

# Potential of life cycle thinking tools for sustainability evaluation of the circular economy



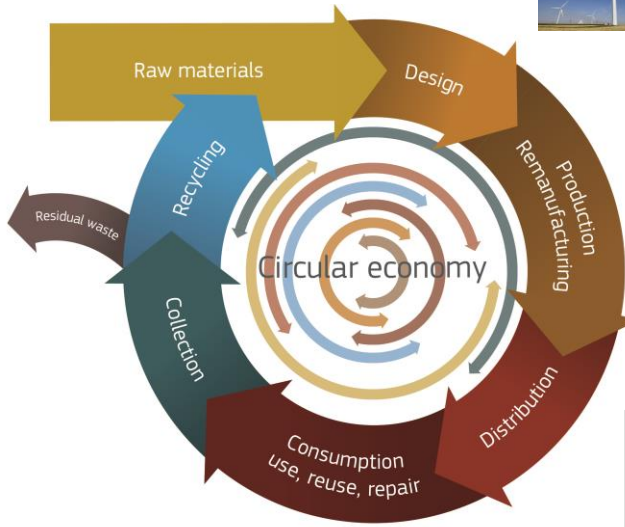
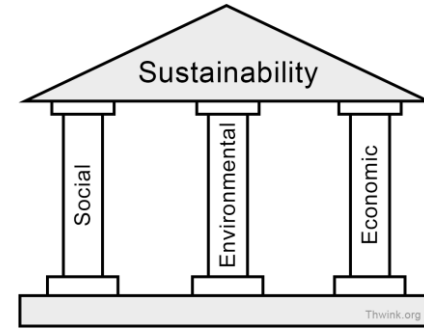


# Starting point

Renewability



Reuse, Repair, Recycle

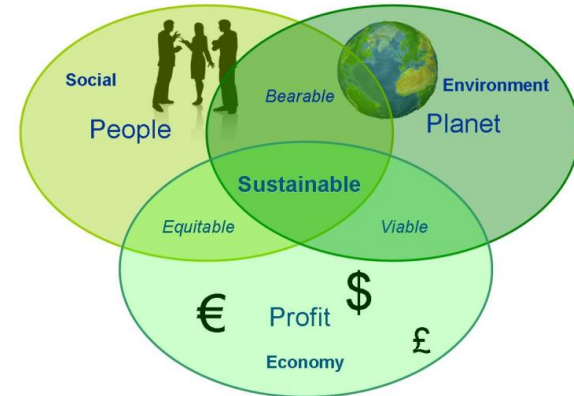
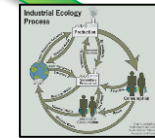


Functional Economy

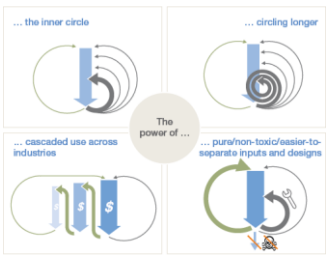
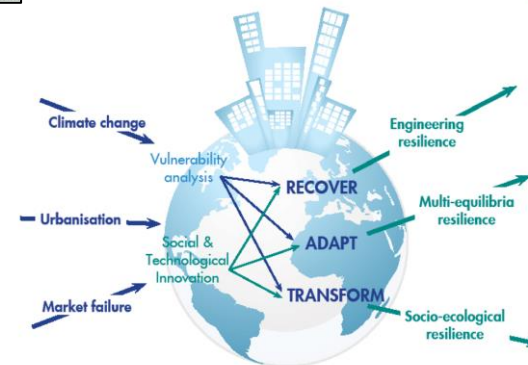
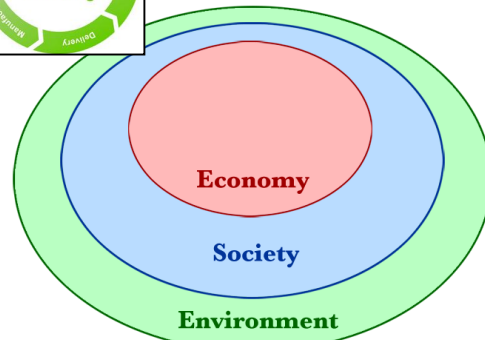
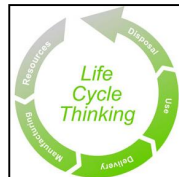
Depollution

