# ESTONIAN OIL SHALE INDUSTRY YEARBOOK 2020

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# **ESTONIAN OIL SHALE** 2020

**INDUSTRY YEARBOOK** 

# 2020 in the Estonian oil shale industry:

Revenues into the State Treasury million euros

Total investments

### 2019 in the Estonian oil shale industry: Investments into the

Revenues into the State Treasury 121

million euros

million euros

Revenues into the

State Treasury

104

million euros

Revenues into the

State Treasury

103

million euros

Revenues into the

State Treasury

120

million euros

Total investments 70 million euros

Total investments

116

million euros

million euros

million euros

### 2018 in the Estonian oil shale industry:

Revenues into the State Treasury 122

million euros

### 2017 in the Estonian oil shale industry:

Total investments 70

million euros

### 2016 in the Estonian oil shale industry:

Investments into the environment 26

63 million euros

Total investments

199

million euros

Total investments

### million euros 2015 in the Estonian oil shale industry:

82

million euros

\* Includes the KKT adjusted amount of resource and pollution charges

\*\* The calculation of workplaces in Eesti Energia as of 2017 follows new basis, taking also into consideration central services of the company and Enefit Solutions

Addresses of the managers
2020 in the Estonian oil shale industry
Framework of activities
Mining
Liquid fuels
Electricity and heat
Fine chemicals and by-products
The oil shale industry and the environment
Research based industry
Contribution into education and the community.

Investments into the environment

> million euros

Workplaces for

people

Sales revenue million euros

environment 21

Workplaces for 6530 people

Investments into the environment 55

Workplaces for 7303 people

Investments into the environment 31 million euros

Workplaces for 7387 people\*\*

Workplaces for 6400

people

Investments into the environment

Workplaces for 7411 people

Sales revenue 725 million euros

Sales revenue 772 million euros

Sales revenue 663 million euros

Sales revenue 606 million euros

Sales revenue 669 million euros

# **ADDRESSES OF THE MANAGERS**

We embarked on a new journey



Eesti Energia invested in 2020, 16.8 million Euros into research and development activities. We are searching with the assistance of researchers, innovative energy solutions that are useful and convenient for clients, accelerating the development of green technologies and establishing the future electricity grid. We are also together with researchers looking for solutions, how the production of electricity and oil would be with the smallest possible footprint and sustainable.

Hando Sutter Chairman of the Management Board of Eesti Energia

We have a long term experience in processing oil shale, skills and technology that we are now developing into a sustainable chemical industry. We desire that it will generate as much revenue as possible, for the Ida-Viru County and the state - that the workplaces will be maintained, competency increases and nature will be preserved.

We analysed in cooperation with the TalTech Oil Shale Competence Centre, plastics that occur in Estonian households and studied their suitability with the technology of the chemical industry.

It became apparent with the assistance of researchers that the chemical industry allows for reprocessing also such plastics that currently can only

If we have been talking for some time about the cli-

mate crisis and continue to do so, then this year to

the given crisis, has been added the raw materials

and energy crisis that puts everything into new light,

as well as forces us to re-evaluate decisions already

made. The crisis and ever increasing prices, have

brought us into a situation, in which the environment

friendlier decisions made to date, no longer justify

themselves and we cannot use them. Oil shale is

again in the boilers.

# Many crisis side by side



Priit Orumaa Chairman of the Management Board of the Kiviõli Keemiatööstus

The raw material and energy crisis arrived at the right time, raising the question about our readiness to solve the climate questions as currently planned, so be incinerated or landfilled. This important technological development allows in the future to produce from waste plastics, suitable oil as input for the chemical industry. Plastic thereby contains three times more oil than oil shale and we at the same time solve the problem of waste plastic.

Chemistry is indeed the next stage of development, in the oil shale industry, where in addition to oil shale we take into use, the plastics left over from waste handling and old tyres. The aim is to do this carbon neutrally.

We can make the green transition by utilising the current experiences and technologies, from the oil shale industry. We must find solutions how to execute current activities, more sustainably and with a significantly smaller footprint. The aim should not be to abandon oil shale for the sake of principle, but the aim must be, how to best valorise oil shale with a minimal footprint.

The cooperation of Eesti Energia with researchers, indicates that this is possible and this all, is just the beginning of the journey. This is a journey to zero or towards a carbon neutral economic model.

that after we have boldly abandoned fossil fuels we do not face the reality that we are incapable of covering the increased energy needs. If in light of the current medical crisis, we must select who to treat and who not to, then in the case of hasty decisions as well as not thought through energy policy, the time is not so distant when we must select, to whom we give electricity and to whom not.

It is loved in the case of the green transition, to talk about how it affects the Ida-Viru County and the local employment. It actually affects every inhabitant of Estonia, through more expensive electricity and heating rates.



Ahti Asmann Chairman of the Management Board of Viru Keemia Grupp

# **Changes require rapid** and bold risk management

2020 will be remembered by all of us as an exceptional year – the pandemic, closed borders, isolation, fighting the virus. The year taught us as a society, to function and consume differently, as well as to test our values. It was also so for businesses – some saw opportunities, others were incapable of adapting to the changes.

The previous year for VKG was foremost a year of risk management. The decrease in demand for petroleum products, due to the coronavirus, in the first half of the year, brought the market into a free fall. The strong demand at the same time, for our low sulphur content shale oil marine fuel, was still preserved even in the most difficult times. The growth in sales of phenol products was the strongest in history. There was also increased interest in coke, among Western European companies. We entered the US market with fine chemical products. High efficiency, a strong financial position and activity

# The pillar of sustainability is research and development activity



Kalle Pirk TalTech Virumaa College Head of the oil shale competence centre

2020 brought the oil shale industry into the light a whole, combining into one, for example wind of the green transition. It is important to direct this imaginary light beam, as far as possible. It is essential to obtain for many upcoming years, a clear picture of the policies and regulations that affect the development of oil shale companies. It is only through this that a planned phasing out or development activities in new directions are possible. The pillar of sustainability is in any case, research and development activity. Companies and research institutions have already contributed into it, for decades and precisely thanks to these traditions, we are currently not in so called "starting boxes", but in a consciously planned process of changes.

The Green Deal on its own, provides an additional impetus, to view the developments ahead, as based on core values, is a strong basis for moving along, with the market changes. We will continue in 2021 with the search for business, in fields where a natural demand is present, free competition functions and profitability does not depend on political decisions.

We were capable of preserving the usual work routine, despite all crisis, regulatory uncertainties, foremost thanks to a functional risk management system, as well as the capacity to quickly and boldly react under changing circumstances. We contributed a lot of energy into protecting the health of our employees and preventing the spread of the virus. Timely action and the responsible attitude of the people of the group, into the prevention of the spread of the virus, allowed to keep the company working and continue the uninterrupted provision of vital services.

energy, hydrogen production, the chemical industry and use of oil shale. The key question of the Estonian oil shale industry and there through the development or regression of the country, but foremost of Ida-Viru County, is the fitting into the strategy of the European Green Deal. The challenge lies in how would the oil shale industry win the most, under the conditions of the Green Deal - what activities should be in focus and in what directions are the needs for innovation acutest. It can be stated on the basis of research work, started in 2020 that one of the directions selected, is the application of oil shale and oil shale processing technologies, more than currently into the chemical industry, through focussing on the circular economy.

# HOMAT

# 2020 in the Estonian oil shale industry:

Revenue into the State Treasury

76

million euros

Total investment

Investments into the environment

Workplaces for

Sales revenue

8 57

people

# In comparison to 2019:

million euros

Revenue into the State Treasury -37%

Investments into the environment Total investment -35%

-33%

Workplaces -748

Sales revenue -31%

million euros

Oil shale mining

-24%

# **2020 IN THE OIL SHALE INDUSTRY OF ESTONIA**

Shale oil production -1%

Exports of fine chemical and phenol products

+33%

45

million euros

Oil shale electricity -50%

Oil shale industry CO<sub>2</sub> emission -35%

The Estonian oil shale industry, in 2020 continued to be in a wave of change. The branch of industry was capable of developing and producing shale oil, supplying the country with electricity produced from oil shale, participating in the circular economy, with by-products, developing research, reducing environmental impact and contributing to the community, during the economic and health crisis. Production continued and vital services were ensured, also under the emergency situation.

The total contribution in 2020, of Eesti Energia (EE), Viru Keemia Grupp (VKG) and Kiviõli Keemiatööstus (KKT), into the State Treasury was over 76 million Euros.

The largest tax revenue of the oil shale industry companies, accrued to the state from the salaries of 5 782 persons - in total 33.9 million Euros – as well as from environmental charges - 33.3 million Euros. The average salary in 2020, related to employees of the oil shale industry, was 1 555 Euros.

The oil shale industry companies, in the name of a cleaner environment, cooperate with research and development institutions, to supplement and develop existing technologies, as well as take into use, new technologies that allow for realising the green transition. The companies, also in the economic crisis of 2020, were capable of developing new technologies, increasing the efficiency of production. They realised environment saving projects, to the extent of 45 million Euros. 18 million Euros were contributed into research and development activities.

The oil shale industry, is moving towards cleaner production. The air emissions alone have decreased over the years, despite the consistent increase of shale oil production volumes. The SO<sub>2</sub> emissions decreased by over 40%, in comparison to the previous year, NO<sub>2</sub>, emissions 26% and the emission of particulates has also decreased by 21%. These indicators have decreased within the last six years, over 64%.



