The future of Shale Oil

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Enefit

Plan of the lecture

- Enefit introduction
- Oil shale in Estonia. Historical overview
- Shale oil today
- Shale oil in future

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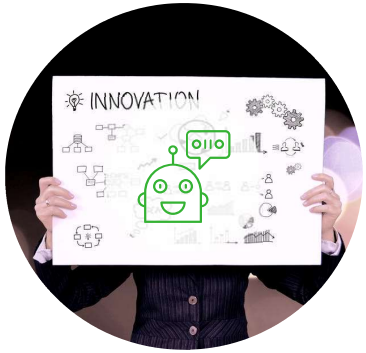
Established in	Home Markets	Employees
1939	5	5500
Clients	**Sales Revenue 2022**	**EBITDA 2022**
700 000	2218 M €	420 M €

Customer Services

Renewable Energy



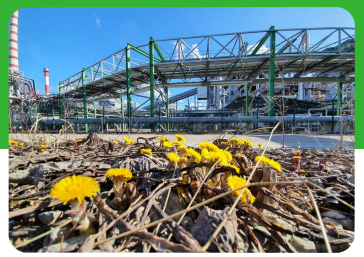
R&D

Large scale electricity and oil Production

Network Services

We have created energy for more than 100 years




1916
First oil shale mines in Estonia

1924
First oil plant & oil shale-fired power plant

1949-1969
Four oil shale fired power plants

1980
Enefit's Narva Oil Plant

2004
New CFB units for Narva Power Plants

2010
Investment decision for new power units

2012
The new Enefit 280 plants stands up

2015
The new Auvere 300 MW power plant started production

2021
Laying of the cornerstone the second Enefit 280 plant

2045
Eesti Energia's combined CO_2 emissions are 0

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Oil Shale

Parameter	
Moisture, w%	8-12
Organic material (dry), w%	25-27
LHV, MJ/kg	7-10
Shale Oil yield in Enefit process, wt%	13.5

Oil shale is a sedimentary rock with significant amounts of kerogen, which **when heated** releases **oil and gas.**

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Enefit has more than 40 years pyrolysis experience

1st generation technology
Enefit140

2nd generation technology
Enefit280

3rd generation technology

- Total production of oil shale oil 700 000+ tonnes from 2024 (currently 450 000 t)
- 85% of amount is fuel oil and 15% gasoline

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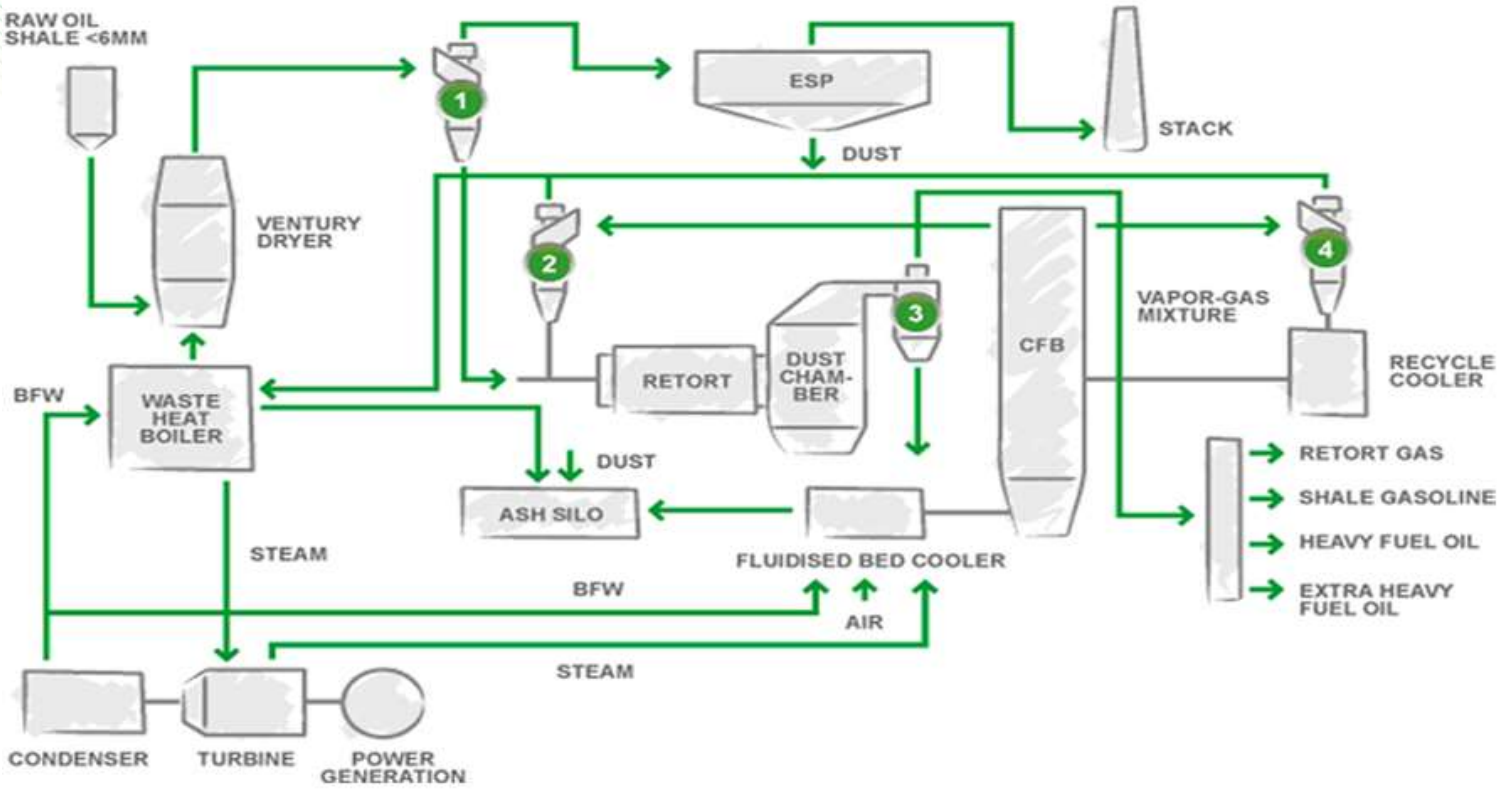
Enefit 280



