KRAJETE

Learning From Nature.

Status July, 2014

Company Facts

- Established 2012 as “Krajete GmbH” (“Limited Liability Company”)
- **Pioneer in 4th Generation Biofuels.** Slogan “Learning From Nature.”
- Private owned; 1.0 mio. EUR spent on overall development (funds, own, earned)
- 4 employees (3 PhDs, 1 Dipl.-Ing)
- 3 PhD topics funded, 3 diploma thesis (TU Vienna - biology, JKU Linz - chemistry)
- 5 patents applications (2011 – 2014), new field with almost no prior art
- Assets: 2 benchscale reactors (1 L, 10 L) in Vienna, in steady operation since 2009 + gas bottle fleet (15 x 50 l) and mobile compressor for sampling of industrial gases, truck and CNG car from 9/2013
- Customer pool diversified: **car producers, power producers, international gas organizations, steel companies, biogas companies, machine producers**

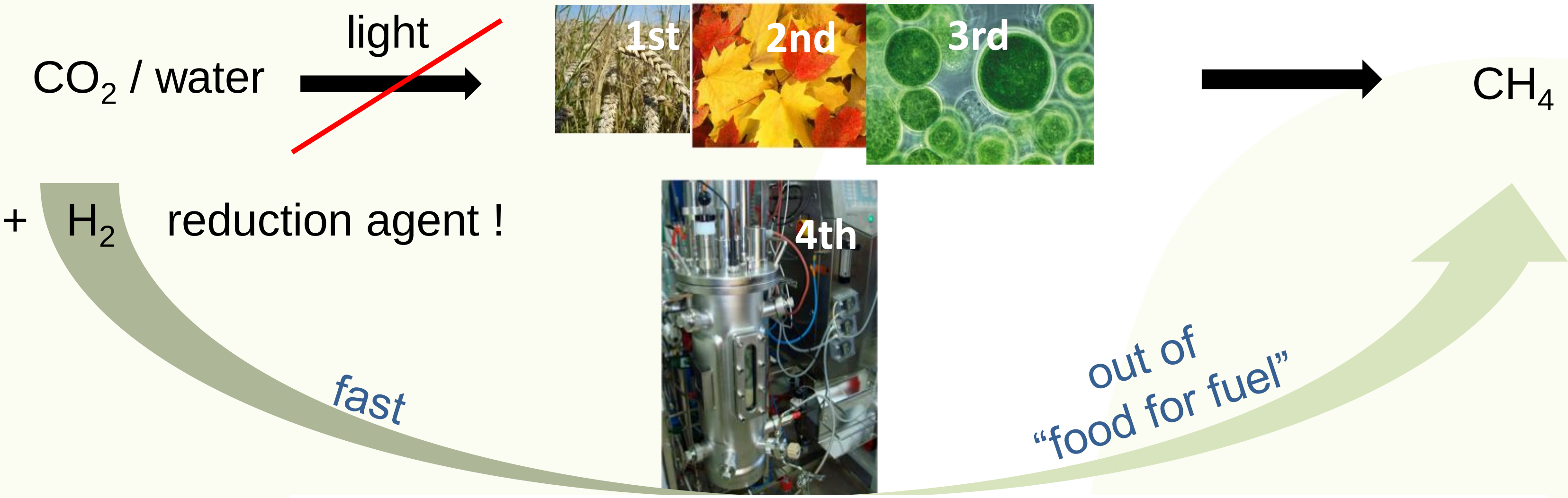
Our Novel Approach: Biofuel Without Biomass

$$CO_2 \quad + \quad 4\,H_2 \quad \rightarrow \quad CH_4 \quad + \quad 2\,H_2O \qquad - 130\ \text{kJ/mol}$$

efficiency, 78% max.

