NEXTCCUS Project

Next Generation Electrochemical System for Sustainable Direct CO_2 Capture and Utilization/Storage as Clean Solar Fuel

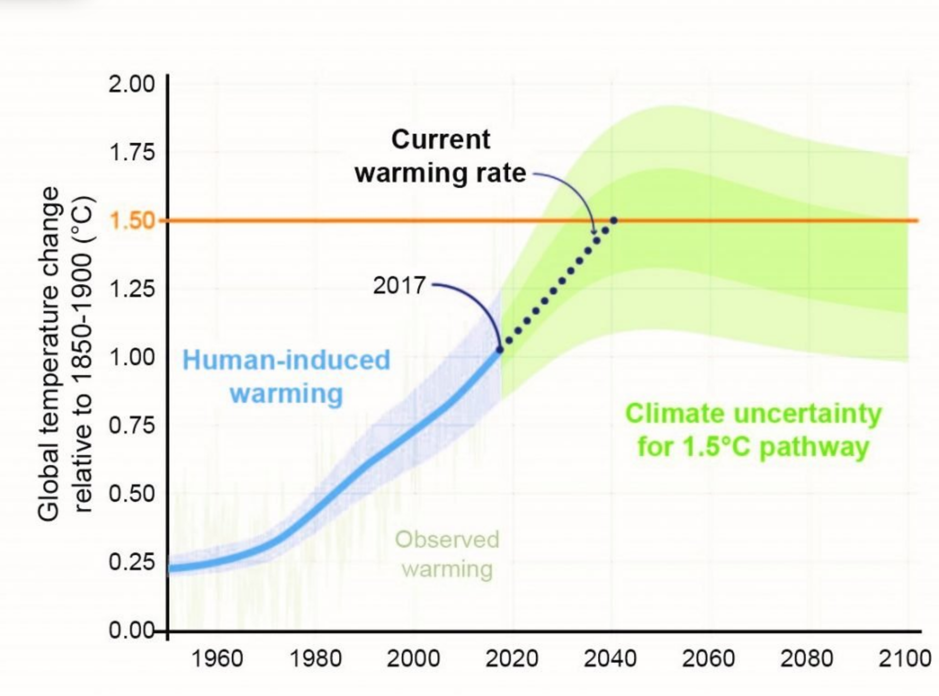
Mahmoud Zendehdel

IRITALY Trading Company Srl

m.zendehdel@iritalytrading.com

09.06.2022

Climate change battle



The **1.5°C Scenario (1.5-S)** describes an energy transition pathway aligned with the 1.5°C climate ambition – that is, to limit global average temperature increase by the end of the present century to 1.5°C, relative to pre-industrial levels. It prioritises readily available technology solutions, which can be scaled up at the necessary pace for the 1.5°C goal.

1.5-S

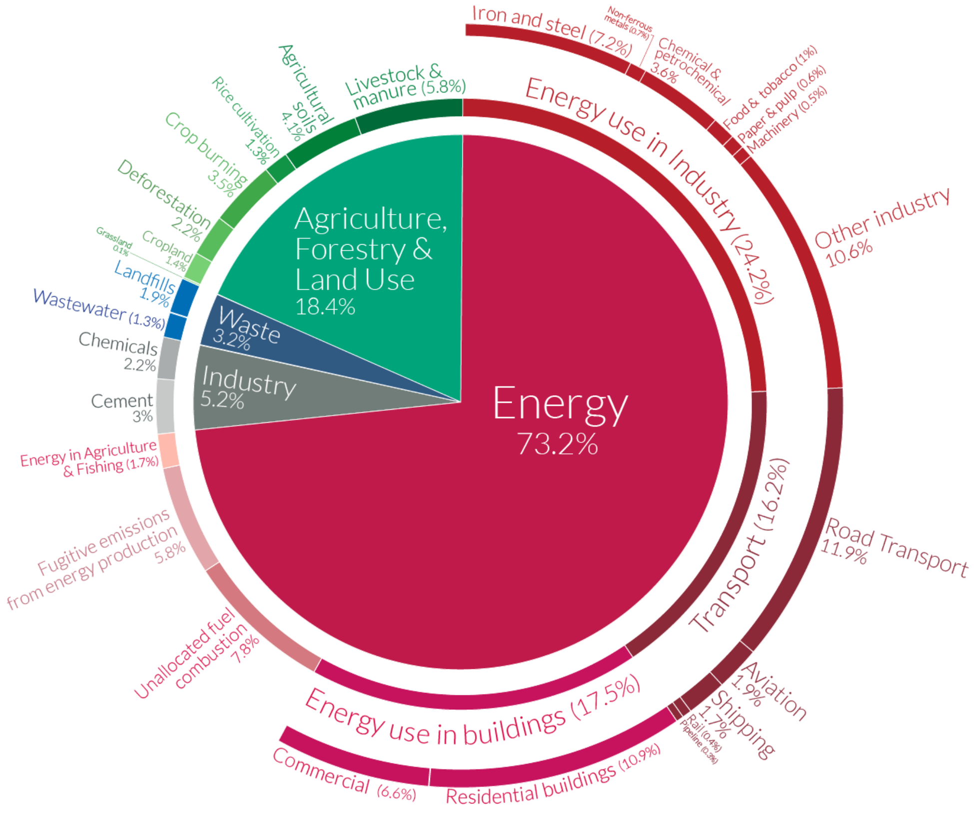
Time is of the essence, and a rapid decline in emissions must begin now to preserve a fighting chance to hold the line at 1.5° C.
The time imperative requires careful investment and policy choices in the coming decade.

