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Appying EcoDesign guidelines when designing rolling stock

In relation to recovery rates

Ulrika Överstam
Bombardier Transportation

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Ulrika Överstam, Ph D

Bombardier Transportation

- EcoDesign engineer
  - Chemicals / Chemical compliance
  - LCA /EPD / Recycling
  - HSE
  - Standardization and collaboration (ISO, SIS, UNIFE)

- 3 years at Bombardier Transportation
- 8 years with a company mainly focusing in robotics, power and automation technology

BOMBARDIER
Overview

Bombardier is the world's largest manufacturer of both planes and trains, with a worldwide workforce of **70,900**(1) (2) people.

Bombardier is headquartered in Montréal, Canada. Our shares are traded on the Toronto Stock Exchange (BBD) and we are listed on the Dow Jones Sustainability World and North America indexes. In the fiscal year ended December 31, 2015, we posted revenues of **18.2 billion USD.**

(1) As at December 31, 2015, including contractual and inactive employees. Subsequent to the end of the fiscal year, we decided to take steps to optimize our workforce with a combination of manpower reduction and strategic hiring. These figures do not reflect the planned changes.

(2) 3,950 product development engineering, Corporate office and other employees are not allocated to a reportable segment.

BOMBARDIER TRANSPORTATION
Overview

Bombardier Transportation, a global leader in rail technology, offers the broadest portfolio in the rail industry and delivers innovative products and services that set new standards in sustainable mobility.

BOMBARDIER ECO4 technologies – built on the four cornerstones of energy, efficiency, economy, and ecology – conserve energy, protect the environment and help to improve total train performance for operators and passengers. Bombardier Transportation is headquartered in Berlin, Germany, and has a very diverse customer base with products or services in more than 60 countries. It has an installed base of over 100,000 vehicles worldwide.

BOMBARDIER TRANSPORTATION
A global player with a European base

Revenues 2015[1]: $8.3 billion **Employees[2]: 39,400**

Global Headquarters

Production Sites

(1) As at December 31, 2015

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BOMBARDIER
the evolution of mobility

EcoDesign at Bombardier

- Minimize the environmental impact through out the entire life cycle of a product and ensure environmental compliance

- Elimination of hazardous material and substances
- Increase recyclability and recoverability
- Effective use of resources, material and energy
- Energy efficiency optimization
- Low emissions, particulate and gases
- Safe environment for passengers, customers and employees
- Product environmental compliance
- Transparent environmental communication

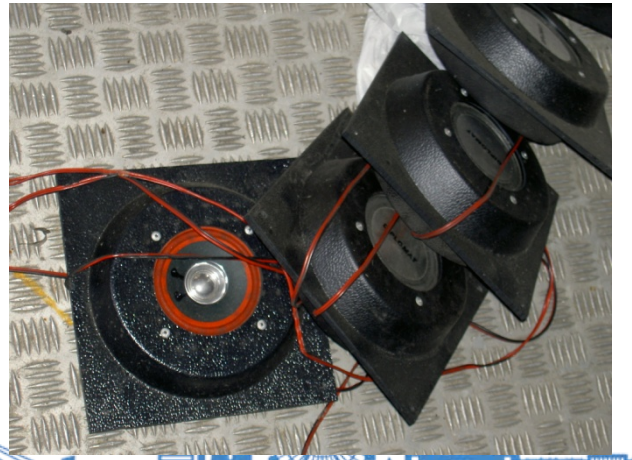
Recycling of Rail Vehicles – Swedish examples

From Hallquist in Nykroppa 2005, dismantling of old SJ vehicles.

