

**RECOMMENDATIONS ABOUT HOW TO MODEL  
SUBSTITUTED MATERIALS BASED ON THE LCA CASE  
STUDY OF THE CONSTRUCTION AND DEMOLITION WASTE  
MANAGEMENT IN LOMBARDY**

***Lucia Rigamonti, Sara Pantini***

***Politecnico di Milano - Department of Civil and Environmental Engineering, Italy  
MatER Research Center, c/o Consorzio L.E.A.P., Piacenza, Italy***

**RESEARCH PROJECT: ENVIRONMENTAL EVALUATION OF THE C&D WASTE MANAGEMENT SYSTEM IMPLEMENTED IN LOMBARDY REGION**



***OBJECTIVES:***

- ❖ Quantifying construction and demolition waste (CDW) amount and flows within the management system of Lombardy Region
- ❖ Investigating types, amount, quality and actual market of “secondary products” obtained from CDW recycling plants (highlighting limiting factors for their market)
- ❖ Assessing the environmental performance of the current regional system through the application of the *Life Cycle Assessment (LCA)* methodology
- ❖ Identifying benefits and critical aspects of the CDW recycling chain
- ❖ Defining possible improving actions based on the state-of-the-art recovery technologies and the LCA results of the current management scenario, to be compared and evaluated from a life cycle perspective

## LOMBARDY REGION - ITALY



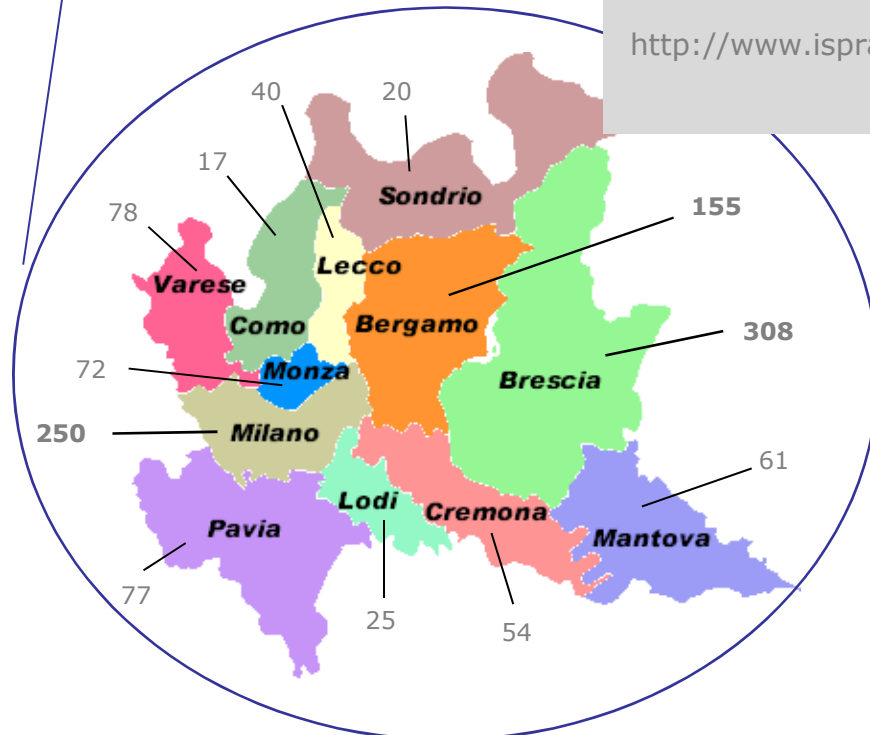
**AREA:** 23.844 km<sup>2</sup>  
**POPULATION:** 10 MILION (1/6 ITALIAN POPULATION)  
**GROSS DOMESTIC PRODUCT (GDP):** 22% ITALY'S GDP  
**ADMINISTRATIVE DIVISIONS:**  
 12 PROVINCES, 1 METROPOLITAN CITY (MILANO), 1530 COMMUNES