# **Oil shale products for export**

Estonia exported in 2020, according to Statistics Estonia, increased to 7.4 TWh that was 36% more, in comparison to goods in a comparable value to the previous year that were 2019. valued at 14.3 billion Euros. The export of shale oil, assisted in balancing the balance of transport fuels – 99% of the shale An important part of the electricity consumed in Estonia, is oil produced in Estonia, is sold to other countries. still produced in the homeland. The three oil shale industry

Three oil shale companies produced in 2020, over a million tons of shale oil, in total 1.15 million tons. The volume of oil production was comparable to 2019 and despite the great fluctuations in petroleum prices, as well as problems caused by the pandemic, was stable.

Estonia has largely thanks to oil shale energy, been until 2018 the country in Europe, with the lowest dependency on imported energy. Estonia in 2020, due to changed carbon taxation policy, exported 3.7 TWh. The import of electricity, in 2020



### THE ESTONIAN OIL SHALE INDUSTRY IN FIGURES IN 2020

	Sales revenue (EUR)	Average number of employees	Oil shale mined (t)*	Tax footprint (million EUR)**
Companies of Eesti Energia related to the oil shale industry	276 244 338	3 634	5 005 541	46 105 778
Viru Keemia Grupp	195 051 675	1 603	3 292 597	24 423 418
Kiviõli Keemiatööstus	25 497 149	545	896 517	5 933 877
TOTAL	496 793 162	5 782	9 194 655	76 463 073

\* Geological reserves without losses

\*\* Labour taxes, resource and pollution fees, corporate income tax, customs value added tax, property tax

companies in 2020, produced from oil shale and oil shale gas, close to 3 TWh of electricity, which is 54% of the total electricity produced in Estonia.

The sales of oil shale fine chemical products, is on a rising wave. VKG produced in 2020, 2 288 tons of valuable fine chemical and phenol products, as well as exported them, at a value of 4 million Euros. This is 35% more than in 2019. VKG fine chemical products, are used throughout the world, in the production of pigments, liquid crystals and medicinal products.



# FRAMEWORK **OF ACTIVITY**



# More flexible mining right fee system

The Government of the Republic in 2020, amended the system of calculating the level of natural resource market price dependent mining right fees, to become more flexible, due to the sharp decreases in the price of petroleum. The changes in prices on the market, now are reflected quicker in the fees.

The world market price for petroleum in March 2020 for example, decreased within 14 days 50%. The mining right fees had until then, been connected with the market price of energy products of the quarter preceding the reporting quarter. The change to the formula for establishing the fees, was made with the aim to reduce risks and effects of the economic crisis. The regulation passed, connected the mining right fee calculation, with the energy product prices of the reporting quarter.

The average price in 2020, of heavy fuel oil with 1% sulphur content (as quoted in Rotterdam), was 234.98 Euros per ton. The fee rate associated with the quarterly price, was in 2020 according to the new regulation, 0.345-0.89 Euros per ton.

# **Special diesel fuel for mining**

The Government of the Republic allowed starting from 1 July 2020, for a two year period, as state aid, to use special diesel fuel for the mining of oil shale. The fuel many be used on land allocation service areas, industrial territory, as well as in ash storage areas, in equipment and devices intended for the mining of oil shale. The exception made by the government, assists in alleviating the economic difficulties caused by the pandemic, saves costs, allows work to continue and maintains jobs.

## Lower fee rate for oil shale ash

Oil shale fly and bottom ash, as of the beginning of 2020, is classified as non-hazardous waste. This also changed the basis for applying pollution charges, in comparison to previously. The Riigikogu passed at the start of the summer, an amendment to the Environmental Charges Act that temporarily reduced the pollution charge, for storing the oil shale fly and bottom ash. The idea of the legislative amendment, was to exceptionally in 2020, apply in connection with the coronavirus SARS-CoV-2 crisis that causes the COVID-19 disease, for the oil shale fly and bottom ash, a pollution charge rate, of 1.31 Euros per ton, instead of the valid 2.98 Euros.

# Limiting the sulphur content of marine fuel

The International Maritime Organisation, at the end of 2016, approved an amendment of MARPOL (the International Convention for the Prevention of Pollution from Ships) that limits the sulphur content of marine fuels, used in the world seas. The sulphur content of marine fuel, as of the beginning of 2020, must not exceed 0.5%, instead of 3.5%. The change in the regulation increased the demand for shale oil, on the world market.

Approximately 99% of the shale oil produced in Estonia, is sold to the largest traders on the global fuel market. Shale oil is an important component in the preparation of marine fuel. The sulphur content of the shale oil produced in Estonia, is on average 0.8% that qualifies it, based on sulphur content, as corresponding to 1% *Low Sulphur Fuel Oil* (LSFO).

# National energy and climate plan until 2030

The government approved in December 2019, the national energy and climate plan until 2030. The most important aim of it, is to reduce the emissions of Estonian greenhouse gases by 80% by 2050 (incl. by 70% by 2030). The emissions of greenhouse gases, according to this plan, additionally need to be reduced by 13% by 2030, in comparison to the 2005 level, in the fields of transport, small scale power, agriculture, waste management, forestry and industry. This means that in 2030, the emissions can be 5.5 million tons CO<sub>2</sub> equiv.



# Climate neutral Europe 2050

The European Commission plans with the long term strategic vision "A clean planet for all", within the next 30 years to bring the emission quantities of greenhouse gases to zero, in the European Union. Renewable energy must ensure by 2030, more than half of the total energy needs that is at least twice as much as currently. The European Union wants to reduce the emissions of greenhouse gases by 2030, in comparison to the 1990 level by 40%, under consideration is to raise the given aim to 55%.

Estonia is in principle in favour of setting a European Union wide aim of climate neutrality by 2050, but in parallel must function sufficient transition measures that support the given process. It must be thereby taken into consideration, the starting level, as well as differences of the member states and different industrial fields.

# Impact of the price of CO<sub>2</sub> emission quotas

The higher the price of  $CO_2$  emission quotas, the more expensive it is to produce electricity from oil shale in Estonia. The price of  $CO_2$  emission quotas significantly impacts the production costs of electricity through direct burning of oil shale, especially in the case of older production equipment, with larger  $CO_2$  capacity.

The emission right price of a  $CO_2$  ton, at the beginning of 2018 was less than 10 Euros, then already by February of the same year, it had increased to about 20 Euros per ton. The average

market price in 2020 remained on the level of the previous year, 24.8 Euros per ton of CO<sub>2</sub>. It fluctuated in 2020 in the range 17.7-32.5 Euros per ton of CO<sub>2</sub>. The lowest price of the year was in the spring, as a result of the decrease on the world markets having taken place because of the COVID-19 pandemic. The highest price was established at the end of the year, after the European Union made the decision to reduce its emission quantities of greenhouse gases by 55% by 2030. The price starting then has been increasing.





The European Union Emissions Trading System, is a means of reducing the emissions of greenhouse gases within the union. The quantity of CO<sub>2</sub> quotas offered on the market, is constantly reduced and the logical consequence of this is, them becoming more expensive. The reduction in the general quantities of units of greenhouse gases will be starting from 2021, 2.2% per year, instead of the current 1.74%. The number of units on the market, with a reduction in emissions of CO<sub>2</sub>, will start to be reduced even faster than currently. Fields that have a risk of carbon leakage, will continue to receive units, to avoid the "moving" of emissions out of bounds. It is planned for the reduction of the risk, in the case of certain fields, to apply a mechanism of carbon dioxide limit tax.

# **COVID-19** pandemic

The second larger influencer of the year of the oil shale industry, besides the economic crisis was the health crisis that resulted from the coronavirus that had hit the entire world. An emergency situation was established in Estonia on 13 March 2020 that lasted until 17 May 2020. organisation was changed, if required. It was thanks to this, possible to keep the level of infection low, at the workplace. Larger pauses in production did not occur and the provision of vital services was ensured, without interruption.

Companies set to the forefront, the health of employees, applied quickly, thought through precautionary measures and were capable of avoiding larger setbacks. The crisis committees of companies executed preventive work, ensured required personal protection and disinfecting means, as well as organised at the workplace, voluntary vaccination. Work



The amendments of the Government of the Republic, in the charges for mining rights and ash storage, as well as in the use of special diesel fuel, assisted in alleviating the economic difficulties caused by the pandemic, through cost savings, continuation of work and maintenance of jobs.







The layer of oil shale, in the Estonian deposit of oil shale, between Rakvere and Narva, is 1.4–2.9 metres thick. More than a billion tons of oil shale have been extracted from this deposit, in over one hundred years, in underground mines and above ground guarries.

## Less oil shale for electricity production

Oil shale was mined in 2020 by Eesti Energia, Viru Keemia Grupp and Kiviõli Keemiatööstus. Kunda Nordic Tsement that previously also mined oil shale that used it as fuel in the production of cement, ceased the production of clinker in 2020, thus no longer requiring oil shale.

The three companies in 2020, mined a total of 9.2 million tons of oil shale that is the smallest quantity within the last 30 years. The volume mined, compared to 2019, was reduced by 3 million tons.

It was thus mined in 2020, less than half of the state established maximum permissible extraction rate - 20 million tons of the geological oil shale reserves. EE is allowed to extract 15.01 million tons per year, but extracted only 33 percent thereof. KKT mined of the annual limit value, of 1.98 million tons, 61 percent. VKG mined of its annual limit that is 2.77 million tons, 119%. The company used the right to extract more than the limit, on account of the unused limit of previous years.

