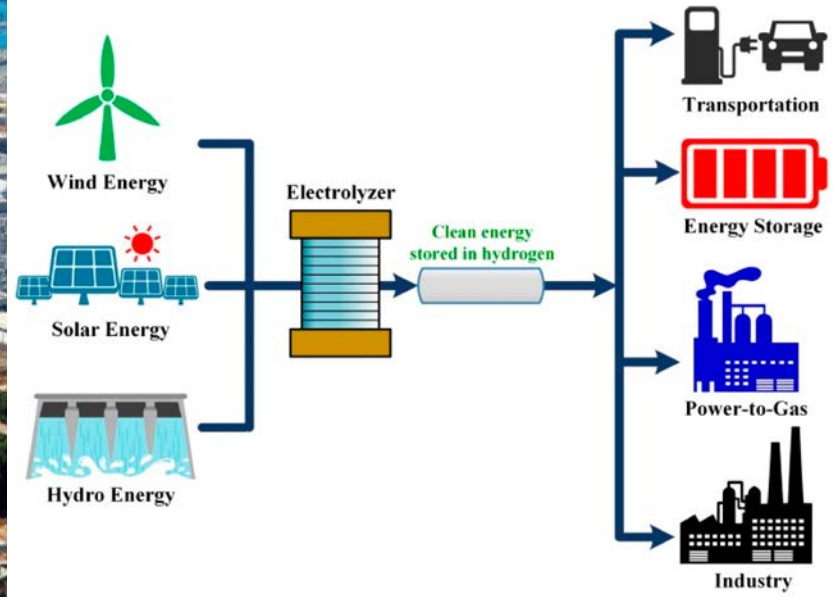
# Hydrogen Valley di Civitavecchia
# 9 Ottobre 2023
# The Role of Hydrogen in Europe and Italy: Projects and Potentials of Civitavecchia

Università degli Studi Guglielmo Marconi




# The role of hydrogen in the EU policies

## EU Hydrogen strategy (COM/2020/301) 2020

- Investment agenda
- Boosting demand + scale-up production
- Creating a supportive framework
- Promoting research and innovation

## REPowerEU (SWD/2022/230) → Hydrogen Accelerator May 2022

- 10 Mt of domestic H2 production
- 10 Mt of renewable H2 imports

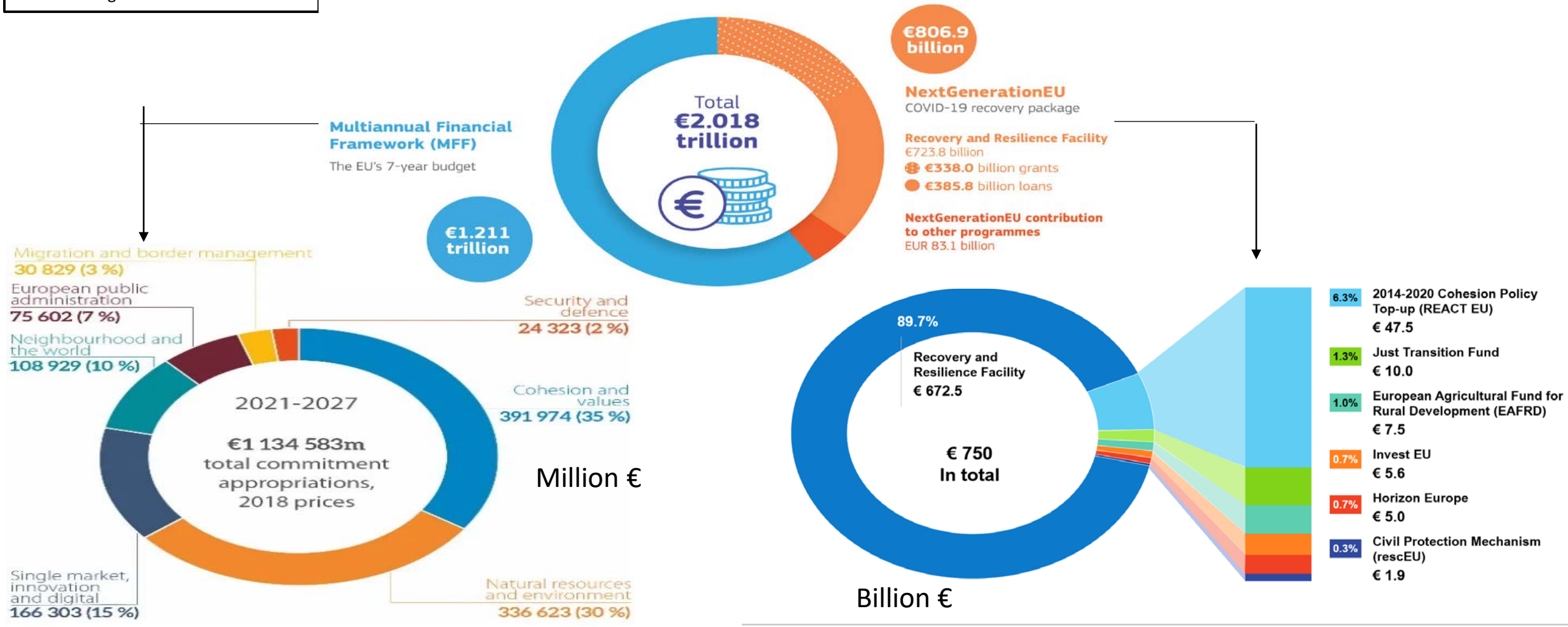
## EU Hydrogen Bank (COM/2023/156) March 2023