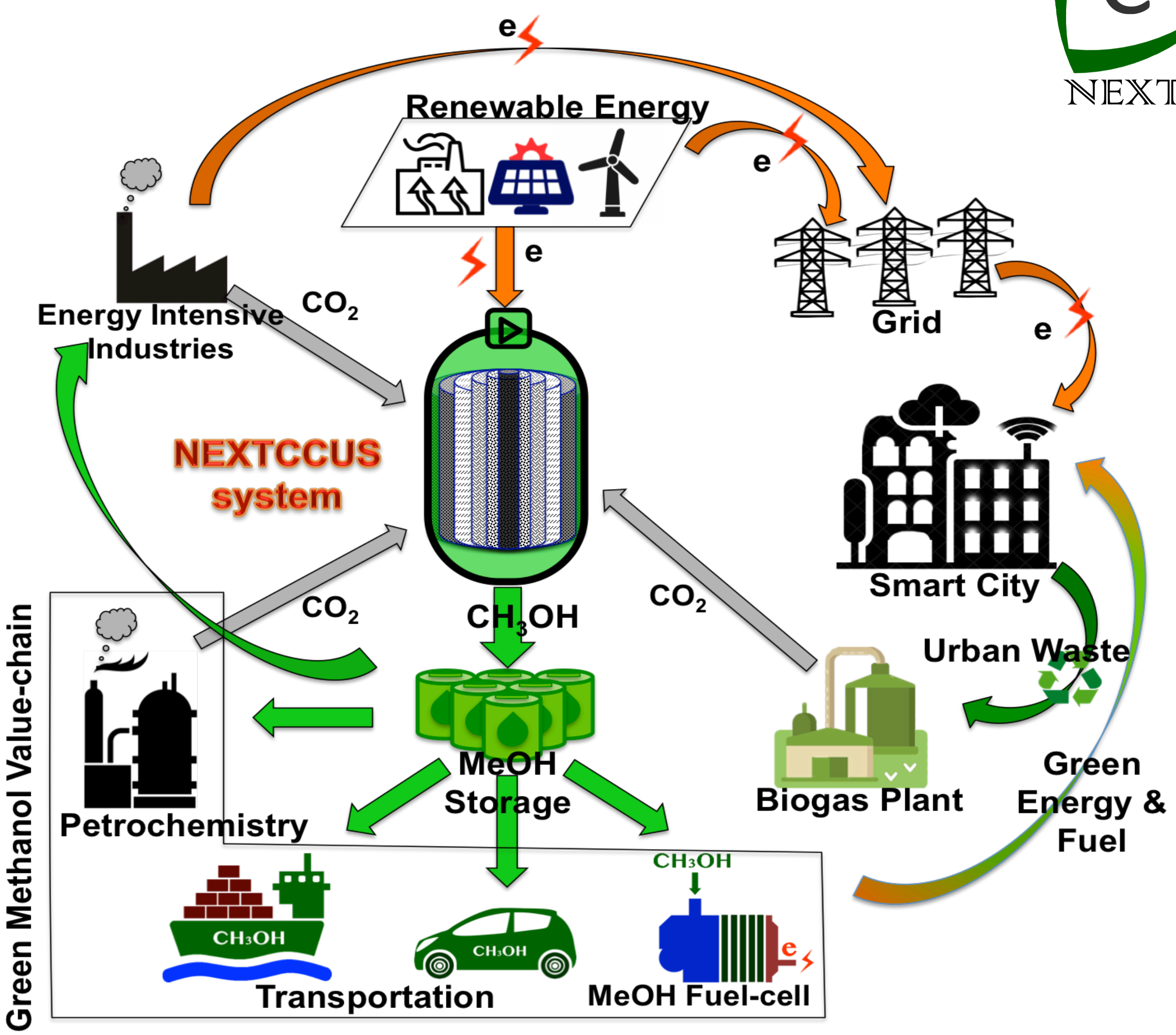
IRENA's 1.5° C Scenario, 2022

Accelerating CCS Technologies

Circular Carbon Economy of NEXTCCUS

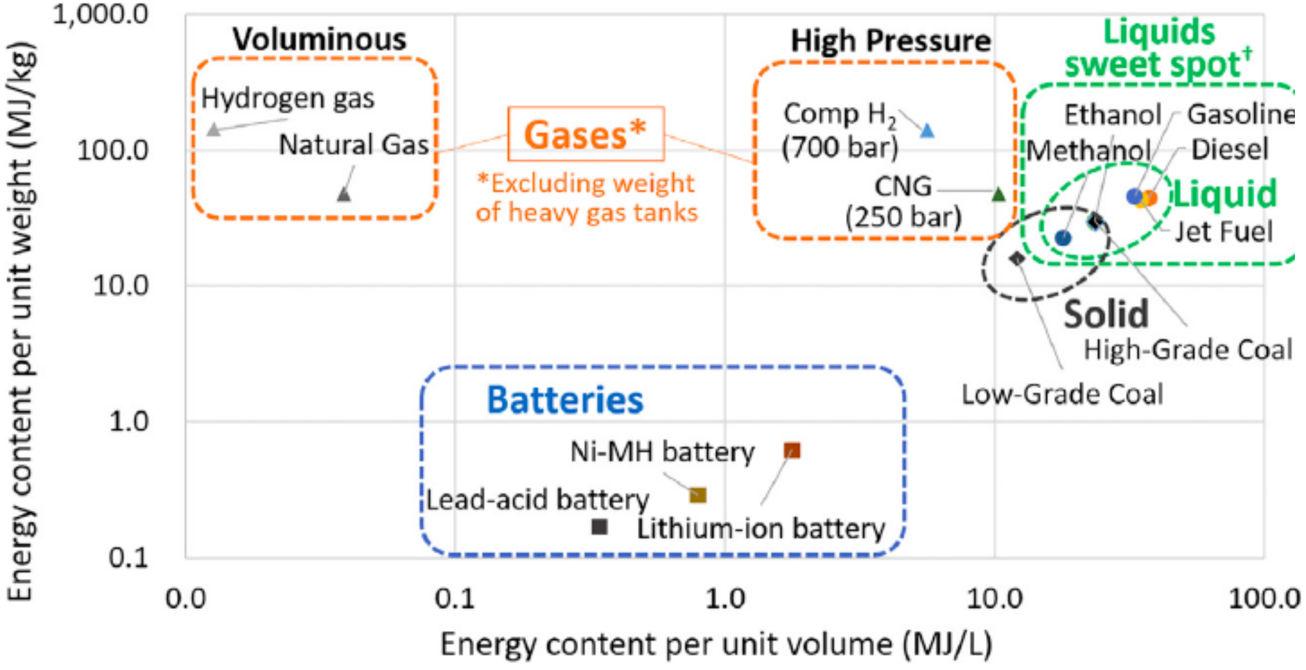
NEXTCCUS



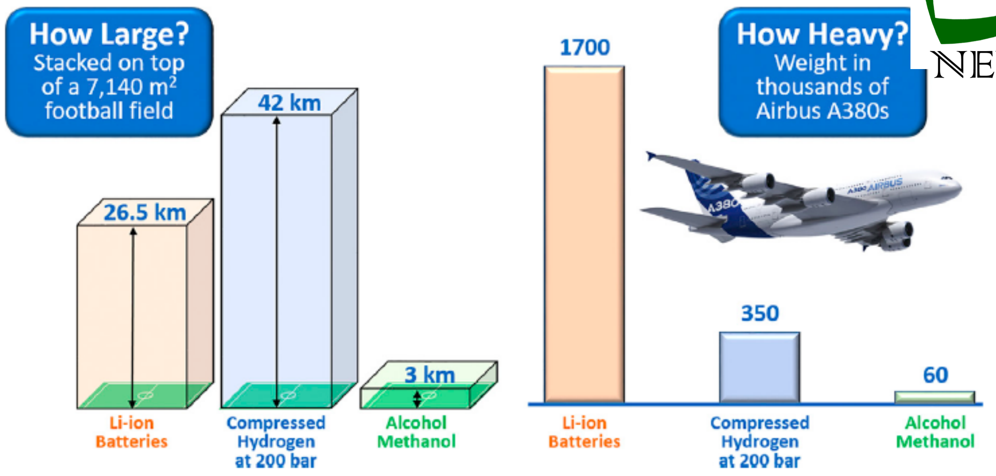


