

Advanced Photoelectrocatalytic Devices for Coupling Bio- and Solar-Refinery

Gabriele Centi, *Coordinator of DECADE*
ERIC aisbl & Univ. of Messina

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Title Project: **DistributEd Chemicals And fuels production**
from CO₂ in photoelectrocatalytic **Devices (DECADE)**

#EUGreenWeek
2021 PARTNER EVENT





WORKING TOGETHER TO CREATE A
COMMUNITY TO ADDRESS THIS CHALLENGE

SOLAR FUEL CHALLENGE

Positioning DECADE role

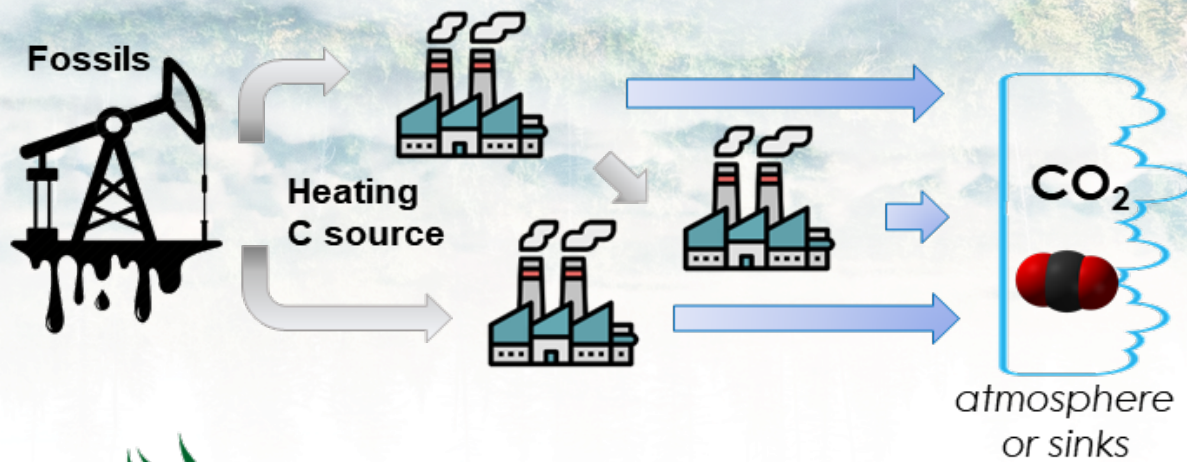


This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 862030

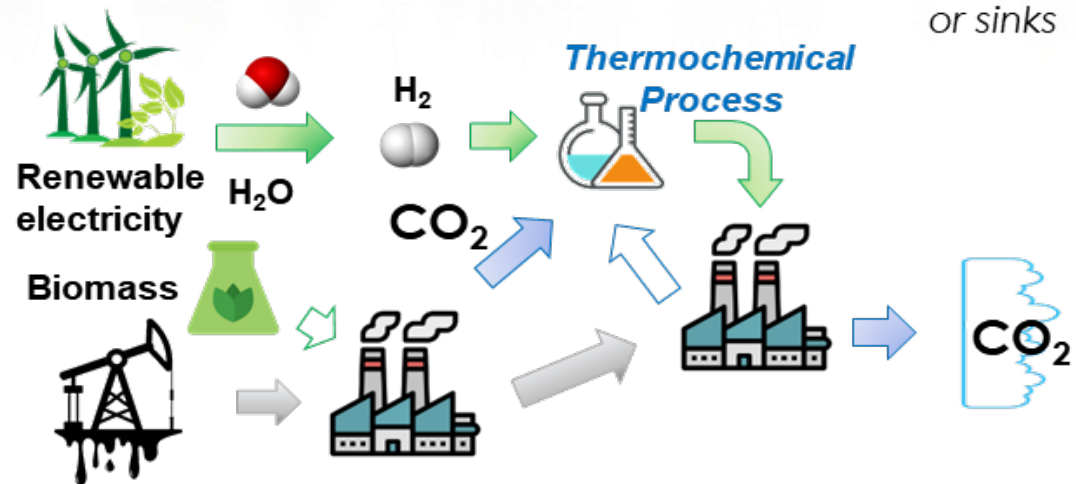


From linear to circular economy

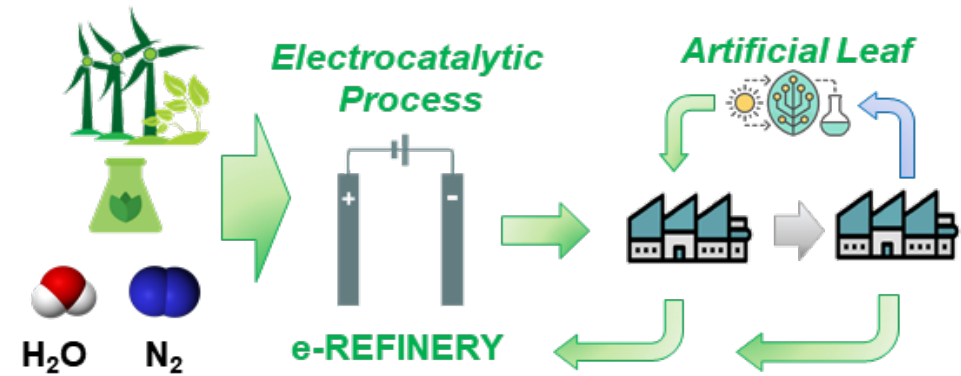
a linear model
a)



indirect circular model
b)



direct & full circular economy
c)

