Application of Life-cycle assessment in optimization of municipal waste management systems

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GP – LCA in Waste management

Application of Life-cycle assessment in optimization of municipal waste management systems

- Based on the PhD thesis: **Integrated Municipal Waste Management System Decision Support Model**

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- **Aim** - to create a better understanding of dedecision support mechanism in optimising the municipal WM systems from the environmental and the economic points of view

- **An integrated Life model for municipal WM** was created and tested in an empiric context of Alytus region in Lithuania in order to optimize regional waste management strategies

Municipal waste management

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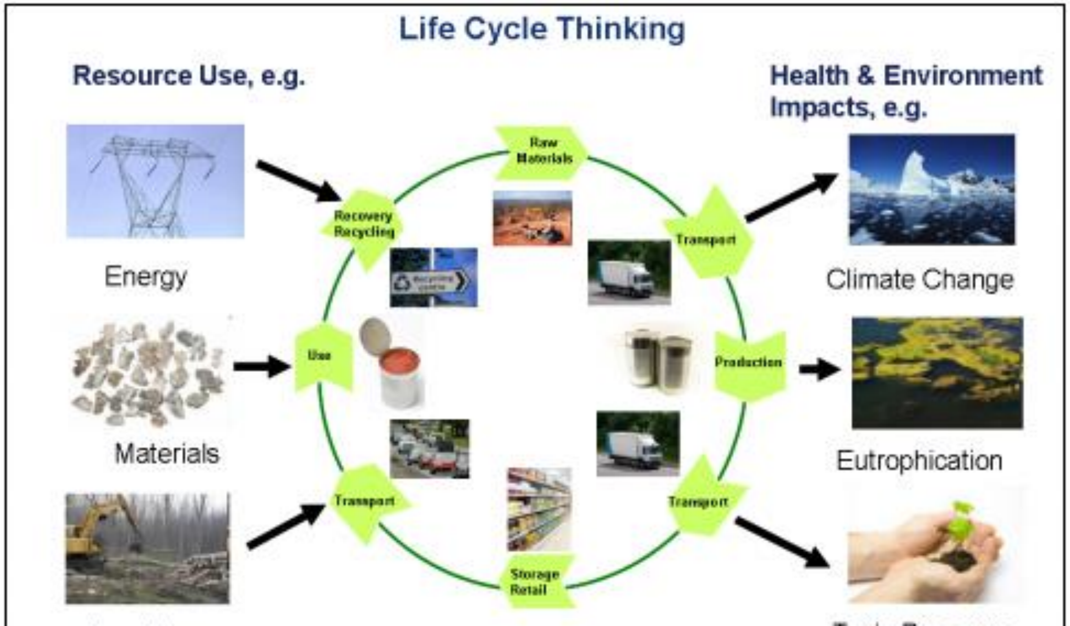
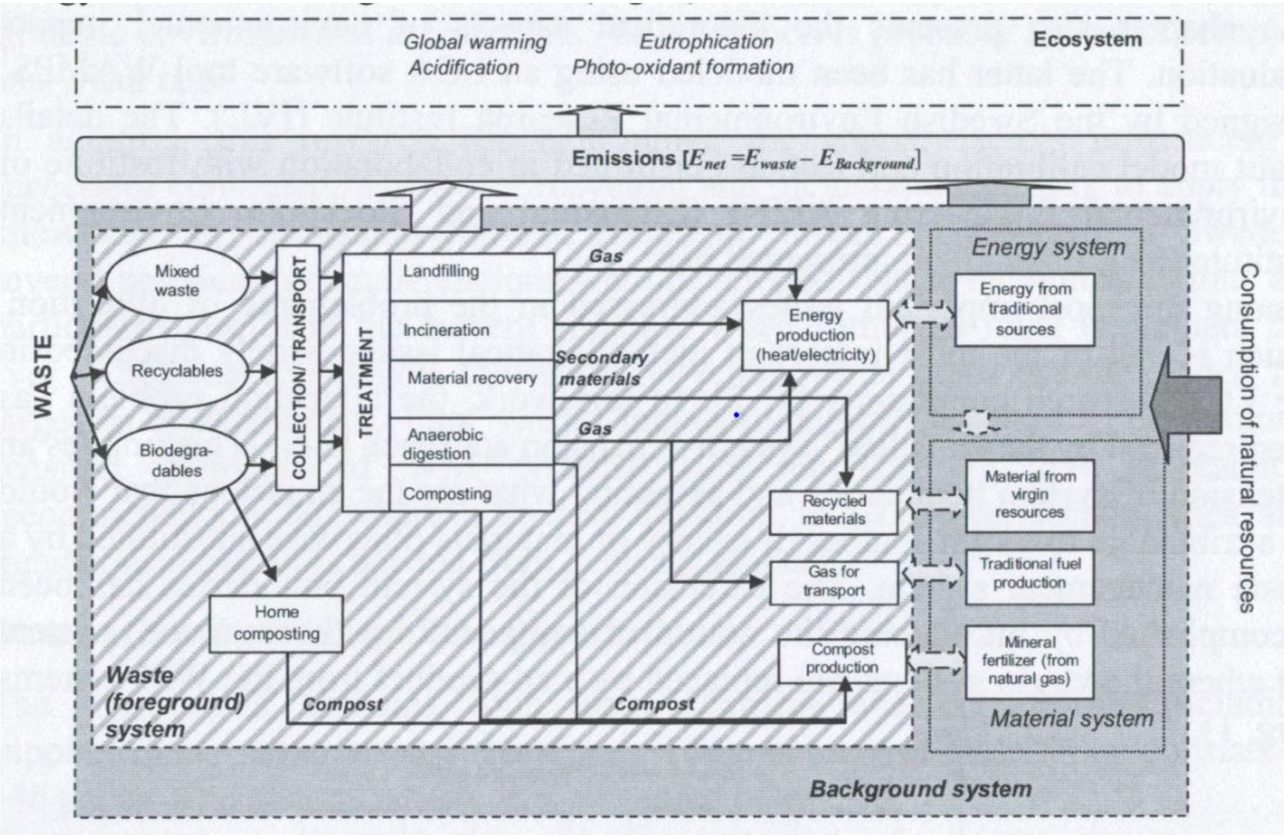
- **Aim:** Optimization of **municipal waste management** system
- **Purpose:** to help **local decision-makers** in designing integrated waste management solutions that are ecologically optimal
- Study uses **Life cycle assessment (LCA)** methodology **to build a model and test different waste management scenarios in order to see whether the waste management hierarchy is influenced by regional conditions**
- Study also tests to which variables in waste management systems the end results of the LCA are most sensitive
- Discussion is built around **a case study in Lithuania, Alytus region** where several waste management scenarios have been analyzed and compared in the LCA framework
- The study reveals several methodology related issues and discusses what **implications waste-related policy intervention** would have on the environmental outcomes of different waste management scenarios



