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

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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

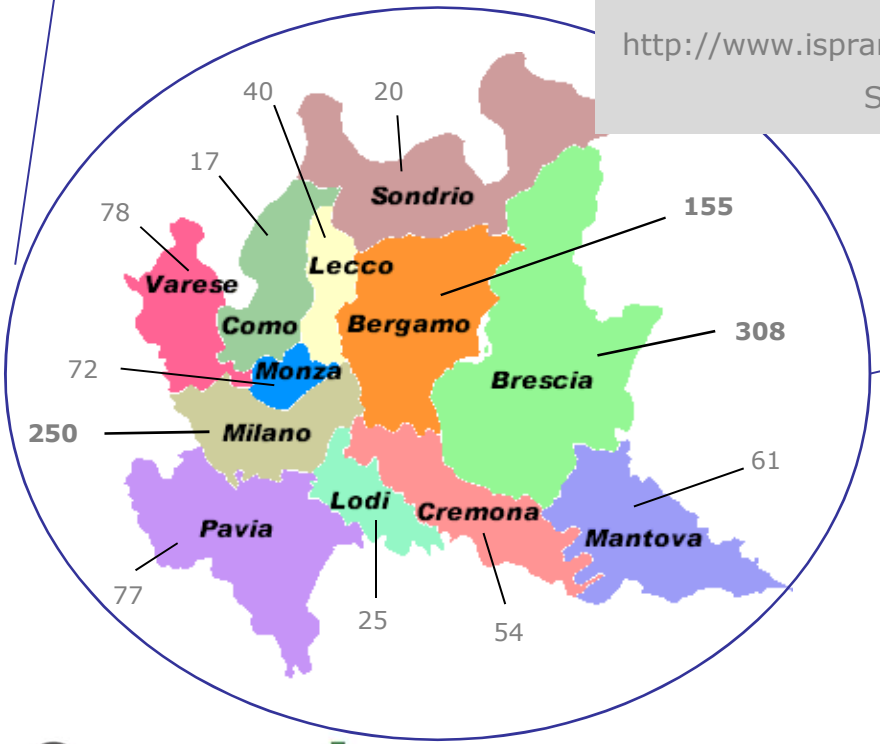
AREA: 23.844 km^2
POPULATION: 10 MILION (1/6 ITALIAN POPULATION)
GROSS DOMESTIC PRODUCT (GDP): 22% ITALY'S GDP
ADMINISTRATIVE DIVISIONS:
12 PROVINCES, 1 METROPOLITAN CITY (MILANO), 1530 COMMUNES

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/RapportoRifiutiSpeciali_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