**Non hazardous CDW generation in Italy (2013): 47.9 Mt**  
**Non hazardous CDW generation in Lombardy (2013): 10.6 Mt**

Source: ISPRA REPORT 2016

<http://www.isprambiente.gov.it/files/pubblicazioni/rapporti/RapportoRifiuti>

Speciali\_Ed.2016n.246\_Vers.Integrale.pdf



### CDW MANAGEMENT SYSTEM

1157 PLANTS IN OPERATION IN 2016:

- LANDFILLS: 39
- RECYCLING PLANTS + TRANSFER STATION: 1118

SOURCE: CATASTO GEOREFERENZIATO DEI RIFIUTI REGIONE LOMBARDIA

<http://www.cgrweb.servizirl.it/cgrweb/ricerca.do>

## **NON-HAZARDOUS CDW INCLUDED IN THE STUDY:**

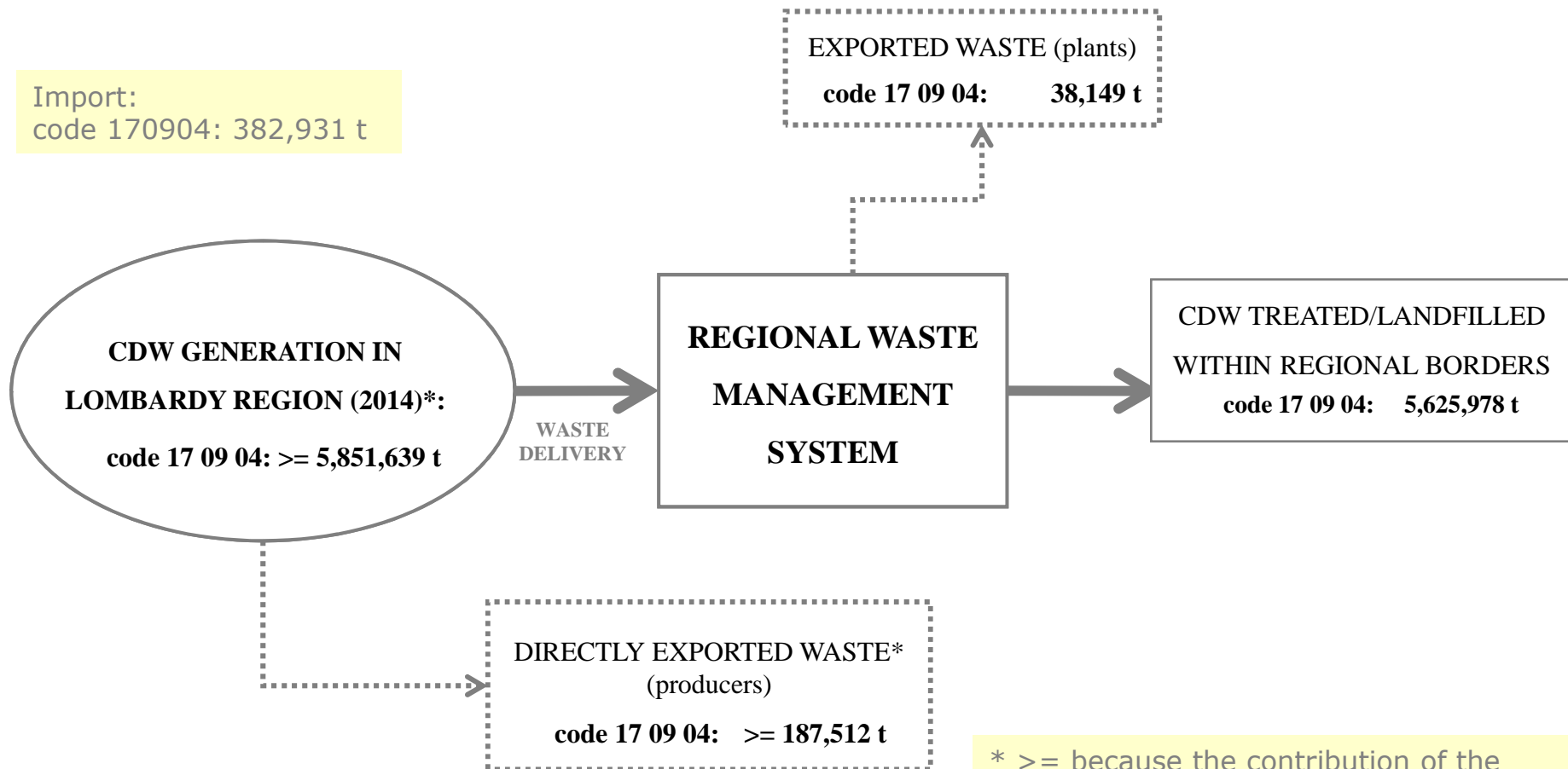
### EUROPEAN WASTE CODE 17 XX XX:

- **17 01 concrete, bricks, tiles and ceramics**
  - CONCRETE (17 01 01)
  - BRICKS (17 01 02)
  - TILES AND CERAMICS (17 01 03)
  - CONCRETE, BRICKS, TILES AND CERAMICS IN MIXTURES, NOT CONTAINING DANGEROUS SUBSTANCES (17 01 07)
- **17 02 wood, glass and plastic** (17 02 01, 17 02 02, 17 02 03)
- **17 03 bituminous mixtures, coal tar and tarred products** (17 03 02)
- **17 04 metals (including their alloys)** (17 04 01, 17 04 02, 17 04 03, 17 04 04, 17 04 05, 17 04 06, 17 04 07, 17 04 11)
- **17 08 gypsum-based construction materials** (17 08 02)
- **17 09 other construction and demolition waste**
  - MIXED CONSTRUCTION AND DEMOLITION WASTES, NOT CONTAINING DANGEROUS SUBSTANCES (17 09 04)



**CDW DATA PROCESSING WAS BASED ON COMPULSORY ENVIRONMENTAL DECLARATIONS (MUD) ANNUALLY PRESENTED BY COMPANIES, TREATMENT FACILITIES AND OBLIGED PRODUCERS**