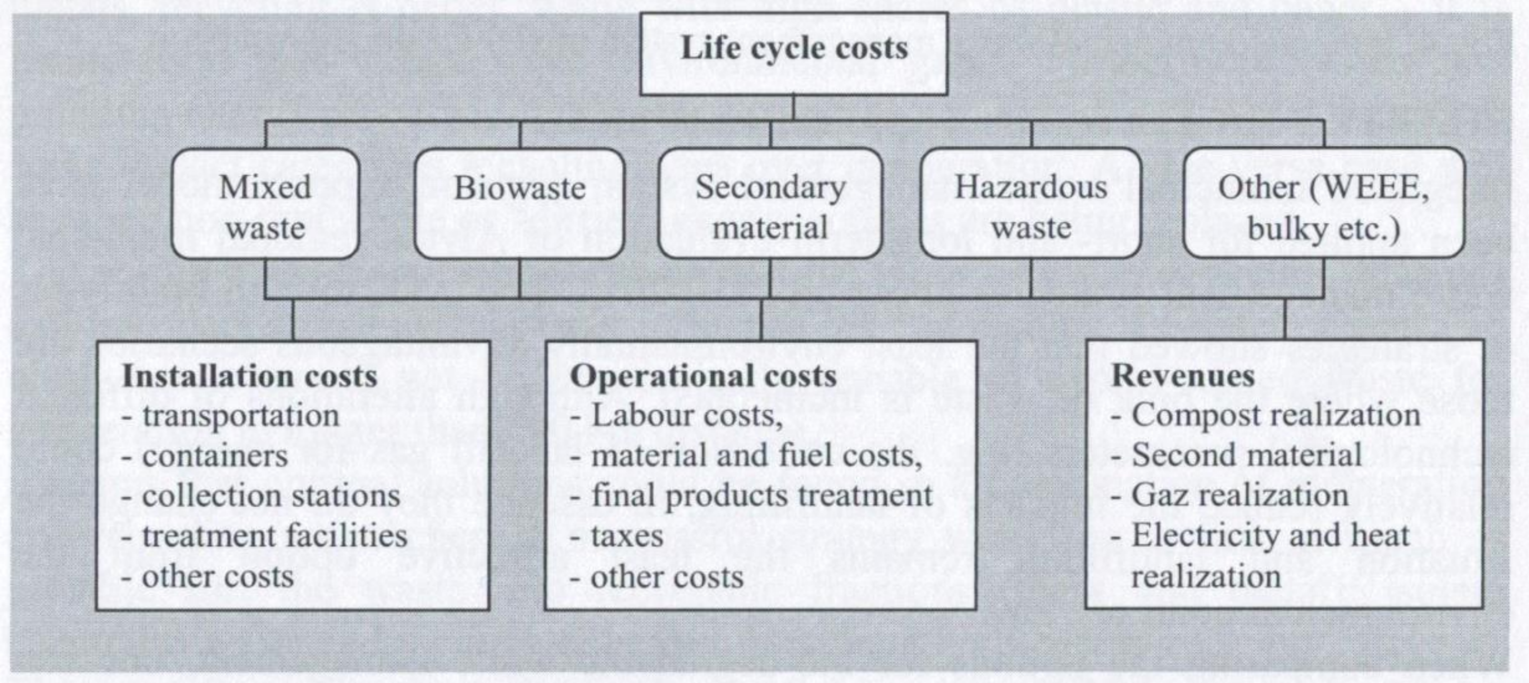
https://eplca.jrc.ec.europa.eu

Conceptual model depicting the WM

- Modelling was assisted by the **LCA software** tool **WAMPS** - **Waste Management Planning System**, which was designed by the Swedish Environmental Research Institute (IVL), tested and calibrated in collaboration with the Institute of Environmental Engineering APINI (Lithuania) and Stockholm Environment Institute SEI (Estonia)



Conceptual Life cycle costing (LCC) model



- In this **model LCC** is applied by dividing the waste flow into five fractions: **mixed waste**, **bio-degradable fraction**, **recyclables** (glass, paper, metals and plastcs), **hazardous waste** and **rest fraction**.
- For each of this fractions infractructure and operation costs as well as potential revenues are calculated.

