A world map composed of a grid of small blue dots. The country of Estonia is highlighted with a cluster of red dots. The map is centered on the Atlantic Ocean, with North America to the left and Europe to the right.

Estonian Solid Heat Carrier Technology (TSK) as a Development Platform for Oil Shale Processing

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Agenda

1. RESOURCE BACKGROUND

- The potential of oil shale is immense
- Shale oil is commercially produced in only 3 countries
- The difficulties in development

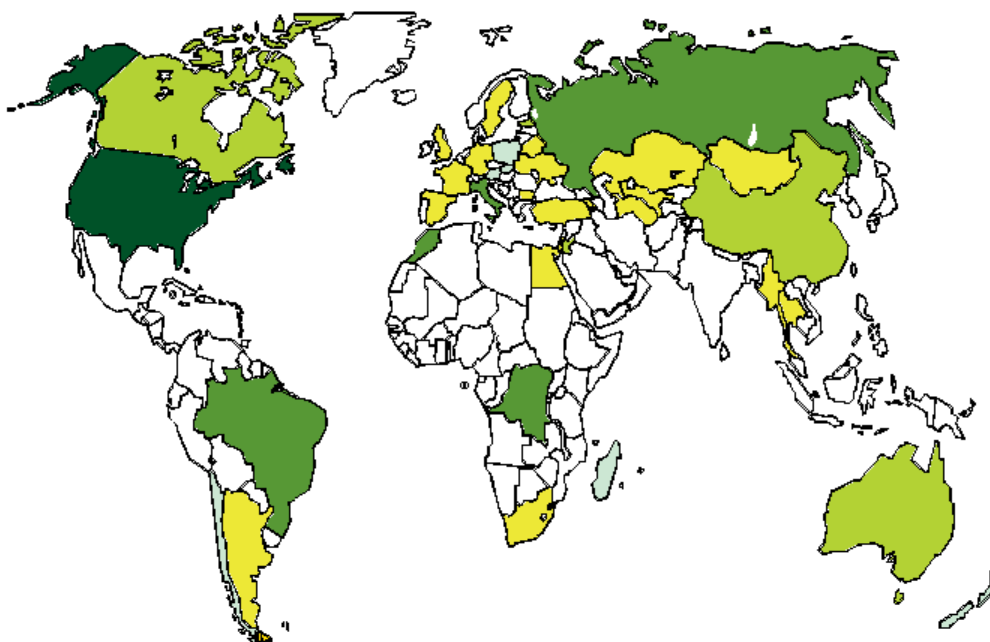
2. TECHNOLOGY BACKGROUND

- In-situ and above ground processes are not competing
- Above ground retort comparison and why the TSK is best
- Description of TSK technology and development advantages

3. EE's DEVELOPMENT ACTIVITIES

- Estonian
- International

Untapped potential – worldwide oil shale deposits



- There is more than 3 trillion barrels of shale oil worldwide
- Several countries have economically valuable shale deposits - not currently utilized



Success does not come easily

Processing sustainably is difficult - only 3 deposits processed long term world wide:

- Estonia (est. 1920)
- China (est. 1930/1989)
- Brazil (est.1981)



Development is more than selecting a technology

Keys to Project Success:

- knowledge of shale type, yield and processability
- deposit size to provide 30 years operating life
- technology adaptable to the shale type
- infrastructure - roads, rail, port, power, water
- services – manning, support industries
- markets – small to large scale demands
- **long term vision by all parties**
- **accommodative stakeholders- Government, Community, Landholders- to allow development**

Shale oil is not conventional oil – industry development requires government help.

