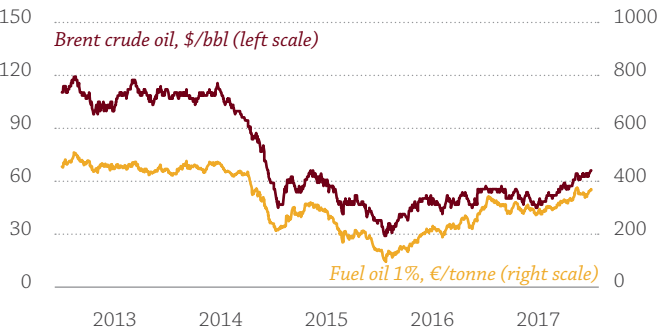
### Record quantity of shale oil

In Estonia, two technologies are used to obtain shale oil: the older upright retorts using a gaseous heat carrier (Kiviter technology) and the newer solid-fuel-carrier horizontal retorts (Petroter and Enefit). The last of these have lower CO<sub>2</sub> emissions and much higher energy performance.

Compared to five years ago, shale oil production volumes have doubled. In 2017, three Estonian companies produced 1.02 million tonnes of shale oil, which is a five-year high and 16% more than the years ago. As in previous years, 90% of the output was exported. Shale oil of Estonian origin was sold mainly to the Netherlands and Belgium, as well as to Sweden, Malta and Denmark. Finnish companies purchased oil from Estonia for use in production of marine fuel.

THE ESTONIAN OIL SHALE INDUSTRY’S LIQUID FUEL OUTPUT, 2013-2017 (THOUSANDS OF TONNES)					
	2013	2014	2015	2016	2017
Eesti Energia	214	265	337	318	395
Viru Keemia Grupp	358	433	506	451	536
Kiviõli Keemiatööstus	56	62	72	83	89
<b>TOTAL</b>	<b>628</b>	<b>760</b>	<b>915</b>	<b>852</b>	<b>1 020</b>

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



Source: Thomson Reuters

**In 2017, Estonia produced over one million tonnes of shale oil for the first time.**



In 2017, VKG processed oil shale in three Petroter plants and two Kiviter plants. The other two Kiviter plants were idle due to lack of oil shale. The newest oil plant Petroter III, which has a high operational reliability, operated 331 days last year and produced 149,300 tonnes of commercial shale oil. Output from Eesti Energia's Enefit280 plant was 186,000 tonnes.

#### **Price favours shale oil**

The market situation in 2017 was favourable for oil shale companies thanks to the rise in fuel prices. The drop in the prices of oil in the early part of the year brought the price of a barrel of Brent crude to 45 USD, but it rebounded to 67.20 USD by the end of the year. The average price of crude oil for the year was 54.25 USD/barrel, which is 25% higher than in 2016.

The price rise on the world markets was offset by the dollar losing 16% of its value – as a result, the price of Brent crude rose only 4.7%. The price of fuel oil on the world market underwent a major rise in 2017. The average price of oil was EUR 274 per tonne – close to 40% higher than in 2016 and 17% higher than in 2015.

#### **Cleaner marine fuels**

The advantage of shale oil is its low sulphur content and its flow compared to density – it does not need to be heated. In January 2020, the international convention MARPOL enters into force for prevention of marine pollution caused by ships in international waters. The new regulation sets forth 0.5% as the maximum sulphur content for marine fuels, which will result in a major change on the marine fuels market. The heavy fuel oil

**The average world market price of crude oil increased by 25% in a year.**

#### **TYRES AS RAW MATERIAL**

Estonia generates about 10,000 tonnes of old tyres a year; Europe, over three million tonnes. In 2017, Eesti Energia launched the processing of old tyres to generate energy at the Iru waste incineration plant. Old tyres can also be used to produce oil. Successful trials were held at Enefit oil plant to this end. Emissions into air were within the allowable limits and the quality of the oil produced did not become inferior.

On the basis of the final report on the testing, the Ministry of the Environment will be able to draft a bill on cessation of tyres as a type of waste, which is one of the steps needed to create the legal footing for use of shredded tyres to produce shale oil. This would allow Estonia to rid its forests of old tyres, as they would now become a valuable raw material.

The company would have the capacity to process 100,000 old tyres each year.

with a maximum 3.5% sulphur content currently used for making marine fuel will have to find a new use as a raw material for refineries or fuel for power plants. The sulphur content of the shale oil produced by Estonian manufacturers is an average 0.8%, which meets the criteria for low-sulphur fuels.

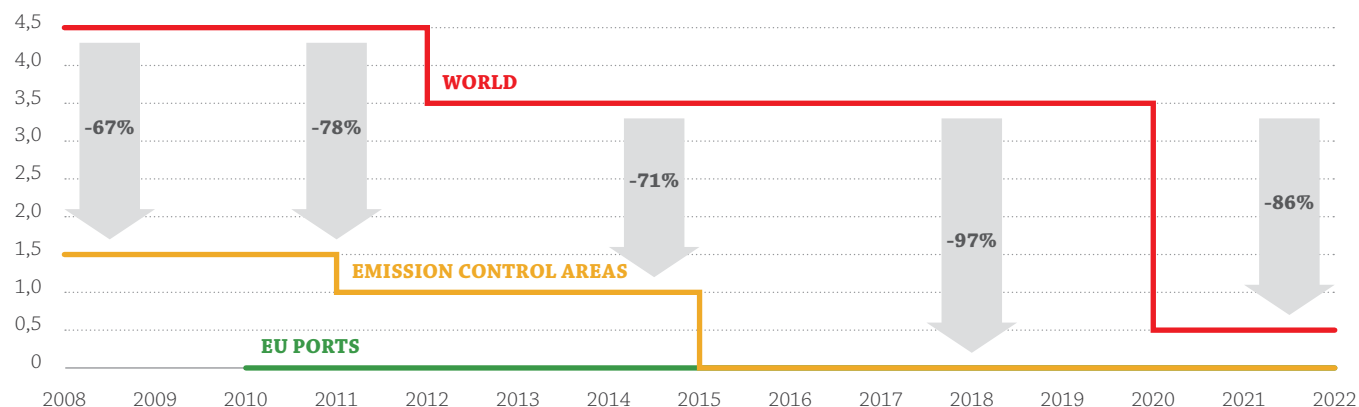
### Higher-quality products

Oil producers are actively developing technologies to refine shale oil into fuels with higher value. Enefit Energiatootmine introduced a petrol refinement device that significantly increases the quality of the oil shale petrol produced at the plant. The technol-

ogy allows the mercaptan content in end products to be reduced and nearly all hydrogen sulphide removed. Now, oil shale petrol can be used more extensively and profitably, and the refinement has no additional effects on the surrounding environment.

