Energy balance of recycling: paper and plastics

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- Object of the study:

  describing the relation between recycling and energy use – for paper and plastics – based on scientific information

- First phase: *the non-local material perspective*

Non-local material perspective	***Local product perspective***
No specific analysis at product level	Specific analysis at product level (production, waste collection, recycling…)
No country specific analysis	Country/region specific analysis (production, transport, waste handling,… adapted to local reality)
System: world	System: Belgium & neighbouring countries/regions in world
Based on literature study	Cooperation with industry
Not specified	Belgian energy mix
Paper (fine paper, graphic paper, office paper)	Copy paper
Most important polyolefins (HDPE, LDPE, LLDPE, PP) withfocus on packaging	e.g. LDPE packaging foil
Expandable Polystyrene	EPS insulation
No use phase considerations	Quality aspects
General estimations	Specific data

Comparative study on the total energy use of products based on primary versus recycled materials: first phase

- ***Reviewed literature***
  - *WRAP(2006), Environmental Benefits of Recycling, An international review of life cycle comparisons for key materials in the UK recycling sector, ISBN: 1-84405-263-X*
  - *ADEME (2001), Bilan environnemental sur les filières de recyclage: l'état des connaissances ACV, 31-12-2001*
  - *TNO-rapport (2005), A.M.M. Ansems, T.N. Ligthart, Oplossingsrichtingen voor het beheer van huishoudelijk verpakkingsafval in Nederland, TNO, maart 2005*
  - *ICF Consulting (2005), Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions : 2005 Updat, Final Report, Contract No. K2216-04-0006, Submitted to : Environment Canada and Natural Resources Canada, October 31 2005*

Comparative study on the total energy use of products based on primary versus recycled materials

- **How can recycled and virgin material be compared ?**
  - The complete sharing of all material processing (environmental) ***costs*** between all produced materials: **WHY ?**
  - **The system perspective**: *virgin and recycled material processing are part of a wider industrial metabolism and it is difficult to compare their material outputs loose from the entangled processes*
  - **Retrospective or prospective** comparison of product systems ?

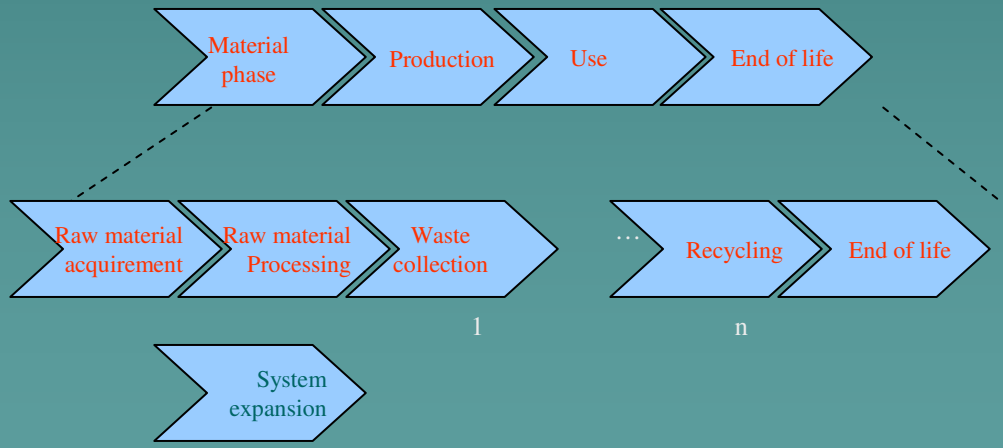
THE RESEARCH QUESTION NEEDS TO BE DETAILED:

Scope and aim !

