No Compromise on Quality is Critical to Solid Recovered Fuel Production in Cyprus

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The Challenge

Meeting European Environmental Targets
• Waste Framework Directive Recycling Target
• Landfill Directive Biodegradable Waste Diversion Target
• Renewable Energy Directive Target

Identifying Cost Effective and Sustainable Solutions for Waste
• AD and composting options – poor residue quality issues
• Building a thermal treatment plant is a major barrier
• High quality and consistent fuels are required by industrial thermal processes like cement production
The Opportunity

- Municipal Solid Waste is an indigenous fuel source to the island
- A major thermal conversion industry is available on the Island (Vassiliko Cement Works Ltd)
- Major investments in new advanced technologies and alternative fuel handling systems
- Significant fossil fuel substitution
- Significant demand for Solid Recovered Fuel (SRF) as an auxiliary fuel
- Rates of substitution increase with fuel quality
- 30-40% or higher substitution rates are possible
- Could represent a bulk market for 110,000 t SRF
- **Multi-criteria analysis consistently identifies MBT SRF cement industry as the most sustainable option for MSW management in Cyprus** (Nikolaides *et al* 2016)
Advantages and Disadvantages of MBT → SRF

Advantages
• 100% participation rate
• Captures all recoverable value
• Established technologies
• Control over product outputs through advanced biodrying and separation technologies
• Minimises landfill disposal (a zero rate is achievable)
• Simple bin and collection systems
• Flexible and adaptive to future demands
• Does not compete with other recycling schemes

Disadvantages
• Mixed waste treatment favoured less than source separation
• Negative public perception towards waste processing facilities
• Markets and quality are critical for fuel and other outputs
Shanks MBT - Frog Island, East London, 180,000 t/y MSW
Average ELWA SRF Analysis

**SRF Composition**

- **Paper and Card** 33%
- **Plastic Film** 23%
- **Rigid Plastic** 14%
- **Textiles** 15%
- **Other** 15%

- **Waste origin** = 97% MSW, 3% commercial
- **85% of material** = paper, card, plastics & textiles
- **'Other’** = misc combustibles, ferrous & non-ferrous, putrescible
- **Material shred size** = 50mm (variable according to off-take market requirements)
- **Particle Size <50mm** = 98% (VCW PSD <35mm)
- **Energy potential (CV)** = 17.0MJ/kg (net CV) (VCW <16 MJ/kg)
- **Moisture content** = 16.9% (VCW <18%)
- **Ash content** = 7% (VCW <15%)
- **Chlorine** = 0.41% (VCW <0.8%)
- **Delivery method** = compacted & loose loaded on trailers for road haulage
- **End use** = pre-heating, cement kiln pre-calciner
- **Production potential** = 27.5% of input, by weight
# MBT Mass Balance

<table>
<thead>
<tr>
<th>Route</th>
<th>Outputs</th>
<th>Frog Island, Target</th>
<th>Jenkins Lane, June 2014</th>
<th>Cumbria 2014/15</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversion</td>
<td>SRF/RDF</td>
<td>115,679 (64.3%)</td>
<td>6,756 (45.7%)</td>
<td>55,814 (48.8%)</td>
<td>Used as alternative fuel in cement production and in efw plant</td>
</tr>
<tr>
<td>Diversion</td>
<td>Moisture</td>
<td>52,380 (29.1%)</td>
<td>5,007 (33.9%)</td>
<td>31,612 (27.7%)</td>
<td>Evaporative losses</td>
</tr>
<tr>
<td>Recycling</td>
<td>Mixed Metals</td>
<td>3,827 (2.1%)</td>
<td>283 (1.9%)</td>
<td>2,622 (2.3%)</td>
<td>Recycled through the scrap metal industry</td>
</tr>
<tr>
<td>Recycling</td>
<td>Glass &amp; Stone</td>
<td>1,776 (1.0%)</td>
<td>229 (1.5%)</td>
<td>8,763 (7.7%)</td>
<td>Used as aggregate in road building</td>
</tr>
<tr>
<td>Recycling</td>
<td>Fines (0 - 6mm)</td>
<td>6,138 (3.4%)</td>
<td>91 (0.6%)</td>
<td>8,518 (7.5%)</td>
<td>Goes for further treatment for land restoration</td>
</tr>
<tr>
<td>Landfill</td>
<td>Dust</td>
<td>200 (0.1%)</td>
<td>0 (0.0%)</td>
<td></td>
<td>Extracted from refinement air treatment</td>
</tr>
<tr>
<td>Landfill</td>
<td>Fines (0 - 6mm)</td>
<td>548 (3.7%)</td>
<td>6882 (6.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landfill</td>
<td>RDF</td>
<td>1,872 (12.7%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Input t</strong></td>
<td>179,800 (100.0%)</td>
<td>14,787 (100.0%)</td>
<td>114,211 (100%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary**