IRITALY Trading

Why Methanol



Energy Density Comparisons of Several Energy Carriers



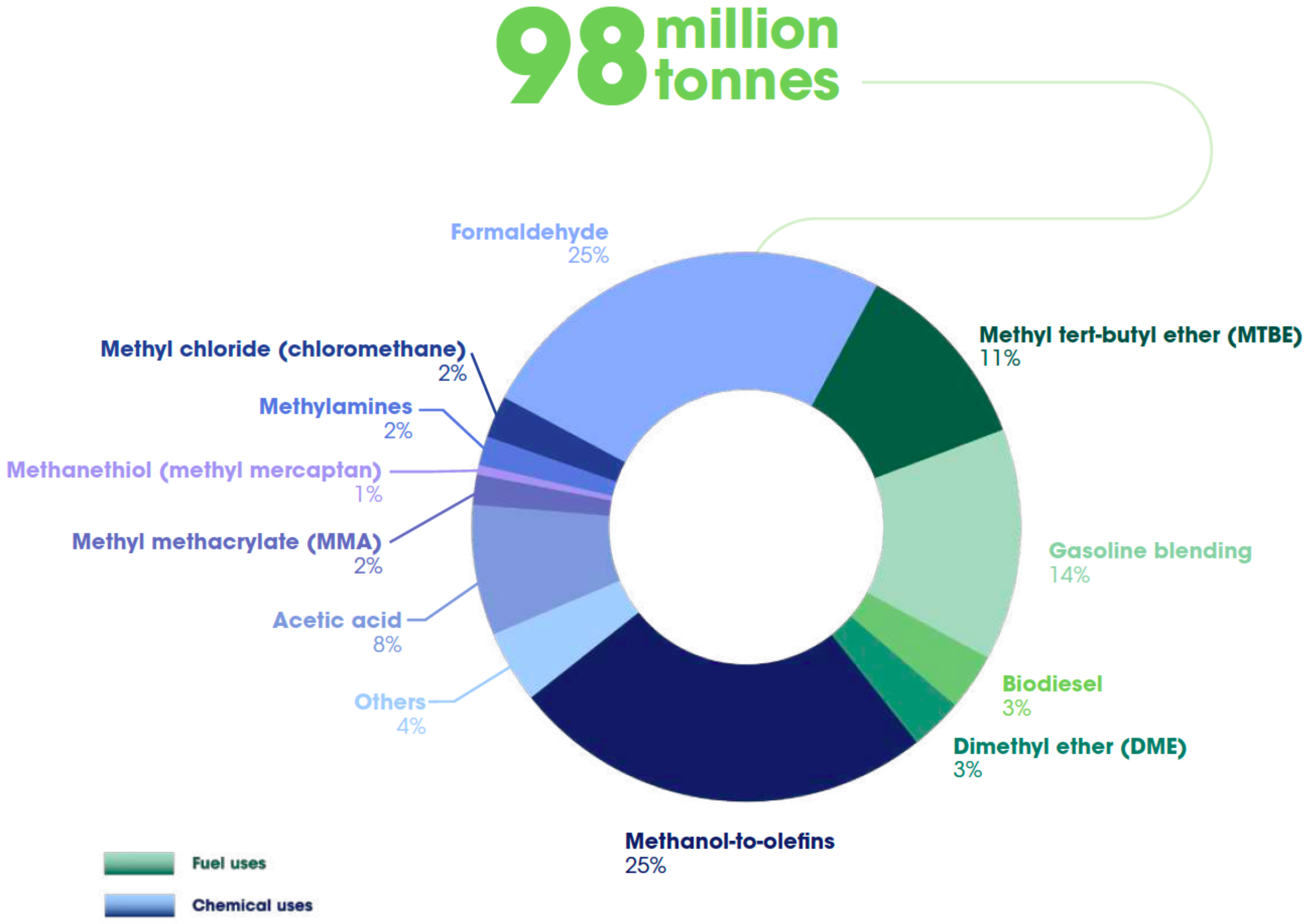
Battery, Hydrogen, and Alcohol Energy Reservoirs, Sized for 3 hr (94 TWh) Storage of Global Energy Needs in 2050

