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LIFE CYCLE ASSESSMENT OF A BIOGAS PLANT WITH BIOMETHANE AS TRANSPORT FUEL FROM PIG MANURE

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LIFE CYCLE ASSESSMENT OF A BIOGAS PLANT WITH BIOMETHANE AS TRANSPORT FUEL FROM PIG MANURE

The following work is a task of the LIFE+ European project named BIOGRID developed with the economic backing of the European Commission:

Biogas injection into the natural gas grid and its use as a vehicle fuel by the upgrading with a novel CO_2 capture and storage technology

LIFE07 ENV/E/00829

www.lifebiogrid.eu

LIFE CYCLE ASSESSMENT OF A BIOGAS PLANT WITH BIOMETHANE AS TRANSPORT FUEL FROM PIG MANURE

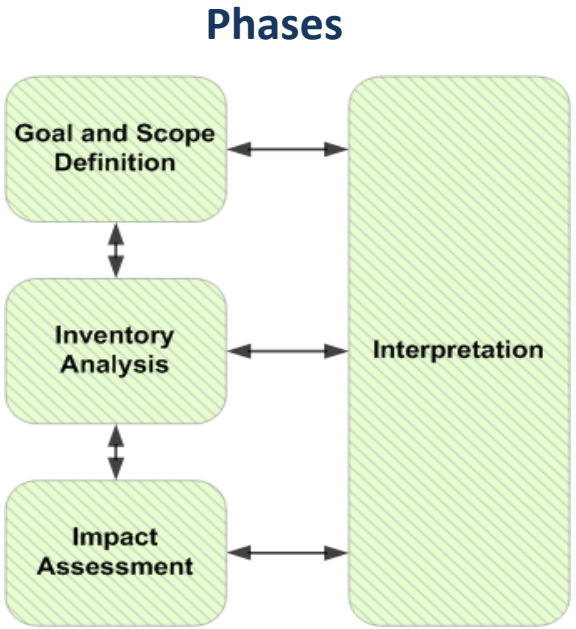
There will be one LCA:

- Biomethane used as transport fuel from pig manure

Following the international regulations:

- ISO14040:2006. Environmental management. Life Cycle Assessment. Principles and framework

- ISO 14044:2006. Environmental management. Life Cycle Assessment. Requirements and guidelines



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LCA Methodology:

- **CML 2001**: defines midpoint categories according to themes
  - Data base: Eco-Invent 2.2
- Impact categories: **=>**
- **RECIPE (2010):** an update of the Eco-Indicator 99 with an endpoint approach

CATEGORY	*REFERENCE*
Global warming potential (Carbon footprint)	**kg CO_2**
Ozone layer depletion	**kg CFC11**
Water acidification	**kg SO_2 eq. or mol H^+**
Water eutrophication	**kg PO_4^{3-} or kg O_2**
Tropospheric ozone formation/Smog	**kg C_2H_4**

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- **Goals:**
  - **To calculate the environmental impact associated with Biomethane as a vehicle fuel from PURINES ALMAZAN biogas production plant.**
  - **To demonstrate the use of the LCA method with the carbon-negative-bioenergy concept, which consists in the combination of the biogas production plant with two carbon capture and storage (CCS) prototype systems.**
- **Scope:**
  - **Biomethane is a naturally occurring gas which is produced by the so-called anaerobic digestion of organic matter. The upgrading of the biogas resulted from anaerobic digestion produces a very high quality biomethane with different types of applications. In this study, the production of CO_2-negative-fuel has been considered.**

	CH_4	CO_2	N_2	CO	O_2
Biogas	66.89%	31.37%	1.46%	0.01%	0.01%
Biomethane 1	92.0%	7.0%	1.0%	---	---
Biomethane 2	95.0%	4.0%	1.0%	---	---
Biomethane 3	96.5%	2.5%	1.0%	---	---

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- **Definition of the functional unit:**
  - ***Generation of 320 Nm^3 of biomethane used as a vehicle fuel.***