In 2017, VKG launched a project to refine circulation oil, allowing up to 30,000 tonnes more oil to be produced and increase the yield of Petroter plants even further. As the project ends in 2019 the company will forgo adding coke to circulation and producing electrode coke. The cost price of commercial oil will also improve, as will the value-added generated by processing of oil shale.

### CHANGES IN MARINE FUEL SULPHUR LIMITS 2008–2022



# Heat

In 2017, a total of 7.58 TWh of heat was generated in Estonia – about the same as a year earlier. Because it is not technologically possible to efficiently store or transport thermal energy, Estonian heat output remains more or less equal to consumption.

Thanks to insulation of buildings and renovation of heating systems, demand for municipal heat has decreased in Estonia with each passing year. Generation of heat from oil shale has been 1.3 TWh in each of the last three years, around one-fifth of local consumption.

## Oil shale by-products used for residential heat

A majority of the residential heat produced in Estonia is from more renewable CHP plants. At Balti power plant near Narva, Eesti Energia generates municipal heat from oil shale and biomass. In 2017, the 400MW plant produced 125,000 MWh of heat. All of the thermal energy produced at Balti power plant is supplied by the city of Narva’s district heat networks to more than 60,000 heat and hot water consumers, and industrial consumers in the vicinity are also supplied with steam at a pressure of 15 atm.

VKG Soojus uses the residual heat from processing of oil shale to heat its areas of service. The company provides heating service to the Kohtla-Järve and Jõhvi area through a 18.5 km long heat pipeline constructed in 2012. The heating line starts on VKG production territory in Kohtla-Järve and it passes through several municipalities to the merge point with the distribution grid.

VKG Soojus distributes the heat and steam generated in the oil shale industry both to industrial enterprises in Ida-Viru County

and consumers in the region; electricity from co-generation is also used across Estonia.

Co-generation of heat and power at KKT covers heat demand from the whole city of Kiviõli and the needs of the company itself.

## More affordable heat from oil shale

In 2017, the ceiling for the consumer price of heat approved by the Competition Authority averaged EUR 60.70 per MWh. Residential heating was still more affordable than the average in the cities and towns where heat is generated as a by-product of the oil shale industry, Narva consumers paid the least for residential heat in 2017. Narva Soojusvõrk sells heat produced by Eesti Energia Balti power plant at a price of 35.33 /MWh, plus VAT. Kiviõli consumers buy heat from KKT at a price of 48.64 €/MWh. The price in the VKG Soojus heating network district in Ahtme, Jõhvi and Kohtla-Järve is 55.52 /MWh of heat.

## OIL SHALE COMPANIES’ HEAT OUTPUT AND HEAT CONSUMPTION IN ESTONIA, 2013–2017 (GWH)

	2013	2014	2015	2016	2017
Enefit Energiatootmine	584	603	614	596	564
Viru Keemia Grupp	650	581	532	506	452
Kiviõli Keemiatööstus	90	107	108	123	125
Kunda Nordic Tsement	188	191	97	104	219
<b>TOTAL</b>	<b>1512</b>	<b>1482</b>	<b>1351</b>	<b>1329</b>	<b>1360</b>
Consumption of thermal energy in the form of district heating in Estonia	8098	8015	7789	6235	6360

Source: EE, VKG, KKT, KNT, Statistics Estonia

# Fine chemical industry

Oil shale chemicals fall into two categories: oil shale chemicals (alkylresorcinol fractions) and fine chemicals. The first ones have wide applications, such as in the rubber and plywood industry, and in making moulds for casting. Oil shale phenol fractions are also used as epoxy resins in the plywood and petroleum industry. The phenols produced in Estonia are used to make tyres with high wear resistance and Lexus and Toyota car parts.

Fine chemicals include products with a high level of purity, used by the cosmetics, perfumery and electronics industry. A number of pharmaceuticals and hair dyes are made from fine chemicals. Chemicals produced in Estonia can be found in Keune, Estel and Schwarzkopf hair dyes. They are also used to make liquid crystals for LCD monitors.

EXPORT OF FINE OIL SHALE CHEMICALS AND PHENOLS, 2013–2017 (IN EUROS)

	2013	2014	2015	2016	2017
Fine chemical industry	1 089 228	719 168	1 034 909	730 309	968 059
Phenols containing over 50% phenols	10 821	41 849	39 596	6 212	4 411
<b>TOTAL</b>	<b>1 100 049</b>	<b>761 017</b>	<b>1 074 505</b>	<b>736 521</b>	<b>972 470</b>

Allikas: Statistikaamet

## Customers all over the world

VKG is today the only company in Estonia that distils valuable fine chemicals from the shale oil plants that use the Kiviter technology. VKG is capable of producing extremely pure (more than 99%) chemicals that can fetch up to several dozen euros per kilogram.

The biggest consumers of oil shale chemicals are companies in the EU, Japan and India. Fine chemicals made in Kohtla-Järve are also sold to Latin American countries and Iran. In 2017, Estonia exported close to a million euros worth of fine chemicals and phenol products.

Fine chemicals are made from by-products of oil shale processing, thereby supporting the development of circular economy in the oil shale industry. Most challenges and obstacles related to production of fine chemicals are bound up in the high costs related to R&D, marketing and the obligation stemming from the EU’s so-called REACH regulation to register chemical compounds.

**Estonia exports approximately one million euro’s worth of oil shale based fine chemicals per year.**





OIL SHALE INDUSTRY

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AND THE ENVIRONMENT

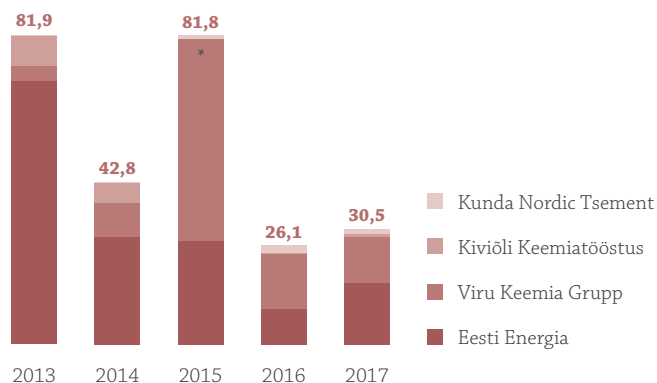
# Investments into the environment

## Close to 93 million euros into the environment

In 2017, oil shale companies paid the state around EUR 62 million in environmental charges, of which one-third comprised resource charges for mining and use of water. Pollution charges for emissions and landfilling waste related to mining and processing made up around EUR 42 million. Investments into the environment amounted to more than EUR 30.5 million.