- Investment agenda
- Boosting demand + scale-up production
- Creating a supportive framework
- Promoting research and innovation

## EU Hydrogen initiatives

- Clean Hydrogen Partnership
- European Clean Hydrogen Alliance
- Hydrogen Public Funding Compass

## EU funding programmes



# EU funding programs

## Recovery and Resilience Facility

- 337.97 B€ on in grants and 385.85 B€ in loans
- Relevant areas for hydrogen development

1) *European Flagship PowerUp*
Building and sector integration of 6 GW of electrolyser capacity and production and transportation of 1 million tonnes of renewable hydrogen across the EU by 2025.

2) *European Flagship Recharge and Refuel*
Targeting sustainable transport and charging stations (examples: waterborne, buses, public transport)

## Horizon Europe

- Total budget 95.5 B€
- Budget breakdown

1) Excellent Science 25 B€
2) Global Challenges and European industrial competitiveness 53.5 B€
3) Innovative Europe 13.6 B€
4) Widening participation & strengthening the european research area 3.4 B€

- Relevant areas for hydrogen development

1) Pillar II:
   15.35 B€ for Digital, Industry and Space
   15.12 B€ for Climate, Energy and Mobility
2) Pillar III:
   10.10 B€ for European Innovation Council

## CEP Transport & Energy Calls for proposals

- Total budget 7 B€
- Opening date: 26/09/2023
  Deadline date: 30/01/2024
- Description: Increase the sustainability of the trans-European transport network to meet the European Green Deal objective of cutting transport emissions by 90% by 2050

## CEF Joint Call 2023

- Total budget 0.129 B€
- Opening date: 07/07/2023
  Deadline date: 27/03/2024
- Description: R&I projects to accelerate the Clean Energy Transition.

## InvestEU

- Total budget 26.2 B€ (expected to mobilise more than 372 B€ of public and private investment)
- Budget breakdown

1) Sustainable infrastructure 9.9 B€
2) research, innovation and digitalisation 6.6 B€
3) Small and medium-sized companies 6.9 B€
4) Social investments and skills, across the EU 2.8 B€

- Relevant areas for hydrogen development

1) Sustainable infrastructure window breakdown
- Clean and sustainable transport modes
- Systems for energy savings in buildings
- Storage
- Improvement of energy infrastructure interconnection levels
- Innovative technologies contributing to climate resilience

