Future of Recycled Mineral Materials from C&D waste

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Project background

- Situation today (Canton Zurich)
  - Annual amount of C&D waste: 1.6 Mio. t
  - Demand for recycled building minerals (RM): 1.45 Mio. t
    - 70% used in excavation sector
    - Hesitating application in construction sector (30%)
  - Recycling rate of C&D waste: ±90%

- Expected situation in the mid-term future
  - Strongly increasing amount of C&D waste
  - Demand for building materials
    - Decrease for building minerals in excavation
    - Increase in building construction

- Problem
  - Suspected unsufficient demand for recycled building minerals in the mid-term future and breakdown of material recycling
Project goals & System boundaries

- Contentual goals
  - Overview on possible market constellations including the socio-political context in 2020
  - Strategic orientations on how to assure the high recovery rate in the mid-term future

- System boundaries
  - Temporal: 2020
  - Spatial: Canton Zurich

- Procedural goals
  - Giving the cantonal administration body an understanding of the FSA procedure as well as of its potentials and limits for waste management planning
Formative Scenario Analysis (FSA)

- Procedural overview of FSA (adopted from Scholz & Tietje, 2002)

1: Goal formation

2: Identification of impact factors

3: Assess direct impacts

4: Perform impact analysis

5: Define future states

6: Assess consistency

7: Construct scenarios

8: Select scenarios

9: Describe and interpret selected scenarios
Step 3 - Assess direct impacts

- **Procedure**
  - Knowledge integration workshop (incl. consensus building) among 20 system experts representing different stakeholders (administration, pressure groups, business, academia)
    - Working in subgroups of 5 experts representing different stakeholders
  - Assess direct impacts between pairs of impact factors based on
    - 0: no direct impact
    - 1: weak direct impact
    - 2: strong direct impact

- **Example**
  
<table>
<thead>
<tr>
<th>Amount C&amp;D waste</th>
<th>Energy price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Step 6 - Assess consistency

- **Procedure**
  - Applied consistency rating
    - -1: The future states cannot occur at the same time (*inconsistent*)
    - 0: The future state occur independently (*uncorrelated*)
    - 1: The occurrence of one future state supports the other (*supporting*)
    - 2: The occurrence of one future state induces the other (*causality*)
  - Individual consistency assessment among extended working group
  - Adjustment of individual consistency matrices based on formal procedure

- **Example**

<table>
<thead>
<tr>
<th>Impact factor</th>
<th>Amount C&amp;D waste</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Future state</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.6 Mio. t</td>
</tr>
<tr>
<td>Demand ratio construction</td>
<td></td>
</tr>
<tr>
<td>43% (2.5 Mio. t)</td>
<td>-1</td>
</tr>
</tbody>
</table>
Step 8 - Scenario selection

- **Goal**
  - Selection of a small number of representative scenarios that are as consistent and heterogeneous as possible (*Tietje, 2005*)

- **Procedure**
  - Combination of two different approaches in order to cover the spectrum of possible future states as good as possible

**Inductive**
- Data-driven formal selection
- Focus on **consistency** & heterogeneity

**Deductive**
- Concept-driven selection
- Focus on **representativeness** & heterogeneity
Characteristics of impact factors

- E.g. system grid…

<table>
<thead>
<tr>
<th>Active impact factors…</th>
<th>Ambivalent impact factors…</th>
</tr>
</thead>
<tbody>
<tr>
<td>affect other impact factors disproportionately high compared to being affected by other impact factors</td>
<td>Both strongly affect and are affected by other impact factors</td>
</tr>
<tr>
<td>Regulatory</td>
<td>highly embedded</td>
</tr>
<tr>
<td>Contextual character</td>
<td>sensible/critical</td>
</tr>
</tbody>
</table>

Active impact factors:
- Landfill taxes
- Recovery costs
- Communication

Ambivalent impact factors:
- Energy price
- Constructors’ responsibility
- Gravel price
- Distance ratio (landfill/recycl.)
Insights into system behavior

- Illustration of two opposed feedback-loops, which both involve the highly embedded "demand ratio of RM in construction" and are affected by the "amount of C&D waste"
## Overview of scenarios

