RECOVERED WOOD FROM RESIDENTIAL AND OFFICE BUILDINGS

ASSESSMENT OF GHG-EMISSIONS FROM REUSE, RECYCLING, AND ENERGY GENERATION

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INTRODUCTION

- Current research work aims at establishing a sustainable resource management for office and residential buildings in Vienna
- Special focus is set on the use of wood and GHG mitigation
- Use of wood for structures in an urban area (Vienna) – 3 Scenarios
- Examination of the flows of building timber, the stored timber within the buildings and the waste wood management for 3 Scenarios
- The investigated system covers 63 % (27,600 t) of annual building and demolition timber (44,000 t), which is 75 % of total amount of annual waste wood in Vienna (62,000 t)
- Analysis of properties and amounts of waste wood and available infrastructure
- Assessment of future resource potential for material and thermal use
- Assessment of carbon sink, greenhouse effect
CITY OF VIENNA – ANALYSIS OF THE SYSTEM

system boundary "Vienna with hinterland"

ATMOSPHERE

rawmaterial extraction and refinement

building-material production, prefabrication and supply hinterland

building-material production, prefabrication and supply Vienna

building construction (housing, reinstatement, Industrial- and comercial build.)
civil engineering (traffic buildings, Bridges, Infrastructure, hydraulic engin.)

secondary resource management (collection and sorting, treatment, utilisation and disposal)

Vienna

default

secondary resource management (collection and sorting, treatment, utilisation and disposal)

Vienna

system boundary "Anthroposphere Vienna and hinterland"

HYDROSPHERE

secondary resource management (collection and sorting, treatment, utilisation and disposal)

system boundary "natural metabolism"

PEDO- und LITHOSPHERE

ghg-emissions from reuse, recycling, and energy generation

Grafic: A. Merl 2004
3 SCENARIOS

Input into Stock 2001 of Residential and Office Buildings

Scenario 1: Actual state – business as usual
Scenario 2: Maximal use of wood according to legislation
Scenario 3: only use of (mixed) wooden structures

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SCENARIO 1: FLOWS OF TIMBER IN VIENNA 2001


\[ \text{Input: 25,828 t} \]
\[ \text{Output: 14,717 t (to stock)} \]
\[ \text{11,109 t (to waste management)} \]

Laminated glued timber: 363
Plywood: 882
Sawn timber, big intersection: 7007
Sawn timber, small intersections: 5079
Sawn Timber cladding, formwork: 7152
Laminated timber elements: 2061
Particle boards: 1642
OSB: 1642

Residential and Office Buildings

 Stored Wood:
In Structures 3,571,500 tons
In Finishings: 808,000 tons

Input: 16,516 (from stock)
Output: 16,516 (to waste management)

Building Construction Erection

Input: 25,828 t
Output: 14,717 t (to stock)
11,109 t (to waste management)

Private and Public Waste Collection Vienna

Private and Public Waste Collection Vienna

Landfill

Ashes: 490

Cogeneration Vienna

Timber contaminated with glue: 2547
Timber treated and untreated: 15660

Reuse/Recycling Vienna

Old timber, big intersections: 16314
Old timber, small intersections: 6202

System boundary “Office and Residential Buildings Vienna”

Emissions from incineration: 945
Sawn timber for reuse: 8005
Wood to particle board production: 8005

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Scenario 2: Simulated Flows of Timber

Building Construction Erection
- Input: 89,748 t
- Output: 15,405 t (to stock)
  74,343 t (to waste management)

Residential and Office Buildings
- Input: 73,343
- Output: -16,516

Stored Wood:
- In Structures: 3,571,500 tons
- In Finishing: 808,000 tons

Private and Public Waste Collection Vienna
- Input: 16,516 (from demolition) + 15,405 (from erection)
  Output: 31,920 (to energy generation and recycling)

Landfill
- Timber contaminate with glue
  - Ashes

Cogeneration Vienna
- Timber treated and untreated
  - Waste timber from recycling

Reuse/Recycling Vienna
- Old timber, untreated
- Big intersections

System boundary "Office and Residential Buildings Vienna"
- Emissions from incineration
- Sawn timber for reuse