- Diversion: 93.3% 79.6% 76.5%
- Recycling: 6.1% 4.1% 17.5%
- Landfill: 0.10% 16.4% 6.0%
- Total: 100% 100% 100%
Rotary Biodrying Research with Vassiliko Cement Works, Cyprus

- Metabolic heat removes water from biodegradable waste
- Critical control of microbial activity at low moisture
- Optimised rotation, aeration and temperature management
- Minimises drying time: <3 days
- Small plant footprint, reduced capital and operating costs
- Maximises calorific value, fuel homogeneity and recyclate recovery
- Direct combustion or pretreatment in advanced thermal treatment (gasification)
- Local developed technology
Rotary Biodrying Technology Can Reduce Processing Time to ≤3 Days and Increase Fuel Properties and Consistency.
Vassiliko Cement Works at a Glance

• Established in 1963
  – First production in 1967
  – 2nd Lepol Kiln line in 1969
  – 3rd Lepol Kiln line in 1975
  – 4th Lepol Kiln line in 1985
  – New BAD 2-string 5 stage Pre-Calciner Kiln 2011
  – State of the art feeding system for alternative fuels 2014-2016

• Cement Plant
  – Location: Vassiliko, Cyprus
  – Raw materials: Main quarry 7 km from plant
  – Kiln capacity: 2 m tpa clinker – the biggest cement kiln in Europe
  – Grinding capacity: 2,4 m tpa cement
  – Other infrastructure: Vassiliko port
Push floor feeding bin for RDF
2.6 Photo - Chopped Tyres Push Floor Feeding Bin
Push floor feeding of chopped tyres to screw feed
Alternative fuel and raw material delivery and supply system
Debaling and Drum screening for imported baled RDF/SRF
Tubular ‘pipe’ belt conveyor transporting from Debaler over to Feed Bins
Important quality criteria for SRF used in cement kilns

• Cl content: Cl can cause build up formation in static combustion chambers (calciner) restricting gassflow.
• Ash content: ash is incorporated in the product of the kiln as raw material. Clinker reactivity can be affected.
• Moisture content: Causes expansion in cement kiln gasses and increased power consumption. It also affects the combustion profile and transport of the material to the kiln.
• Particle size: the smallest the better. Combustion of coarse material is slow and the retention time in the calciner may not be adequate for complete combustion.
• NOx emissions increase with increasing particle size and moisture of SRF.
• Calorific value: Always related to Cl content and ash content. Using SRF with high calorific value reduces Cl and ash input for a specific thermal substitution.
• Homogeneity: The most important parameter for smooth kiln operation. Variable moisture, calorific value, particle size etc cause fluctuations in cement kiln temperatures with detrimental effects on product quality.
SRF utilization at Vassiliko Cement Works

• Test with compost like output (CLO) from Larnaka MBT plant were performed on 2014-2015.
• CLO was fed to the calciner for a period of 6 months
• Thermal substitution of 5 % was hardly reached with more than 100 tns utilized on a daily basis. There was negative impact on clinker quality and process performance.
• Since 2015, high quality SRF is imported from abroad.
• Currently, more than 300 tns of SRF is utilized on a daily basis equivalent to approximately 30 % thermal substitution.
• Successful tests has been carried out with more than 400 tns of SRF fed to the kiln on a daily basis.
Effect of AF utilization on NOx baseline emissions

DSS- MBM co-ground, TDF-RDF pre-blended
Effect of AF utilization on Specific Electrical Energy Consumption (SEEC)

DSS- MBM co-ground, TDF-RDF pre-blended
Conclusions

- High diversion and recovery rates can be achieved close to 100%
- Captures all the residual value in waste
- Compatible with recycling systems
- A significant and committed end user is available for fuel products in Cyprus
- Critical fuel production processes and quality control to a specification (moisture, chemical composition) are necessary and achievable
- The technology combination is a great opportunity for Cyprus and would be a major lost opportunity if not taken forward