WORKSHOP: EPD, THE CURRENT DEBATE AND CHALLENGES
BRUSSELS, 10 DECEMBER 2015

END OF LIFE – MODULE C AND D

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OVERVIEW PRESENTATION

- Introduction LCA and module D
- Important concepts
- Modelling module D
- Building case study
- PEF approach recycling
- Discussion and conclusions

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INTRODUCTION EOL AND MODULE D

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INTRODUCTION | EUROPEAN INITIATIVES

Different European initiatives

- Construction products regulation
  - BWR 3 Hygiene, health and the environment
  - BWR 7 Sustainable use of natural resources
- Resource efficiency opportunities in building sector COM(2014) 445
  - Focus on resource use and reduction of environmental impact of buildings
- Closing the loop - An EU action plan for the Circular Economy COM(2015) 614/2
  - Ecodesign focusing on issues such as reparability, durability, upgradability, recyclability, or the identification of certain materials or substances
- Product environmental footprint (PEF)
  - Stimulating the use of “green” products by a harmonised communication
  - LCA methodology (not construction specific)
- ISO TC59 / SC17 : Sustainability in building construction
  - Environmental declaration of building products and environmental performance of buildings
- CEN TC 350 : Sustainability of construction works
  - European framework standardisation LCA

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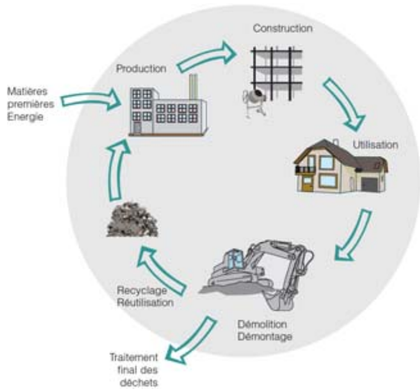
INTRODUCTION | **CONTEXT CEN TC 350**

Life Cycle Assessment of buildings and construction products

- **EN 15804:2012+A1** – Environmental product declarations – core rules for the product category of construction products
- **EN 15978:2012** – Assessment of environmental performance of buildings – Calculation method



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INTRODUCTION | **LIFE CYCLE STAGES**

Framework EN 15804 / EN 15978

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INTRODUCTION | **END OF LIFE**

End-of-life stage in EN15804/15978

- Starts when construction product is replaced, dismantled or deconstructed
- Includes
  - De-construction, demolition (C1)
  - Transport to waste processing (C2)
  - Waste processing for reuse, recovery and/or recycling (C3)
  - Disposal (C4)
- System boundary when reaching the end-of-waste state

  → See further

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INTRODUCTION | **MODULE D**

Module D in EN 15804 / EN 15978

= environmental **loads and benefits** **beyond** the buildings life cycle resulting from…

- recycling of materials
- reuse of products
- (recovery of) energy leaving the product system

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INTRODUCTION | **MODULE D**

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Module D in EN 15804 / EN 15978

= environmental **loads and benefits beyond** the buildings life cycle resulting from…

- recycling of materials
- reuse of products
- (recovery of) energy leaving the product system

loads → impacts related to recycling process or incineration

benefits → avoided impacts related to avoided production of primary materials or energy

- optional ? → « potential »

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INTRODUCTION | **MODULE D**

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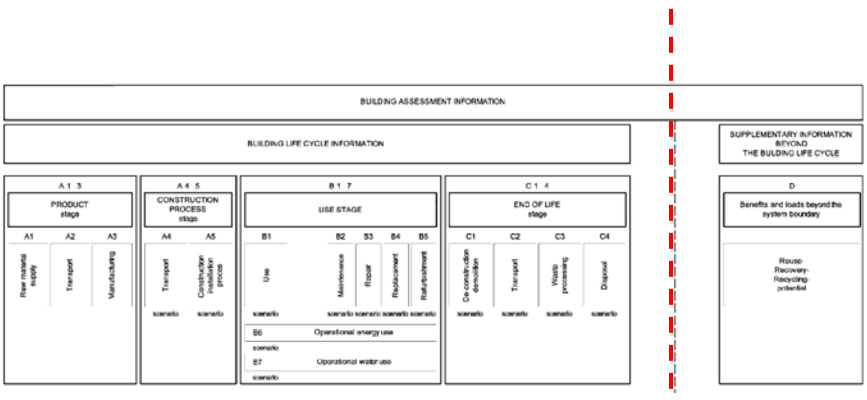
Module D in EN 15804 / EN 15978

= environmental **loads and benefits beyond** the buildings life cycle resulting from…

- recycling of materials
- reuse of products
- (recovery of) energy leaving the product system

beyond → after the end-of-waste point (system boundary)



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IMPORTANT CONCEPTS

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IMPORTANT CONCEPTS | **SYSTEM BOUNDARY**