* Estimated upfront infrastructure costs for China, assuming 200 cars per 1000 people of each type.
^ Methanol and ethanol can use existing infrastructure (with minor modifications) built for incumbent liquid fuels.

Estimated Infrastructure Costs for Distributing New Fuels in China in 2050

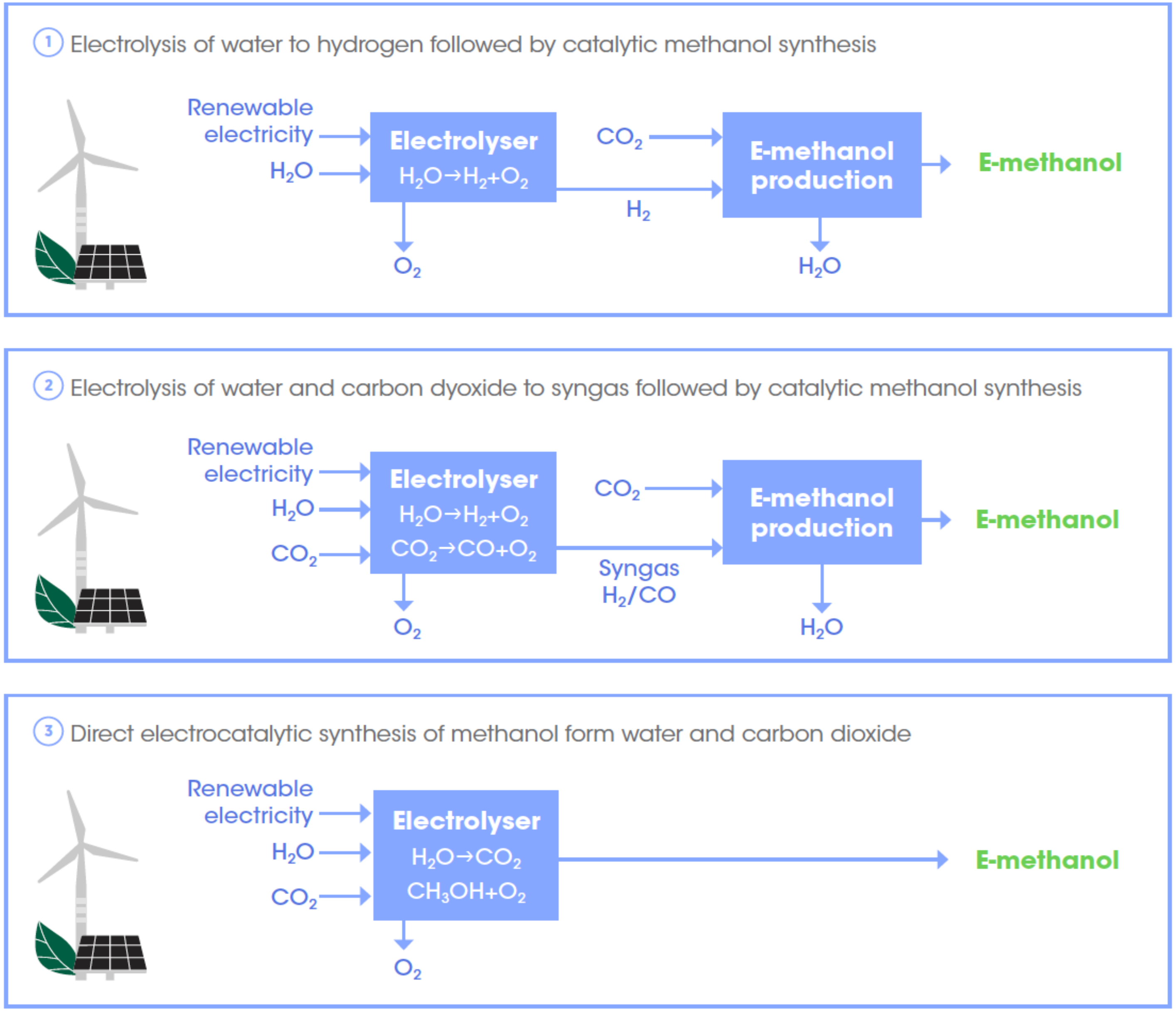
C.F. Shih, Joule, 2018, 2, 1925.

