

# CZECH BIOFUELS TECHNOLOGY PLATFORM

## CO<sub>2</sub> TRANSFORMATION CENTRE

**Leos Gal**

The Head of Steering Committee  
Czech Biofuels Technology Platform  
PRAGUE – CZECH REPUBLIC

[leos.gal@seznam.cz](mailto:leos.gal@seznam.cz)

00420-736505012

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# EU – SINGAPOERE POLITICAL PARTNERSHIP FRAME



EU-Singapore Partnership and Cooperation

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52014PC0070>

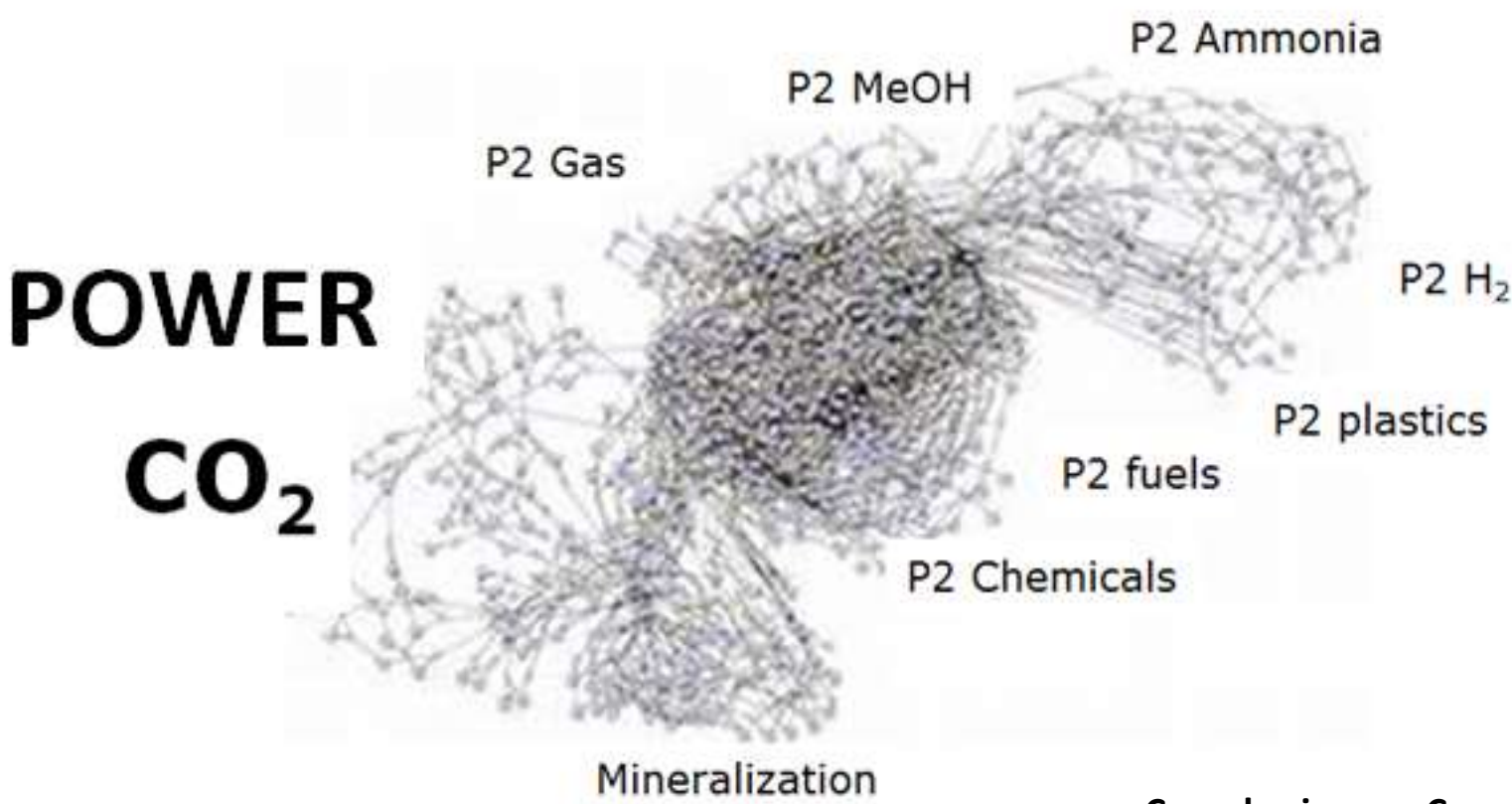


19 October 2018

[https://trade.ec.europa.eu/doclib/docs/2019/february/tradoc\\_157684.pdf](https://trade.ec.europa.eu/doclib/docs/2019/february/tradoc_157684.pdf)