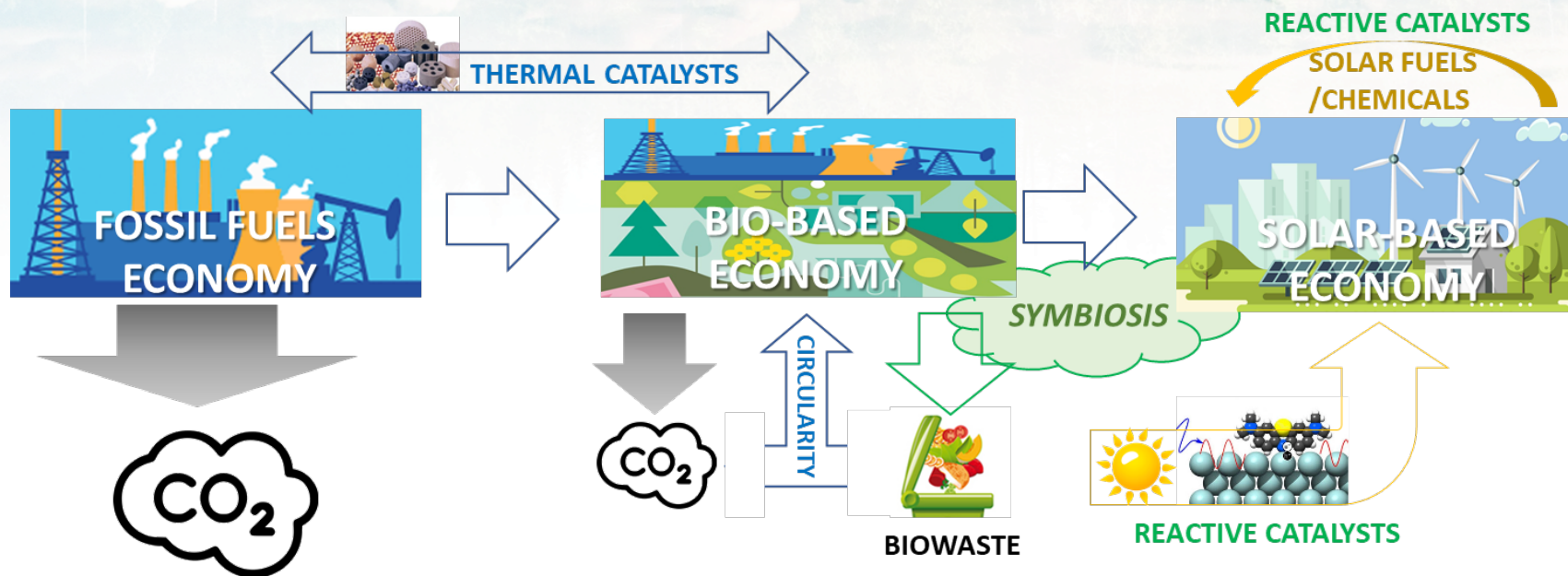


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The Catalyst Review 4 (2021) 8-13 (part 1)