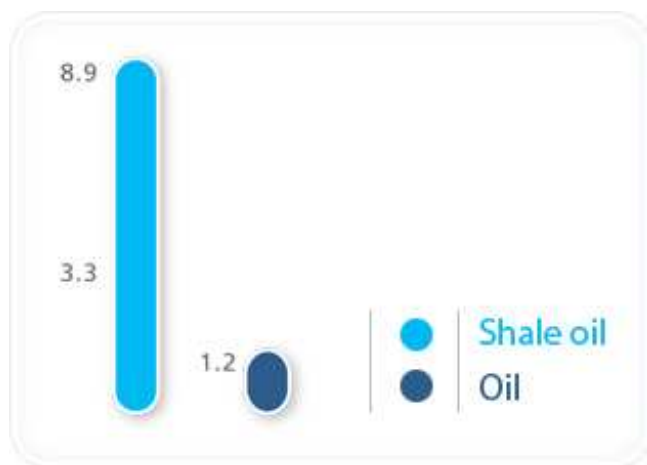
Know your deposit to choose your technology

EE's Goal: Technology adaptable to a variety of shales

- **Deposit size** – required to be above a limiting size to ensure adequate return on development
- **Shale type** – carbonate or clay based: strength throughout processing steps
- **Shale properties** – grade, abrasivity, melting point, moisture, base: process design issues
- **Deposit variability** – impurities, range of properties likely to be encountered: robustness of process and controls required

There are no processes to be bought “off the shelf” for new shale deposits. Each deposit is unique and technology must be adapted!

In-situ or surface processing – depends on the resource



- There is significantly more shale oil¹ than proved conventional oil reserves²
- Some shale is suitable for in-situ, some is suitable for surface processing
- **In-situ and surface processing are not competing technologies – they can be complimentary**

The full utilization of oil shale's potential requires both in situ and surface processing

1 (Põlevkivi – Õlikivi, Oil Shale – Source of Oil, Vello Kattai, 2003)
2 (BP Statistical Review of World Energy, 2007)

Surface Processing – focus on development and environment

1. Development Stage - Time to Market

- The development of a new type of retort from idea to industrial scale will take 5-10 years to complete
 - *Bench scale -> Pilot Scale -> Semi industrial scale -> Industrial scale*
- TSK is an industrial process with a long development history

2. Resource Utilization

- Gaseous heat carrier (lump): Kiviter, PetroSix, Fushun (resource waste)
- Solid heat carrier (fines): TSK and ATP pilot plant (no resource waste)
- The TSK is a solid heat carrier process using fines – all mined shale is used

3. Environmental Performance

- CCS readiness is an absolute requirement for new units
- An economically valuable solution to the ash must be possible
- The new TSK will be CCS ready and ash recycling options are already being developed

**The acceptance of waste in the conventional oil industry is a thing of the past
- all resource must be utilized!**

What is the TSK technology?

Galoter Process:

- Thermal decomposition (pyrolysis) of the organic fraction of oil shale (kerogen) by heating in a horizontal rotary kiln without oxygen at up to 500°C using hot ash as the heat-carrier
- Also known as Solid Heat Carrier process, developed after WWII in Russia - patent expired in 1990

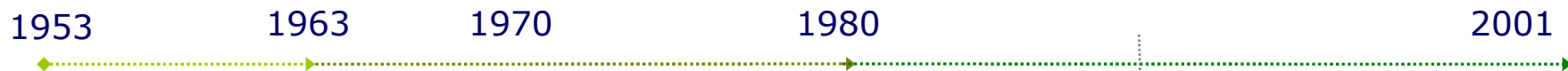
TSK Technology:

- Based on significantly modified Galoter process and long-term commercial operating experience
- EE owns several patents for a modified Galoter process - received patent for TSK in 2001
- EE's Oil plant, using the TSK technology, is the only successful industrial application of the Galoter process

TSK Technology Development



- First experimental Estonian retort was built in 1921 ("J. Pintsch" retort)
- Solid Heat Carrier process (Galoter process) was first introduced in Estonia in 1953