# Double bound $C=O_2$ (strong and very stabile molecule)

But potentially transferable into several rational (potentially feasible) ways

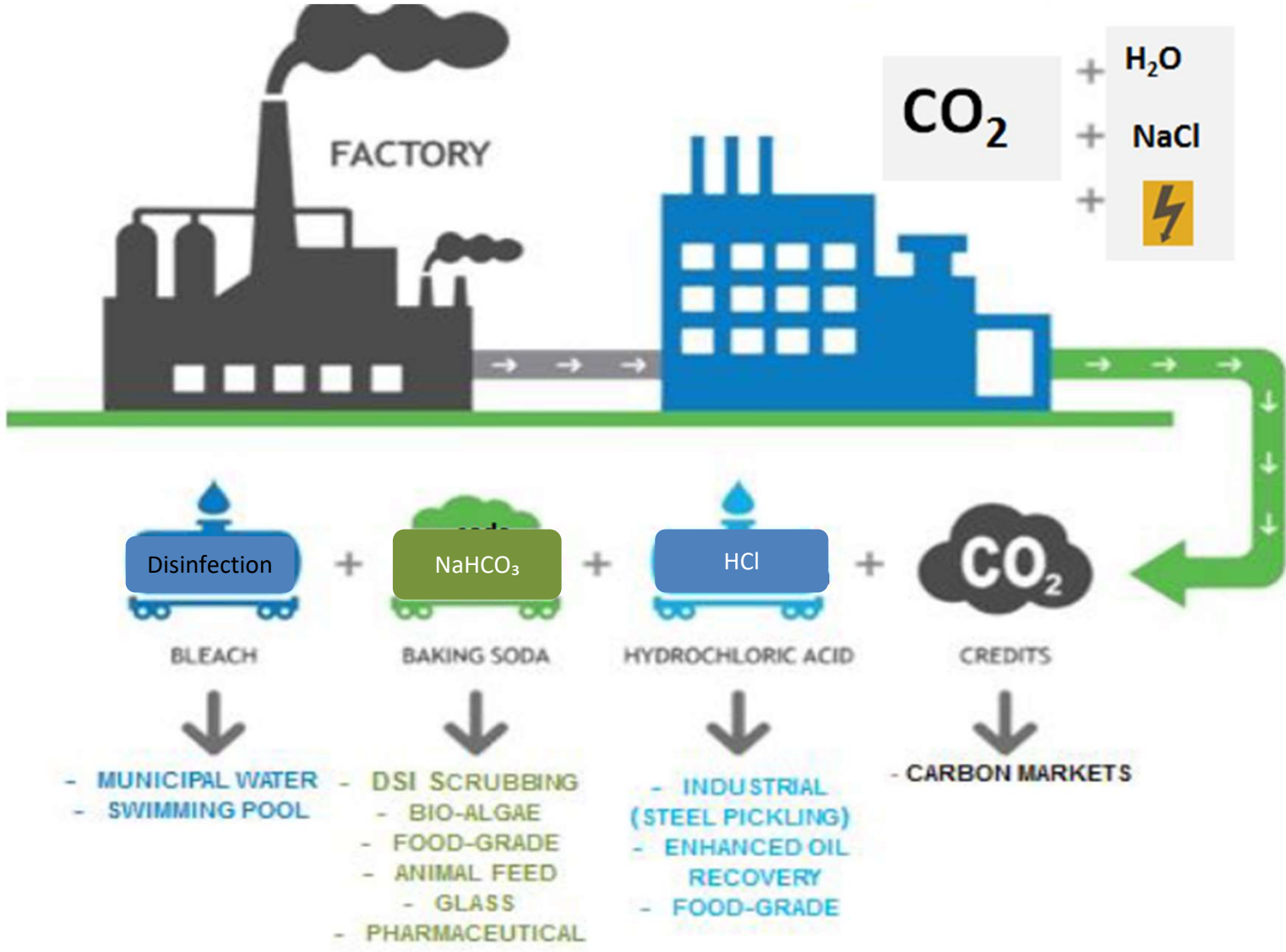


**Complex issue - Complex approach:**  
Biology  
Biochemistry  
Biophysics  
Chemistry  
Physical chemistry  
Electro technics  
Chemical technology  
Energy coupling...

# Fundamental conditions of successful transformation CO2

external energy (power) is necessary!!!

