



From Animal Wastes Towards Green Fuels: A Sustainability Assessment

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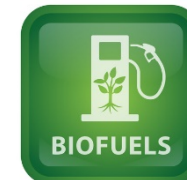
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Presentation Outline

- Biofuels
- «FatFuel» ➤ Animal wastes upgrading towards high specification green fuels production
- Environmental assessment of green fuels production via animal wastes catalytic hydrotreatment (Well-to-Tank Analysis, WTT)
 - Life Cycle Assessment (LCA)
 - » Methodology
 - » Results
 - » Conclusions



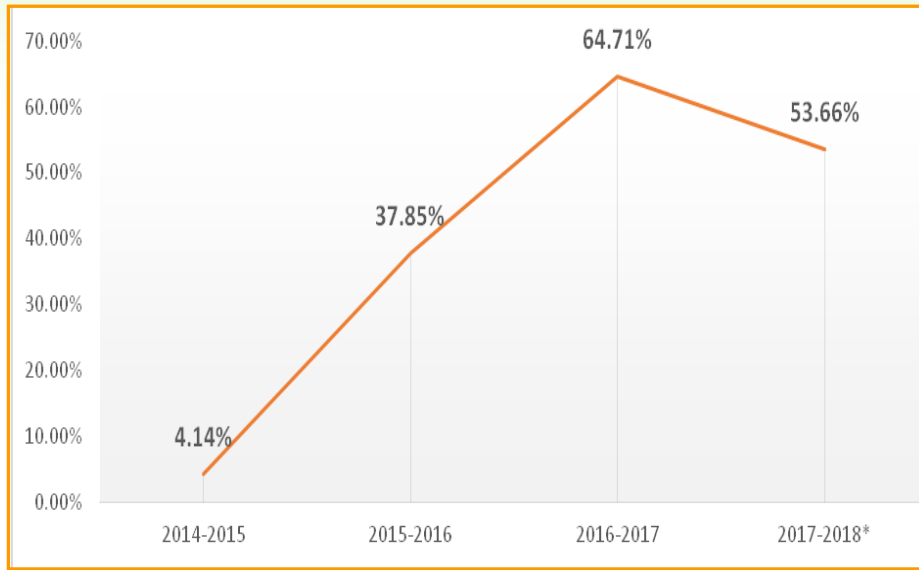


- Fossil resources depletion ↪ alternative energy resources
- Biodiesel 1st generation (Fatty Acid Methyl Esters, FAME)
 - Energy crops cultivations «Food-Versus-Fuel»
 - Residual Biomass Valorization ↪ renewable transportation fuels
 - » Fuels from waste (cyclic economy): waste cooking oils, agricultural/municipal wastes
 - » **Animal Wastes** ↪ valuable low-cost residual feedstoc

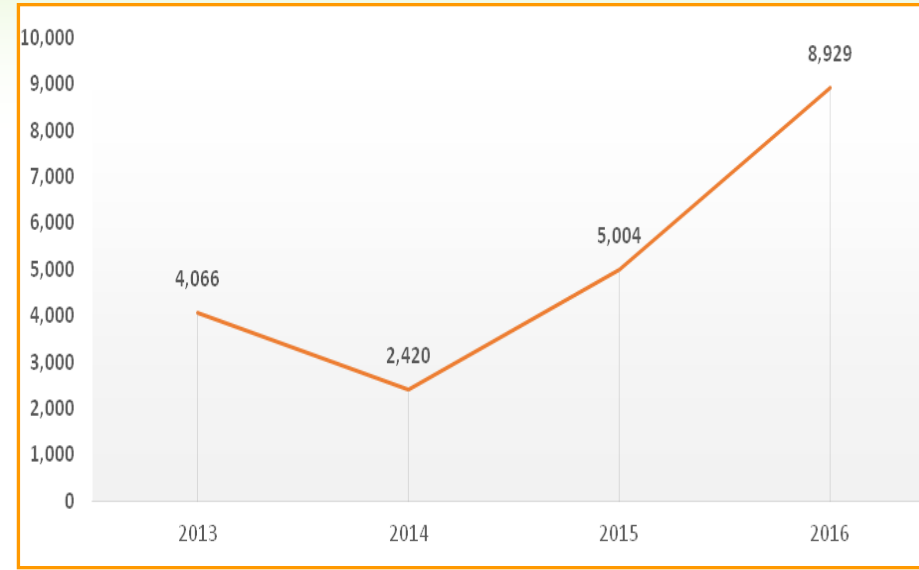




Animal Wastes Availability



Animal wastes annual quantities (tn)



