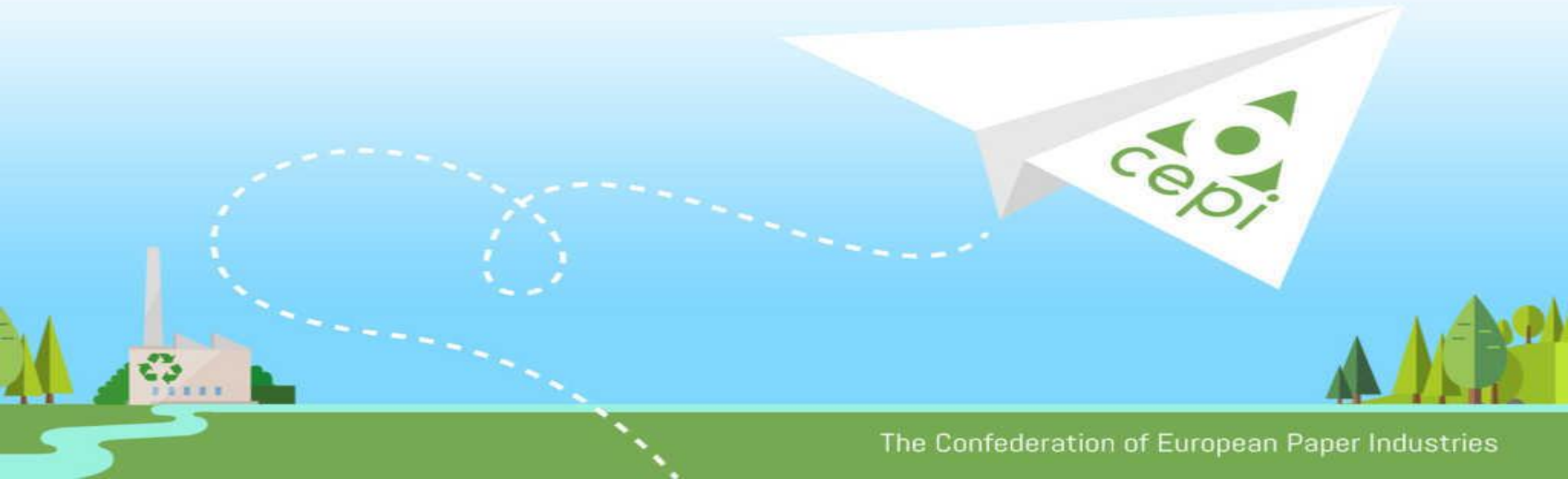


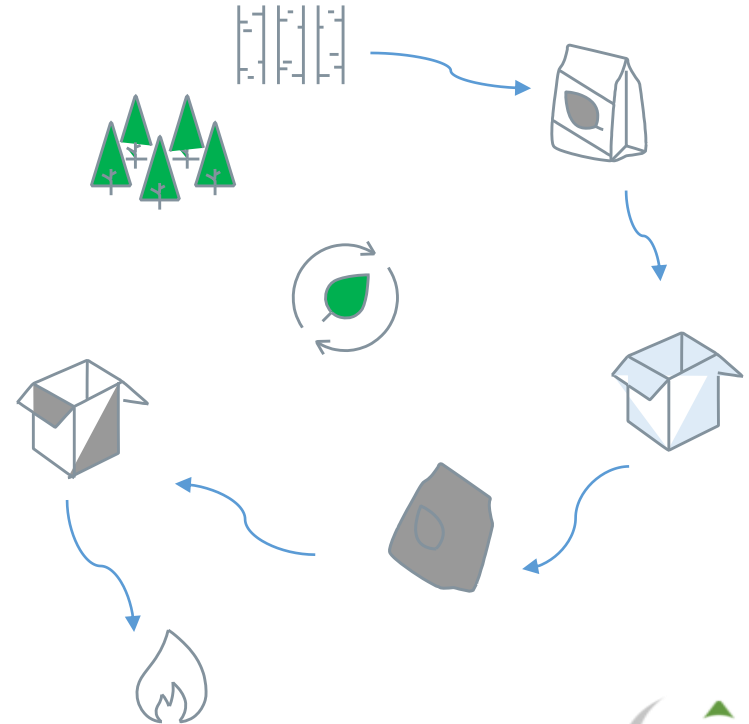
Refining the environmental impact of fibre-based products in circular economy