Import:  
code 170904: 382,931 t



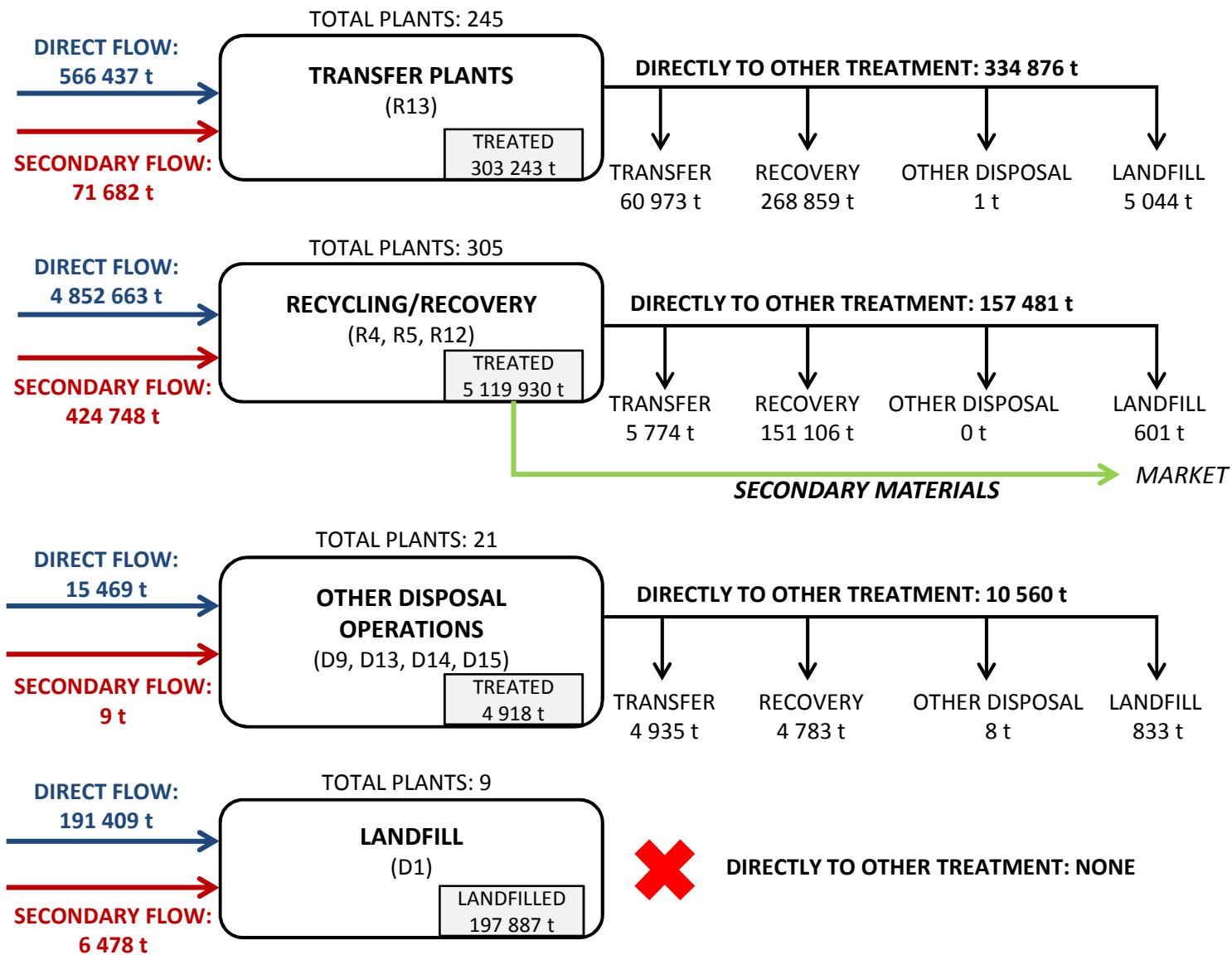
\* >= because the contribution of the producers not obliged to fill in the MUD is not included (as not quantifiable)

# PRELIMINARY RESULTS OF STEP 1: CDW FLOWS

**code 17 09 04:**  
**5,625,978 t**

Treatment:

- 91.0 % RECYCLING/RECOVERY
- 5.4% TRANSFER STATIONS
- 3.5% LANDFILL
- 0.1% OTHER DISPOSAL OPERATIONS



## RECEIVED WASTE

MIXED CDW  
(code 170904)



EXCAVATED SOIL  
(code 170504)



LARGE BLOCKS  
(code 170904)