EU ETS  
price  
1 t CO<sub>2</sub>





## EIT Climate-KIC

## Climate change mitigation and adaptation

- EIT Digital: Information and Communication Technologies
- EIT Food: Food innovation and production
- EIT Health: Healthy living and active ageing
- EIT InnoEnergy: Sustainable energy
- EIT Raw Materials: Exploration, extraction, processing, recycling and substitution

### A VISION for Smart CO<sub>2</sub> Transformation in Europe

Using CO<sub>2</sub> as a resource

Enabling European industry to become more resource-efficient, sustainable and competitive



#### RECOMMENDATIONS

- Continued and increased levels of national and EU funding for CO<sub>2</sub> utilisation fundamental research targeting (but not exclusively):
  - CO<sub>2</sub> catalytic science
  - CO<sub>2</sub> reaction kinetics
  - Novel CO<sub>2</sub> reaction pathways
  - Novel reactor designs
  - CO<sub>2</sub> process separation techniques
- Direct utilisation paths from impure gas sources (cement, power generation, etc.) in a single process without needing a first CO<sub>2</sub> separation and purification step

### A Strategic European Research and Innovation Agenda for Smart CO<sub>2</sub> Transformation in Europe (SERIA)

SHARED EUROPEAN  
MODULAR PILOT PLANTS  
and  
VERIFICATION CENTRES

- Establish longer term European and national funding pathways to enable progress from fundamental research to commercialisation.

# SHARED EUROPEAN MODULAR PILOT PLANTS and VERIFICATION CENTRE

## VISSION:

CO<sub>2</sub> TRANSFORMATION – entire issue concentrated into one place  
**CO<sub>2</sub> transformation „SHOP WINDOW“**

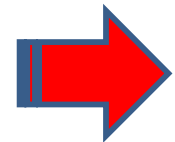
## MISSION:

Partly Physically  
Partly Virtually

Technology installation for real transfer (MeOH, CH<sub>4</sub>...)  
Audio-video comprehensive documentation

## GOALS: Systematization !!!

- HISTORY of CO<sub>2</sub> R&D
- CURRENT R&D position state of the art
- FUTURE prediction and perspectives



# GOALS - VERIFICATION CENTER of CO<sub>2</sub> TRANSFORMATIONS in CZECH REPUBLIC

- 1. POLITICAL** - Reaction to IPCC (aiming science to CO<sub>2</sub> due to Paris agreement results)
  - Czech Republic in EU FIRST PLACE position - industry (share per head in EU)
  - Long term Czech chemical history and science background

## 2. SYSTEMATIZATION

Pilot (demo) R&D projects (founded by EU) concentration in one place

(R&D history, outlook, pathways upscale, LCA, effectivity, advantage-disadvantage of particular routes, social impact, bottlenecks...)

## 3. Confrontation/competition between different transformation pathways

**GW**I - (Global Warming Impact)    **R**M**I** - (Raw material input)    **T**M**R** - (Total material input)

**C**E**D** - (Cumulative energy demand)    **W**I - (water input)    **C**T**E**- (Carbon transfer efficiency) ..... Upscale Limits, Economy

## 4. EDUCATION - EXPOSITION

Running (and upcoming) pathways demonstration = **EU CO<sub>2</sub> policy - shop window**

(involve students, public - excursion,... running transformation in reality and audio-video program about next CO<sub>2</sub> pathway potential)

## 5. R&D – small scale testing FLEXIBILITY (impurities, effectivity, catalytic issues, clones, ...)

## 6. CZECH & SINGAPOURE know-how **INNOVATIVE - Smart managing just in time**

6.1. Competitive products for chemical industry and transport

6.2. Optimization relations

**RES - POWER distribution - H2 - CHEMICALS - FUELS - grid connection on time**

SHARED EUROPEAN  
MODULAR PILOT PLANTS and  
VERIFICATION CENTRE



**I. STAGE**

**Summarizing of the demonstration plants and R&D results**

1. CARBON CAPTURE STORAGE – CCS

**CO<sub>2</sub> Capturing**

2. ELECTROLYSIS/ membrane separation

**H<sub>2</sub> Production/Storage**

3. DEMONSTRATION OF TECHNOLOGICAL POSSIBILITIES

**CO<sub>2</sub> + H<sub>2</sub> to Chemicals  
Power to Chemicals  
Chemicals to Power**



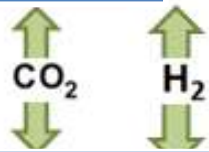
SHARED EUROPEAN  
MODULAR PILOT PLANT  
VERIFICATION CENTRE

CO<sub>2</sub> - Electricity - H<sub>2</sub>O (H<sub>2</sub>)