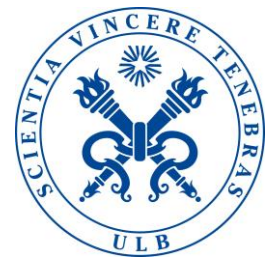


Industrial Ecology/Symbiosis

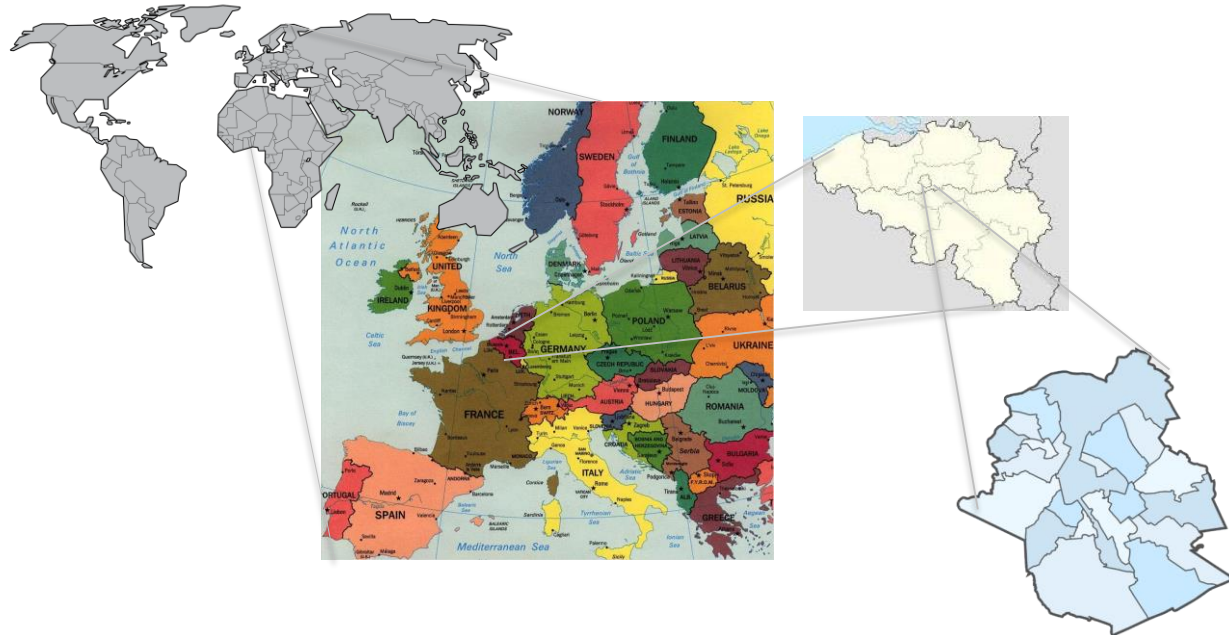
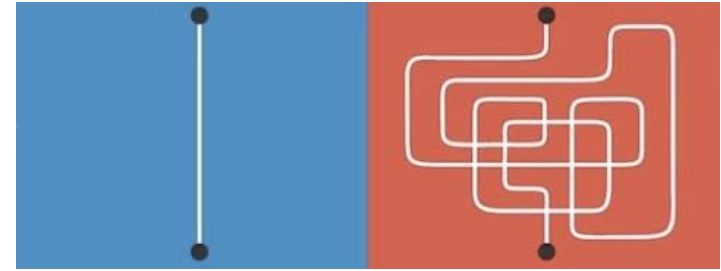


Eco Design





# Challenges in sustainability measurement





# Need for measurement?

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**Circularity performance**  
(resource use, resource loss, renewability)

**Differentiation**

**Sustainability performance**  
(econ, envi, soc)



**Management**



**Trade-offs**



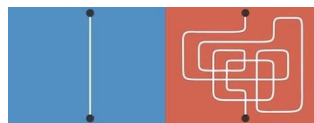
**Improvement**



**Impact displacement**

**Optimisation**

**Direct and Indirect impacts**



**Decision support**

<b>Materials</b>	<b>Produits</b>	<b>Organisations</b>	<b>System</b>
<b>Micro</b>		<b>Meso</b>	<b>Macro</b>



# Circularity indicator initiatives (non exhaustive)

## MACRO

- National circular economy indicator system in China (by Geng et al. 2012, J Cleaner Prod)
- Zero Waste index (by Zaman & Lehmann 2013 J Cleaner Prod)

## MESO

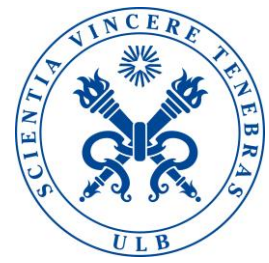
- LCA-based Eco-costs Value Ratio (by Scheepens et al. 2016 J Cleaner Prod)
- Resource Productivity indicator (M/SFA based) (by Wen & Meng 2015, J Cleaner Prod.)