Integrated municipal waste management system model for decision support

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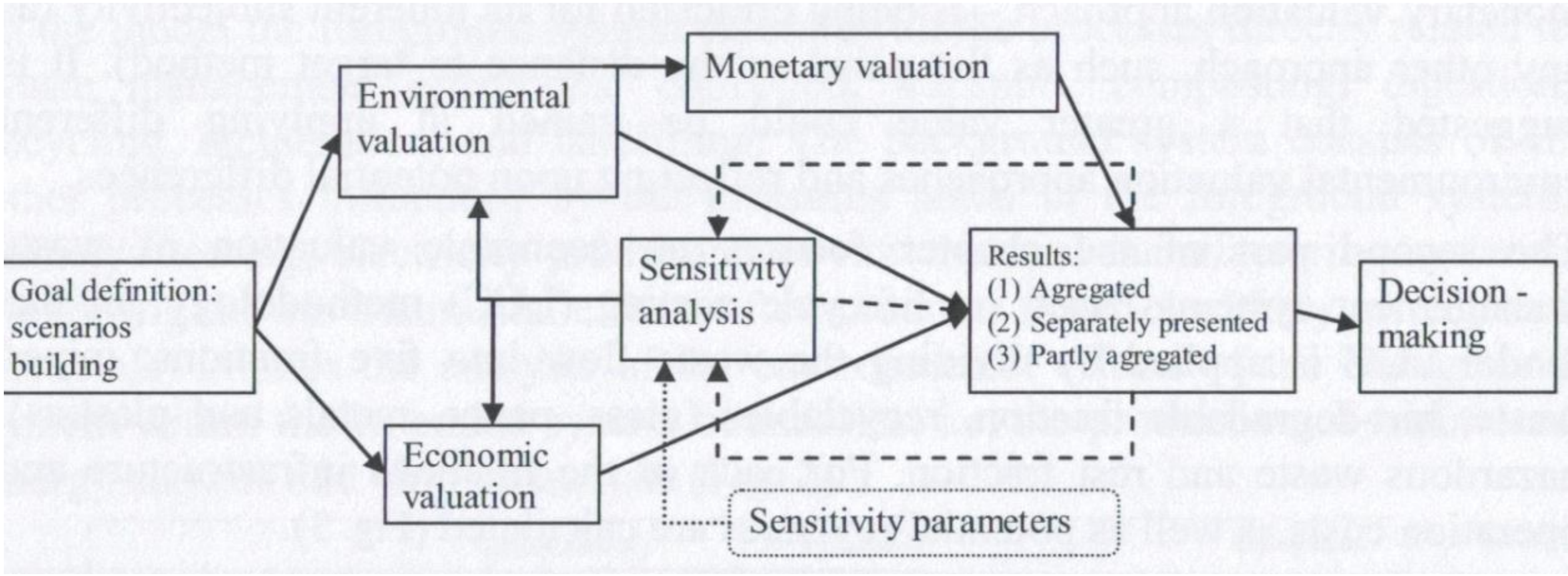


- Developed integrated model suggests performing **a sensitivity analysis prior to taking concrete decisions**, i.e. determing input values more carefully for the parameters that are influencing the end results the most.

Case study -
Region of Alytus in South Lithuania

- **Alytus region** is one of 10 administrative units in the country with about **half of the population residing in the cities** and the **rest in rural areas and small towns**
- The region represents a typical setting in Lithuania, where **half of the population lives in individual houses**
- Both Alytus town and the villages have typical features of a non-metropolitan part of the country and represent about half the country's population

- General characteristics of Alytus region:

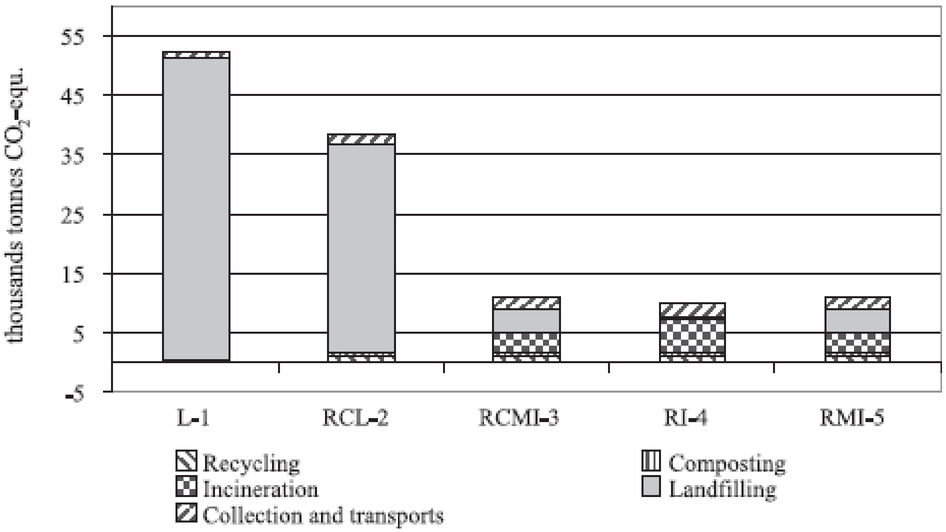
Total population	216,400
Population in single family houses	33,300
Population in blocks of flats	97,100
Rural population	86,000
Total number of households	87,500
Total waste (tonne year^{-1})	40100
Waste per capita (kg year^{-1})	190