Ulrich Leberle, Catharina Hohenthal, CEPI
Ulla Forsström, VTT

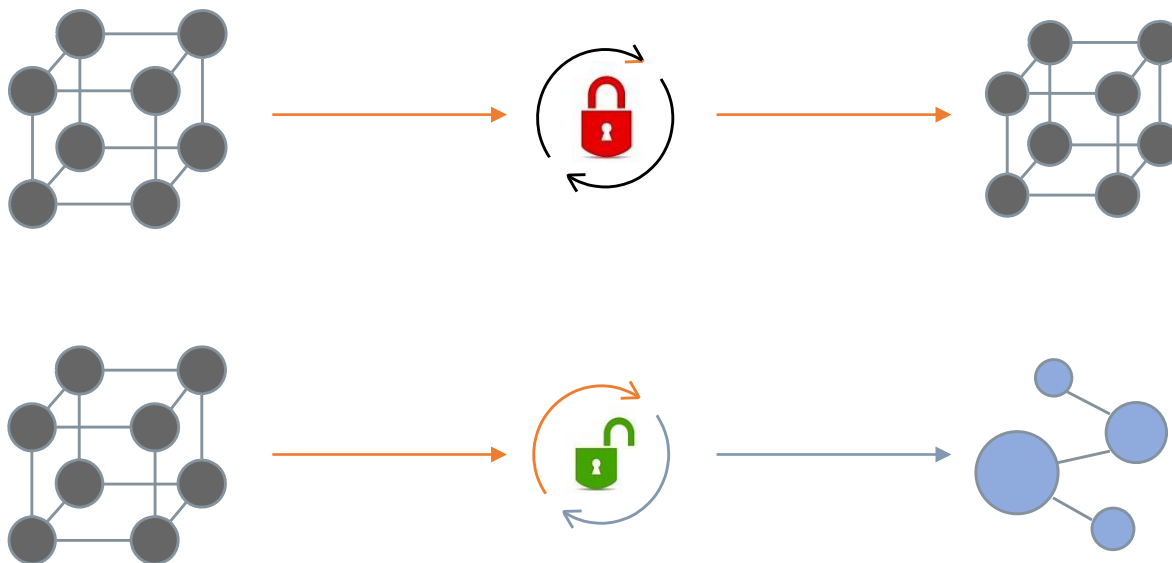


Background – what's the problem?

