Update on European Carpet Recycling Activities and Experiences

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One Challenge  - Two Approaches

EUROPE

economical

CARPET RECYCLING

UNITED STATES

technical

One Solution ?
Timetable of the European Carpet Industry

**1993** GUT put Recycling on its agenda as a priority action
- economical and ecological viable disposal and recycling systems for carpets
- landfill is not a solution
- development of strategies for the recycling of “Post Consumer Carpet Waste”

**Initiation of several research projects**
- Tamara-project (MWI)
- Carpet as solid fuel in moving bed reactor → energy recovery
- COCARE Coding for Carpet Recycling

**1996** set up of RECAM-project
- Closed loop recycling of carpet materials

**1998 – 2002** Carpet Recycling Europe (CRE)

**2002- 2004** Carpet Recycling Nederland (CRN)
The RECAM Project

SUSTAINABLE CLOSED LOOP SYSTEM FOR RECYCLING OF CARPET MATERIALS

Partners: DSM ENICHEM TFI GUT

1996-1999 project funded by the EC (Brite Euram)
The RECAM System

- identification and sorting
  - key technologies for successful carpet recycling

- CRE pilot project
- financed by GUT members
- supported by RECAM partners
The principle idea of the CRE-project

Carpet waste → Sorting Plant

PA 6 carpets → Recycling
PA 66 carpets
PP carpets
PES carpets
Wool carpets → Energy recovery or recycling
Others
Automatic sorting at CRE
The practical results of Carpet Recycling Europe

- **Carpet Waste** 
  - CRE-Sorting Plant
  - **PA 6 Carpets**
  - **PA 66 Carpets**
  - **PP Carpets**
  - **PES Carpets**
  - **Wool Carpets**
  - **other Carpets**

**PA 6 content**
- ~27%

**PA 6 content based on input**
- 4.6% to (5.4%) PA 6

**PA 6 content based on input**
- 400 to 450 gPA6/m² based on 1.57 kg/m²

**17% to (20%)**
Comparison with published figures by PA 2000

Prediction by PA 2000

- 10,000 t of virgin PA-6 from
- 120,000 t of carpet waste
- Calculation without any losses during processing!
- PA-6 content in PCCW 8.3%
  - with minimum losses! 9.25%

Realistic figures by CRE

- Theoretical available: 6.5%
- Theoretical collectable: 4.5%
- Practical results 4.6%
Carpet Recycling Netherlands

Feasibility study of introducing carpet waste recycling in the Netherlands

Ministry of Economic Affairs/Novem → Initiator of project

Ministry of Spatial Planning, Housing and the Environment:

- Authorities
  - VROM
    - Product Policy/Waste Policy
- Industry
  - VNTF/ECA/CRE/GUT
- Consumer
  - Consumer

Potential stakeholders (including raw material suppliers and retail trade)

Waste management branch

Econ. Affairs
Energy Policy
MJA2-scope enlargement
It is recommendable to use as much as possible carpet waste as secondary fuel, as this will lead to substantial environmental and economic gains. As stated above, this implies that the carpet waste should be collected as mono stream.

Especially with regard to the domestic market for carpet (waste), (additional) possibilities should be created for collecting carpet waste as mono stream, for instance via separate containers for carpet waste at municipal domestic waste transfer stations. Perhaps NVRD (the waste management branch organization in the Netherlands) may also play a role here.

However, the realisation of such facilities lies beyond the scope of the VNTF and the remaining Dutch carpet industry.
The facts behind the recommendation

- Simple comparison of energy consumption and energy savings with the software LESS, developed by the NOVEM

- More complex LCA-Calculation by GUT, based on the RECAM-Project

   identical results
Different scenarios

Basis for the RECAM – LCA

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Landfill</th>
<th>Municipal Waste Incineration</th>
<th>RECAM material, textile, chemical and thermal recycling</th>
<th>Recycling Cement industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>84 %</td>
<td>16 %</td>
<td>0 %</td>
<td>0 %</td>
</tr>
<tr>
<td>1998</td>
<td>82,1 %</td>
<td>15,7 %</td>
<td>0 %</td>
<td>2,2 %</td>
</tr>
<tr>
<td>2005</td>
<td>0 %</td>
<td>30 %</td>
<td>37,3 %</td>
<td>32,7 %</td>
</tr>
</tbody>
</table>
Based on the recycling scenario, described by the RECAM report, a LCA–study comes to the conclusion that the environmental impact of carpet waste can be reduced by factor 2
The modified scenario for NL

