EXPLORING THE SOCIO-ECONOMICS OF ENHANCED LANDFILL MINING

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Exploring the socio-economics of ELFM: overview

- Introduction
- Conceptual framework to explore the socio-economics of ELFM
- Step 1: Assessing the economic potential of an ELFM project
  - Case study: Closing the Circle
  - Methodology
  - Results
- Step 2: Assessing the environmental potential of an ELFM project
- Step 3: Estimating the socio-economic potential of ELFM in Flanders
  - Methodology
  - Results
- Conclusion

Exploring the socio-economics of ELFM: introduction

- Human use of materials is one of the major drivers of global environmental change.
- Environmental problems occur during
  - (i) the extraction of resources,
  - (ii) the processing of raw materials,
  - (iii) when emissions and wastes are returned to the natural environment after the materials have been use
- Domestic material extraction 60 billion tons (2009) to 115 billion tons (2030)

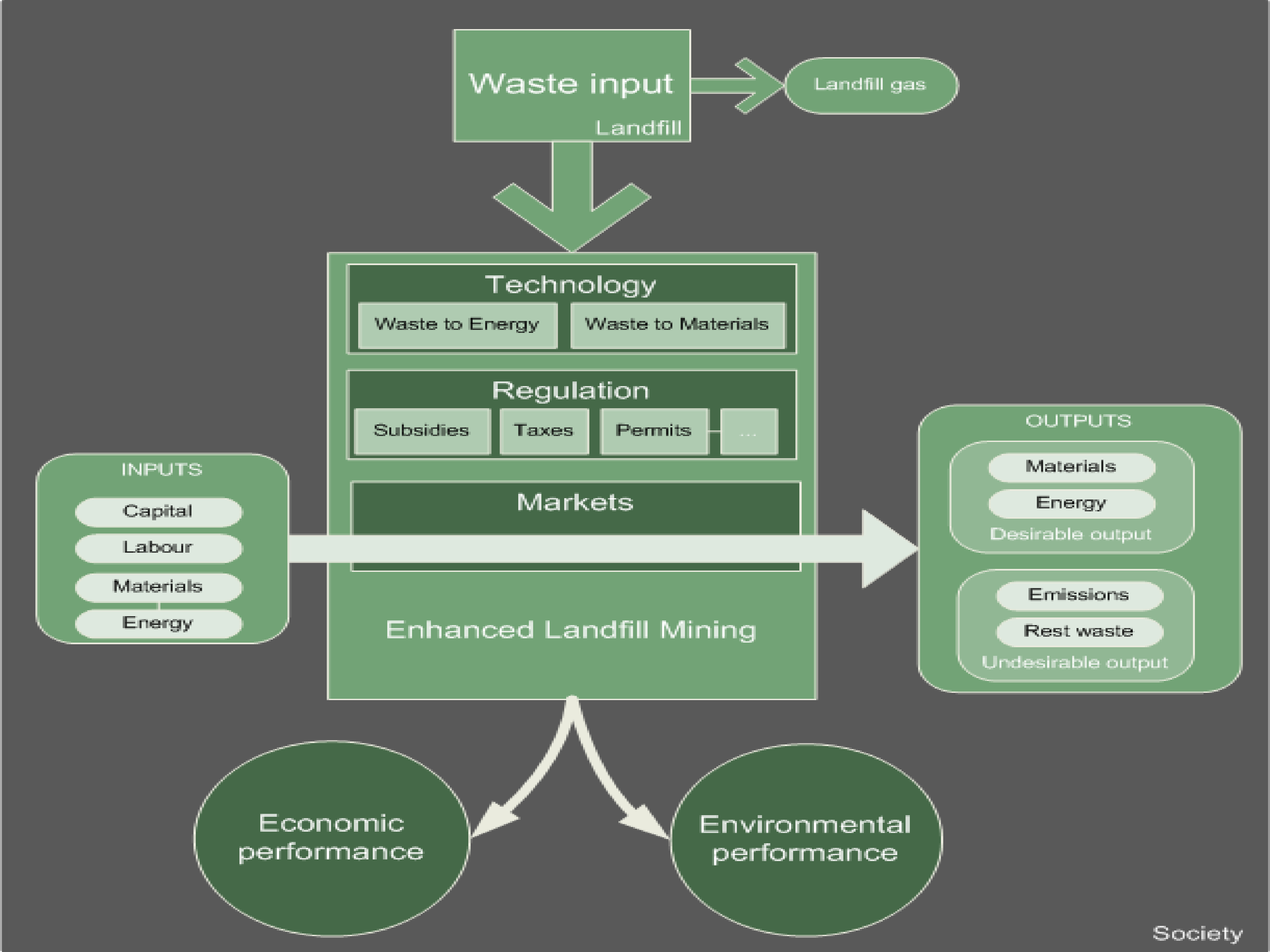
➔ sustainable use of our resources

➔ enhanced waste management (EWM)

➔ enhanced landfill mining (ELFM)

Conceptual framework to explore the socio-economics of ELFM

- Hierarchical approach to waste management with different waste strategies (recycling, incineration, landfilling)
- In general recycling has the lowest impact in total energy use and global warming potential