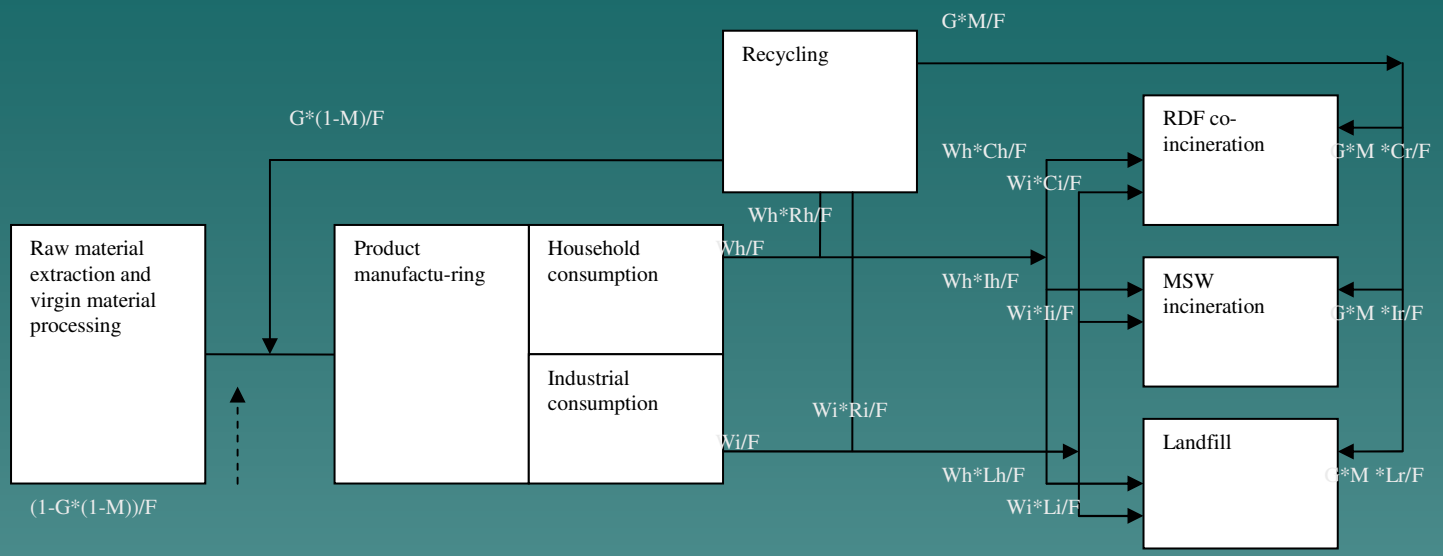
Comparative study on the total energy use of products based on primary versus recycled materials

- **SYSTEM DEFINITION** heavily impacts the result throughout the study
  - The model: **open loop recycling vs closed loop recycling**
  - The methodology: **life cycle perspective**

  *To be able to compare two systems in one comparison, the product systems had to be **expanded. But where to stop expanding ?***



Mass flow in considered closed loop recycling system



With G = Wh*Rh+Wi*Ri
F = 1-G*(1-M)*(1-S)

W: fraction of waste from h or i
R: recycling rate from h or i
M: material losses of r
S: substitution rate
C: co-incineration rate for waste from h, i, and r
I: MSW incineration rate for waste from h, i, and r
L: Landfill rate for waste from h, i, and r

The postscripts h, i and r stand for households, industry and recycling.