End-of-waste state > Based on EU Waste Framework directive

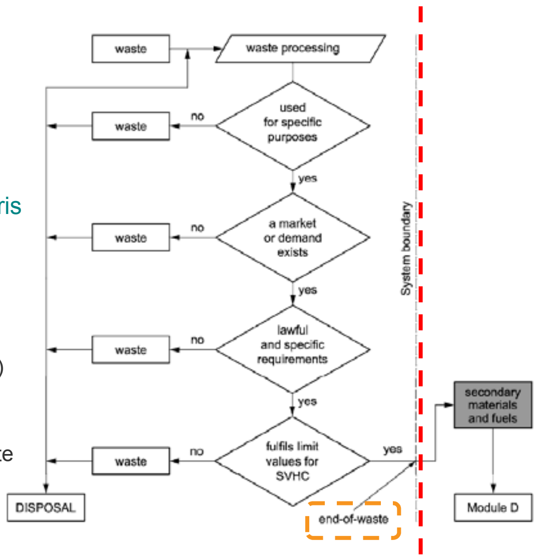
Not always easy to define

Example: reuse of construction debris coming from concrete

Crushing

a. No specific purposes (yet)
> **module C3** (waste processing)

b. specific purposes (e.g. secondary granulates for concrete or mortar)
> **module D** (pre-recycling)



According to **EU waste framework directive** (2012)

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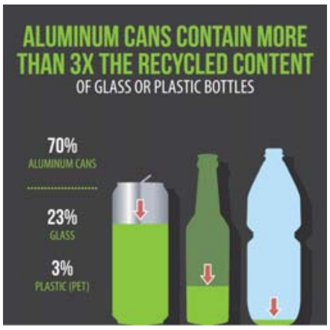
IMPORTANT CONCEPTS | **RECYCLING**

Recycled Content (RC) versus Recycling Rate (RR)

- RC = secondary materials used on input side → production phase
- RR = output used for recycling → EOL phase



Retrieved from www.aluminum.org (The Aluminum Association)

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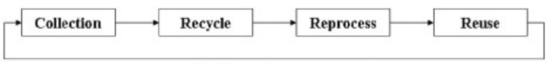
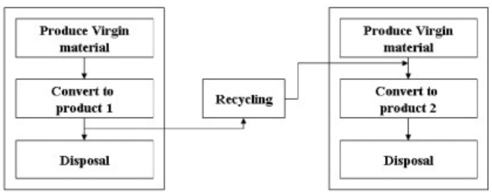
IMPORTANT CONCEPTS | **RECYCLING**