INNOVATION

SMART ELECTRICITY MANAGEMENT

- Distribution - grid
- BATTERY
- V2G
- P2 Chemicals
- P2 Hydrogen
- e - mobility
- g - mobility



HYDROGEN  
STORAGE

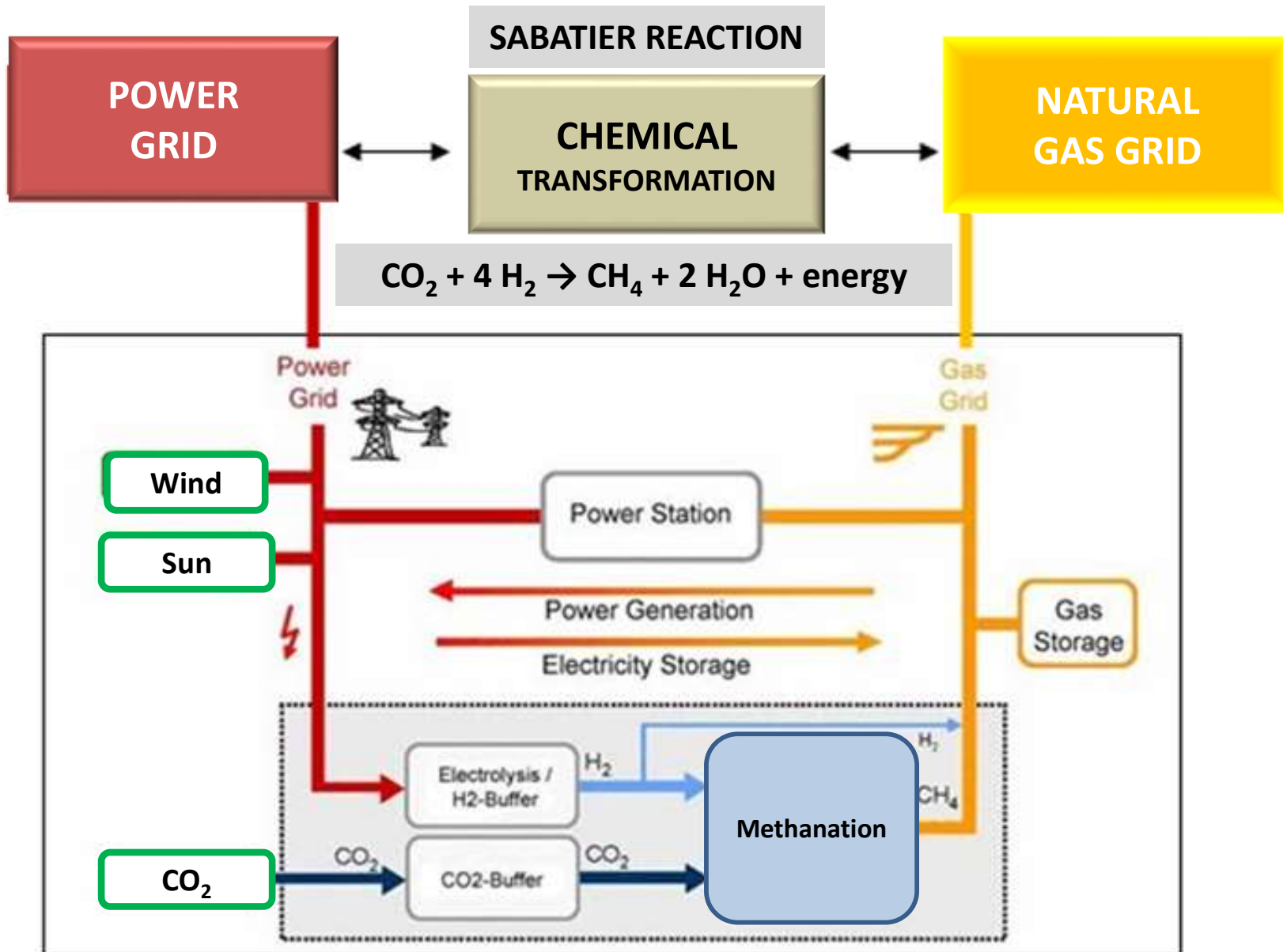
CO<sub>2</sub> Mineralization

DIRECT  
CO<sub>2</sub> CONVERSION

INDIRECT  
CO<sub>2</sub> CONVERSION

ENERGY OUTPUTS

# SECTOR COUPLING - POWER TO GAS



SHARED EUROPEAN  
MODULAR PILOT PLANTS and  
VERIFICATION CENTRE



**II. STAGE - DEVELOPMENT SCIENCE R&D&I**  
**State of the art + Future perspectives**

1. CARBON CAPTURE STORAGE – CCS

**CO<sub>2</sub> Capturing**

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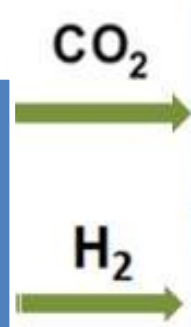
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CO<sub>2</sub> NATURAL BIOLOGICAL SEQUESTRATION, BECCS