The annual limit of Kunda Nordic Tsement, of 0.2 million tons remained unused.

The volume of oil shale mined by Eesti Energia was reduced noticeably for the second year in a row, for as a result of the more expensive carbon guotas, they could produce electricity from oil shale only at those times, when the price of electricity on the market became high. The development directions of Eesti Energia, considering the climate policy of Europe, foresee the reduction of electricity from oil shale, as well as an increase in the production of liquid fuels and renewable energy.

The government obligated Eesti Energia that belongs to the state, to maintain until 2023, the capacity to produce electricity from oil shale, regardless of the market situation, at the level of 1 000 MW that is the average consumption of Estonia.

### MINING OF OIL SHALE MINING 2013-2020

Permitted annual lim	it, (th t)	201	L3	201	14	201	15	20	16	20	17	20	18	20	19	20	20	average %
Eesti Energia AS	15 010	11 830	79%	11 614	77%	11 083	74%	9 732	65%	11 157	74%	11 296	75%	7 458	50%	5 006	33%	67%
Viru Keemia Grupp AS	2 772	2 344	85%	2 483	90%	2 637	95%	1 791	65%	3 239	116%	3 487	126%	3 520	127%	3 293	119%	95%
Kiviõli Keemiatööstus	1 980	755	38%	1 058	53%	1 350	68%	1 581	80%	1 164	80%	1 088	55%	1 084	55%	897	45%	67%
AS Kunda Nordic Tsement	238	98	41%	113	47%	116	49%	0	0%	74	31%	74	31%	65	27%	0	0%	28%
TOTAL	20 000	15 027	75%	15 268	76%	15 186	76%	13 104	66%	15 634	80%	15 945	80%	12 127	60%	9 196	46%	67%

\* The data for the years 2014-2016 have been adjusted by the consolidated balance of mineral resources

# **More efficient mining**

Every year automation in the mining of oil shale has increased. Companies are investing tens of millions of Euros, to digitalise increasingly more work processes. The collection and analysis of data assists in making decisions that make production more efficient, innovative and reduce the environmental footprint.

Eesti Energia took into use in the Narva guarry, the largest Komatsu bulldozer in Europe that weighs 113 tons. The exhaust gases of the powerful machine, contain 80% less particulates and half less nitrogen emissions, compared to the



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Actual volumes mined (th t)\* Use of annual limit (%)

2013-2020

bulldozers that previously did the work. The productivity of the new machine is also 10% higher. The work of the operator controlling the bulldozer is more comfortable and safer.

A new bulldozer and excavator started work in the Põhja-Kiviõli II guarry. A noticeable change is that if previously were in use, mainly Komatsu equipment, then now the equipment of other producers is also being tested.

# Expanded mining area

The mining area of the Kiviõli Keemiatööstus expanded to the areas of the Põhja-Kiviõli II oil shale quarry that until now had been untouched and the deposits of oil shale increased by approximately 8 million tons. The expansion became possible as the process of expropriation that had lasted for 10 years came to an end. Parcels of land were taken into use in the mining area that remained between already mined lands. This in turn means less blasting works and drier oil shale.

There will be at the current mining volumes, with the added areas, sufficient oil shale still for up to ten years. The Kiviõli Keemiatööstus uses over half of the mined oil shale, for producing oil in its own company. The remainder is sold to other companies that process oil shale.

# **Downtime caused** by the pandemic

Eesti Energia in 2020 suspended twice, the work in the Estonia mine because of the pandemic. Approximately 800 miners were sent home in April and August, to prevent the spread of the virus. The temporary suspension of mining, did not jeopardise the production of electricity and oil, as the company had accumulated a sufficient reserve, in the oil shale warehouse.

The VKG Ojamaa mine, required a reduction to a 60% load, for 10 days in the autumn, because of the spread of the virus.

# Authorisation for establishing a new mine

The Enefit Kaevandused of Eesti Energia received authorisation from the Environmental Board, for 30 years to mine from the Uus-Kiviõli mine, located on the lands of the rural municipalities of Alutaguse and Lü<sup>¨</sup>ganuse, up to 6 million tons of oil shale annually. The application for the mining permit was presented already 15 years ago.

The mining will be done in cooperation with VKG, but will not begin prior to 2025, when the Environmental Board has placed on the Uus-Kiviõli, but also the VKG Ojamaa mine permits, the condition that 40 percent of the waste rock generated in the enrichment of oil shale, must go into recycling.

There are geological reserves in the VKG Ojamaa mine, for at least 8 years and it is planned during this time to produce 4.3 million tons of oil shale, per year. It is intended at the depletion of the mine, to move onto the mining areas of Uus-Kiviõli.

## **Drones as assistants**

Eesti Energia used in 2020 drones for the purposes of safety, precision and time savings, in mining areas. Drones assist in mapping the storage volumes of oil shale and measure objects. The remaining stores of oil shale of the Estonia mine for example, can with the assistance of a drone be measured within an hour, instead of half a day. It is also possible to collect more measurement data, with a drone than manually.



### **OIL SHALE VALUE CHAIN**





# **LIQUID FUELS**



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Shale oil is used as raw material for the chemical industry and as impregnation oil, for heating boilers and industrial furnaces, as well as an additive to marine fuels. Estonia is one of the largest shale oil producers in the world.

The strong aspects of shale oil on the liquid fuels market, in comparison to heavy fuel oil, are its low sulphur content and good flow per density. It is therefore not required to heat it before using. The average sulphur content of shale oil of Estonian producers, is 0.8%. The world's best knowledge on shale oil production is in Estonia.

### PRODUCTION OF LIQUID FUEL BY THE ESTONIAN OIL SHALE INDUSTRY (TH T)

	2014	2015	2016	2017	2018	2019	2020
Eesti Energia	265	337	318	395	410	442	452
Viru Keemia Grupp	433	506	451	536	607	637	612
Kiviõli Keemiatööstus	62	72	83	89	92	94	92
TOTAL	760	915	852	1 020	1 109	1 173	1 156

## Again over a million tons of shale oil

The Estonian oil shale industries again in 2020, together produced over a million tons of shale oil. The annual oil production was equivalent to that of 2019, the total volume decreased by only 17 thousand tons. The production continued to be sold abroad, approximately to the extent of 99%: primarily to Holland and Belgium, but also to Sweden, Malta and Denmark.

VKG processed oil shale in 2020 in three Petroter plants and in three shale oil plants, functioning with the Kiviter technology. The company in April 2020, conserved one more oil plant, functioning on the Kiviter technology, as it used oil shale purchased from outside the group that became so expensive that producing oil from it, would no longer have been profitable.

Eesti Energia established an all time production record in the production of shale oil, in the Enefit 140 and Enefit 280 oil plants – 452 thousand tons or 10 thousand tons, more oil were produced than the production record of the previous year.

2020 was a notable year for Eesti Energia, as it was the first year in which the company used oil shale more for the production of liquid fuels than for the production of electricity. Production increased primarily because of the improved reliability of the Enefit 280 oil plant and the oil yield.

# **Billions of Euros of national wealth**

It becomes apparent from the analysis of the research com-The continuation of the oil shale industry is affected by the pany KPMG, ordered by the Estonian Chemical Industry Asamendments to the trading system of greenhouse gases that sociation that with the production of shale oil, it would be the European Union will establish. A sharper than assumed possible to create over the next 20 years, national wealth for price increase, of the CO<sub>2</sub> emission rights or reduction of the Estonia, in excess of 8.2 billion Euros, 7.5 billion according to quotas set aside free of charge, would already by 2030 make the conclusions of the experts, would be distributed between the production of shale oil uncompetitive, on the global marcooperation partners, the public sector, employees and the ket and the national wealth of the Estonian state, would republic. The share of the owners of the oil shale companies and main smaller than expected, by 4.5 billion Euros. investors, would be throughout the entire period, approximately 0.7 billion Euros.

## Two technologies are used in Estonia to produce shale oil:



Older gas heat carrier (GHC) vertical retorts (e.g. Kiviter technology)



Newer, solid heat carrier (SHC) horizontal retort (Petroter and Enefit technology) that have a low CO<sub>2</sub> emission and extremely high energy efficiency The volume of oil production of the Kiviõli Keemiatööstus was influenced by improvements and investments of the recent past few years, in the solid heat carrier (SHC) system, developed in the 1960s. This has increased the reliability of the equipment and increased the volume of production by over 90 thousand tons per year.

# TECHNOLOGY USED FOR THE PRODUCTION OF ESTONIAN SHALE OIL

<b>GHC</b> Best available technique	Tec Increas techno enviro	chnical solutions of the efficiency of the efficiency of the efficiency of the solution of the	y of the ty and vation t	<b>SHC</b> Best available echnique
t	Kiviter echnology	Technology	SHC, Enefit technology Technology Petroter	· · · · · · · · · · · · · · · · · · ·
Gas	generator process	Technology process	Galoter process	
GHC Direct the ga	<b>C method</b> t control of aseous heat carrier	Process method	<b>TSK meet</b> Tahke soojuskan kaudne juhti	dja imine

### Pyrolysis of Estonian oil shale

Source: AF-Consulting

# Fluctuating price of crude oil

The price of crude oil was influenced in 2020 by the record exports of Saudi Arabian crude oil, accompanied at the same time by a decreased demand due to the COVID-19 pandemic, but also the agreements on production limits by the OPEC+ member states. The price of crude oil fell for the first time in history, into the negative and concerned was the largest price decrease after the 2008 financial crisis.