Closed loop versus Open loop recycling



(a) Closed-loop recycling



(b) Open-loop recycling

Image courtesy: Ho Ha, Materials&Design 2012

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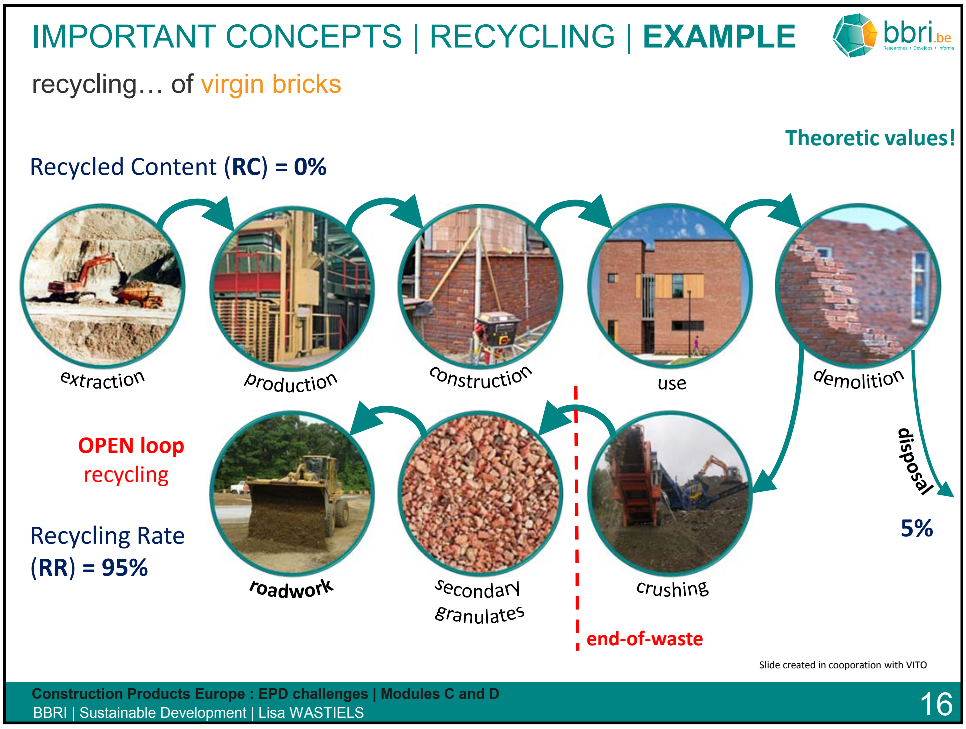
IMPORTANT CONCEPTS | RECYCLING | EXAMPLE
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recycling… of virgin bricks
Theoretic values!
Recycled Content (RC) = 0%
extraction
production
construction
use
demolition
disposal
5%
OPEN loop
recycling
Recycling Rate
(RR) = 95%
roadwork
secondary
granulates
crushing
end-of-waste
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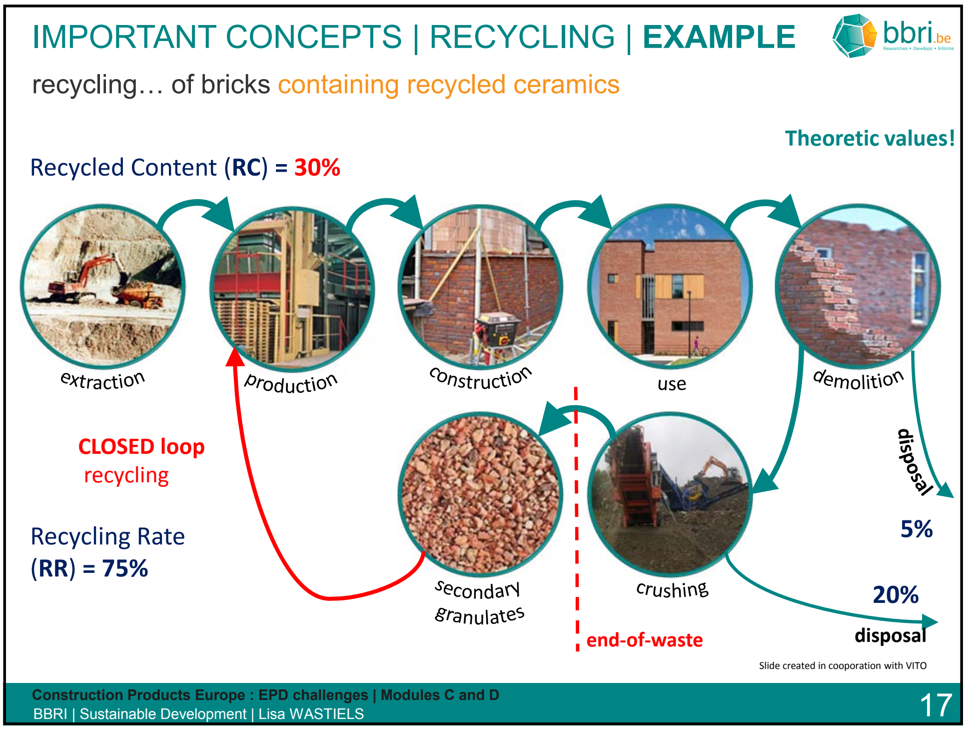
IMPORTANT CONCEPTS | RECYCLING | EXAMPLE
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recycling… of bricks containing recycled ceramics
Theoretic values!
Recycled Content (RC) = 30%
extraction
production
construction
use
demolition
disposal
5%
CLOSED loop
recycling
Recycling Rate
(RR) = 75%
secondary
granulates
crushing
20%
disposal
end-of-waste
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IMPORTANT CONCEPTS | **ALLOCATION**

100:0 allocation (within system boundary) – **Recycled Content Approach**

- Secondary materials and fuels in the production phase of the product system are considered
- Waste processing during any module of the product system included within the system boundary

Module D (beyond system boundary) – **optional** (Avoided Impact Approach)

= **net environmental benefits or loads** resulting from the reuse, recycling and energy recovery related to their net output flow

- ADDING impacts related to the recycling or recovery process from beyond the system boundary – up to the functional equivalence
- SUBTRACTING impacts resulting from the avoided production from primary resources
- Applying a justified value-correction factor to reflect the differences in functional equivalence

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MODELLING MODULE D

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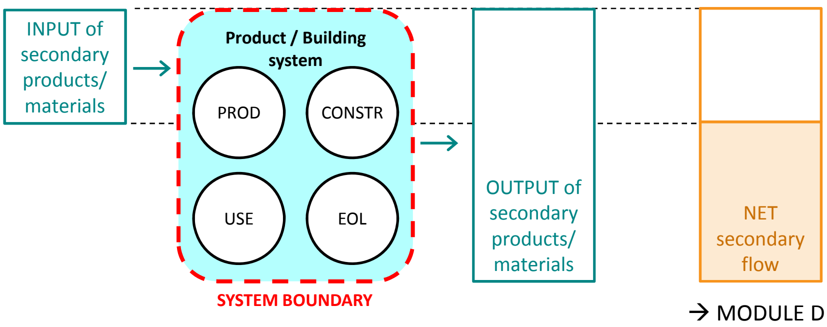
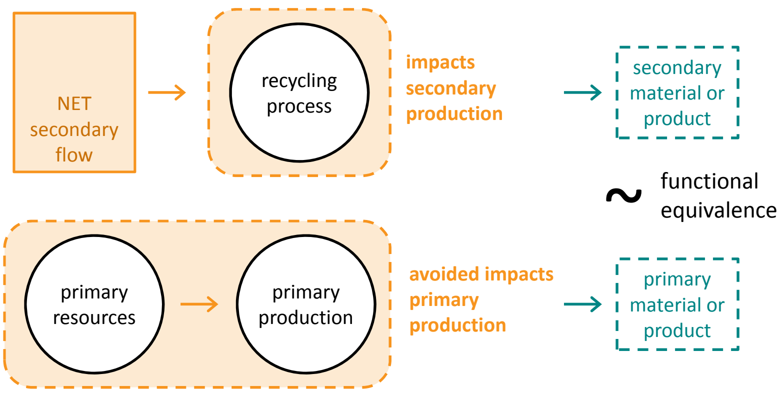
MODELLING MODULE D | **GENERAL PRINCIPLES**

