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Greenhouse gases emission in soybean biodiesel life cycle: methylic route x ethylic route

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InLCA/LCM 2006 - Business and Government Moving Ahead

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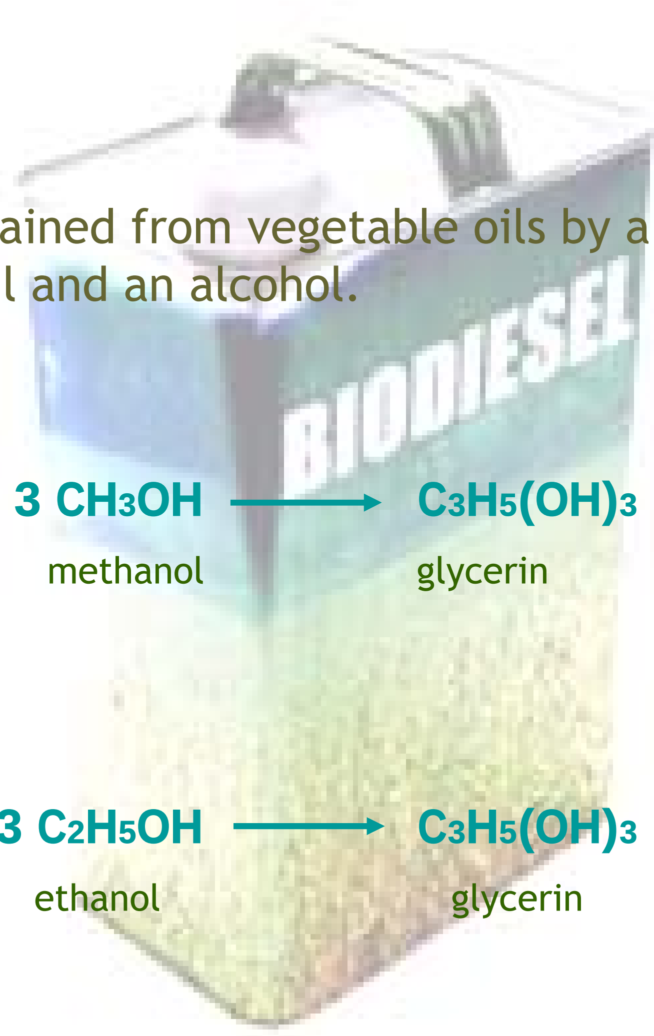
1. Introduction



Biodiesel:

Diesel-like fuels obtained from vegetable oils by a transesterification reaction between oil and an alcohol.

Methylic route:

$$C_3H_5R_3 + 3\,CH_3OH \longrightarrow C_3H_5(OH)_3 + 3\,CH_3R$$

vegetal oil methanol glycerin methyl ester

Ethylic route:

$$C_3H_5R_3 + 3\,C_2H_5OH \longrightarrow C_3H_5(OH)_3 + 3\,C_2H_5R$$

vegetal oil ethanol glycerin ethyl ester

2. Biodiesel in Brazil

- National Biodiesel Production and Use Program - 2004
  - Introduce biodiesel in the Brazilian energetic grid
  - environmental, economic and social approach

- Federal Law 11097 - 2005

  2005 – 2007: approved an addition of 2% biodiesel to diesel

  Potential market: **800 million L/year**

  2008 – 2012: incite an addition of 2% biodiesel to diesel

  Safe market: **1,000 million L/year**

  after 2013: incite an addition of 5% biodiesel to diesel

  Safe market: **2,400 million L/year**

2. Biodiesel in Brazil

- 3 industrial sites of biodiesel production in Brazil

Soyminas Biodiesel:

Site: Cassia (MG)

vegetal raw material: sunflower

Production: 12,000 m^3/yr - 40% of installed capacity

Agropalma:

Site: Belém (PA)

vegetal raw material: waste of palm oil

Production: 24,000 m^3/yr – technology: partnership with UFRJ

Biolix:

Site: Rolândia (PR)

vegetal raw material: soybean and sunflower

Production: 9,000 m^3/yr – experience with buses from municipal district

3. Greenhouse gases emission in soybean biodiesel life cycle: methylic route x ethylic route

3.1 Methodological Requirements

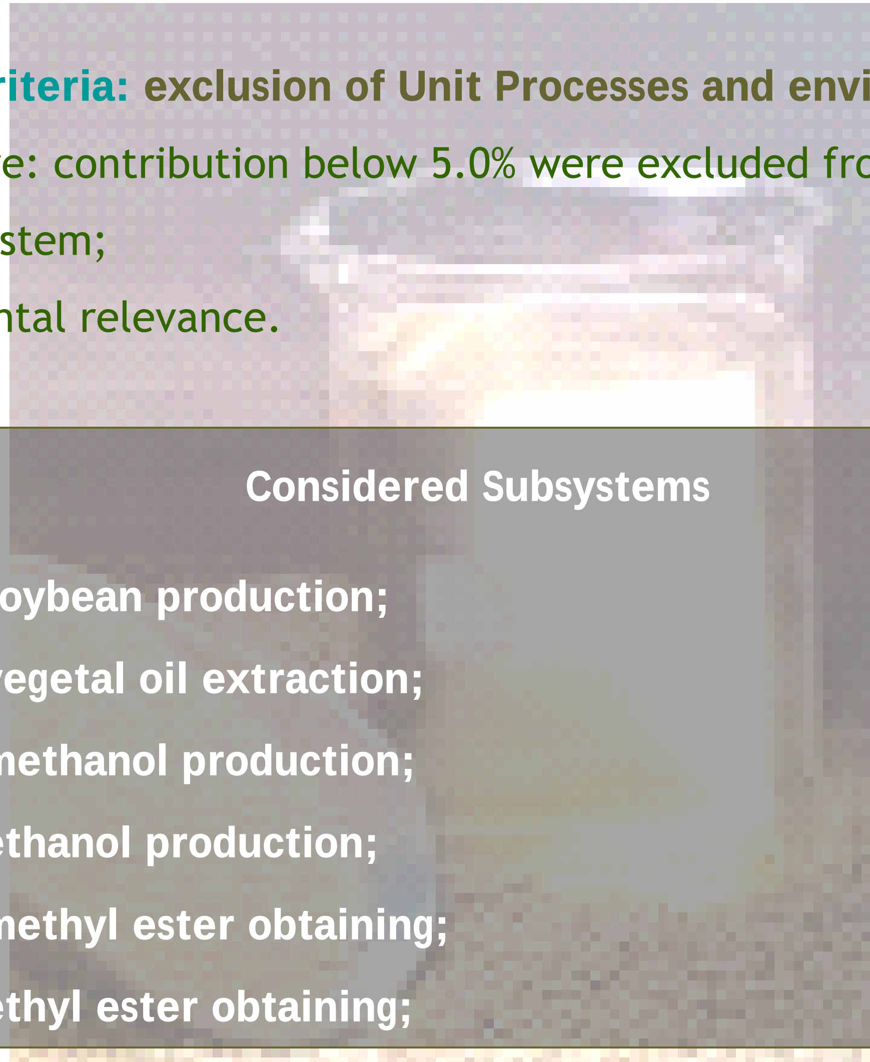
Objective - to conduct an streamline to compare the environmental performance in terms of greenhouse effects (CO_2, CH_4 and N_2O) from methylic and ethylic routes of biodiesel production

Function - to generate energy for internal combustion engines

Functional Unit – to generate 1000 MJ of energy for internal combustion engines

Scope – cradle to gate approach

3.2 Boundaries Refining



- **Exclusion Criteria: exclusion of Unit Processes and environmental loads**
  - quantitative: contribution below 5.0% were excluded from the product system;
  - environmental relevance.

Considered Subsystems

- soybean production;
- vegetal oil extraction;
- methanol production;
- ethanol production;
- methyl ester obtaining;
- ethyl ester obtaining;