- Price uncertainty of recycled materials is a major obstacle for recycling
- New concept of Enhanced Waste Management (see Jones et al.)
- ELFM includes the valorization of the historic waste streams as both materials (Waste-to-Material, WtM) and energy (Waste-to-Energy, WtE)
- Performance drivers of ELFM? ➔ conceptual framework



Waste input
Landfill
Landfill gas
Technology
Waste to Energy
Waste to Materials
Regulation
Subsidies
Taxes
Permits
...
Markets
Enhanced Landfill Mining
INPUTS
Capital
Labour
Materials
Energy
OUTPUTS
Materials
Energy
Desirable output
Emissions
Rest waste
Undesirable output
Economic performance
Environmental performance
Society

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Step 1: Assessing the economic potential of an ELFM project

- Case study: Remo landfill site in Houthalen-Helchteren
- Methodology:
  - Cost-benefit analysis
    - identify the impact of certain aspects (markets, regulation and technology) on the performance of Enhanced Landfill Mining
    - not an optimization model but rather an interesting tool to tackle uncertainty
  - Internal rate of return

$$NPV(x \mid \alpha) = \sum_{t=1}^{T} \frac{CF_t(\alpha)}{(1+x)^{t-1}} = 0 \Rightarrow x^*(\alpha) = IRR$$

  - Partial sensitivity analysis (elasticities ($[IRR_2/IRR_1].[\alpha_1/\alpha_2]$).
  - Monte carlo sensitivity analysis