The modern oil shale industry is making great efforts to reduce and avoid the ecological footprint. During the last five years, oil shale companies have invested a total of over EUR 263 million into the environment. The goal of most projects launched and carried out in 2017 is to modernize the production process and improve the quality of ambient air.

## ESTONIAN OIL SHALE COMPANIES' DIRECT AND INDIRECT ENVIRONMENTAL INVESTMENTS IN 2013–2017 (MILLIONS OF EUROS)



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

## Recognition for environmental efforts

The topic of the environment has been in the focus for the oil shale industry from year to year. Companies have done much for the development of the field and their efforts have not gone unnoticed. In various years, Eesti Energia and VKG have both won the award handed out by the state for achievement in the field of the environment. In 2017 Eesti Energia received recognition as the company with the most environmentally friendly production process.

In spite of the complicated economic environment, oil shale industry companies act responsibly and preserve their values. In 2017, the responsible enterprise forum bestowed a certificate on Eesti Energia for responsible enterprise and a gold-level quality label. Viru Keemia Grupp won a bronze quality label. The label is given to companies that take part in the Estonian responsible enterprise evaluation, and which put a premium on sustainable development, contributing strategically into the development of society and the natural environment.

Eesti Energia's promotion of environmentally friendly principles and healthful lifestyles in its work culture did not go unnoticed. The Estonian Association for Environmental Management bestowed a "Green Office" label on the headquarters on Lelle Street in Tallinn. The European Green Office labels are awarded to organizations that have stood out for their environmentally aware solutions in their work environments, such as separate collection of waste, efficient use of water and energy, and raising the awareness of employees.

# Restoring the landscape

An integral part of oil shale mining is the process of reconditioning former opencast areas to return them as close to the pre-mining condition as possible or at least create an equivalent landscape. During or after completion of the work, oil shale companies give mining areas the appearance mandated in the reconditioning project, level the landscape, and, where necessary, plant forest or establish bodies of water. The reconditioning work must be performed in a properly planned manner to allow the former industrial territory to meld into the surroundings and find use as, for instance, a recreational area.

## **New uses for former mining areas**

The oil shale industry works to leave properly reconditioned and orderly areas behind after production is ended. Simultaneously with mining, restoration operations are carried out in the quarries, with new forest planted in the areas used. In total over half a century, oil shale companies have planted seedlings and young trees on 14,000 hectares. Former industrial areas have grown into tall forests with diverse plant and animal life.

In 2017, oil shale companies afforested 4 hectares of former open-cast territory. Compared to years past, less forest was planted, as the Ministry of Defence plans to expand its Sirgala training area. In addition, Eesti Energia performed technical recultivation on 155 hectares of industrial landscape, levelling the surface of the post-mining area and creating new surface features.

## **Quarry turned into a lake**

In summer 2017, reconditioning work ended in Eesti Energia's Narva Quarry in a mining claim consisting of a separate tract of close to 5 square kilometres of land. A new pine and silver-birch forest was planted on the levelled land, in cooperation with the State Forest Management Centre. Two new roads were built for forest maintenance. To protect the Mustajõe nature area in the immediate vicinity of the former mining area, a 50-metre wide dam was built against the boundary of the protected area. After pumping of water was ceased, a lake formed in the former open-cast due to the rise in the groundwater level and restoration of the water regime. The Eesti Energia environmental service made a proposal to start calling the lake Rästikmetsa (Viper Forest Lake) thanks to the thriving snake population in the vicinity.

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**In the past 50 years, oil shale enterprises  
have planted 14,000 hectares of trees.**



# Emissions into ambient air

In the field of the environment, one of the most important goals for oil shale companies is improvement of the quality of ambient air. By 2030, Estonia must reduce greenhouse gas emissions by 40% compared to 1990, as required by the European Union’s climate package.

## A united effort for cleaner air

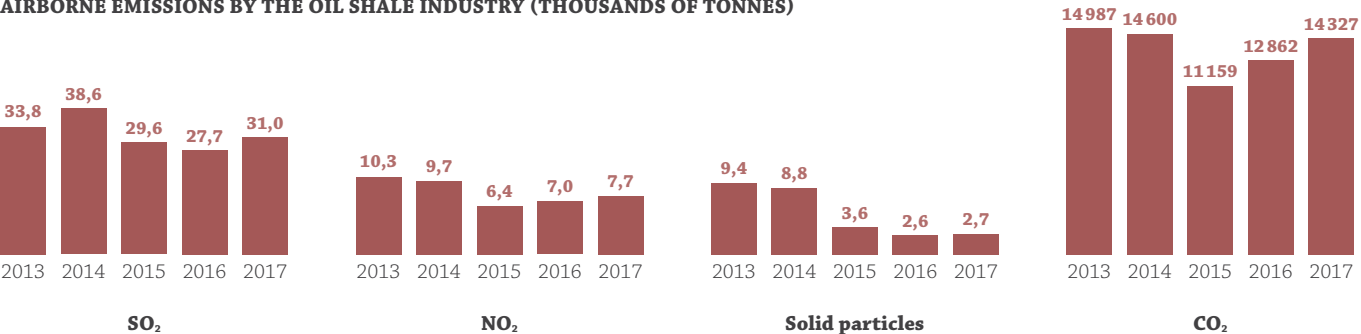
The oil shale industry has been moving for years toward more efficient and cleaner energy generation, investing into new technologies and updating older production equipment with more modern filtration devices. Despite the constant increase in production volumes, SO<sub>2</sub> emissions have decreased by over 8%, NO<sub>2</sub> emissions by 25% and solid particulates by a whole 71%. Studies corroborate the efforts made by industry – findings show that the air in Estonia and Ida-Viru County is among the clearest in all of Europe.

## Millions into technology

The air quality in the Kiviõli area will make a major leap forward thanks to the installation of an electrical filter on the smokestacks of KKT’s solid-hear-carrier reactor. As a result of an investment of close to EUR 2 million, the particulate content of smoke gases will improve markedly; to a lesser degree, hydrogen sulphide indicators will also improve. In addition, the spread of odorants will be reduced and the operating reliability of equipment will improve.

In 2017, VKG Energia completed work on a gaseous fuel steam boiler for combustion of oil shale gases the cost of which was EUR 10 million. Pollutant content in the emissions is now significantly lower thanks to the more efficient combustion mode.

