POLITECNICO
MILANO 1863

POLITECNICO
MILANO 1863

Dubai, November the 25th 2017, Keynote Lecture, at:

ICFMCE – International Conference on Functional Materials and Chemical Engineering

ICFMCE 2017

BIoGaS-to-liQUID (BIG SQUID™) module for CO_2 reuse

Flavio Manenti

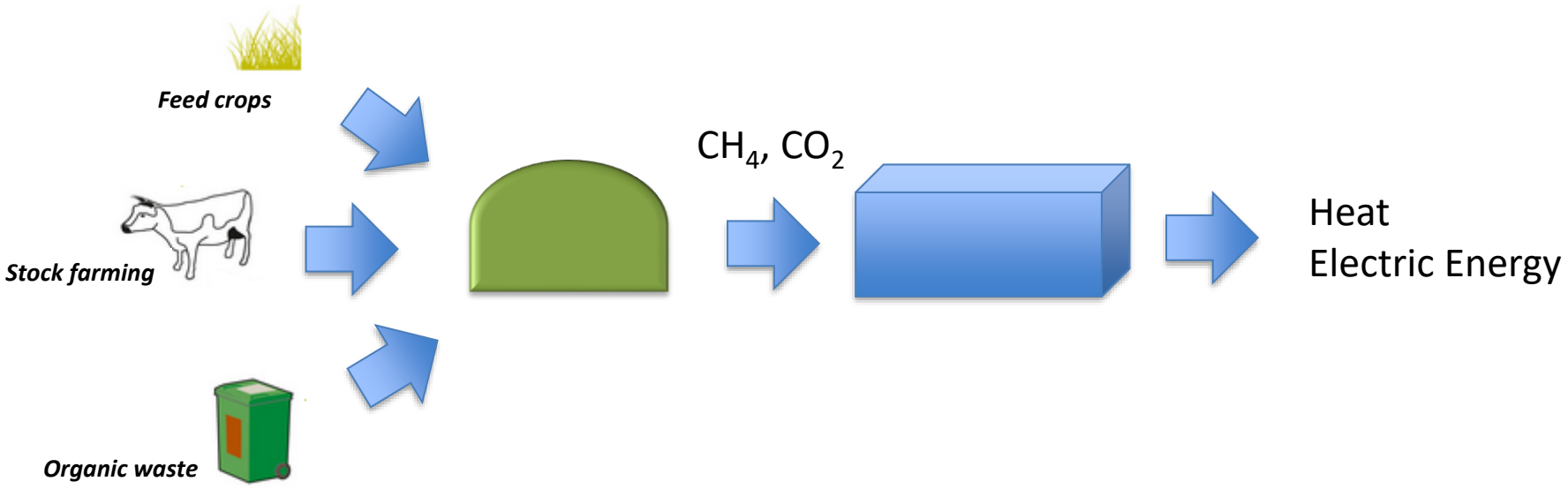
CMIC Dept. "Giulia Natta"

Centre for Sustainable Process Engineering Research (SuPER)

Biogas *today* - CHP

Biogas means simultaneous generation of heat and electrical energy provided to the national network

Combined Heat and Power (CHP) generation



Biogas *today* - CHP

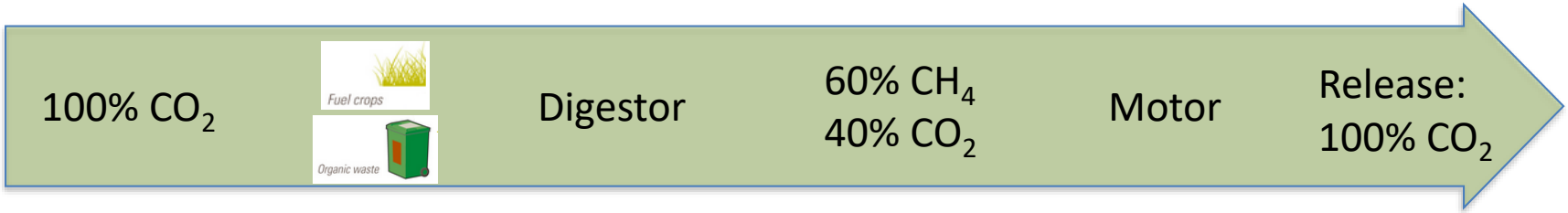
The biogas is currently profitable thanks to the incentives

1 MWh biogas plant (60% methane/40% carbon dioxide) gives a profit for the electric energy sold to the market at flat rate:

- 0.23 €/kWh → 1.84 M€/y revenues

CO_2 utilization:

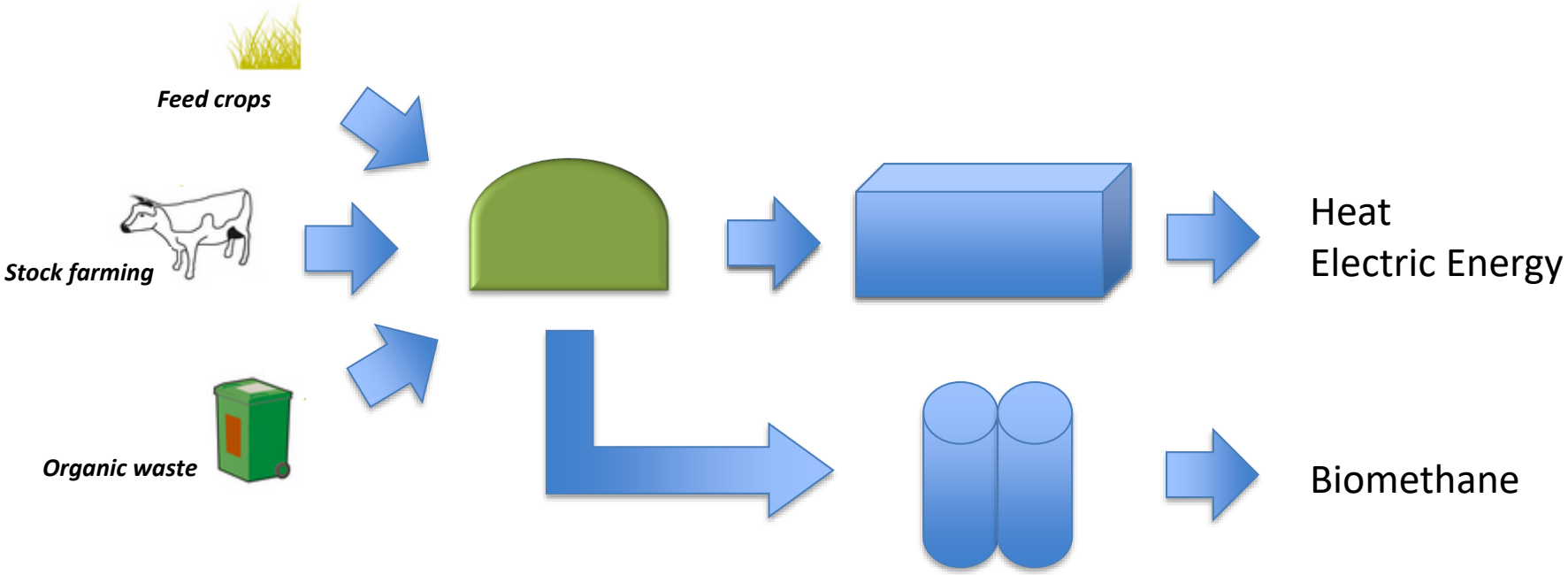
- CO_2 fixed in the organic feedstock is totally converted back



1 MWh plant: 7852 t/y of CO_2 released back to the atmosphere

Biomethane option

An incoming possibility could be the biogas upgrading to biomethane and fed to the National NG structure



Biomethane option

The biomethane is a potential solution

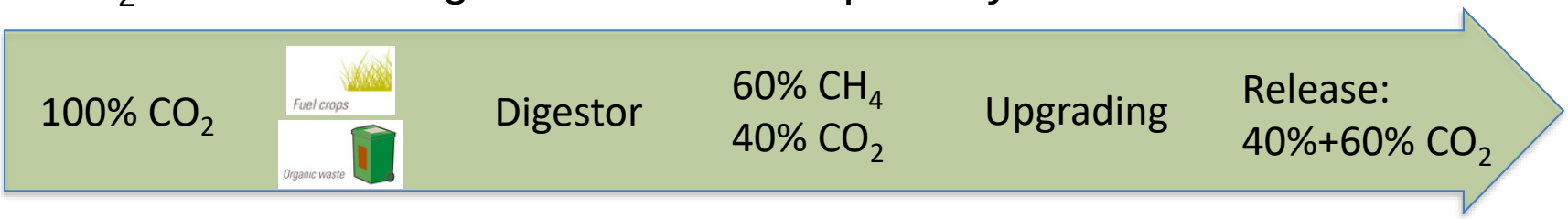
- Although several issues are still open: (de-)odorization, impurities…

1 MWh biogas plant (60% methane/40% carbon dioxide) gives a profit for the biomethane production:

- no incentives: 0.11 €/kg → 0.21 M€/y
- (max) current incentives: 0.41 €/kg → 0.77 M€/y

CO_2 utilization:

- CO_2 fixed in the organic feedstock is partially converted back

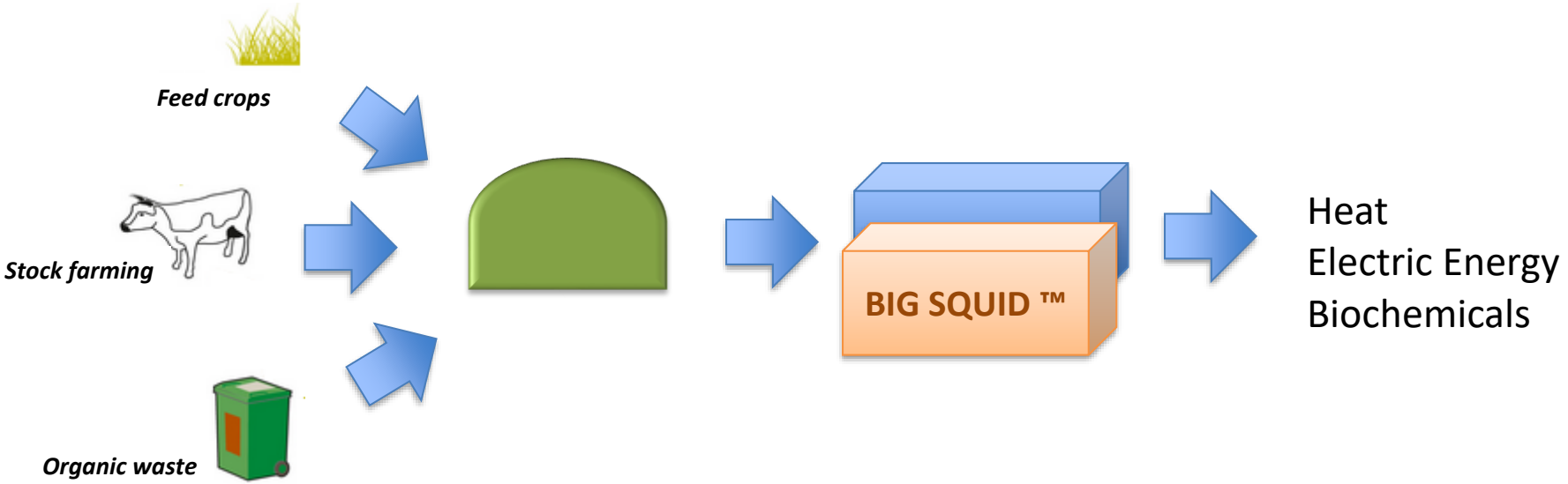


1 MWh plant: 3141 t/y of CO_2 are (**locally**) released

Biogas-to-liquid (BIG SQUID™) – CHPC

Bio-building-blocks is a new perspectives that transforms the biogas into valuable chemicals in liquid form