The average Brent crude oil price in 2020, was 43.2 dollars per barrel. This is significantly lower than the average price of 2019 – by 32.5%. The price of crude oil by the end of 2020, was USD 51.8/bbl, in spring of the same year the price was USD 19.33/bbl.

The market price of fuel oil, with 1% sulphur content, in 2020 shifted similarly to the Brent crude oil price. The average price

### **MARKET CONDITIONS 2020**

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1% heavy fuel oil FOB	\$/t	443	357	201	142	175	237	256	271	256	271	291	322
NWE (\$/t)													
Brent petroleum	\$/bbl	63.60	55.74	34.25	26.45	32.26	40.75	43.20	45.00	41.92	41.72	43.80	50.10

per ton.

4,5

4,0

3,5

30

2.5

20

1,5

1.0

0,5

Ω

**-67%** 

-78%

**EU PORTS** 

# **Green light for the** new plant

The Government of the Republic in the spring, authorised Eesti Energia to increase equity capital, as a financial contribution of 125 million Euros. The decision allows Eesti Energia to establish a new Enefit 280 plant, to increase the production of liquid fuels, but also to valorise the most important mineral resource of Estonia, create new jobs, support Ida-Viru County, as well as to reduce the social risks resulting from the changes taking place in the field of energy, in the region.

## **Smarter industry**

VKG is phasing in a computer program that assists the company to better plan resources. Planning includes the company accounting, as well as sales and purchasing activity, but also production, repair and maintenance processes, as well as payroll and personnel accounting and data management.

for the year, of 1% fuel oil, developed to be on the fuel oil

market, 32.4% lower, in comparison to 2019 - 234.9 Euros

CHANGES IN THE SULPHUR LIMIT

VALUE 2008-2022

-71%

**EMISSION CONTROL AREA** 

2008 2010 2012 2014 2016 2018 2020 2022

-86%

-97%

THE WORLD

# **Oil from plastic waste and tyres**

The production of oil also assists in solving environmen-Eesti Energia started in 2020 cooperation with the Tallinn Unital problems. Every year car users in Estonia, leave behind versity of Technology Virumaa College Oil Shale Competence approximately 12 000 tons of tyres that have been warn into Centre, to study the possibilities of processing plastic waste in unfit for driving. Their quantity for the whole of Europe, is the oil plant, together with oil shale, in the production of liquid over three million tons. fuels. It is desired with the study, to learn how is it possible to use plastic waste, in industrial volumes in the production The Environmental Board granted Eesti Energia a complex of oil. It would at the same time make it possible, to convert waste that until now had not been suitable for processing, into valuable liquid fuel or chemicals.

permit that allows in the production of oil, to replace up to 10% of oil shale, with shredded tyres. This allows in the future to process in production more old tyres than created, during the year in Estonia.

The environment wins in two ways at a time, in the production of oil from old tyres. This allows to reuse waste that previously lacked handling solutions. It also means that equivalently less oil shale is required for the production of oil. This is a good example of how the circular economy functions.



The technology is capable of handling more plastic waste then with current knowledge, emerges in Estonia, reduces the CO<sub>2</sub> emissions of production and improves the quality of liquid fuel.



# ELECTRICITY AND HEAT

The changes in the production of electricity from oil shale, started in the previous year continued in 2020. The share of oil shale in the production of electricity started to decrease gradually from 2008, when it reached 90%. Oil shale electricity in 2018 still accounted for 76% of the total of all electricity produced in Estonia. A sharp decrease came thereafter. The share of oil shale electricity was 57% in 2019 and in 2020 54%.

The reason for these changes is the nearly 4 fold increase in the market price of CO<sub>2</sub> and the larger quantity of cheaper electricity, produced quota free in third countries.

Electricity production in 2020, in Estonia was 5.5 terawatt hours (TWh) of electricity that in comparison to the previous year, is 27% less. The electricity consumption of Estonia was 8.44 TWh.

The total volume of electricity produced from oil shale and oil shale gas was 3 TWh. This is 40% less, in comparison to 2019. The production of electricity from renewable sources, in 2020 grew to 2.5 TWh in Estonia.

### PRODUCTION OF ELECTRICITY OF OIL SHALE COMPANIES IN ESTONIA 2014–2020 (GWH)

	2014	2015	2016	2017	2018	2019	2020
Eesti Energia	9 343	7 312	8 695	9 363	8 658	4 352	2 457
incl. from oil shale	9 003	6 745	8 203	8 741	8 074	3 691	1 825
Viru Keemia Grupp	217	311	352	416	466	474	446
Kiviõli Keemiatööstus	39	41	44	51	52	47	46
TOTAL	9 599	7 664	9 091	9 830	9 176	4 873	2 949
incl. shale oil electricity	9 259	7 097	8 212	8 747	8 081	3 695	1 834

# Less electricity directly Environment friendlier from oil shale

Eesti Energia, VKG and KKT produced in 2020, electricity from Eesti Energia reduced the production of electricity from oil shale, due to the changed market situation. The production of oil shale gas, in total 857 GWh that is approximately 30% of electricity directly from oil shale decreased in 2020, in comthe total volume of electricity production of the companies. parison to the previous year, over 50% – to the level 1.8 TWh The share of electricity produced from oil shale gas, in 2018 per year. The production directly from oil shale in 2018, was was 10%. still 8 TWh of electricity per year.

The oil shale power plants of Eesti Energia, located in Ida-Viru County were in 2020, indispensable compensators of capacity shortages, when many Scandinavian electricity producers had stopped production due to accidents. These power plants with flexible and controllable production capacity, are capable of within a few hours, to increase production 20 times and alleviate the electricity shortage on the market. Such a capacity assists in avoiding an even greater increase in the price of electricity.

The reduction of production volumes has brought along chancase the work of the production units should cease. The given ges in the work organisation of Eesti Energia, wherefore nearinvestment adds even more flexibility to energy production, ly 1 300 workplaces were lost. The electricity production cato react quicker to price changes. occurring on the market. pacity will be preserved, with the decision of the Government of the Republic of Estonia, until 2023, to the extent of 1 000 The VKG Põhia thermal power plant produced in 2020, 893 MW that is the average volume of electricity consumption in GWh of energy, of which a part was electricity, while the re-Estonia. mainder was thermal energy and steam.

### **PRODUCTION OF ELECTRICITY OF OIL SHALE** IN ESTONIA 2014-2020 (GWh)



# oil shale gas

Eesti Energia can use the gas with high calorific value, separating as a by-product of oil production, besides oil shale as a fuel in all blocks of the Eesti power plant, as well as in the energy blocks of the Auvere power plant, to the extent of 50%. The innovations reduce the environmental impact of electricity production and the production becomes more flexible.

EE invested in 2020 1.9 million Euros into increasing the capacity of the oil shale gas boiler, of the Eesti power plant, as well as started the installation of new start-up burners for the block 5 boiler 5B. These burners allow to start the boiler, in

VKG Energia produces electricity as well as thermal energy, from gas and heat separated from the production of shale oil, as well as depending on the turbine type, either as coproduction or in the condensation regime. The company roes in April 2020, to become the largest thermal electricity plant with controllable production capacity, producing 40 782 MWh of electricity that was 15.5% of the 262 496 MWh produced in Estonia, instead of the previous 4.5%.

## More economical heating from oil shale

The annual production of heat produced from oil shale gas, has been 1.1 TWh, which is is approximately one third of the Estonian district heating consumption. The limit price for heating, without value added tax, was in 2020 for the end consumer, according to data of the Competition Authority, on average 63 Euros per MWh. All companies producing thermal energy from oil shale and gas, sold heat at a price lower than the Estonian average.

The cheapest thermal energy in Estonia, offered on the basis of district heating, was provided in 2020 to approximately 55 000 inhabitants of Narva. The price of heating had changed for the inhabitants of Narva, by the end of the year to €39.83/ MWh. The Narva Soojusvõrk purchases heating produced from oil shale and biomass from the EE Balti power plant. A total of 692 sites are heated through the Narva Soojusvõrk and the total capacity of the consumers extends to 333 MW. The surrounding industrial consumers are additionally supplied with 15 atmosphere steam.

VKG Soojus supplies the consumers of the Kohtla-Järve and Ahtme-Jõhvi region, since 2018 with thermal energy, at the rate of €52.66/MWh. The VKG subsidiary produces room heating environment friendlily, using foremost for it, residual gas emerging from the processing of oil shale. The heat and steam accompanying the oil shale industry, is sold by VKG Energia to the Ida-Viru County industrial companies and regional consumers. The electricity from coproduction is sold throughout Estonia. VKG Energia in the immediate vicinity of Kohtla-Järve, additionally sells thermal energy as steam, for consumption in industrial processes, as well as hot water for heating buildings.

The inhabitants and companies of the city of Kiviõli, consumed the thermal energy obtained through the KKT coproduction of thermal and electrical energy, through the mediation of Kiviõli Soojus, at the price of €50.03/MWh.



Environmental solutions are offered also to other branches of the economy, through the circular economy: for example waste timber is used for the production of renewable energy.

# Replacing oil shale with biomass

Eesti Energia produced in 2020, 378 GWh of electricity from renewable sources, of which the majority was electricity produced from biomass. The use of biofuel instead of oil shale, reduces the need to buy CO<sub>2</sub> quotas that in turn improves the efficiency and competitiveness of the plants.

