LIFE CYCLE ASSESSMENT OF AGRICULTURAL RESIDUES UTILIZATION FOR BIOGAS DEPLOYMENT

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Outline

- Introduction
- Aims and Objectives
- Methodology
  - Life Cycle Assessment (LCA)
  - Gabi Software
- Results
- Conclusions

Introduction

- The massive use of fossil fuels on our daily life has led to an increase in the greenhouse gas GHG in the atmosphere and this subsequence affects global warming.
- Production of biogas from agricultural residues, energy craps and municipal waste is becoming increasingly important to reduce the GHG emissions.

Biogas

First generation

- Corn
- Wheat
- soybean

Second generation

- Agricultural residues (corn stover, wheat straw)
- Municipal Waste

Does the emission mitigation of biogas production from agricultural residues; digestate (by-product of a biogas production system) when substitutes the conventional mineral fertilizer is considered as a real environmental issue?

For this research

Life cycle analysis, using Gabi software 4, is a tool have been used to quantify and evaluate the environmental impact of products through all stages in their life cycle.

Aims and Objectives

- To assess, quantify and model the impact that climate change will have on the production of biogas from agriculture residues.

- To undertake the a holistic life cycle environmental assessment of typical biogas production system from agricultural residues with comprehensive digestate utilization as an alternative to mineral fertilizer.

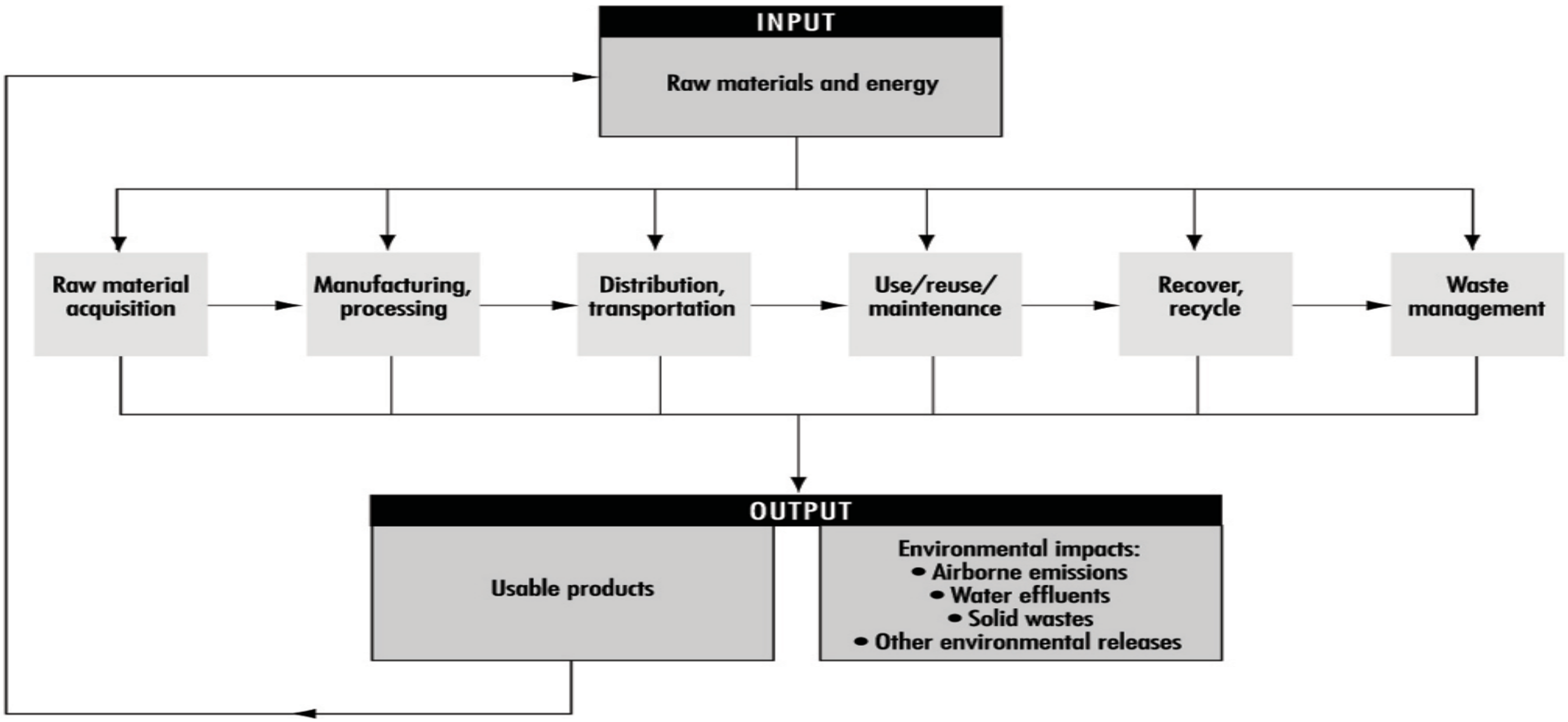
Methodology

Life Cycle Assessment (LCA): Analyses and comparisons of product, process and services according to the ISO standard covering the whole life cycle from the production of raw materials to end of life.

