

# EU SOLARIS

The European Research Infrastructure  
for Concentrated Solar Power

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## CST for Solar Chemistry and Solar Fuels



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Chemical Process Research Institute - CPERI  
Centre for Research and Technology Hellas - CERTH



## Quick introduction

### ❖ APTL - Aerosol & Particle Technology Laboratory

- Established in 1996, located in Thessaloniki, Northern Greece
- Research in the science and technology of fine particles and their suspensions in various media
- Accomplishments include: 2014 Taipei Expo Award, 2010 European Council Advanced Grant, 2006 Descartes Prize, 2006 IPHE Technical Achievement Award for solar hydrogen research and others

### ❖ CPERI - Chemical Process & Energy Resources Institute

- Sustainable & Clean Energy, Environmental Technologies, Chemical and Biochemical Processes, Advanced Functional Materials

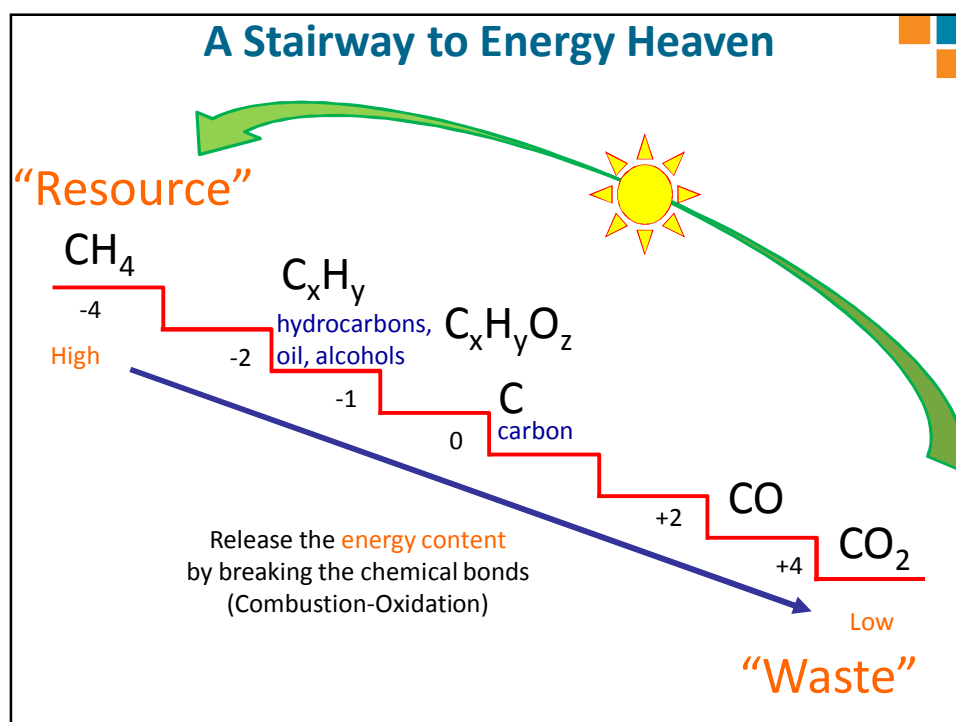
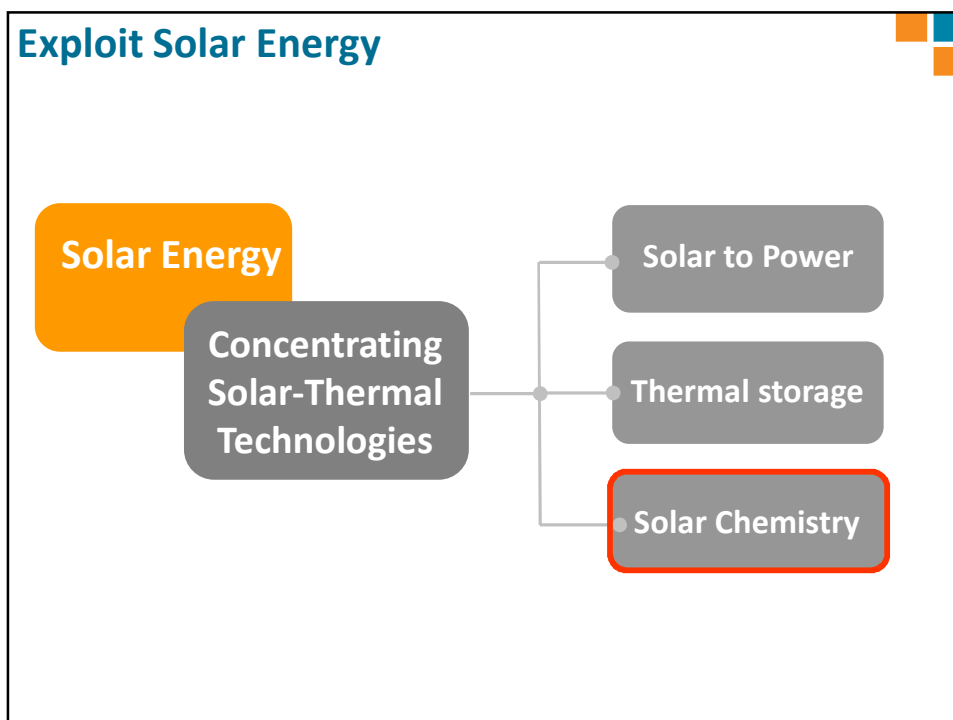
### ❖ CERTH – Centre for Research and Technology Hellas