CHP into CHPC (Combined Heat, Power and Chemicals)



Biogas-to-liquid (BIG SQUID™) – CHPC

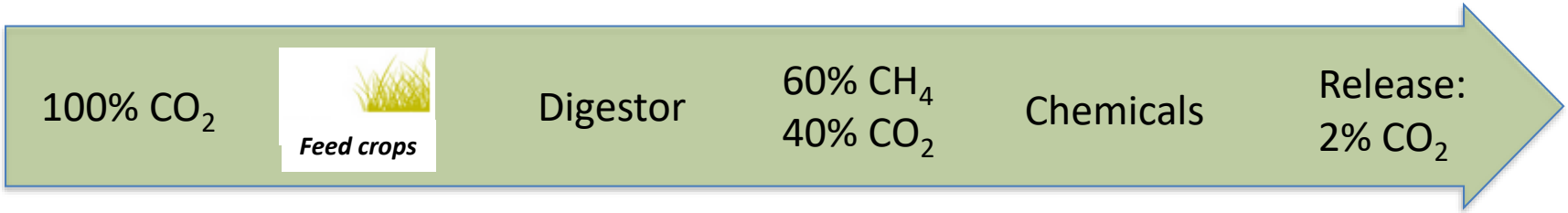
The upgrading of biogas to biochemicals allows to convert also CO_2 into high added-value products

Example without incentives, 1 MWh biogas plant (60% CH_4/40% CO_2):

- Electric Energy: 0.11 €/kWh → 0.88 M€/y revenues
- Acetic Acid: 0.5 €/kg → 1.87 M€/y revenues

CO_2 total utilization:

- CO_2 fixed in the organic feedstock is totally converted



1 MWh plant: 63 t/y of CO_2 are released back to atmosphere

The BIG SQUID™ module

Non-invasive and flexible solution:

- Compact “Synthesis Module” 1.5m x 1.5m x 4 m to be installed at the end of existing plants

- Parts of the Synthesis Module itself can be changed in every moment with small investment to change chemical product

- The target chemical product depends on the local market (methanol, DME, Acetic acid, fuel…) and interests

- Acetic acid (precursor of plastics, polymers, fibers) has a total sequestration of carbon content of the worst biogas

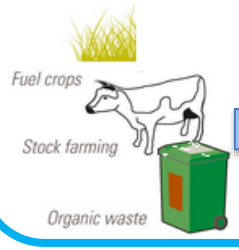
The BIG SQUID™ module

BIoGaS-to-liQUID (BIG SQUID™)

Existing biogas (CHP)