## MICRO

- Material Circularity Indicator (MCI) (by Ellen MacArthur Foundation & Granata 2015)
- Circular Economy Indicator Prototype (CEIP) (by Cayzer et al. 2017)
- Circular Economy Toolkit (CET) (by Evans & Bocken 2017)
- Circular Economy Index (by Di Maio & Rem 2015, J Env Protection)
- Circularity assessment (by Circle Economy & PGGM 2014)



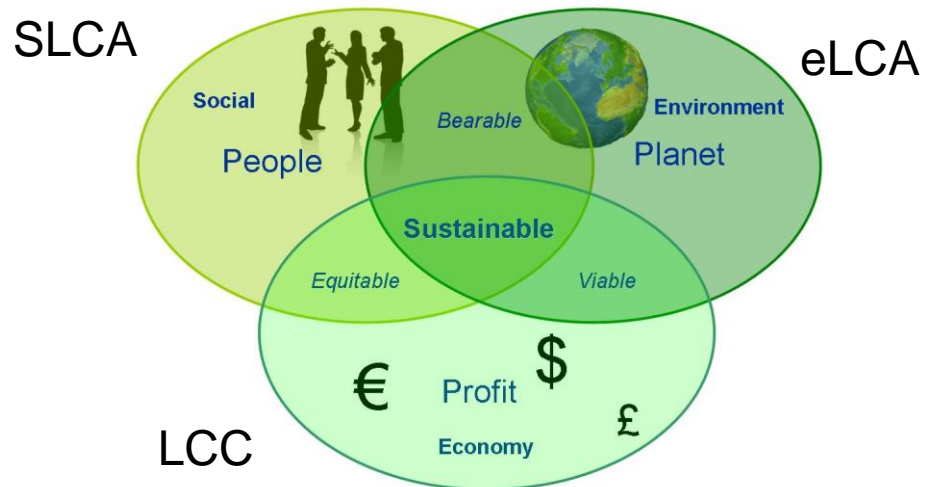


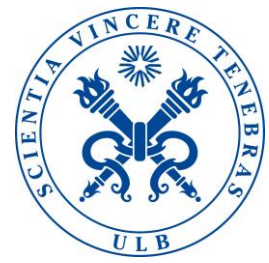


# Circularity indicator initiatives

## General observation

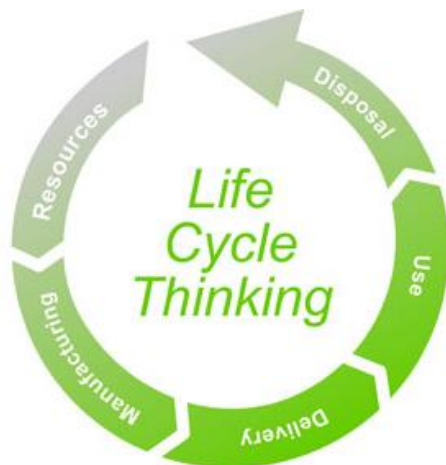
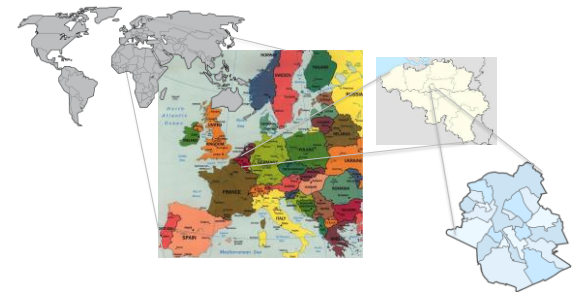
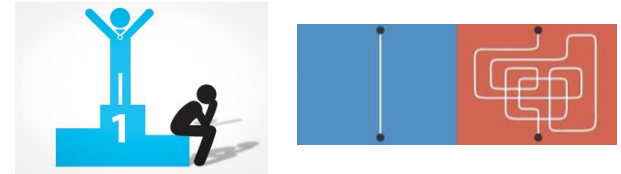
- Interesting initiatives
- Often focused on material and energy flows
- ✓ • Environmental and economic impacts are not sufficiently integrated
- ~ • Social dimension deserves more attention
- ✓ • Indirect and displacement effects?
- ? • Systemic approach seems not to be sufficiently integrated



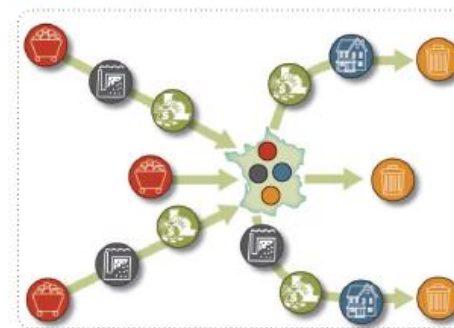


# Perspectives

- Systemic approach seems not to be sufficiently integrated
  - IO-LCA (MR EE IOA – Hybrid LCA) (Genovese et al. 2017)
  - Consequential LCA
  - Territorial LCA



D. Country LCA





# Input – Output LCA

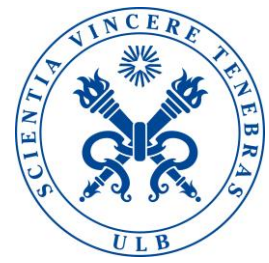
**Composition of inputs required by a sector to produce its products**