Catalyst *“Archaea”*

Process *“Methanogenesis (“Biological Methanation”)*



CO_2 / water ~~light~~ → CH_4

+ H_2 reduction agent !

fast

out of “food for fuel”

“Photosynthetic Bypass”

4 th Generation Biofuels

(**<u>150 times faster than 1st, 2nd & 3rd generation biofuel!!</u>**)

Our Simple Setup

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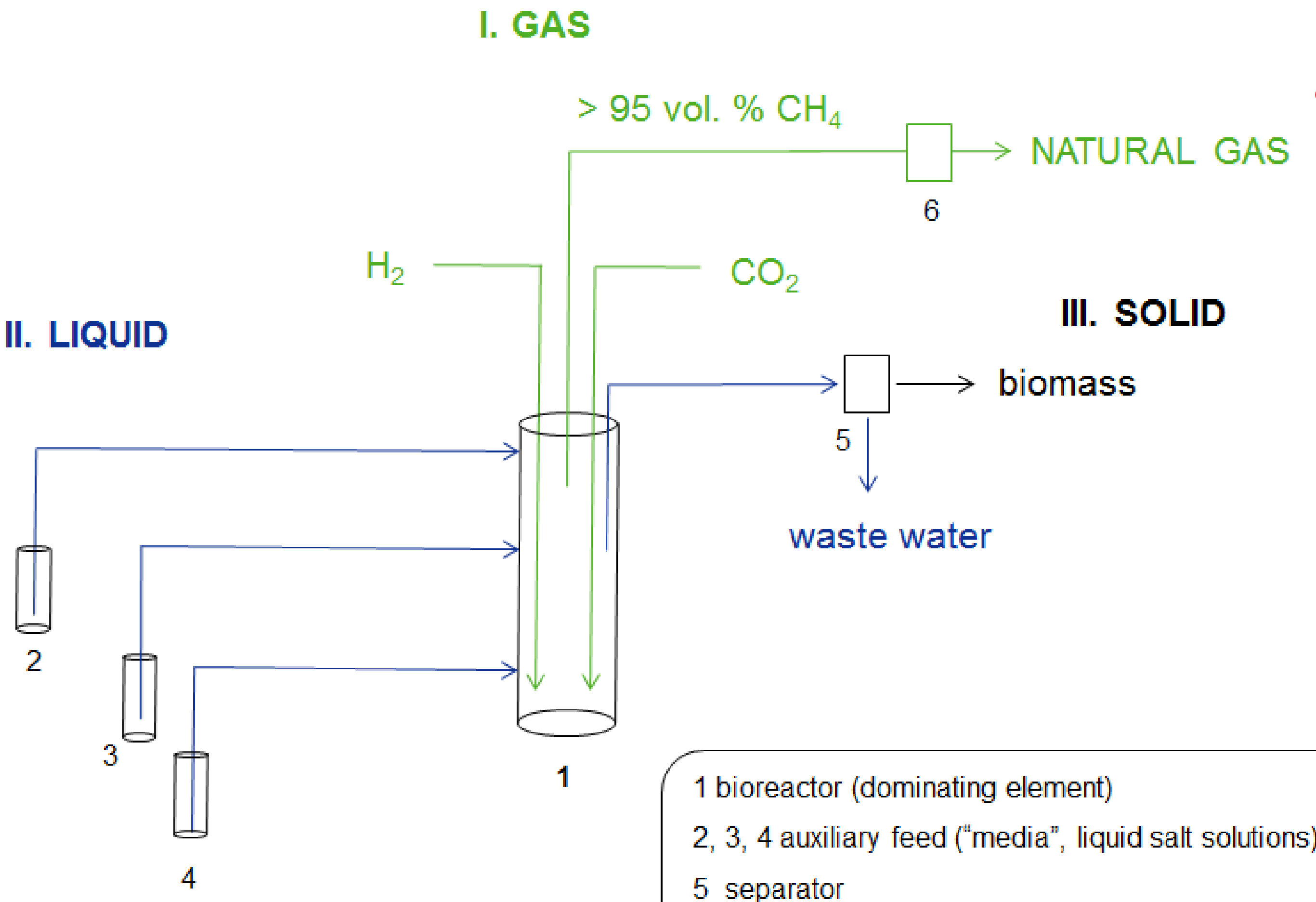


Simpler than commercial methanation processes!