Recycling of passenger wagons from the 60's

Fractions

Disassembled EEE

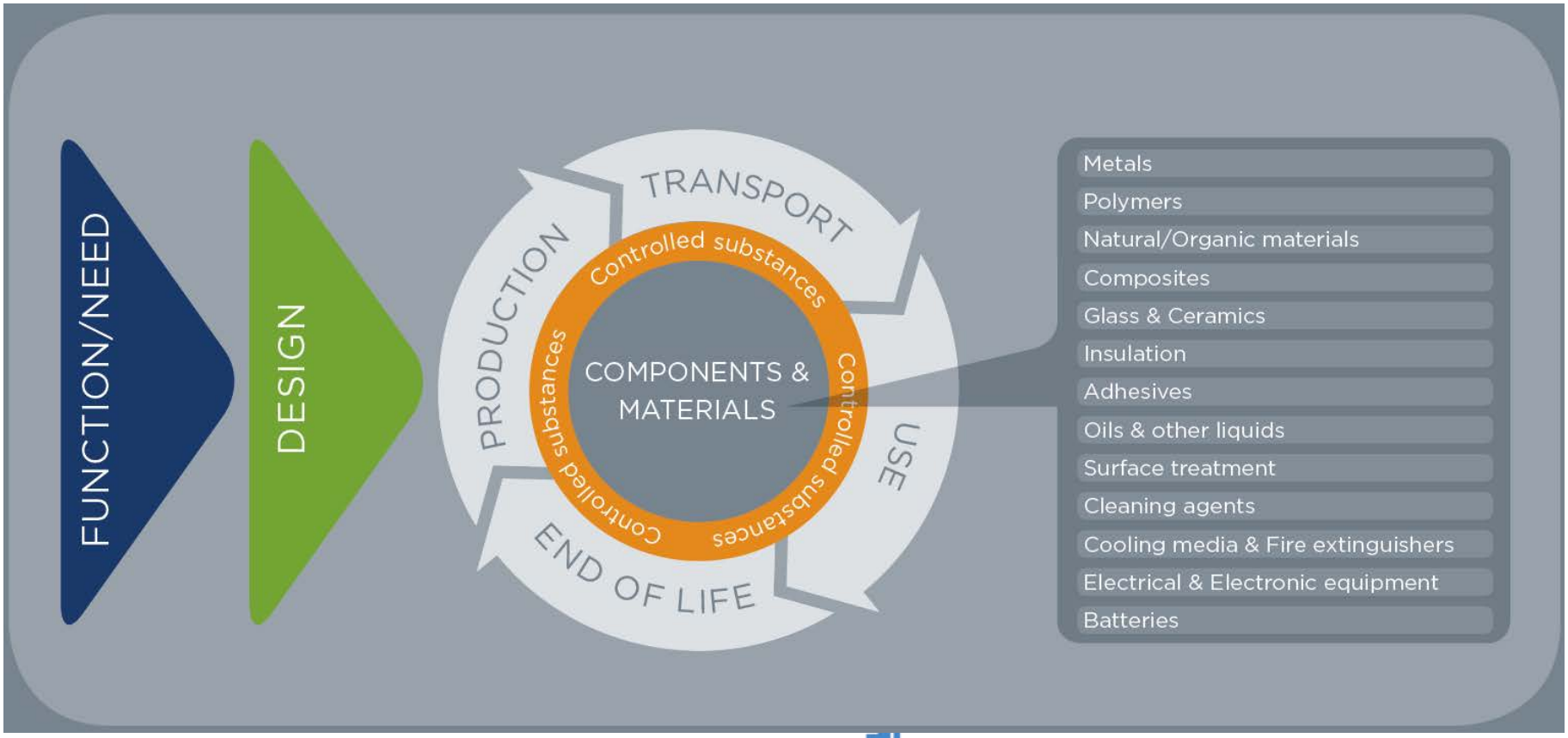


Electronic waste fraction

Insulation


JONSAC
Ren säck vid varje hämtning
Miljövänligt papper
Förnybar råvara

EcoDesign gudielines at Bombardier



EcoDesign guidelines at Bombardier

CONSIDER THE FUNCTION
Consider what function to create, not which product

CONTROL MATERIALS AND SUBSTANCES
Avoid using controlled substances and ensure safe handling for any that must be used

SAVE ENERGY
Reduce energy consumption and reuse energy whenever possible

OPTIMIZE WEIGHT
Use innovative structural features and high strength materials to minimize weight

ENHANCE HOUSE-KEEPING
Minimize energy and resource consumption in the production phase

SIMPLIFY STRUCTURE
Use as few joining elements as possible to facilitate repair and recycling

ENHANCE UPGRADE
Promote easy repairability and upgrade

ENSURE PROTECTION
Invest in strong and resistant materials and suitable surface treatments