2) Research & Innovation

## Innovation Fund

- Total budget 40-50 B€
- Objectives

1) Support projects with highly innovative technologies, processes or products, which are sufficiently mature and have a significant potential to reduce greenhouse gas emissions

2) Offer financial support tailored to market needs and risk profiles of eligible projects, while attracting additional public and private resources

3) Ensure that the Innovation Fund's revenues are managed in accordance with the objectives of the EU emissions trading system

## LIFE programme

- Total budget 5.43 B€

# IT funding program

## Piano Nazionale di Ripresa e Resilienza

- Total budget 191.5 B€
- Budget breakdown

1) Digitalizzazione, innovazione, competitività e cultura 40,32 B€
2) Rivoluzione verde e transizione ecologica 59,47 B€
3) Infrastrutture per una mobilità sostenibile 25,40 B€
4) Istruzione e ricerca 30,88 B€
5) Inclusione e coesione 19,81 B€
6) Salute 15,63 B€

- Relevant areas for hydrogen development

23,78 B€ for M2C2 – Energia rinnovabile, idrogeno, rete e mobilità sostenibile of which 3.19 B€ for M2C2I3: "Promuovere la produzione, la distribuzione e gli usi finali dell'idrogeno".
In detail 0.5 B€ for "Produzione in aree industriali dismesse", 2 B€ for "Utilizzo dell'idrogeno in settori hard to abate", 0.23 B€ for "Sperimentazione dell'idrogeno per il trasporto stradale", 0.3 B€ for "Sperimentazione dell'idrogeno per il trasporto ferroviario" and 0.16 B€ for "Ricerca e sviluppo sull'idrogeno"

# GENERAL PROJECT INFORMATION


- **PROPOSAL REFERENCE**: LIFE20 ENV/IT/000575
- **FULL TITLE:** Hydrogen demonstration in city, port and mountain area to develop integrated hydrogen valleys
- **ACRONYM:** LIFE3H
- **CALL / PRIORITY AREA:** LIFE2020 – Environment and Resource Efficiency
- **SECTOR**: Air quality and emissions including urban environment
- **START DATE:** 01/09/2021 - **END DATE:** 30/09/2025
- **BUDGET:** € 6.339.853 **– EU contribution:** € 2.978.671 (46,98%)

# PARTNERSHIP

**COORDINATING BENEFICIARY:** Regione Abruzzo

**ASSOCIATED BENEFICIARIES**

- Società Chimica Bussi Spa
- Autorità di Sistema Portuale del Mar Tirreno Centro Settentrionale
- Port Mobility S.p.A.
- Rampini S.p.A.
- CFFT
- Greenture (ex Snam 4 Mobility spa)
- Comune di Terni
- Società Unica Abruzzese di Trasporto (TUA) spa
- UNeed.IT Srl
- Università degli Studi di Perugia
- Università degli Studi Guglielmo Marconi
- CITRAMS – Università de L'Aquila