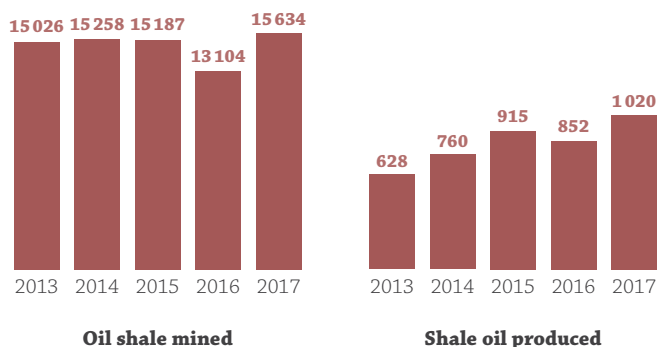
AIRBORNE EMISSIONS BY THE OIL SHALE INDUSTRY (THOUSANDS OF TONNES)



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

At year's end, construction on VKG Oil's EUR 1.5 million pipe conveyor was completed. The modern conveyor is used to transport semi-coke generated in Kiviter-based production directly to the end deposition site, via a closed system. This reduces the need for automotive transport and will reduce the amount of dust and emissions. The result is lower emissions into air, and a cleaner production territory and environment. In addition to being environmentally friendly, the conveyor system also translates into positive economic benefits.

VKG also launched work to neutralize areas of the landfill prone to overheating so as to reduce odour nuisance in future and improve the quality of ambient air. In 2017, the company submitted to the Environmental Board an action plan for reducing odorants. To map the situation, measurements and modelling were conducted. On this basis, measures were developed for reducing odorants and a EUR 600,000 investment plan was approved.



Another factor resulting in lower emissions into ambient air stems from the fact that KKT changed over to more economical LPG-fuelled trucks in 2017.

One of the most important investments for Eesti Energia was the renovation of the energy unit no. 8 at Eesti Power Plant. As a result of the renovation performed in the second half of the year, one boiler in the unit will be capable of using up to 50% of the shale gas, as opposed to the earlier 13%. This will do much to help decrease environmental impact of power generation from oil shale, as the by-product of liquid fuel production process – shale gas – will be used more effectively and thus less oil shale is required.

### Vigilance over air quality

The permanent ambient air quality monitoring station, established by Eesti Energia near the Sinimägede hills, and the Environmental Investment Centre was connected to the national online network of monitoring stations in 2017. The monitoring station measures quantities of sulphur dioxide, benzene and hydrogen sulphide in ambient air. In addition, the monitoring station also provides valuable information for managing air quality, measuring wind direction and speed, relative humidity and temperature. The information makes it possible to decide which steps are the best for reducing odour-related nuisances in the vicinity of plants.

# Water in the oil shale industry

When oil shale is mined, water is pumped out of the mines and directed into sedimentation basins for the removal of suspended solids. The mining water is then returned to nature.

The main source of mining water is rainwater. It makes up 80% in quarries and close to 50% in underground mines. A smaller portion of mine water comes from closed mines in the vicinity and groundwater.

In 2016, a sedimentation basin and modern pump station were established in Eesti Energia's Estonia mine's exhausted chamber units. Water analyses support the effectiveness of the sedimentation basin. The water pumped out is so pure that laboratory testing reveals scarcely any suspended solids at all.

## Heavier tax burden in rainy years

In 2017, the four oil shale mining companies pumped out a total of 194.8 million cubic metres of water from the opencasts and mines.

As the volumes of pumped-out water are directly proportional to the amount of precipitation, it is hard for companies to project the amount in charges to be paid to the state for pumping of water.

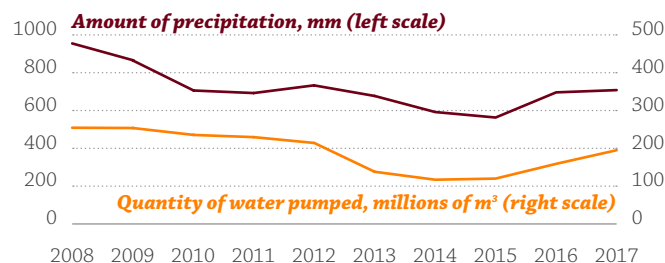
In 2017, in accordance with a Government regulation, companies paid EUR 19.48 per 1,000 m<sup>3</sup> pumping water out of quarries; the rate for pumping out mines was 54.32 per 1000 m<sup>3</sup>. In total, oil shale companies paid EUR 7.2 million in fees for special use of water.

## Kilometres of new pipelines and clean canals

In 2017, Enefit Kaevandused completed a five-year-long project in Alutaguse Rural Municipality – the installation of a water pipeline close to 50 km in length and nine bore wells. The locations of the water network and bore holes were determined together with the local governments and the community. As a result of the works, over 150 households, along with the Illuka kindergarten and primary school, received new and reliable water supply and a clean source of drinking water.

**In 2017, oil shale enterprises  
paid 7.2 million euros  
into the state treasury  
for pumping out  
the mining water.**

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



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

In 2017, Enefit Kaevandused cleaned Jõuga Canal of obstructions and sediment – totalling 3 kilometres – and performed maintenance on the Põllualuse Ditch and Ratva Stream – 7 kilometres. The cleaned water in the Estonia Mine’s underground sedimentation basin will be directed back into nature via the Jõuga Canal. To avoid waterlogged areas after the Viru Mine is filled with water, two overflow bore wells were established on the edge of Põllualuse Ditch, which will be used to direct excess water out of the mine. In this way, Ida-Viru County gained two additional “witch’s wells”.

#### **Re-use in water resource management**

In 2017, preparations were launched to design a new landfill for VKG Energia’s Põhja (Northern) Thermal Power Plant’s reconditioned ash deposition site. The company also initiated a project to assess the environmental impacts of the expanded landfill and waste deposition technology. In future, the recovery of rainwater and leachate collected from the landfill is being weighed, as this will ensure more efficient use of water resources.

## Uses for by-products of the energy generation process

#### **Keyword: circular economy**

In 2017, the circular economy was the central topic in the oil shale industry. Its potential in the oil shale sector was discussed thoroughly at a conference organized by the Tallinn University of Technology’s Virumaa College Oil Shale Competence Centre and VKG’s annual environmental seminar. Sector experts discussed the developments in existing directions in the circular economy: use of fly ash in construction and agriculture, the polymer industry and production of concrete and treating phenolic water. The possibility of using by-products of the oil shale industry in completely new fields was also considered.

In Estonia, energy generation results in close to 20 million tonnes of by-products each year. Slag waste is generated by processing and enhancement of oil shale, while electricity generation results in ash. For years now, oil shale companies have been dedicated

to finding new applications for by-products of the industry. This reduces the impact of the oil shale sector on the environment and is also good for the economy. There are many examples of successful uses of the by-products of energy generation, from use of ash and gravel in road construction to creation of a theme park on a hill of mine waste.

