Estonia’s Experience in Reusing Oil Shale Ash

Tõnis Meriste
Coal, Brown Coal and Oil Shale

Oil Shale:
- Relatively low calorific value
- High content of minerals
- High CaO content in ash

<table>
<thead>
<tr>
<th>Different Fuels</th>
<th>Coal</th>
<th>Brown Coal</th>
<th>Oil shale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, %</td>
<td>5-13</td>
<td>10-30</td>
<td>10-12</td>
</tr>
<tr>
<td>Ash, %</td>
<td>5-25</td>
<td>15-35</td>
<td>43-47</td>
</tr>
<tr>
<td>Sulfur, %</td>
<td>0.5-3</td>
<td>1-3</td>
<td>1.5-1.8</td>
</tr>
<tr>
<td>Calorific value, MJ/kg</td>
<td>20-28</td>
<td>10-20</td>
<td>8-10</td>
</tr>
</tbody>
</table>
Power Plant Ash Handling

- **TURBINE GENERATOR**
- **AUXILIARY TRANSFORMER**
- **FUEL STORAGE**
- **MAIN GRID**

**Fuel Storage**
- Oil Shale to boiler

**Main Grid**
- Power to Main Grid

**Boiler**
- Steam to turbine
- Bottom Ash
- Ash Mixers

**Flue Gas Treatment**
- Cyclones
- Electrostatic Precipitators

**Closed Hydraulic Ash Handling System**
- Ash Slurry to Ash Landfill

**Dry Ash Handling**
- Electrostatic Precipitators

**Ash Landfill**
- Ash Slurry to Ash Landfill
- Water for Ash Transfer from Plant

**Main Grid**
- Fly ash

**Ash to Consumers**
We annually generate 5-6 millions of tons of oil shale ash classified as hazardous waste and covered with environmental tax.

Majority of this amount is stored in landfills, today max 5% has been reused

We have stored in our ash landfills approximately 260 millions of tons of ash

We have taken target to increase the reuse/recycling of oil shale ash 5 times during 5 years
Oil Shale Ash Properties

- Oil shale ash properties (chemical, granulometric etc.) depend on the burning conditions (PC versus CFB), but also from the separation point (bottom ash, fly ash)
- Properties will change remarkably during hydro transport

<table>
<thead>
<tr>
<th></th>
<th>PC Bottom</th>
<th>PC ESP I</th>
<th>CFB Bottom</th>
<th>CFB ESP I</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂, %</td>
<td>3.10</td>
<td>12.00</td>
<td>8.90</td>
<td>16.80</td>
</tr>
<tr>
<td>CaO, %</td>
<td>50.75</td>
<td>36.08</td>
<td>49.39</td>
<td>29.52</td>
</tr>
<tr>
<td>CaO&lt;sub&gt;free&lt;/sub&gt;, %</td>
<td>24.84</td>
<td>13.56</td>
<td>11.86</td>
<td>8.45</td>
</tr>
<tr>
<td>MgO, %</td>
<td>15.19</td>
<td>11.39</td>
<td>9.25</td>
<td>8.33</td>
</tr>
<tr>
<td>Particle size, mm</td>
<td>0.1-0.16</td>
<td>0-0.045</td>
<td>0.63</td>
<td>0-0.045</td>
</tr>
</tbody>
</table>
Oil Shale Ash for Building Materials

• The use of oil shale ash as building material
  – 1922 as raw material for the building blocks
  – In 1940 binding mixtures (kukermite)
  – Since 1961 production of pore concrete building blocks by autoclave method
  – Additive in concretes and dry mixes

• Before economic downturn more than 150 000 m³/y building blocks were produced
Oil Shale Ash for Cement Production

- Oil shale fly ash has been used in Kunda Cement Factory (KNC) as raw material for the portland composite cement (CEM II type) – 20-30% added to the clinker according to the standard.

- Portland oil shale cement – no decreasing, stable, higher corrosion and frost proof, lower water demand etc.

- Important ash parameters are the content of free CaO, specific surface, content of chlorine, granulometric composition.