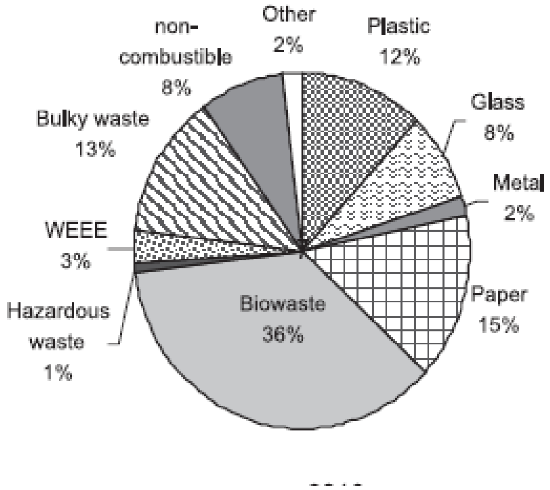
Different waste treatment methods used in the scenarios

Treatment methods in scenarios	L-1	RCL-2	RCMI-3	RI-4	RMI-5
Individual composting	3160	3160	3160	3160	3160
Separate collection of material and recycling	1806	9030	9030	9030	9030
Separate collection of bio-waste and composting		4064	2710	1806	1806
Landfilling of mixed waste	40184	28,896			
Mechanical-biological treatment (MBT)			30,251		31,154
Bio-stabilisation after MBT			7676		8579
Incineration after MBT			17,157		17,157
Landfilling after MBT			5418		5418
Incineration of mixed waste				31154	
Total waste generated (tonne year^{-1})	45,150	45,150	45,150	45,150	45,150

1. **L-1 – reference scenario** (landfilling). Most of municipal solid waste is landfilled.
2. **RCL-2 - scenario (recycling, composting and landfilling)**. Separate collection of secondary material and recycling; separate collection of biodegradable waste and composting; landfilling of remaining mixed waste.
3. **RCMI-3 – scenario (recycling, composting, MBT and incineration)**. Separate collection of secondary material and recycling; separate collection of biodegradable waste and composting; mixed waste is sent for mechanical-biological treatment (MBT), after which three outputs are produced: (i) non-combustible waste; (ii) stabilised fraction (to landfilling); and (iii) combustible (to incineration).
4. **IR-4 – scenario (recycling and incineration)**. Separate collection of secondary material and recycling; mixed municipal solid waste incinerated without any pre-treatment.
5. **RMI-5 – scenario (recycling, MBT and incineration)**. Separate collection of secondary material and recycling, mixed waste is sent to MBT

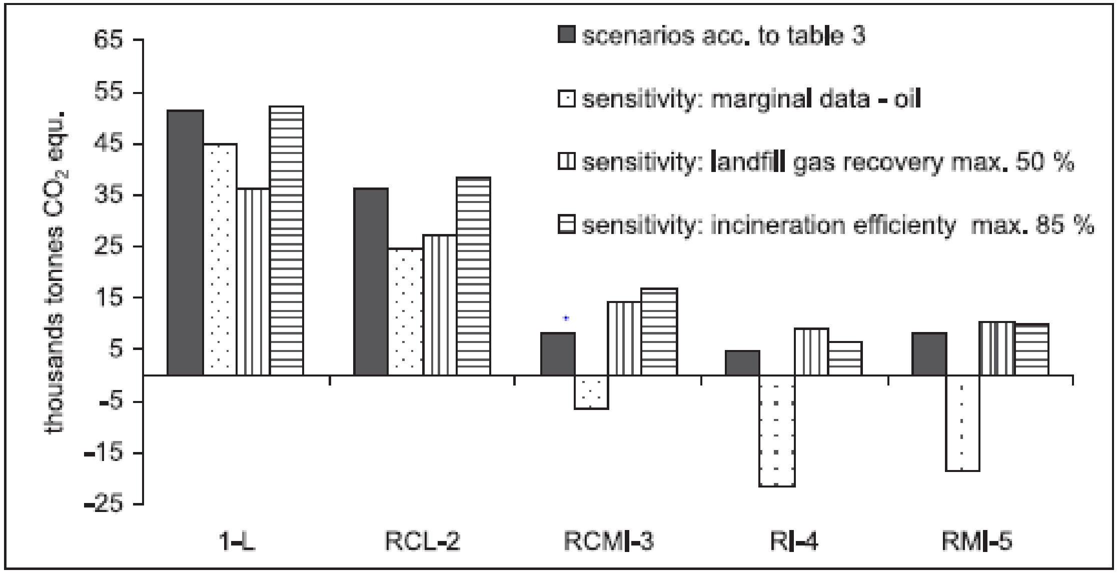
Results for impact category global warming