## MOBILE PLANT (TYPE B)



## ALL-IN RECYCLED AGGREGATES (0/63)



## SEPARATED MATERIALS

**FERROUS METALS**



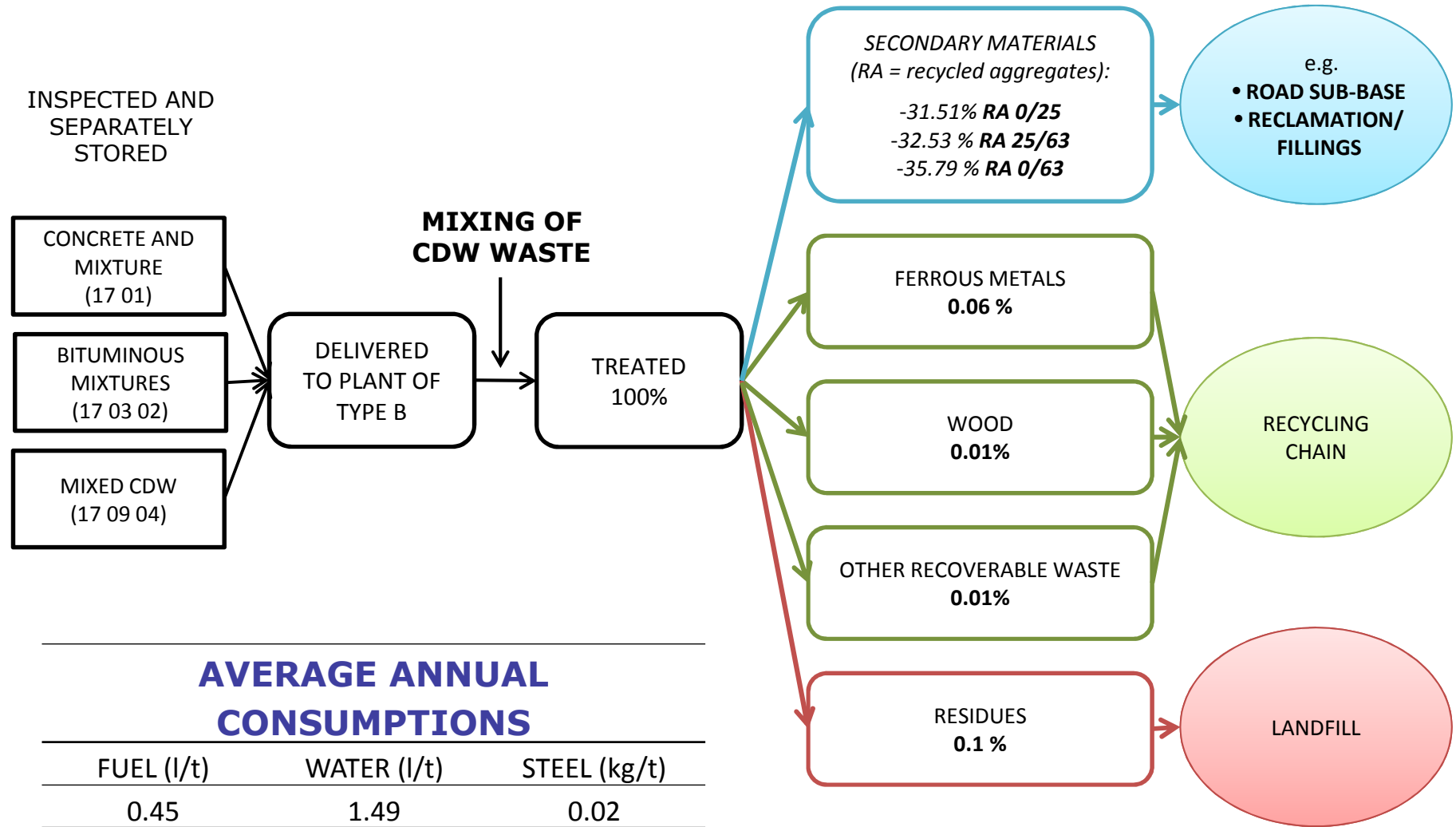
**WOOD**



**OTHER (MIXED) (WOOD, RUBBER,...)**



## MASS BALANCE OF TYPE B:

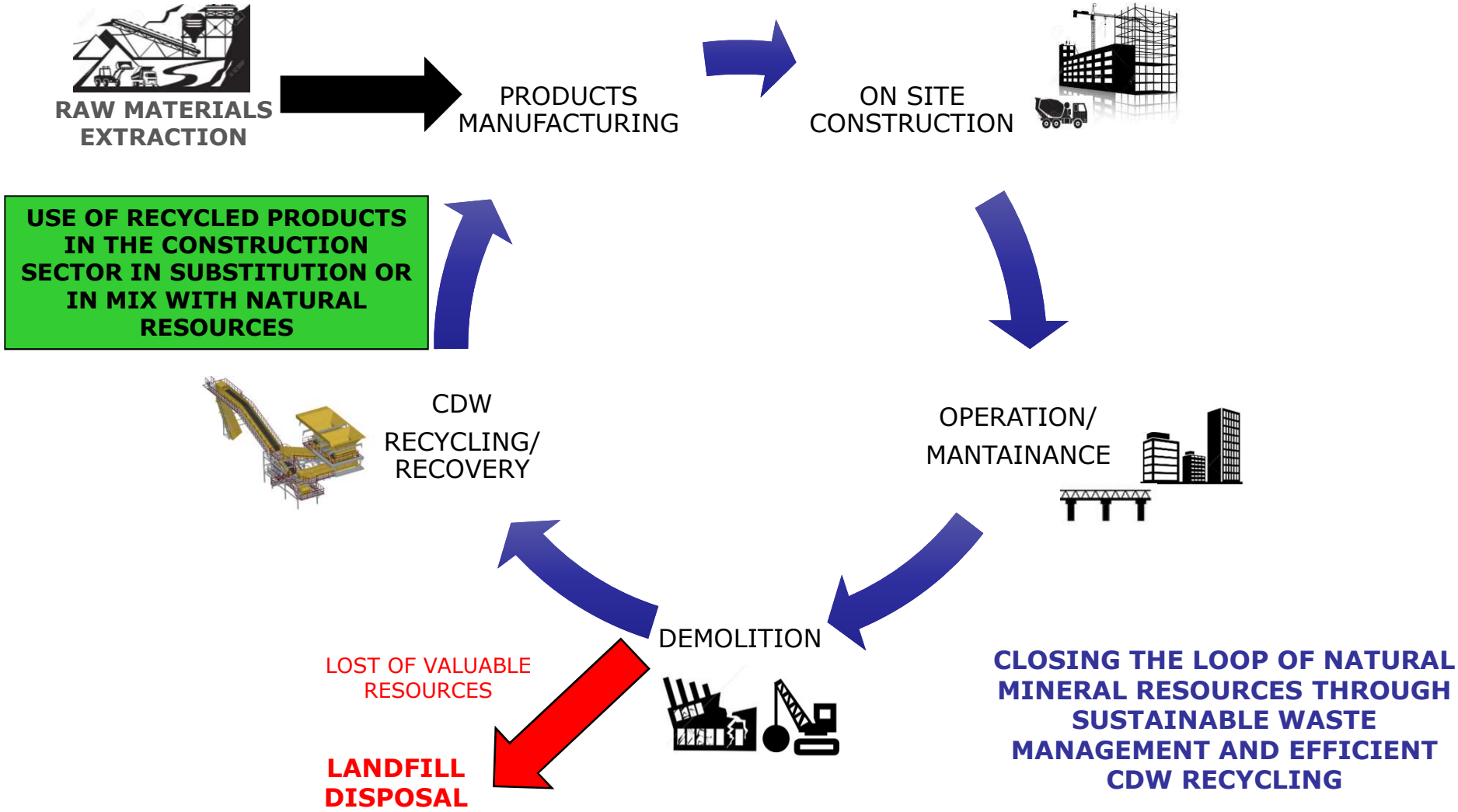


### AVERAGE ANNUAL CONSUMPTIONS

FUEL (l/t)	WATER (l/t)	STEEL (kg/t)
0.45	1.49	0.02



**STEP 3: MODELLING THE SUBSTITUTION OF VIRGIN RAW MATERIALS**

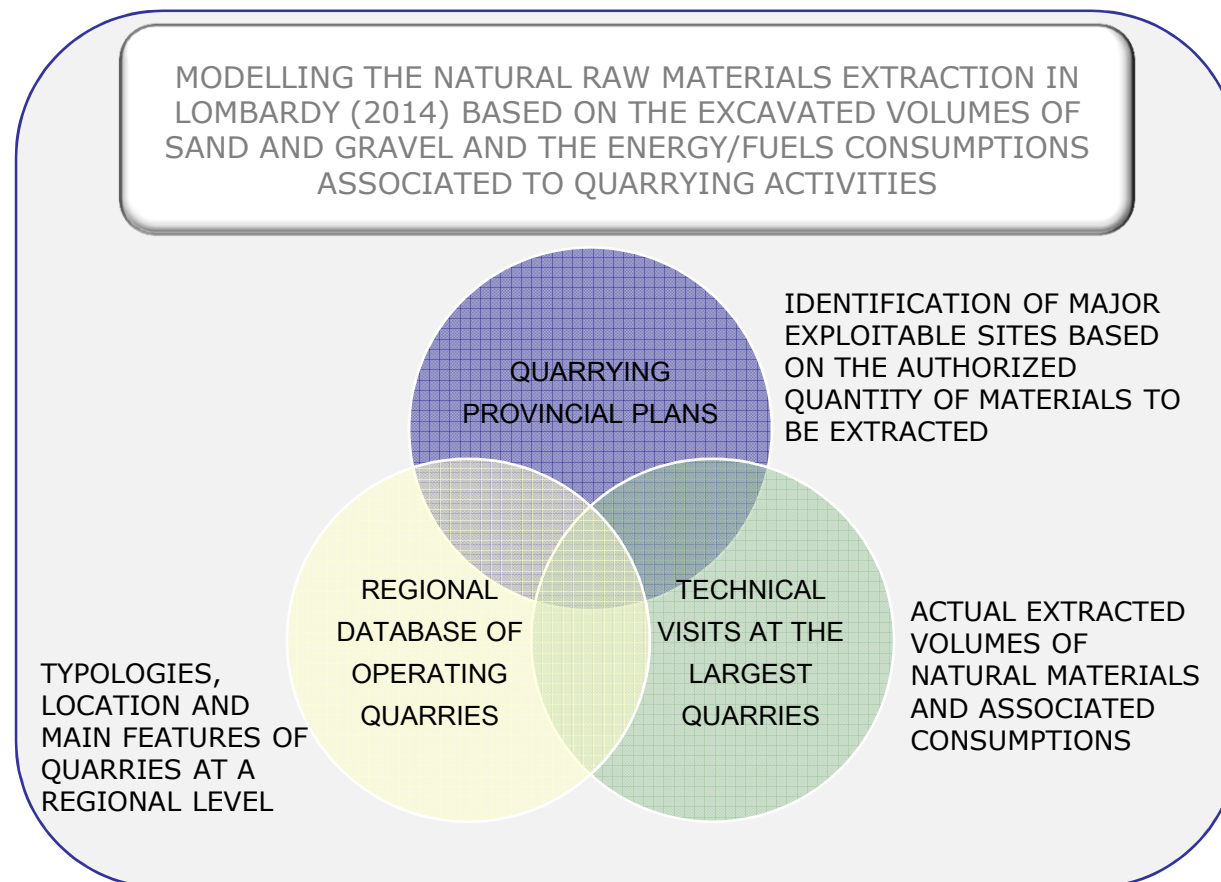


## **Substitution of natural aggregates**

- Modelling the "avoided impacts" associated with the "avoided extraction" of natural resources in Lombardy
- Need of taking into account not only for the quantity of recycled aggregates but also for their quality and their actual market