The on-going transformation

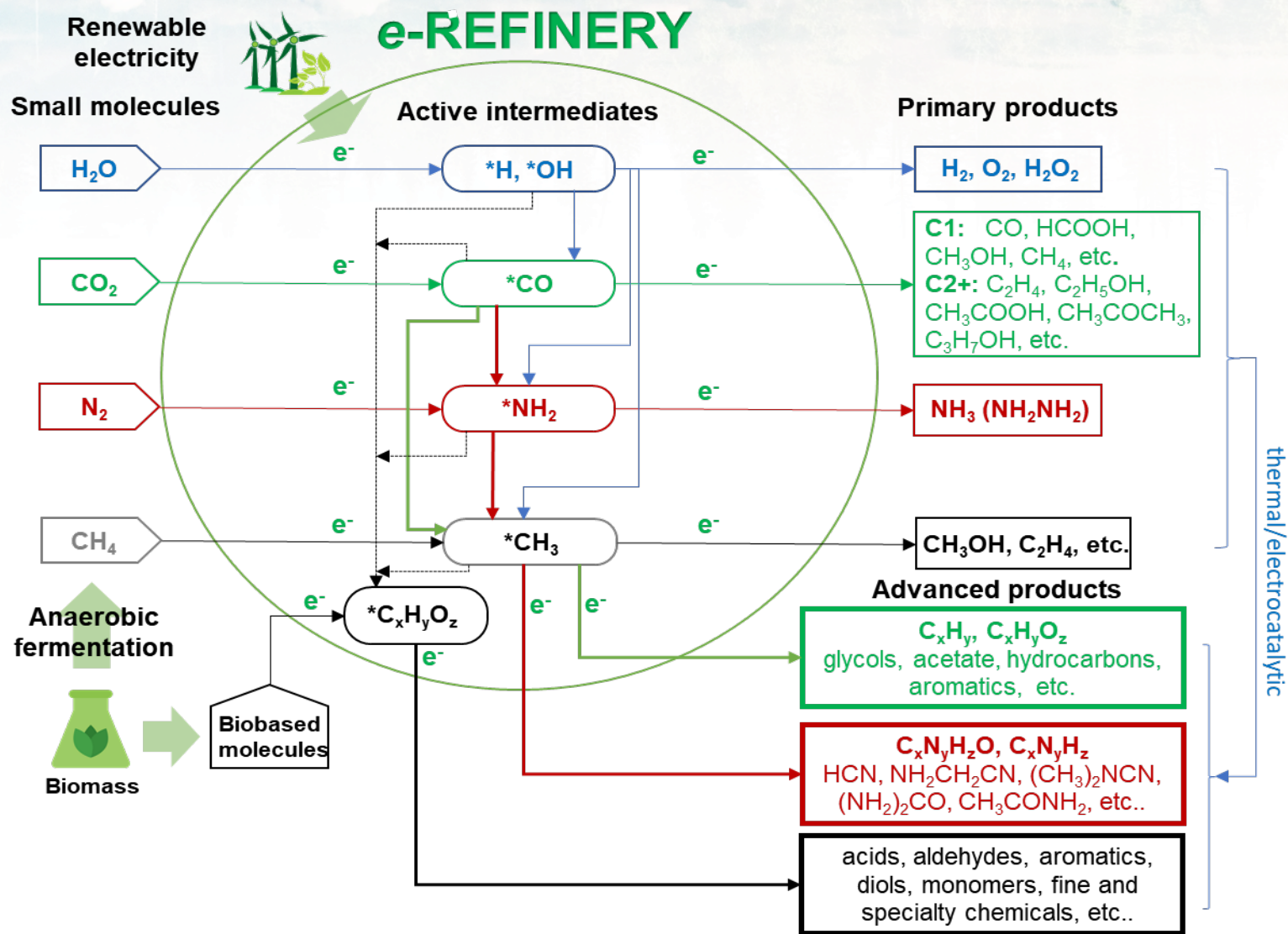


Initial transition from FF to a *mixed FF & bio-based economy*
 ⇒ **adapting thermal** catalysts

Next step ⇒ **solar-based economy** (in **symbiosis** with bio-based economy)
conceptually new catalysts, indicated as **reactive** catalysts.

e-Refinery

from small and biobased molecules to a framework of chemical production (**e-chemistry**) alternative to that based on fossil fuels (petrochemistry)



The Catalyst Review 4
(2021) 8-13 (part 1)



DECADE CONCEPT



*and novel (breakthrough)
approach*

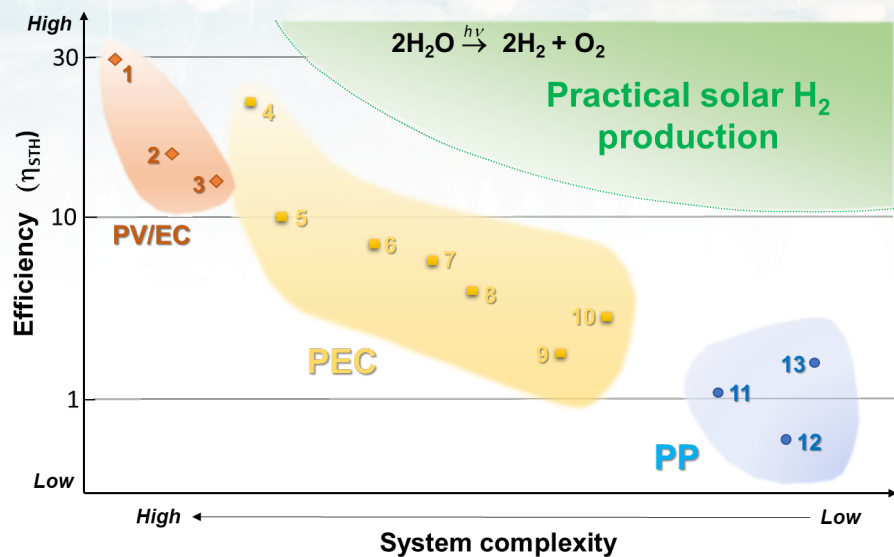


Challenges addressed

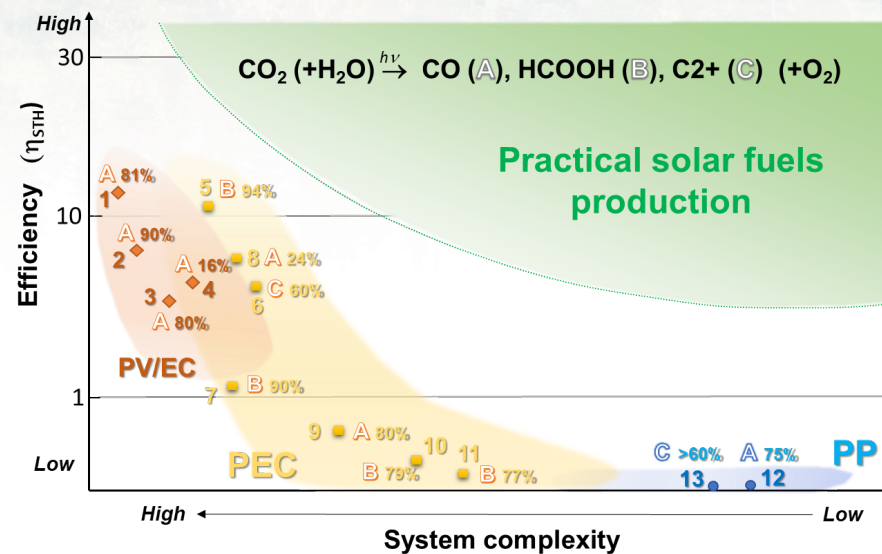
- A **novel PEC concept** engineered to form the **SAME** product on both sides of the cell, and **avoid** the formation of **O₂** (common in H₂O splitting & most CO₂RR approaches)
 - because in most of artificial leaf applications oxygen is a **waste** product (which **reduces** the effective overall efficiency)
- Integrate solar use in *biorefineries* (⇒ **e-refinery**)
- Develop flexible solutions with **multiple market** (chemicals and fuels)
- Novel solution to improve **circular economy** and **lower carbon footprint** in chemical & energy processes
- Develop **compact** design PEC cells, with easier scalability to be used as **artificial leaf**
- Realize **process intensification**