Global methanol demand



IRENA, Innovation outlook: Renewable methanol, 2021

e-methanol production from CO_2



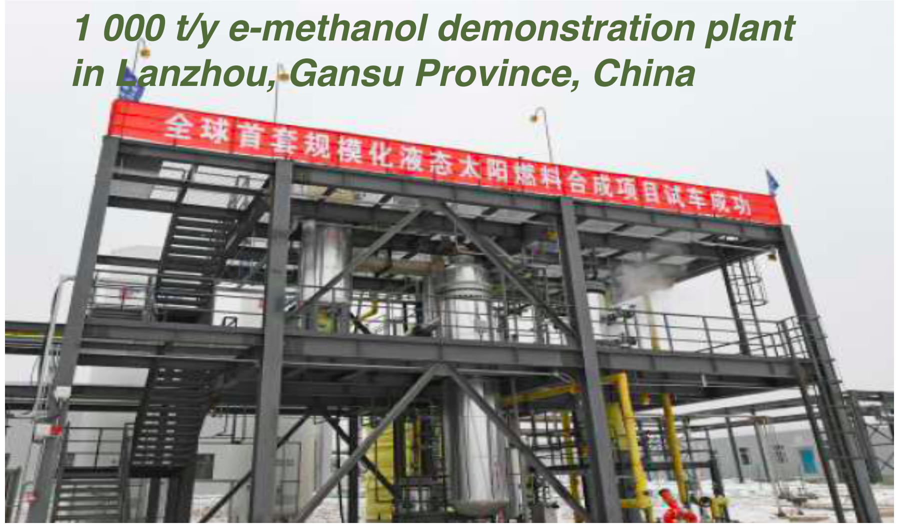
IRENA, Innovation outlook: Renewable methanol, 2021

e-methanol industrial plants

"George Olah Renewable CO_2-to-Methanol Plant" of CRI in Iceland

Enerkem's MSW to biofuels (methanol and ethanol) plant in Alberta, Canada

1 000 t/y e-methanol demonstration plant in Lanzhou, Gansu Province, China



e-methanol as a sustainable fuel

IRENA, Innovation outlook: Renewable methanol, 2021

NEXTCCUS Partners

#	Participant organization name	Country	Type
1 (PCo)	IRITALY Trading Company S.r.l	IT	SME
2	Consiglio Nazionale delle Ricerche, Institute of Structure of Matter	IT	RES
3	Hellenic Mediterranean University (HMU), Mechanical Engineering Department	EL	HE
4	University College London, Institute for Materials Discovery	UK	HE
5	Argonne National Lab & Indiana University–Purdue University Indianapolis	US	RES
6	Grivita Rosie (GRIRO)	RO	IND
7	IRCELYON, Institut de recherches sur la catalyse et l'environnement de Lyon	FR	RES
8	Institut de chimie physique, Université paris-Saclay	FR	HE

NEXTCCUS Objectives

Overarching Aim: Towards a sustainable energy technology with negative carbon footprint to produce methanol at SATP conditions by developing and scale-up an innovative electrochemical system in order to enable sustainable CO_2 capture, direct conversion and storage as liquid fuel.

OBJECTIVE #1. Realization of a system for sustainable CO_2 capture and direct reduction to methanol working at SATP conditions.

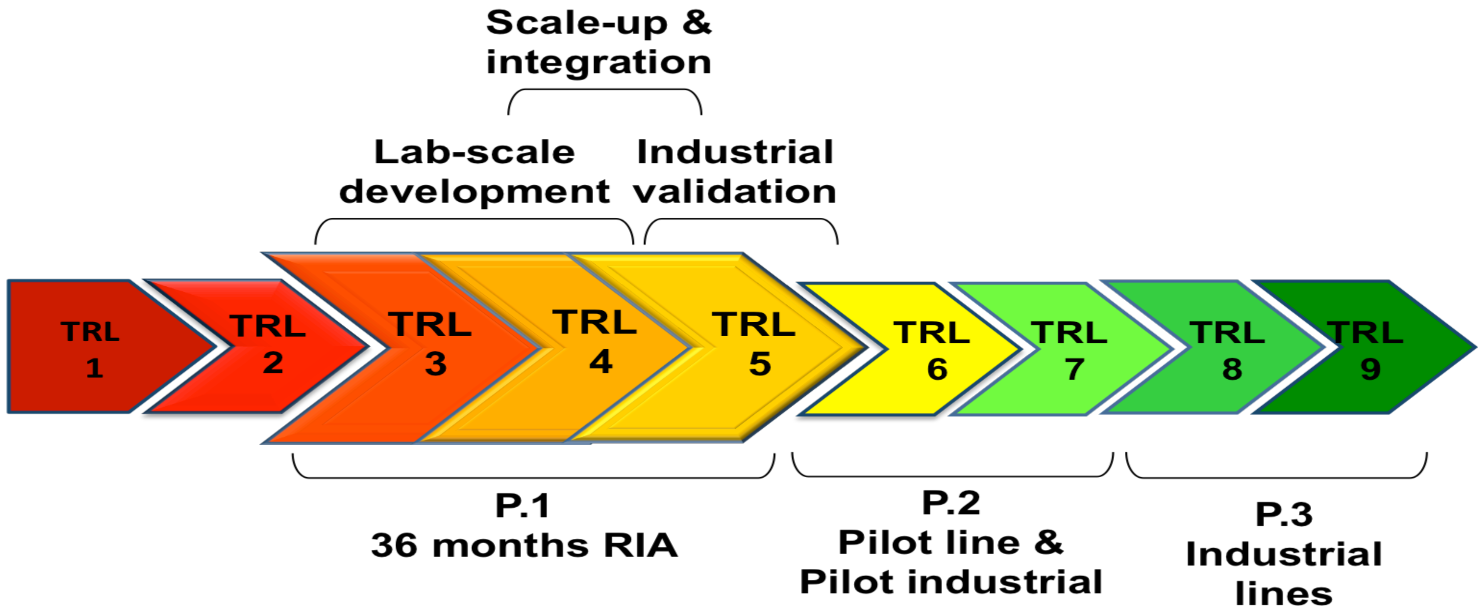
OBJECTIVE #2. To demonstrate cost effectiveness of the technology by developing volume manufacturing.

OBJECTIVE #3. Reducing the emission of carbon intensive industries with a sustainable CO_2-based circular economy solution.

OBJECTIVE #4. Reducing the environmental and energy impacts of the system.

OBJECTIVE #5. To demonstrate a feasible road-map toward commercialization.

