Update on European Carpet Recycling Activities and Experiences

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One Challenge - Two Approaches

EUROPE

technical

UNITED STATES
economical

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)
Incineration of carpet waste in MWI

Questions to be answered:

- What is the environmental fate of heavy metals?
- Does PA lead to higher NO-emissions?
- Are Dioxins formed or emitted when carpets are incinerated?
- Do ashes contain harmful substances?

Forschungszentrum Karlsruhe

CO-COMBUSTION OF CARPET WASTE WITH TYPICAL HOUSEHOLD WASTE
Results

- The addition of carpet waste did not lead to instabilities in the plant,
- The higher calorific value of the carpet waste caused no problems,
- The CaCO₃ content of the carpets (filler) resulted in a reduction of SO₂ and HCl emissions due to the formation of CaSO₄ and CaCl₂ in the ashes,
- The heavy metal content of the ashes showed only the typical distribution and there was no effect registered that could be ascribed to the carpet waste,
- The same was true for dioxin and furane emissions in the off-gases,
- The polyamide content in the carpet waste caused only a very small increase of the NO concentrations in the off-gases.
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
- PA 66 carpets
- PP carpets
- PES carpets
- Wool carpets

Recycling → Energy recovery or recycling

Others
Automatic sorting at CRE
The practical results of Carpet Recycling Europe

Carpet Waste → CRE-Sorting Plant → other Carpets

- PA 6 Carpets
- PA 66 Carpets
- PP Carpets
- PES Carpets
- Wool Carpets

PA 6 content ~27% 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:

- Ministry of Economic Affairs/ECA/CRE/GUT
  - VNTF/ECA/CRE/GUT
  - VROM
    - Product Policy/Waste Policy

Econ. Affairs
- Energy Policy
- MJA2-scope enlargement

Potential stakeholders
- (including raw material suppliers and retail trade)

Waste management branch

authority

industry

consumer

GUT
Carpets tested for a better living environment
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 NOVEM

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

identical results
complex LCA Scope

Raw Material

Raw Material

Raw Material

Production of Carpets

Use of carpets

Disposal of Carpets

existing inventories?
different types of carpets
the question of lifetime
different scenarios

part 1

part 2

part 3
Different scenarios

Basis for the RECAM –LCA

always with energy recovery!

<table>
<thead>
<tr>
<th>Szenario</th>
<th>Landfill</th>
<th>Municipal Waste Incineration</th>
<th>RECAM</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>
The RECAM-LCA (CML)

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 easte**
  - Transport 20 km, 16t LKW, 50%
    - Containersystem
      - Transport 100 km, 16t LKW, 50%
        - Aufbereitung (Schreddern, Pelletieren)
          - Transport 300 km, 16t LKW, 80%
            - Cement industry

- **Contract**
  - Transport 20 km, 16t LKW, 50%
    - Collection via Recycling station
      - Transport 100 km, 16t LKW, 50%

- **Domestic**
  - Transport 10 km, Auto
    - Collection via Recycling station
      - Transport 75 km, 16t LKW, 50%

- **Carpet Waste**
  - 26%
  - 53%

- **Landfill**
  - MWI
  - Landfill
Energy savings

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

Energieeinsparung [TJ/a]

100% landfill reference point
ZERO 2003
Szenario 1 (2006)
Szenario 2 (2006)
Szenario 3 (2012)
Szenario 4 (2012)

status quo 2004
Overall Comparison


- Use of resources
- Climate change
- Ozone layer depletion
- Acidification (soil/water)
- Nutrification
- Human toxicity
- Eco toxicity
- Formation of photo oxidants
- Land use
- Noise

Environmental release vs Environmental burden
The situation in 2004

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

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>
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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

Energy losses (Transportation and processing)

Energy gains

landfill 1998 A B C D E Recam
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 recourses
  - Acidification
  - Land consumption
  - Formation of photo oxidants
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

80%
Impact assessment for eco toxicity (ECA)
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

- 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)

- Domestic Waste: 19316; 4.9%
- Production Waste: 43012; 11.0%
- Construction Waste: 231480; 59.1%
- Hazardous Waste: 18281; 4.7%
- Other: 44491; 11.4%
- Mining: 54308; 13.9%
- Carpet 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

<table>
<thead>
<tr>
<th>Thermoplastics in [kt]</th>
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<tr>
<td>LDPE</td>
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- Plastics application
- Non-Plastics application including textiles and carpets: 2.9% of all thermoplastics
- Carpet application: 1.7% of all
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
What are the benefits?
(See “conclusions” in EU report)

- 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

- 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
Railroad ties in Europe?