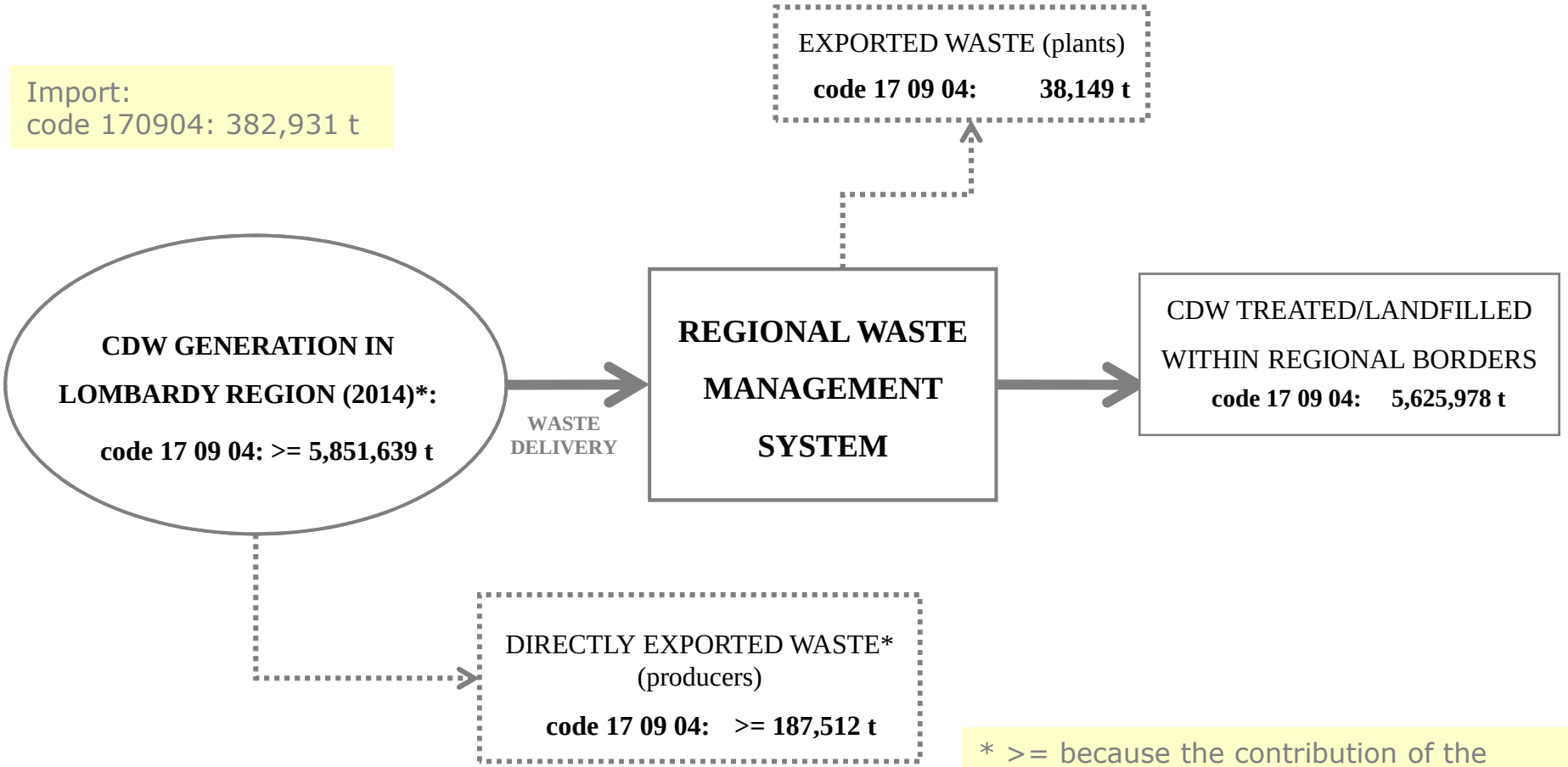
NON-HAZARDOUS CDW INCLUDED IN THE STUDY:

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)

PRELIMINARY RESULTS OF STEP 1: CDW FLOWS

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



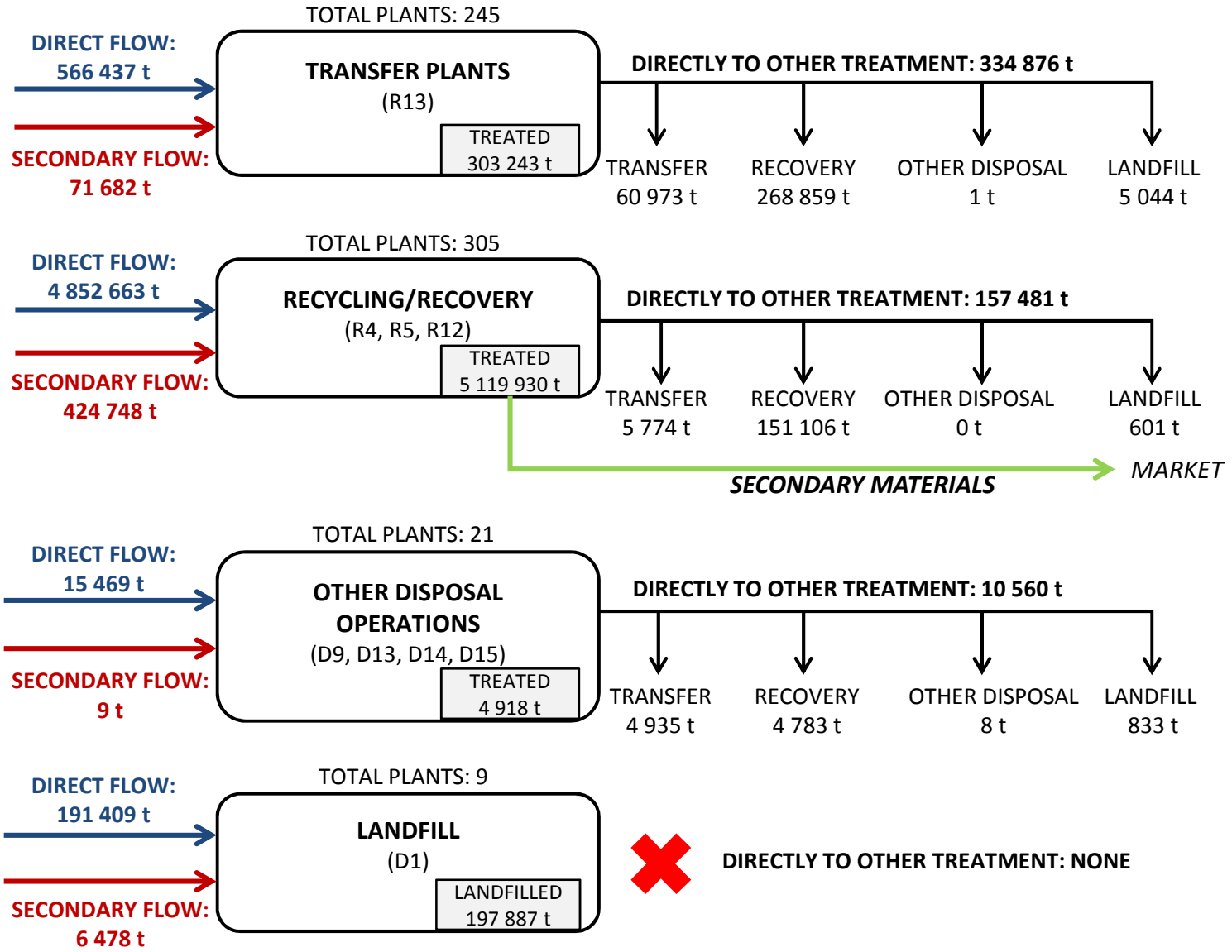
* >= because the contribution of the producers not obliged to fill in the MUD is not included (as not quantifiable)