Roadmap and benefits of the technology



- Low CAPEX/OPEX and easy scale-up
- Integration of the CO_2 capture and conversion in one instrument
- Low energy consumption and low EPBT
- Flexibility to various feedstocks
- Highly durable electrodes and catalysts
- Flexibility to supply the energy from various sources of power
- Easy integration with carbon and/or energy intensive industries

Challenges

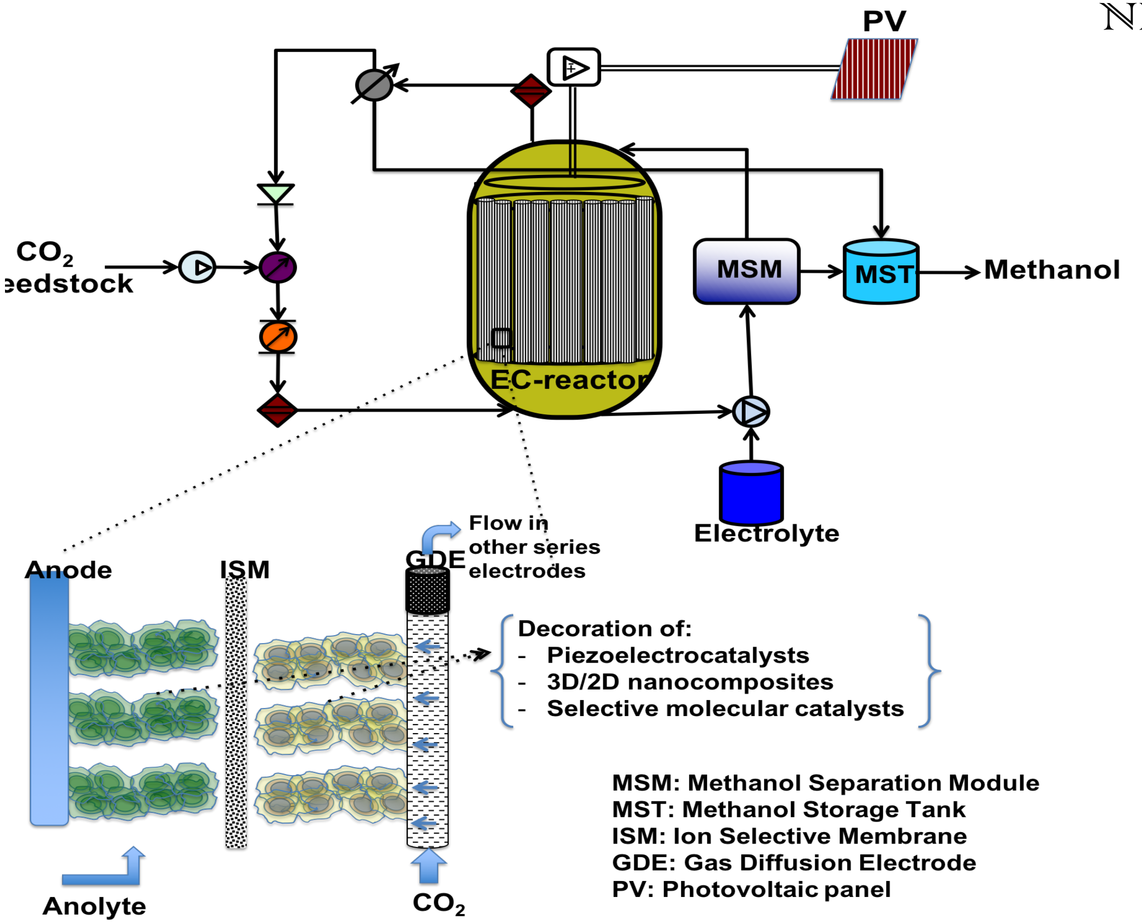
Scientific Challenges:
1) High thermodynamic barrier for breaking the C=O bond (750 kJ/mol);
2) Low reaction selectivity;
3) Poor solubility of CO_2 (0.33 mol/L at 25 ºC and 1 atm);
4) Limited stability of electrocatalysts against chemical/thermal exposure;
5) Low current densities efficiency at SATP conditions.

Technical Challenges:
1) Complex and high-cost nature of present mature electrolyzers;
2) Complicated design of the reactors;
3) Separation of the product from reaction medium;
4) Multi-step process from CO_2 capture to methanol production;
5) Gas pressure drop in the fully liquid based reactors.

Commercial Challenges:
1) Use of noble metal-based catalysts;
2) High OPEX of hydrogen generation step with electrolyzers;
3) High-cost up-scaling programs (mainly for scale-up of the electrolyzers);
4) Long EPBT;
5) Sensitivity to the electricity price and grid intensity.