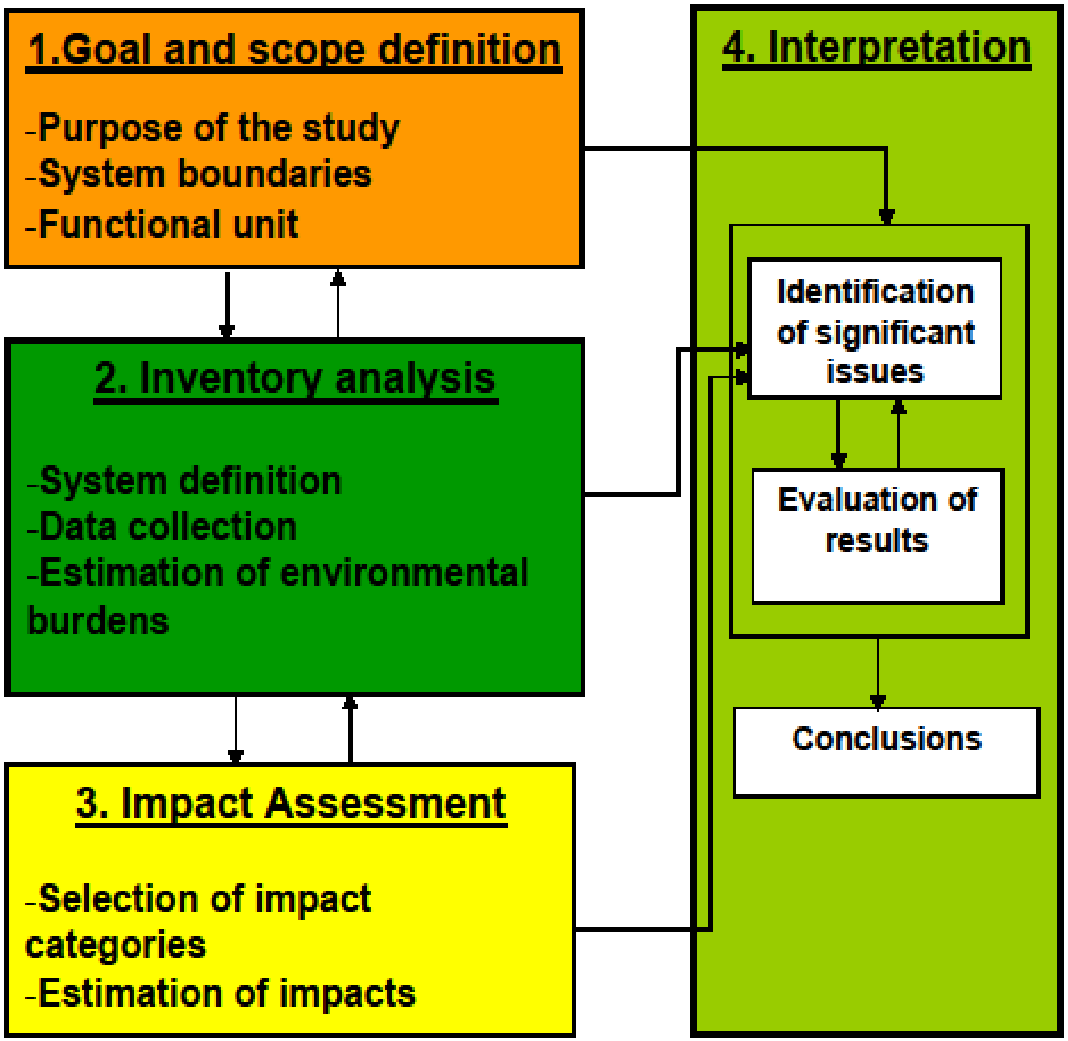
LCA can be used for:

- Carbon Footprint
- Water Footprint
- Critical Review
- Social LCA
- Life Cycle Costing (LCC)