- **Data quality indicators:**

Data quality indicator	Parameter
Time period	The life cycle inventory (LCI) is made for the daily average (based on annual data)
Geography	Almazan Biogas production plant
Type of representativeness	Mixed data, data from specific processes, average data from specific processes with similar outputs and theoretical calculations have been used and done. Primary data are collected from the Purines Almazan plant. Eco-Invent database has been used for generic data and environmental impact data.
System boundaries	Cradle to grave analysis with options (refer to “system limits” for detailed explanation)

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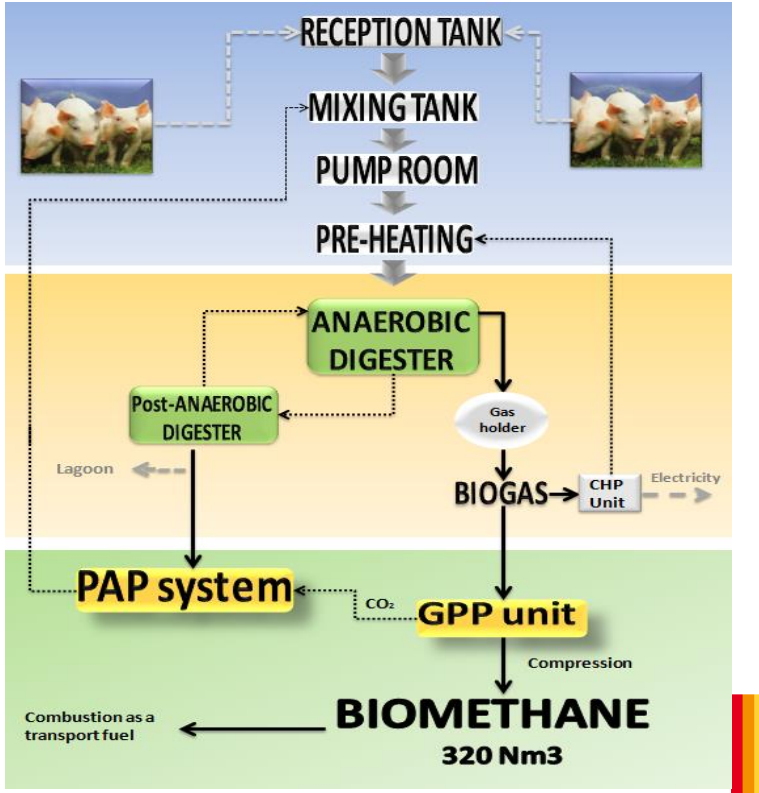
- **System boundaries:**

  - Transport of the manure to the biogas production plant.
  - Material and energy consumption of Pre-treatment (reception tank, mixing tank, pump room and pre-heating) and the digestion process of the manure.
  - Material and energy consumption upgrading the biogas obtained from The Gastreatment Power Package (GPP system) and Pilot Algae plant (PAP system)
  - Biomethane storage at biogas production plant
  - Use stage of the biomethane as biofuel including its combustion emissions.
  - Heat production in the CHP unit (recirculated to pre-heating in a closed loop).
  - CO_2 captured by the manure.



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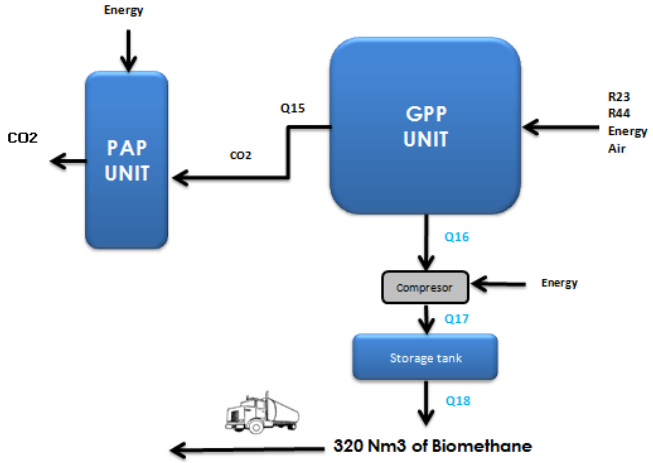
• LIFE CYCLE INVENTORY