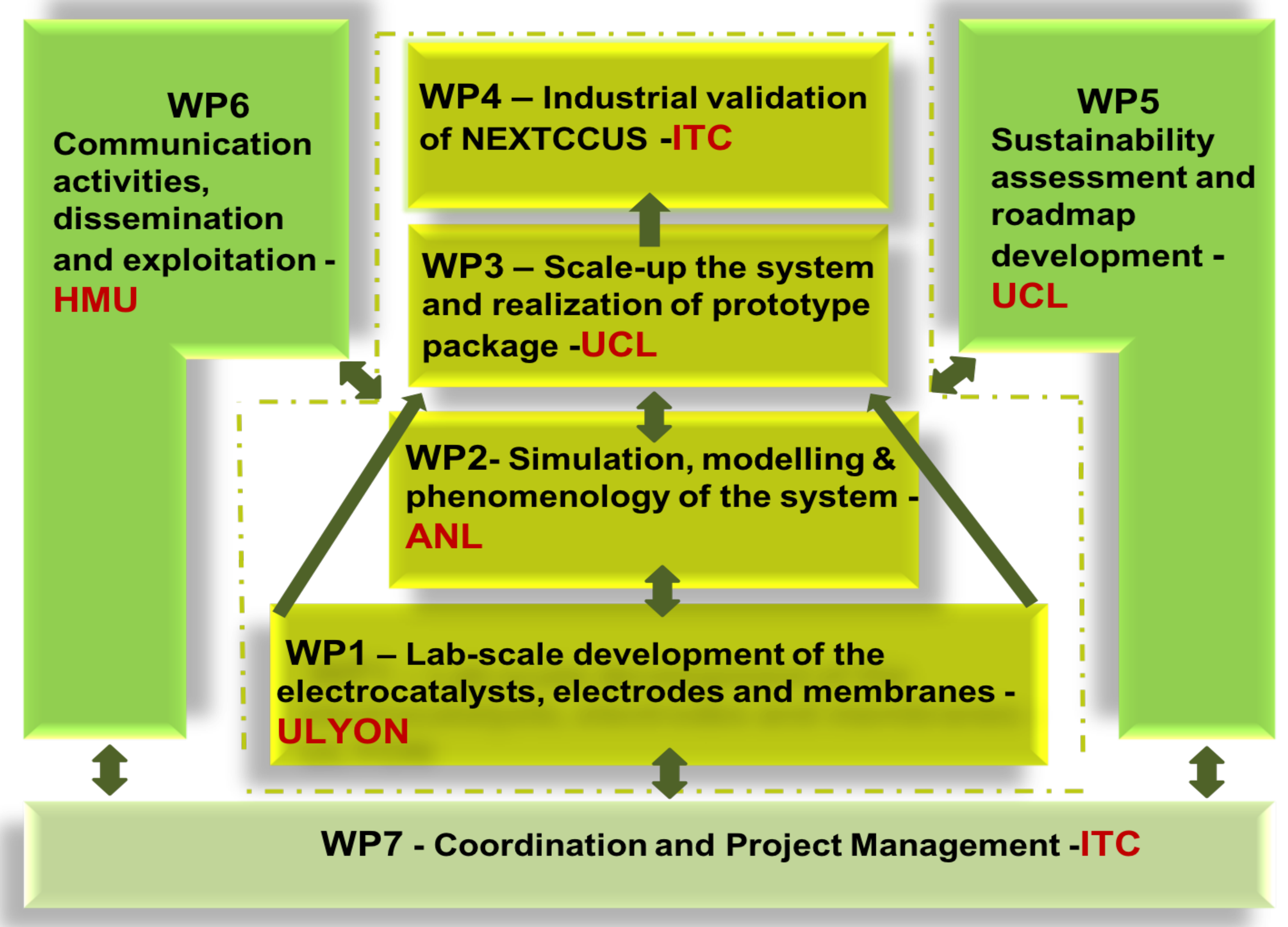
NEXTCCUS technological solutions

- Direct electrochemical CO_2 reduction at SATP conditions
- CO_2 gas diffusion electrodes (GDEs)
- Piezo-electrocatalytic effect
- 2D transition metal carbides and nitrides (MXenes)
- Selective molecular catalysts