25.1 w%

12.7 w%

62.2 w%

1. Oil shale cyclone
2. Heat carrier cyclone
3. Dust chamber cyclone
4. Ash recycle cyclone

ESP – Electrostatic precipitator
BFW – Boiler feed water
CFB – Circulating fluidized bed

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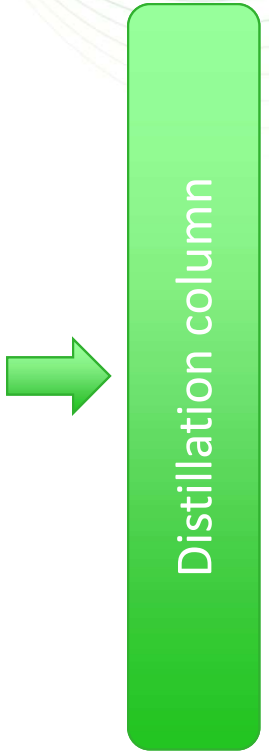
E280 vs Brent fractional composition comparison



Fraction Name	Boiling range, ºC	Brent, Cut yield, %	E280, Cut yield, %	Fractions we separate
Light Naphtha	IBP-177	22,7	13	Shale Gasoline
Heavy Naphtha	177-204	8,8	5	Shale Fuel Oil
Kerosene	204-316	10	10	
Straight-run GO	316-343	14,7	22	
Light vacuum GO	343-454	17,6	30	
Heavy vacuum GO	454-540	13,2	20	
Vacuum residue	540+	13	0	

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Shale gasoline and Brent naphtha comparison

	Shale gasoline	Brent Naphtha
Sulphur, wt%	1,07	0,0041
Density	0,77	0,73
Parafins, vol%	15	60 +
Olefins, vol%	55	<1
Bromine number, gBr2/100g	100	<1
Nitrogen, ppm	400	2
Oxygen, wt%	0,5	0
Metals, ppb	6000	<5
MON	70	60
Oxydation stability, min	10	>200

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Shale fuel oil and Brent same fractions comparison

	Shale fuel oil	Brent Σ fractions
Sulphur, wt%	0,65	0,36
Density	1,030	0,86
Oxygen, wt%	6	<0,1
Bromine number, gBr2/100g	35	5
Nitrogen, ppm	2000	562
Metals, ppb	6000	<5
Vanadium, ppm	<0,1	5
Al+Si, ppm	100	<5
Ash, ppm	700	<10

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Semi-coke gas main properties

Components (E280 – summer 2023)	mol%
N2	17.3
CO2	13.6
CH4	12.1
H2	10.6
CO	7.8
C2H6 Ethane	7.1
C2H4 Ethylene	8.9
Other organic components (C2-C6)	19
H2S	1.8