Organic Feedstock

Anaerobic digestion



CHPC Concept

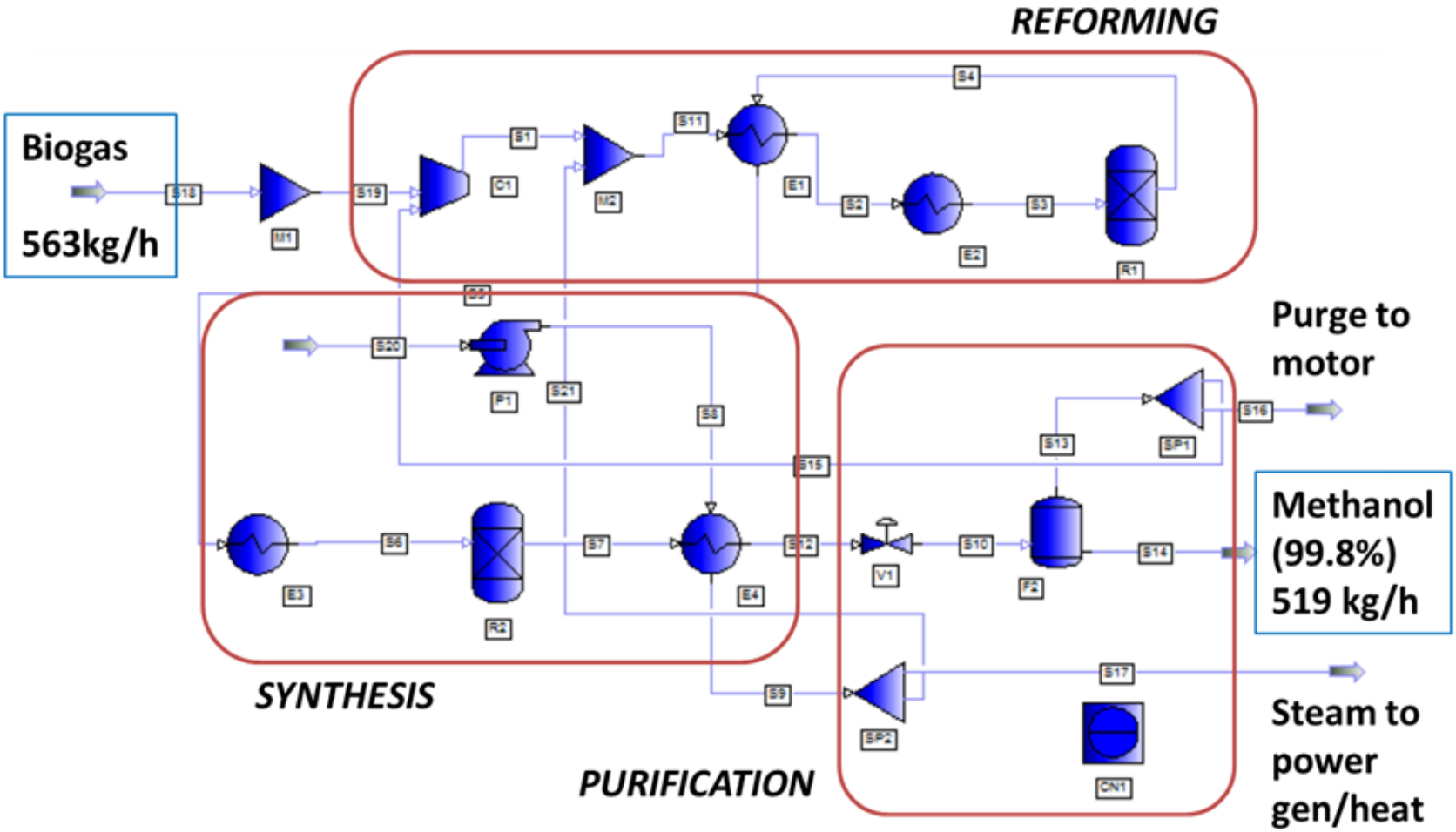
Biogas reforming

Chemical synthesis

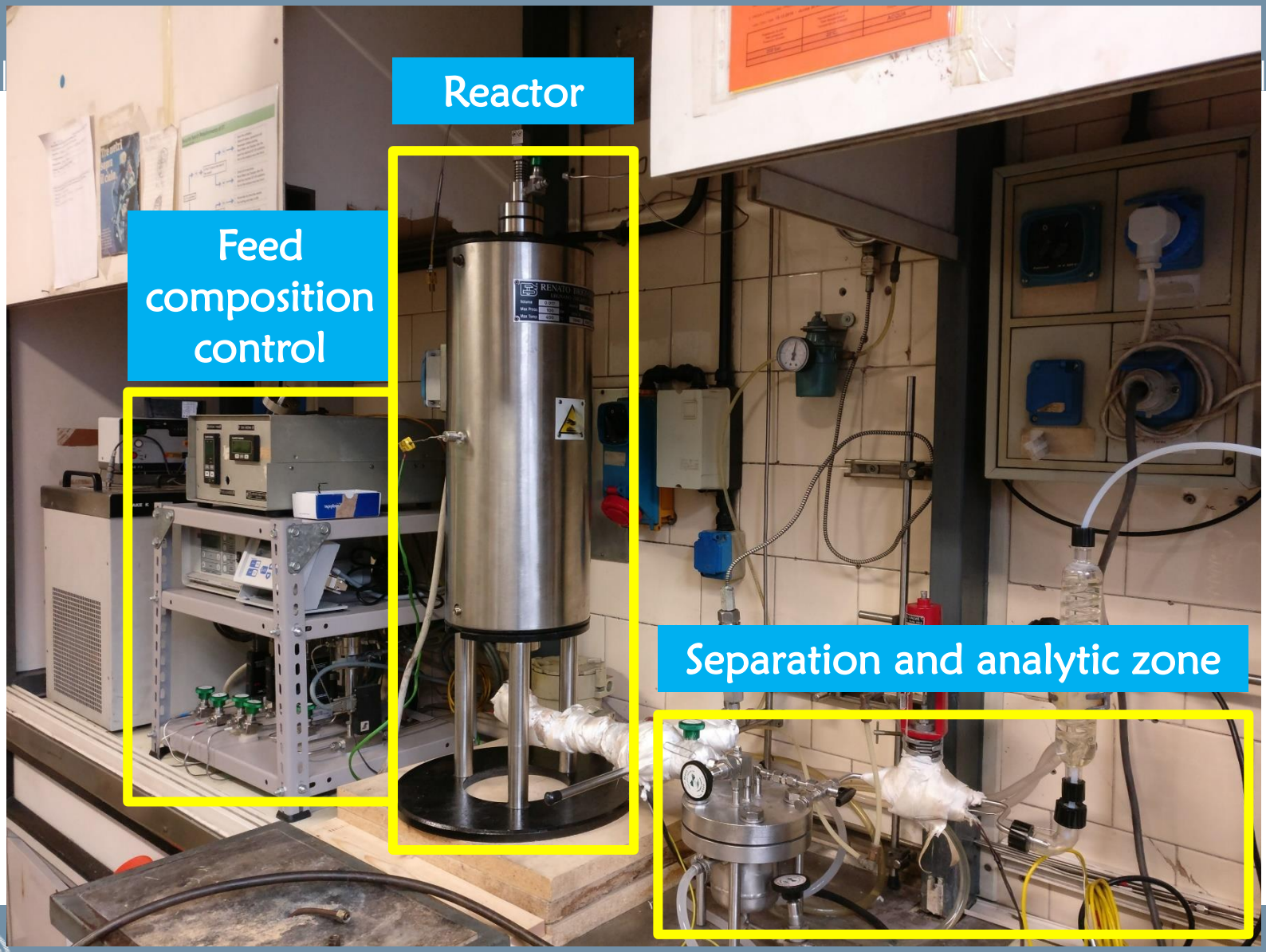
Bio-MeOH
Bio-DME
Bio-Acetic Acid…

New, portable, non-invasive module for biogas upgrading

Simulation
CASE: Biogas-to-biomethanol



Demo-scale validation



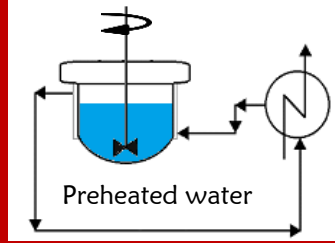
Catalytic system

CZA

- Cu [15-80 %] → Active sites for methanol synthesis
- ZnO [15-50 %] → Maintain the Cu in optimal dispersion
- Al_2O_3 [4-30 %] → Increase surface area and copper disperion