AVOID MIXES
Promote upgrade, repair and recycling by using few, simple and recycled materials

EXTEND LIFETIME
Optimize the design for the estimated lifetime

PROVIDE INFORMATION
Ensure transparency for controlled substances and label parts and materials for easy identification

Positive

- Control materials and substances
- Enhance house-keeping
- Simplify structure
- Avoid mixes
- Ensure protection
- Extend lifetime

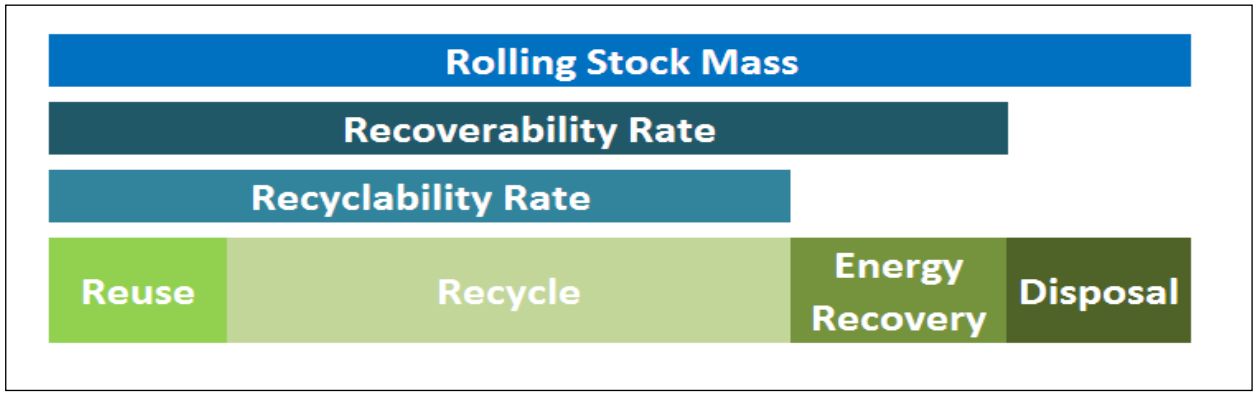
Dilemmas

- Optimize weight – Avoid mixes – Save energy
  - Polymer containing other materials
    - less weight
    - Polymers can be energy recovered, however reinforcements eg glass fiber or other ceramic materials not
  - Lamination – polymers/metals
    - Lower metal recycling due to impurities
      - Higher requirements on metal smelter plans (eg flue gas cleaning)
  - Light weight material (polymers)
    - Hazardous chemicals

Overview of the UNIFE Calculation method

- Main features

- Recycling technologies cover the four main treatment processes, which are reuse, recycling, energy recovery and disposal



- Description of pre-treatment, dismantling and shredder stages, clear calculation paths
- Definition of material categories appropriate for rail vehicles
- Common agreement on material recovery (MRF) and energy recovery factors (ERF)
  - on each stage of the recycling process and
  - for each defined material category

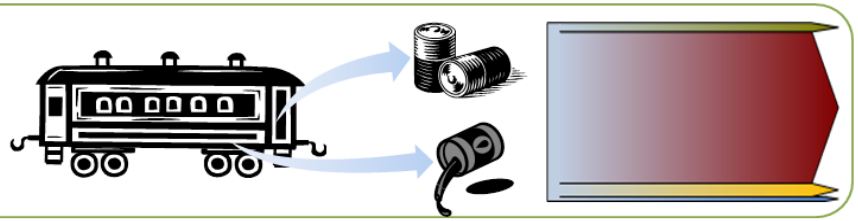
  ⇒ goal: make dismantling more attractive than shredding
- „Qualification list“ for pre-treatment and dismantling

Overview of the UNIFE Calculation method

- Recycling process ⇒ basis for Calculation

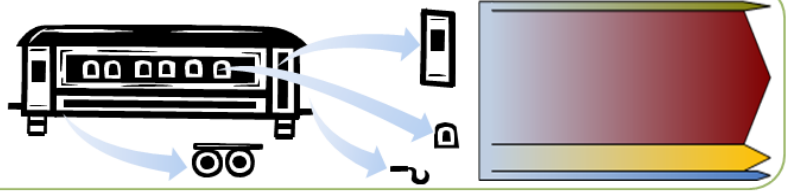
Pre-treatment

- Take vehicle to a safe place
- Extraction of fluids ⇨ sent for recycling, energy recovery or disposal
- De-pollution: removal of hazardous components