GHG emissions from reuse, recycling, and energy generation
SCENARIO 3: SIMULATED FLOWS OF TIMBER

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## WOOD STORED IN BUILDINGS - STOCK

<table>
<thead>
<tr>
<th>Kind of wood stored in the buildings, measurements.</th>
<th>Amount [t]</th>
<th>Waste management option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams in ceilings, big intersections, span from 4 to 6 m (10 m), not treated</td>
<td>1,616,800</td>
<td>Reuse, recycling, thermal use</td>
</tr>
<tr>
<td>Wood integrated in various structures, small intersections, not treated</td>
<td>141,000</td>
<td>recycling, thermal use</td>
</tr>
<tr>
<td>Boards integrated in various structures, not treated</td>
<td>986,500</td>
<td>recycling, thermal use</td>
</tr>
<tr>
<td>Beams in roof frames and roof structures, big intersections treated and not treated</td>
<td>481,600</td>
<td>Reuse, recycling, thermal use</td>
</tr>
<tr>
<td>Small intersections in roof frames and roof structures, treated and not treated</td>
<td>110,600</td>
<td>Recycling (not treated), thermal use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wood stored in Structures</th>
<th>3,571,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boards in various floors, various measurements, treated</td>
<td>352,500</td>
</tr>
<tr>
<td>Wood in doors, windows etc, treated</td>
<td>399,000</td>
</tr>
<tr>
<td>Interior components like wall and ceiling panelling etc, treated</td>
<td>56,500</td>
</tr>
</tbody>
</table>

| Total amount of treated and untreated natural wood in Vienna | 4,370,500 |

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CARBON REPOSITORY, STORED ENERGY

Amount of Wood and CO₂-Equivalents stored in Buildings in Vienna 2001

<table>
<thead>
<tr>
<th></th>
<th>Stored Energy [PJ]</th>
<th>Wood stored in Structures</th>
<th>Wood stored in Finishings</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of stored Wood [t]</td>
<td>67,9</td>
<td>3.571.500</td>
<td>808.000</td>
<td>4.379.500</td>
</tr>
<tr>
<td>CO₂ - Equv. [t]</td>
<td>15,4</td>
<td>6.543.606</td>
<td>1480.396</td>
<td>8.024.001</td>
</tr>
</tbody>
</table>

Annual CO₂ – Emissions of the City of Vienna: 9 Mio. tons

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TIMBER STORED IN STRUCTURES - CHANGE

Development of Stored Timber in Structures

Amount stored in Structures until 2001: 3,570,000 t

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Development of Stored Carbon Dioxide Equivalents

Change of Stored CO2-equv. Scenario 1
Change of Stored CO2-equv. Scenario 2
Change of Stored CO2-equv. Scenario 3

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MATERIAL AND/OR THERMAL USE

- **material use**
  - **reused**
    - e.g. beam reused as beam complete or in part
  - **recycled**
    - e.g. beam processed to board

- **thermal use**
  - **heat**
  - **power and heat**
    - co-firing with fossil fuels
    - only wood fuel
    - co-firing in waste incinerator

- **cascading/down cycling**
  - e.g. beam to particle board/paper/cardboard

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- measurements
- optic condition
- strength property
- careful dismantling
- disconnection of parts
- contamination (mechanical, chemical, inorganic matter)
- damage from varmints
- feasibility of separation (economically & technically)
WASTE MANAGEMENT OPTIONS 2001 IN VIENNA

Recovered from wood from structures ->

Secondary resource management 2001

Landfill Prohibited:
landfill ordinance 1996

Energy use

Material use

Thermal use of recovered wood 2001 in Vienna: 18,207 t/a (66%) + 468 t residuals from recycling
Available infrastructure:
6 Incinerators: 836,500 t/a
2 Incinerators: no data
20 (in-plant) Incinerators: no data
Average transport distance: 5 – 10 km
Starting 2006: Biomass CHP – Plant, only for fresh wood (186,000 t/a, u=40% - 133,000 dry wood); average Transport distance for 80%: 70-80 km, for 20% no data, assumption: 100 km