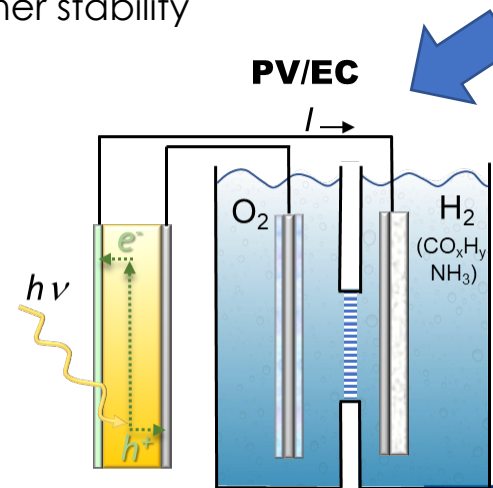
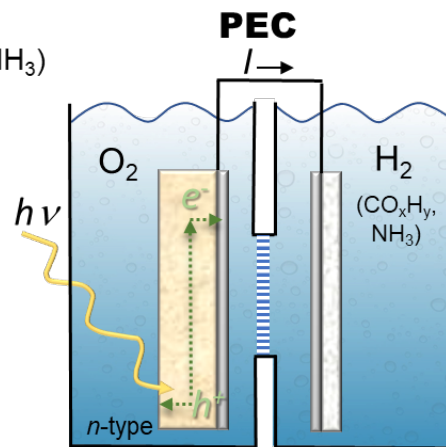
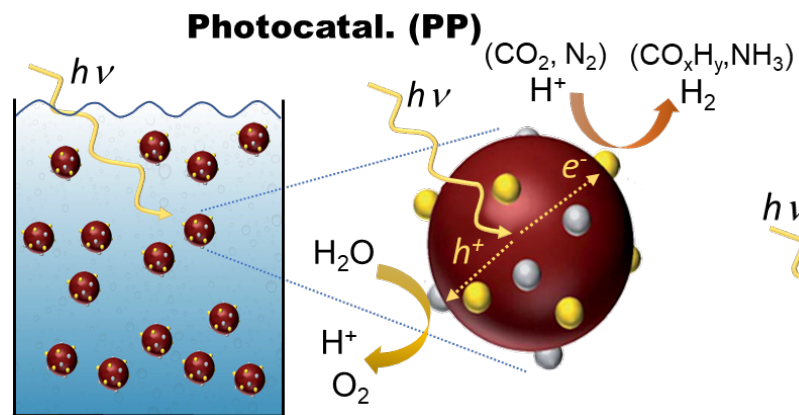
PEC approach



Motivations



- Enhanced efficiencies (higher current densities)
- Higher stability



DECADE project concept

- **Input**

- (bio)ethanol and CO₂ (biorefinery)

- **PV/EC system**

- **ANODE**

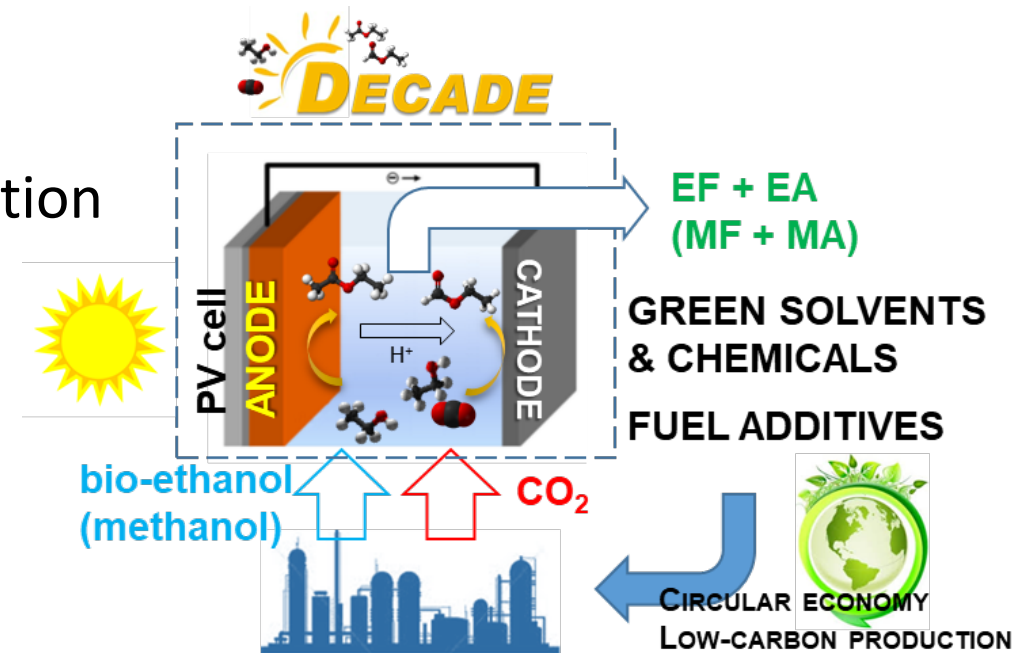
- Ethanol oxidative dimerization \Rightarrow ethylacetate