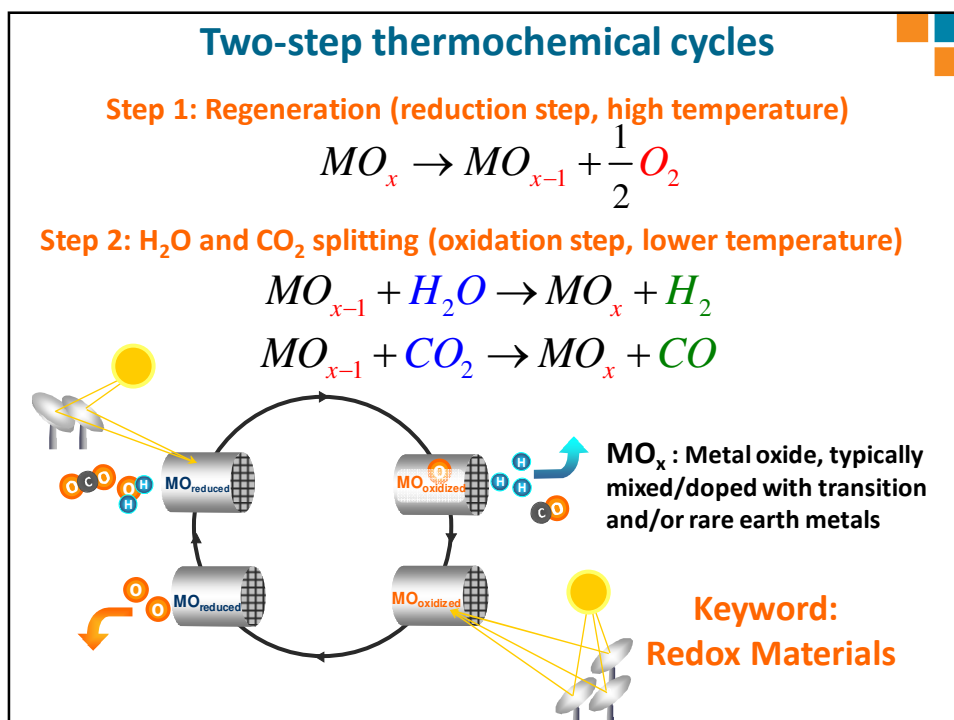
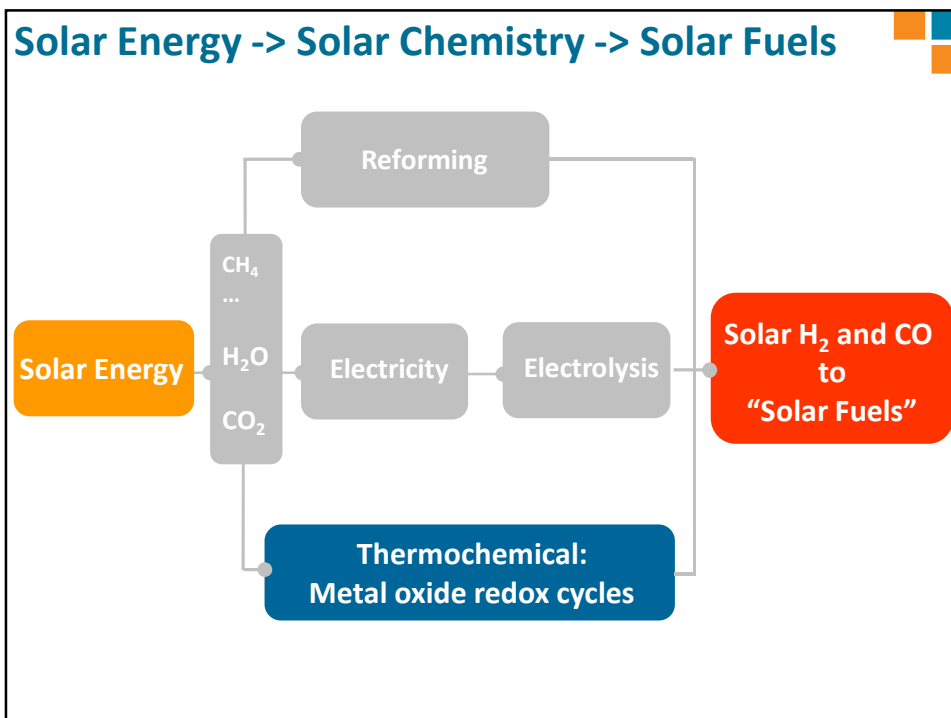
- One of the leading Greek Research Centres and the largest in energy science and technology
- Private non profit body governed by public law
- >500 scientific, technological and administrative personnel