1 bioreactor (dominating element)
2, 3, 4 auxiliary feed ("media", liquid salt solutions)
5 separator
6 mild gas treatment (optional)

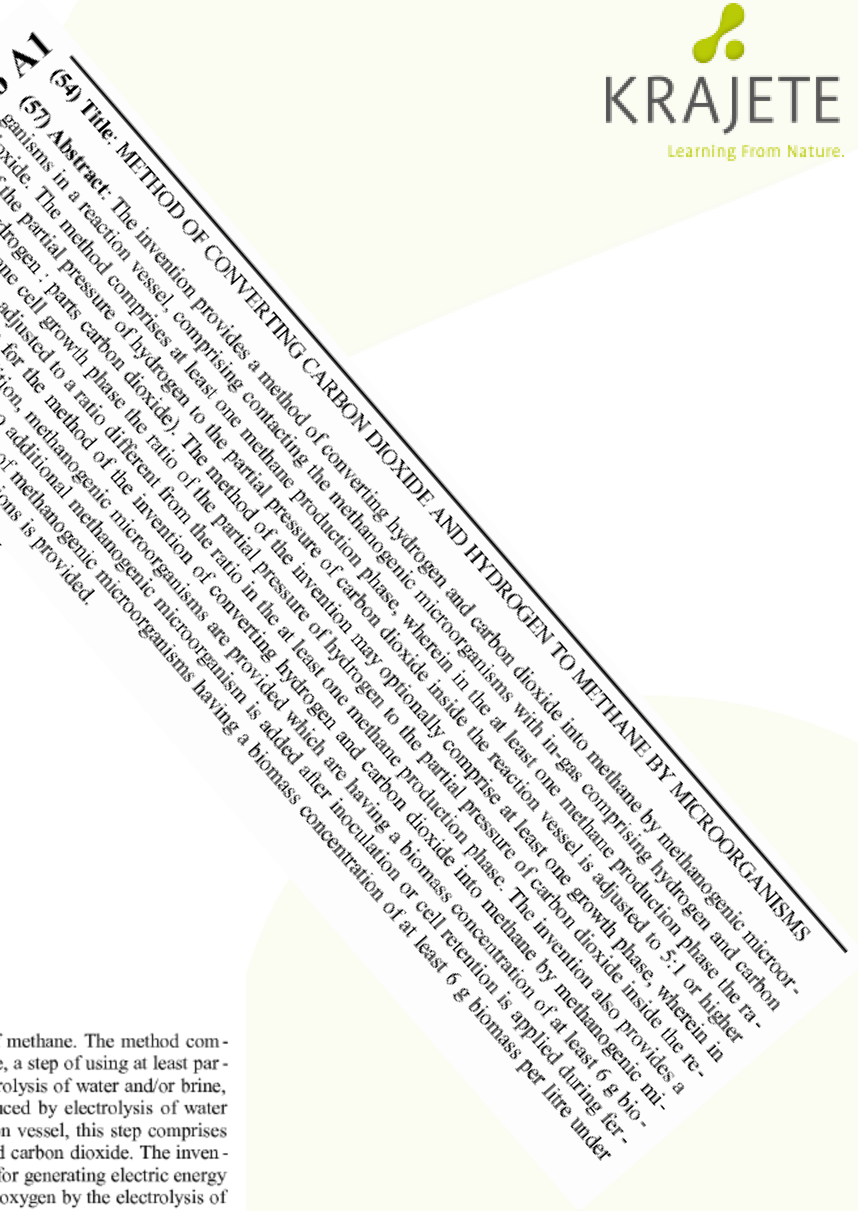
What are Benefits of our Process ?