#### **New uses for limestone**

Mine waste mainly consists of limestone with a small quantity of oil shale as well. In 2017, the oil shale industry generated around 6.26 million tonnes of mine waste, which is around 40% less than last year. Over half of it was used as crushed limestone for road construction, landscaping and filler.

As mine waste is essentially limestone, recovery of mine waste means less demand for limestone quarrying – fewer quarries des-

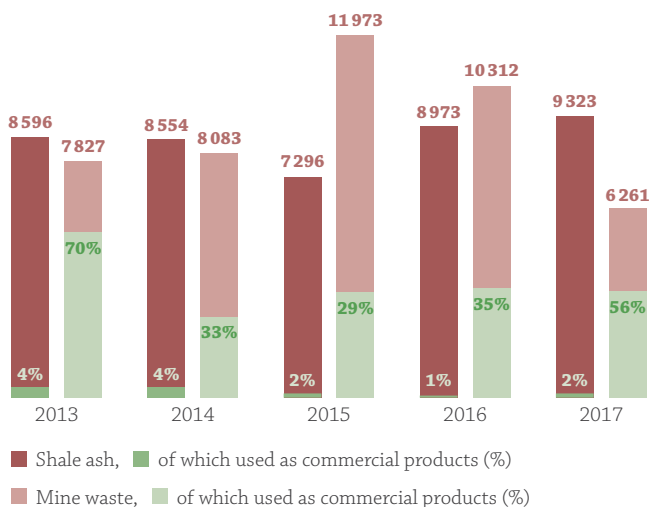


ignated specially for limestone have to be opened. Limestone as a by-product of oil shale mining has good filtration properties and is well-suited for use in road construction in layers that need to be permeable by moisture. Due to the cost of transport, the crushed mine waste has only been used in Ida-Viru County, but Eesti Energia is working to organize transport of limestone in more distant locations as well.

### Ash, a valuable raw ingredient

In 2017, the Estonian oil shale industry generated 9.23 million tonnes of ash, 2.8% less than last year. Unlike mine waste, the potential of ash as a raw material is still untapped – only 1.6% of ash was given a second life.

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



Fly ash generated as a by-product in oil shale-burning power plants is valuable substance and has been used in construction and agriculture. Fly ash has also seen use in closing of exhausted oil and gas deposits. Compared to other technological solutions, the use of cement containing ash results in better hermetic properties in bore holes and improved ability to withstand extreme environments. As the CO<sub>2</sub> that accumulates in sealed bore holes does not escape into the atmosphere, this can also decrease greenhouse gases.

The international company CemExpert-Int has produced over 300,000 tonnes of special cement containing fly ash and sealed over 15,000 bore holes in oil and gas extraction sites worldwide. The company and its technology takes part in the international project SOAR (shale oil ash recycling), which aims at finding and developing effective technologies for closing oil and gas sites to keep carbon dioxide from leaking into the atmosphere.

### Houses and plastic from ash

Oil shale ash has been used successfully for producing masonry units and other construction materials. Until the end of 2016, VKG produced environmentally friendly Roclite construction blocks, made from a mixture of recovered fly ash, sand and water. This innovative construction material is ecologically clean and does not release any harmful compounds into the environment. In early 2017, VKG sold this subsidiary to the Nordics' leading maker of aerated concrete, Aeroc International.

Under the leadership of the Estonian Plastics Association, the possibilities of using fly ash as a filler material for polymer are being investigated. The results of the studies confirm that compared

to talc and chalk, fly ash has the best qualities for use as a filler for polymer. Europe’s biggest polymer producer has also taken an interest in the research. Plastics manufacturers are planning to start developing the operation in 2020.

**Ash as a fertilizer for organic cropland**

Fly ash has been used on conventional fields for decades as a fast-acting neutralizer of acidic soil. A few years ago, Eesti Energia marketed a soil additive made from fly ash, called Enefix. Products made of fly ash create better growth conditions for plants, help soil assimilate nutrients and minerals, reduce the risk of contracting plant diseases and curtail growth of moss in lawns.

Compared to other soil additives, Enefix with its high calcium carbonate content neutralizes soil pH more rapidly and enriches it with microelements at the same time. In 2017, the company launched testing of the environmentally friendly soil additive free of chemical compounds in organic agriculture as well. The testing confirmed that Enefix’s natural origin, rich mineral content, positive effects on additional yield and alkaline composition for neutralizing acidic soil make this soil additive a necessary and suitable product also for use in organic agriculture.

**FLY ASH**

Fly ash is formed in the process of scrubbing smoke gases when generating power from oil shale. Power plant flues have special filters that catch the tiny particles of ash.

**Mission: recovery and re-use**

Oil shale companies are investing into innovation and actively seeking for ways of efficiently recovering production waste that is actually more of a by-product. This helps to conserve oil shale as a natural resource, make production more resource-efficient and create new jobs. The impact of the industry on the environment decreases, the sector’s competitiveness increases, and economic benefits are generated as well.

In spite of the efforts, much remains to be done in the oil shale sector with regard to recovering by-products. In 2017, 56% of the mine waste generated during the year was recovered along with just 2% of fly ash. Compared to 2016, these figures have risen, but they are still modest considering the inroads made by green mind-sets and the principles of the circular economy.

The biggest challenge faced by companies when it comes to recovering ash is to develop markets outside Estonia, and recognize and legalize the use of ash in other countries. More cost-effective opportunities are also being sought for transport of ash along with possibilities to apply oil shale ash in other fields as well.

**PROPERTIES OF FLY ASH, CHALK AND TALC AS FILLER**

	Fly ash	Chalk (CaCO <sub>3</sub> )	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 <sup>3</sup>	2,7 g/cm <sup>3</sup>	2,7 g/cm <sup>3</sup>
Percentage granular	85%	84%	50%

Source: Estonian Plastics Association



OIL SHALE

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AND ESTONIAN SOCIETY



# Oil shale industry’s contribution to society

In 2017, oil shale companies paid over EUR 103 million into the state treasury as taxes. In spite of the changes in the operating environment, companies have always found ways to give back to society. They promote innovation, support education, research and environmental projects and underwrite community initiatives in Ida-Viru County.

## Jobs for more than 7,300 people

The oil shale industry is one of the largest employers in Ida-Viru County and all of Estonia. In 2017, the companies in the sector employed more than 7,387 people.