Co-precipitation synthesis

$Cu(NO_3)_2 \cdot 2.5H_2O$
$Zn(NO_3)_2 \cdot 6H_2O$
$Al(NO_3)_3 \cdot 9H_2O$



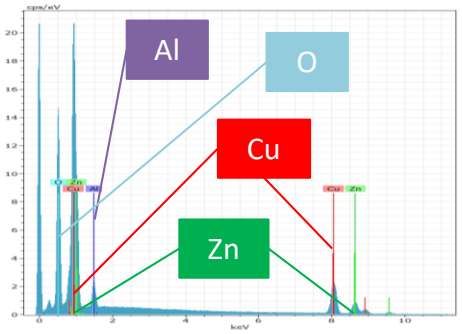
Na_2CO_3 - pH7 - 70°C - 1h

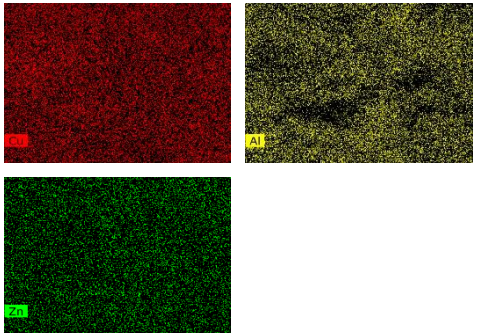
Synthesized product

Calcined
T=350°C
6h

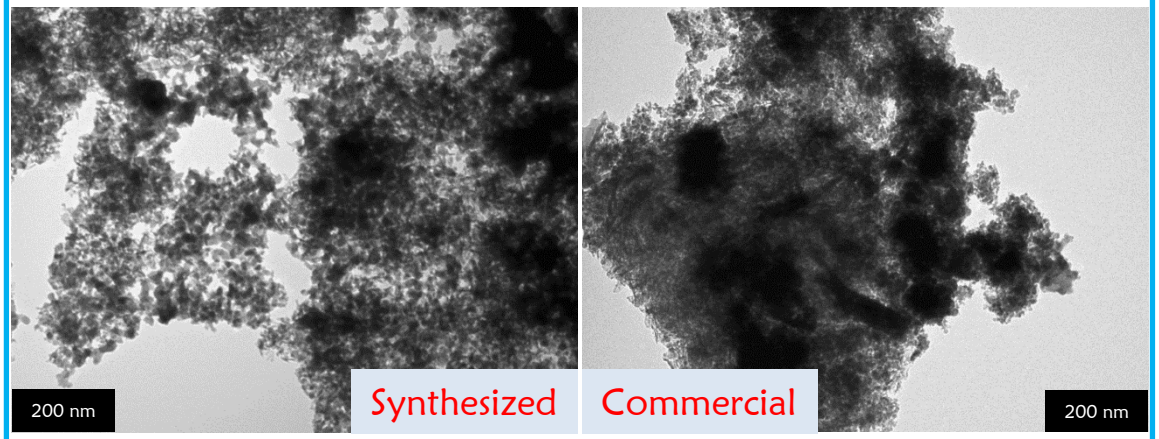
Catalyst characterization and kinetics