Animal wastes utilization → biodiesel production via transesterification

EU : 800 thousand tons animal fats were used as feedstock for biofuels production (2019)



FatFuel : Green Fuels Production via Animal Wastes Catalytic Hydrotreatment



Small-scale catalytic hydrotreatment pilot unit



HDT



Animal Wastes

Green Fuels

Properties	Units	Green Fuel	Market Diesel EN 590	Paraffinic fuels EN 15940
Density	g/ml	0.787	0.820-0.845	0.765-0.8
Viscosity (40°C)	cSt	3.29	2-4.5	2-4.5
S	ppm	4.2	<10	<5
Oxidation stability	H	>44	>6	>20
Cetane Index	-	79.3	>46	>70
Flash point	°C	126	>55	>55
Net heating value	MJ/kg	44.4	~43	~43
H ₂ O	wt%	0.005	<0.02	<0.02
Total Acid Number (TAN)	mg KOH/g	0	~0.5	-

* Dimitriadis, A, Chryssikou, L. Bezergianni. S. Scale up hydrotreatment of animal fats experimental data for green transportation fuels from TRL3 to TRL5 plant (in preparation)

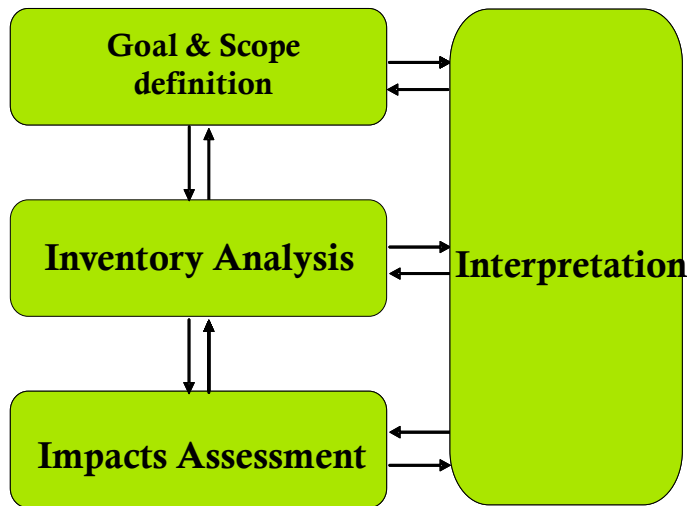


Life Cycle Assessment (LCA)

Technique assessing environmental aspects associated with a product over its life cycle

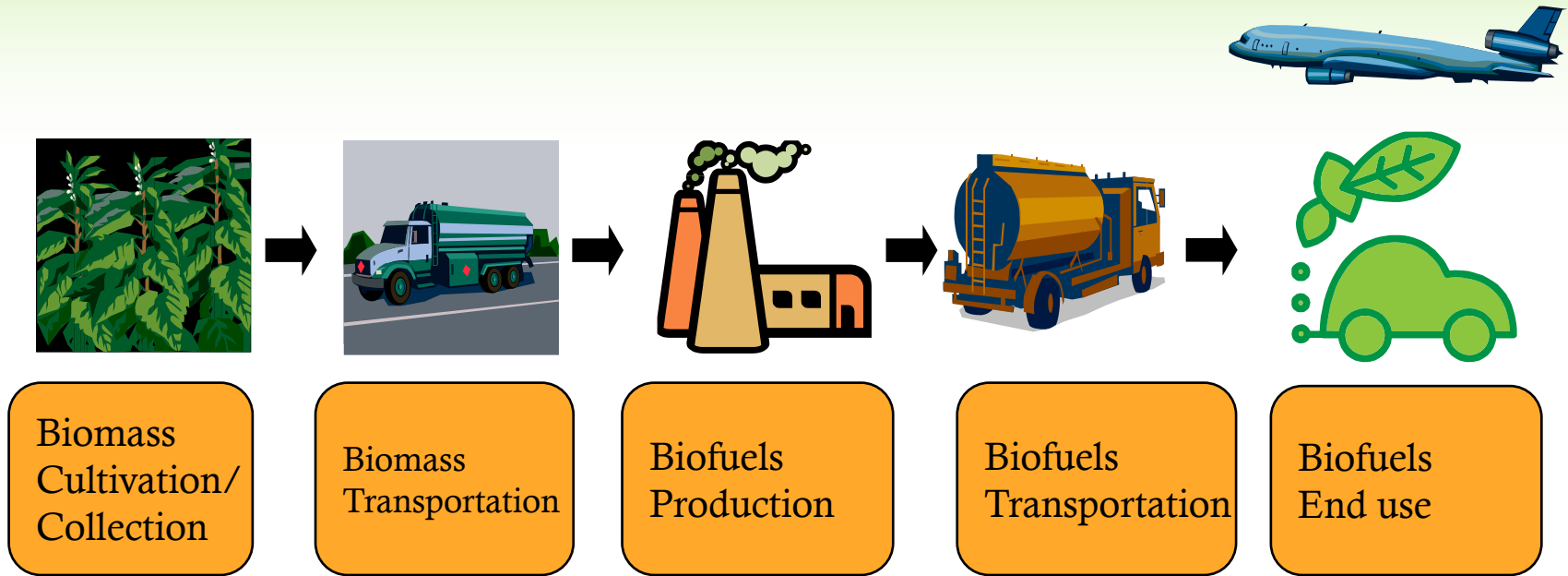
- contribution analysis of the life cycle stages to the overall environmental load → process improvements to low carbon emissions
- comparison between products for internal use