In 2017, oil shale companies paid close to EUR 40 million in workforce taxes. During a year, the average wage level in companies has risen by over 8% to EUR 1,522. This is more than one-fifth higher than the average gross wage in Estonia and 35% higher than the average gross wage in Ida-Viru County.

The oil shale sector is an attractive employer, as employees are offered good career opportunities, work involving a high amount of responsibility, and competitive wages. Based on responses from over 6,000 people, an annual study initiated by the job site cvkeskus.ee to determine the most sought-after employers

## EMPLOYMENT IN THE ESTONIAN OIL SHALE SECTOR (2017)

Total employees	7387
Average number of years worked	16
Average gross monthly wage (EUR)	1522
Change in gross wage compared to 2016 (%)	+8,4%

in Estonia awarded the title to Eesti Energia in 2017. The company’s trump card was seen as the fact that it devotes attention to employee development, ensuring investment into recruitment and younger employees within the organization and continuing competence. For several years in a row, Eesti Energia leads most Estonian companies in the number of internships offered.

## Increasing demand for workforce

An analysis of need for workforce and skills conducted by the Estonian Qualifications Authority found that the needs for specialized workforce in the decade ahead in the energy and mining sector is greater than current training output. Despite the fact that the wage level in mining outstrips the Estonian average by 130% overall and the average of the energy sector by 150%, the number of people entering higher education in these specialities has dropped by one-half in the last five academic years.

According to the forecast, there is an annual need for 280 new employees in the main professional areas in the field: 230 in energy, construction of electrical networks and electrical installation, and close to 50 in mining. At the Tallinn University of Technology, including its Virumaa College, six curricula are directly related to the oil shale industry. In the 2017/2018 academic year, only 245 students in the applied higher education and bachelor’s degree studies started their educational careers.

The analysis shows that 105 new people will be needed in the field of chemicals, rubber, plastic and construction materials industry to replace those who are retiring. The greatest needs in the field are for chemical and industrial engineers.



# Supporting education

## **Strong future players**

The rising generation of engineers will largely determine how innovative and beneficial the oil shale industry will be 20 years from now. This is why oil shale companies are continually engaged in initiatives for getting young people interested in STEM subjects and the energy sector.

In 2017, Eesti Energia provided EUR 20,000 in support for the development of education programmes at the Energy Discovery Centre. The Energy Discovery Centre programmes complement the school curricula and are aimed at all age groups starting from primary school students to upper secondary level. Thanks to the support, the discovery centre was able to update its study materials and create even more appealing study formats for students to spark an interest in energy and engineering starting from a young age.

## **Increasing interest in STEM subjects**

In cooperation between Jõhvi Upper Secondary School, VKG, Eesti Energia and Eastman Specialties, the STEM elective syllabus for 11th grade students at Jõhvi Upper Secondary School was created in 2016/2017 academic year. As the STEM acronym indicates, the course covers four fields: science, technology, engineering and math. Besides lectures, the STEM programme includes study trips to oil shale sector companies. For instance, students learned about heat and power generation at VKG and received an overview of the development of the energy field. Upper secondary school students learned about green footprints and other environmental topics on a field trip to Ojamaa Mine. Eesti Energia hosted students at Narva Quarry, with a lecture that discussed financial management, development of new mines and the role and work of geolo-

gists in mining. On a trip to the Eesti Energia subsidiary Enefit Solutions, participants were told about production processes and on-the-job safety. As the course is popular and considered essential, the STEM elective will be continued in 2018/2019 as well.

## **The Five Schools Competition**

In 2017, for the sixth year in a row, VKG supported participation of Ida-Viru County's upper secondary school students in a science and math tournament held for the 52nd time.

At this high-level, all-Estonian competition, top students show off their knowledge in math, chemistry and physics. Originally waged between the top five schools with in-depth science programmes, the tournament gave an Ida-Viru team a berth for the first time six years ago. Thanks to VKG's support, Ida-Viru County students who are interested in science and math subjects and who see their future as being linked to technology are able to compete at the tournament.

On combined field trips to KKT, Tallinn University of Technology and the Tallinn University of Technology's Virumaa College, upper secondary school students from Kiviõli, Narva and Sillamäe students learned about possibilities for studying and working in the oil shale, oil shale production and chemistry sector. They also received an overview of existing scholarship programmes.

## **Recognition for the most diligent**

As in years past, oil shale companies awarded scholarships to the most diligent students. Funding for enrichment activities for Ida-Viru County youth can be sought through the Ida-Viru County Talented Youth Energy Fund, established by Eesti Energia and the

Ida-Viru County Association of Local Governments. The fund aims to support engineering education to increase youth interest in the field and making the content of study more interesting to them. The Energy Fund has been in operation since 2013 and has provided scholarships to 200 youngsters so far. There were a record number of candidates in 2017 – applications were submitted by about 150 students.

Enefit Kaevandused awarded scholarships to the best students in the mining speciality at the Ida-Viru County Vocational Education Centre. The company supports studies to popularize the mining speciality and to ensure a steady supply of future professionals in the field.

For another year in a row, VKG handed out scholarships through the Tallinn University of Technology Development Fund for students majoring in technology, chemistry and energy. In 2017, scholarships in a total of EUR 6,700 were awarded on two occa-

sions. The VKG scholarship is open to applicants who are bachelor's or master's students in professional higher education at the Tallinn University of Technology and Tallinn University of Technology's Virumaa College.

#### **Art – semi-coke – fly ash – oyster mushrooms**

The Estonian Academy of Arts Department of Interior Architecture master's degree students conducted a study on the spatial and material potential of residual phenomena of the Estonian oil shale industry. The project gave rise to ideas on how to enhance the value of these phenomena: the idea of revitalization of the abandoned Viivikonna mining town, broader applications for masonry units made from fly ash, the Püssi ash heap as a potential model use of the manmade landscape and speculation about using plants and microbes to reduce the toxicity of semi-coke. The findings of the study were released as an exhibition at the Mektory school of technology at the Tallinn University of Technology and an international oil shale conference in Jõhvi.

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**The education initiative of the oil shale enterprises is to get young people interested in STEM subjects and the energy sector.**

# Supporting innovation and knowledge export

Thanks to long-term cooperation between oil shale enterprises and scholars, Estonia has become one of the world's top centres for expertise in oil shale. There is international demand for the know-how amassed over the century and it can be exported successfully to other oil shale "powers". Eesti Energia has shared oil shale know-how with more than ten countries. The knowledge and skills of Estonian experts have been harnessed everywhere in the world, starting from the US and China all the way to Uruguay, Morocco and Thailand.