- **CATHODE**

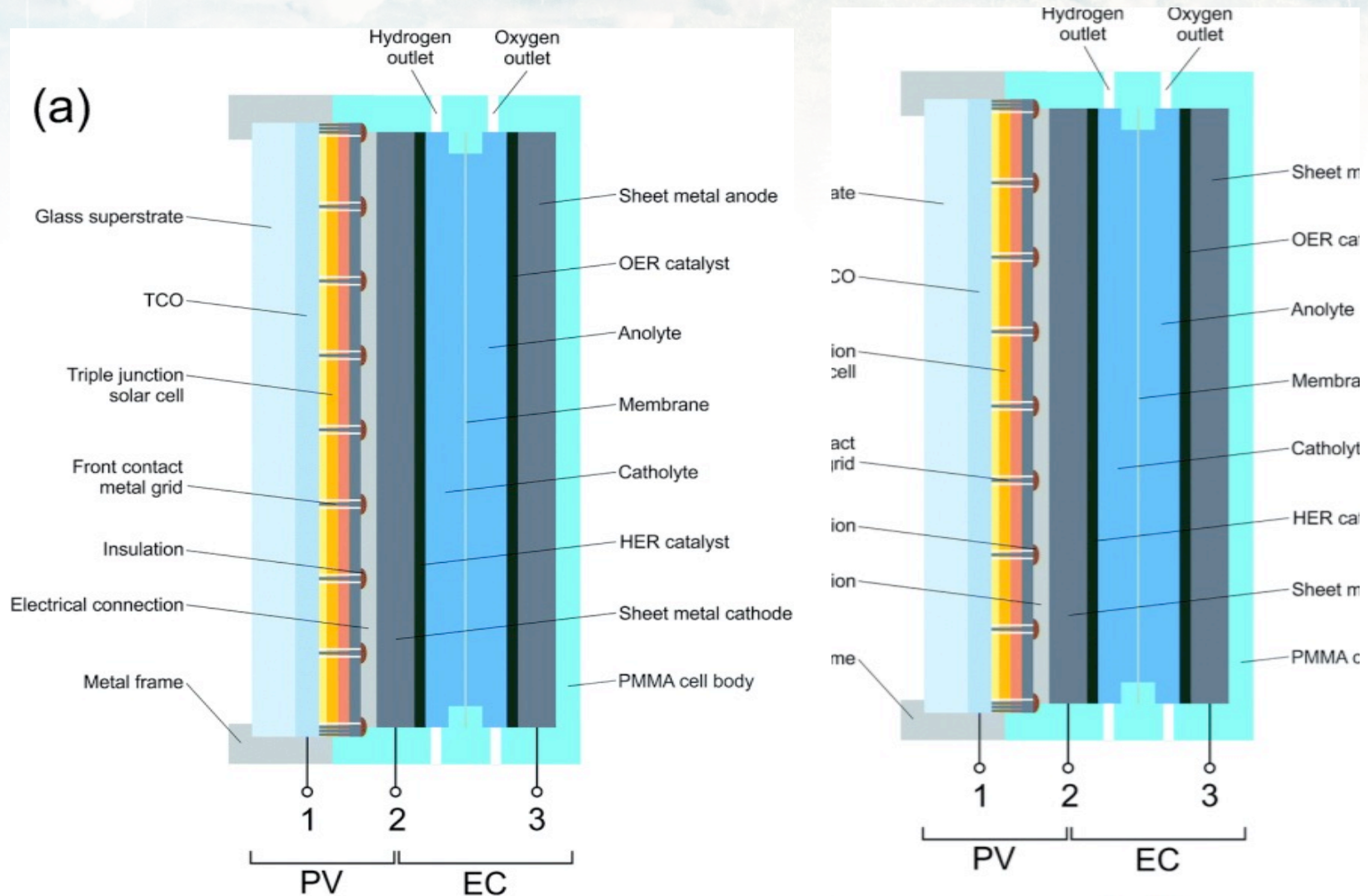
- CO₂ reduction (to acetate) with its catalytic reaction with ethanol to form ethylacetate (**EA**)
 - Formate also formation and reaction of ethylformate (**EF**)