LCA Framework



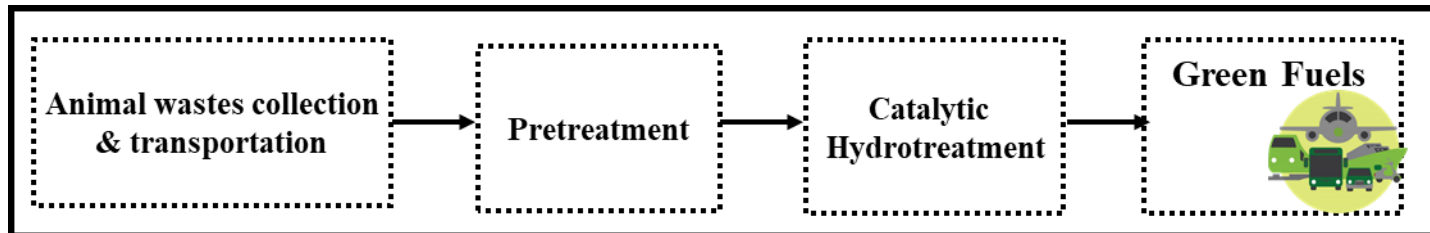


LCA & Biofuels





Environmental characterization of green fuels production via animal wastes catalytic hydrotreatment in terms of GHG emissions



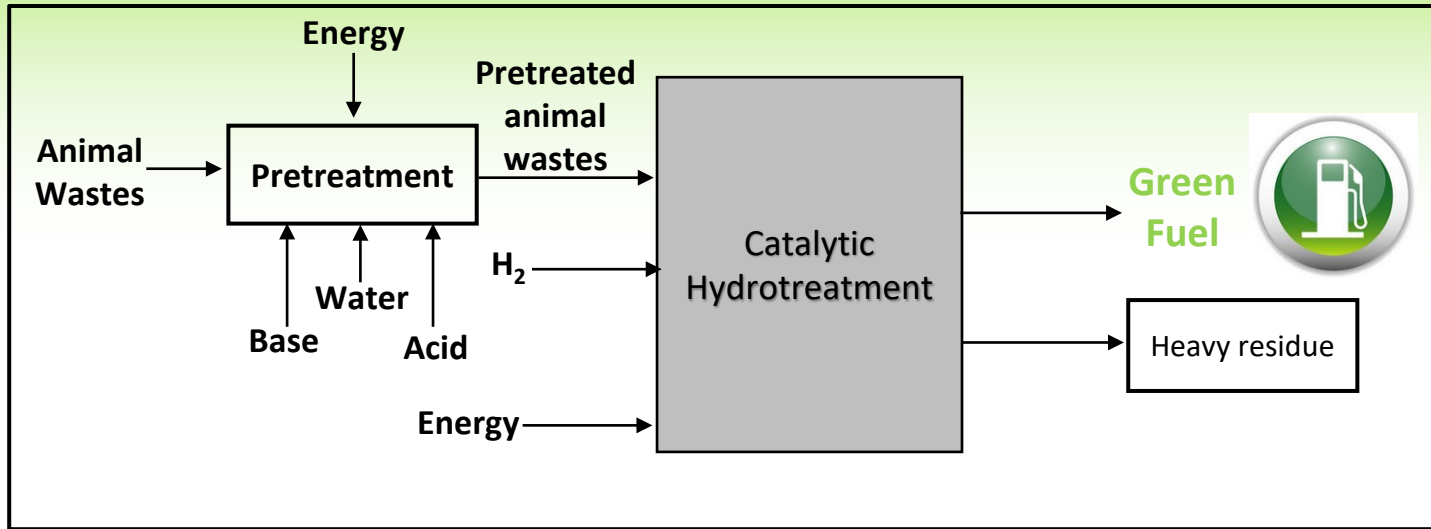


- Inventory data
 - Experimental & literature data
 - Process Simulation (Aspen Plus V11)
 - GEMIS 5.0
- Impacts evaluation
 - Global Warming Potential (GWP, CO₂-eq)
- Results interpretation