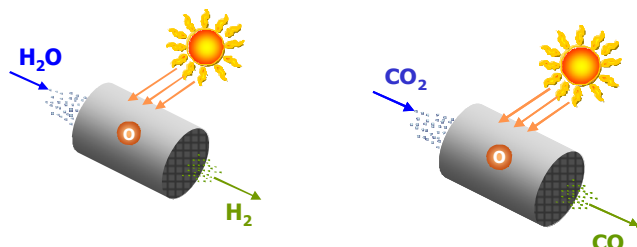
20 YEARS  
APT  
LABORATORY  
1996-2016

Save the Date:  
Thessaloniki, Greece  
June 2-3 2016

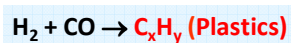
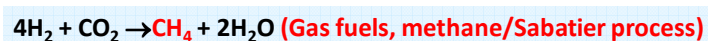
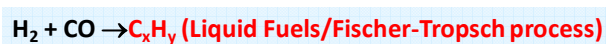




## Carbon Neutral Solar Fuels from CO<sub>2</sub> and H<sub>2</sub>O



### Solar Synthesis Gas

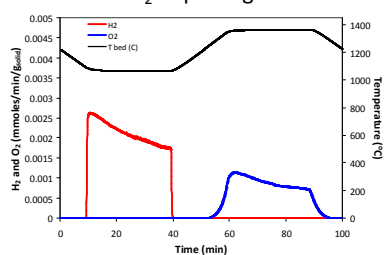