- **Products and Uses**

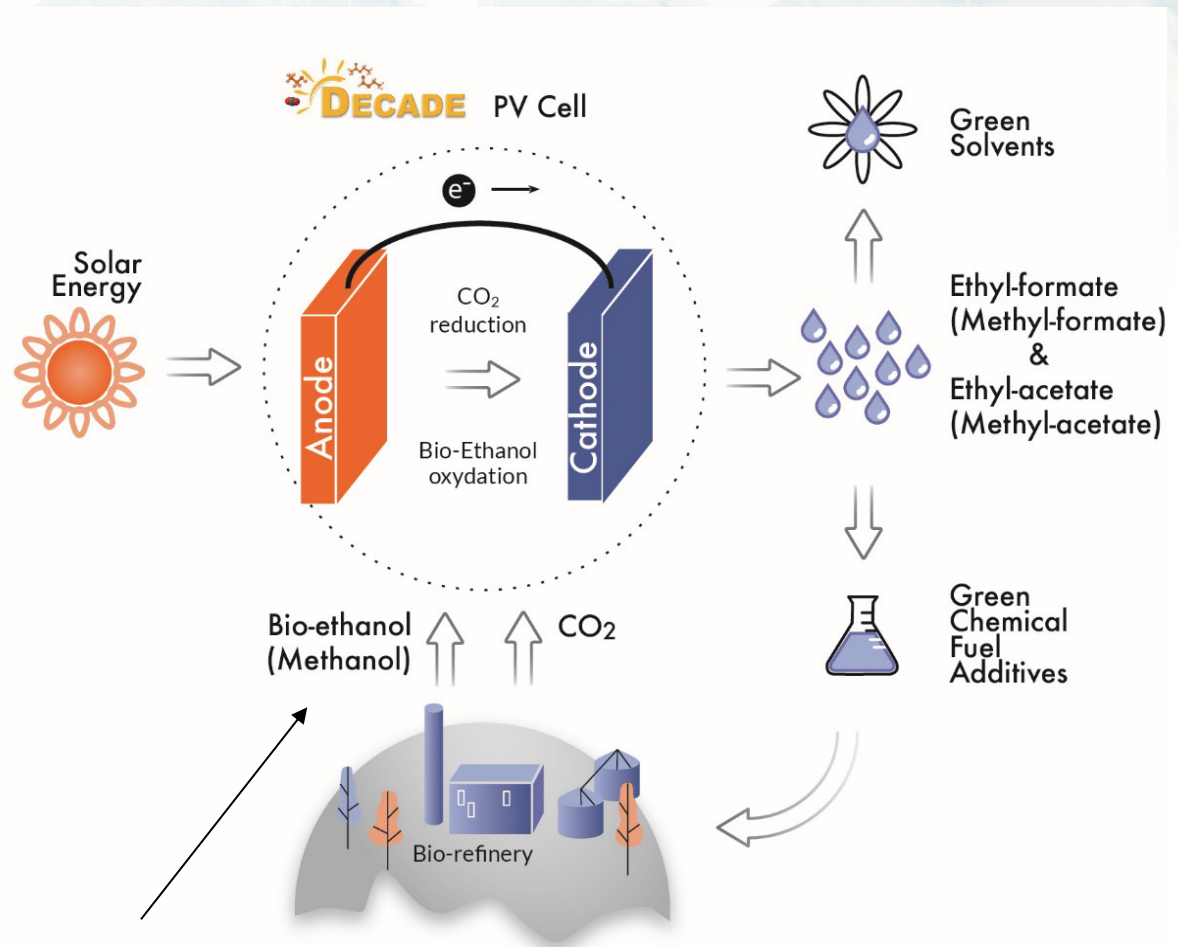
- EA+EF mixture in ethanol used as green solvents and fuel additives



PV-EC DECADE device



DECADE project concept & consortium



A similar chemistry also from methanol

R&D Institutions

Prof. Domen for benchmarking results

Industry or industry-oriented centers

TRL 3
Electrocatalyst development

PEC reactor & components developers

System integration & prototyping

System validation & assessment
TRL 5



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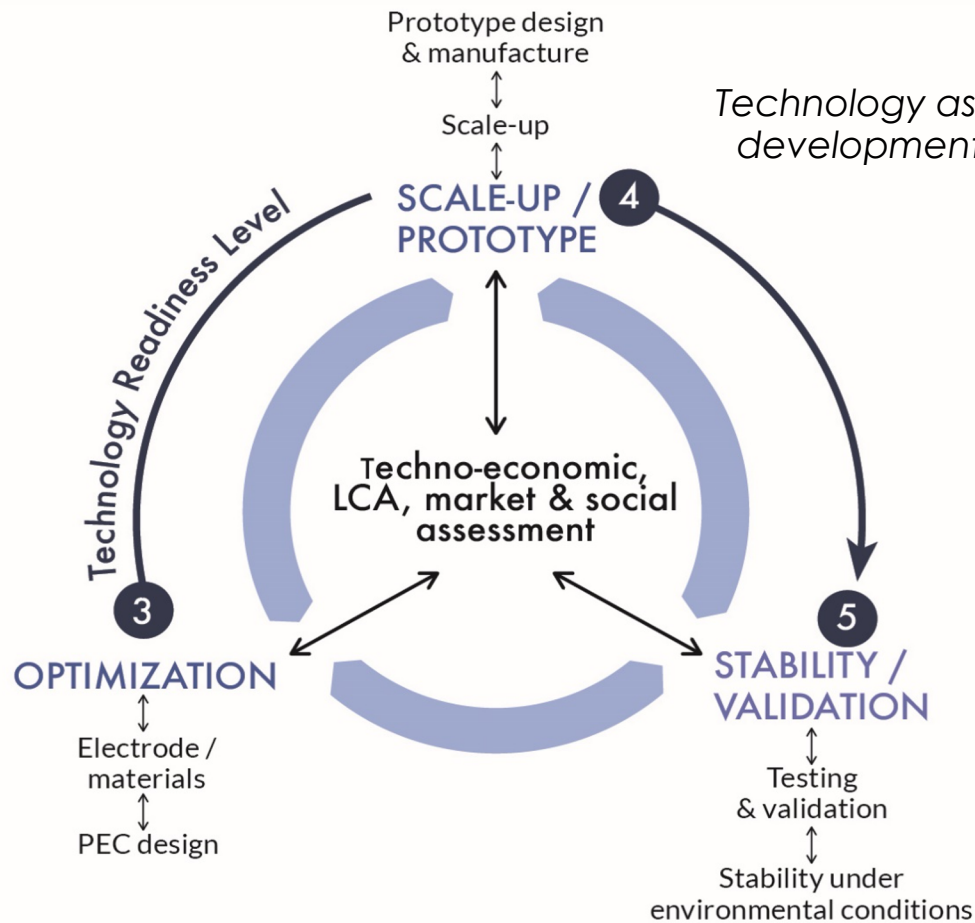