LCA of a Product



LCA methodology: ISO 14044

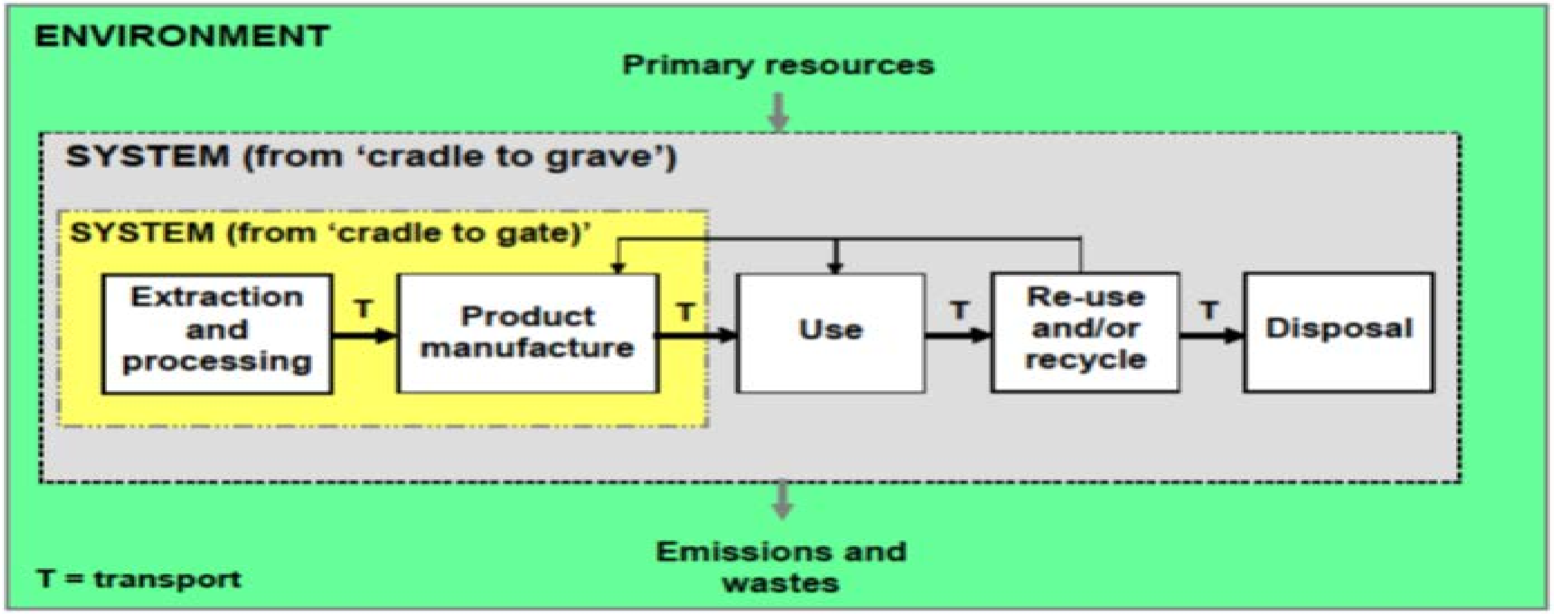


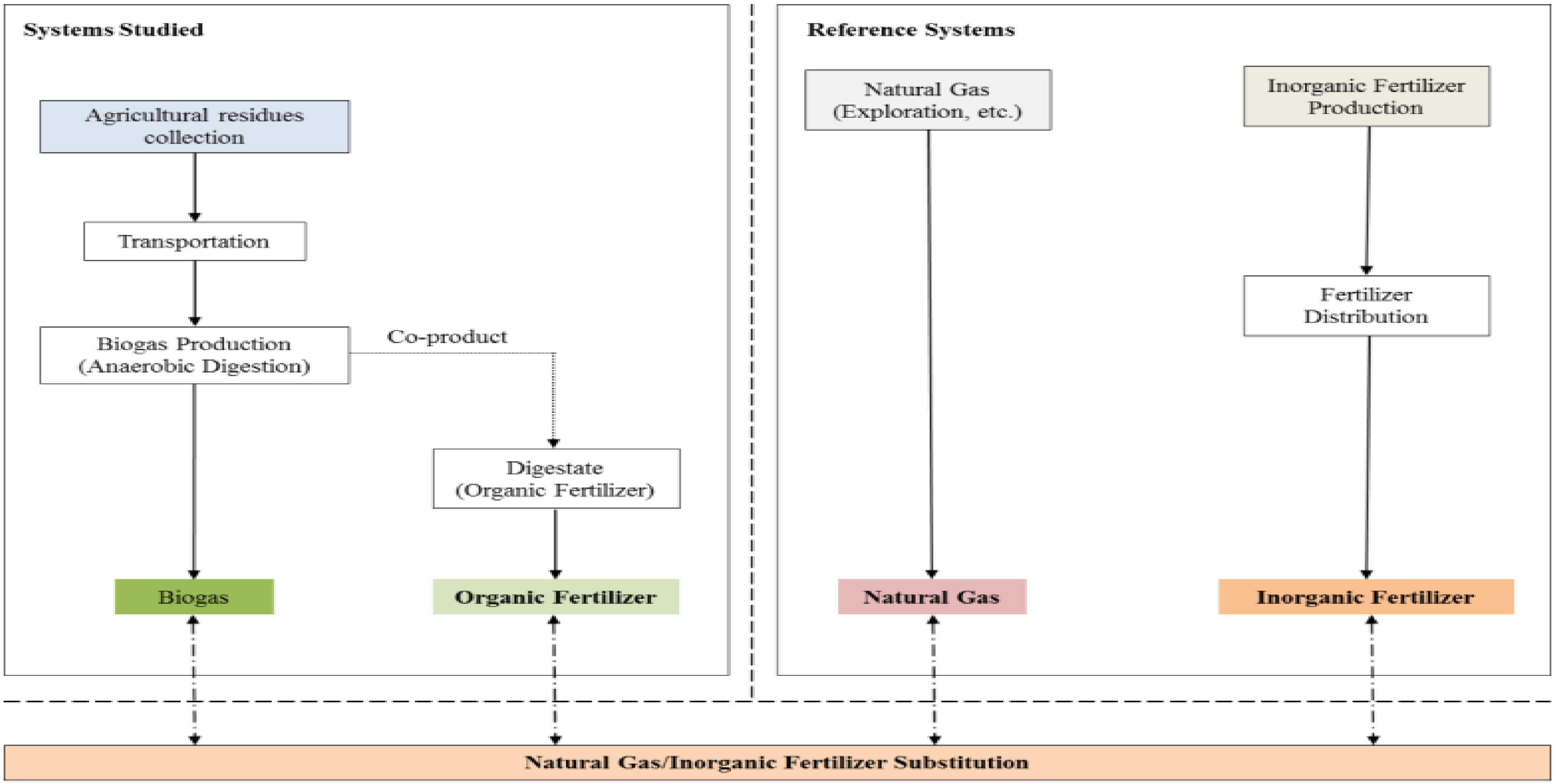
Goal: To assess from ‘‘cradle-to-grave’’ the environmental performance of comprehensive production and utilization of biogas and digestate from agricultural residues

The **scope** of the assessment (Life Cycle Inventory – LCI) include impacts and credits occurring during residue collection, transportation of residue, conversion of residue to biogas in an anaerobic digestion plant, and the use of the biogas and digestate to substitute conventional natural gas and mineral (chemical) fertilizer, respectively.

System Boundary:

Covers all the phases from agricultural residue collection from the field to the final utilisation of biogas to produce energy.





Scheme of the system boundary for the collection of agricultural residues for the production of biogas for bioenergy.

Functional unit

The functional unit used for evaluating the environmental performance of the biogas production system is: 1 ton of dry residue input from common agricultural crops including maize, millet, sorghum, rice and wheat.

Agricultural residues collection, at farm

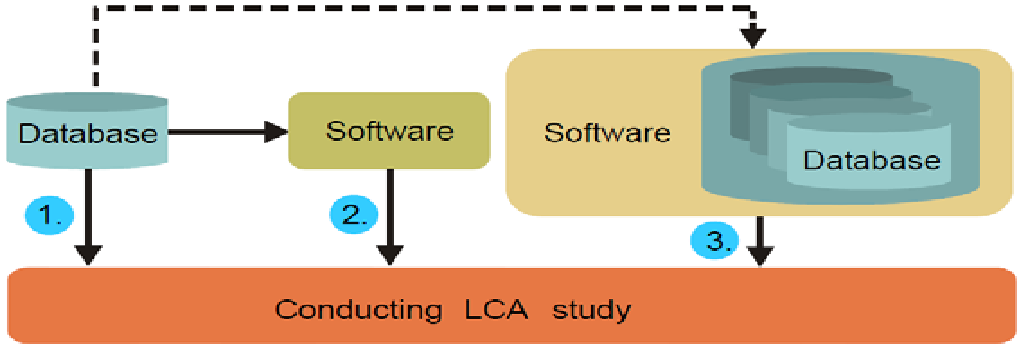
Inputs	**Amount**	**Unit**
Baling [work processes]	5.7143	pcs.
Loading bales [work processes]	5.7143	pcs.
Transport, lorry 20-28t, fleet average [Street]	0.7716	tkm
Outputs		
Residue, at farm [plant production]	1000	kg