		PRODUCERS AS CONSUMERS								FINAL DEMAND			
		Agric.	Mining	Const.	Manuf.	Trade	Transp.	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Govt. Purchases of Goods & Services	Net Exports of Goods & Services
PRODUCERS	Agriculture												
	Mining												
	Construction												
	Manufacturing												
	Trade												
	Transportation												
	Services												
Other Industry													
VALUE ADDED	Employees	Employee compensation								Final demand GROSS DOMESTIC PRODUCT			
	Business Owners and Capital	Profit-type income and capital consumption allowances											
	Government	Indirect business taxes											

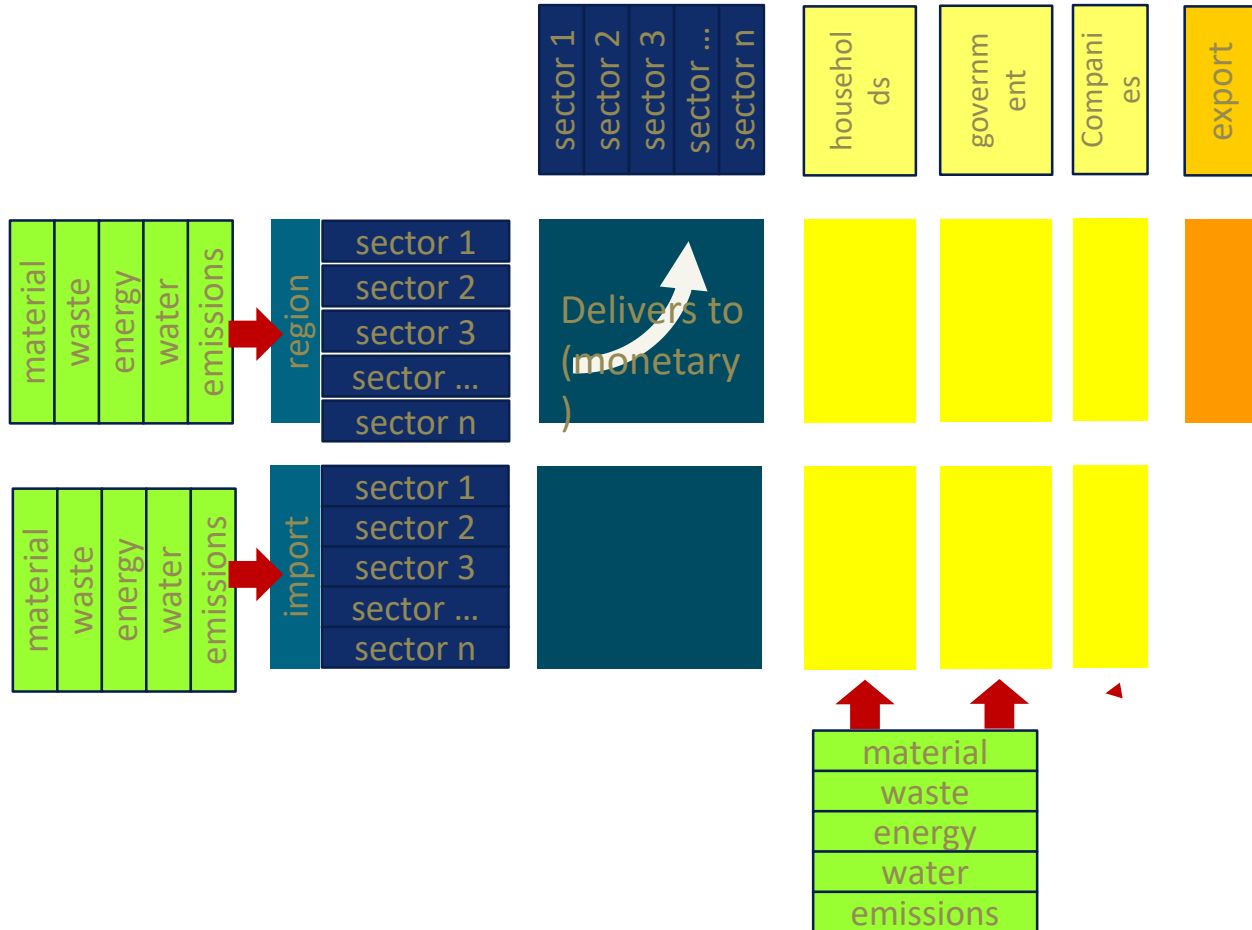
**Distribution of the production of one sector throughout the economy**