3.3 Material Balances

Ethylic Route

High Heat Value: 33.30 MJ

Process: Transeterification

Yield (vegetal oil to biodiesel): η = 94.3%

Biodiesel density: ρ = 0.8803 kg/L

Biodiesel production: B100 = 26.44 kg

Methylic Route

High Heat Value: 32.66 MJ

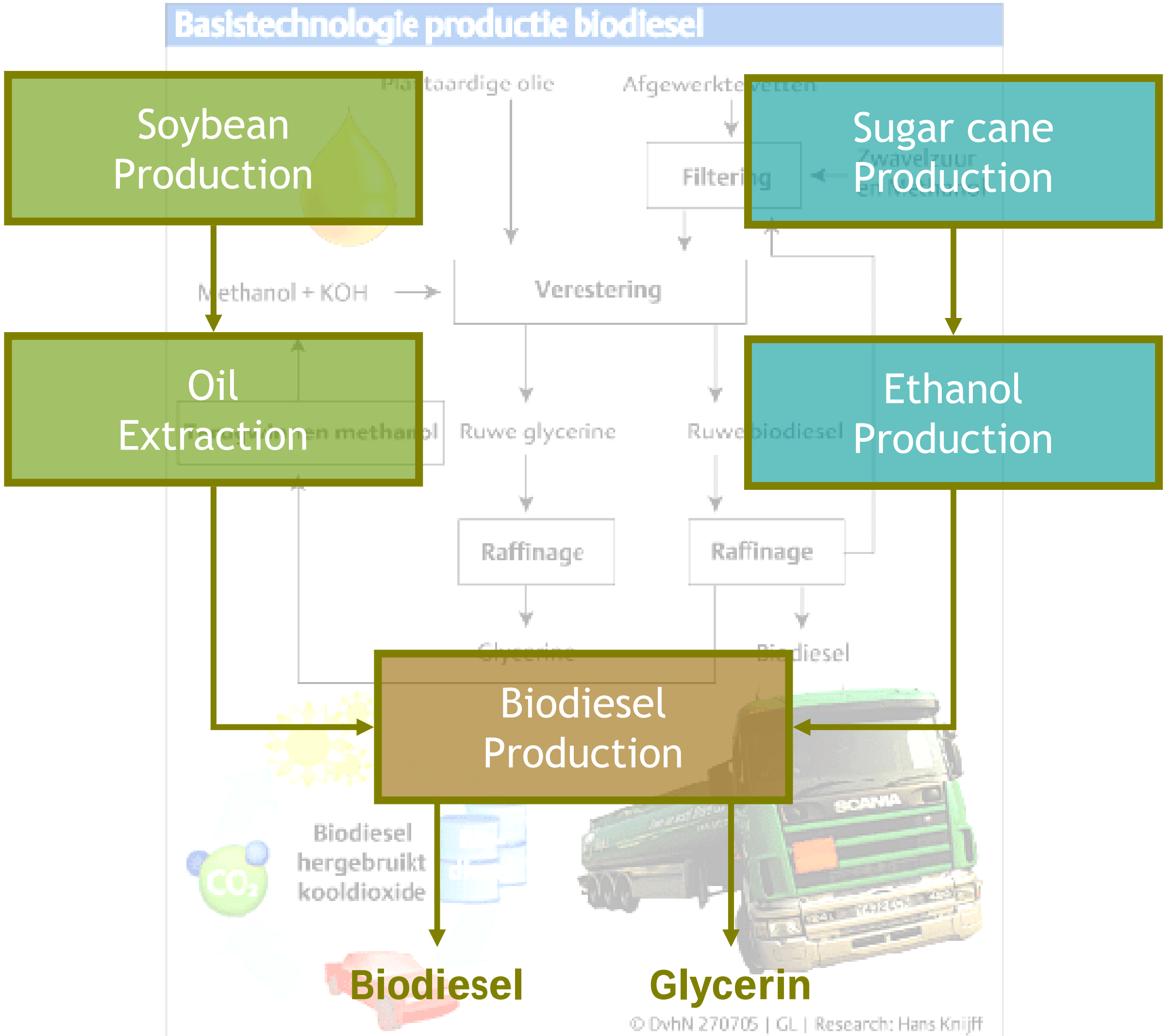
Process: Transeterification

Yield (vegetal oil to biodiesel): η = 97.5%

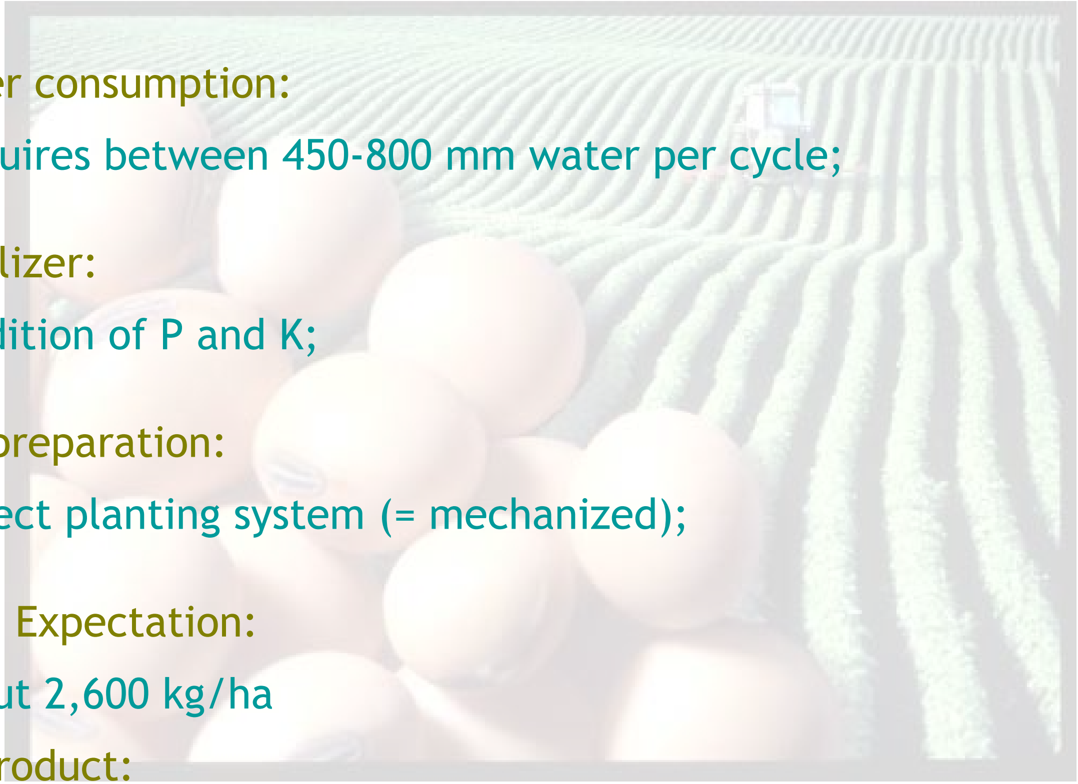
Biodiesel density: ρ = 0.8695 kg/L

Biodiesel production: B100 = 26.62 kg

3.4 Product System – Ethylic Route



Soybean Production



- Maturation cycle:
  - 129 ± 7 days;
- Water consumption:
  - requires between 450-800 mm water per cycle;
- Fertilizer:
  - Addition of P and K;
- Soil preparation:
  - Direct planting system (= mechanized);
- Yield Expectation:
  - about 2,600 kg/ha
- Co-product:
  - soy oil

Vegetal Oil Extraction

- Technological Route:

  - extraction with steam and solvent (hexane)

- Unit Process:

  - soybean receiving and storage;
  - seeds preparation;
  - oil extraction;
  - oil degumming;
  - solvent recovery

- Co-products:

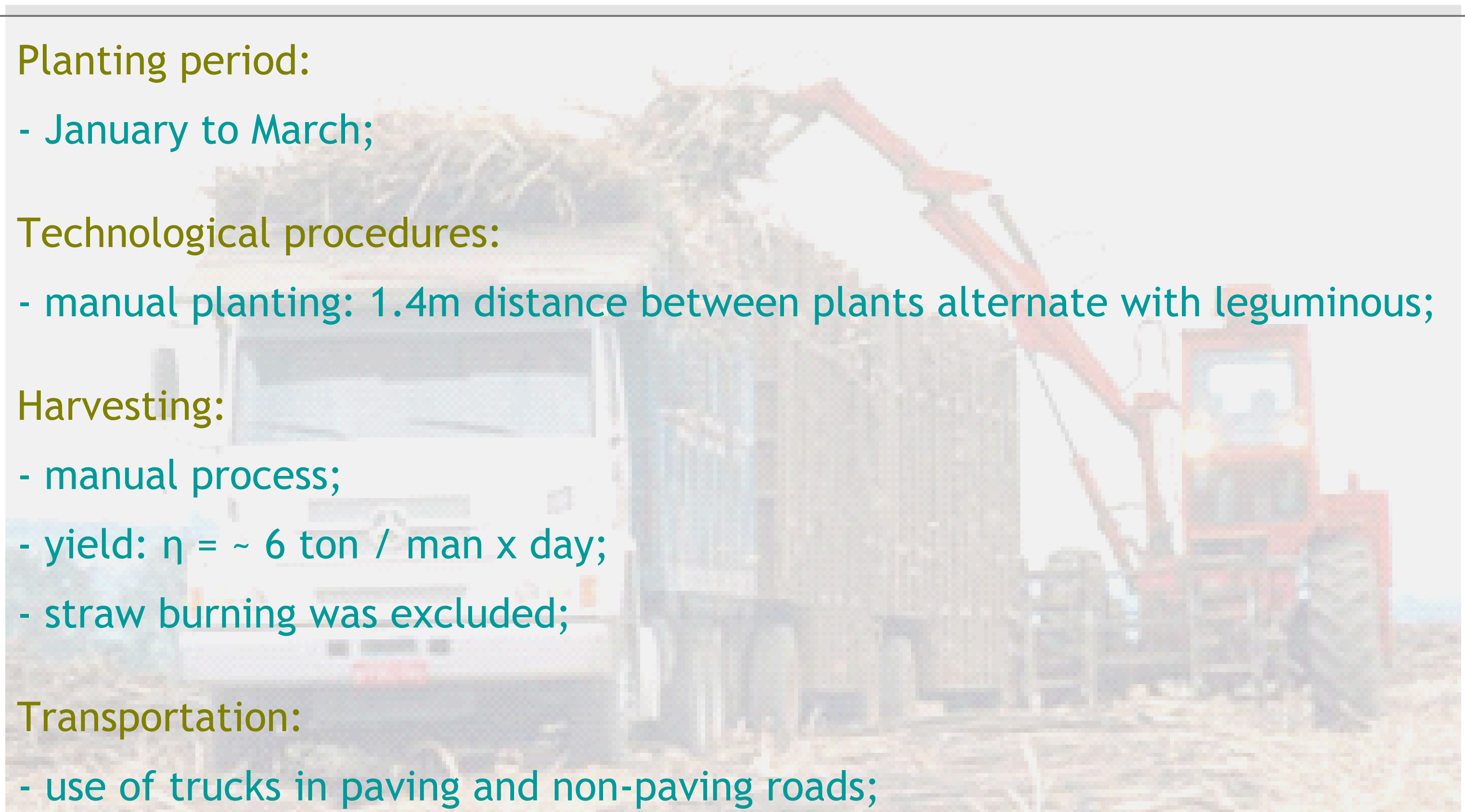
  - soy meal;

- Allocation:

  - Mass Criteria:

    meal **82%** and oil **18%**

Sugarcane production



- Planting period:
  - January to March;
- Technological procedures:
  - manual planting: 1.4m distance between plants alternate with leguminous;
- Harvesting:
  - manual process;
  - yield: η = ~ 6 ton / man x day;
  - straw burning was excluded;
- Transportation:
  - use of trucks in paving and non-paving roads;

Ethanol Production

- Process steps:

  - sugarcane washing, cutting and crushing;
  - bagasse burning: thermal and electric energy;
  - soup fermentation: **Melle – Binot Process** (*Saccharomyces cerevisae)*
  - distillation and alcohol rectification

- Yields:

  - 1 ton sugarcane $\simeq$ 68kg ethanol (0.1 – 0.7% water);

- Premise:

  - CO_2 emission from bagasse burning was considered its suppose that this amount is going to be absorbed by other plants;

- Co-products:

  - fusel oil: residual amount

Soybean Ethylic Ester obtaining

- Technological Route:

  - alkaline transesterification with NaOH: it was considered the production of NaOH by mercury cell route)

- Methanol amount:

  - to achieve high efficiency in the transesterification its necessary a ratio of 6:1 from methanol to vegetal oil;

- Complementary steps:

  - ethanol recovery and biodiesel purification;

- Yields:

  - η = 94.3% (oil to biodiesel)

- Co-products:

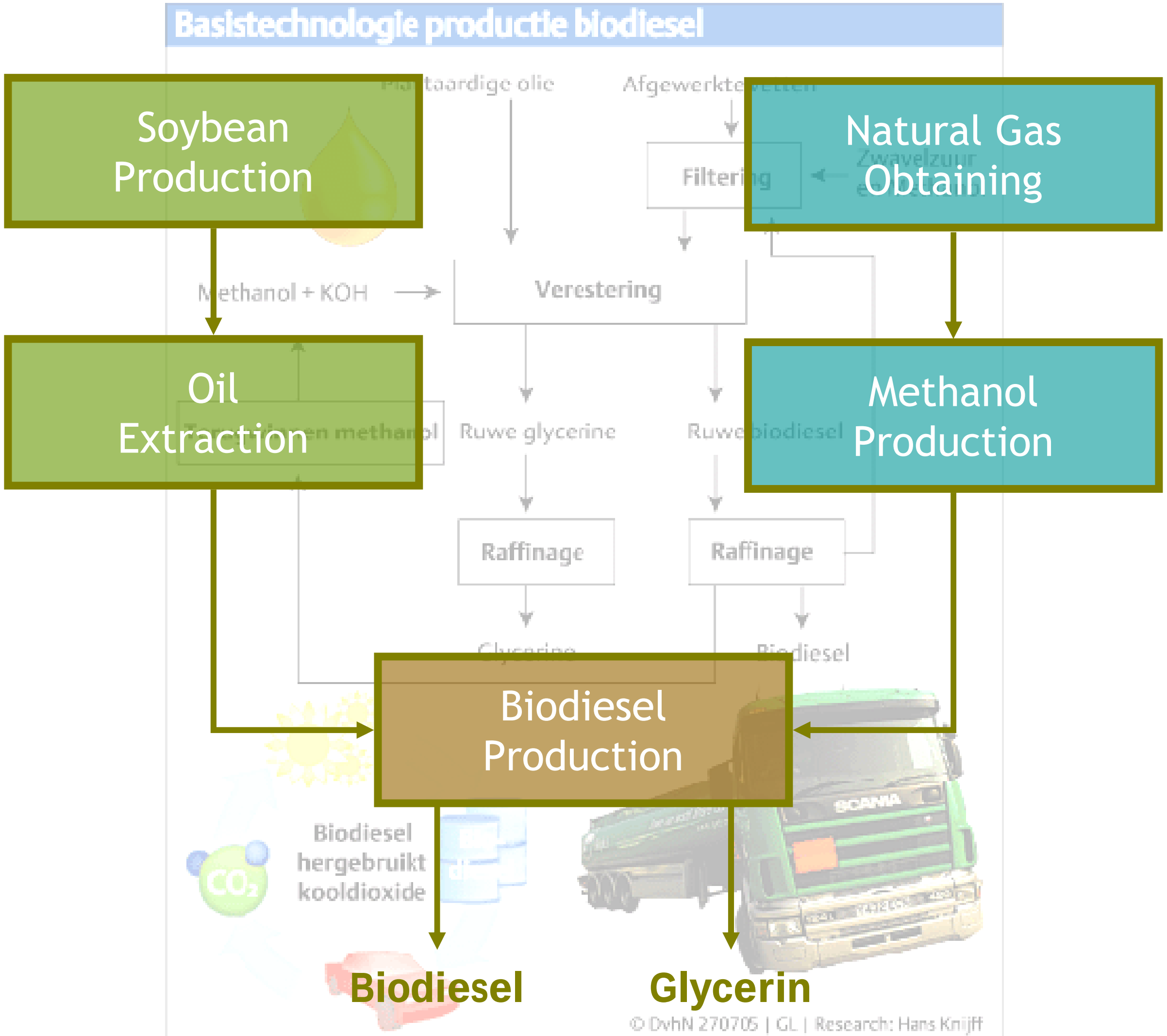
  - Glycerin

- Allocation:

  - Mass Criteria:

    biodiesel **91%** and glycerin **9%**

Product System – Methylic Route



Natural Gas Obtaining

- Crude Natural Gas sources modeling:

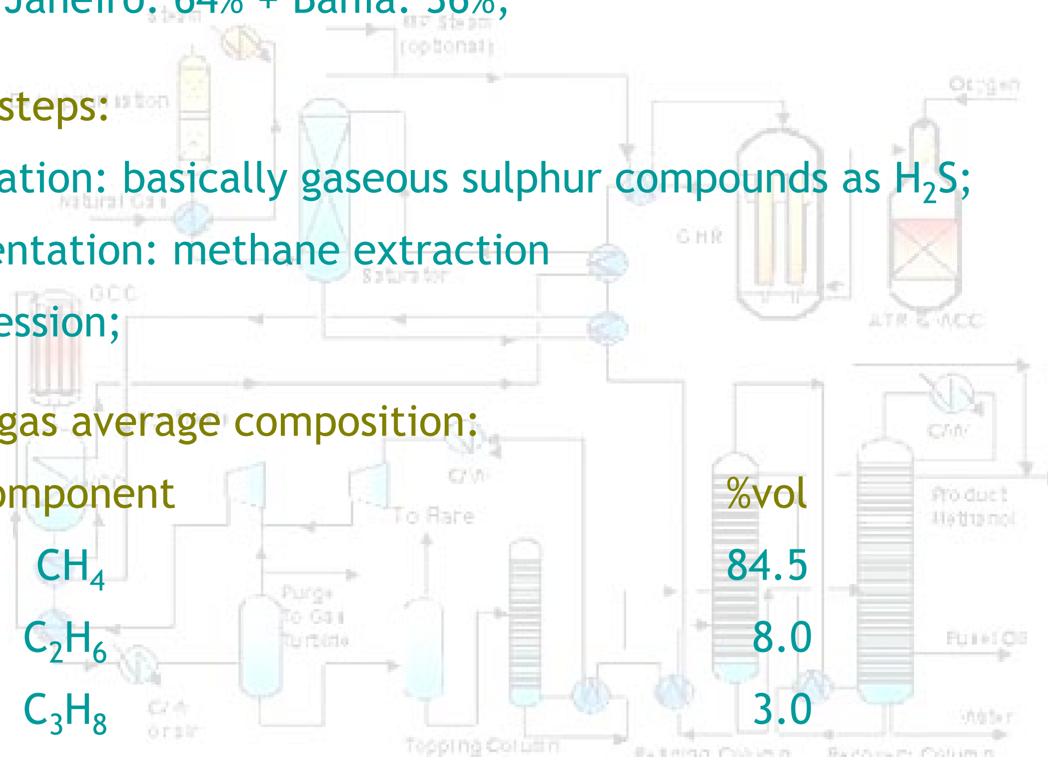
  - Rio de Janeiro: 64% + Bahia: 36%;

- Process steps:

  - purification: basically gaseous sulphur compounds as H_2S;
  - fragmentation: methane extraction
  - compression;

- Natural gas average composition:

Component	%vol
CH_4	84.5
C_2H_6	8.0
C_3H_8	3.0
C_4H_{10} and heavy fractions	3.5
CO_2	1.0



Methanol production

- Methanol sources modeling:
  - Brazil: 50% + Importation: 50% (Punta Arenas – Chile);
- Technological approach:
  - ICI Low Process Methanol: P = 5-10 atm and T = 200-300°C;
- Process steps:
  - hidrodessulfurification: basically gaseous sulphur compounds as H_2S;
  - reforming: contact reaction between steam and natural gas with Cu as catalyst
  - heat recovery;
  - compression;
  - methanol synthesis: contact reaction between carbon oxides and hydrogen and catalyst mixture (Cu + Zn + Al);
  - purification by distillation

Soybean Methylic Ester obtaining

- Technological Route:

  - alkaline transesterification with NaOH: it was considered the production of NaOH by mercury cell route)

- Methanol amount:

  - to achieve high efficiency in the transesterification its necessary a ratio of 6:1 from methanol to vegetal oil;

- Complementary steps:

  - ethanol recovery and biodiesel purification;

- Yields:

  - η = 97.5% (oil to biodiesel)

- Co-products:

  - Glycerin

- Allocation:

  - Mass Criteria:

    biodiesel **91%** and glycerin **9%**

3.6 Results

Subsystem	Greenhouse Gases Emission (g/RF)					
	Ethylic Route			Methylic Route		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Soybean Production	2,94E+04	2,91E+01	1,32E+00	2,99E+04	2,96E+01	1,37E+00
Vegetal Oil Extraction	5,35E+03	9,97E+00	4,85E-02	5,45E+03	1,01E+01	4,93E-02
Ethanol Production	6,39E+03	1,98E-02	6,34E-01	-	-	-
Methanol Production	-	-	-	9,55E+02	7,29E+00	-
Soybean Ethylic Ester Obtaining	7,56E+03	1,82E+01	4,07E-02	-	-	-
Soybean Methylic Ester Obtaining	-	-	-	7,61E+03	1,83E+01	5,00E-02
Total	4,87E+04	5,73E+01	2,04E+00	4,39E+04	6,54E+01	1,46E+00

4. Conclusion

The study makes conclude that:

- The emissions of greenhouse gases CO_2 and N_2O was a little bit higher in ethylic route than in the methylic process
- Apart from the technical performance of both biodiesel, methanol production had impose less environmental loads than ethanol obtaining
- In terms of CH4 emission, methylic route has proven to be more aggressive to the environment than the technology that deals with ethanol.
- This can be explained because of the energetic consumption during the operations of compression of natural gas and methanol synthesis

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Tanks for your attention!!

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