Contemporary technology allows to use besides oil shale, also waste timber as fuel. Waste is concerned that has no other purpose than to be used as fuel in energy. It is possible to use in the three newest energy production blocks of the Narva power plants, besides oil shale, up to the extent of 50% biomass and produce from it renewable energy.

### HEAT PRODUCTION OF OIL SHALE COMPANIES 2015-2020 (GWH)

	2015	2016	2017	2018	2019	2020
Eesti Energia Narva Power Plants	614	596	564	582	584	523
Viru Keemia Grupp	532	506	452	454	452	436
Kiviõli Keemiatööstus	108	123	125	139	144	143
TOTAL	1 254	1 225	1 141	1 175	1 180	1102





# FINE CHEMICALS AND BY-PRODUCTS

The by-product of oil production with the Kiviter technology is phenolic water, from which VKG separates precious chemicals, with a purity of up to 99.8%. A total of 2 288 tons of fine chemical and phenol products, were in 2020 produced at VKG that is equivalent to the production of 2018 and 33.5% more than in the previous year. The Kiviõli Keemiatööstus produced in 2020, a total of 407 tons of fine chemical products.

All companies dealing with the valorisation of oil shale, are looking for solutions how to increasingly use the by-products emerging in the processing of oil shale that accumulate in the course of a year, in total 20 million tons. The largest part of this, is formed by the waste rock that separates in the enrichment of oil shale that can be taken into circulation as limestone, ash and semi-coke emerging in the production of oil, as well as the ash that remains from electricity production. The waste rock and limestone gravel produced from it, is used in road construction, construction and maintenance works. Studies are very promising also for using bottom ash in the production of different materials and in planning are also corresponding plants. The realisation of these plans would reduce the environmental footprint of the oil shale industry, enliven the circular economy and reduce the storage fees for waste, of the companies. Some of the ash to date, has found utilisation for improving the soil of fields, as well as in road construction and to a certain extent also in the production of cement.

### OIL SHALE FINE CHEMICALS AND PHENOL EXPORTS 2014-2020 (IN EUROS)

Product group	2014	2015	2016	2017	2018	2019	2020
Fine chemicals	719 168	1 034 909	730 309	968 059	2 767 446	3 058 440	4 078 053
Summary oil shale phenols	41 849	39 596	6 212	4 411	0	9 503	15 400
TOTAL	761 017	1 074 505	736 521	972 470	2 767 446	3 067 943	4 093 453

Source: Statistics Estonia

## The circular economy creates new outlooks

Green and a conserving way of thinking, forces to turn increasingly more attention on how to utilise waste of production processes, but also to things that are warn and have gone through one life cycle. One of the principles of the circular economy, is to produce such goods and provide such services that the occurrence of waste would be as little as possible. The circular economy also allows the oil shale industry, to use resources more rationally than previously. A large part of the development projects of oil shale companies are to a greater or lesser extent, connected with a transition to the circular economy.

VKG is contributing increasingly more into the development of oil shale chemistry. This extends the value chain of use, of oil shale and reduces waste. A lot of attention and time is required, besides the expensive studies and development activities, also for the registration of the chemical substances, based on the obligations, resulting from the European Union so called REACH regulation, as well as the marketing of fine chemical products produced on the basis of oil shale.

## Valuable phenols

The VKG production of oil shale phenols are alkylresorcinol fractions, high purity fine chemical resorcinols and adhesive resin type synthetic products. VKG sells of the total production of fine chemicals and phenol products, 95% as exports, in total for more than 4 million Euros. The main markets to where the products were sold, were Great Britain, India, Italy, Belgium and the United States of America. Acrylic resorcinols are required in the production of moulds, as well as adhesive resins in the rubber, plywood and petroleum industries. The high purity fine chemical products produced by VKG from oil shale (2-methylresorcinols, 5-methylresorcinol anhydrides and 5-methylresorcinol monohydrates) are found in the crystals of LCD monitors, hair colours, as well as medicines. The price of one kilogram of high purity fine chemicals may reach many tens of Euros.

The phenols Honeyol 80, Honeyol and Rezol, produced by VKG in Kohtla-Järve, are contained for example, in car parts of Lexus and Toyota. They are also used in the production of high durability tyres.

# **Oil shale ash**

The giant ash plateaus located in the vicinity of the Narva plants, are one of the largest and most visible footprints of the oil shale industry. These store the ash that results in the boilers, in the course of burning, in the oil shale power plants. The ash is of two types, of which one settles on the bottom of the hearth and is called bottom ash. The other type of ash is carried from the hearth, along with the gas flow that is referred to as fly ash. The bottom ash accounts for 30-40% of the mass of ash flow and fly ash 60-70%.

The oil shale industry in 2020, generated 5.1 million tons of ash that is 22% less than in the previous year. 2.87 million tons of ash were generated in boilers of Eesti Energia that is approximately 30% less than the previous year and in comparison to 2018, even 60% less.

Eesti Energia recovered only 2% or 60 000 tons of ash, in construction and agriculture. A new type of technology is used in VKG, for storing the ash that mainly is generated in the production of oil: the ash is stored moistened and compacted, such that a waterproof layer emerges and this layer is in turned covered with semi-coke. 1.86 million tons of ash, emerged in 2020 at VKG.



# Sales geography of fine chemicals broadened

VKG markets in the European Union countries, over 40 chemicals produced from oil shale. VKG after a registration process that lasted five years, entered the market of the United States of America (USA) and possesses the right to sell the oil shale chemical product HoneyoITM. HoneyoITM has two larger fields of use, on the new market: the production of rubber resins in the tyre industry and the production of adhesive resins for the timber industry. Concerned is one of the best alternatives to the widespread chemical, resorcinol that is widely used on the US market, thus HoneyoITM also has a high potential on the market there.

# Waste rock

Waste rock consists primarily of limestone and contains small quantities of oil shale, 3.95 million tons of waste rock emerged in 2020, in the oil shale industry. The volume of waste rock produced, decreased over the year by 2 million tons or 34%.

Limestone is suitable for building roads, large squares, dams, large volume structures and other massive objects, as well as for the repair of forest roads. The limestone that results as a by-product of oil shale mining, is suitable for the construction of rail and highways, as a filler material. This has been confirmed by the Tallinn University of Technology study, ordered by Eesti Energia. The study also reached the conclusion that the use of the limestone in the construction of the Rail Baltic railway line, allows alleviating the environmental damage that would accompany the opening of new guarries.

It was found in the study by the Tallinn University of Technology and Eesti Energia that a part, estimated to be 3 million cubic metres, of the sand required as filler material for the construction of the Estonian section of the Rail Baltic railway line, can be replaced with ordinary limestone gravel, produced

from oil shale waste rock. The limestone produced from waste rock, is suitable according to a specific recipe, combined with sand, as filler material in the construction of railways and that foremost in the lower layers of the embankment.

The Environmental Board granted Enefit Kaevandus, the right to reuse waste rock, in a quantity of up to 3 million tons, for the construction of the substructure of the solar power station being established on the territory of the Estonia mine. A major obstacle in the recovery of waste rock, are the expenses related to the transport of large quantities to more distant reaions.

3.98 million tons of waste rock were recovered, in 2020 that emerged through mining that is slightly more than the volume produced in the preceding year. VKG recovered from this, 1.75 million tons of waste rock. Eesti Energia took into the circular economy, a record amount of waste rock that amounted to 2.2 million tons that is twice more than in comparison to 2018 and 2019. It is remarkable that the company itself, recovered more waste rock than was additionally created in the same vear.

## **Recycling of oil shale ash**

A study ordered from the Tallinn University of Technology and the TTK University of Applied Sciences, confirmed to Eesti Energia that oil shale ash is suitable for stabilising large peat areas and it can be used in the construction of the Rail Baltic line. The railway construction would require 175 000 tons of ash that is more than the currently recoverable amount.

Eesti Energia produces the soil improver Enefix that is suitable for improving the yields, on traditional and organic fields, as a neutraliser of pH levels. Oil shale ash has in comparison to previously, obtained additional value thanks to the burning of

chipped wood, as with it is accompanied a greater content of nutrient elements. Such extremely base lime fertiliser, the pH level of which extends to 13, allows for guickly adjusting the pH level of soil.

The first tons of oil shale ash granules, were spread in the spring of 2020, onto the fields of Räpina, in cooperation with the companies Eesti Energia, Scandagra Estonia and Roxtrade. The test batch of the oil shale ash granules, were produced in the laboratory of the National Institute of Chemical Physics and Biophysics (NICPB). The characteristics of the produced

granules, are to the extent of 95% identical with the powdery would reduce the environmental burden of Ida-Viru County ash. A natural material was used as a binder. and would reduce the need to mine natural resources in Europe, as well as the world on the whole.

The granulated oil shale ash is easier to transport and is suitable for use in ordinary fertiliser dispersers. It is planned to build by 2022, for the production of granules from oil shale ash, a plant in the vicinity of the Balti power plant.

The exclusion of oil shale ash "from among hazardous waste, furthers the circular economy in industry. The new in 2019 released, Estonian original standard, EVS 940:2019 "Burnt shale for the plastics industry. Specifications and conformity Ragn Sells is planning to start production in 2025, to valorise criteria", allows for starting to use oil shale ash, in the plastics in a carbon neutral process, more than one million tons of oil industry. Standardisation allows using ash, officially as a proshale ash waste. The taking into circulation of oil shale ash. duct that allows increasing the quantities used.