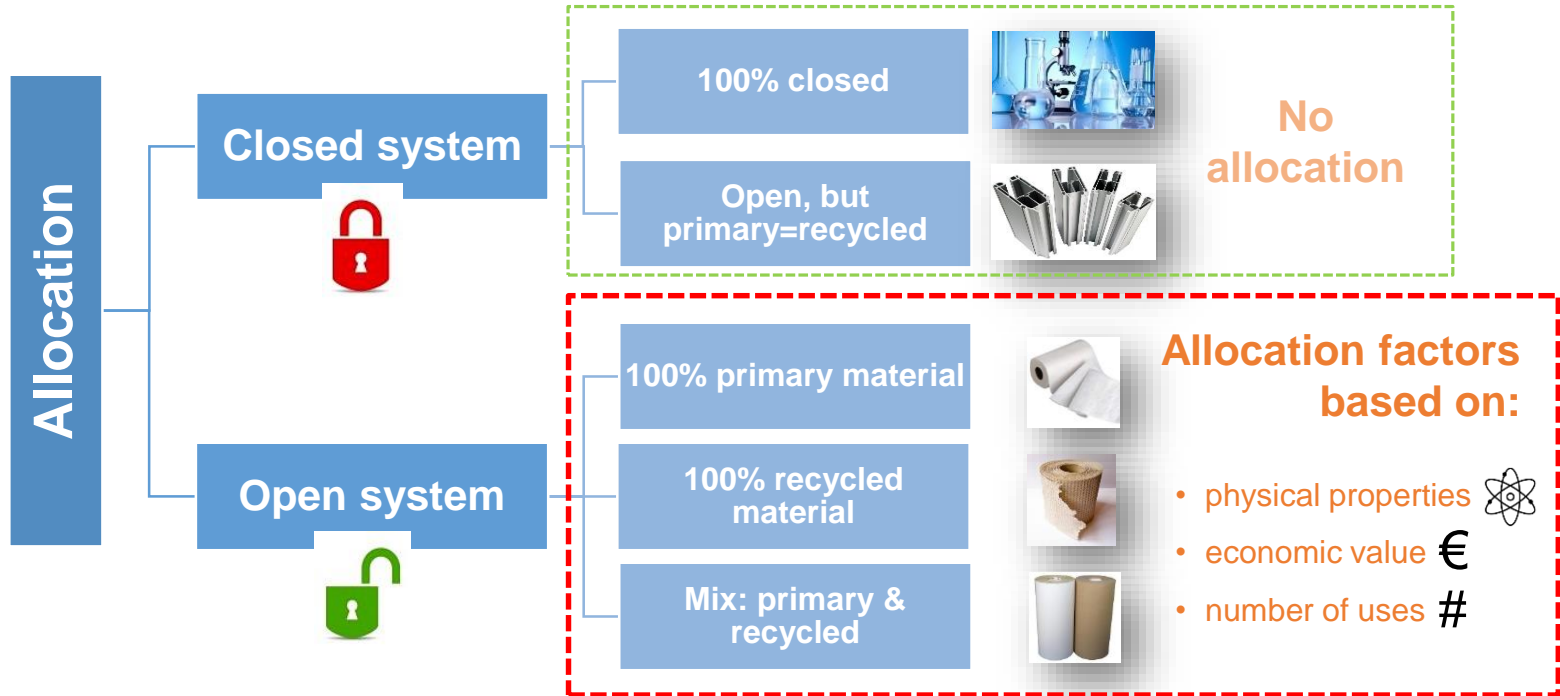
- When paper and packaging product fibres are used more than once and recycled back to the same product or as a raw material for another product, the environmental impacts of the production of the virgin pulp has to be allocated to several products.
- To how many products and in what way the allocation is made has been a question for a long time.