1. Patented Process & Registered Process
2. Mild, Selective Process, no

   purification needed
3. Stable, Adaptative & Easy Control
4. High Conversion
5. Green Image & Low Cost

   (REACH compliant, sustainable, no hazardous waste)

1. Strong IP & ®



WO 2012/110256 A1

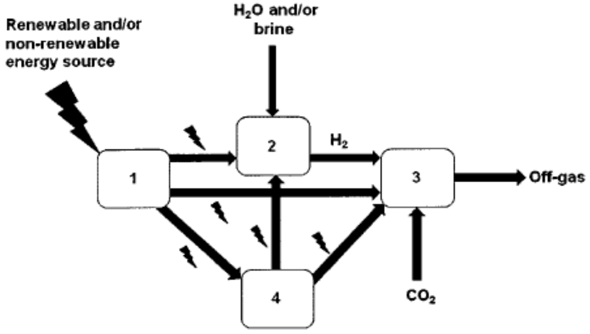
(54) Title: METHOD OF CONVERTING CARBON DIOXIDE AND HYDROGEN TO METHANE BY MICROORGANISMS

(57) Abstract: The invention provides a method of converting hydrogen and carbon dioxide into methane by methanogenic microorganisms in a reaction vessel, comprising contacting the methanogenic microorganisms with in-gas comprising hydrogen and carbon dioxide. The method comprises at least one methane production phase, wherein in the at least one methane production phase the ratio of the partial pressure of hydrogen to the partial pressure of carbon dioxide inside the reaction vessel is adjusted to 5:1 or higher (parts hydrogen : parts carbon dioxide). The method of the invention may optionally comprise at least one growth phase, wherein in the at least one cell growth phase the ratio of the partial pressure of hydrogen to the partial pressure of carbon dioxide inside the reaction vessel is adjusted to a ratio different from the ratio in the at least one methane production phase. The invention also provides a bioreactor suitable for the method of the invention of converting hydrogen and carbon dioxide into methane by methanogenic microorganisms. In addition, methanogenic microorganisms are provided which are having a biomass concentration of at least 6 g biomass per litre, wherein no additional methanogenic microorganism is added after inoculation or cell retention is applied during fermentation, and also the use of methanogenic microorganisms having a biomass concentration of at least 6 g biomass per litre under continuous fermentation conditions is provided.

WO 2012/110257 A1

(54) Title: SYSTEM AND METHOD FOR STORING ENERGY IN THE FORM OF METHANE

Figure 1



(57) Abstract: The present invention provides a method and system for storing energy in the form of methane. The method comprises at least a step of generating electric energy from a renewable and/or non-renewable energy source, a step of using at least partially the electric energy generated from a renewable and/or non-renewable energy source for the electrolysis of water and/or brine, thereby producing hydrogen and/or oxygen, and a step of using at least partially the hydrogen produced by electrolysis of water and/or brine and carbon dioxide for producing methane by methanogenic micro-organisms in a reaction vessel, this step comprises contacting the methanogenic microorganisms with an in-gas feed comprising at least said hydrogen and carbon dioxide. The invention further provides a system for storing energy in the form of methane comprising at least one device for generating electric energy from a renewable and/or non-renewable energy source, at least one device for producing hydrogen and oxygen by the electrolysis of water and/or brine, and at least one bioreactor comprising a reaction vessel suitable for growing, fermenting and/or culturing methanogenic microorganisms. Also provided is said bioreactor.