→
2,5
times



→
6
times



Patented TSK process is undergoing significant developments today

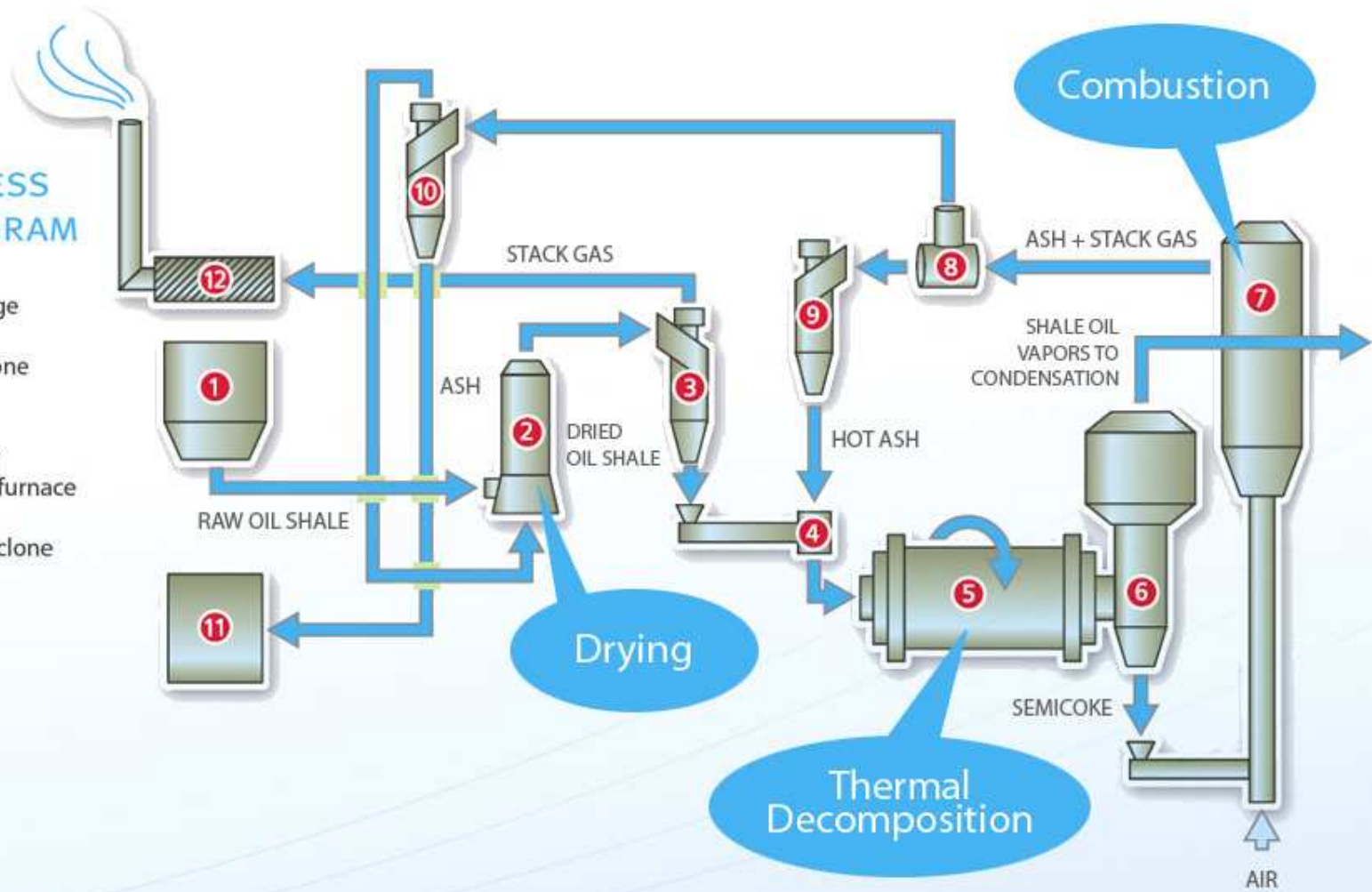
Initial patent of *Galoter* process by USSR, expired in 1990

2001 EE obtained a patent for the TSK

How does the TSK Work?