- Pretreatment of the manure
- Manure anaerobic digestion
- **Upgrading and use step**



Upgrading			Inventory for 320 Nm³ of biomethane	
Item	Daily data consumption	Unit	Data	Unit
GPP				
Input				
Biogas flow	249,6	m³	**473.3**	**m³**
Electricity consumption	93,9	kWh	**320**	**kWh**
R23 Refrigerant	0.0049	kg	**0.0094**	**kg**
R404 Refrigerant	0.0049	kg	**0.0094**	**kg**
Air	168.0	m³/h	**318.5**	**m³**
Air compressor	4,7	kWh	**8.9**	**kWh**
Output				
Biomethane flow			**298.22**	**m³**
PAP				
Input				
Electricity consumption	10.8	kWh	**17.9**	**kWh**
Water	0.18	m³	**0.30**	**m³**

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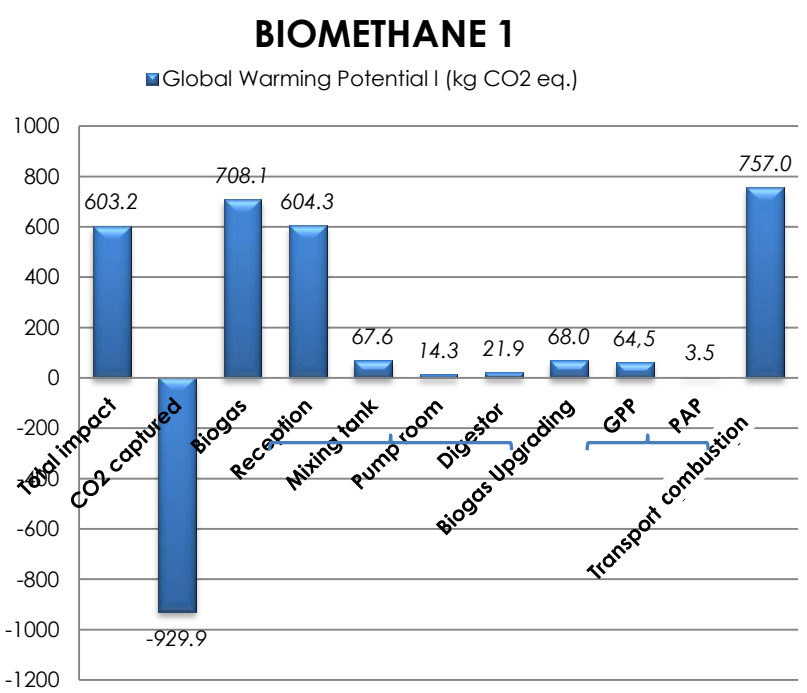
- **ENVIRONMENTAL IMPACT ASSESSMENT**

BIOMETHANE 1	Global Warming Potential I (kg CO_2 eq.)
Total impact	**603.2**
CO_2 captured	-929.9
Biogas	*708.1*
Reception	604.3
Mixing tank	67.6
Pump room	14.3
Digestor	21.9
Biogas Upgrading	*68.0*
GPP	64.5
PAP	3.5
Transport combustion	*757.,0*

-153,8



Other impact categories: ***Acidification (kg SO_2 e), Eutrophication (kg NOx e), Photochemical oxidants (kg ethylene eq), Ozone layer depletion (kg CFC-11 eq), ReCiPe (PT)***