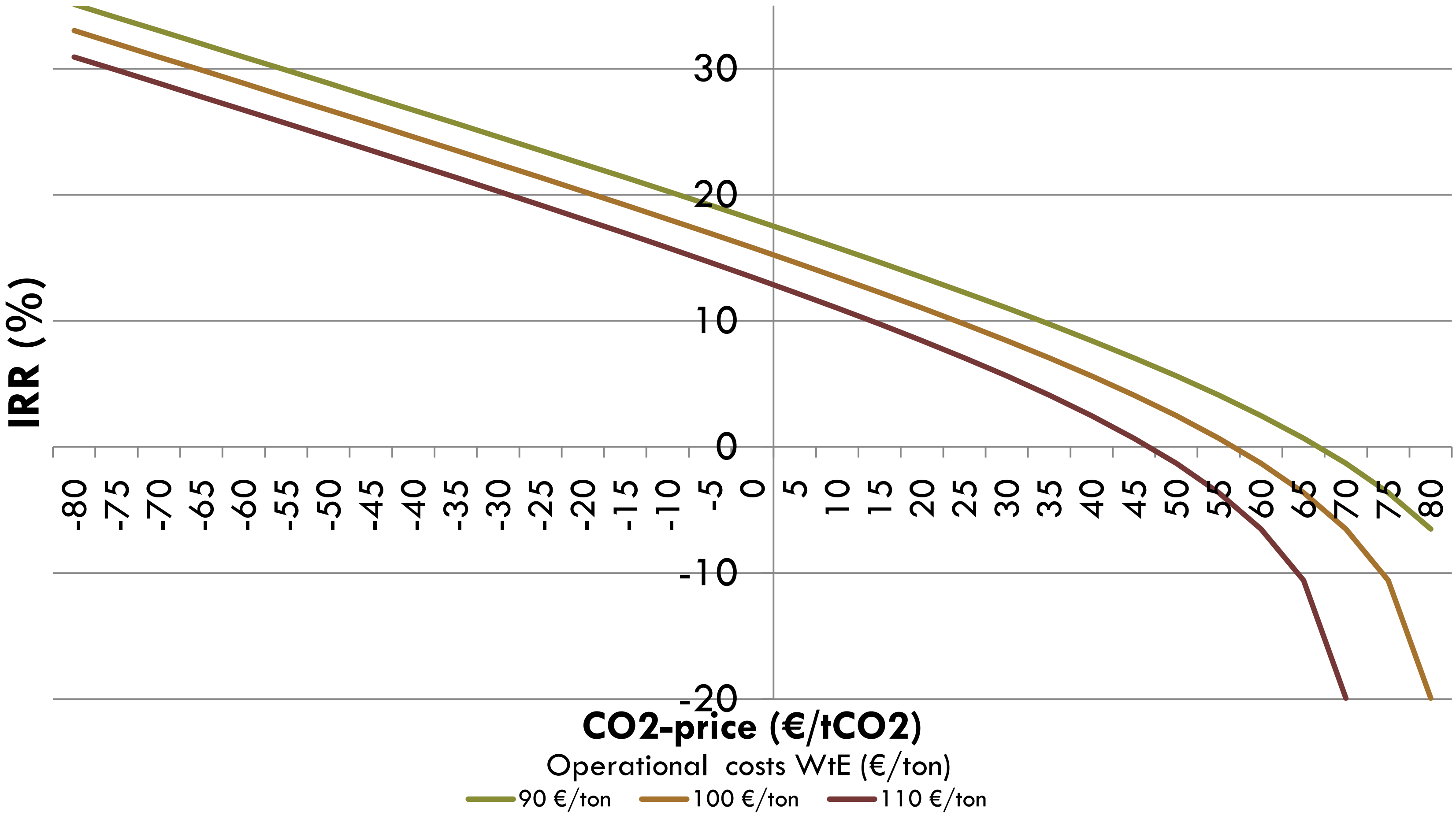
Costs	Benefits
Investment costs	Revenues from materials
Storing costs	Metals
Waste-to-Energy plant	Shredder
Rolling stock	Construction materials
Waste-to-Material plant (metal recuperation)	
Crush and sieve installation	
Operational costs	Revenue from energy production
Energy production (incineration costs)	Electricity
Landfill mining (digging costs, presorting costs, crush and sieve costs, recuperation costs, storing costs)	(Landfill gas)
Emission costs[a]	(Heat)
(Taxation costs)	
(Post-closure care and monitoring)	Support schemes
	Energy subsidies (e.g. green power certificates)
	Investment support
Other possible costs	Other possible benefits
(expenses incurred in project planning)	Carbon capture benefits[a]
(research costs)	(Avoided post-closure care and monitoring)
	(Land value)
...	...