Property	Value
Density, kg/Nm3	1.28
LHV, MJ/Nm3	35-45

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E280 vs Brent other properties comparison

- Our total shale oil is even lighter than Brent
- There are a lot differences between Shale oil and Brent, that in some cases are advantageous, but in some are disadvantageous

Main differences are:

- ✓ Shale oil does not contain the heaviest fraction, which is difficult to Upgrade
- ✓ Sulphur compounds are distributed opposite comparing to crudes, that results in very high Sulphur amount in gasoline, but decreasing to the bottom
- ✓ The above statement explains why shale oil containing Sulphur compounds are relatively easy hydrogenated
- ✓ Shale oil is the pyrolysis product which explains huge unsaturation of all the shale oil fraction, make it unstable

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We create value

The residual value of Enefit Power's assets is nearly **one billion euros**

Enefit Power contributed in 2022 **90.5 million €** to the state treasury.

Enefit Power investments for new Enefit plant: **300+ million €**

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Welcome to the virtual tour!

We look forward to you to discover the Enefit plant that will be an important part of the future chemical industry.
Virtual tour – Enefit280 (energia.ee)

Strategic ambition based on owner expectation

Strategy describes an EP ambition for the transformation of shale oil production to chemicals production, which is the key to sustainable and long-term operation of Enefit assets

- **Progressively switching from liquid fuels to chemical industry feedstock production in line with the principles of circular economy**
- **Maximum use of plastic waste, end-of-life tires and other suitable waste material**
- **Achieve carbon-neutral chemical production by 2040**

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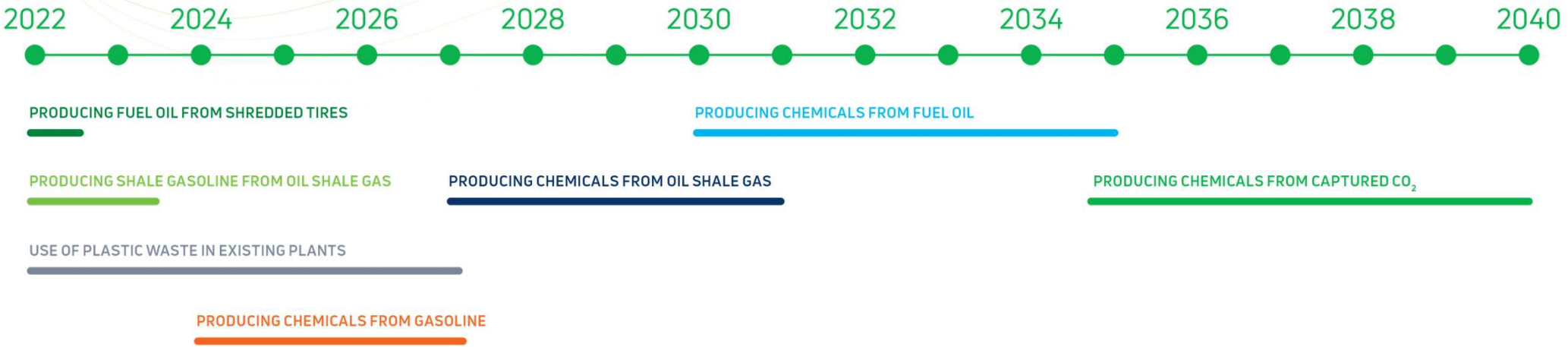
Our roadmap to a carbon-neutral chemical industry