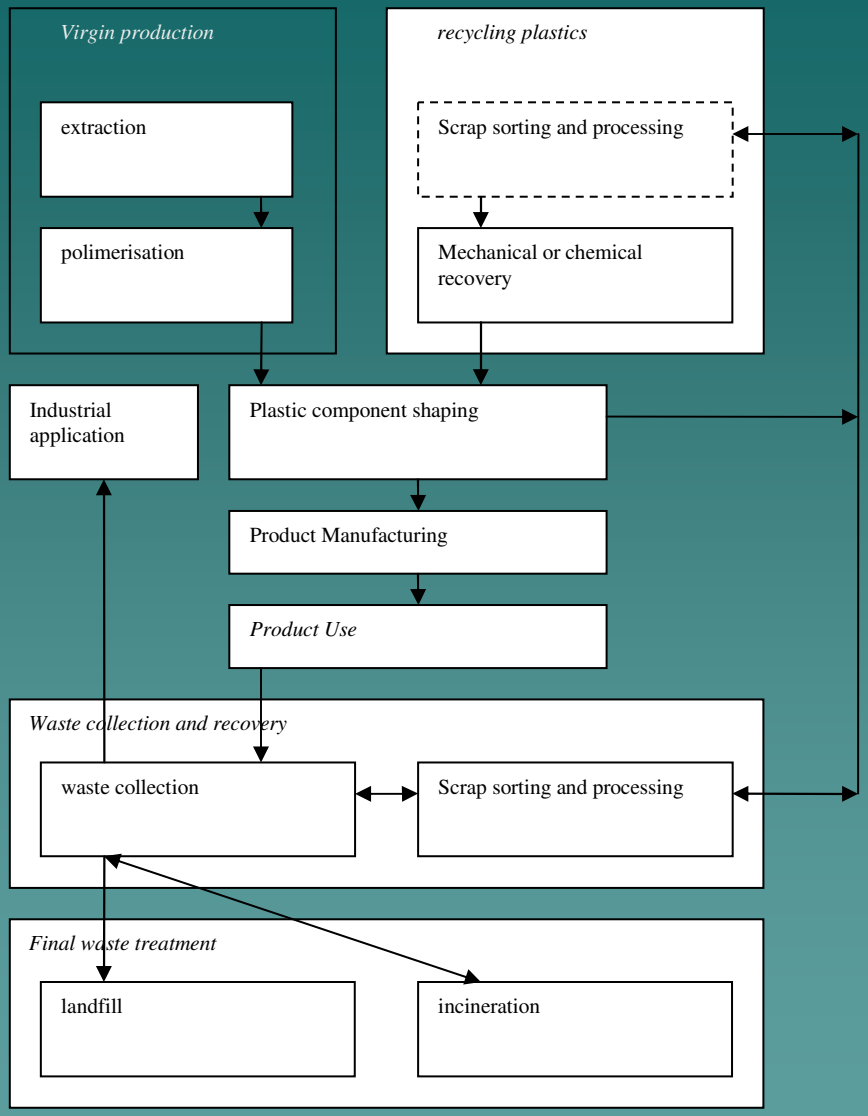
In the notations of the above figure, the formula used in calculating the total energy consumption and GWP is[1]:

Etot = (1/F)*(1-G*(1-M)) *Ev + / Energy consumption raw material phase/
(1/F)*(Ep + Eu) + / Energy consumption product manufacturing and use phase/
(1/F)*G*(1-M)* Er + / Energy consumption recycling/
(1/F)* (Wh*Ch+Wi*Ci+G*M*Cr)*Ec+ / Energy consumption co-incineration/
(1/F)* (Wh*Ih+ Wi*Ii+G*M* Ir)*Ei+ / Energy consumption incineration/
(1/F)* (Wh*Lh+Wi*Li+G*M*Lr)*El + / Energy consumption landfill/