TSK PROCESS FLOW DIAGRAM

1. Oil shale storage
2. Drier
3. Dry shale cyclone
4. Mixer
5. Drum reactor
6. Dust separator
7. Aero-fountain furnace
8. Separator
9. Heat carrier cyclone
10. Ash cyclone
11. Pulp tank
12. Filter



Main Advantages of the TSK Process

Proven Technology

Almost 80 years of shale oil expertise, more than 50 years of experience developing the solid heat carrier process

Environment

- Oil Extraction process itself is water free
- Waste is a stable ash, ~ 1% organic content
- Able to process organic waste products and rubber crumb

Fuel

- Uses fine-grained shale (from 0 to 25 mm) with a low heating value
- All mined shale can be used in the process – no wasted resource

Efficiency

- The Process Chemical efficiency is 80%
- The product yield against Fischer Assay is 103%

Product Quality

- Shale oil with:
- low water content (< 0.3 %)
 - low solid particles (< 0.15%)
 - low viscosity (1.2 centistokes +15°C)
 - low sulphur content (< 0.7%)
 - low pour point (-15 °C)
- Retorting gas:
- high calorific value (46.8 MJ /Nm³)

TSK Process Features

- Operations carried out in separate units allowing:
 - Individual control mechanisms to better handle variation in feed quality
 - More timely maintenance access
 - Sparing of high maintenance items for improved availability
- Uses readily available equipment from many other industries
- Uses low-cost materials - minimal use of alloys
- Provides good hydrocarbon yields - ability to maximise carbon combustion from ash
- Provides flexibility to process different shale types in addition to different hydrocarbon sources - organic wastes and old tires
- Can be easily started and stopped without fear of equipment damage or major emission releases

The TSK technology is well positioned for a leadership role in the commercialisation of oil shale worldwide

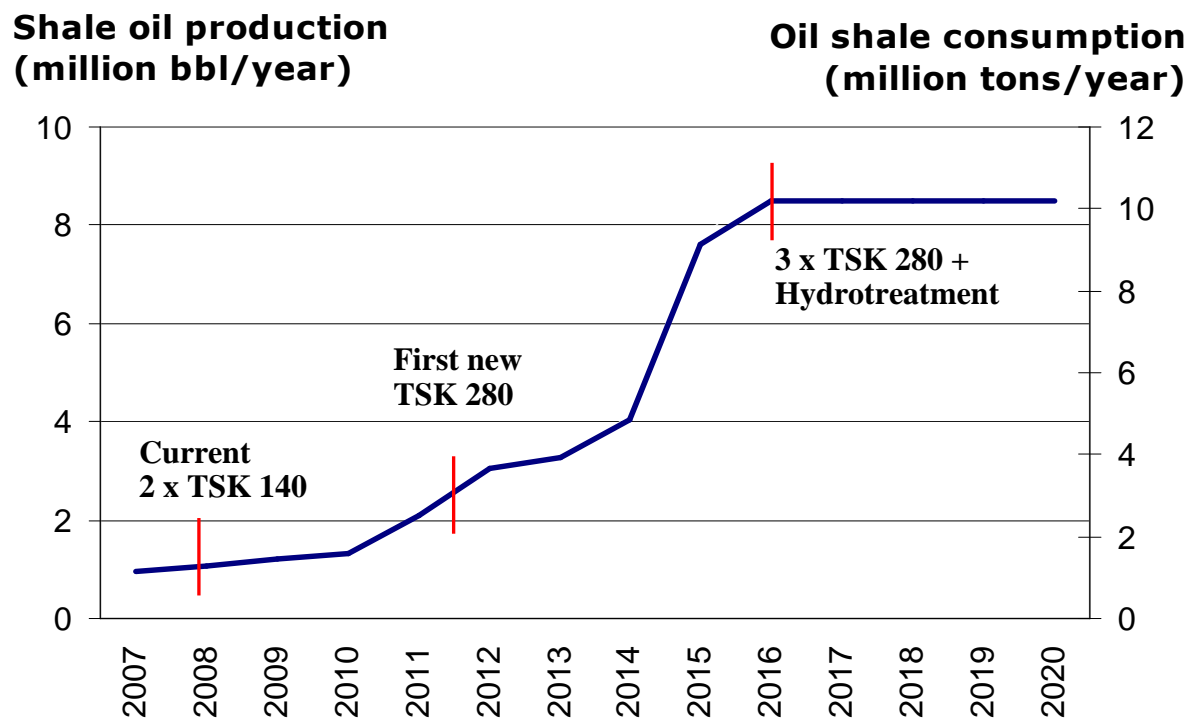
Technology drives strategic developments