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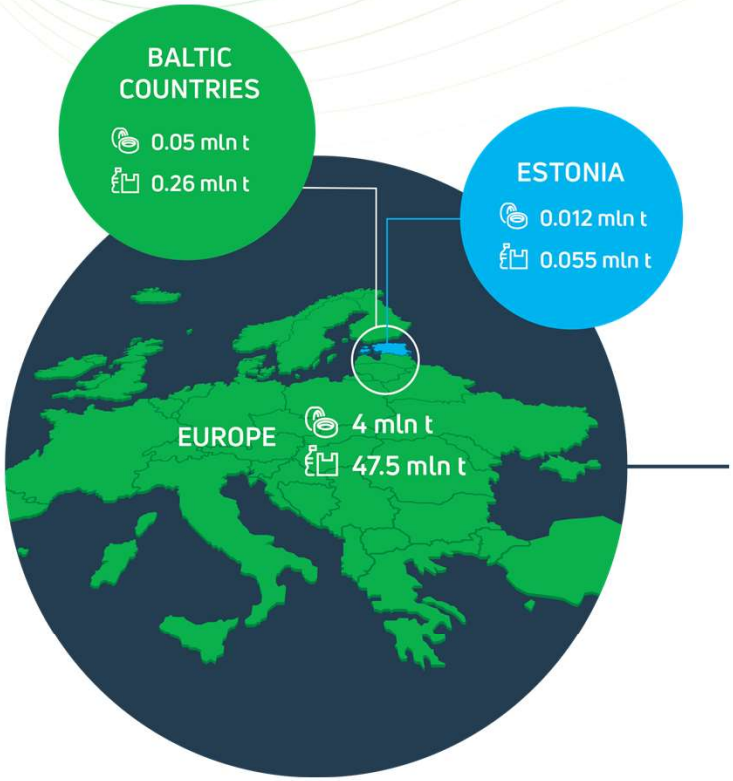
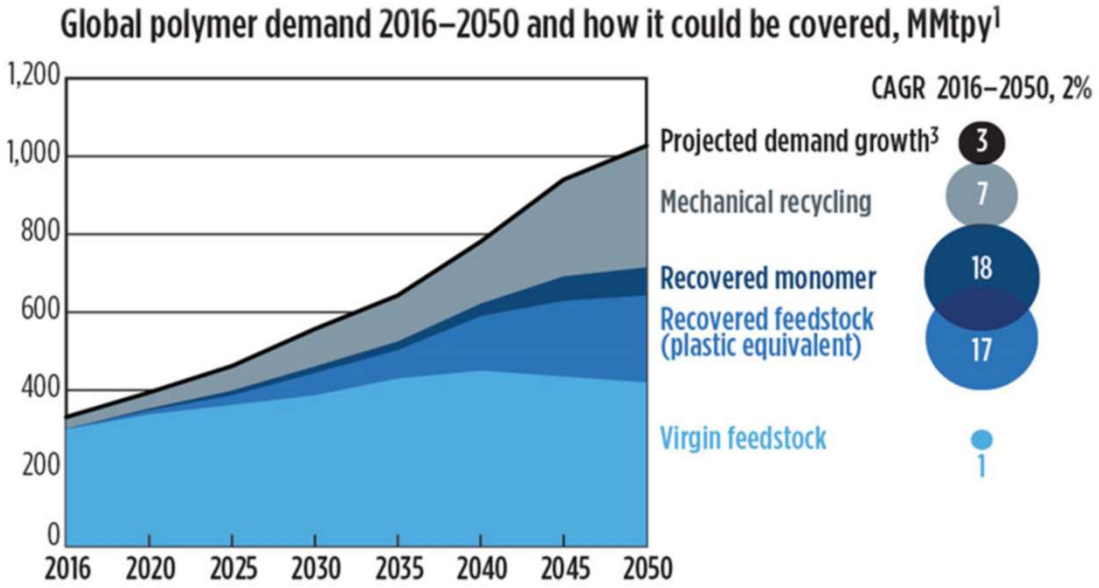
We are able to recycle more than 11% of waste tires produced annually in Europe We can process 0.5% of all European plastic waste per year without significant modifications. Enefit technology is both modifiable and scalable.



Amount of plastic waste and end-of-life waste tires created annually



[1] Scenario based on a multi-stakeholder push to boost recycling, regulatory measures to encourage recycling, consistent progress on technologies, and $75/bbl oil price.
[2] Compound annual growth rate. Mechanical recycling limited by downcycling and applicable materials, monomerization limited by applicability to condensation polymers only, pyrolysis limited by likely rise in input costs.
[3] After demand reduction, assuming annual global GDP growth of 3.1%.

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Enefit's contribution to circular economy: pyrolysis of mixed plastic waste + end-of-life tires

- ✓ **Lower CO_2 emissions and contribution to recycling**
- ✓ **Enefit has effective and robust technology which complies with EU environmental regulations**
- ✓ **Plastic waste contains approx. 6x more oil than our current raw material oil shale**

- ✓ Industrial processing of End-of life tires has been started this August (1800 t processed)
- ✓ Feeding system for Plastic waste co-processing industrial tests is in FEED engineering phase (Industrial test planned for middle of next year)





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Our ambition is to produce products that are not burnt

CURRENT PRODUCTS	SHALE GASOLINE	SHALE FUEL OIL	SEMI COKE GAS
USAGE	Motor fuel blending component	Bunker fuel component	Power production
MAIN CLIENTS	Major traders supplying gasoline to West-Africa	Shipping companies	Enefit subsidiary company

Based on:

- ✓ tests
- ✓ feedback from market participants
- ✓ economical and environmental calculations

we are currently considering which development alternative to choose

From fuel producer to commodity chemical quality standards feedstock producer

Possible new products depending on the development alternative chosen:

- Naphtha
- Reformate
- Methanol
- Benzene
- Raffinate
- Mixed xylenes
- P-Xylene
- O-xylene
- M-xylene
- Toluene
- LPG

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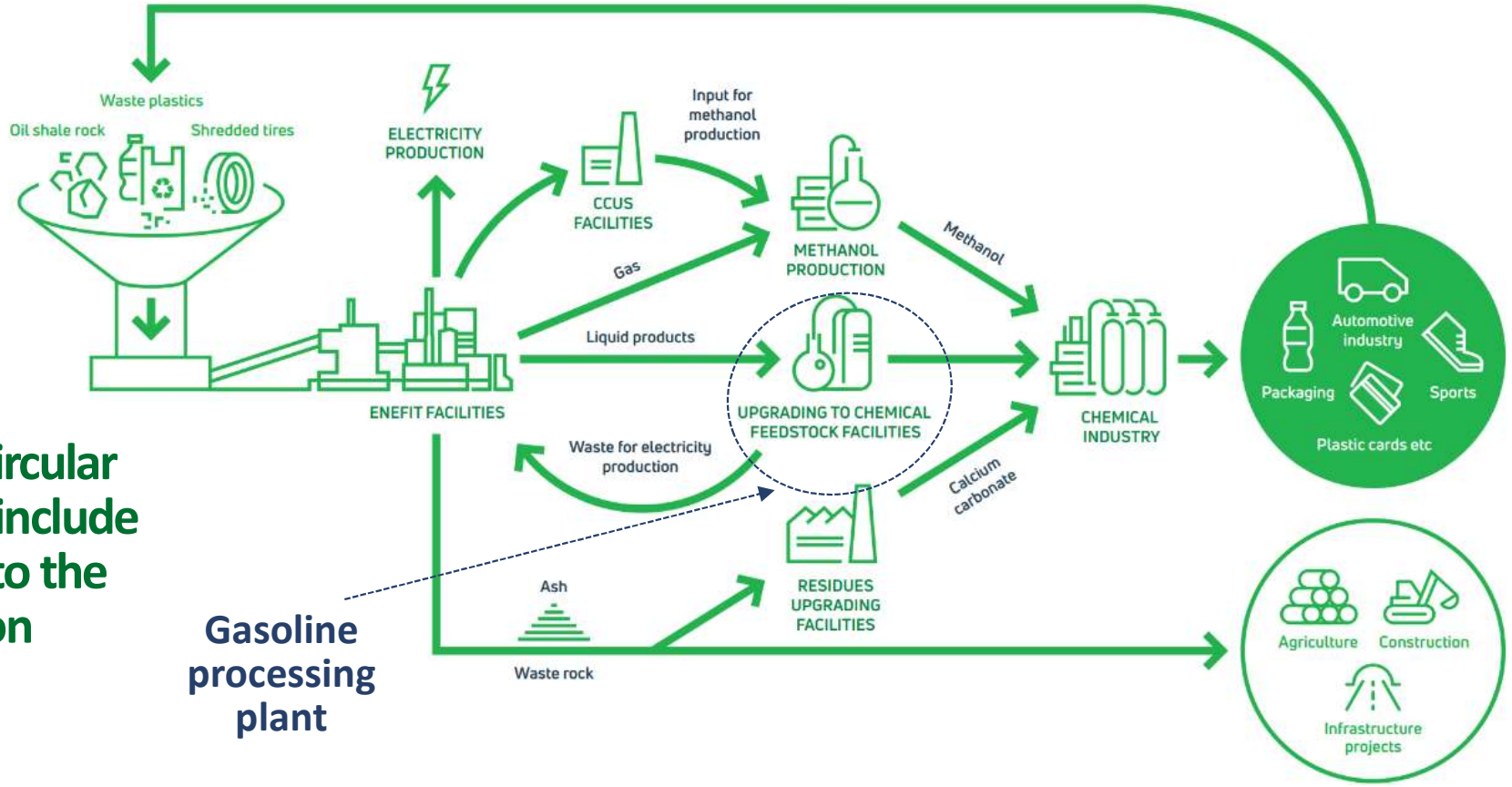
Enefit helps to solve environmental challenges using pyrolysis technology



Through the circular economy, we include other sectors to the green transition

Gasoline processing plant