PRELIMINARY RESULTS OF STEP 1: CDW FLOWS

code 17 09 04: 5,625,978 t

Treatment:

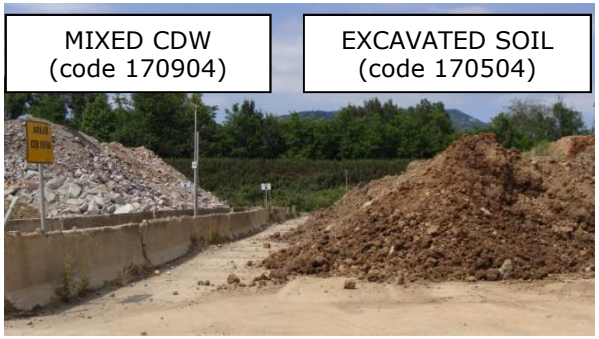
- 91.0 % RECYCLING/ RECOVERY
- 5.4% TRANSFER STATIONS
- 3.5% LANDFILL
- 0.1% OTHER DISPOSAL OPERATIONS



MOBILE TREATMENT PLANT – TYPE B

RECEIVED WASTE

MIXED CDW
(code 170904)



EXCAVATED SOIL
(code 170504)

LARGE BLOCKS
(code 170904)

MOBILE PLANT (TYPE B)

ALL-IN RECYCLED AGGREGATES (0/63)