DECADE approach

Integrated development of materials and PEC reactor/prototype with technologic, economic, LCA, market & social assessments to guide the increase of Technology Readiness Level (TRL) from 3 to 5.

an integrated approach with prototype at the core

- INPUT**
- FET project
 - Beneficiary experience
 - International partner experience

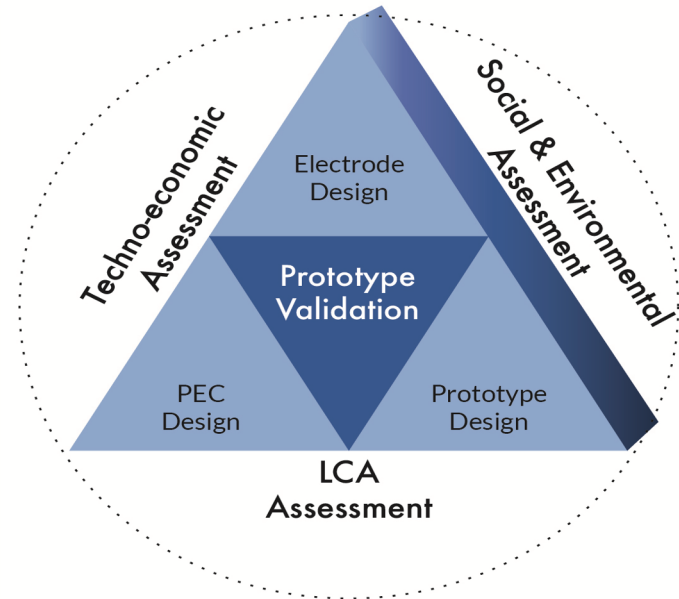


Technology assessment to guide development (from TRL 3 to 5)



- OUTPUT**
- Green Solvents
 - Green Chemical Fuel Additives
 - PEC

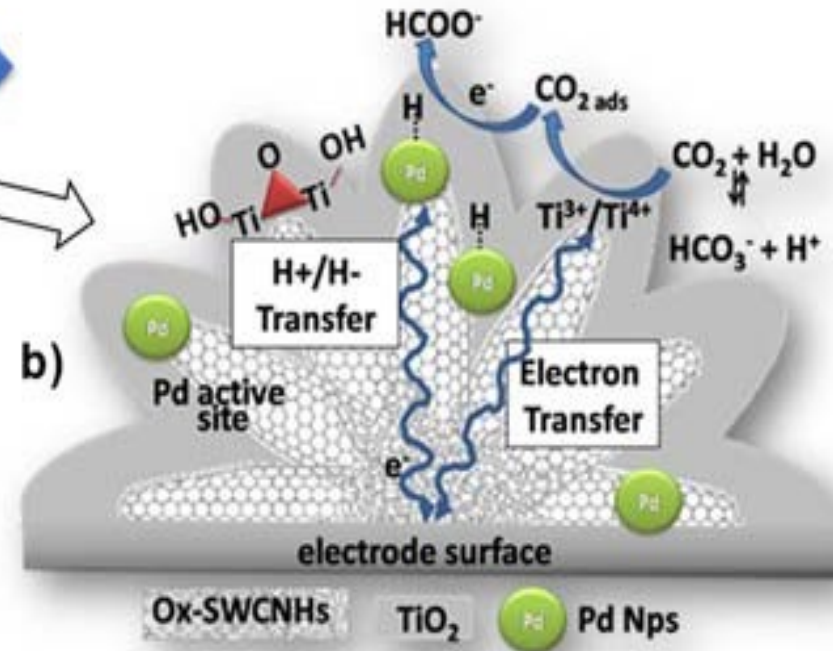
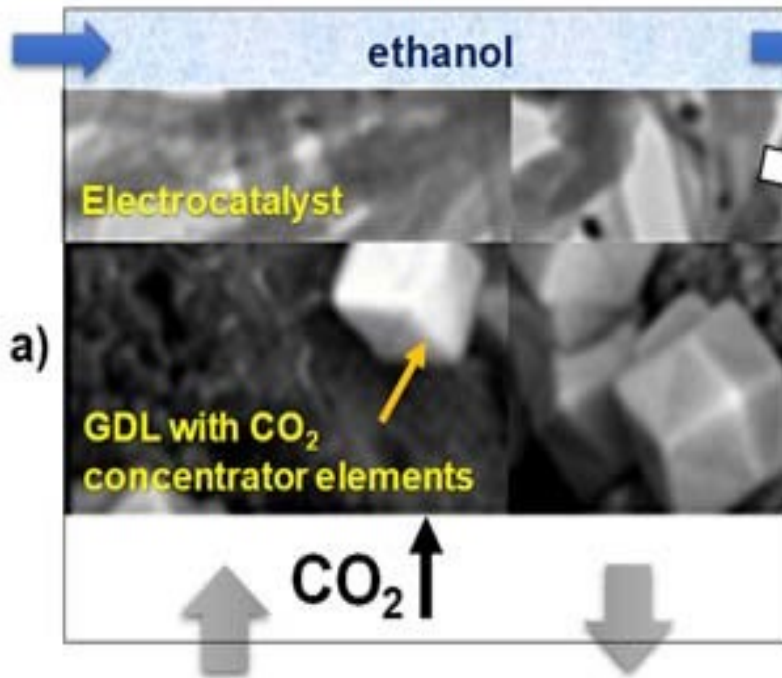
Markets prospects and business cases are part of the project