SEM-EDX synthesized catalyst



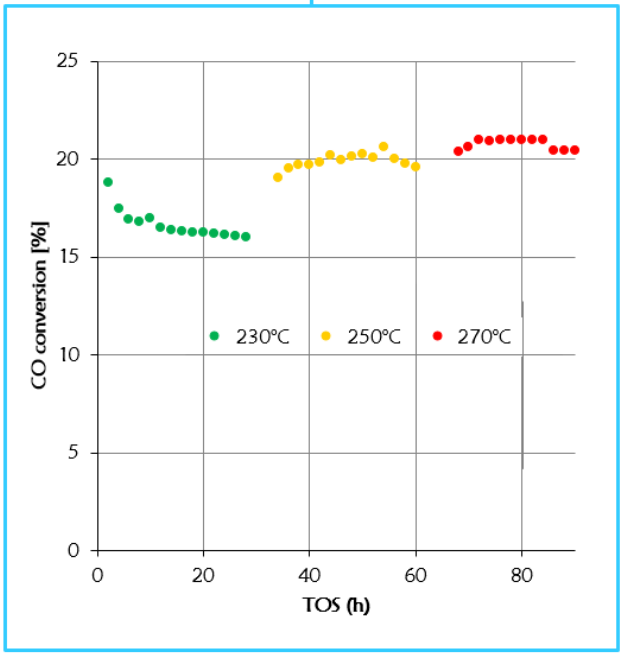


TEM comparison

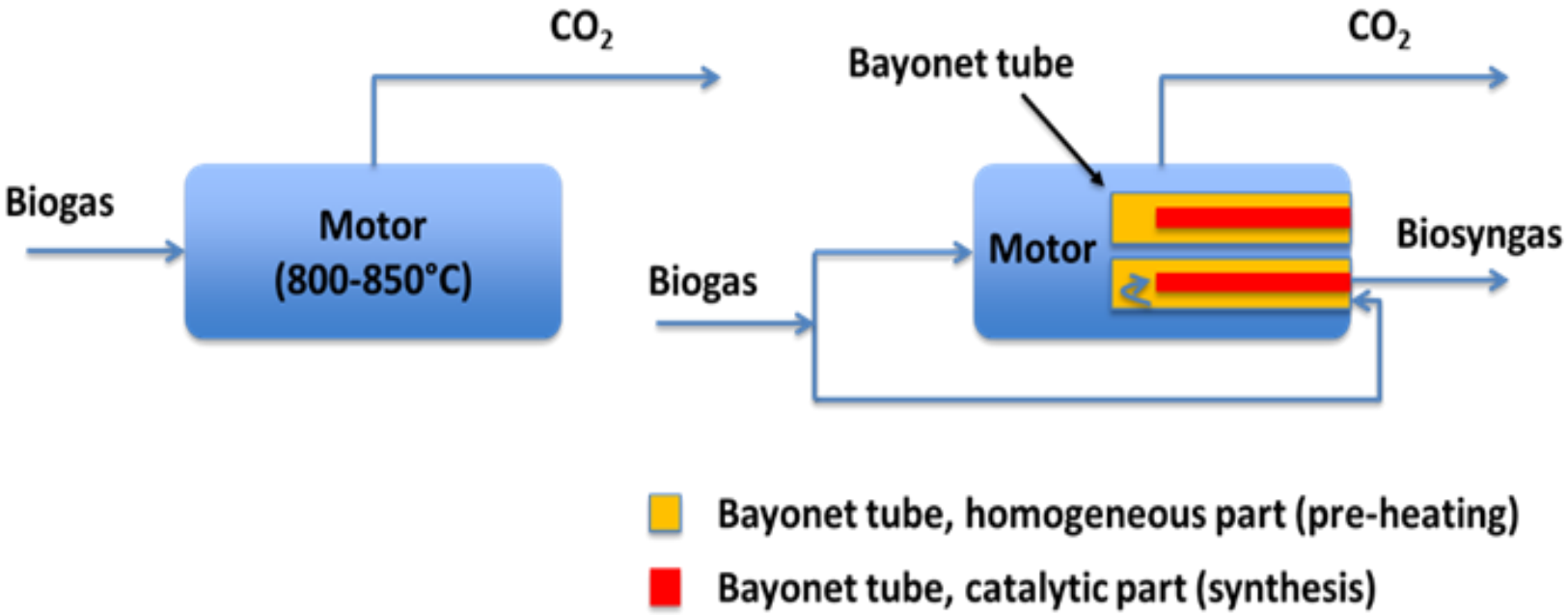


Temperature influence

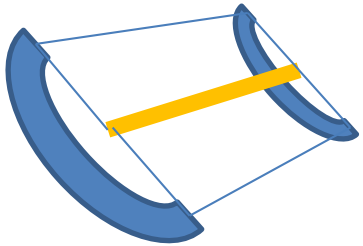
Rising the temperature the CO conversion increases



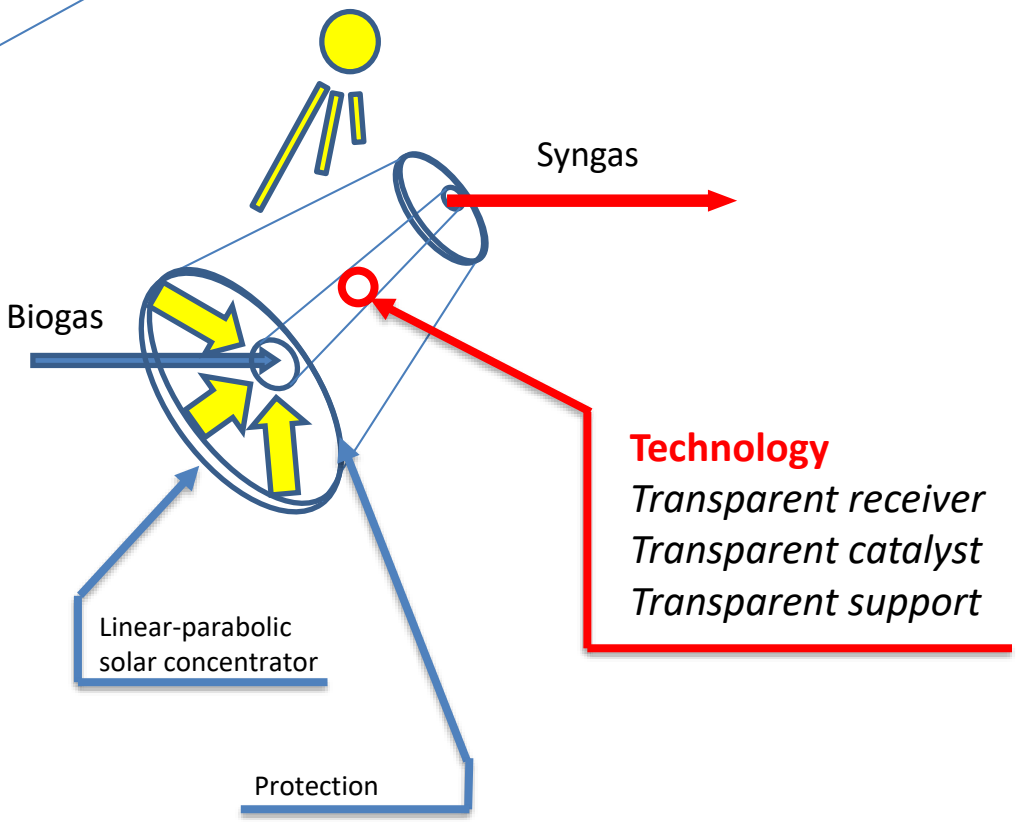
Advances (Priority: 102017000073797, June 2017)