<table>
<thead>
<tr>
<th>Impact factor</th>
<th>Current state</th>
<th>Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-1</td>
<td>A-2</td>
</tr>
<tr>
<td><strong>Amount of C&amp;D waste</strong></td>
<td>1.6-1.8 Mio.</td>
<td>3</td>
</tr>
<tr>
<td>Demand ratio excavation</td>
<td>48%</td>
<td>3</td>
</tr>
<tr>
<td><strong>Demand ratio construction</strong></td>
<td>9%</td>
<td>3</td>
</tr>
<tr>
<td>Image of RM</td>
<td>worse</td>
<td>3</td>
</tr>
<tr>
<td>Pollutant potential of RM</td>
<td>worse</td>
<td>3</td>
</tr>
<tr>
<td>Law &amp; standards</td>
<td>supporting</td>
<td>3</td>
</tr>
<tr>
<td>Recovery costs</td>
<td>35-45 CHF/t</td>
<td>1</td>
</tr>
<tr>
<td>Gravel price</td>
<td>12-15 CHF/t</td>
<td>3</td>
</tr>
<tr>
<td>Landfill tax</td>
<td>25-35 CHF/t</td>
<td>3</td>
</tr>
<tr>
<td>Energy price</td>
<td>625 CHF/t</td>
<td>3</td>
</tr>
<tr>
<td>Distance ratio (landf./rec.)</td>
<td>high</td>
<td>1</td>
</tr>
<tr>
<td>Techn. innovative ability</td>
<td>low</td>
<td>3</td>
</tr>
<tr>
<td>Communication</td>
<td>insufficient</td>
<td>3</td>
</tr>
<tr>
<td>Constructors’ responsibility</td>
<td>low</td>
<td>3</td>
</tr>
</tbody>
</table>
Type A scenarios

Building renewal based on closed material cycles

- **Common characteristics**
  - Huge annual amounts of C&D waste
  - High demand ratios of RM
  - Clear material standards
  - Exhausted technological potential
  - Efficient recovery process (pollutants, costs)
  - Good image of RM

- **Main differences**

<table>
<thead>
<tr>
<th>Scenario subtype</th>
<th>Gravel price</th>
<th>Landfill tax</th>
<th>Energy price</th>
<th>Scenario name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>3 (high)</td>
<td>3 (high)</td>
<td>3 (high)</td>
<td>Recovery through price regulations</td>
</tr>
<tr>
<td>A-3</td>
<td>1 (low)</td>
<td>1 (low)</td>
<td>1 (low)</td>
<td>Recovery as self-runner</td>
</tr>
</tbody>
</table>
Type C scenarios

Building renewal based on primary materials consumption

- **Common characteristics**
  - Huge annual amounts of C&D waste
  - Low demand ratio of RM in construction
  - Law&standards not intensified
  - Unexhausted technological potential
  - High pollutant potential
  - Bad image of RM

- **Main differences**

<table>
<thead>
<tr>
<th>Scenario subtype</th>
<th>Demand ratio exc.</th>
<th>Recovery costs</th>
<th>Gravel price</th>
<th>Landfill tax</th>
<th>Scenario name</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>3 (high)</td>
<td>3 (high)</td>
<td>3 (high)</td>
<td>3 (high)</td>
<td>Stagn. demand in construction</td>
</tr>
<tr>
<td>C-2</td>
<td>1 (low)</td>
<td>1 (low)</td>
<td>1 (low)</td>
<td>1 (low)</td>
<td>Market monopoly of PM</td>
</tr>
</tbody>
</table>
Discussion of scenarios

- Large differences among the resulting pool of scenarios
  - Material recovery rate ranging from 33%-90%
  - No scenario with stagnating amounts

- The demand ratio of RM is mainly determined by the interplay of material prices, material qualities (pollutants, mechanical properties), and the environmental awareness of constructors
  - Demand in excavation depends more strongly on financial incentives than in construction, where the quality standards are higher, especially for structural applications
  - Quality standards for RM are important for fostering their demand in construction (\(\rightarrow\) uncertainty, liability)
  - Technological innovations can improve material qualities of RM as well as reduce their pollutant concentrations
  - In case of high environmental awareness, the demand of RM in construction can become a self-runner
Strategic orientations

- Several options to intervene in the C&D waste recovery system
  - Voluntary
    - Informations (1)
    - Quality assurance (2)
    - Tech. Innovations (3)
  - Obliging
    - Legal regulations (4)

(Poon, 2007; Rao et al., 2007)
Discussion of procedural goals

- Potentials of FSA as a planning tool...
  - Provides generic insights into possible future states of a system
  - Points out those system aspects and their interrelations that are involved in system development on a generic level
  - Creates the relation between change in system aspects and the resulting development of the whole system
  - Creates an intervention space based on sound system understanding (strategic orientations)

- Limits of FSA...
  - Working out strategies and actions needs to consider higher level of details (e.g. differentiate between specific types of C&D waste, etc...)
  - FSA is adequate and powerful in the initial phase of a planning process
Further research

- Comprehensive context analysis of C&D waste generation
  - Synthesis of future studies concerning the above mentioned context dimensions (BFE, ARE, Seco,…)

- Deepened analyses of qualities and corresponding application areas of different recycled building materials to establish detailed standards

- …
Thank you very much for your attention

- Selected references