CO<sub>2</sub> MINERALIZATION

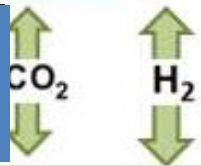
EU FLAGSHIP - GRAPHENE

QUANTUM ENERGY (PEC – Photo electrochemical cells, Photosensitizer compounds, Photocatalysts, Artificial leaf...)

MICROBIOLOGY DEVELOPMENT

INDIRECT CO<sub>2</sub> CONVERSION PROGRESS

Power to  
Ammonia  
Nitrogen-Hydrogen



H<sub>2</sub>  
development

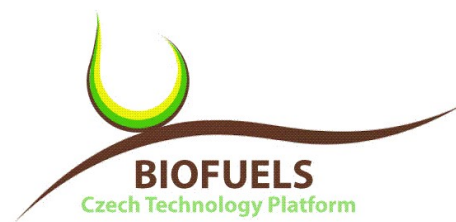
- Syngas →  
- Syngas →

GREEN Ethylene  
GATEWAY to  
Green Plastics Chemistry

GREEN Methanol  
GREEN SYNGAS  
GATEWAY to  
Chemistry  
Olefins, Aldehydes, Alcohols,  
Waxes, Ammonia, Urea, ...

NG - ENERGY OUTPUT

# CZECH BIOFUELS TECHNOLOGY PLATFORM



**Thank you for your attention**

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The head of Steering Committee  
Czech Biofuels Technology Platform

PRAGUE

CZECH REPUBLIC

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VERIFICATION CENTRE

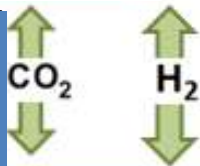
CO<sub>2</sub> - Electricity - H<sub>2</sub>O (H<sub>2</sub>)

INNOVATION

SMART ELECTRICITY MANAGEMENT

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H<sub>2</sub>  
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CO<sub>2</sub> NATURAL BIOLOGICAL SEQUESTRATION, BECCS

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QUANTUM ENERGY (PEC – Photo electrochemical cells, Photosensitizer compounds, Photocatalysts, Artificial leaf...)

MICROBIOLOGY DEVELOPMENT

INDIRECT CO<sub>2</sub> CONVERSION PROGRESS

- Syngas  
- Syngas

GREEN Methanol  
GREEN SYNGAS

GATEWAY to

Chemistry

Olefins, Aldehydes, Alcohols,  
Waxes, Ammonia, Urea, ...

GREEN Ethylene  
GATEWAY to  
Green Plastics Chemistry

NG - ENERGY OUTPUT

# TOP SCIENCE

## New and immature technologies CO<sub>2</sub> capture

- Permeable membrane materials MOF (Metal organic framework) ZIF (zeolite) COF (covalent)...
- Molten Carbonate
- High-pressure combustion with solvent capture
- Supersonic separator
- DAC – Direct Air Capture

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MODULAR PILOT PLANT  
VERIFICATION CENTRE

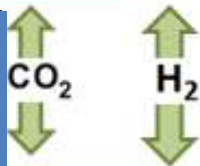
CO<sub>2</sub> - Electricity - H<sub>2</sub>O (H<sub>2</sub>)

INNOVATION

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H<sub>2</sub>  
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NG - ENERGY OUTPUT



TOP SCIENCE

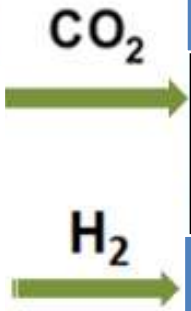
BECC – Bio CCS

Biogenic Carbon Capture and Sequestration

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MODULAR PILOT PLANT  
VERIFICATION CENTRE

CCS membrane CO<sub>2</sub>/N<sub>2</sub>  
RES development

- INNOVATION**  
SMART ELECTRICITY MANAGEMENT
- Distribution - grid
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CO<sub>2</sub> MINERALIZATION

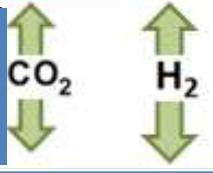
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QUANTUM ENERGY (PEC – Photo electrochemical cells, Photosensitizer compounds, Photocatalysts, Artificial leaf...)