LCA Framework (2/4)

System boundaries



System boundaries production's process

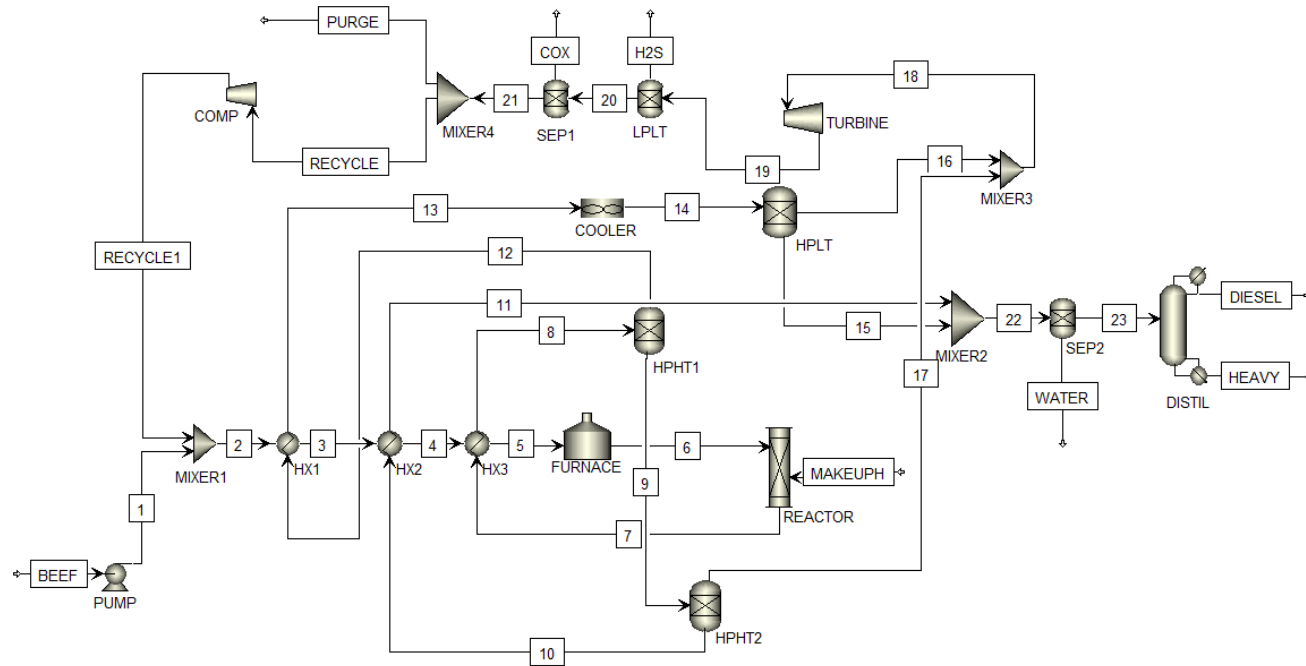
Technical reference:

- Annual capacity hydrotreatment unit:
 - 13500 t (320 operation hours)
- Functional unit:
 - 1 m³ green fuel
- Negligible impacts:
 - animal wastes collection & transportation
 - construction, installation, decommissioning etc.



LCA Framework (3/4)

Process Simulation



Flow diagram of the animal wastes catalytic hydrotreatment

- Aspen Plus model input data:
 - Flow rates calculation
 - Appropriate equipment selection
 - Stream properties determination



Inventory data based on Aspen simulation results

Inputs	Unit	Value
Animal Fats	m/m ³ biofuel	0.98
Energy		
Electricity	kWh/m ³ biofuel	18.7
Fuel gas	kWh/m ³ biofuel	2.96 10 ⁻⁵
H ₂	kg/m ³ biofuel	19.99
Outputs		
Biofuel	m/m ³ biofuel	0.89

● Assumptions

- Greek electricity grid
- data quantification based on total liquid product hydrotreating unit
- hydrotreating catalysts' production GHG emissions production negligible