- 71-79% of KNC cement is CEM II type, until now largely more than 20 Mt. Same type of cement is also produced in Latvia and Russia.
Ash in Road Construction

- One of the bigger use area for the oil shale ash as been road construction, from 1970 it was widely used in Estonia, Latvia, Lithuania, Belarus and Russia.

- Ash has been used for dust control on the roads by covering those with oil shale ash layer (15-20 cm layer of gravel and ash mixture). From 1971 to 1986 more 1000 km of such roads was built and those are still in use.

- Due to the reduced availability of proper road skeleton (body) materials (gravel) and good binding properties of the oil shale ash, it was used largely on the building of the monolithic bases for the road (up to 30% additive to usually no suitable materials).
Oil Shale Ash in Agriculture

- Majority of Estonian agricultural soils are acidic, but neutral soil is more preferable.
- In acidic soils is high mobility of the Al and Mn ions (toxic for the plant roots) and low assimilability of the major nutrients (P, K, N).
- Oil shale ash can and has been used for the soil neutralization as it contains Ca, but also K, Mg, S, P and microelements. Granulation improve the controlled release of active substances.
- At the same time trace elements like As, Pb, Ni have to be monitored so as not to cause problems (i.e. additional pollution).
Oil Shale Ash For Flue Gas Cleaning

- One of the common environmental problems of power production from fossil fuels is the SO\textsubscript{x} emissions and removal of this pollutant.

- The majority of available methods use CaO or CaCO\textsubscript{3} as binding agent in dry, semidry or wet processes.

- We will install in our powerplants (with the help of Alstom) a semidry DeSO\textsubscript{x} system (NID) that uses the oil shale fly ash as a S binding agent. 4 units by 180 MW will be in use in 2012.

- The use of the fly ash in the DeSO\textsubscript{x} process will remarkably reduce the costs and dependence on CaO suppliers.
Mass Stabilizing of Soils and Hazardous Sediments

- Oil shale ash can be used as stabilizer or binder in the processes of stabilization of unstable soil in road/railroad construction or heavily contaminated soils/ sediments.

- Use of the oil shale ash in different binding mixtures helps to create low carbon solutions and replace a remarkable proportion of cement.

- Estonia is an associated partner in SMOCS (Sustainable Management Of Contaminated Sediments) project that seeks suitable solutions for the contaminated sediments around the Baltic Sea ports.
Backfilling of Underground Mines

• For oil shale mining, the room and pillar method is used. This technology assures acceptable stability of the ground and minimum subsidence but causes ca. 30% loss of mineable volume.

• Oil shale ash and oil shale enrichment waste can be used as hardening and mechanically strong material to backfill the mined chambers.

• First new large scale underground test will be made in November this year to test suitable mixtures in the large scale, measure leachate properties and hardening characteristics in actual underground conditions.
Backfilling of Underground Mines

• In a longer perspective, this test could lead to the development of underground mining technology with minimum losses and maximum ground stability
CO$_2$ Sequestration

- During oil shale thermal treatment, carbonates will be broken down and mineral CO$_2$ released.
- This process could be at least partly reversed and CO$_2$ could be stored in a stable way.
- In the light of the CCS Directive and the Estonian geological conditions that do not allow CO$_2$ underground storage (no suitable formations), use of the ash CO$_2$ binding properties can be one part of the solution.
- As the reaction between dry ash and CO$_2$ is slow (low reactivity), our first efforts are headed to the use of alkaline ash transportation water for the CO$_2$ capture – flue gas washing process.
- Laboratory test for the optimization of large scale process will start latest in 2011.
Ash as Raw Material for the Chemical Industry

There has historically been a strong interest in use of fly ash for production of higher value added materials than traditional cements and concretes.

- Zeolites
- Geopolymers
- Different fillers
- Filter materials etc.
Still a Lot to Be Done to Make These Possibilities Realities

- OSAMAT project under LIFE+ funding to activate the use of oil shale ash in road construction and also in other binding mixtures
- Registration oil shale ash under the EU REACH demands, that enables in the future to use oil shale ash as raw material
- Different applied research works for the new application in cooperation with Estonian and international research organizations
- Finding new partners to start large scale reuse projects
We strongly believe that oil shale ash is an opportunity and not a problem

Thank you for the attention!