Concept design for the GDL-type cathode for CO₂ reduction

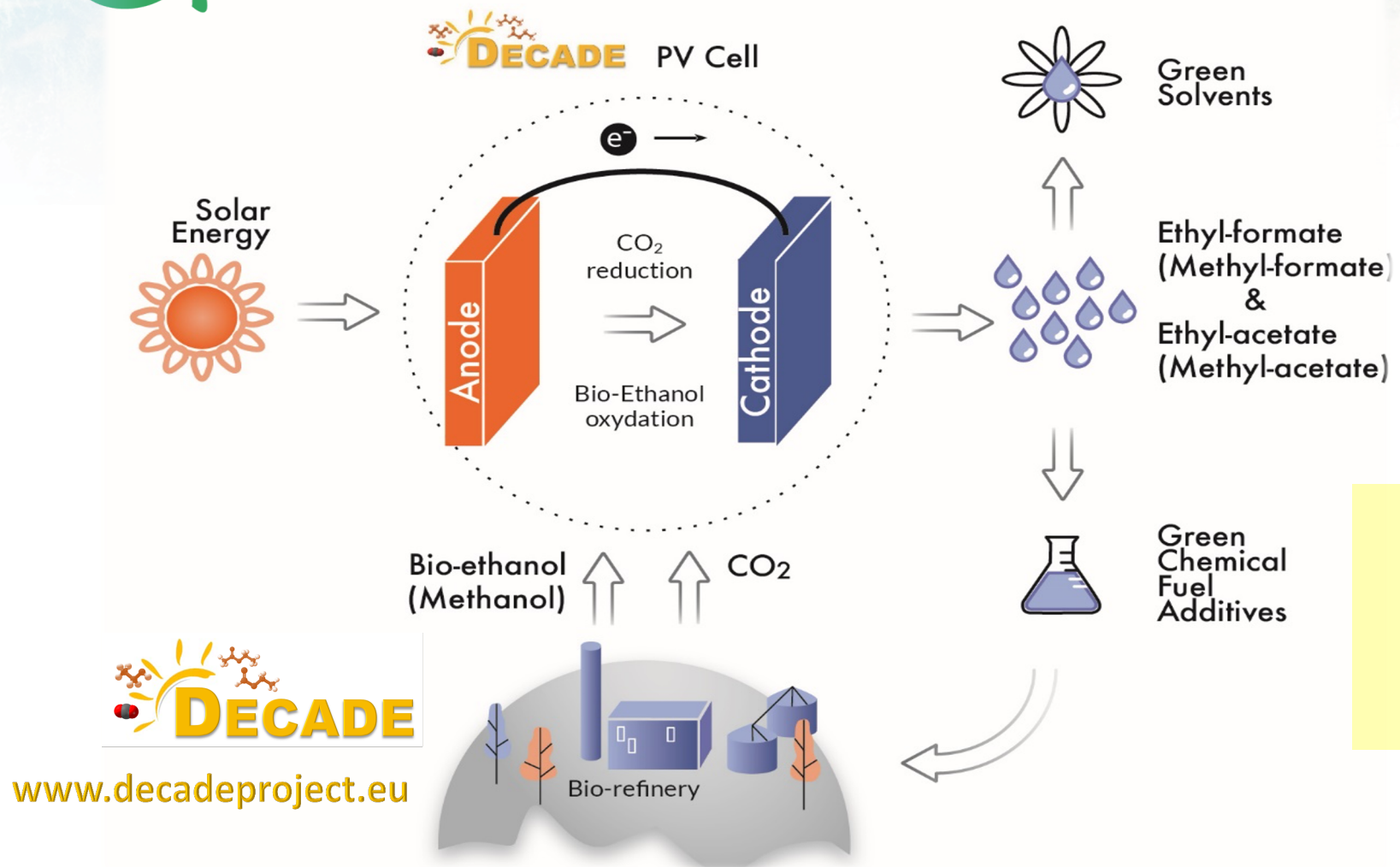
GDL membrane integrating element that improved the three-phase boundary at the electrocatalyst between CO₂, catalyst and protons

biomimetic multi-functional core-shell Pd@TiO₂/ox-SWCNHs (Single-walled carbon nanohorns) heterostructures



confined-space distribution of nanoparticles within a metal-oxide phase that envelops a CNS (carbon nanostructures) scaffold

DECADE project: develop next generation PEC devices to use CO₂ and bioethanol to produce green chemicals and fuels



SUMMARY

OUR VISION:

Integrate solar use in biorefineries (⇒ e-refinery) for a new zero-pollution model of distributed production of chemicals & fuels

Conclusions

- **DECADE** will develop a novel PV/EC device engineered to use waste CO₂ and bio-alcohols as feeding inputs to synthesize value-added products.
 - enhanced energy efficiency and better addressing market requirements and needs for moving to a solar economy
 - Focus on ethanol, but also methanol case to lower the carbon footprint in methanol plants producing added-value chemicals.
- Explore potential use of this novel PEC device for a **multi-purpose solution** to improve *circular economy* and *lower carbon footprint* in chemical & energy processes.

CHANGE