Dismantling

- Dismantling parts for reuse or to facilitate the separation of materials for recycling or disposal
- As much manual material separation as possible
- Metals: sent for recycling
- Polymers: sent for recycling or energy recovery

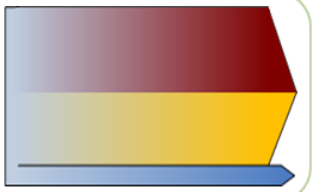


Shredding

- The remaining part of the vehicle: sent for shredding
- Recycling of ferrous metals

After Shredder residue

- The non-metallic shredder residue: preferably recycled before sent to incineration process



Mass flows

- Reuse
- Material Recycling
- Energy Recovery
- Disposal

Recoverability of rolling stock

Vehicle	Recyclability	Recoverability	Year
OMNEO	92	95	2014
REGINA X55	93	98	2012
FLEXITY Outlook	92	98	2012
INNOVIA APM 300	95	98	2012
INNOVIA ART 200	93	96	2010
SPACIUM	93	98	2010
TALENT 2	92	96	2010

Results from published EPDs

Summary

- Designing for enhanced recycling may hinder the use of new materials (mixed, light weight, lower cost)
- New designs may effect the recyclability and/or recoverability rate

- A common way on how to calculate recycling and recoverability rates can help drive the development of new materials, product designs and recycling methods

- Compromise is necessary – difficult but possible

Thank you!

Ulrika Överstam

Ulrika.overstam@rail.bombardier.com

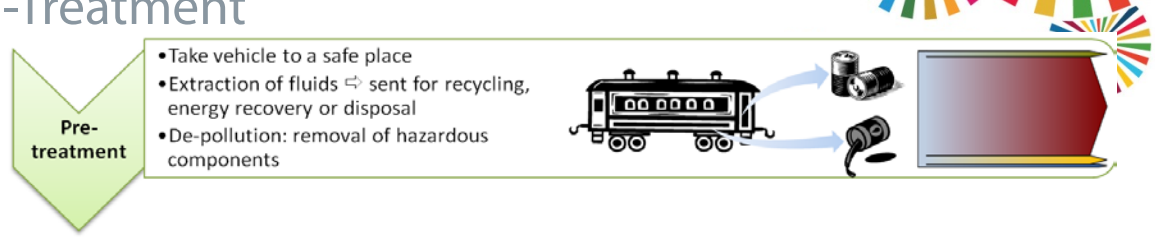
+46 10 852 77 01

+46 738 66 15 93

Additional slides

Applying the Calculation Method step by step

- Recycling process ⇒ Pre-Treatment



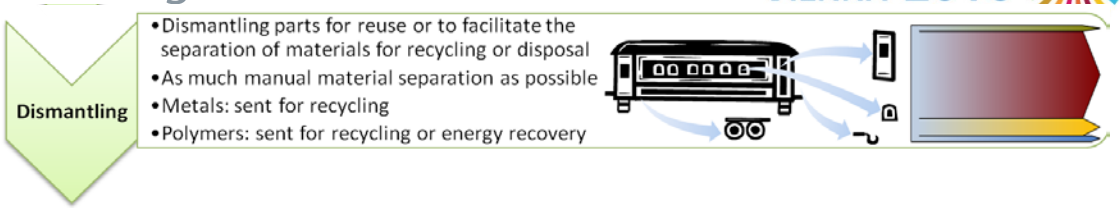
Parts to be removed during pre-treatment

Material, substance, part	Criteria	Dismantling/ Drainage
Fluids	Present	YES
Gases, explosives	Present	YES
Catalytic capacitors	Present	YES
Pollutants and hazardous substances	Present	YES
Fire extinguisher	Present	YES
Braking sand	Present	YES
Batteries	Present	YES, use take-back system
Greases	Present	YES
Oil	Present	YES
Other substances which can influence the recycling process	Present	

After pre-treatment no substances showing negative influence on the recycling process shall remain inside the vehicle