## Flv ash

separates from oil shale in the production of electricity, in the process of cleaning smoke gases. The smoke flues of the power plants contain special filters that capture from the fly ash with high calcium content, tiny particles of ash.

## **Bottom** ash

forms in the hearth chamber and is removed from the base of the hearth. The bottom ash is of varying grain size. It currently lacks recycled use and is to the full extent directed to the ash fields.

SOLID BY-PRODUCTS ACCOMPANYING THE OIL SHALE INDUSTRY (TH T) AND THEIR USE AS PRODUCTS (%)

	2014	2015	2016	2017	2018	2019	2020
Oil shale ash	8 554	7 296	8 973	9 323	9 387	6 499	5 118
Waste rock	8 083	11 973	10 312	6 261	6 461	5 970	3 953



The test batch of the oil shale ash granules were produced in the laboratory of the National Institute of Chemical Physics and Biophysics (NICPB). It was thus proven that it is possible to granulate oil shale ash, according to the requirements of the field of agriculture.



# THE OIL SHALE INDUSTRY AND THE ENVIRONMENT

The environmental impact of oil shale industry has decreased during the entire period of reindependence of Estonia. It has resulted on the one hand, from a decrease in the volumes of mining and the fulfilment of contemporary environmental requirements. All oil shale companies, are still additionally constantly looking for solutions, how to use oil shale as efficiently and conservingly as possible, with the contemporary knowledge and technological possibilities. It is sensible to invest into this development direction and to cooperate with universities, as the use of environment conserving technologies saves nature, but also provides an economic effect, as well as increases the support of the local community to the oil shale industry.

# **Approximately 14 million Euros** into the environment

The oil shale companies paid the state in 2020, over 30 million Euros in environmental charges, of which more than half were resource fees for mining oil shale and water use.

million Euros. This is nearly 22 million Euros less than in 2018. This was the result of a sharply reduced need for oil shale. The companies at the same time, invested nearly 14 million Euros into projects that reduce environmental impact.

Pollution charges related to the mining and handling of brown gold, for the storage of emissions and waste, amounted to 18

### DIRECT AND INDIRECT ENVIRONMENTAL INVESTMENTS

### OF ESTONIAN OIL SHALE COMPANIES 2013-2020 (MILLION EUROS)

	2013	2014	2015	2016	2017	2018	2019	2020
Eesti Energia	69,8	28,5	27,4	9,4	16,2	40,8**	10,9	6,5
VKG	3,9	8,9	53,5*	14,4	12,1	9,4	8,4	5,2
ККТ	8	5,2	0	0,4	0,8	4,2	1,8	2,0
KNT	0,2	0,2	0,9	1,9	1,4	0,5	0,4	-
TOTAL	81,9	42,8	81,8	26,1	30,5	54,9	21,5	13,7

\* Includes indirect environmental investments in connection with expansion of production volumes and establishment of the oil shale oil plant Petroter III \*\* Includes investments in the development of the Auvere power plant. Investments of 328.4 million Euros were made in 2013-2018, into the Auvere power plant.

## Water in the oil shale industry

The declared environmental charges in 2020 in Estonia, were 3 million Euros less than in 2019. The most environmental charges were paid in 2020 in Ida-Viru County (29.5 million Euros) and Harju County (12.8 million Euros). The most declared charges in 2020 were the charge for the right to mine a mineral resource (17.3 million Euros), pollution charge for waste disposal (15.3 million Euros), charge for special use of water (13.4 million Euros) and ambient air pollution charge (5.9 million Euros).

Water inevitably also moves, with the moving of the surface. Water must be pumped out of the cavities, when mining oil shale and directed into sediment pools, where it later settles. It thereafter has access back to nature. The quantity of water to be pumped out, depends largely upon how snow or rain rich the year has been. The share of rain water in guarries for example, is 80 and in mines 50 percent. The remainder is groundwater.

Companies in 2020, in mining oil shale pumped out of guarries and mines, a total of 155 million cubic metres of water that is 5% less than in the previous year.

The companies paid when pumping water out, 20.67 Euros from quarries and 57.64 Euros from mines, per 1000 m3. The level of the charge for the special use of water and their increase per year, was established by the Government of the Republic of Estonia, in its regulation for the years 2016–2025. The oil shale companies, due to the dry year, paid in 2020 charges for the special use of water, 7.7 million Euros that is nearly 6% less than in the previous year.



# Less environmental charges

The reasons for the decline include the temporary reduction in the charge for storing oil shale ash, reduction in the quantities of oil shale mined, as well as a reduction in the fly and bottom ash quantities occurring while handling oil shale.

# Drinking water is safe

The study of the researchers of the University of Tartu, ordered by the Health Board in 2020, confirmed that the drinking water of Ida-Viru County is safe for the consumers. The substances found in the course of the study, do not make it possible to claim that the oil shale industry would have expressed an impact on the drinking water of the Ida-Viru County public water supplies. The findings could rather originate from other human caused sources, such as inherited pollution or the distribution network.

# Mining water and area, to generate electricity

A detailed plan was established in 2020, for the Estonia mining area that allows to construct there, the first pump hydroelectricity power plant in Estonia, with a capacity of up to 50 MW.

Waste rock and limestone gravel will be used to construct its upper water reservoir. The construction of the power storage device of up to 50 MW, will presumably be completed by the end of the decade and it will be possible to reuse up to 5 million tons of waste rock, in its construction. Existing mining passages will be taken into use, for establishing the lower reservoir.

A pilot project is currently in the works, the aim of which is to by 2025-2026, to initially construct a pump hydroelectric power plant, with a capacity of 2 MW.

Eesti Energia is additionally making preparations in the industrial area of the Estonia mine, for the construction of two somewhat different solar power plants, of which the capacity of the first one will be at least 3 MW, with an annual production of approx. 2 800 MWh and the second, at least 5 MW, with an annual production of approx. 4 400 MW. The solar



power plants would cover the annual needs of about 2 400 average households. The first of these solar power plants, will be completed in the I half of 2023. The Estonia mine will start using green electricity from solar power plants, even to the extent of 10% of its total consumption.

# Clean from residual pollution

Larger cleaning works were initiated in 2019, in the catchment area of the Purtse river, in Ida-Viru County. The pollution in the area was caused from 1920-1980, by the oil shale processing plants, located in Kohtla-Järve and Kiviõli.

The old riverbed was cleaned to the extent of nearly 13 kilometres, in the largest project of liquidating residual waste in Estonia and a new riverbed was established in the extent of 3.47 kilometres. The cleaning of a 1.4 kilometre section of the Purtse river, was started in the summer of 2020.

A significant part of a 14 hectare phenolic bog area has also been made safe. The cleaning works from residual pollution, were ordered by the Ministry of the Environment. The cost of the works, lasing until the end of 2022 is 21 million Euros and it is jointly financed by the European Cohesion Fund, Environmental Investment Centre and the Estonian state.

The making safe of the residual pollution was started in the summer of 2020, on the former territory of the Kohtla-Nõmme tyre plant. The pollution was caused by the oil plant established with British capital that operated on the territory in the 1930s, as well as the tyre plant, established during the Soviet period. The pollution is spread over an area of 2 000 m2 and the polluted layer extends to a depth of 1.9 m, from the surface. Removed in the framework of the Life IP CleanEST project, will be 1 200 tons of oil waste, found on the ground, as well as the polluted surface beneath it.

# **Air emissions**

The oil shale companies, for the sake of a cleaner air environ-The emission quantities of SO<sub>2</sub> decreased over 40% in comment, have for years moved towards a more efficient and cleparison to the previous year, NO<sub>2</sub> emission quantities 26% aner energy production, investing into new technologies and and the emission of particulates has also decreased by 21%. supplementing older production equipment with contempo-These indicators over the last six years, have decreased by rary cleaning devices. Air emissions, thanks to this, decreased over 64%. Such a large decrease has emerged foremost on also in those years in which the production of electrical power account of the power plants of Eesti Energia. The company remained high. A reduction in the production of electricity in declared in 2020, 2.2 million tons less CO<sub>2</sub> and 2.5 thousand 2019 and 2020 from oil shale, has also sharply reduced the tons less SO<sub>2</sub> emissions. quantity of air emissions.

# The emission of greenhouse gases has reduced significantly

The share of Estonia in the creation of the greenhouse gas, taking into consideration the entire world is very small. Estonia's share in the emission quantities of greenhouse gases of the Member States of the European Union is 0.5 percent. of the oil shale industry, were 5.2 million tons that means a reduction of approximately 35% in comparison to 2019 and even 60% compared to 2018.

The Estonian installations belonging to the European Union trading system of allowed emission quantity units, for greenhouse gases, had a reduction in CO<sub>2</sub> emissions in 2020, in comparison to the previous year, of 40% and compared to 2018, even 63%. The CO<sub>2</sub> emissions of the three companies



## CO<sub>2</sub> EMISSION IN THE ESTONIAN INSTALLATIONS BELONGING TO THE EUROPEAN UNION EMISSIONS TRADING SYSTEM 2013-2020 (MILLION TONS)

Estonia has reduced in comparison to 2013, in the 47 installations belonging to the  $CO_2$  emissions trading system, emissions in total 68%. This means that Estonia has nearly reached the aims set for 2030, already ten years ahead of the deadline.