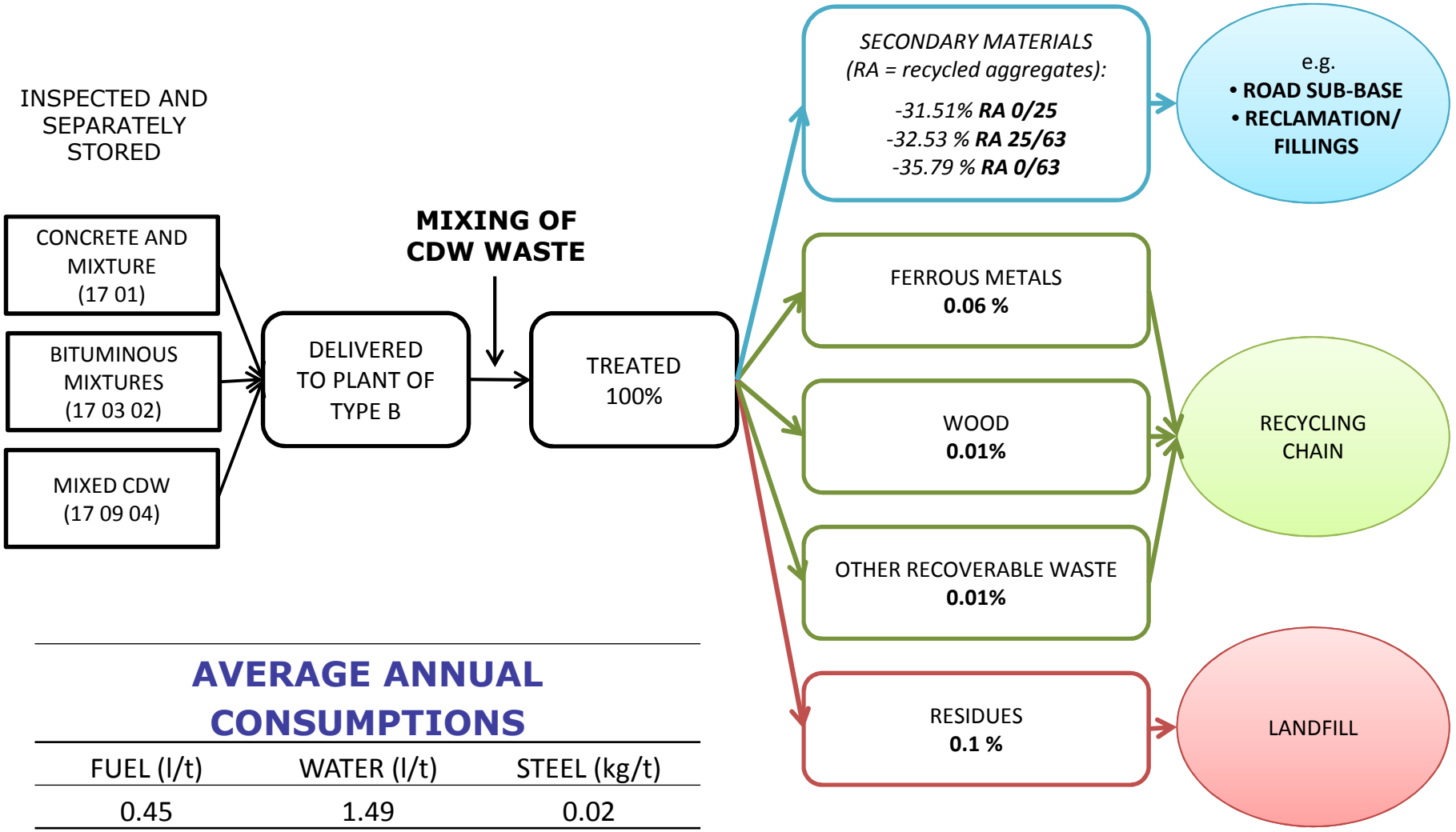
SEPARATED MATERIALS

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

LCA STUDY STEP 3: CLOSING THE LOOP

STEP 3: MODELLING THE SUBSTITUTION OF VIRGIN RAW MATERIALS

RAW MATERIALS EXTRACTION

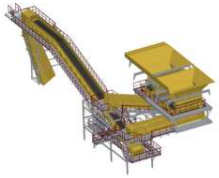
PRODUCTS MANUFACTURING

ON SITE CONSTRUCTION

OPERATION/ MANTAINANCE

DEMOLITION

CDW RECYCLING/ RECOVERY



USE OF RECYCLED PRODUCTS IN THE CONSTRUCTION SECTOR IN SUBSTITUTION OR IN MIX WITH NATURAL RESOURCES

LOST OF VALUABLE RESOURCES

LANDFILL DISPOSAL

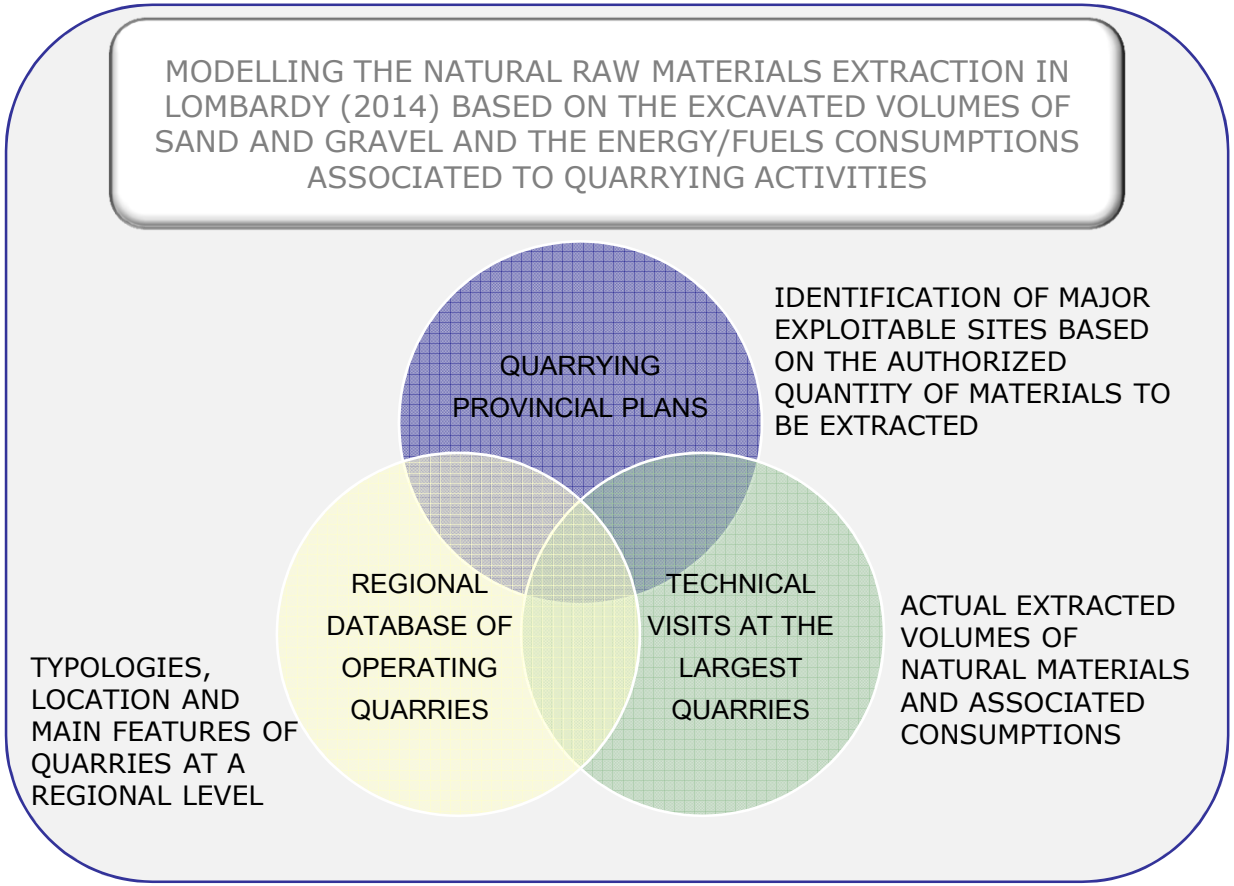
CLOSING THE LOOP OF NATURAL MINERAL RESOURCES THROUGH SUSTAINABLE WASTE MANAGEMENT AND EFFICIENT CDW RECYCLING

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

REGULATION EU n° 305/2011	*Harmonised conditions for the marketing of construction products (repealing Council Directive 89/106/EEC)* **CE MARKING**

"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

CIRCULAR 5205/05

Defines technical and performance criteria that recycled aggregates should satisfy with respect to the intended end-uses, including frequencies of control.
The environmental requirements refer to the limits for eluates set by All.3 of DM 5 February 1998.

❖ RECYCLED AGGREGATES FOR THE CONSTRUCTION OF EMBANKMENT BODY	ALL. C1
❖ RECYCLED AGGREGATES FOR THE CONSTRUCTION OF ROAD SUB-BASE	ALL. C2
❖ RECYCLED AGGREGATES FOR THE CONSTRUCTION OF ROAD BASE	ALL. C3
❖ RECYCLED AGGREGATES TO BE USED FOR ENVIRONMENTAL RECLAMATION AND FILLINGS	ALL. C4
❖ RECYCLED AGGREGATES TO BE USED FOR ANTI-FREEZE, ANTI-CAPILLARY AND DRAINING LAYERS	ALL. C5
❖ RECYCLED AGGREGATES FOR CONCRETE PRODUCTION (Rck<15 Mpa)	EN 12620 EN 8520 -2

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

STEP 3: MODELLING THE SUBSTITUTION OF NATURAL AGGREGATES

"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

	C3 ROAD BASE	C4 ENVIRONMENTAL RECLAMATION AND FILLINGS
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

MORE RESTRICTIVE

LESS RESTRICTIVE

COEFFICIENT A ?

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

CONCLUSIONS

- 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

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THANK YOU FOR YOUR ATTENTION

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LEAP
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POLITECNICO
MILANO 1863
3rd MatER Meeting
Innovation and Trends in Waste Management
May 22nd - 23rd, 2017
Politecnico di Milano, Campus PIACENZA
May 22nd, 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 23rd, 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 3rd 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
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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.
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