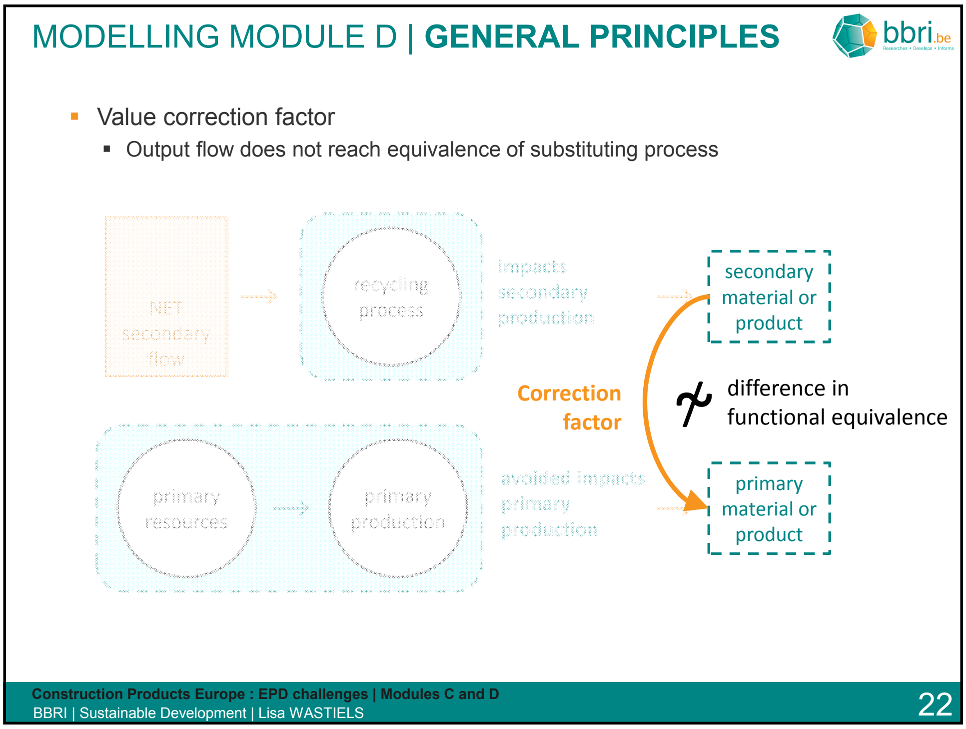
- Net output flow = output flow – input flow



MODELLING MODULE D | **GENERAL PRINCIPLES**

- Module D = impacts recycling process – impacts of substituted process
- Substituted process based on « functional equivalence »




MODELLING MODULE D | GENERAL PRINCIPLES
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Value correction factor
Output flow does not reach equivalence of substituting process
NET secondary flow
recycling process
impacts secondary production
secondary material or product
Correction factor
difference in functional equivalence
primary resources
primary production
avoided impacts primary production
primary material or product
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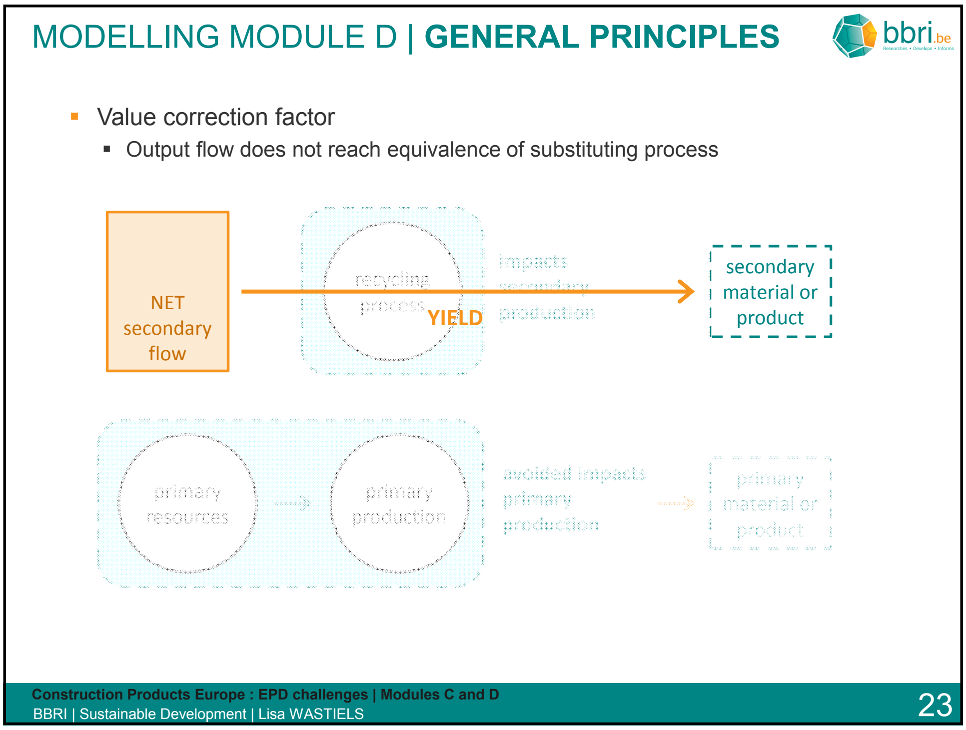
MODELLING MODULE D | GENERAL PRINCIPLES
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Value correction factor
Output flow does not reach equivalence of substituting process
NET secondary flow
recycling process
YIELD
impacts secondary production
secondary material or product
primary resources
primary production
avoided impacts primary production
primary material or product
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MODELLING MODULE D | **COMPLEXITY**