Figure 1.1 Input–Output Transactions Table





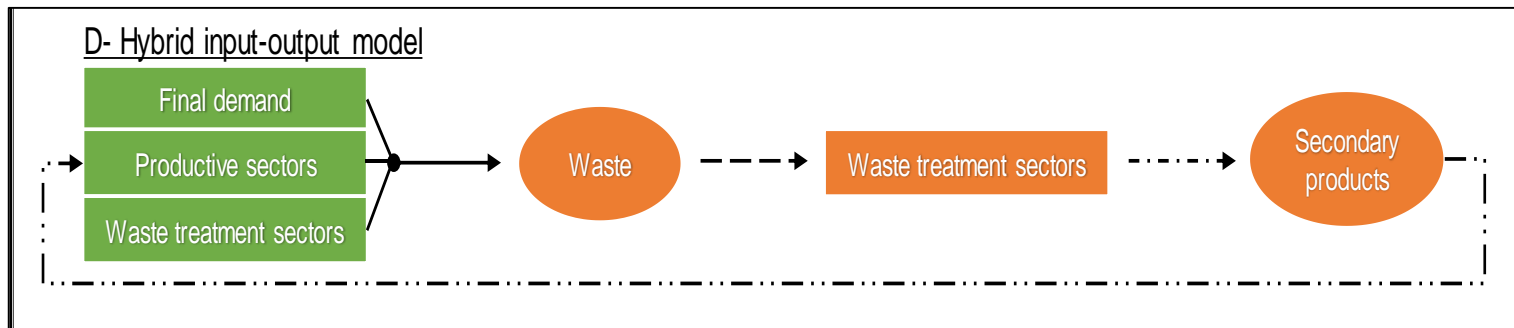
# Input – Output LCA



Slide borrowed from Karel Vanacker. Thanks!

# Input-output analyses

- Potential for CE assessment? Most advanced models can trace..



<b>D – HIO</b>				
Sector 1	$Z_s + Z_w$		$Y$	$x$
⋮				
Sector $n$	$Z_s + Z_w$		$Y$	$x$
Resources	$R_s + R_w$			$r$
Supply of waste	$Wsup_s + Wsup_w$		$Wsup_Y$	$w_{sup}$
Use of waste	$Wu_w$			$w_u$
Emissions	$B_s + B_w$		$B_Y$	$b$
Total inputs	$x'$			

At subnational, national or global level

# Input-output analyses

- Potential for CE assessment? Indicators from models and analyses..

D – HIO			
Sector 1			
⋮	$Z_s + Z_w$	$Y$	$x$
Sector $n$			
Resources	$R_s + R_w$		$r$
Supply of waste	$Wsup_s + Wsup_w$	$Wsup_Y$	$w_{sup}$
Use of waste	$Wu_w$		$w_u$
Emissions	$B_s + B_w$	$B_Y$	$b$
Total inputs	$x'$		

## Indicators from HIOT:

- Waste intensity per sector (waste<sub>in</sub>/ production<sub>out</sub>, in ton or €)
- Waste treatment rates per waste material (e.g. Recy. rates for metals, paper)
- Use rate of sec. products in economic sectors
- Emission intensity of waste treatment (and other) sectors

→ State of circularity in a region & direct impacts (EXAMPLE)

## Indicators from input-output analysis:

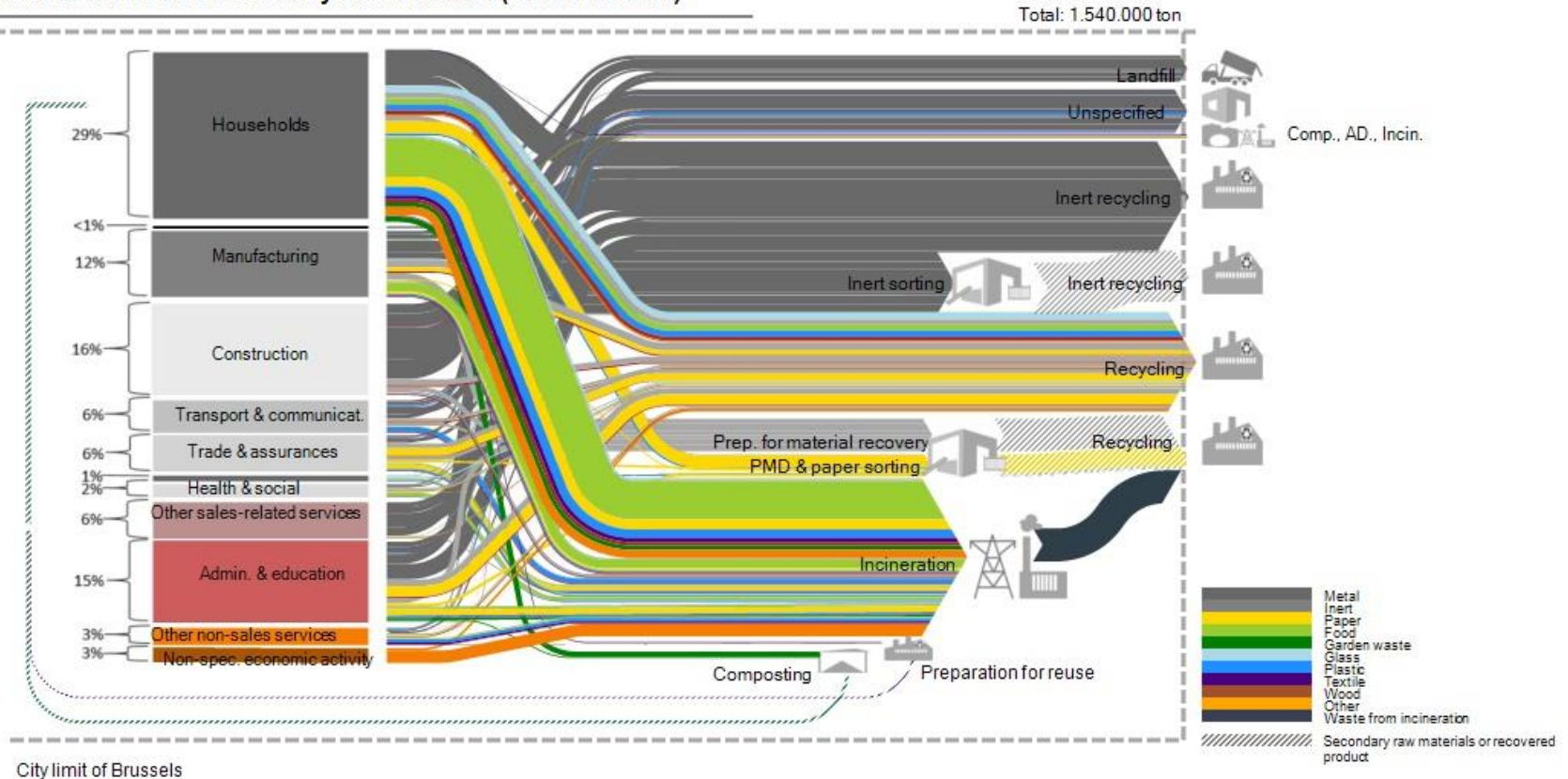
- Waste footprint: Direct and indirect waste generation linked to household consumption
- Direct and indirect environmental 'impacts' from the consumption of products (secondary and primary)