Step 1: Assessing the economic potential of an ELFM project

- Important drivers:
  - WtE efficiency;
  - Electricity price;
  - CO_2 price;
  - Investment costs of the WtE installation;
  - Operational costs of energy production;
  - ELFM support

Parameter	Relationship IRR
WtE efficiency(%)	36.0 (+)
Electricity price (€/MWh)	10.9 (+)
CO_2 price (€/ton CO_2)	26.9 (-)
Investment WtE (€/ton)	6.1 (-)
Operational costs WtE (€/ton)	4.2 (-)
ELFM support (€/MWh)	15.9 (+)

Step 1: Assessing the economic potential of an ELFM project



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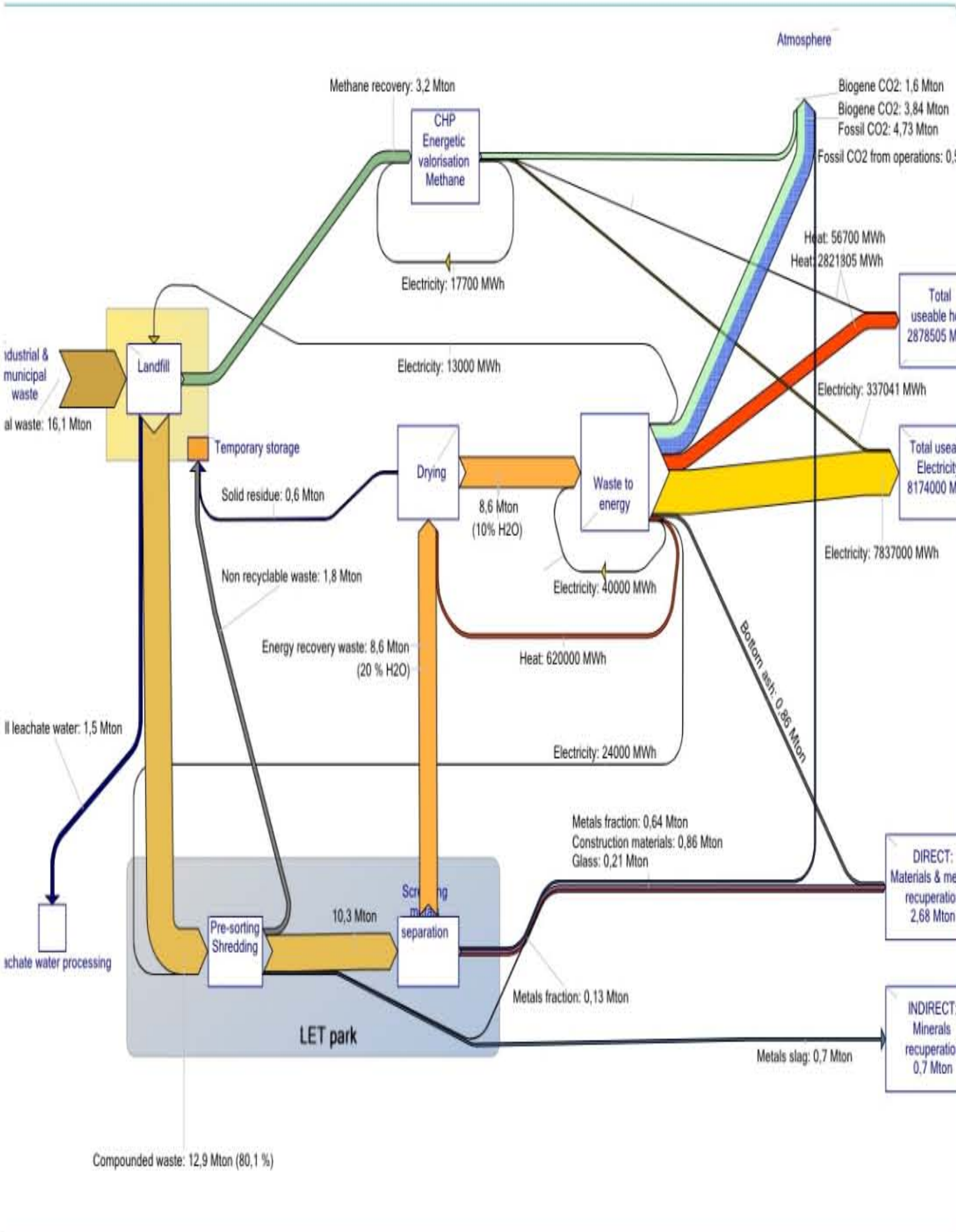
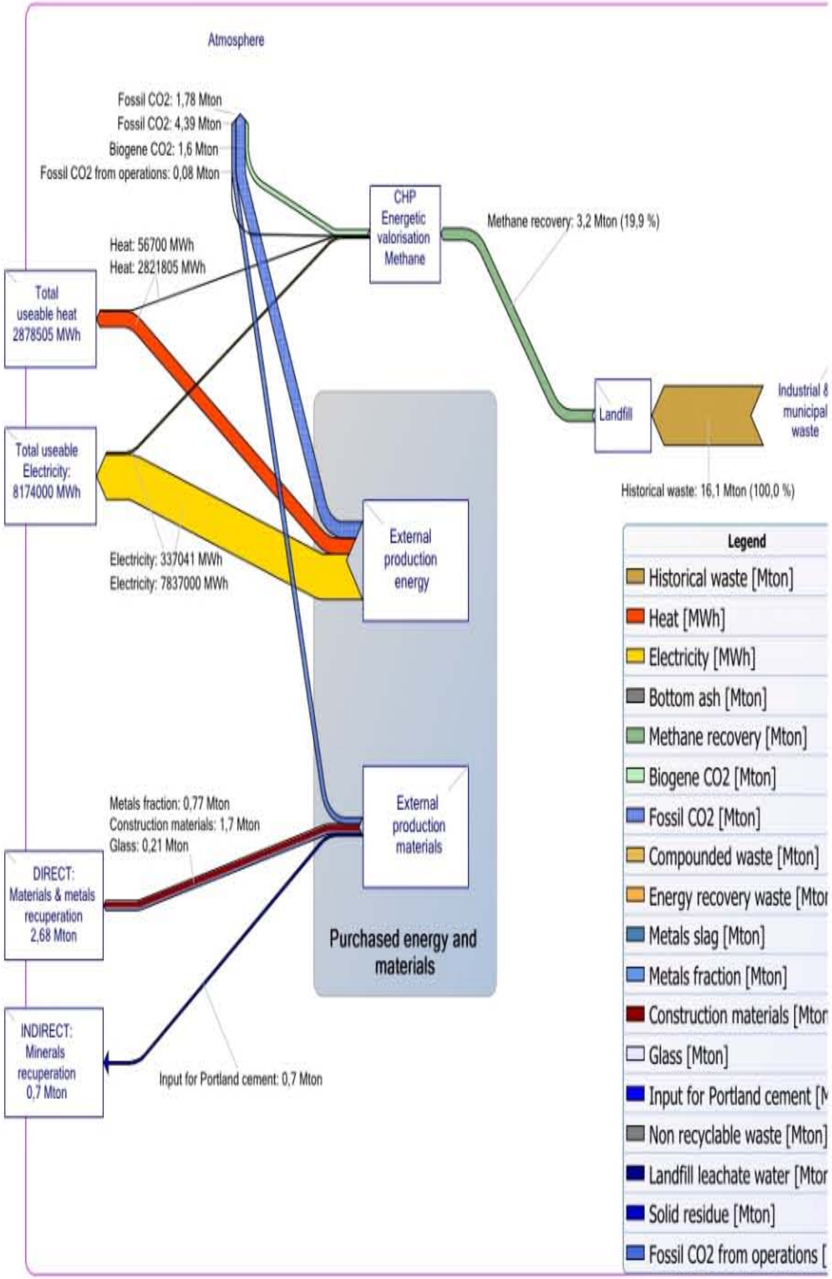
Step 2: Assessing the environmental potential of an ELFM project