Material use of recovered wood 2001 in Vienna: 30,100 t/a (34 %)
Type of utilisation/recycling:
•particle board industry: 8,005 t, transport distance is
•Sawmill in Vienna (flooring, furniture industry, etc): 1,500 t, average transport distance is 5 – 20 km)
•Agriculture (small amount from recycling sawmill

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GHG – EMISSIONS OF WASTE MANAGEMENT PROCESSES

CO₂ - Emissions for Secondary Resource management of Recovered Wood

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sorting and collecting</th>
<th>Landfill</th>
<th>conditioning and cogeneration</th>
<th>Recycling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>500</td>
<td>1000</td>
<td>500</td>
<td>1000</td>
<td>3000</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>750</td>
<td>1250</td>
<td>750</td>
<td>1250</td>
<td>3000</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>1000</td>
<td>1500</td>
<td>1000</td>
<td>1500</td>
<td>3500</td>
</tr>
</tbody>
</table>

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ACCOUNT BALANCE OF GHG - EMISSIONS

CO₂ Account Balance

Szenario 1  Scenario 2  Scenario 3

Secondary Resource Management  Substitution of oil
Neutral emission from stock  Stored in new product
Account Balance

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ADDITIONAL BENEFITS FOR RECYCLING

Benefits for recovered wood to sawn timber (reuse, recycling) and recovered wood to particle boards:

• Substitution of stand establishment / tending / site development, debarking (2 – 3 kg CO₂-equiv./m³) – Scenario 1: 52 t

• Substitution of forest area (sawn timber 1 ha/1,075 t_dry mass; chips for particle boards 1 ha/1,67 t_dry mass) : Scenario 1: 5.672 ha

Benefits recovered wood sawn timber
(reuse, recycling; processes located in Vienna):

• Substitution of drying process, for reuse also substitution of sawing process (approximately 20 kg CO₂-equiv./m³) Scenario 1: 44 t

• Substitution of transports from saw mill to Vienna (in average 80 tkm/t of sawn timber) Scenario 1: 32 t
SCENARIO 1: COMPARISON OF WMO`s

For Scenario 1 three Waste Management Options are compared:

1. All recovered wood 2001 (27,625 t) to energy generation in CHP plants, substituting fossil fuels (12,788 tons of oil), produced energy from wood: 470 TJ

2. Maximal recycling: 22,625 tons of wooden products, 85 TJ energy from wood and 385 TJ energy from oil

3. All recovered wood (25,625 t) going to landfill – which is prohibited in Austria – only for demonstration reasons. 470 TJ energy from oil has to be produced

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Comparison of Recycling, Energy and Landfill

Produced Energy from Waste wood: 470 TJ
Produced Energy from Waste wood: 85 TJ
Produced Energy from waste wood: 8 TJ
Oil: 385 TJ
Oil: 470 TJ

Secondary Resource Management
Substitution of oil
Additional emission of oil
Neutral emission from stock
Stored in new product
Account Balance

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Substituted forest area from recycling/reuse: 15.760 ha
FINDINGS AND CONCLUSIONS

• The stored wood within the buildings in Vienna represents both a source of reusable construction material and a potential substitute for fossil fuels.

• For any future material and/or energetic uses, it is necessary to know the configuration and the potential of the stock built in the city.

• After the final service life of a (recycled) wooden product energy generation should take place in order to contribute efficiently to GHG – mitigation.

• In order to optimise the management of recovered wood with respect to both ecological and economical concerns, the design of wood building components must reflect recycling considerations in addition to criteria for thermal utilisation.

• Recommendations on appropriate component design shall be given for building design practitioners (e.g., “design for recycling,” “design for energy generation”)

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FINDINGS AND CONCLUSIONS

• All involved actors (e.g., wood industry, energy experts, building industry, building design practitioners, etc.) together shall develop a strategy how to optimise the life cycle of wooden building materials (e.g., design and property of building elements and the consequences for management of recovered wood, accurate and quick deconstruction, reuse, recycling, energy generation, etc.).

• The use of renewable materials in the building sector can be expected to continue increasing. To realise the potential of these renewable resources, a well-equipped infrastructure for the management of recovered wood must be established.

• Recycling or reuse of wood substitutes forest area and contributes to protection of natural ecosystems and increase the availability of wood for several applications.

• Transport distances should kept short.