Functional equivalence

- "secondary material […] can be declared as substituting primary production […] when it has reached functional equivalence of the substituted primary material"

→ cannot always be defined unambiguously

Difficulty

- Recycling potential not always clear
  - which material is it substituting?
- Possibility of different recycling routes
  - e.g. recycling of glass
    → used for production of float glass
    → used for production of glass wool insulation
- Possibility of different substituting materials
  - e.g. secondary concrete aggregates for roadworks
    → substituting: river aggregates
    → substituting: aggregates crushed at local mine

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MODELLING MODULE D | **COMPLEXITY**

Strong insights in primary and secondary production processes needed

- Yield
  - e.g. 1kg steel scrap produces less than 1kg secondary steel
- Value correction factor
  - E.g. secondary plastic can only be used in lower grade applications (downcycling)
- Theoretical primary production process
  - e.g. glass cullets are used for production of primary float glass
  - e.g. steel scrap is used in "primary" production of steel
- Impact of « recycling process » (e.g. transport, grinding,…)

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Building Case Study

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Wastiels, L., Van Dessel, J., & Delem, L. (2013). **Relevance of the recycling potential (module D) in building LCA : A case study on the retrofitting of a house in Seraing.**
In *Proceedings of SB13, Sustainable Building Conference, Graz, September 25-28* (pp. 955–964). Graz.
Best Paper Award.
In *Proceedings of SB14, Sustainable Building Conference, Barcelona, October 28-30*. Barcelona. (Fast track Best paper SB13)

Wastiels, L., Delem, L., & Van Dessel, J. (2013). **To module D or not to module D? The relevance and difficulties of considering the recycling potential in building LCA.**
In *Proceedings of LCA Conference 2013, avniR, Lille, November 4-5*. Lille.

Building Case Study

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CASE STUDY | **INTRODUCTION**

Module D

- Not often included in building LCA
- Argued to be important for metals
- What is impact for other building materials?

Relevance of including module D in building LCA ?

- Impact compared to other life cycle stages
- Discussion of module D impact

→ Case study analysis

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CASE STUDY | **INTRODUCTION**

Existing building

- multi-family house
- 4 storeys
- Main composition:
  - Brick walls
  - Sloped roof with ceramic tiles

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CASE STUDY | **INTRODUCTION**

Building renovation with steel roof

- Main structure of existing walls and floors
- Insulated from inside (system wall, mineral wool, gypsum boards)
- Aluminium windows and doors
- Interior walls (system wall, min wool, gypsum boards)
- Steel roof structure and steel roof covering

CASE STUDY | **METHODOLOGY LCA**

Life cycle assessment at building level

- Cradle-to-grave
- Including module D

Methodology

- Principles ISO 14040, EN15804, EN 15978
- Software Simapro, **Ecoinvent v2.2**
- Impact method: **ReCiPe Endpoint** / Hierarchist

- RSL of **60 years**
- Including replacement for SL < RSL
- Excluding technical installations

- EOL scenarios based on Belgian average (current)

CASE STUDY | **METHODOLOGY LCA**

System boundaries

- Materials to recycling: system boundary at gate of sorting plant
- Waste incineration:
  - Loads within the system boundaries
  - No potential benefits from energy production (lack of data + small fraction of materials)
- Module D:
  - Recycling potential of materials
  - Exported energy generated by PV panels
  - No energy recovery (see above)

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CASE STUDY | **METHODOLOGY LCA**