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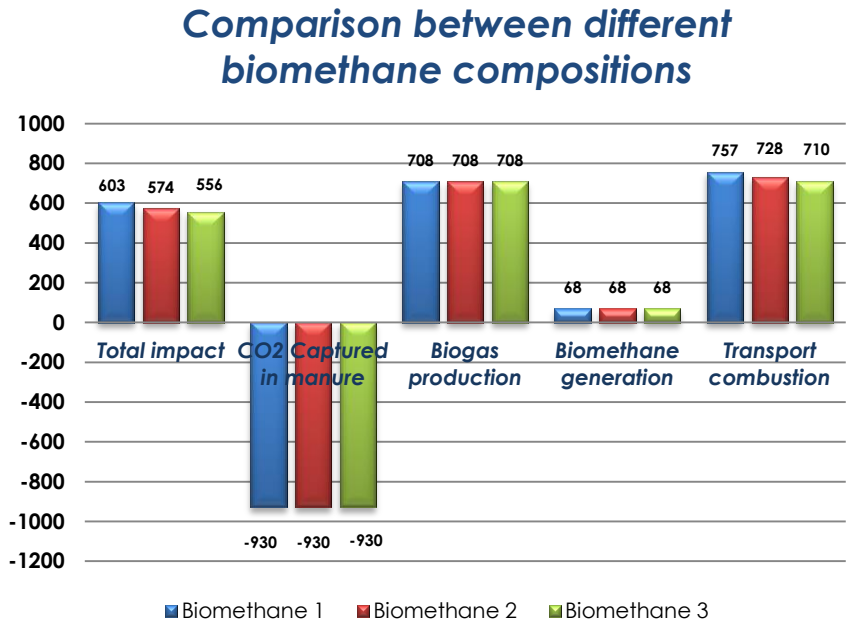
- **ENVIRONMENTAL IMPACT ASSESSMENT**
  Global Warming Potential kg CO_2 eq.



	Biomethane 1	Biomethane 2	Biomethane 3
Total impact	**603.2**	**574.1**	**556.3**
CO_2 Captured in manure	-929.9	-929.9	-929.9
Biogas production	708.1	708.1	708.1
Biomethane generation	68.0	68.0	68.0
Transport combustion	757.0	727.9	710.1

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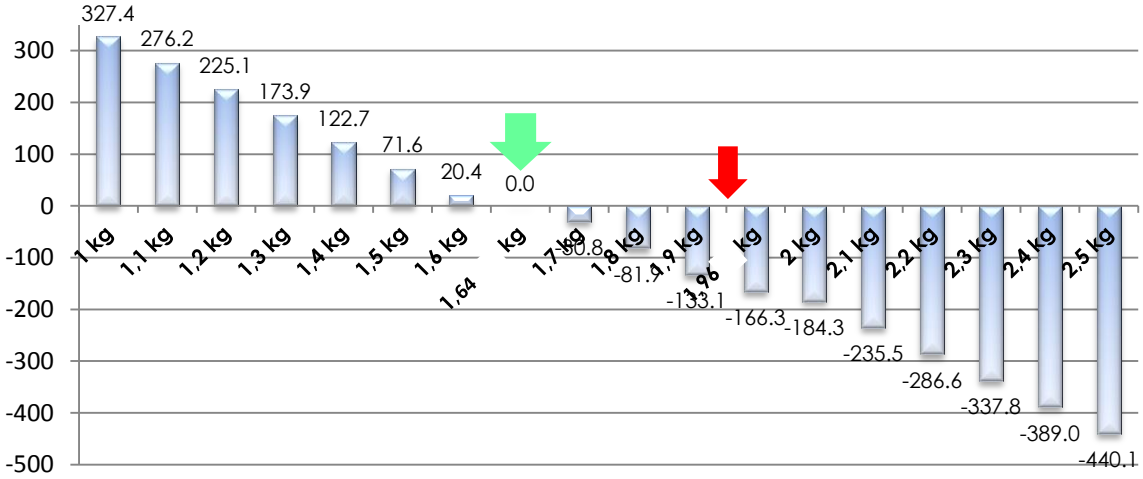
- **SENSITIVITY ANALYSIS:**

  Different CO_2 content in pig manure

kg eq. of CO_2 per 320 Nm^3 of Biomethane generated



The process could be considered neutral in CO_2 emissions when pig manure content is 1.64 (kg/Nm^3) approximately