## Successful megaproject in Jordan

The highest honour for Estonian oil shale expertise was Eesti Energia's USD 2.1 billion electricity project in Jordan. It is the world's largest single investment into oil shale energy and the largest foreign investment by the Kingdom of Jordan. The successful completion of the megaproject in 2017 shows that Eesti Energia has sufficient competence as a developer of similar technology transfer projects throughout the world and that Estonia is a repository for know-how that is needed in the rest of the world.

### KEROGEN

Kerogen is a mixture of organic compounds contained in oil shale. Besides hydrocarbons, it contains oxygen, sulphur and nitrogen. Kerogen originates from the fossilized remnants of organisms that lived in water. Kerogen is the substance that makes oil shale valuable as a natural resource, as it burns and can be thermally processed to obtain oil and gas. Kerogen content can be as high as 75-80% in some oil shales, but ordinarily does not exceed 20-30%. A concentrate of 90% kerogen can be isolated from kukersite oil shale. This concentrate is used as a raw ingredient in the chemical industry.

Many Estonian geologists, engineers and scientists contributed to the project. The energy and oil content of samples collected from Jordanian El Lajjun and Attarat oil shale deposits in the course of geological site investigations from 2008 to 2013 were analysed at the Oil Shale Competence Centre's fuels technology science and test lab. From 2008 to 2013, chemical engineers tested approximately 3,000 samples in the Kohtla-Järve laboratory.

## Breakthrough in the use of kerogen

In cooperation with specialists from the company Kerogen, the chemists at the University of Technology are developing a new technology for obtaining various chemical products based on kerogen. Scientists intend to convert the kerogen in oil shale directly to chemical products, skipping the shale oil step. This would significantly reduce emissions of carbon dioxide and phenolic pollution.

Attempts to enhance kerogen have spanned more than 100 years in Estonia. Already one of the founders of the Estonian oil shale industry, Paul Kogermann, studied decomposition of kerogen by various chemical means.

## Exploring mines online

From 2017, the Land Board's geoportal has a map application that can be used to view the locations of underground passages, pillars and rooms. The application is based on a study carried out by Tallinn University of Technology Institute of Geology scientists in 2015.

### **A research-based industry**

Each year, Estonian oil shale companies invest millions of euros into carrying out scientific research in the field of energy. All this to ensure that wise decisions in the oil shale industry will bring greater benefits for the state and the sector would be sustainable in the future. To ensure the innovative development of the field, companies work closely with universities: production of oil from end-of-life tyres is being tested, fine chemicals are being developed, and new ways for using fly ash are being explored.

### **The RITA programme for investigating natural resources**

In re-independent Estonia, the state has had scant interest in exploration of local geological resources. Investigation of the socioeconomic potential of the resources and the environment-related challenges has seen but a modest effort. In 2017, the RITA programme was set up to support R&D on the government level, used to fund various types of natural resources studies. The goal of the programme is to introduce the most expedient and innovative ways of using Estonia's natural resources and to give the state input for planning future developments.

A consortium led by the Estonian Research Agency and the University of Tartu (the University of Tartu, Tallinn University of Technology, and the Research Council) launched development of more efficient, environmentally friendly and sustainable ways of using natural resources harboured in the earth's crust. The cost of the three-year-long project is EUR 1.26 million and it will be funded from the Estonian Research Council, European Regional Development Fund and the Estonian state.

The consortium's study will deal with four topics related to oil shale:

1. Bioleaching with suitable microorganisms to isolate the metals found in graptolite-argillite, widespread in northern Estonia.
2. Socioeconomic impacts of mineral extraction, and specifically how to balance positive impacts on economic growth against adverse impacts on the environment.
3. The impact of new technologies on solid waste management. What kinds of changes in the composition of solid waste will stem from the adoption of new technologies, how this will affect the handling of waste with regard to landfills or recovery and what sorts of new uses of waste can we expect?
4. The innovation of mining technologies. As society develops, conditions for mining are becoming more stringent, and this should make mines much cleaner in terms of the environment and resource effectiveness. The study forecasts what the mines of the future will be like.

## MAJOR SPECIFIC RESEARCH STUDIES

Research and development activity	Implemented by	Funding source
Preparing draft conclusions regarding best available techniques for use of Estonian oil shale for generating energy	Tallinn University of Technology	Ministry of the Environment
Transforming fly ash into a valuable commodity	Tallinn University of Technology	EIT (Raw Materials)
Analysis of possibilities of using mining technologies involving filling, economic and environmental requirements in implementing the technology	Tallinn University of Technology	Environmental Investment Centre
Use for non-energy purposes of retort gases generated during production of Estonian shale oil	Tallinn University of Technology	Ministry of the Environment
Studies in the field of oil shale technologies for Enefit Energiatootmise AS	Tallinn University of Technology	Enefit Energiatootmise AS
New technological platform for enhancement of oil shale kerogen: partial oxidation into dicarboxylic acids and further transformation into valuable dicarboxylic acid derivatives	OÜ Kerogen (TTÜ)	SA Archimedes
Awareness and attitude of the population in regard to mineral resources	Turu-uuringute AS	Ministry of the Environment
Environmental impacts on groundwater and surface water as well as on landscapes from potential mining of Virumaa natural resources, analyzed with environmental and geological models together with alternative remediation measures	University of Tartu	Environmental Investment Centre
Recovery of secondary polymer waste and oil shale ash as a raw input for construction materials. Composite peat-based material with pretensioned polymer rebar	University of Tartu	Environmental Investment Centre
Rendering safe the NORM waste generated in the Molycorp Silmet AS production process (diffusion of fly ash in residues)	University of Tartu	Molycorp Silmet AS
Handling of leachate and polluted runoff from the Kohtla-Järve industrial waste and semi-coke landfill 2016-2017	Ministry of the Environment	Environmental Investment Centre
Determining priority areas for oil shale mining based on natural environment and economic conditions	Ministry of the Environment	Environmental Investment Centre
Reconditioning a collapsed shaft opening (Käva 2, Kohtla Rural Municipality)	Environmental Board	Environmental Investment Centre
Cleaning the phenolic waste water from Narva oil plant using granulated fly ash – development of process	KBFI	Environmental Investment Centre
Use of granulated oil shale fluidised bed boiler ash as a soil amendment – leachate study	Estonian University of Life Sciences	KBFI

### **Standardization of the oil shale sector**

The existence of standards applicable to oil shale simplifies and supports the everyday activity and development of labs. In 2015, the Oil Shale Competence Centre at the Tallinn University of Technology's Virumaa College started organizing standardization of the oil shale sector in cooperation with the Estonian Centre for Standardization's oil shale and oil shale products processing committee (EVS/TK 57). The technical committee on standardization includes VKG, Eesti Energia, KKT, the Estonian Environmental Investment Centre, the Estonian Mining Society, and Tallinn University of Technology and Tallinn University of Technology's Virumaa College Oil Shale Competence Centre.