### AIR EMISSIONS ACCOMPANYING THE OIL SHALE INDUSTRY (TH TONS)

	2014	2015	2016	2017	2018	2019	2020
SO <sub>2</sub>	38,6	29,6	27,7	31,0	26,5	15,7	9,3*
NO <sub>2</sub>	9,7	6,4	7,0	7,7	7,1	3,8	2,8*
Particulates	8,8	3,6	2,6	2,7	2,3	1,4	1,1*
CO <sub>2</sub>	14 600	11 159	12 862	14 327	13 290	8 100	5 254
Oil shale mined	15 258	15 187	13 104	15 633	15 944	12 127	9 195
Shale oil produced	760	915	852	1 020	1 109	1 173	1 156

The KNT data contain all of the air emissions of the company, of which the majority emerge from the burning of waste fuels

\* Missing from the data, are the data of Kunda Nordic Tsement

\*\* Geological reserve of the mined oil shale

# **Cleaner air and healthier people**

The Health Board ordered from the University of Tartu, a study on the relationship between air pollution levels and diseases. The study highlighted that in comparison to the study executed in 2015, the air that children breathed out, contained significantly less respiratory tract inflammatory marker or elevated levels of fractionated nitrogen oxide.

The principle pollutants in ambient air causing illness, are benzene, particulates and especially fine particulates. The impact of these pollutants, appears foremost in chronic diseases such as asthma, development of allergies, as well as pneumonia or bronchitis, suffered in childhood.

The highest content of benzene is in the vicinity of Narva, the areas west of Narva, as well as in the area of Jõhvi. The share of local emissions is especially small, especially in the case of fine particulates, in the area of Kiviõli. The industrial companies in the field of oil shale, should according to the results of the study, focus more than currently, on the restriction of benzene and fine particulates.

The cause of becoming more frequently diseased with lung cancer, among Ida-Viru County men, according to the study concerning the years 1992-2015, in the evaluation of the researchers of the University of Tartu, is industrial pollution. The

difference in the frequency of becoming diseased with lung cancer, in the last decades has still been reduced, between Ida-Viru County and the rest of Estonia. There was a reduction in becoming diseased with lung cancer, during the study vears, in Ida-Viru County of 28.9%, while at the same time it grew significantly, in areas outside of oil shale 13.3%.

The reduction in becoming diseased with lung cancer, in Ida-Viru county, can be associated with the improvement of the quality of the environment there, as the companies mining oil shale, have started using more environment conserving production technology.



# Improving urban air quality

VKG has made many projects for improving the air quality of the reliability of both of the SHC devices. In addition to the Kohtla-Järve, to reduce the environmental impact of the comincrease in the volume of production, the number of interruppany, ensuring the sustainable development of the industry. tions has been reduced that significantly reduces environmenas well as improving the living environment of the local resital disturbances. dents.

The Environmental Board in 2019, approved the compiled action plan of VKG, for the reduction of odours. The load on the ambient air was significantly reduced, three years ago with the closure of the Lõuna thermal energy plant. Electricity and thermal energy is produced since that time, from oil shale gas, only in the VKG Energia, Põhja thermal energy plant that is equipped with new, efficient sulphur capturing devices.

The generator device of the company, will be renewed with the loan received from KredEx. Renewed with the same will also be the receiving area of oil shale and ash removal system, a new dephenolisation system will be built and a new The Kiviõli Keemiatööstus in 2020, contributed into increasing heavy oil cleaning node will be established.

# **Estonian climate ambitiousness**

It is possible to fulfil the ambition of Estonia, to be climate neutral by 2050, if the public as well as private sector contribute to it and also the non-profit organisations. The given conclusion was reached in 2019, in the study completed on the possibilities for increasing climate ambition, by the Tallinn Centre of the Stockholm Environment Institute.

# Waste storage facilities for mining, under observation

The Ministry of the Environment evaluates in 2020, the en-Changes that could threaten the stability of the storage facilivironmental condition of the closed mining waste storage facities of mining waste, were not noticed with the inventory. The lities. Inventoried were the old waste rock heaps of the oil emission quantities of pollutants separating into the ambient shale mines of Kava, Kukruse, Sompa, Edise and Rutiku. It is air, were also everywhere, many times lower than the allowed being examined, if any heap could cause a risk to the health of limit values. The Kukruse storage of waste rock and two heaps people or the environment. The previous inventory was done out of the four at Sompa, still continue to have hotspots. The in 2011-2012. contents of hazardous substances in groundwater, did not exceed in most heaps, the limit values for industrial land. A It became apparent from the study that the condition of the moderate polluting of the groundwater was only found in the Kukruse waste rock heap has not deteriorated and the experts immediate vicinity of the Kukruse waste rock storage. This recommend that the heap should be classified from the curdoes still not pose a threat to the wells of the closest homes, rent A category, into the B category. as these are located upstream from the waste rock storage.

The company additionally uses the gas collected in the SHC device, for the production of electricity and heat. The plant was connected in 2020, with the gas pipeline, to reduce the direct heating of oil shale.

It is required to invest 17 billion Euros, according to the analysis to achieve the aim. The same study highlights that until 2040, the global demand for shale oil will increase and in the given period it is not possible to bring the emissions to zero. The fields of land use and forestry that also bind emissions, have their role to fulfil, besides the reorganisation of production, for reaching climate neutrality.



# RESEARCH BASED INDUSTRY

# 66

If the history of Estonian oil shale mining and industry is over a hundred years long, then more or less as long is the Estonian oil shale education and research. Both are in their field, at the top in the world. The knowledge and practical experience accumulated with the century are demanded also elsewhere in the world. Estonia indeed exports oil shale know-how, to other oil shale countries, starting with the United States of America and concluding with Russia, Myanmar, as well as Turkey.

Oil shale has since 1958 been studied thoroughly, in the Ida-Viru County, when in Kohtla-Järve was founded the Oil Shale Scientific Research Institute (the later Oil Shale Institute). The bearer of its continuity in Kohtla-Järve, is currently the Oil Shale Competence Centre of the Tallinn University of Technology Virumaa College, a research and testing laboratory of technology of fuels, with an international reach.

The companies of the oil shale industry continuously contribute into innovation, to reduce the environmental impact of the company, increase production volumes through technical innovations and innovative technologies, ensure the sustainable development of the oil shale industry and improve the living environment of local residents.

The pandemic and the economic crisis reduced in 2020, the investment capacity of companies. The companies of the oil shale industry, invested in total, 18 million Euros into research and development activities.

# Standardisation of the field of oil shale

The Oil Shale Competence Centre of the Tallinn University of Technology Virumaa College, coordinates the activities of the technical committee on oil shale and processing of oil shale products, created within the Estonian Centre for Standardisation. The existence of standards applicable to oil shale, simplifies and supports the daily activities and development works of the laboratories. Ten standards have been prepared and released, since 2015, under the leadership of the committee. Prepared were in 2020 drafts of 6 standards of which 4 were released:

EVS 652:2020 Shale oils – Method for determination of sediment content and ash

A reworking of the Estonian original standard, EVS 652:1994 that has taken into consideration new European and international standards, applicable to apparatus and reagents, updated the text and terminology of the standard, made editorial corrections; a chapter has been added on established requirements, concerning the diameter of particles, to be captured on filter paper; added has been a supplemental analysis possibility for samples of shale oil, with the specification "as received", where the water content of the sample is not previously established and the formula for taking this into consideration is provided.

EVS 940:2019 Burnt shale for the plastics industry. Specifications and conformity criteria Estonian Standard in English

The English translation version of the standard EVS 940:2019 "Burnt shale for the plastics industry. Specifications and conformity criteria", was prepared in cooperation with Eesti Energia.

EVS-ISO 334-MOD:2020 Coal and coke. Determination of total sulphur. Eschka method

The international standard was taken over using the reprint method, with Estonian remarks. The standard treats in addition to the determination of general sulphur in coal, brown coal, lignite and coke, also in oil shale, as well as in the solid wastes of its thermal treatment and burning, using the Eschka method as a reference method. Added to the standard were supplements on oil shale and its thermally treated products, taking into consideration the specific characteristics of oil shale and oil shale products. A water extraction method was added as an alternative method, as were some important specifications, required for executing analysis.

EVS-ISO 587-MOD:2020 Coal and coke. Determination of chlorine using Eschka mixture.(ISO 587:2020, modified)

The international standard has been taken over in English, with Estonian remarks. A modified new version of the standard. The given international standard treats the determination of chlorine content in coal, brown coal, lignite, peat, coke, oil shale and the solid waste of its thermal treatment and burning, using the Eschka mixture. The standard includes amendments that allow for the determination of chlorine content, on the basis of the standard, also in oil shale and semi-coke.

The compilation of a completely new Estonian standard was initiated in 2020, in cooperation with companies – EVS 943 "Synthetic fuels. Fuels (Class F). Specification of Estonian Shale Oil". The Estonian Chemical Industry Association, Viru Keemia Grupp, Eesti Energia, Kiviõli Keemiatööstus, Estonian Environmental Research Centre, University of Tartu, Estonian University of Life Sciences and the Oil Shale Competence Centre of the TalTech Virumaa College, belong to the workgroup of compiling the standard.