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NG - ENERGY OUTPUT

# TOP SCIENCE

## CO<sub>2</sub> mineralization

- AGRO Industry       $(\text{NH}_4)_2\text{SO}_4$
- Building Industry     $\text{CaCO}_3$ , Geopolymer
- Food Industry        E 170,  $\text{NaHCO}_3$ ...
- Chemical Industry     $\text{NaClO}$ ,  $\text{HCl}$ ,  $\text{Na}_2\text{CO}_3$ ,...

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 MODULAR PILOT PLANT  
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**CCS** membrane CO<sub>2</sub>/N<sub>2</sub>  
**RES** development

- INNOVATION**  
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Power to Ammonia  
 Nitrogen-Hydrogen

↑ CO<sub>2</sub> ↓  
 ↑ H<sub>2</sub> ↓

H<sub>2</sub>  
 development



**EU FLAGSHIP - GRAPHENE**

**QUANTUM ENERGY** (PEC – Photo electrochemical cells, Photosensitizer compounds, Photocatalysts, Artificial leaf...)

**MICROBIOLOGY DEVELOPMENT**

**INDIRECT CO<sub>2</sub> CONVERSION PROGRESS**

- Syngas →  
 - Syngas →

**GREEN Methanol  
 GREEN SYNGAS**

GATEWAY to  
**Chemistry**  
 Olefins, Alkdehydes, Alcohols,  
 Waxes, Ammonia, Urea, ...

**GREEN Ethylene**  
 GATEWAY to  
**Green Plastics Chemistry**

**NG - ENERGY OUTPUT**

# TOP SCIENCE

## GRAPHENE and derivatives

- CCS
- Conversion CO<sub>2</sub> to fuels
- Conversion CO<sub>2</sub> to graphen

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MODULAR PILOT PLANT  
VERIFICATION CENTRE

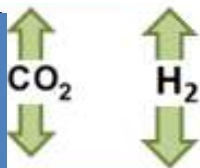
CCS membrane CO<sub>2</sub>/N<sub>2</sub>  
RES development

INNOVATION

SMART ELECTRICITY MANAGEMENT

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H<sub>2</sub>  
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NDGQs -Nitrogen-Doped Graphene Quantum dots

Liquid fuels CH<sub>3</sub>CH<sub>2</sub>OH, C<sub>2</sub>H<sub>2</sub>,.....

QUANTUM ENERGY (PEC – Photo electrochemical cells, Photosensitizer compounds, Photocatalysts, Artificial leaf...)

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NG - ENERGY OUTPUT

# TOP SCIENCE

## Photocatalytic conversion CO<sub>2</sub>

photon – quantum of light  
(or other form of electromagnetic radiation)

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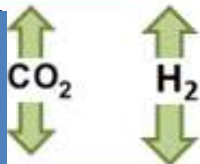
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H<sub>2</sub>  
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NDGQs -Nitrogen-Doped Graphene Quantum dots

Liquid fuels CH<sub>3</sub>CH<sub>2</sub>OH, C<sub>2</sub>H<sub>2</sub>,.....

Quantum

Photo - Engineered Catalysts   
Photo - electrochemical - H<sub>2</sub> production  
Photolysis

MICROBIOLOGY DEVELOPMENT

INDIRECT CO<sub>2</sub> CONVERSION PROGRESS

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Olefins, Aldehydes, Alcohols,  
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GATEWAY to  
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NG - ENERGY OUTPUT



# TOP SCIENCE

## Microbial CO<sub>2</sub> conversion

- Metabolism of microorganisms
- Electroactive bacteria,....

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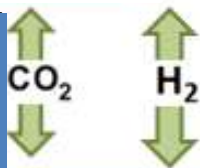
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H<sub>2</sub>  
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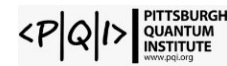


NDGQs - Nitrogen-Doped Graphene Quantum dots

Liquid fuels CH<sub>3</sub>CH<sub>2</sub>OH, C<sub>2</sub>H<sub>2</sub>,.....