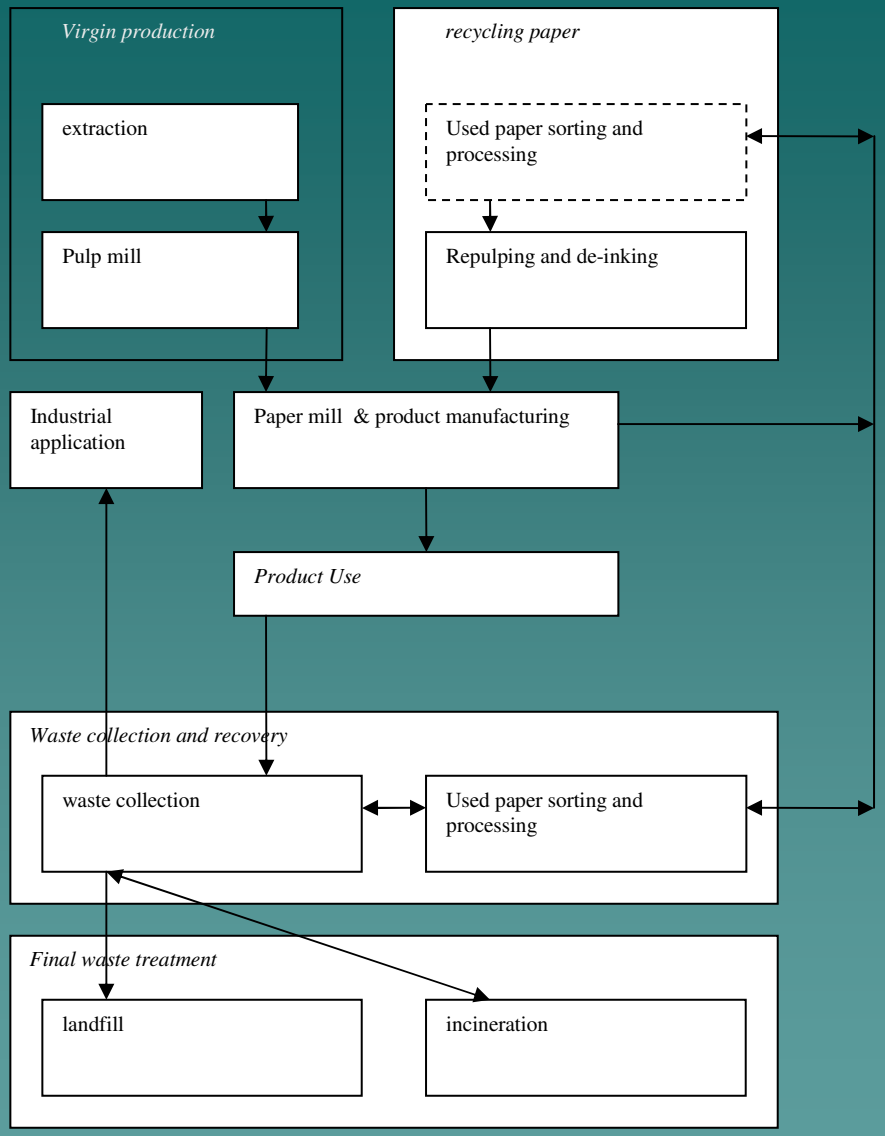
With Ex: the per kg energy consumption (or GHG emissions) of process/phase x (transports included).; Etot: the per product unit total energy consumption (or GHG emissions) of the system.

[1] Somewhat more complicated terms taking into account different waste transport modes are used in our calculations.

Life Cycle of plastics



Life Cycle of paper



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- **RECYCLING COST OR BENEFIT**

  - Although the results were assessed to be highly dependant on national specificities and used technology, and the calculated results cannot be taken over in a specific context, some general guiding conclusions can be made.

    In all studies recycling was considered to generally have a benefit over other waste handling options.

    the smaller processing energy consumption of material recycling compared to virgin material processing

    the more efficient valorization of the feedstock energy in recycling compared to other waste handling options

  - The size of the recycling benefit was highy dependant on different process parameters

  - The costs due to the emission of greenhouse gasses: less clear / the case of the paper waste

  - Other parameters

(Key) Issue	Paper	Plastics
Type of material under consideration	X	X
Assumed (marginal) electricity mix	X	X
Differences in energy systems material production	X	X
Substituted fuel upon energy recuperation from waste	X	X
Alternative use of saved wood	X	
Alternative use incineration capacity	X	
Inclusion of carbon sinks	X	
Anaerobic degradation wood waste	X	
High cost virgin material manufacturing and the used technology	X	X
Energy mix used in material manufacturing	X	X
Substitution rate		X
Type of material substituted		X
Recycled material rate	X	X
Degree of contamination of the waste		X
Energy content of the waste		
Recycling rate	X	X
Waste handling of the not recycled fraction	X	X
Transport distance to the recycling plant		X
Material loss rate	X	X
Efficiency of energy recovery from waste	X	X
Type and performance landfill installation	X	

Comparative study on the total energy use of products based on primary versus recycled materials

- **Study continuation**
  - In a second phase, the consequences of recycling for PEC and GWP will be further illustrated by means of specific products:
    - Printing paper
    - PP/PE packaging materials and EPS thermal insulation
  - The ***local product perspective*** (the Belgian and regional situation in Europe)
- **Three steps:**
  - **Scope and aim**
    - Redefinition of the research question, descriptive analysis or change oriented ?
  - **System definition**
    - The system borders (or: « where to stop expanding ? »)
  - **Data gathering**
    - Theoretical sources, but also from practice (industry, government, …)

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- Conclusion before the second phase:
  - Making the results of the first phase public
    - On our web sites: **www.irgt-kint.be** and **www.produitrecycle.info**
  - Gathering comments, suggestions, propositions of taking part in the project…
  - Broadening the discussion

Thank you for your attention !