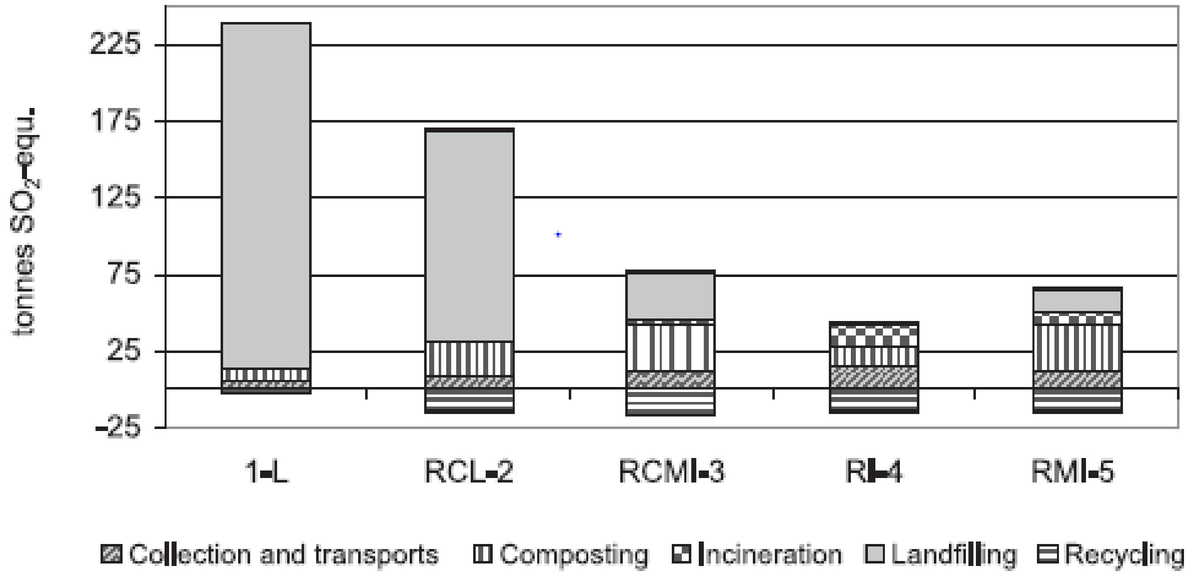
Impact category	L-1	RCL-2	RCMI-3	RI-4	RMI-5
Global warming (tonne CO_2-equiv)	51,230	36,445	8226	4617	8187
Acidification (tonne SO_2-equiv)	236	155	49	24	48
Eutrophication (tonne O_2-equiv)	2286	1580	537	319	536
Photo-oxidants (tonne C_2H_4-equiv)	37	25	–7	–11	–7

Sensitivity results for impact category global warming



- Overall, the **maximum rate of incineration represented by scenario 4** appears to be the technology that is most efficient in minimizing **greenhouse gas emissions**, though the substituted electricity and its respective environmental impacts were calculated taking the average Lithuanian electricity mix (at present mainly from nuclear power).

Results for impact category acidification



A positive effect of recycling is seen in all relevant scenarios, especially in the **acidification category**, where the net effect is an ecological benefit.

The most likely explanation is that the production of materials from virgin material resources requires considerable amounts of energy based on ‘dirty’ fuels such as coal and crude oil.

Conclusions

- Application of an **LCA approach** in this case study has shown that **landfilling gives the worst environmental results** compared to the other waste management options;

- When it comes to the **biodegradable waste fraction**, **aerobic composting** is not a better option compared to **incineration** with energy recovery in all impact categories. This indicates that, under defined circumstances, the **waste management hierarchy should be applied flexibly;**

- The use of an **LCA approach in modelling** the waste management systems provides also a good opportunity to map the entire system in its entirety and makes it possible to assess the data quality requirements;

- Therefore, **LCA models** in **the waste management** area should be complemented with other decision-making tool such as **Life Cycle Costing** (LCC), **Social Life Cycle Assessment** etc.

List of references

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Thank you!

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Questions welcome