**Sustainable Storage of Carbon AND Hydrogen!**

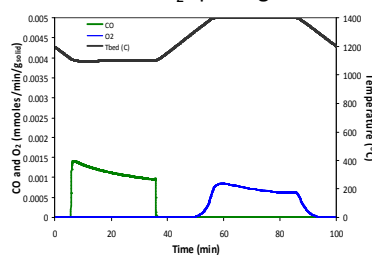
## Redox materials I

### Substituted ferrites: NiFe<sub>2</sub>O<sub>4</sub>

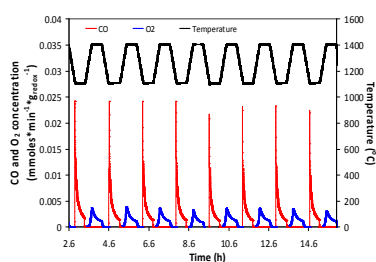
H<sub>2</sub>O splitting



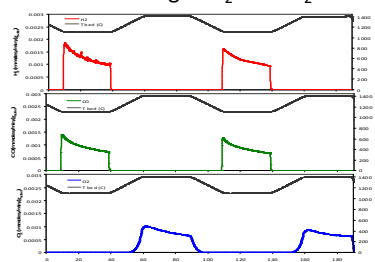
CO<sub>2</sub> splitting

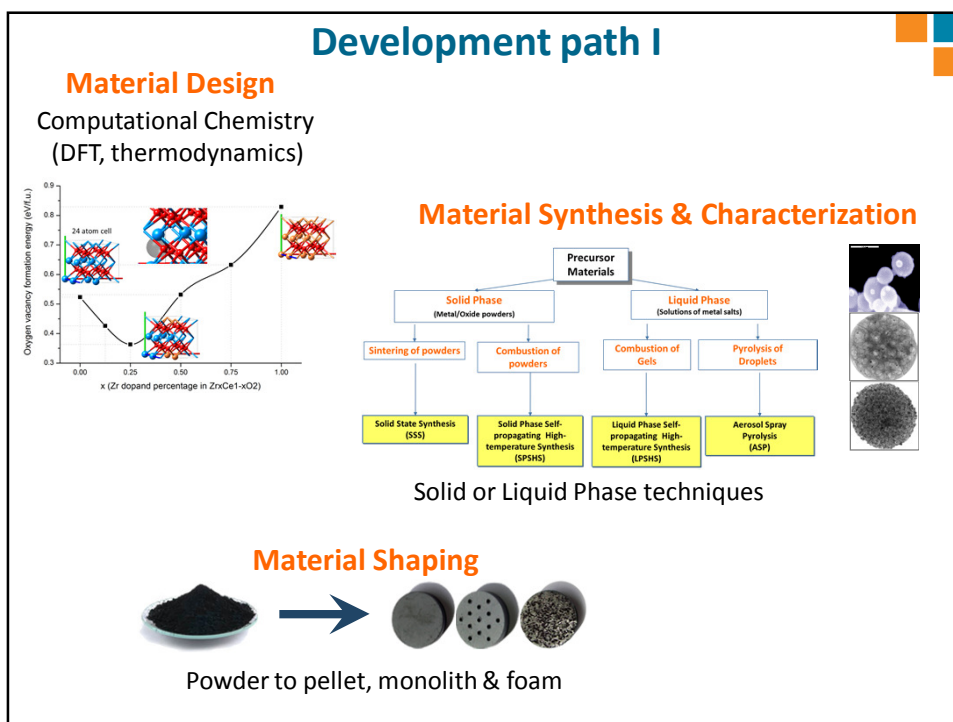
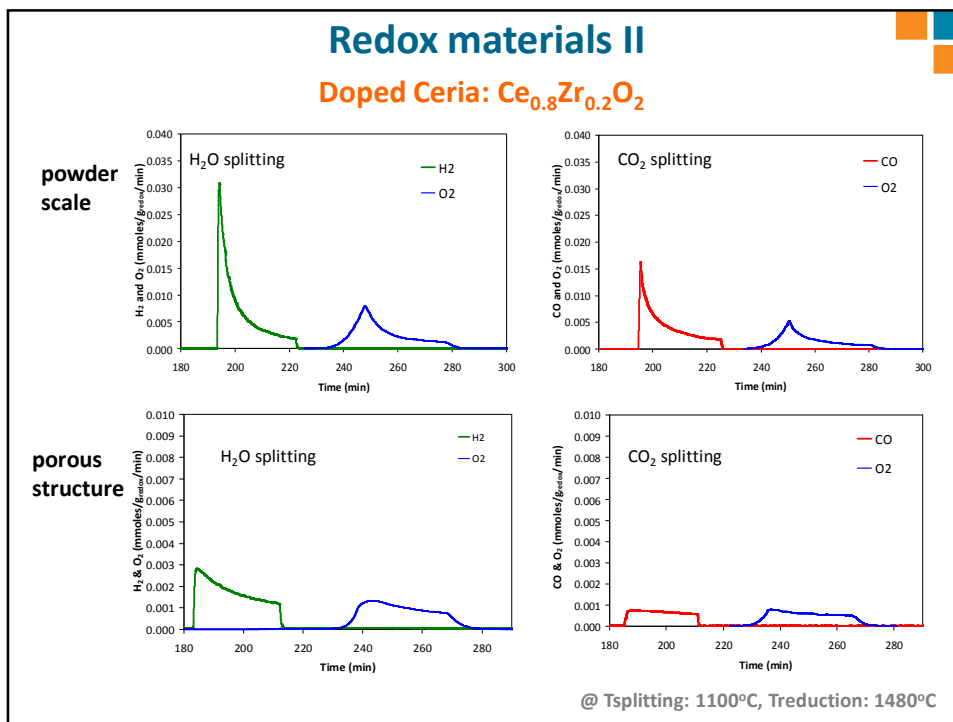