Biogas anaerobic digestion process, at plant

Inputs	Amount	Unit
Anaerobic digestion plant covered, agriculture [fuels]	4.82E-04	pcs.
Electricity, low voltage, at grid [supply mix]	301.94398	MJ
Residue, at farm [plant production]	1000	kg
Transport, lorry 3.5-20t, fleet average [Street]	27.276	tkm
Treatment, sewage grass refinery, to wastewater treatment, class 3 [wastewater treatment]	6.0949	m^3
Heat, natural gas, at boiler condensing modulating >100kW [heating systems]	393.53	MJ
Outputs		
Biogas [Biomass fuels]	595.2	kg
Digested matter from agricultural anaerobic digestion [organic fertiliser]	989.0	kg

What is Gabi Software?

is an LCA creation tool, it automatically tracks all material, energy, and emissions flows, giving instant performance accounting in hundreds of environmental impact categories



The biogas production system is modelled using LCI data from the ecoinvent database (Ecoinvent v2.0) (Ecoinvent 2007) in the commercial GaBi 4 LCA software (Eyerer 2006).

Key assumptions

- Baling operation with the bale size of about 1.4 m^3, 700 kg on dry basis is assumed.
- A transportation distance of 100 km radius from farm to the processing plant is assumed in the assessment.
- The baled residue is loaded and transported (delivered) from the farm to the anaerobic digestion plant using 20-28 ton heavy-duty diesel vehicles.
- The LCA was done based on the guidelines for LCA according to ISO 14040:2006/14044:2006 (ISO 2006). The system boundary of this LCA is cradle-to-grave (residue collection, transportation, biogas production and distribution, and use).
- The CML method (Guinee *et al.,* 2001) developed by the Centrum for Milieukunde in Leiden, Netherlands (CML) was chosen to assess inventory flows.

Results

The results of the analysis per functional unit (1 ton of agricultural residue processed) for ADP, AP, EP, GWP, ODP, HTP, POCP, FAETP and TETP are depicted in Table 1 (next slide).

▪ ADP	Abiotic Depletion Potential
▪ AP	Acidification Potential
▪ EP	Eutrophication Potential
▪ FAETP	Freshwater Aquatic Ecotoxicity Potential
▪ GWP	Global Warming Potential
▪ HTP	Human Toxicity Potential
▪ ODP	Ozone Layer Depletion Potential
▪ POCP	Photochemical Ozone Creation
▪ TETP	Terrestrial Ecotoxicity Potential

Environmental emissions saving for biogas production and utilization from 1 ton agriculture residues

Impact Category	Unit	Amount
ADP	kg Sb-Equiv.	-44.9338
AP	kg SO_2-Equiv.	-16.9939
EP	kg Phosphate-Equiv.	-1.92822
GWP	kg CO_2-Equiv.	-10329.4
ODP	kg R11-Equiv.	-0.0007
HTP	kg DCB-Equiv.	-2695.38
POCP	kg Ethene-Equiv.	-1.43929
FAETP	kg DCB-Equiv.	-73.0778
TETP	kg DCB-Equiv.	-55.5836

- The results revealed that there is a huge potential savings could be obtained per ton of dry agricultural residues. The result shows that per ton of dry agricultural residues, GWP yielded the highest reduction (i.e., 10329 kg CO_2-Equiv.), followed by HTP (i.e., 2696 kg DCB-Equiv.).

- Similarly, the results showed that agricultural residues based biogas resulted in substantial net reduction ADP, AP, EP FAETP, and TETP i.e., reducing around 44.93 kg Sb-Equiv., 17 kg SO2-Equiv., 1.9 kg Phosphate-Equiv., 73 kg DCB-Equiv., and 55.6 kg DCB-Equiv. per ton of dry agricultural residues, respectively.

- If any government was to commit to a policy and incentive (for the domestic production of biogas), that would initiate and facilitate the development of biogas production from agricultural residues, and that would help substantially in climate change mitigation.

Conclusion

An LCA of agriculture residues utilization for biogas production revealed that agricultural residues utilization for biogas production would lead to high environmental benefits in terms of ADP, AP, GWP, EP, HTP, ODP, FAETP, and TETP.

Acknowledgment

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Thank you for listening!

Questions ???

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