Quantum

Photo - Engineered Catalysts  
Photo - electrochemical - H<sub>2</sub> production  
Photolysis



Metabolic engineering, PBE-Photo Bio Electrochemical systems,  
MES - Microbial Electro Synthesis  
bacteria interaction with electrodes by exchanging electrons,

INDIRECT CO<sub>2</sub> CONVERSION PROGRESS

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GREEN Ethylene  
GATEWAY to  
Green Plastics Chemistry

NG - ENERGY OUTPUT

# TOP SCIENCE

## Indirect CO<sub>2</sub> conversion

### Primarily to CO

- Thermochemical
- Photochemical
- Electrochemical
- Biochemical
- Catalytic hydrogenation
- Low temperature plasma

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**INNOVATION**  
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**NDGQs -Nitrogen-Doped Graphene Quantum dots**  
Liquid fuels CH<sub>3</sub>CH<sub>2</sub>OH, C<sub>2</sub>H<sub>2</sub>,.....

**Quantum** Photo - Engineered Catalysts  $\langle P|Q|I \rangle$  PITTSBURGH QUANTUM INSTITUTE www.pqi.org  
Photo – electrochemical – H<sub>2</sub> production  
Photolysis

Metabolic engineering, PBE-Photo Bio Electrochemical systems,  
MES - Microbial Electro Synthesis  
bacteria interaction with electrodes by exchanging electrons,

**Thermomechanical, Plasmolysis,...**

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- Syngas →  
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# TOP SCIENCE

## POLYMERS

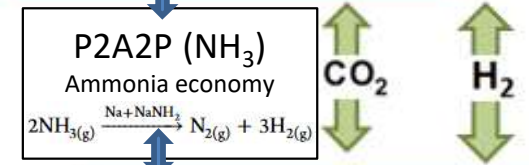
- Polycarbonates
- Ethylenglycol - for PEG,PET
- Methylglyoxal – formaldehyde replacement
- Furandiol – fuels additive
- etc....

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**INNOVATION**  
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**HYDROGEN**



**NDGQs - Nitrogen-Doped Graphene Quantum dots**

Liquid fuels CH<sub>3</sub>CH<sub>2</sub>OH, C<sub>2</sub>H<sub>2</sub>,.....

**Quantum** Photo - Engineered Catalysts  $\langle P|Q|I \rangle$    
Photo - electrochemical - H<sub>2</sub> production  
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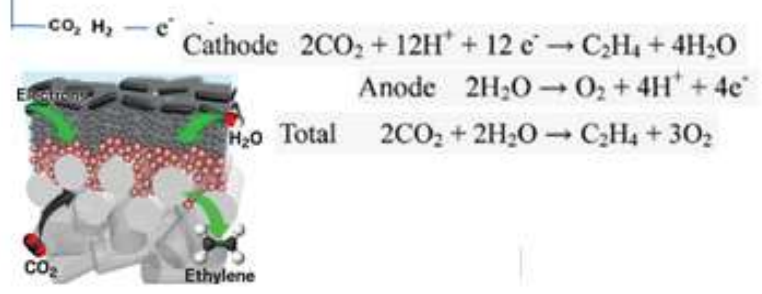
Metabolic engineering, PBE-Photo Bio Electrochemical systems,  
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**Thermomechanical, Plasmolysis,...**

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# TOP SCIENCE

## HYDROGEN

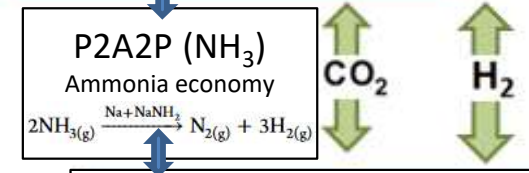
- HER ( Hydrogen Evolution Reaction)
- Storage HCOOH, NH<sub>3</sub>,...

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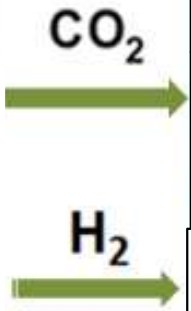
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HER hydrogen evolution reaction  
H<sub>2</sub> Storage  
H<sub>2</sub> FUEL CELLS  
PEC photo electrochemical cells

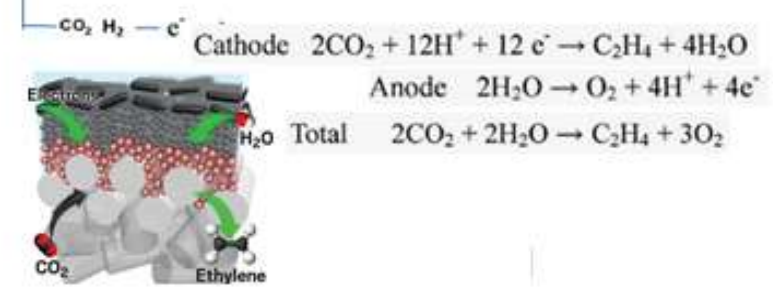


**NDGQs -Nitrogen-Doped Graphene Quantum dots**  
Liquid fuels CH<sub>3</sub>CH<sub>2</sub>OH, C<sub>2</sub>H<sub>2</sub>,.....