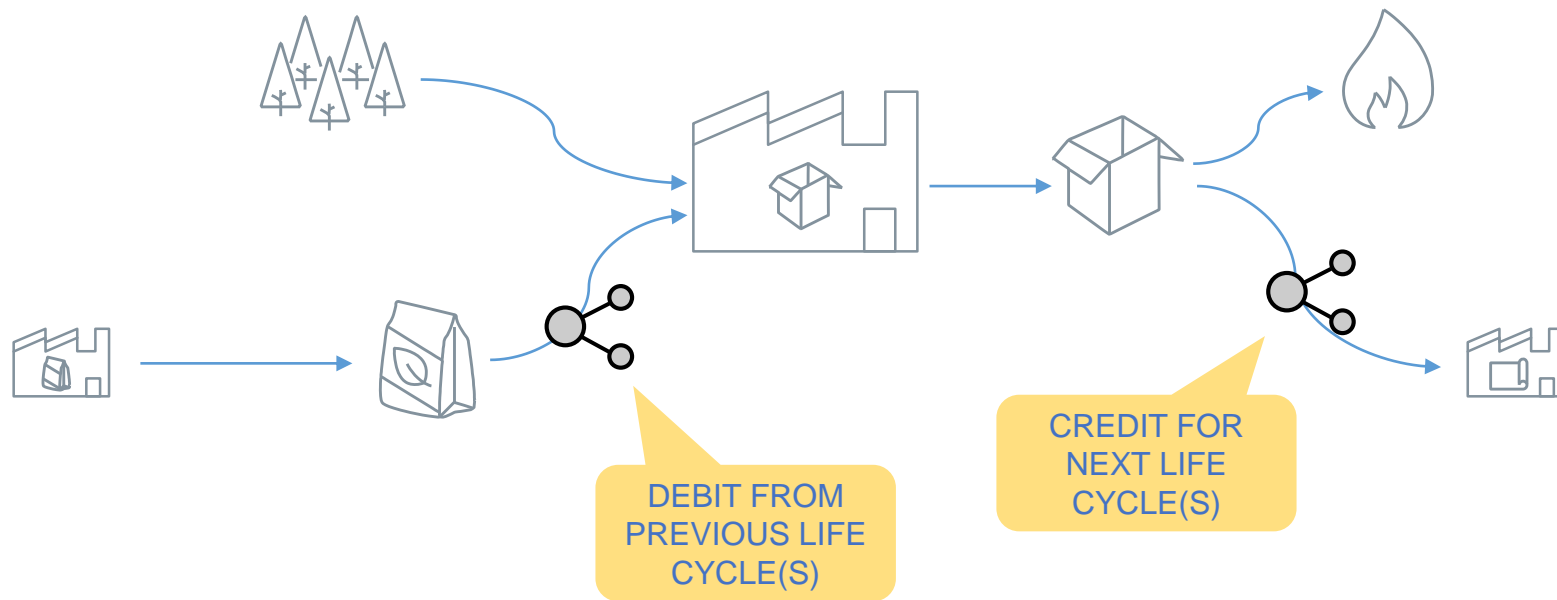
Recycling differs



Allocation also differs

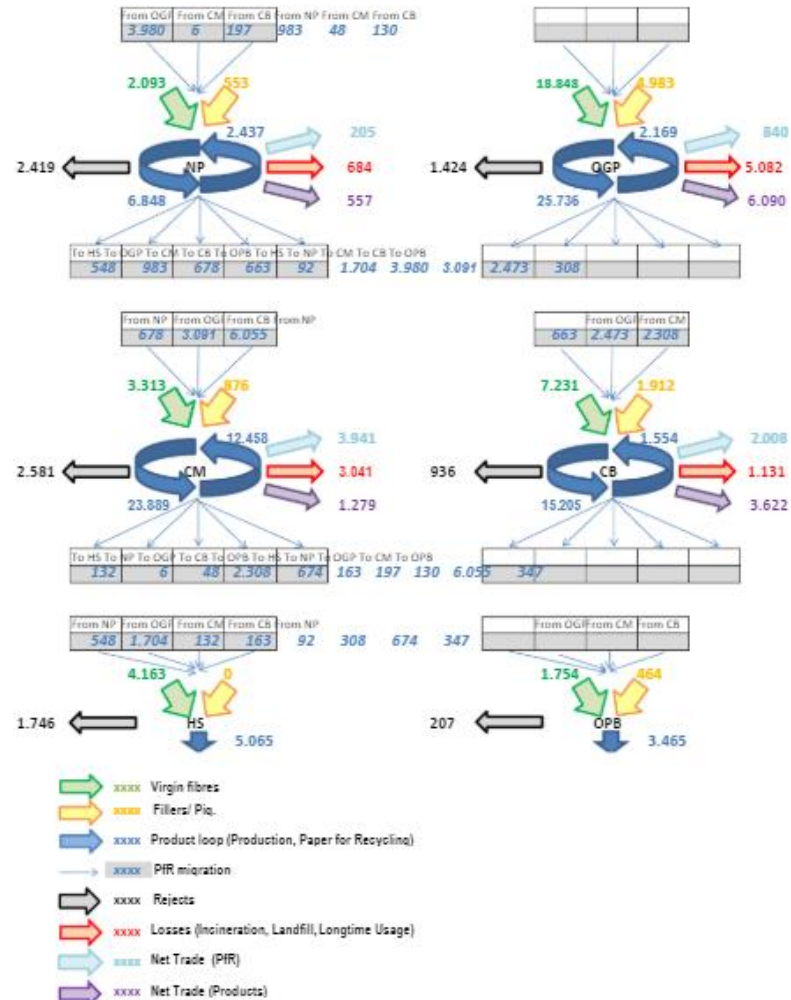


Recycling in paper industry



Fibre flow model - Mass balance for the whole CEPI area

NP- News paper
OGP- Other graphic paper
CM- Case materials
CB- Carton board



Allocation rules currently applied to fibre-based products



- The available methods include allocation factors that need to be defined based on vague criteria and assumptions – **Different assumptions – different results!**



- The Reffibre method has an answer for the paper and board products, due to the fibre flow model and real statistical data – **No Assumptions – unified calculations!**

Allocation method proposed in REFFIBRE EU project

Based on ISO 14067 allocation formula

$$E_M = E_V + E_{EoL} - R \cdot A \cdot E_V \longrightarrow$$

- 100% primary raw materials
- A allocation factor =?