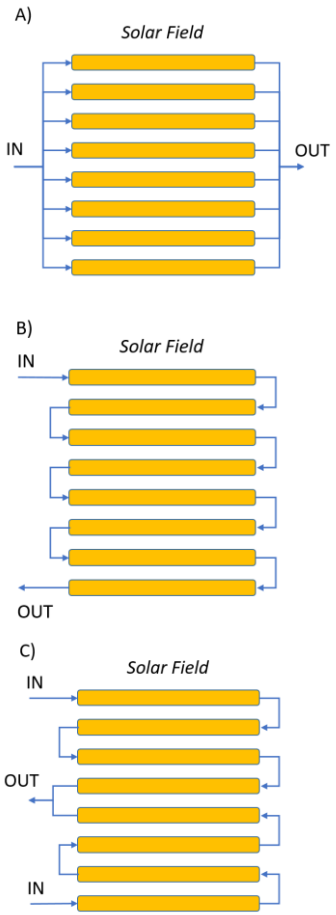


Advances (Priority: 102017000001505, Jan 2017)

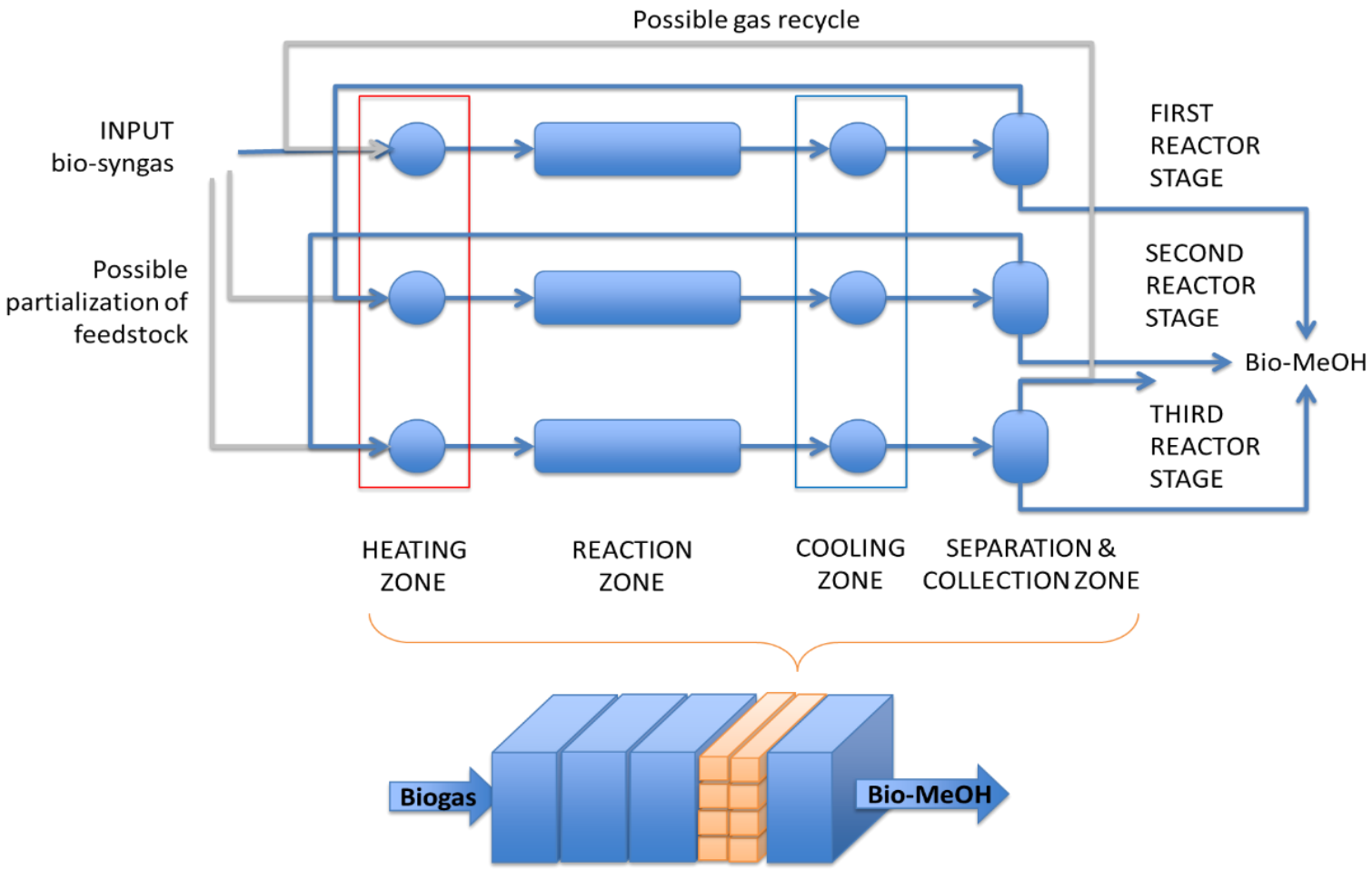


Concentrating Solar Thermal Reactor

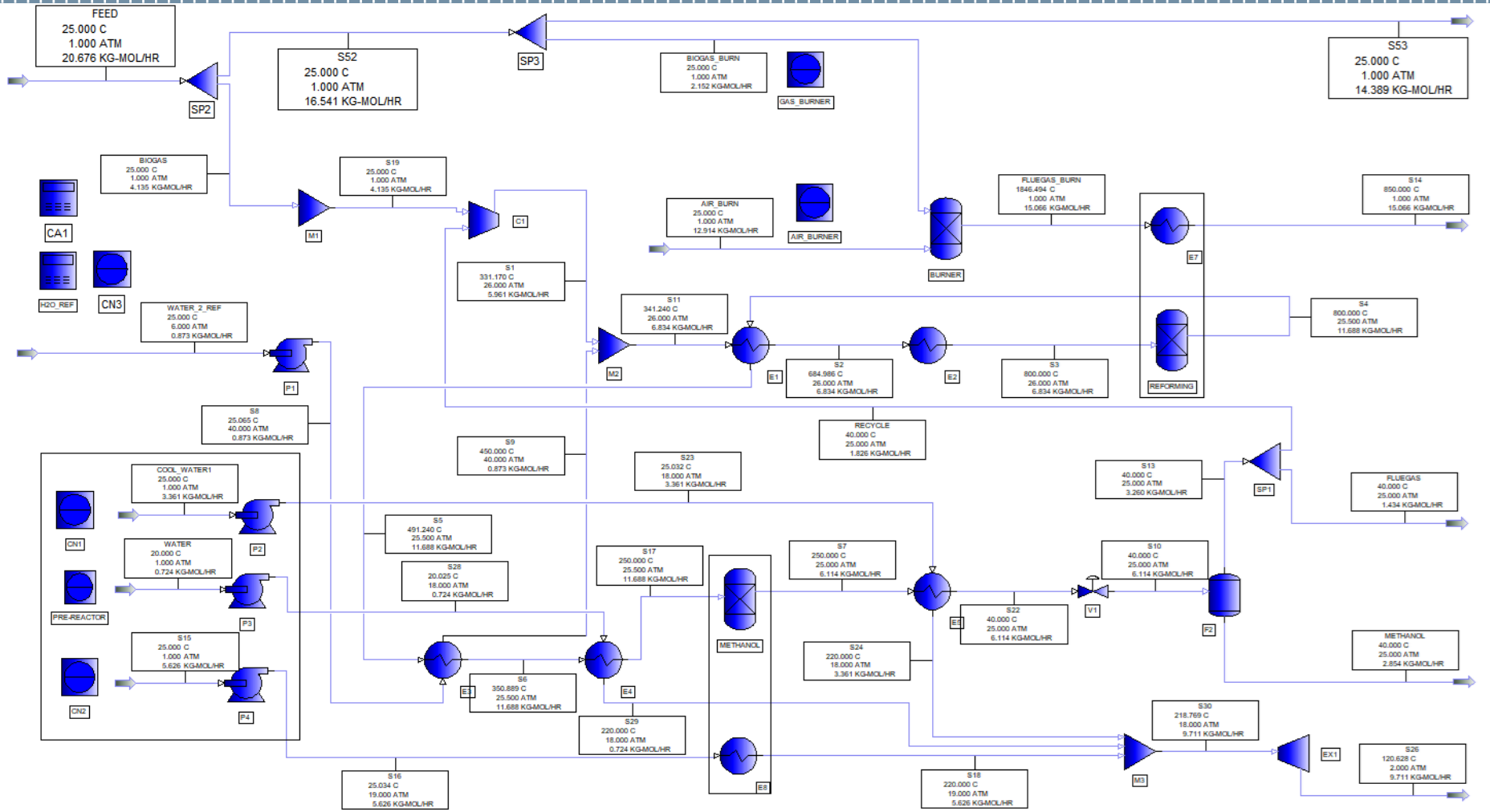




Advances (Priority: 102017000073797, June 2017)



Basic engineering
Energy self-sustainable BIG SQUID™ methanol



CAPEX/OPEX

1 MWh plant

- BIG SQUID™ Methanol 2.5M€
- BIG SQUID™ DME 2.6M€
- BIG SQUID™ Acetic Acid 2.9M€

Payback is 2.6-3.2y without incentives

Preliminary non-exclusive agreements

- with FAT for construction
- Schneider-Electric for sales support solutions

Market & policies

- Italy (2’000 plants); Europe (18’000 plants)
- Italian government perspective: -1.2G€/y of biogas incentives

Industrial solutions and services

- Patented technology
- Two engineered solutioins:
    - BIG & SMALL SQUID: 0.6 MWh and 0.2 MWh
    - standardized EPC, monitoring and control
- Dedicated re-optimized solution using RobOpt™
    - feedstock and engineering
- Remote/field maintenance and monitoring (FAT)