**Quantum** Photo - Engineered Catalysts  $\langle P|Q|I \rangle$  PITTSBURGH QUANTUM INSTITUTE www.pqi.org  
Photo - electrochemical - H<sub>2</sub> production  
Photolysis

Metabolic engineering, PBE-Photo Bio Electrochemical systems,  
MES - Microbial Electro Synthesis  
bacteria interaction with electrodes by exchanging electrons,

**Thermomechanical, Plasmolysis,...**



- Syngas →  
- Syngas →

**GREEN Methanol  
GREEN SYNGAS**

GATEWAY to  
**Chemistry**  
Olefins, Alkdehydes, Alcohols,  
Waxes, Ammonia, Urea, ...



# TOP SCIENCE

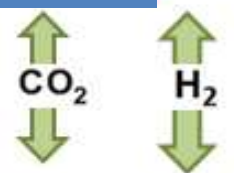
Create connected energy management system

RES – Power distribution (storage) – H2 – Chemicals – Fuels – Grid  
just in time smart managing Power to X

# CO<sub>2</sub> VERIFICATION CENTRE - FUNDAMENTS for GREEN CARBON INDUSTRY

## SHARED EUROPEAN MODULAR PILOT PLANT VERIFICATION CENTRE

CO<sub>2</sub> - ČEZ, EON, EPH, Třinecké železářny, Acelor Mital, Lafarge, ....



ČZU - FAPPZ prof. Ing. Pavel Tlustoš, CSc.



VŠB – Ústav environmentálních technologií  
prof. Ing. Lucie Obalová, Ph.D. - prof. Ing. Kamila Kočí, Ph.D.



PARTNER - GERMANY

MU Brno – Přírodovědecká fakulta – Ústav experimentální biologie  
doc. Mgr. Monika Vítězová, Ph.D.



PARTNER – POLAND Polytechnika Opolska Maria Madej-Lachowska

VŠCHT  
doc. Ing. Karel Ciahotný, CSc.  
doc. Ing. Tomáš Hlinčík, Ph.D.

ÚCHP A.V. Ing. Pavel Izák (membrány)



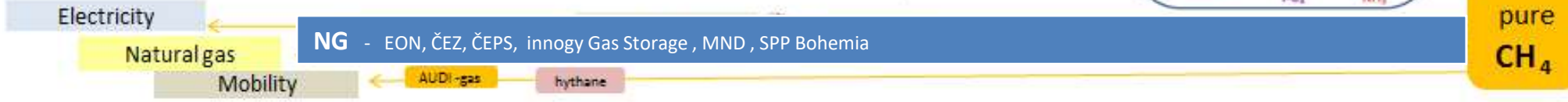
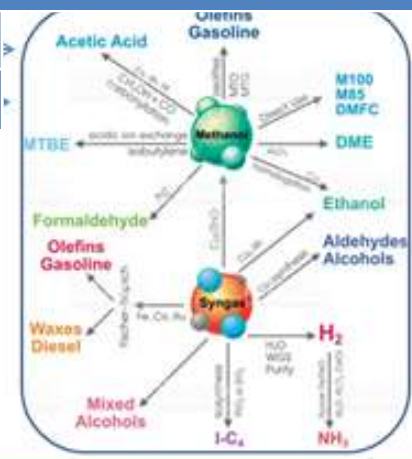
CEITEC prof. Ing. Martin Trunc Dr. (keramické kompozity)



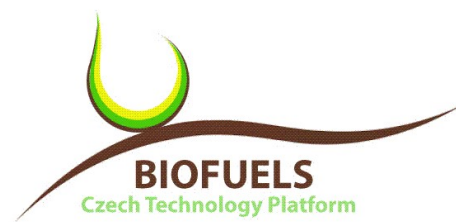
CPMTOW Centrum polymerních materiálů a technologií Otty Wichterla

VŠCHT.Lab nízkoteplotního plazmatu doc. Ing. Vladimír Scholtz, Ph.D.

VŠB TUO Faculty of Materials Science and Technology



# CZECH BIOFUELS TECHNOLOGY PLATFORM



**Thank you for your attention**

Leos Gal

The head of Steering Committee  
Czech Biofuels Technology Platform

[leos.gal@seznam.cz](mailto:leos.gal@seznam.cz)

00420-736505012