In 2017, the committee launched the process of transposing, by reprint method, one English-language international standard including notations relevant to Estonia. As a new feature, two original Estonian standards were prepared, of which one was published.

### **STANDARDS PREPARED AND PUBLISHED IN 2017**

EVS 664:2017 Solid fuels. Sulphur content. Determination of total sulphur and its bonding forms. Due to the increasing significance of environmental protection, determination of sulphur and its bonding forms in various materials is becoming more important as well. This also pertains to oil shale, in which sulphur occurs in several forms, and where total sulphur content must most frequently be determined. This is a new treatment of the previous version of the standard. A key change in the standard is the addition of the instrument-based method to the existing method for determination of total sulphur and redactions in the text of the standard.

### **STANDARDS IN PREPARATION**

EVS 668:1996 Kukersite oil shale. Determination of moisture.

EVS-ISO 587:1997 Solid mineral fuels. Determination of chlorine using an Eschka method.



# Giving back to the community

The charity and sponsorship activities of oil shale companies are largely centred on Ida-Viru County, supporting the local communities in preserving their traditions and advancing local life.

## **From Tommy Cash to world-class ballet**

Summer 2017 saw the first instalment of the music festival Sound of the Hills at the Estonian Mining Museum, the goal of which was to introduce the charms of Ida-Viru County and create a positive link between the region and contemporary culture. Over 40 artists from Estonia and elsewhere took the stage in four locations. Among them were Tommy Cash, Röövel Ööbik, Gorō Lana and St. Cheatersburg. The festival will be held again in 2018.

The Jõhvi Ballet Festival made possible by VKG is an important cultural event in Ida-Viru County and in parts of Russia, giving locals an opportunity to enjoy top-flight ballet without travelling far from home. The successful partnership between VKG and Jõhvi Concert Hall goes back years. In the context of the 2017 festival, the company supported young dancers just starting to make their way in ballet, so that future talented performers could showcase their skills to a broader audience on the big stage.

## **Miners' Day marked by 6,000**

On the last Sunday in August, 6,000 people gathered at Kohtla-Nõmme to mark one of the more important community events in the region – Miners' Day. At the event held on the Estonian Mining Museum territory, several society competitions and games were held for young and old. Attendees danced as live bands played and there was a chance to go on underground mining museum tours.

The joint organizers of Miners' Day were Eesti Energia and VKG for the second year in a row.

## **Exercise is healthy**

For a number of years now, the largest public sports event in Ida-Viru County has been the Narva Energy Run. Eesti Energia is major sponsor and co-organizer. In 2017, the event, which is held over one of the most attractive courses, set a new participation record, with over 4,500 runners starting. The Estonian champion in the half-marathon were crowned at the event: Rio Olympic athletes Roman Fosti and Lily Luik.

KKT has made a point of supporting junior football programmes in Ida-Viru County. The company's funding has helped young soccer players take part in international competitions for several years in a row.

## **30 litres of blood to save lives**

In cooperation with Ida-Viru Central Hospital's blood service, VKG holds a blood drive four times a year. The company itself has many long-time donors, and each year new volunteers join the initiative. In 2017, VKG's employees gave over 30 litres of blood.

## **Cleaning up the surroundings**

At VKG's traditional community cleanup day in 2017, this the company's employees helped with yard work and groundskeeping at Kiikla Children's Home. Enefit Energiatootmine cleaned up Narva's Pähklimäe exercise trail.

## A SELECTION OF EVENTS IN THE OIL SHALE SECTOR IN 2017

### JANUARY

VKG sells VKG Plokk, a company operating on the construction materials market, to Aeroc International AS.

### JUNE

Wireless connectivity arrives at 40 km of Enefit Kaevandused's Estonia mine, helping to improve on-the-job safety and increase the efficiency of mining processes.

The electricity generating capacity of VKG Energia reaches a record 76 MW.

### AUGUST

The equipment operators at the Põhja-Kiviõli II oil shale opencast take part in the CAT Balticum competition.

Enefit Kaevandused completed installation of water lines for 150 households to ensure reliable water supply and clean drinking water.

### SEPTEMBER

Eesti Energia's Jordan project wins an innovation prize at the Asian Power Awards 2017.

Eesti Energia completes successful tests of shredded tyres at its oil plants.

### MARCH

Eesti Energia completes the funding of the USD 2.1 billion electricity project in Jordan.

### NOVEMBER

Jõhvi hosts the Oil Shale Competence Centre's conference, "Oil shale industry in the circular economy".

Responsible waste management is in the focus at VKG's traditional environment-themed day.

### APRIL

The ministers of the environment, and the ministries' secretaries general and advisers visit industrial companies in Ida-Viru County and environs, paying a visit to Europe's newest oil shale mine, Ojamaa.

At the meeting between Estonian President Kersti Kaljulaid and VKG management, environmental issues and socioeconomic role of industry in Ida-Viru County and Estonia are discussed.

### JULY

The Narva Quarry, owned by Enefit Kaevandused, tests a drone for evaluation of mining volumes and visual checks of walking draglines.

The oil shale industry labs at Eesti Energia are merged into one and the reliability of the lab is certified by accreditation.

As part of the Estonian Presidency of the Council of the EU, VKG hosts the EU 27's officials responsible for industrial policy, introducing challenges and perspectives in the oil shale industry.

### OCTOBER

Representatives from Komatsu visit Põhja-Kiviõli II oil shale opencast.

Eesti Energia launches a petrol filtration device that will increase the quality of Estonian shale petrol.

Eesti Energia's environment day is held at the Estonian Film Museum. The topic: "Greater efficiency – smaller footprint".

### MAY

VKG is awarded a bronze label for responsible enterprise.

The mining rescue squad at Enefit Kaevandused celebrates its 70-year anniversary.

### DECEMBER

Põhja-Kiviõli II opencast carries out test blasting and the XR82 xcentric ripper is tested.

Estonia mine sets an all-time production record, mining 9.8 million tonnes of oil shale in a year.

Estonia Mine turns 45 years old.



## Estonian oil shale industry in 2017

Income into the  
state treasury

103

million

Total  
investments

70

million

Investments  
into the environment

31

million

Positions  
for

7387

people

Sales revenue  
EUR

663

million

## In comparison with 2016

Production of electricity  
from oil shale

+6,5%

Production  
of shale oil

+20%

The average  
oil price

+25%