## Substitution of natural aggregates

- Modelling the "avoided impacts" associated with the "avoided extraction" of natural resources in Lombardy



Technical visits  
+  
Data about quarrying activities from documents yearly prepared by each Province

## Substitution of natural aggregates: quality of recycled aggregates

<b>REGULATION EU n° 305/2011</b>	<i>Harmonised conditions for the marketing of construction products (repealing Council Directive 89/106/EEC)</i> <b>CE MARKING</b>
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*"The placing on the market of a construction product which is covered by a harmonized standard should be accompanied by a declaration of performance in relation to the essential characteristics of the construction product in accordance with the relevant harmonized technical specifications."*

### RECYCLED AGGREGATES MUST COMPLY WITH ALL THE REQUIREMENTS FOR THE USE FOR WHICH THE AGGREGATE IS DESTINED

#### REQUIREMENTS FOR END USES OF AGGREGATES ACCORDING TO EUROPEAN STANDARDS:

EN 12620 Aggregates for concrete

EN 13043 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas

EN 13139 Aggregates for mortar

**VERY LIMITED DEMAND OF RA FOR CONCRETE AND MORTAR PRODUCTION IN ITALY**

**EN 13242 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction**

**MOST COMMON UTILIZATION OF RA IN ITALY**

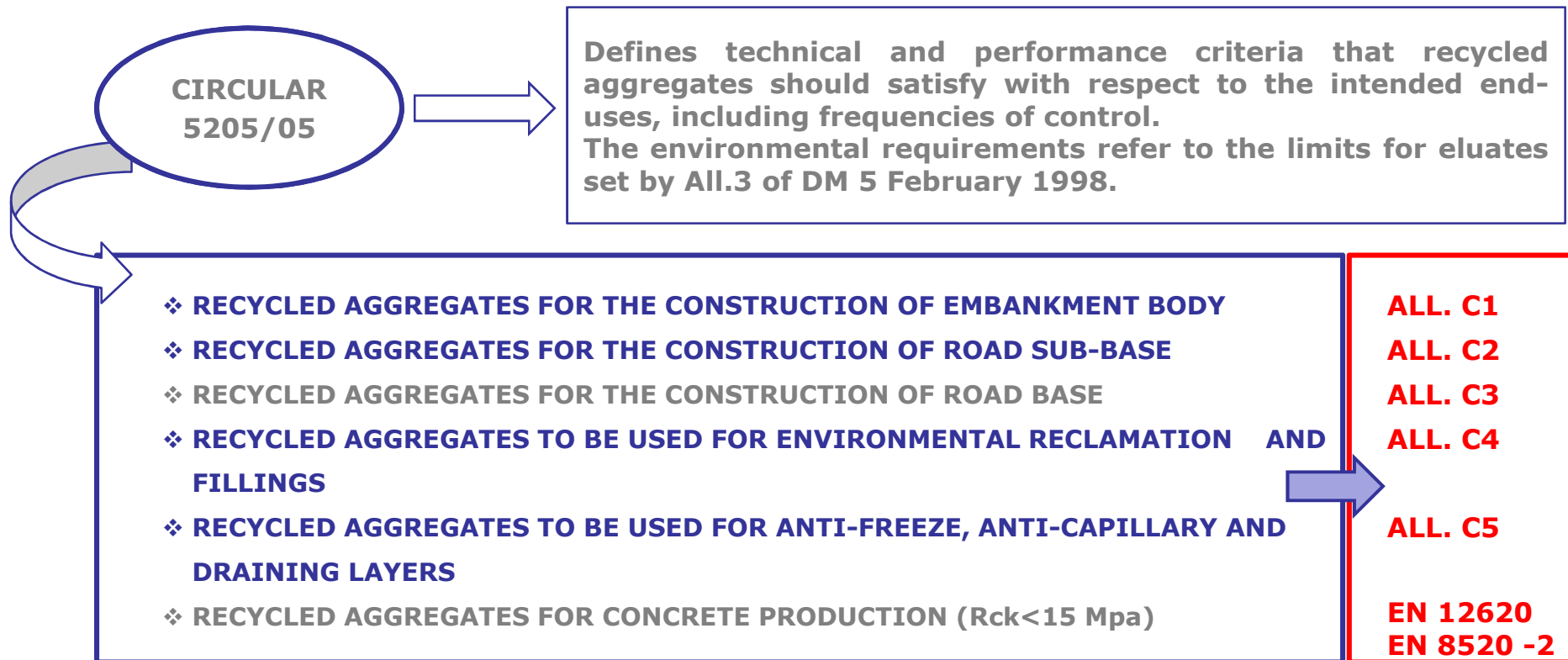
EN 13383-1 Armourstone - Part 1: Specification, Part 2: Test Methods