2. Why emphasis on “mild” ?

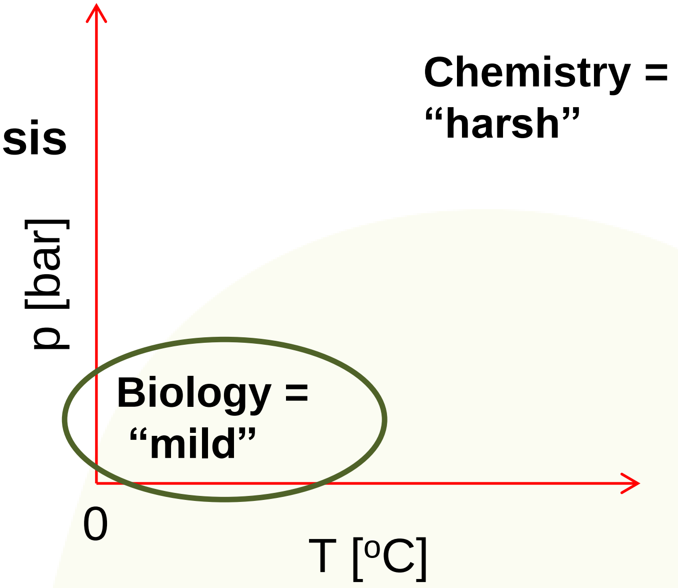
Chemical Methanation (also named “Sabatier Process”) is energy intensive due to extensive

a) heating

b) compression

Chemical Methanation & Biological Methanogenesis

-> same product in different process window



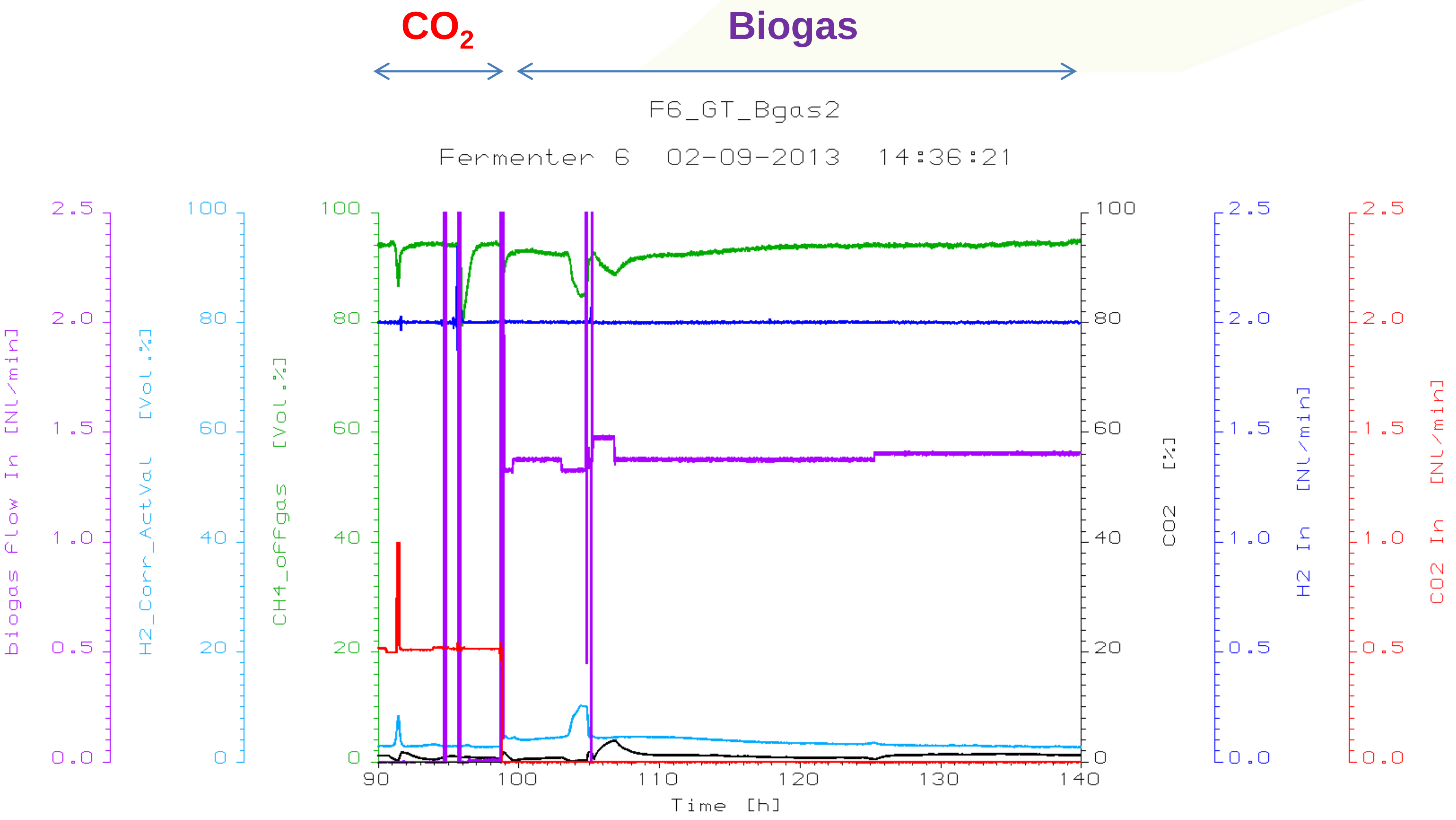
Chemistry **T = 200 – 400 °C / p = 5 – 50 bar**