Allocation method proposed in REFFIBRE EU project

Based on ISO 14067 allocation formula

$$E_M = E_V + E_{EoL} - R \cdot A \cdot E_V \longrightarrow$$

- 100% primary raw materials
- A allocation factor =?

$$E_T = E_V \cdot A_i \cdot C + E_{PP} \cdot C + E_V \cdot (1 - C) + E_{PM} + E_{EoL} - R \cdot A_o \cdot E_V$$

allocation from
previous cycles

impact from processing
recycled materials

recycled content

impact from
papermaking process

allocation to
next cycles

Calculation of allocation factors

MFA=1
MNU=5

Prod. 1

$A_i = 5/5 = 1$
 $A_o = 4/5 = 0.8$

MFA=2
MNU=4

Prod. 2

$A_i = 4/5 = 0.8$
 $A_o = 3/5 = 0.6$

MFA=3
MNU=3

Prod. 3

$A_i = 3/5 = 0.6$
 $A_o = 2/5 = 0.4$

MFA=4
MNU=2

Prod. 4

$A_i = 2/5 = 0.4$
 $A_o = 1/5 = 0.2$

MFA=5
MNU=1

Prod. 5

$A_i = 1/5 = 0.2$
 $A_o = 0/5 = 0$

$$A_i = \frac{MNU}{MFA + MNU - 1}$$

$$A_o = \frac{MNU - 1}{MFA + MNU - 1}$$

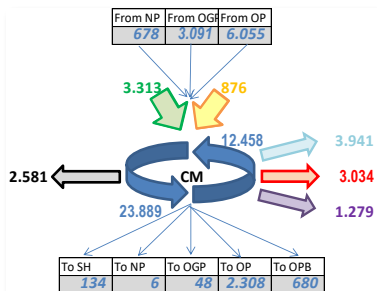
as the fibres get older (MFA ↑),
the allocation to the recycled
fibres entering the system
decreases (A_i ↓)

as less future uses are expected (MNU ↓),
the allocation to the recycled fibres
leaving the system decreases (A_o ↓)

the allocation factor of the recycled
material leaving the system at one
cycle will be the allocation factor of
the recycled material entering the
system at the next cycle
 $A_o(X) = A_i(X+1)$

Allocation factors calculated for Europe using the Fibre flow model

Meinl G. et al. 2016
 Deliverable D1.4.
 European Fibre Flow Model.

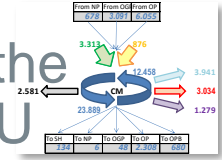


Catharina Hohenthal et al. The ISO 14067 approach to open-loop recycling of paper products: making it operational. Approved in Journal of Cleaner Production.

Product	MFA	MNU	A_i	A_o
Newsprint (NP)	2.01	2.12	0.68	0.36
Other graphic papers (OGP)	1.13	1.82	0.93	0.42
Case Materials (CM)	3.03	2.28	0.53	0.23
Carton Board & Other Packaging (OP)	1.86	2.05	0.70	0.36

Conclusions

- 1) The proposed REFFIBRE allocation method is based on the Fibre flow model, which accounts for paper recycling in EU




- 2) Based on the model, the allocation factors for fibre-based inputs and outputs can be calculated, thus reflecting the real life situation

A_i	A_o
0.68	0.36
0.93	0.42
0.53	0.23
0.70	0.36

- 3) The allocation factors could be used in the equation initially proposed in ISO 14067 and modified according to the needs of paper industry as to account for both recycled and to be recycled fibres.

$$E_T = E_V \cdot A_i \cdot C + E_{PP} \cdot C + E_V \cdot (1 - C) + E_{PM} + E_{EoL} - R \cdot A_o \cdot E_V$$

What next?

- Testing the allocation factors for circular economy cases with real data from Paper industries continues with committed partners 
- Model material flows for other industrial areas based on production and recycling statistics, e.g. metal, glass, and plastic industries....
 - enabling the calculation of the allocation factors for different industries.
- Make allocation formulas operational by calculating the allocation factors based on reliable statistics for several industrial areas.
- Could be yearly up-dated to include new allocation factors for different industrial areas with increased recycling/reuse.



Thank You!

Acknowledgements

www.reffibre.eu

The research has been conducted in close collaboration between ITENE, VTT, PTS, and CEPI in the framework of the Reffibre Project. The research received funding from the EU Seventh Framework Programme under the grant agreement n° 604187.