EE Shale Oil Strategic Goals – 2015

1. **Increase production and sales volumes**
 - Build a new TSK 280 plant; construction starting in 2009
 - Build a shale oil upgrading unit capable of 30,000 bbl/day
2. **Enhance product quality**
 - Double the average product sales price
3. **Improve environmental impact**
 - Further minimize airborne emissions (including CO₂)
 - Develop new economic opportunities for ash
4. **International expansion**
 - Build a commercial application the TSK technology on a deposit outside Estonia by 2015

1. Increase production and sales volumes

2. Enhance product quality
3. Reduce environmental impact
4. International expansion



- TSK 280 design ready by May 2009
- TSK 280 operational by 2011/2012
- 30,000 bbl/day upgraded shale oil by 2016 (4 TSK 280 units)

1. Increase production and sales volumes
- 2. Enhance product quality**
3. Reduce environmental impact
4. International expansion

2008 Hydrotreating Tests Turned Raw Shale Oil Into Attractive Naptha And Distillates

Quality		Raw Shale Composite	Hydrotreated Shale Composite	Brent Naphtha-Dist-VGO
Volume Balance	Percent	100 %	107± %	-
API Gravity	°API	15°	35°	42°
Sulphur	Wt%	0.8	0.015	0.3
Nitrogen	Wt%	0.25	0.025	0.045
Oxygen	Wt%	6.1	0.3	0.15
Hydrogen	Wt%	9.8	12.9+	13.3
Cetane In Diesel	CI(D976)	~ 28	~ 47	~ 49
Bromine No.	'g Br2	45	1	< 2
UOP/Watson K	-	10.5±	11.7±	11.9±

1. Increase production and sales volumes
- 2. Enhance product quality**
3. Reduce environmental impact
4. International expansion



Before and After – raw shale oil and hydrotreated shale oil

1. Increase production and sales volumes
2. Enhance product quality
- 3. Reduce environmental impact**
4. International expansion

Newly Established R&D Program

- Identify optimal CCS solution
- CCS readiness of all new plants
- Meet tight emission limits:
 - PM: 25 mg/Nm³
 - SO₂: 250 mg/Nm³
 - NO_x: 200 mg/Nm³
- Develop new ash cooler
- Implement waste heat boiler
- Backfill to the mines
- Utilize ash as klinker replacement in cement – reduce CO₂ emissions
- Utilize ash heat

Environmental Improvements

Reduce CO₂

Cut Emissions

Increase Efficiency

Improve Ash Handling

1. Increase production and sales volumes
2. Enhance product quality
3. Reduce environmental impact
- 4. International expansion**

Oil Production

- Feasibility study completed
- In concession negotiations with the Jordanian government