Basis for the CRN – LCA

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Year</th>
<th>Cement kills</th>
<th>MWI</th>
<th>Landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>LESS Zero</td>
<td>2003</td>
<td>53 %</td>
<td>33 %</td>
<td>14 %</td>
</tr>
<tr>
<td>A1 1</td>
<td>2006</td>
<td>57 %</td>
<td>43 %</td>
<td>0 %</td>
</tr>
<tr>
<td>B1 2</td>
<td>2006</td>
<td>62 %</td>
<td>38 %</td>
<td>0 %</td>
</tr>
<tr>
<td>C1 3</td>
<td>2012</td>
<td>83 %</td>
<td>17 %</td>
<td>0 %</td>
</tr>
<tr>
<td>D1 4</td>
<td>2012</td>
<td>100 %</td>
<td>0 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>
Dutch basic Scenario

- Production waste
  - Transport 20 km, 16t LKW, 50%
  - Contract
    - Transport 20 km, 16t LKW, 50%
    - Domestic
      - Transport 10 km, Auto
        - Collection via Recycling station
          - Transport 100 km, 16t LKW, 50%
          - Aufbereitung (Schreddern, Pelletieren)
            - Transport 300 km, 16t LKW, 80%
            - Cement industry
          - MWI
          - Landfill

- Carpet Waste
  - Transport 20 km, 16t LKW, 50%
  - Contract
    - Transport 20 km, 16t LKW, 50%
    - Domestic
      - Transport 10 km, Auto
        - Collection via Recycling station
          - Transport 100 km, 16t LKW, 50%
          - Aufbereitung (Schreddern, Pelletieren)
            - Transport 300 km, 16t LKW, 80%
            - Cement industry
          - MWI
          - Landfill
Energy savings

(95kt/a in NL) MWI + Cement kilns versus 100% Landfill

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Year</th>
<th>Energy Savings [TJ/a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nullscenario</td>
<td>2003</td>
<td>993.6</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>2006</td>
<td>1111.2</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>2006</td>
<td>1163.7</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>2012</td>
<td>1384</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>2012</td>
<td>1562.4</td>
</tr>
</tbody>
</table>

Status quo 2004
Overall Comparison


Verbrauch an Ressourcen
Klimaänderung
Ozonschichtabbau
Versauerung von Böden und Gewässern
Überdüngung
Humantoxizität
Ökotoxizität
Bildung von Photooxidantien
Flächenverbrauch
Lärmbelastung
The situation in 2004

- No “recycling” facilities available!
- No separate collection system
- No landfill from 2005

Comparison of different scenarios with the optimal recycling scenario “RECAM”

<table>
<thead>
<tr>
<th>Cement kilns [%]</th>
<th>MWI [%]</th>
<th>Landfill [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>C</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>D</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>E</td>
<td>70</td>
<td>30</td>
</tr>
</tbody>
</table>

Why 70% - 30%?
Collection of carpet waste in Germany

Practical results from PCC-waste collections

Frankfurt (RECAM-project)
- 6,25 kg/inh. (opt. conditions)
- 5,00 kg/inh. as average

Bavaria
- 1,4 to 3 kg/inh.

Assumptions
- 4 kg/inh. collectable mass (realistic scenario)
- 5 kg/inh. maximum collectable mass (optimized collection systems)
Collectable amount of PCCW

Based on realistic assumptions 4 kg to 5 kg of carpet waste can be collected per inhabitant in Germany.

This means:

- 328 kt of PCC-waste (realistic scenario)
  - 58% of the theoretical available mass
- 410 kt of PCC-waste (optimized scenario)
  - 73% of the theoretical available mass

All further calculations are based on the assumption, that it will be possible to collect 70% of the carpets sold.

391 kt in 2005, based on 559 kt sold in 1995 (325 mill. m²) in Germany.
The basic system for the LCA calculations
Energy gains based on LCA- calculations

![Bar chart showing energy gains and losses for different samples (Deponie, 1998, A to E, Recam). The chart indicates energy losses and gains in TJ for each sample, with a breakdown showing energy losses due to transportation and processing. The chart highlights the sustainability benefits of carpet materials in a cleaner living environment.]
LCA : impact assessment

Impact categories

Comparison of impact categories for different scenarios

(A,B,C,D,E, RECAM) is complex.