→ Effect of production and consumption mode (CE model) on other sectors and regions

# Input-output analyses

## EXAMPLE 1: regional state of circularity

Flows of waste and secondary raw materials (Brussels 2014)



### → State of circularity in Brussels

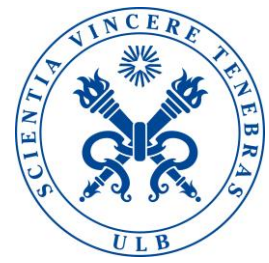
< 1% of the collected waste is used in a way that closes material cycles within city limits

# Input-output analyses

## Limits for CE evaluation

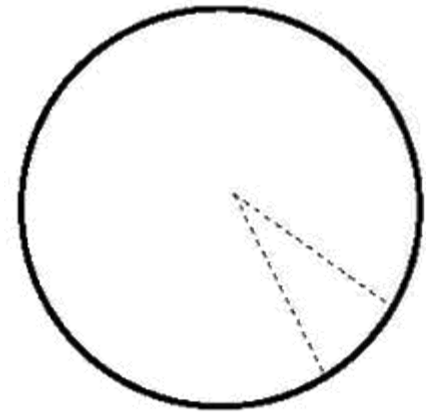
- Economy as it was... at least 5 years ago: new CE business models not included
- Economy model of (max.) 200 sectors: detailed sectoral analysis (waste treatment or service sectors)
- Many flows that are relevant for CE are not included/ not distinguishable
  - Non-commercial activities (Home composting , repair cafés, food banks)
  - Reuse of products
  - Second hand markets
- Environmental assessment: carbon, material, water footprint, not a complete impact assessment



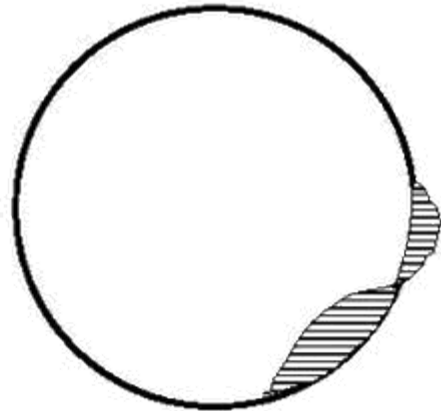


# Consequential LCA

- Substitution effects in multi-output processes
- Substitution effects in open loop recycling
- Alternative use of limited production factors
- General Market effects
- Identification of competing/avoided products
- Identification of marginal technology