Power Production

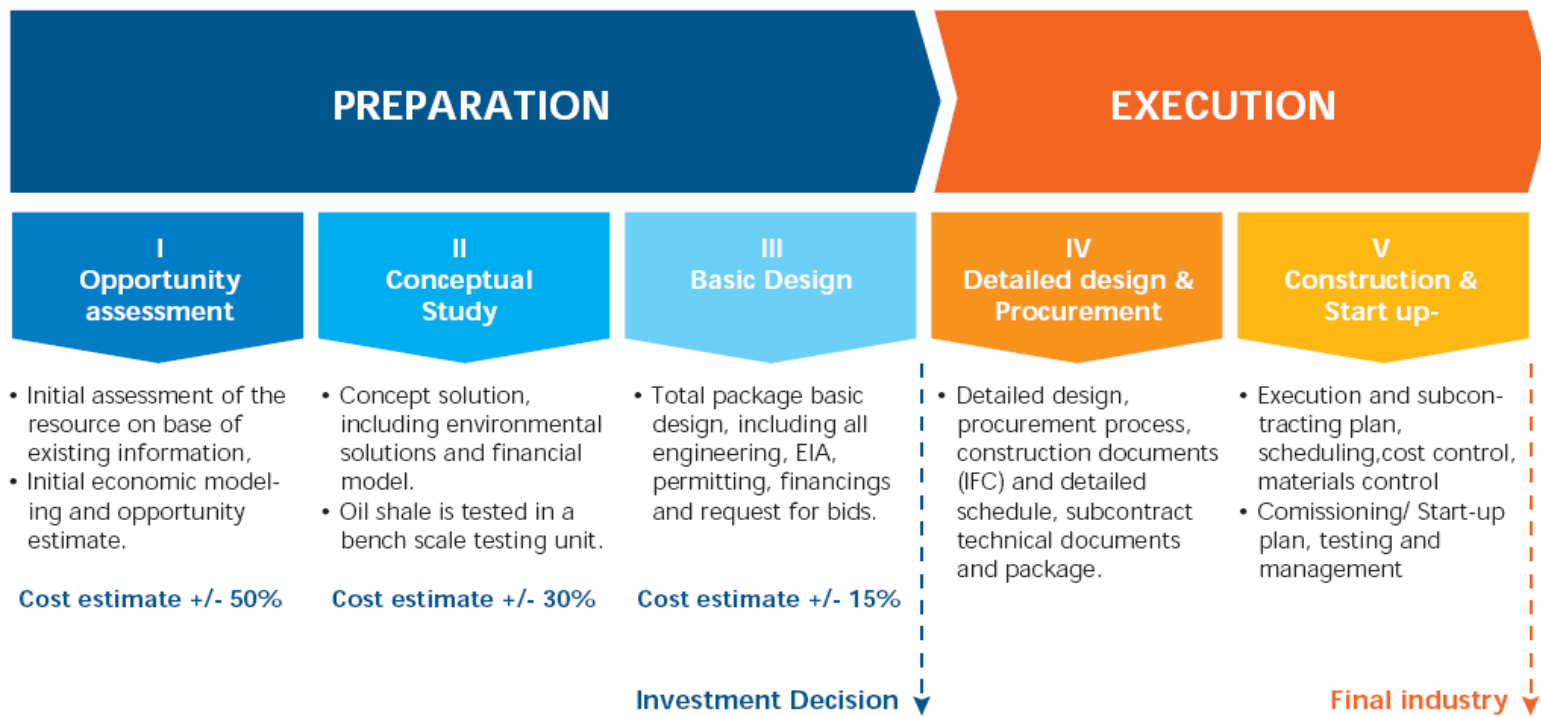
- Exclusive agreement with government - 600-900 MW plant

Our first steps are in Jordan



We are looking for new opportunities to develop oil shale. Eesti Energia's TSK is ready for adoption for new shales.

EE is The oil shale development company - covering all aspects of shale utilization



A “stage gated” approach

EE is now offering their expertise across the world through a range of development services. A “stage-gated” approach provides for re-evaluation of the project feasibility and economics at intermediate stages or ‘gates’. Services cover basic opportunity analysis through construction and start up.

Conclusions

- 1. The potential of oil shale is immense**
- 2. There is resource for both in-situ and above ground processes**
- 3. For surface processing, the proven TSK has many advantages**
- 4. EE's has undertaken a major technology development program in Estonia**
- 5. We are ready to take our expertise to the world. Interested in developing your deposit?**

Thank You!

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