EN 13450 Aggregates for railway ballast

**ALL RECYCLED AGGREGATES PRODUCED BY THE ANALYSED PLANTS HAVE THE CE MARKING**

## Substitution of natural aggregates: quality of recycled aggregates

### ITALIAN LEGAL FRAMEWORK FOR THE UTILIZATION OF RECYCLED AGGREGATES IN THE CIVIL SECTOR



**ALL RECYCLED AGGREGATES PRODUCED BY THE ANALYSED PLANTS COMPLY WITH THE REQUIREMENTS SET BY THE ITALIAN MINISTERIAL CIRCULAR 5205/2005**

### **Substitution of natural aggregates:** market of recycled aggregates

- **the regional market for recycled aggregates is highly unstable and strictly connected to large civil works (e.g. EXPO 2015, highways, ..)**
- **the low cost of natural virgin materials (4-5 €/t), due to the low taxation and lack of restrictions of quarry activities in Lombardy region, is one of the key factors limiting the market of recycled aggregates**
- **there is still diffidence in potential users towards technical characteristics and performances of recycled aggregates due to their origin**
- **the lack in public tenders of the option of using recycled aggregates is nowadays a constraining factor for their utilization**
- **the lack of specific “end of waste” criteria for CDW is one of the reasons for making recycled aggregates less competitive compared to natural aggregates**

**LCA should take into account this situation**

“replacement coefficient”: it quantifies the amount of primary material that can be replaced by the waste-derived material at a certain point (i.e. the point of substitution) of the recycling chain

It can be calculated in two different ways:

- 1) Replacement coefficient =  $A * B$
- 2) Replacement coefficient =  $C$

With

A = coefficient that takes into the quality of the waste-derived material compared to quality of the primary material. This coefficient represents to what extent the inherent properties of the material are kept in recycling activities

B = coefficient that takes into account the existence of a market for the waste-derived material, i.e. it is 0 if there is no market, it is e.g. 0.5 if only 50% of the waste-derived material has a market, it is 1 if all the material is used in the market

C = market-price ratio of the secondary material to the superseded primary material (Schrijvers et al., 2016b)

**Paper under preparation!**

**CIRCULAR 5205/2005: TECHNICAL REQUIREMENTS FOR RECYCLED AGGREGATES FOR DIFFERENT END-USES**

	<b>C3 ROAD BASE</b>	<b>C4 ENVIRONMENTAL RECLAMATION AND FILLINGS</b>
LITHIC MATERIAL OF ANY ORIGIN (FRACTION > 8 mm)	> 90% BY MASS	> 70% BY MASS
GLASS AND VITREOUS SLAG	≤ 5 %	≤ 15 %
ASPHALT	≤ 5 %	≤ 25 %
OTHER MINERAL WASTES	≤ 5 % FOR EACH TYPE	≤ 15 % IN TOTAL AND < 5% FOR EACH TYPE
PERISHABLE MATERIALS (WOOD, PAPERS, ..)	≤ 0.1 %	≤ 0.1 %
OTHER MATERIALS (METALS, RUBBER..)	≤ 0.4 %	≤ 0.6 %
PASSING 63 mm SIEVE (EN 933-1)	-	85 - 100%
PASSING 40 mm SIEVE (EN 933-1)	100%	-
PASSING 20 mm SIEVE (EN 933-1)	≥ 61 % AND ≤ 79 %	-
PASSING 10 mm SIEVE (EN 933-1)	≥ 41 % AND ≤ 64 %	-
PASSING 4 mm SIEVE (EN 933-1)	≥ 31 % AND ≤ 49 %	-
PASSING 2 mm SIEVE (EN 933-1)	≥ 22 % AND ≤ 36 %	-
PASSING 1 mm SIEVE (EN 933-1)	≥ 13 % AND ≤ 30 %	-
PASSING 0.5 mm SIEVE (EN 933-1)	≥ 10 % AND ≤ 20 %	-
PASSING 0.063 mm SIEVE (EN 933-1)	≤ 10 %	≤ 15 %
RATIO BETWEEN PASSING 0.5 mm AND PASSING 0.063 mm	> 3/2	NR
MAXIMUM PARTICLE DIMENSION (EN 933-1)	40 mm	NR
SAND EQUIVALENT (EN 933-8)	> 30	NR
SHAPE INDEX (COARSE FRACTION)	≤ 40	NR
FLAKINESS INDEX (COARSE FRACTION)	≤ 35	NR
LOS ANGELES COEFFICIENT	≤ 30	NR
ECOCOMPATIBILITY (eluate)	ALL. 3 DM 5 February 1998	ALL. 3 DM 5 February 1998