### STANDARDS UNDER COMPILATION

- EVS 943:2020 Synthetic fuels Fuels (Class F) Specification of Estonian Shale Oil
- **EVS-ISO 29541:2015** Solid mineral fuels Determination of total carbon, hydrogen and nitrogen content Instrumental method
- EVS 669:1996 Kukersite oil shale Determination of ash
- EVS 670:1998 Trade oil shale



# **Smart studies and developments**

The contribution of the state into the growth of the knowledge volume of the Estonian economy, is applied through the support measure for smart specialisation. Companies since 2014 can cooperate with Estonian research institutions, ordering from universities and research institutions, required applied studies or product development projects. Applied studies had been conducted by the end of 2020, in the field of oil shale, close to the extent of 2.5 million Euros. Funding has been received from the support measure, among others for studies on kerogen, the impact of the sulphur content of oil shale, optimisation of the characteristics of alkylresorcinol adhesive resins, reduction of the CO<sub>2</sub> footprint of shale oil production and the development of mining technologies.

The government desires to receive recommendations for making research based decisions, as well as applying them to the solution of socioeconomic challenges confronting society, through the support of the state research and development activity or RITA programme, created in 2017, under the Estonian Research Council. Many studies related to oil shale have also received support. It is thus that have been supported studies of special types of mineral resources, to detect in Estonia more expedient and innovative possibilities of use for mineral resources, as well as provide the state an input for planning future developments.

Three large scale studies are taking place from 2017 until 2021, through the RITA programme:

- A study by the consortium led by the University of Tartu (TÜ, TTÜ, Geological Survey of Estonia) "The critical technological, geological, environmental and socioeconomical questions and possibilities for their solution, in valorising the priority mineral resources of Estonia (oil shale, phosphorus, peat, raw metal);
- Study led by the Tallinn University of Technology, in cooperation with the University of Tartu "Alleviating climate change through the CCS and CCU technologies";
- Study led by the Tallinn University of Technology "Innovative technologies of gasification, pyrolysis and burning of oil shale".



# Specific studies in the field of oil shale

### RESEARCH AND DEVELOPMENT WORK

Underground Enrichment of Oil Shale Ore and Storage of Tailings in the Developed A New Technological Platform for Oil Shale Kerogen Valorisation: Partial Oxidation to D boxylic Acids and Further Conversion to Valuable Dicarboxylic Acid Derivatives

Technical Platform for the Conversion of Oil Shale Kerogen to Dicarboxylic Acids

Database of Estonian Subsoil Publications (Phase I)

Effect of Activation Conditions in the Production of Porous Carbon from Oil Shale

Research on Oil Shale Technologies at Enefit Energiatootmine AS

Zoning of Bogs in the Oil Shale Area

New Sulphur-Tolerant Electrodes for Reversible Solid Oxide Cells

Stabilisation of Soil Containing Humic Substances in Road Embankments by mean Oil Shale Ash

Development of Deep Impregnation Technology for Multifunctional (Fire, Rot and In

Protection of Wood on the basis of Oil Shale Ash, Peat Humates and Nanosilicate

Water Pollution Related to Oil Shale Mining in the framework of Climate Change - Bioa

mulation and Bioavailability of Toxic Pollutants in Food Chains of Water Bodies

Recycling of Fermented Residue and Oil Shale Ash - Preparation of Granulation Pilot

Use of Granulated Oil Shale Ash in Organic Farming

Follow-up and Maintenance of Kiviõli Industrial Waste and Semi-Coke Landfill 2019– Applied Study of the Possibilities of Streamlining Mine Survey Operations by Re Monitoring Methods

Applied Research for the Reduction of the CO<sub>2</sub> Footprint of Shale Oil Production

Influence of the Sulphur Content of Oil Shale on the Properties of the Final Product

Applied Research on Optimising the Properties of Oil Shale Alkyl Resorcinol Adhu Resins

Applied Research of the Possibilities of Adding Value and Recycling the Oil Shale A R-S OSA Service  $O\ddot{U}$ 

	EXECUTOR	FINANCER
Area	Tallinn University of Technology	Environmental Investment Centre.
Dicar-	OÜ Kerogeen (research partner: Tal-	European Regional Development
	linn University of Technology)	Fund (NUTIKAS)
	OÜ Kerogeen (research partner: Tal-	European Regional Development
	linn University of Technology)	Fund (NUTIKAS)
	Tallinn University of Technology	Environmental Investment Centre.
	Tallinn University of Technology	Estonian Research Council (Perso- nal research start-up grant)
	Tallinn University of Technology	Eesti Energia AS
	University of Tartu	Environmental Investment Centre.
	University of Tartu	Estonian Research Council (Perso-
		nal research start-up grant)
ins of	Estonian University of Life Sciences	Environmental Investment Centre.
nsect)	Estonian University of Life Sciences	Environmental Investment Centre.
accu-	Estonian University of Life Sciences	Estonian University of Life Sciences
Plant	Institute of Chemical and Biological Physics	Environmental Investment Centre
	Institute of Chemical and Biological Physics	Environmental Investment Centre
2020	Ministry of the Environment	Environmental Investment Centre
emote	Eesti Energia AS (research partner:	European Regional Development
	Tallinn University of Technology)	Fund (NUTIKAS)
	Eesti Energia AS (research partner:	European Regional Development
	Tallinn University of Technology)	Fund (NUTIKAS)
:	Eesti Energia AS (research partner:	European Regional Development
	University of Tartu)	Fund (NUTIKAS)
esive	VKG Oil AS (research partner: Tallinn	European Regional Development
	University of Technology)	Fund (NUTIKAS)
sh of	R-S OSA Service OÜ (research part-	European Regional Development
	ner: Tallinn University of Technology)	Fund (NUTIKAS)



# CONTRIBUTION INTO EDUCATION AND THE COMMUNITY

The Estonian oil shale industry can survive and develop only if the current youths are inspired by the given branch of industry and associate their future with it. The Tallinn University of Technology, University of Tartu, Estonian University of Life Sciences, regional colleges, other higher education institutions and vocational education centres, are taking care that a new generation of researchers, engineers, designers, business managers, planners, equipment operators and people in many other required fields, see their challenges precisely in the field of the oil shale industry.

The oil shale companies on their own part, assist in creating interest among youths, in science and energy, to ensure also in the years to come, the sustainability and development of the industry.

# Noticing and supporting the good ones

VKG has already for 17 years recognised through stipends, good students of the Tallinn University of Technology and supported studies in fields required by the group. VKG in 2020, through the University of Technology Development Fund, distributed to students in the fields of technology, chemistry and energy, stipends for applied higher education, bachelor's and master's studies.

Eesti Energia in cooperation with the Association of Local Authorities of Ida-Viru County, for six years in a row, awarded through the Talented Youth Energy Fund, stipends to 37 bright youths. The given scholarship supports hobby activities of youths of Ida-Viru County, aged 7–19 from research to sports. The aim of the Energy Fund is to recognise youths of Ida-Viru County and to assist in their development. The Energy Fund every year, distributes 9 000 Euros, for supporting the hobby activities of youths of Ida-Viru County.

The renowned competition of Estonian upper secondary school students in sciences – the Five School Competition – celebra-

ted in 2020 its 55th anniversary. VKG has for years supported the participation of the Ida-Viru County team. Ida-Viru has for already nine years sent a combined team, to join the competition of the five strongest schools. 20 representatives of the Ida-Viru County, from the upper secondary schools of Jõhvi and Kohtla-Järve, were sent into the competition, who could test their knowledge of sciences on the highest level.

# Exhibition of the 95th anniversary of the oil shale industry

VKG at the beginning of the year, opened an exhibition dedicated to the 95th anniversary of the oil shale industry. The historical display depicted the birth and development by years, of the oil shale industry, as well as the city of Kohtla-Järve that emerged alongside it, devoting attention to the twists in the oil shale industry, technological progress, as well as the changes in the work conditions and the city.

# **Recognised responsibility**

The economic results alone, are not important for the companies of the oil shale industry. The oil shale companies have a significant impact on the welfare of the entire Ida-Viru County. They observe as responsible companies, the environmental footprint of their activities and their social impact. A shift towards cleaner production is made year over year. Social responsibility has at the same time, become increasingly more important and grown has the contribution into so-called soft values, so that things go as well as possible for the entire Ida-Viru County.

The Responsible Business Forum recognised in 2020, Eesti Energia and Viru Keemia Grupp, with the bronze level quality label. The label is issued to the company for two years. The label is given to companies that have participated in the evaluation of Estonian responsible entrepreneurship that consider the sustainable development of the company important, as well as strategically contribute into social and natural environment development. Th label has been awarded since 2007.

The most successful and competitive companies of 2019 were recognised at the end of 2020. The Viru Keemia Grupp and subsidiary company VKG Oil, achieved in the field of industry and energy, in which competed 403 companies, high positions as 2 and 3. The total of participants were 1 418 Estonian, large, medium and micro companies, of which the best in thirteen categories received recognition.

Corporate social responsibility (CSR) is the natural and voluntary integration of the economic, environmental and social dimensions of a company, into its daily activities, management and business strategy.

# Best place of internship

The competition of the Estonian Employers' Confederation "Best Place of Internship", selected in 2020 as the best regional provider of internship, Eesti Energia. There were last year 179 persons in the company as interns, of which 65% completed their internship in Ida-Viru County and 28% in the Harju County. Eesti Energia contributes every year, in cooperation with educational institutions, into the development of qualified successors. The energy company was submitted into the competition, by its important cooperation partner, the Tallinn University of Technology Virumaa College.