Scenario's recycling potential

Material to be recycled	Secondary material
Steel	Secondary steel (closed loop)
Concrete, screed, …	Secondary aggregates for roadwork (open loop)
Concrete blocks, bricks, facing tiles, …	Secondary aggregates for roadwork (open loop)
Untreated sawn timber, wooden boards, parquet …	Wood chips (open loop)
Interior plaster (crushed with concrete granulates)	Secondary aggregates for roadwork (open loop)
Facing tiles, ceramic wall and floor tiles, …	Secondary aggregates for roadwork (open loop)
PE-foil, vapour barrier, …	Secondary PE aggregates (open loop)
Gypsum plaster board	Gypsum plaster (open loop)
Aluminium in window frames	Secondary aluminium (closed loop)
Glass	Glass cullets (closed loop)

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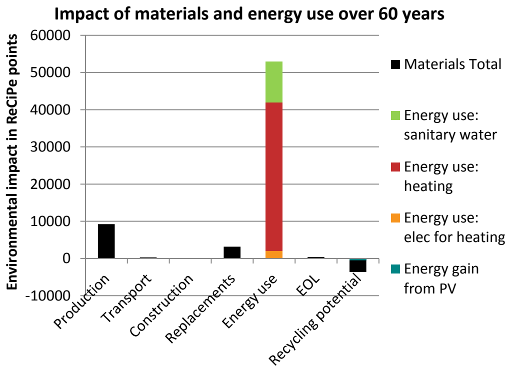
CASE STUDY | **RESULTS TOTAL BUILDING**

Total impact per life cycle stage

- Largest impact in use phase

! impacts energy use will be lower for **passive/NZE** buildings



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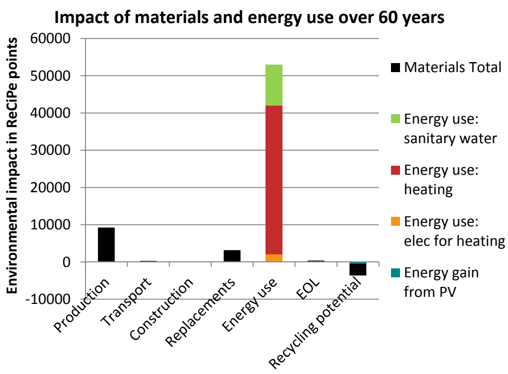
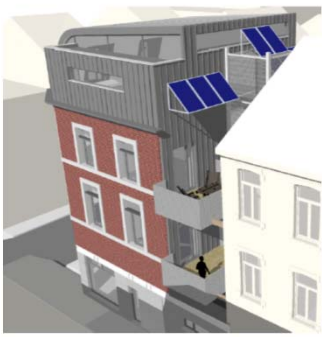
CASE STUDY | **RESULTS TOTAL BUILDING**

Module D in total building

- order of magnitude of replacements
- module D > construction phase and EOL phase

! Case with large amount of **metals**





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CASE STUDY | RESULTS BUILDING ELEMENTS

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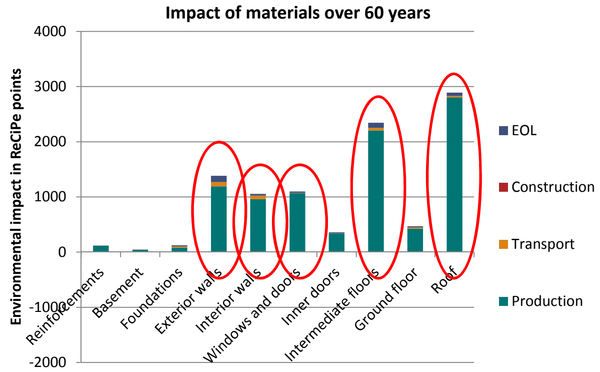
Production, installation and EOL

- Roof : low-alloyed steel (66%)
- Intermediate floors : parquet used for finishing layer (43%), OSB (14%), …
- Exterior walls : concrete block walls (19%), facing bricks (18%), mineral wool (10%), PUR rigid foam board (10%), steel (8%)…
- Interior walls : ceramic wall tiles (35%), steel beams (28%), gypsum board (17%), …
- Windows : aluminium frames (78%), …

! Agricultural land use



CASE STUDY | RESULTS BUILDING ELEMENTS

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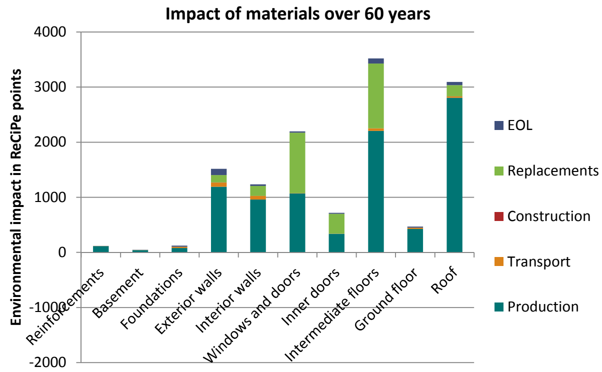
Replacements