Applying the Calculation Method step by step

- Recycling process ⇒ Dismantling

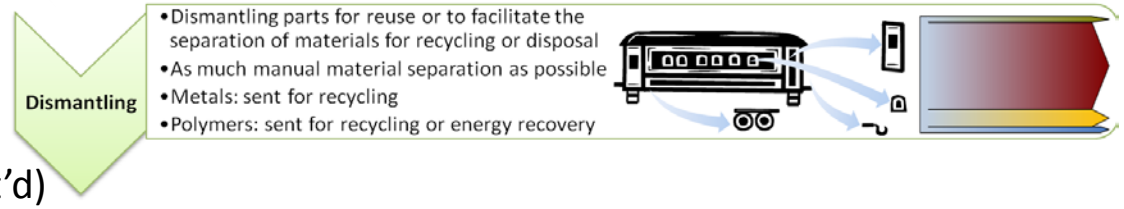


Qualification list for dismantling

Aspects of Recycling	Criteria for dismantling a component or material	Dismantling
Are there any components which can be reused?	Component is present	YES, REUSE step
Accessibility of the component	Directly accessible	YES
	Indirectly accessible	YES
	Inaccessible	NO, though value of material needs to be taken into account
Time to dismantle component	Low	YES
	Considerable time consumption	YES
	Very high	NO, though value of material needs to be taken into account
Valuable material	Present	YES
	Not present	NO

Applying the Calculation Method step by step

- Recycling process ⇒ Dismantling

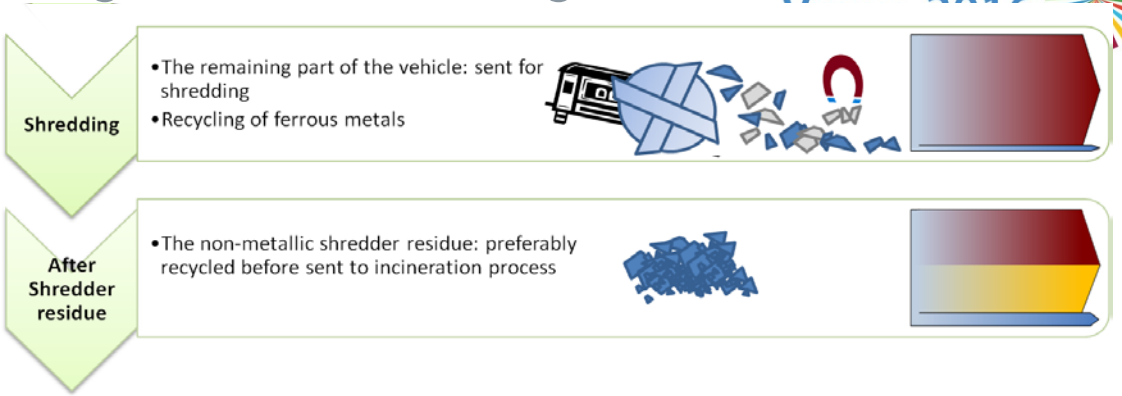


Qualification list for dismantling (cont'd)

Aspects of Recycling	Criteria for dismantling a component or material	Dismantling
Type of connections	Non-destructively detachable	YES
	Partially destructive	YES, but additionally depending on dismantling time and value of material
	Destructive, including damage to component	NO, though value of material needs to be taken into account
Is a state of the art recycling process for the material available?	Optimum process available	YES
	Complex process steps required	NO, though value of material needs to be taken into account
	No process available for material recycling	NO, keep in the vehicle for further processes
Is the material marked according to ISO 11469?	Polymer is marked	YES
	Component is only partly marked	YES
	Not marked	NO, only if the material is known and a state of the art process for recycling is available

Applying the Calculation Method step by step

- Recycling process ⇒ Shredding and after Shredding Residue



- The remaining parts and materials enter the shredding process..
- Sorting into two different material fractions:
  - Shredder Heavy Fraction (SHF) comprising
    - Ferrous metal fraction or ferrous fraction
    - Non-ferrous metal fraction or non-ferrous fraction
  - Shredder Light Fraction (SLF)

- (Note: Components and materials allocated to the shredding process cannot be classified as reusable)