CO<sub>2</sub> multicycle splitting




Co-feeding of H<sub>2</sub>O & CO<sub>2</sub>






## Development path II

### Material Evaluation



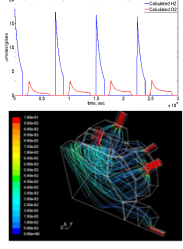
TGA & lab fixed bed reactor

### Lab scale reactor testing



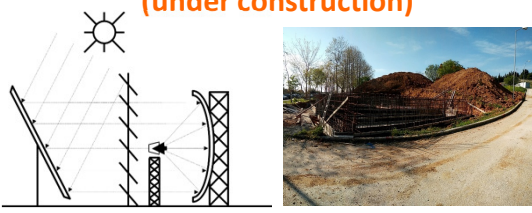
High power solar simulator & reactor

### Modelling & Simulation



Kinetic & thermal modelling

### Pilot scale reactor testing (under construction)



50kW<sub>th</sub> solar furnace (projected finish date mid July 16)

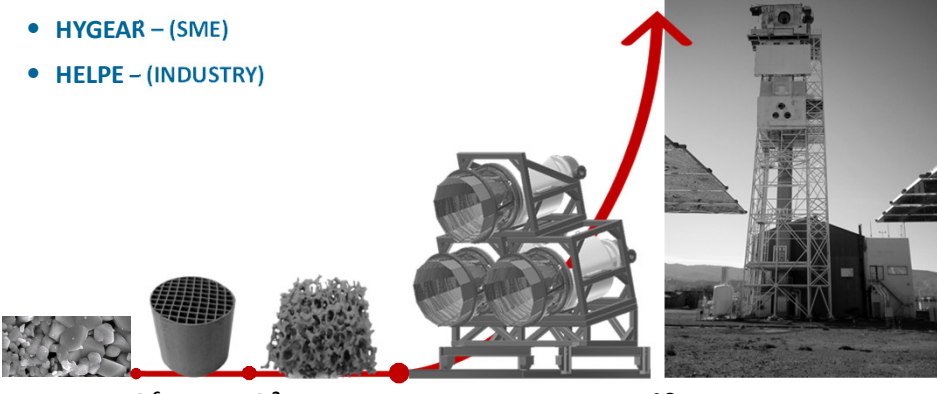
## The Hydrosol-Plant Project

**Thermochemical Hydrogen production in a solar monolithic reactor: construction and operation of a 750 kW<sub>th</sub> plant**