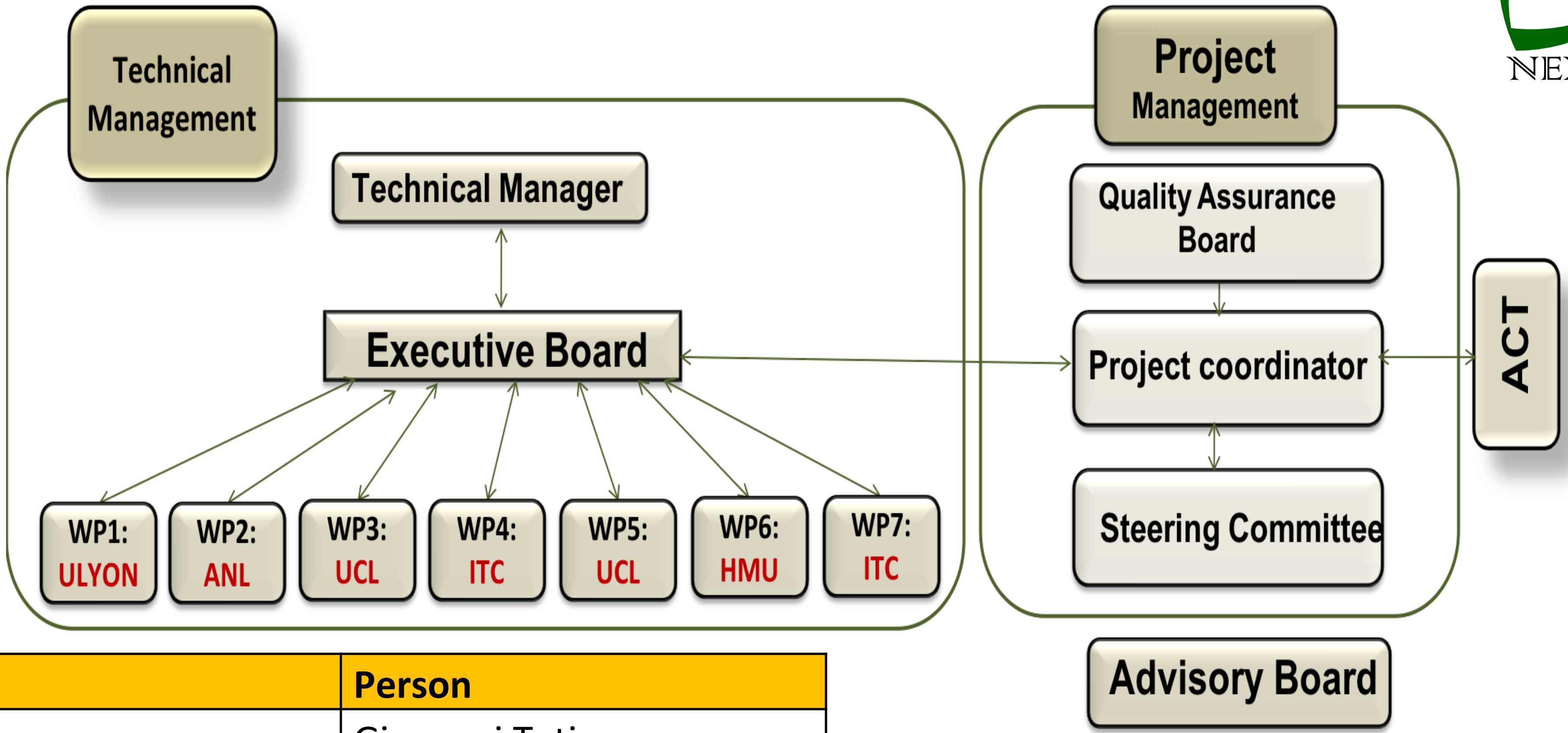


IRITALY Trading

Implementation



Monitoring and management



Role	Person
Coordinator	Giovanni Teti
Technical Manager	Mahmoud Zendehdel
Exploitation Manager	Alessandro Di Loreto
Risk Manager	Valerio Moschella
Dissemination Manager	Mojtaba Abdi-Jalebi
Communication Manager	Narges Yaghoobi Nia

Accelerating CCS Technologies

Advisory board

NEXTCCUS

Name	Experience and expertise
Prof. Corrado Clini	*Former Italy* **Minister for the Environment, Land and Sea of Italy; Coordinator** of the participation of the Ministry for the Environment in the **G8 and G20** activities and meetings; **Director General of the Italian Ministry for the Environment (1990 – 2011)**.
Prof. G. Ali Mansoori	Iranian-American scientist known for his research within **energy**, **nanotechnology** and **thermodynamics**. Emeritus professor at the **Departments of Bioengineering, Chemical Engineering** and Physics at **University of Illinois at Chicago**. He received valuable awards & honors such as **Medal of Fundamental Science** (UNESCO).

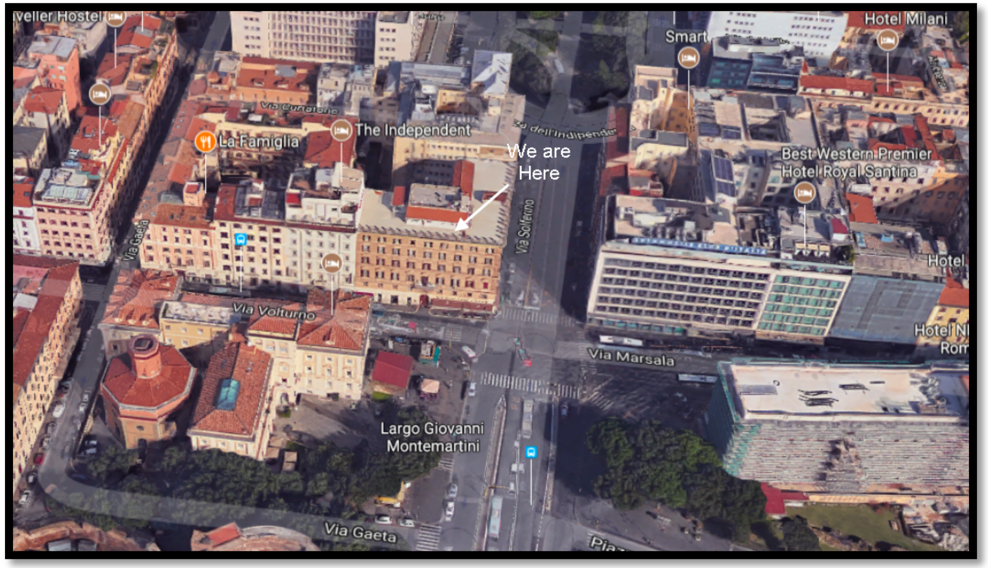
Company	Country	Experience and expertise
ZECCA	Italy	Generation and distribution of energy in Italy [https://www.zeccaenergia.it]
BELLELI	Italy	Energy critical process equipment and EPC of energy plants [http://www.belleli.it]
Walter Tosto	Italy	Oil & Gas, Chemical, Petrochemical & Power markets [http://www.waltertosto.it/en/]
DUFERCO	Italy	Large industrial group active in energy trading, retail and origination; Steel production and distribution; shipping and investment sectors [https://www.duferco.com]
PDOT	Greece	Nanotechnology and printing electronics [https://pdot.tech]
HOPU	Spain	IoT platform and smart cities [https://hopu.eu]
Johnson Matthey, JM	UK	Global leader in sustainable technologies [https://matthey.com/en]
Stoli Catalysts	UK	Experts in process and catalyst development, catalyst coatings, and continuous flow chemistry [https://stolicatalysts.com]
ENGIE	Belgium	Multinational Energy Utility [https://corporate.engie.be/en/engie-belgium/]
MICROPOWER	Italy	Biogas production plant [http://micro-power.it]
Sustainable Ventures	UK	Develop, invest in and create workspaces for sustainable businesses [https://www.sustainableventures.co.uk]
Cambridge Materials	UK	Miniature semiconductor device technology

IRITALY Trading

Accelerating CCS Technologies

NEXTCCUS

IRITALY Trading



IRITALY Trading Company S.r.l.
Via Volturno, 58, 00185 Rome, Italy

Tel & Fax. +39-06-42011718
Email: info@iritalytrading.com

http://www.nextccus.eu

m.zendehdel@iritalytrading.com

CNR Istituto di Struttura della Materia

ΕΛΛΗΝΙΚΟ ΜΕΣΟΓΕΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ

UCL

IUPUI

Argonne NATIONAL LABORATORY

GRiRO

IRCELYON

université PARIS-SACLAY

IRITALY Trading