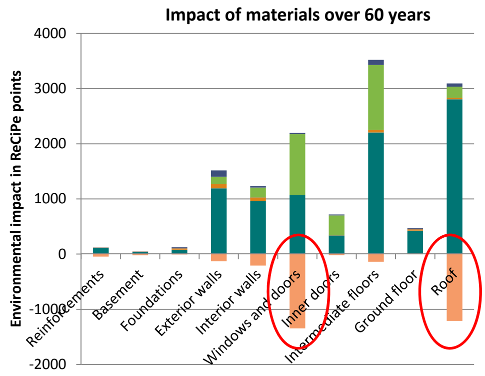
- Windows
- Intermediate floors

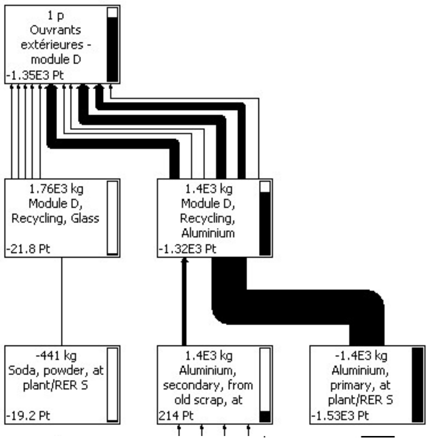


CASE STUDY | **RESULTS BUILDING ELEMENTS**

Module D

- Steel roof → 98% related to steel
- Aluminium windows → 98% related to aluminium (despite RR of 70% for glass panes)





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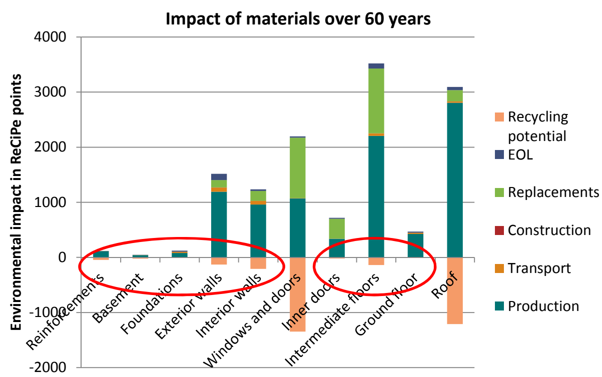
CASE STUDY | **RESULTS BUILDING ELEMENTS**

Module D

- SMALL for other building elements
  - Low recyclability or recycling practice (e.g. mineral wool, gypsum board)
  - Low environmental benefits related to recycling (e.g. concrete, bricks)

! **Renovation** case with existing floors and walls

High recycling rate ≠ high module D impact
→ Module D does not tell the whole recycling story



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CASE STUDY | **HYPOTHESIS NEW CONSTRUCTION**

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What if ?

- Higher impact production
- Higher impact transport and EOL → « heavy » materials
- Module D:
  - Concrete blocks RR = 95%, but…
  - only small difference at building level

→ Module D impacts strongly related to use of metals

! HYP case with new **floors** and **walls**

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PEF EoL APPROACH

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PEF EOL APPROACH | **ALLOCATION OPTIONS**

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3 types of allocation BP X30-323 *(environmental communication:France)*

- 100:0 **Recycled content approach**
  - 100% of the impacts and benefits to producers using recycled materials
  - Incentive to producers to incorporate recycled materials in their products to drive the market
  - Market inbalance: Deposit of secondary material not sufficiently exploited
- 0:100 **Avoided impact approach**
  - 100% of the impacts and benefits to producers producing a recycled product
  - Incentive to producers to make recyclable product to drive the market
  - Market inbalance: Secondary material not sufficiently available to meet demand
- 50:50 **Impacts and benefits divided equally**
  - Market balanced
  - Market inbalance: Secondary material is required but can cause some additional technical constraints

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PEF EOL APPROACH | **EOL FORMULA**

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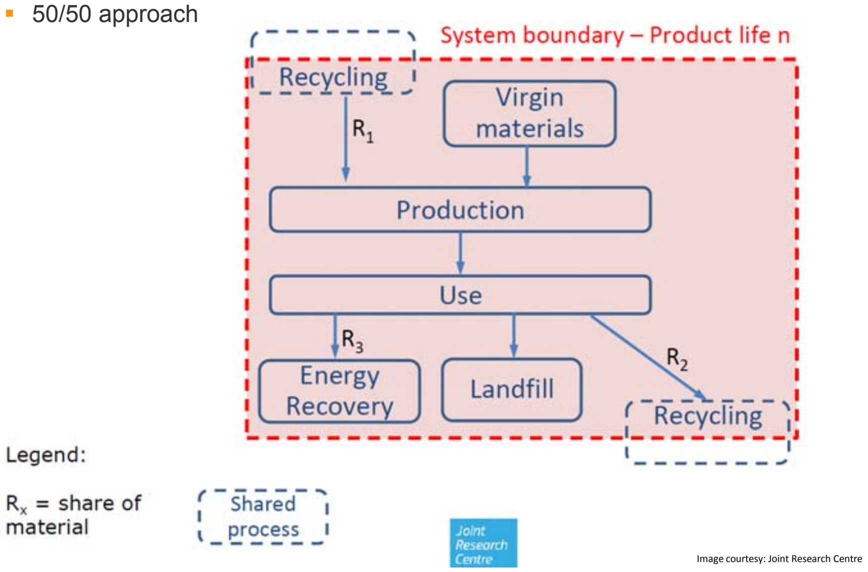
Annex V: Dealing with multi-functionality in recycling situations