Impact of categories is different

- Noise Pollution
- Green House Potential
- Human Toxicity
- Eco Toxicity
- Ozone layer depletion
- Aquatic toxicity
- Energy consumption
- Consumption of resources
- Acidification
- Land consumption
- Formation of photooxidants
Impact assessment for noise pollution

**Situation 1998**
- Cement 0 %, RIP 100 %
- Cement 20 %, RIP 80 %
- Cement 40 %, RIP 60 %
- Cement 60 %, RIP 40 %
- Cement 70 %, RIP 30 %
- RECAM 2005
Impact assessment for human toxicity (HC)

Differences <20% are not relevant

Situation 1998
- Cement 0 %, RIP 100 %
- Cement 20 %, RIP 80 %
- Cement 40 %, RIP 60 %
- Cement 60 %, RIP 40 %
- Cement 70 %, RIP 30 %
- RECAM 2005
Impact assessment for eco toxicity (ECA)

- Situation 1998: Cement 0%, RIP 100%
- Cement 20%, RIP 80%
- Cement 40%, RIP 60%
- Cement 60%, RIP 40%
- Cement 70%, RIP 30%
- RECAM 2005
ECO-Indicator Points

With the help of Eco-Points the complex system can be compared and illustrated in a simpler way.

Fully aggregated final result of the life cycle interpretation by means of ECO-Indicator 95.

Eco-Indicator points [Prozent]

75% 80% 85% 90% 95% 100%

Situation 1998 Cement 0 %, MVA 100 %

Cement 20 %, MVA 80 %

Cement 40 %, MVA 60 %

Cement 60 %, MVA 40 %

Cement 70 %, MVA 30 %

RECAM 2005

Ecological optimisation potential
Let's have a look over the carpet horizon
Waste in Germany (in kt)

- Construction Waste: 231480; 59.1%
- Domestic Waste: 19316; 4.9%
- Production Waste: 43012; 11.0%
- Other: 44491; 11.4%
- Hazardous Waste: 18281; 4.7%
- Mining: 54308; 13.9%
- Carpets Waste: 559; 0.1%
- Bulky Waste: 3003; 0.8%
- Compost: 2413; 0.6%
- Glass; Paper; Plastics; Elektronic Devices: 9938; 2.5%
- Other Municipal Waste: 9262; 2.4%

391.572 kt in total
Consumption of thermoplastics in the EU, 2003

- Total: 38,148 kt
- Carpet: ~660 kt

Plastics application
- Non-Plastics application including textiles and carpets: 2.9% of all thermoplastics
- Carpet application: 1.7% of all thermoplastics
The next steps (1)

Use carpet waste as Refuse Derived Fuel (RDF)

See EU Report:
EUROPEAN COMMISSION – DG ENVIRONMENT
REFUSE DERIVED FUEL,
CURRENT PRACTICE AND PERSPECTIVES
(B4-3040/2000/306517/MAR/E3)
FINAL REPORT; WRc Ref: CO5087-4; JULY 2003
Refuse Derived Fuels (RDF) from MSW can be a strategic component of an integrated waste management system to reach the recycling and reduction targets for biodegradable materials going to landfill as specified under the 1999 Landfill Directive.

Use of RDF in industrial processes offers more flexibility than incineration as it leaves the door open for future recycling programmes as this can be made modular, it does not need to be fed with a constant amount of waste and it does not require the need to invest in capital intense dedicated incineration facilities.

Co-incineration of RDF in coal power plants and cement works shows ecological advantages when compared with incineration in a MSW incinerator primarily due to the effective substitution of fossil fuels, as long as the plants comply with the New Waste Incineration Directive 2000/76.
The next steps (2)

- Separate “High Calorific Wastes” like carpets from other waste streams
- Use them as RDF
- This will help to install collection system
- Besides ecological benefits economic efficiency is given
- Install suitable recycling programs for selected materials like PA 6
- Carpets should not be the only source for PA 6 recycling programs
Step by Step

- Ecological and economical approach

- Step 1: Energy recovery
  - High Calorific Waste
  - Waste reduction Step 1

- Step 2: Material recycling
  - RDF
  - Waste reduction Step 2
  - Material Recycling
EU is supporting Research Projects

- **SEFCO**
  - Solid recovered fuel (SRF) in large scale energy production

- **RECOFUEL**
  - Demonstration of SRF-cofiring-Method in a 600 megawatt power station

- **COBURN**
  - Co-combustion of separated high calorific household waste in power stations.
What happened to PA2000

Moving bed reactor used for energy production

Polymerization sold to DOMO

Plastics recycling (Regranulation) Sold to Vogt-Plastics GmbH

No carpets are recycled anymore. No plans exist to start this operation