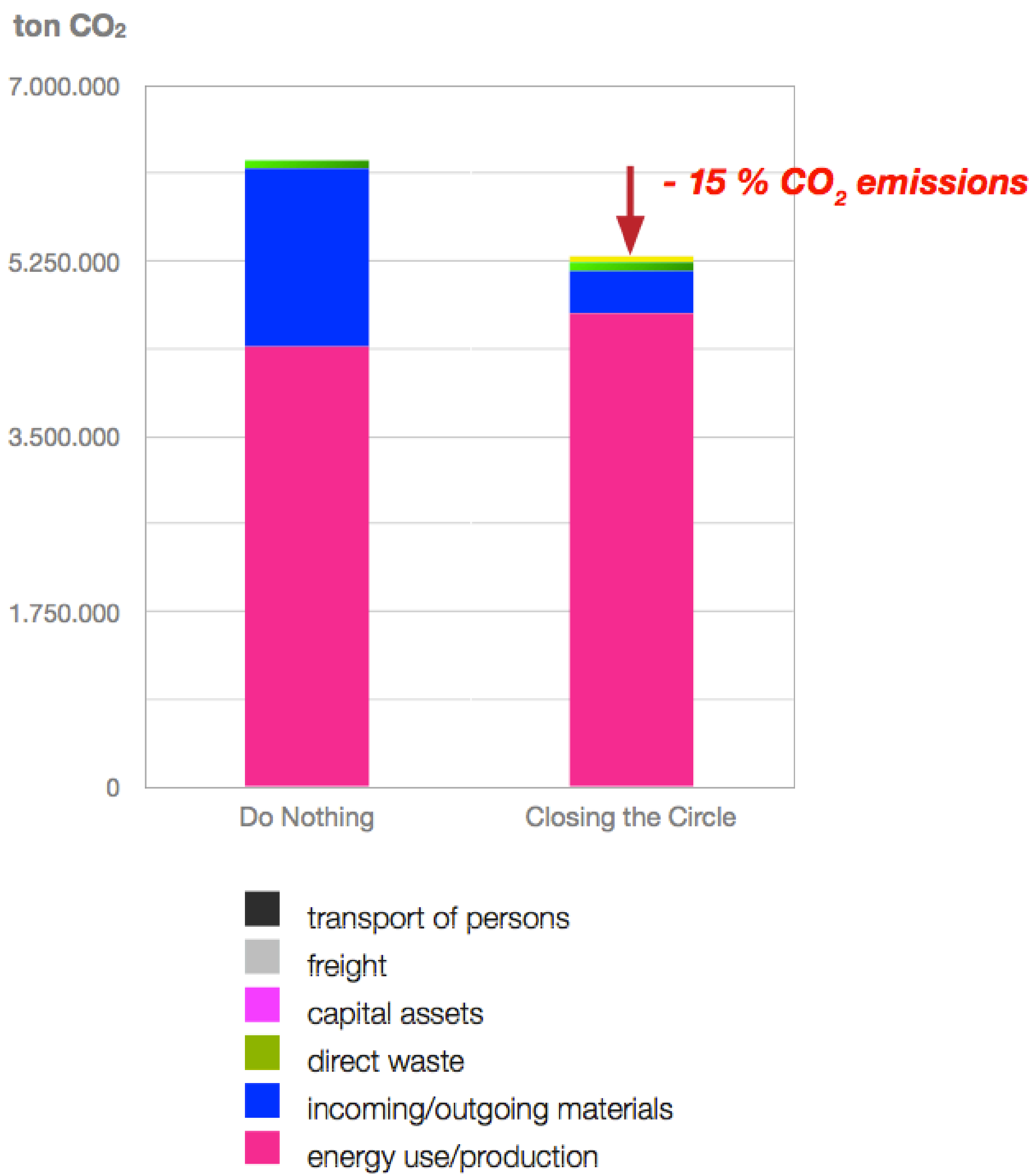
- Impact on greenhouse gas emissions
  - Carbon footprint (Bilan Carbon methodology)
  - CO_2-equivalents
- Categories of activity data
  - (i) emissions from energy production,
  - (ii) emissions from freight,
  - (iii) emissions from transport of people,
  - (iv) emissions from incoming and outgoing materials and services,
  - (v) emissions from direct waste and waste water,
  - (vi) emissions from capital assets.
- See Tielemans and Laevers
- See keynote lecture Serge de Gheldere