Biology **T = 35 – 70 °C** **p = 1 bar**

-> Biology needs less process heat & pressure → <u>it saves OPEX cost !</u>

3. From Biogas to Gas Grid Methane

(example of real raw biogas upgrade, sampled at biogas plant)



4. Is Biology fast ?

Conversion = “MER” = “methane evolution rate”

[m^3 CH_4/m^3 suspension x hour]

Volumetric production: **>25** m^3 CH_4/m^3 susp. x hour

Potential for 5-fold improvement

Very Fast

5. Chemical vs. Biocatalyst in Methanation

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Chemical catalysts:

- Based on **early/late transition metal** catalysts of **high purity** (**Ni, Ru**) and on **mixed metal complexes**, respectively.
- Are expensive due to the **high price of the metal needed.**
- Are **available from few suppliers.**

Our Biocatalyst:

- Multi cascade reaction with **13 enzymes within the cell of archaea microbes.**
- **Biocatalyst is made from CO_2, H_2 and N, S, O, P sources.** It is sufficient to employ an **inoculum** and it **grows on ist own.**
- **No risk of contamination in the bioprocess** since no other organisms can grow on CO_2 in the reactor.

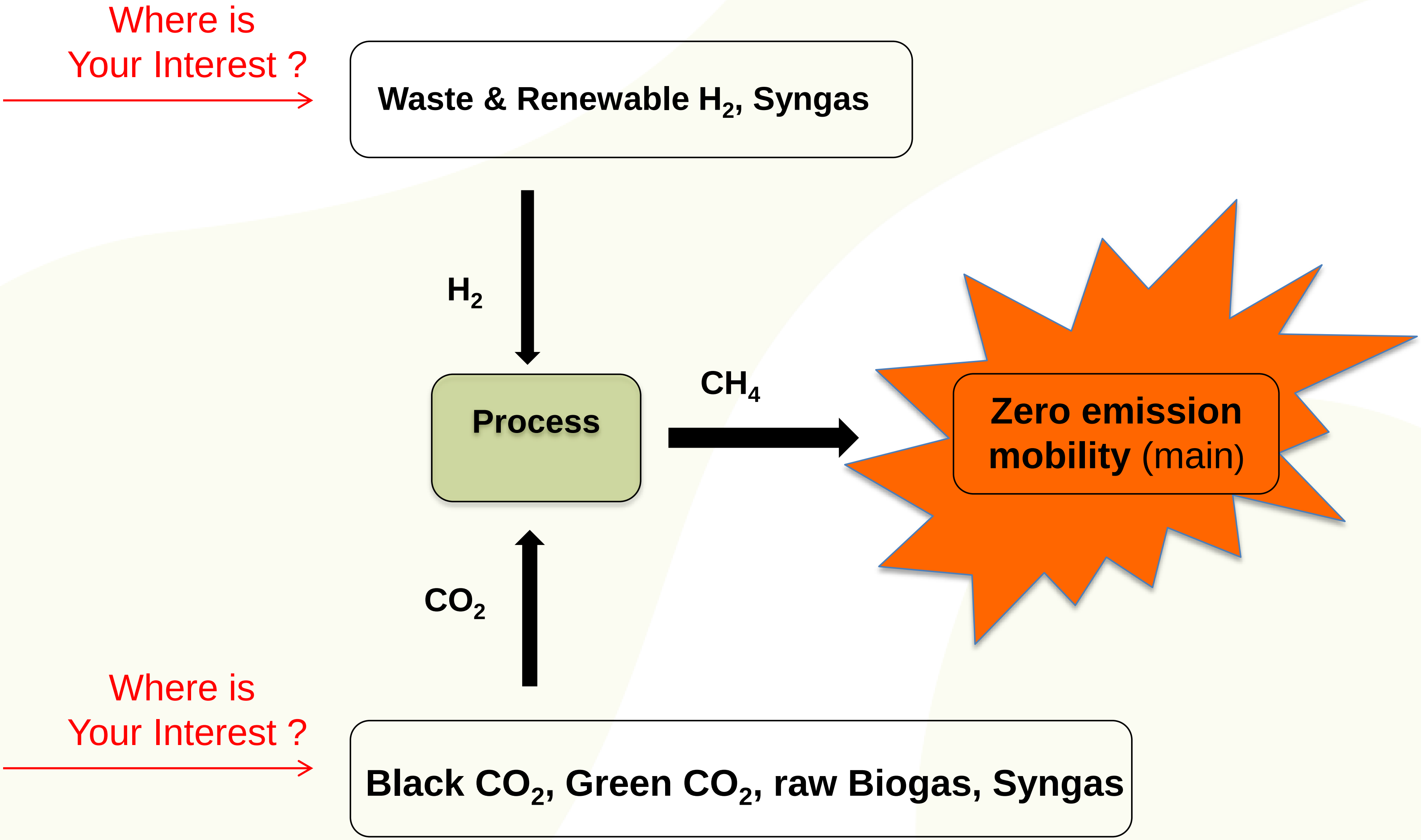
Very Economic to operate!

Process Attributes in a Nutshell

Asset	Parameter	Content	Economic Impact
1	**Energy input**	low, mild conversion at low pressure (1 bar) & low T (65 ^oC)	save compressor & heating/cooling elements; lower OPEX
2	**Selectivity & impurity tolerance**	high, microbes tolerate wide range of contaminants at concentrations that inhibit any other chemocatalysts for methanation reaction	save upstream gas processing operating units (e.g. purifier, desulfurization, PSA, amine scrubber); **feedstock flexibility** (all industrial & biogenic CO_2 and H_2)
3	**Stability, Adaptation & Easy Process Control**	high, suited for intermittency, fast response in adapting to new feedstock sources	application feasible, "power to gas" potential, high operational stability
4	**Conversion**	>25 m^3 methane/m^3 bioreactor x hour, room for 5-fold improvement	lower CAPEX
5	**Catalyst preparation & Image**	easy, it grows in the bioreactor on CO_2 as carbon source; REACH compliant, sustainable	cheap & independent gas conversion, no risk of catalyst poisoning

Our process is a) simple, b) robust, c) dynamic & d) fast!

Applications - General



Where is
Your Interest ?

Waste & Renewable H_2, Syngas

H_2

Process

CH_4

Zero emission mobility (main)