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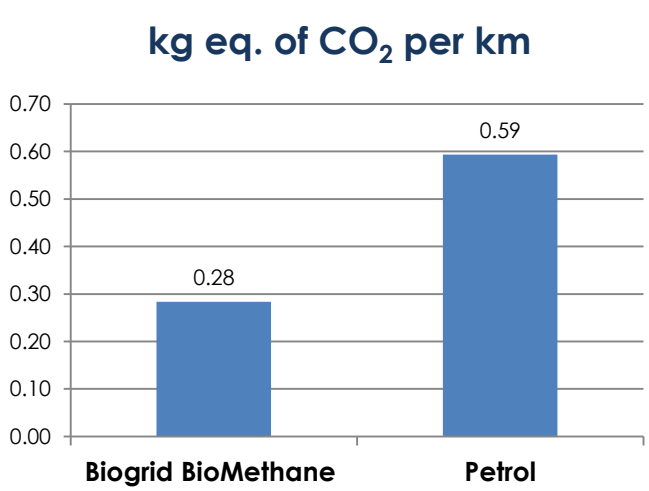
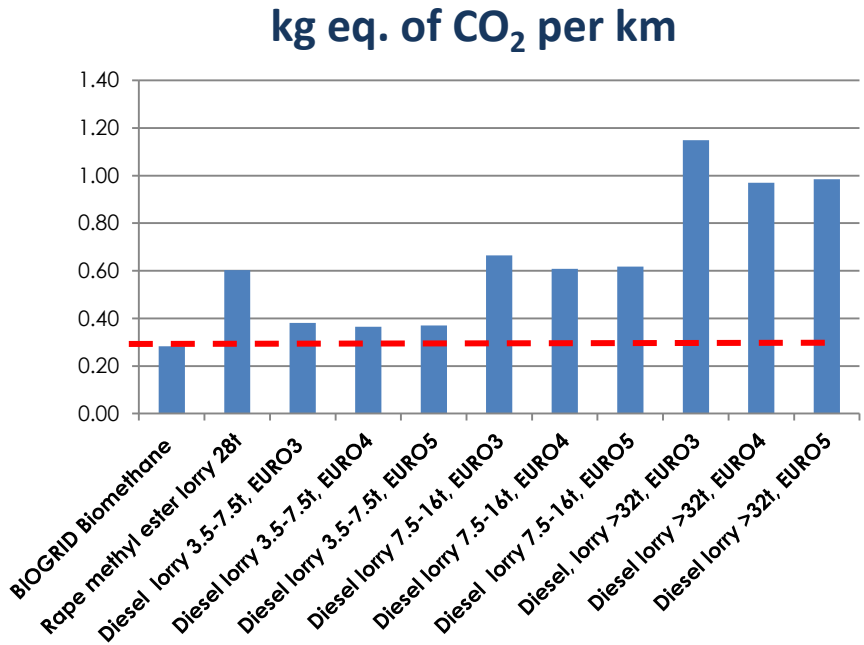
- **COMPARISON BETWEEN DIFFERENT FUELS**

Biomethane vs. Petrol emissions





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• MAIN CONCLUSIONS OF THE STUDY

➢ The stage with the major environmental significance throughout the life cycle of the product under study is the biogas production process with about 90% of the total impact (provided the CO_2 captured is not included), especially if it comes from manure transport which represents 78% of the biogas production stage.

➢ The consumption of electricity during the upgrading of the biogas generated is the main environmental aspect that affects the environmental impact in this module and it represents about 97%.

➢ The use of the Biomethane obtained in the process, represents a huge environmental benefit comparing with other alternative fuels.

➢ Taking manure CO_2 capture into account, the **negative total impact of the biogas production** process and its upgrading means that the manure has captured more CO_2 than the emitted in the consumption processes (as electricity, water, chemical products, etc.). Also, using the PAP system, CO_2 emissions to the atmosphere are avoided by algae sequestration. The rest of the CO_2 that has not been captured is liquefied and stored for different applications such as in the chemical and pharmaceutical industry among others.

➢ The combustion of the entire quantity analysed (320 Nm^3) makes the global impact positive because of its final combustion step.

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