NR=NOT REQUIRED

**COEFFICIENT A ?**

**MORE RESTRICTIVE**      **LESS RESTRICTIVE**

**COEFFICIENT B:**  
sent a questionnaire to all the recycling plants: it includes the question "how much of the produced recycled aggregates did you sell?"

**COEFFICIENT C:**  
Market price of recycled aggregates: 0-3 euro  
Market price of natural aggregates: 5-6 euro



- **The mineral CDW are mainly directed to recycling facilities and only a limited amount is landfilled (< 4%)**
- **Recycling plants produce aggregates mainly used as sub-base materials in road construction or for environmental reclamation and fillings**
- **All produced recycled aggregates in the visited plants comply with the requirements set by the Italian Ministerial Circular 5205/2005 for the intended end-uses and have the CE marking**
- **The regional market for recycled aggregates is highly unstable and strictly connected to large civil works**
- **The substitution of natural materials should be modelled by taking into account not only the quantity of recycled aggregates but also their quality and the actual market → replacement coefficient**



## ACKNOWLEDGEMENT

THE PRESENTED RESEARCH PROJECT WAS FINANCIALLY SUPPORTED BY THE LOMBARDY REGION GOVERNMENT.  
SPECIAL THANKS TO ARPA LOMBARDIA FOR TECHNICAL SUPPORT AND TO ALL CDW RECYCLING PLANT OPERATORS FOR PROVIDING US USEFUL DATA AND INFORMATION.

# THANK YOU FOR YOUR ATTENTION

### CONTACTS

[lucia.rigamonti@polimi.it](mailto:lucia.rigamonti@polimi.it)  
[sara.pantini@polimi.it](mailto:sara.pantini@polimi.it)





## 3<sup>rd</sup> MatER Meeting

### Innovation and Trends in Waste Management

May 22nd - 23rd, 2017  
Politecnico di Milano, Campus PIACENZA

*May 22<sup>nd</sup>, 2017*

- Introduction
- Session 1: Strategies and perceptions on waste management  
Key-note speakers:
  - *Raffaello Cossu, Università degli Studi di Padova (Italy)*
  - *Paul Davison, Proteus Environmental Communications (UK)*
- Session 2: Closing the loop: potentials and critical issues  
Key-note speaker:
  - *Costas Velis, University of Leeds (UK)*
- Poster Session

*May 23<sup>rd</sup>, 2017*

- Session 3: Processes and technologies for energy recovery  
Key-note speaker:
  - *Franz Neubacher, UVP Environmental Management and Engineering (Austria)*
- Poster Session
- Session 4: Processes and technologies for material recovery  
Key-note speaker:
  - *Daniel Boeni, Managing Director WTE plant of KEZO, Hinwil (Switzerland)*

MatER Study Center organises its 3<sup>rd</sup> Meeting on Innovation and Trends in Waste Management. The event arises from the fundamental goal of MatER, that is providing a thorough, objective representation of technologies and policies for material and energy recovery from waste, thereby contributing to move toward sustainable waste management. The Meeting aims at being an update on latest trends in Sustainable Waste Management, dealing with regulatory, strategic and technical-scientific aspects. The event is organised with the scientific support of DICA (Department of Civil and Environmental Engineering) and Energy Department of Politecnico di Milano.

**Call-for-abstract**

Call-for-abstract is open from **May 30<sup>th</sup>, 2016** to **November 30<sup>th</sup>, 2016**.  
Languages accepted are **Italian** and **English**.  
Submitted abstracts will be evaluated according to their innovation and scientific value and will be selected for presentation as **oral communications** or **posters**.  
The authors of a number of leading abstracts will be invited to extend the abstract into a full paper that will be peer-reviewed for publication on "**Waste Management & Research**" or "**Ingegneria dell'Ambiente**", according to the language of the paper.  
For further information, visit the web site [www.mater.polimi.it](http://www.mater.polimi.it).