    - 24/7 service
- Trading app for chemicals
    - POLIMI spin-off

Conclusions

From CHP to CHPC → Feasible

CO_2 direct utilization

- No sequestration
- No purification
- No CO_2/CH_4 ratio adjustment

PROS

Complete conversion

Energy self-sustainability (refurbishing)

Tax policies → tbd

Deep purification

Sales and market limitations

CONS

Thanks for the kind attention

Flavio Manenti

Professor of Chemical Plants and Operations
Executive Board of EFCE, AIDIC, CAPE-WP, AIAC

POLITECNICO DI MILANO
Dipartimento di Chimica, Materiali e Ingegneria Chimica "G. Natta"
Sustainable Process Engineering Research (SuPER) team
Piazza Leonardo da Vinci, 32, 20133 Milano, ITALY

TECHNISCHE UNIVERSITAT BERLIN
Alexander von Humboldt Professor
DBTA (Dynamic und Betrieb Technischer Anlagen) Faculty
Sekt. KWT 9, Strasse des 17.Juni, 135 - D-10623 Berlin, GERMANY

(Mobile) +39.338.5665817
(Phone) +39.(0)2.2399.3273 - +49.(0)30.314.23418
(Email) flavio.manenti@polimi.it
WELCOME… - (Web) http://super.chem.polimi.it