- 50/50 approach



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PEF EOL APPROACH | **EOL FORMULA**

Annex V: Dealing with multi-functionality in recycling situations

- 50/50 approach
- Baseline PEF EoL formula

$$\left(1-\frac{R_1}{2}\right)\times E_V+\frac{R_1}{2}\times E_{recycled}+\frac{R_2}{2}\times\left(E_{recyclingEoL}-E^*_V\times\frac{Q_S}{Q_P}\right)+R_3\times\left(E_{ER}-LHV\times X_{ER,heat}\times E_{SE,heat}-LHV\times X_{ER,elec}\times E_{SE,elec}\right)+\left(1-\frac{R_2}{2}-R_3\right)E_D-\frac{R_1}{2}\times E^*_D$$

virgin + recycled content | recyclability | recoverability | disposal

$= VIRG_{IN} + REC_{IN} + REC_{OUT} + ER_{OUT} + DISP_{OUT}$

PEF EOL APPROACH | **EOL FORMULA**

Annex V: Dealing with multi-functionality in recycling situations

- 50/50 approach
- Baseline PEF EoL formula
- Alternative formulas

1) $$\left(1-\frac{R_1}{2}\right)\times E_V+\frac{R_1}{2}\times E_{recycled}+\frac{R_2}{2}\times\left(E_{recyclingEoL}-E^*_V\times\frac{Q_S}{Q_P}\right)+\frac{R_3}{2}\times\left(E_{ER}-LHV\times X_{ER,heat}\times E_{SE,heat}-LHV\times X_{ER,elec}\times E_{SE,elec}\right)+\left(1-\frac{R_2}{2}-\frac{R_3}{2}\right)E_D-\frac{R_1}{2}\times E^*_D$$

$= VIRG_{IN} + REC_{IN} + REC_{OUT} + ER_{OUT} + DISP_{OUT}$

2) 100:0 approach (e.g. EN 15804:2012)

$$EF=(1-R_1)\times E_V+R_1\times E_{recycled}+R_3\times\left(E_{ER}-LHV\times X_{ER,heat}\times E_{SE,heat}-LHV\times X_{ER,elec}\times E_{SE,elec}\right)+(1-R_2-R_3)\times E_D$$

$= VIRG_{IN} + REC_{IN} + ER_{OUT} + DISP_{OUT}$ (~~REC_{OUT}~~)

3) 0:100 approach (e.g. BPX 30-323-0 for open loop system recycling if the raw materials market is in disequilibrium):

$$EF=E_V+R_2\times\left(E_{recyclingEoL}-E^*_V\times\frac{Q_S}{Q_P}\right)+R_3\times\left(E_{ER}-LHV\times X_{ER,heat}\times E_{SE,heat}-LHV\times X_{ER,elec}\times E_{SE,elec}\right)+(1-R_2-R_3)\times E_D$$

$= VIRG_{IN} + REC_{OUT} + ER_{OUT} + DISP_{OUT}$ (~~REC_{IN}~~)

PEF EOL APPROACH | **EOL FORMULA**

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Annex V: Dealing with multi-functionality in recycling situations

- 50/50 approach
- Baseline PEF EoL formula
- Alternative formulas
  - Currently being investigated in the different pilots

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CONCLUSIONS AND DISCUSSION

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CONCLUSIONS AND DISCUSSION

Module D in building LCA

- Consideration of module D can be significant in building LCA
- For case study:
  - Module D > transportation phase, EOL
- BUT…
- In this case, potential benefits strongly related to use of metals
- Further study is needed (e.g. benefits from energy recovery or export)
- High recycling rate ≠ high module D impact

→ does not necessarily tell something about recycling potential

- Market supply and demand

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CONCLUSIONS AND DISCUSSION

Points of attention in calculating module D

- End of waste point
- Functional equivalence
- Data availability production process

→ Construction product manufacturer is in best position to provide information

- More complex in case of open loop recycling
- Context of circular economy, "design of EoL stage"

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CONCLUSIONS AND DISCUSSION

Methodological issues

- Different allocation methods
  - recycled content approach 100:0
  - avoided impact approach 0:100
  - 50:50 approach
- Recycled content
  - Polluter pays principle
  - Current practice
  - No benefits from recycling potential
- Avoided impact
  - Impacts for virgin production
  - “Potential for recycling” – consider long building life time!

  → Dangerous assumption because direct implications of primary production are compensated over recycling cycle

→ Results from PEF pilots to be awaited + Need for more practical examples

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QUESTIONS ?

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