Machiels Group Remo Site – Closing the circle scenario 14



Machiels Group Remo Site – Do nothing scenario 14




ton CO_2
7.000.000
5.250.000
3.500.000
1.750.000
0
Do Nothing
Closing the Circle
- 15 % CO_2 emissions
transport of persons
freight
capital assets
direct waste
incoming/outgoing materials
energy use/production

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Step 3: Estimating the socio-economic potential in Flanders

- Socio-economic potential is more than only private profitability.
  - Includes also environmental effects (materials recuperation, carbon emissions, …), re-use of the site, …
  - Methodology: social (= society) cost benefit analysis.
- CtC is a pilot ELFM project, what is the potential for scaling up such project in Flanders?
  - Inventory of similar sites in Flanders
  - Flanders: front-runner in sustainable waste management
  - 5- step procedure: Van Der Zee et al., 2004

Potential for scaling up ELFM projects in Flanders

- Database of landfills:
  - OVAM since 1980
  - Landfill sites without permits

  ➔Inventory from ‘Land Information Register’: 1618 sites
- Qualitative selection:
  - Type of landfill?
  - Period of exploitation - Historic trends in waste composition
    - Ash from household heating
    - Food wastes
    - Glass
    - Plastics & Aluminium
    - Bottom ash

Potential for scaling up ELFM projects in Flanders

- Qualitative selection:
  - ➔ 850 sites which are potentially interesting for future ELFM projects.
- Quantitative selection:
  - Economies of scale
  - Pioneer stage CtC
  - Mature stage: 14 – 58 additional sites
    - 20 km^2 minimal area
- On site visit & full investigation necessary.
- Importance of local factors
  - Composition of landfilled material:
    - Building materials – Glass – CHP - ...
    - Possible re-use of the site (legal status)

Step 3: Estimating the socio-economic potential in Flanders

- Positive social cost benefit ratio for development of additional ELFM projects in Flanders

DATA		
Site surface	m²	20.000.000
Costs		
Total	eur	12.779.680.000
Benefits		
Total WtM	eur	1.534.382.080
Total WtE	eur	9.937.782.556
Landfill Reclamation	eur	1.368.000.000
Reduced Carbon Footprint compared to Do Nothing scenario	eur	256.650.240
Total	**eur**	**317.134.876**

Step 3: Estimating the socio-economic potential

- Main drivers of social cost benefit analysis:
  - Private benefits: energy & materials
  - Environmental benefits: re-use of site and carbon footprint.
- This was only a first quick scan. Additional research needed:
  - Other environmental effects than only carbon footprint.
    - E.g., reducing threat of future groundwater pollution
  - Scaling up requires taking into account site-specific conditions.

Exploring the socio-economics of ELFM: Conclusions

- The development and application of innovative technologies is important with a clear focus on WtE efficiency
  - Higher economic performance
  - Higher environmental performance
- Impact of specific material prices is low (heterogeneous waste streams)
- CO_2: emission costs versus carbon capture benefits
- Tailored ELFM policy measures are needed (with focus on both materials and energy valorisation)

Exploring the socio-economics of ELFM: Conclusions

- Complex trade-off issues between economic, social and environmental issues, demonstrates the need for
  - (i) more detailed information of economic, social and environmental aspects and
  - (ii) a clear, integrated decision tool.
- Social cost benefit ratio is positive and ELFM can be scaled up in Flanders but additional research is needed.