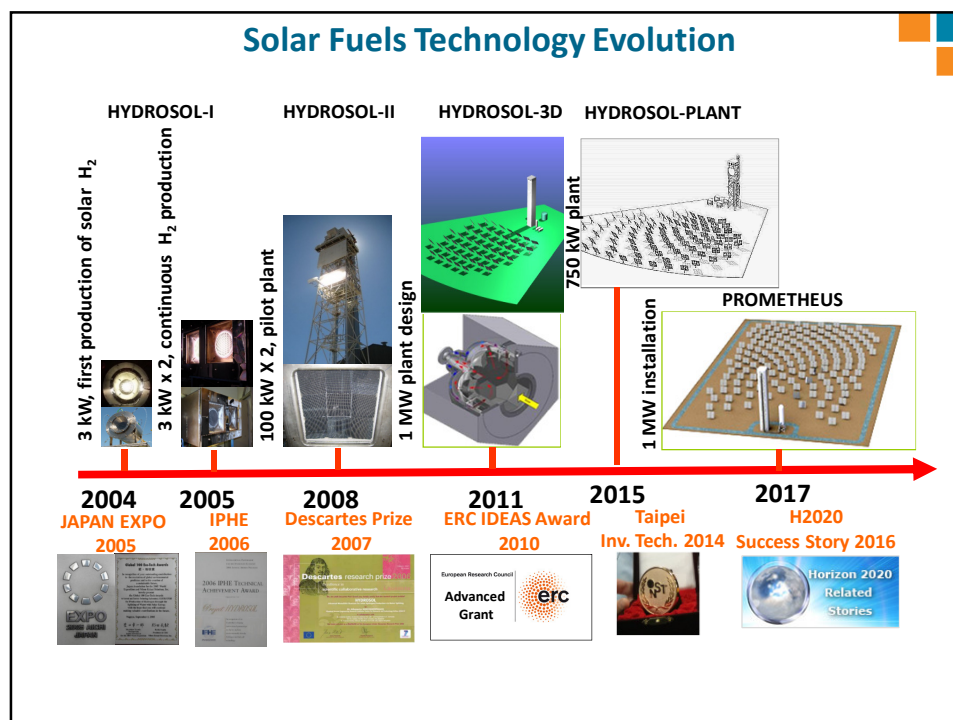
**Partners**

- APTL/CERTH – (Coordinator RES)
- DLR – (RES)
- CIEMAT – (RES)
- HYGEAR – (SME)
- HELPE – (INDUSTRY)

Demonstration of the technology at a larger, closer-to-industrial level



$\times 10^{-6}$  m
 $\times 10^{-2}$  m
 $\times 1$  m
 $\times 10$  m



## The difficult questions

### Cost

- Levelized Cost of 14€/kg H<sub>2</sub> (LHV:120MJ/kg), ?€/kg CO
- Very difficult to answer at this stage: depends on location and plant size among a myriad other factors
- Techno-economic studies exist
- Hard data are missing, no pilot plant case yet (Hydrosol-Plant)

### Efficiency

- $n_{solar\ to\ fuel} = \frac{\Delta H_f\ of\ H_2O}{Q_{in}}$
- Theoretical efficiencies of conversion of solar energy to fuel are up to 70%
- Reported experimental efficiencies so far are much lower

### Why pursuit it?

- Very promising pathway for a sustainable energy future
- The technology is still far from mature
- It works!