CO_2

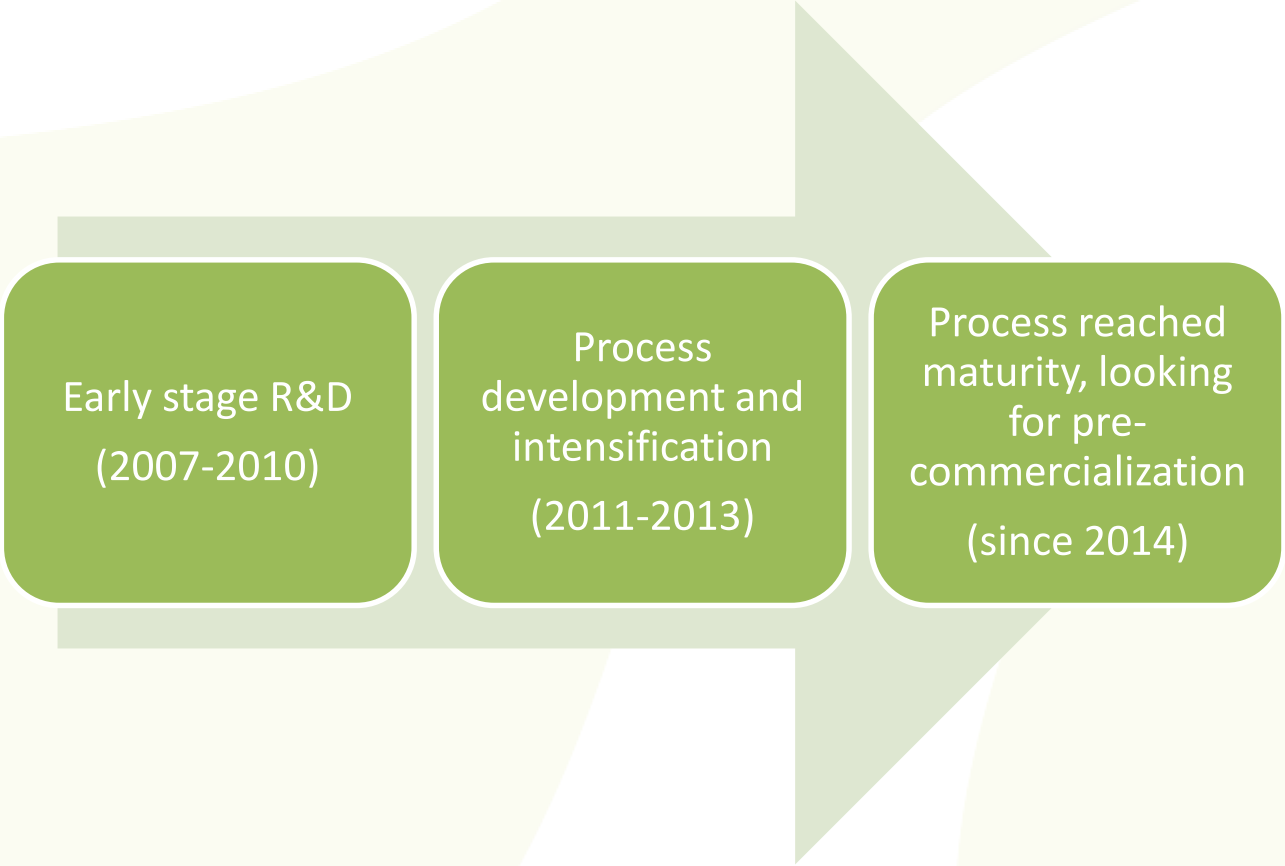
Where is
Your Interest ?

Black CO_2, Green CO_2, raw Biogas, Syngas

Applications - Specific

Industry	Application
1. Mobility	**Carbon Neutral Fuel**, Zero Emission Fuel (CNG / LNG)
2. (Petro)chemical	**Use of existing waste streams, valorization** of increasing H_2 waste streams due to change in oil-cracker feedstock composition
3. Biogas	Direct upgrade from **raw Biogas to Natural Gas**
4. Communities & Power	**Decentralized Fuel Supply** by storing renewable electricity as CNG/LNG; electricitiy storage ("**PtG**") & reuse as heat, mechanical, electrical energy

Development 2007 – 2014
From CO_2 to Energy Independent Communities



Early stage R&D

(2007-2010)

Process development and intensification

(2011-2013)

Process reached maturity, looking for pre-commercialization

(since 2014)

Thank You for Your Attention!

For any questions, do not hesitate to contact us!