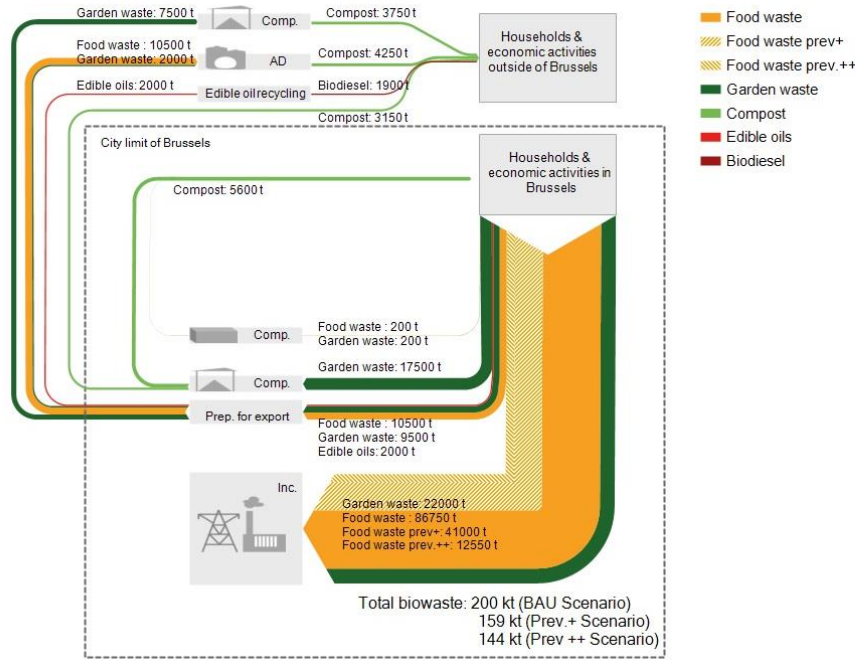
Attributional



Consequential

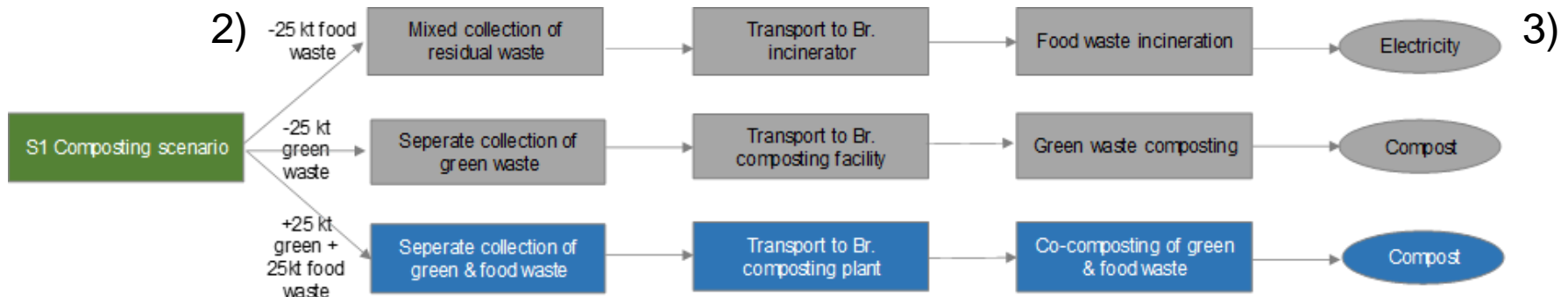
# Consequential LCA

1)



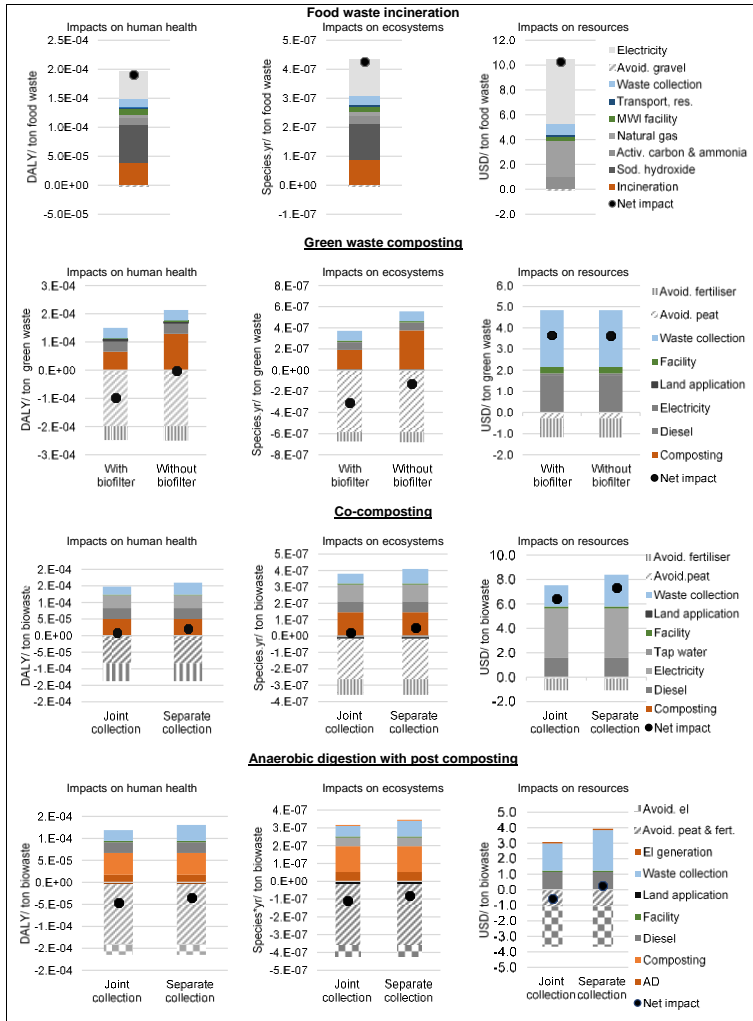
**EXAMPLE:** Environmental consequences of diverting 50kt of Brussels' biowaste from current treatment to more circular management options?