## Challenges

### Materials

- Investigate more material families (ferrites, doped ceria, perovskites)
- Increase the yield (g of H<sub>2</sub> or CO / g of redox material)
- Lower the temperatures
- Material cyclability
- Material stability
- Material deactivation
- There isn't a material that is perfect for both H<sub>2</sub>O and CO<sub>2</sub> splitting, and easily reduced (lower T) and stable under high temperatures
- We are looking to create one with good enough performance over all levels  
→ doping

### Reactors

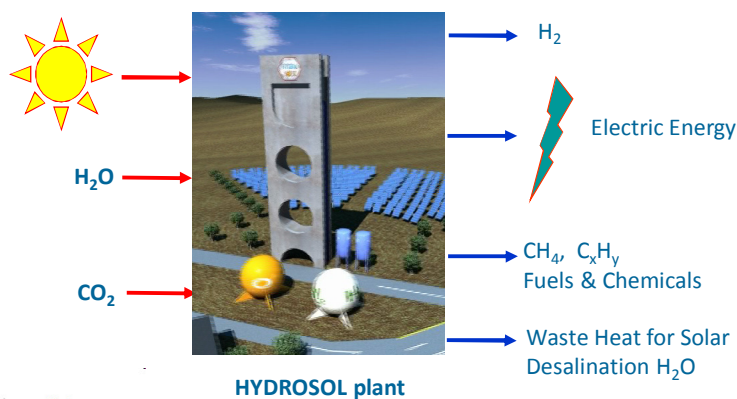
- Extreme temperatures are a big challenge for gas seals, vacuum
- Indirect vs. direct irradiation (windowed vs. tubular reactors)
- Good thermal distribution to avoid hotspots
- Cavity reactors are a good choice

### Infrastructure

- Not dedicated/optimized for solar fuels
- Missing at the larger scale (high power solar towers)

## Carbon Neutral Solar Fuel Plant

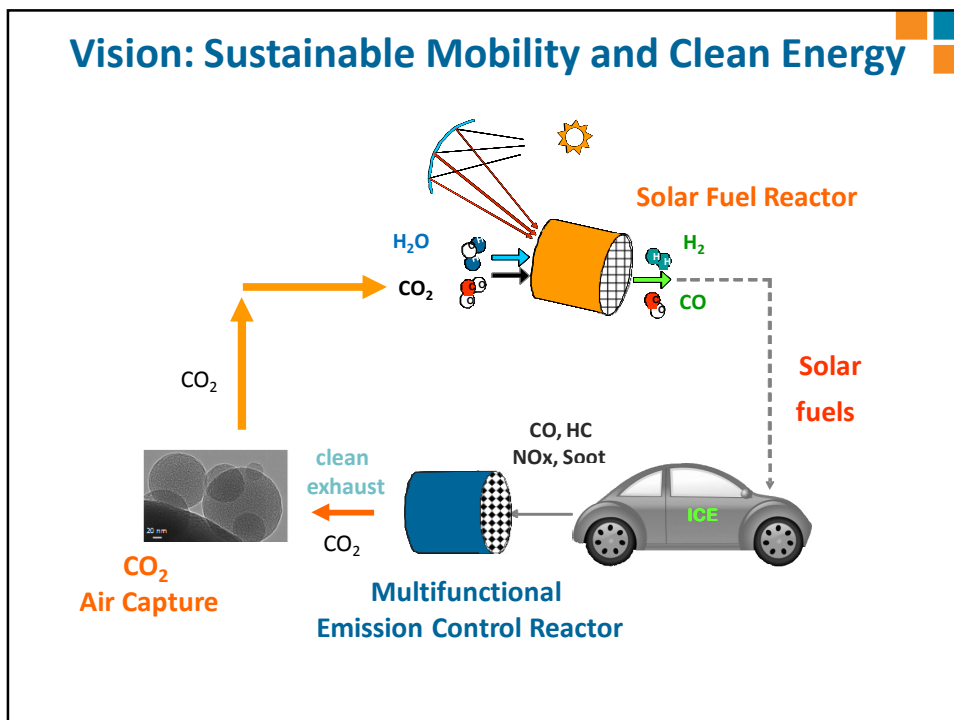
### Green Energy, Transport and Industrial Processes



European Research Council  
Advanced Grant







Thank you for your attention!



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