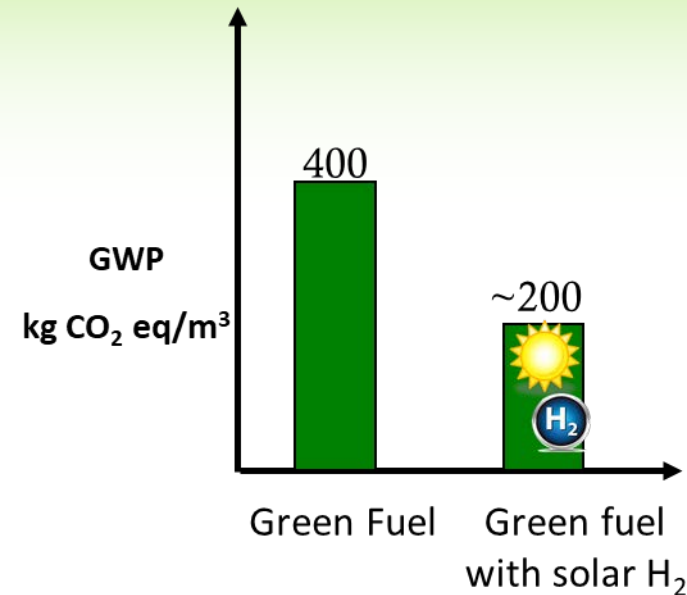
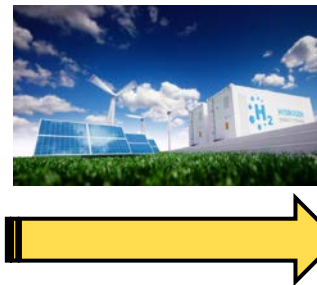
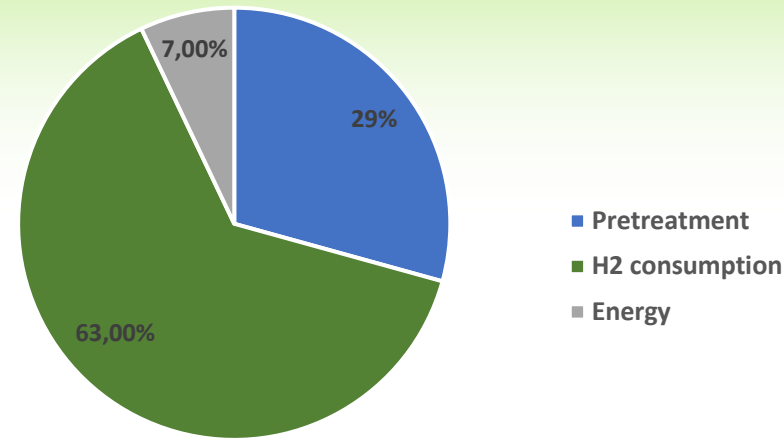
Process stage	kg CO ₂ eq /m ³
Pretreatment	121.39
Catalytic hydrotreatment	
Electricity	28.32
Fuel gas	7*10 ⁻⁷
H ₂	283.25
Total	404.64



Residual feedstock valorization via hydrotreating \Rightarrow potential favorable environmental production process with low emissions

Biofuels production via lipids transesterification:
~320-450 kg CO₂-eq/m³





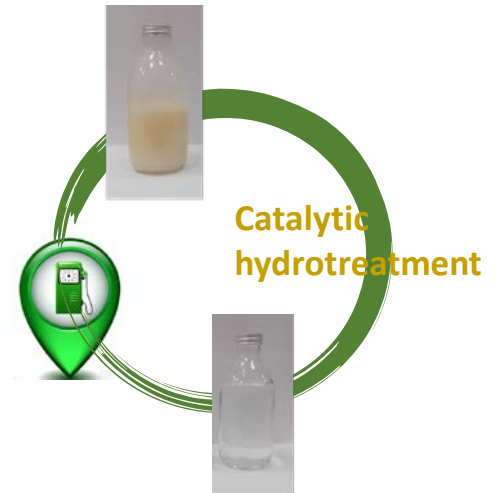
Process contribution to the total GWP of the production process

Renewable H₂ integration → GHG emissions reduction
 Animal wastes → promising residual biomass towards sustainable biofuels production process



Conclusions & Future Work (1/2)

- Environmental assessment of animal wastes upgrading towards green fuels production
 - Well-To-Tank Analysis, WTT
 - » Global Warming Potential, GWP
 - Experimental & literature data
 - Process Simulation (Aspen Plus V11)
 - GEMIS 5.0





Conclusions & Future Work (2/2)

- GHG emissions green fuels production via catalytic hydrotreatment: 404.64 kg CO₂-eq/m³
- H₂ consumption major source GHG emissions ↻ RES H₂ integration
↻ GHG emissions reduction (~200 kg CO₂-eq/m³)
- Animal wastes constitute potential biobased energy resource
- Future research studies ↻ Green Fuels Well-to-Wheel Analysis





Thank you for your attention



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