- 1) Selection of options that are supposed to change in the total biowaste system
- 2) Replacement options
- 3) Substitution effects



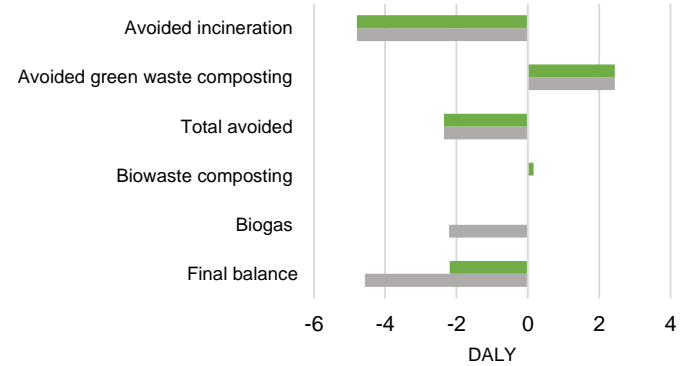
# Consequential LCA

## EXAMPLE: RESULTS

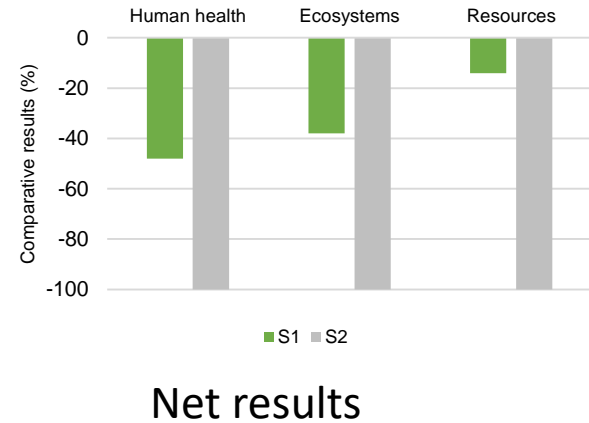


Impacts from replaced processes

Impacts from CE options



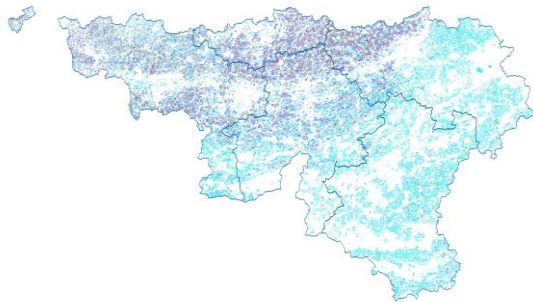
Balance for human health impacts



Net results

# Territorial LCA

Limited land



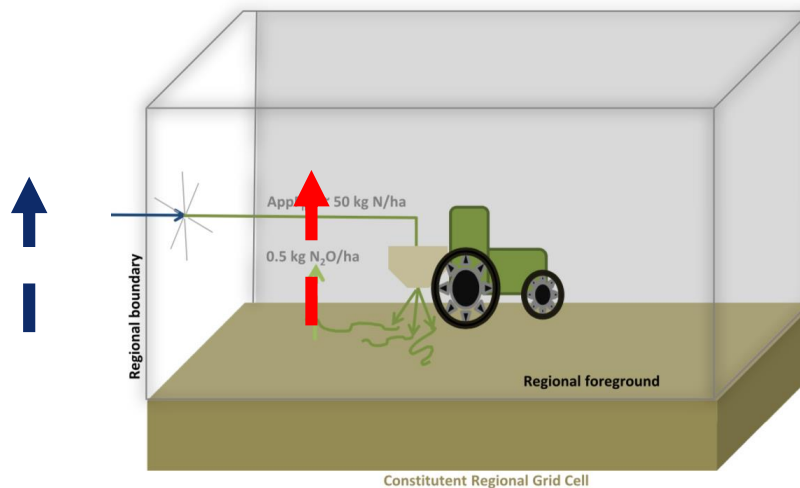
Multiple functions

Think wisely

Where

Which

How much



Territorial LCA  
(TLCA) environmental

(Loiseau et al. 2013)

# In short

## Circular Economy

- Aim for economy wide effects
- Aim for sustainable Development
  
- Need to develop evaluation approaches which incorporate systemic effects
  
- LCT tools as IO-LCA, cLCA and TLCA show potential to contribute to that.





Thank you for your attention!

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