# OBJECTIVES & SCOPE

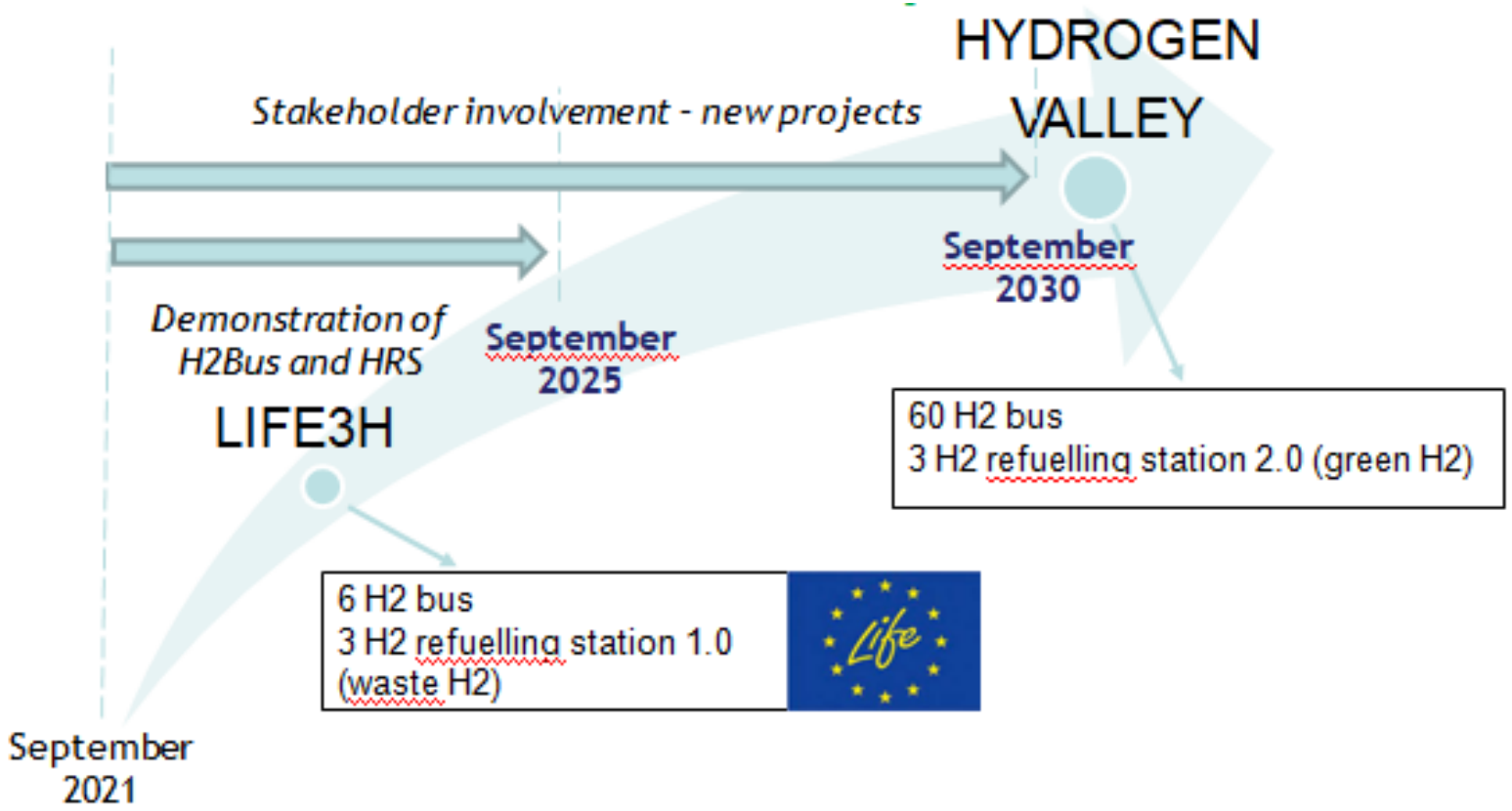
**To set up, demonstrate and exploit 3 Hydrogen Valleys starting from the implementation of H2 buses fueled with surplus H2 coming from local industrial productions thus closing the economical circle locally**

- Build up the first 3 Italian HVs laying the basis of one transregional HV
- Develop common & sustainable road LPT mobility reducing emissions based on H2 buses applied to 3 totally different areas and scenarios
- Implement integrated H2 local policies & regulatory approaches
- Increase circular economy
- Develop a HV implementation strategy and a standard smart sustainable mobility management system that allows extension and replication in other sites
- Raise citizens' awareness & improving policy commitment

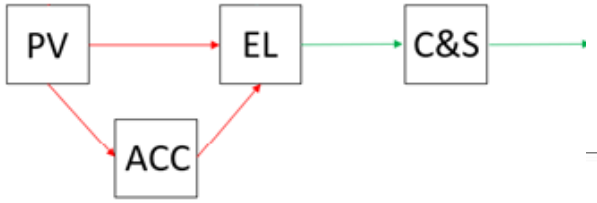


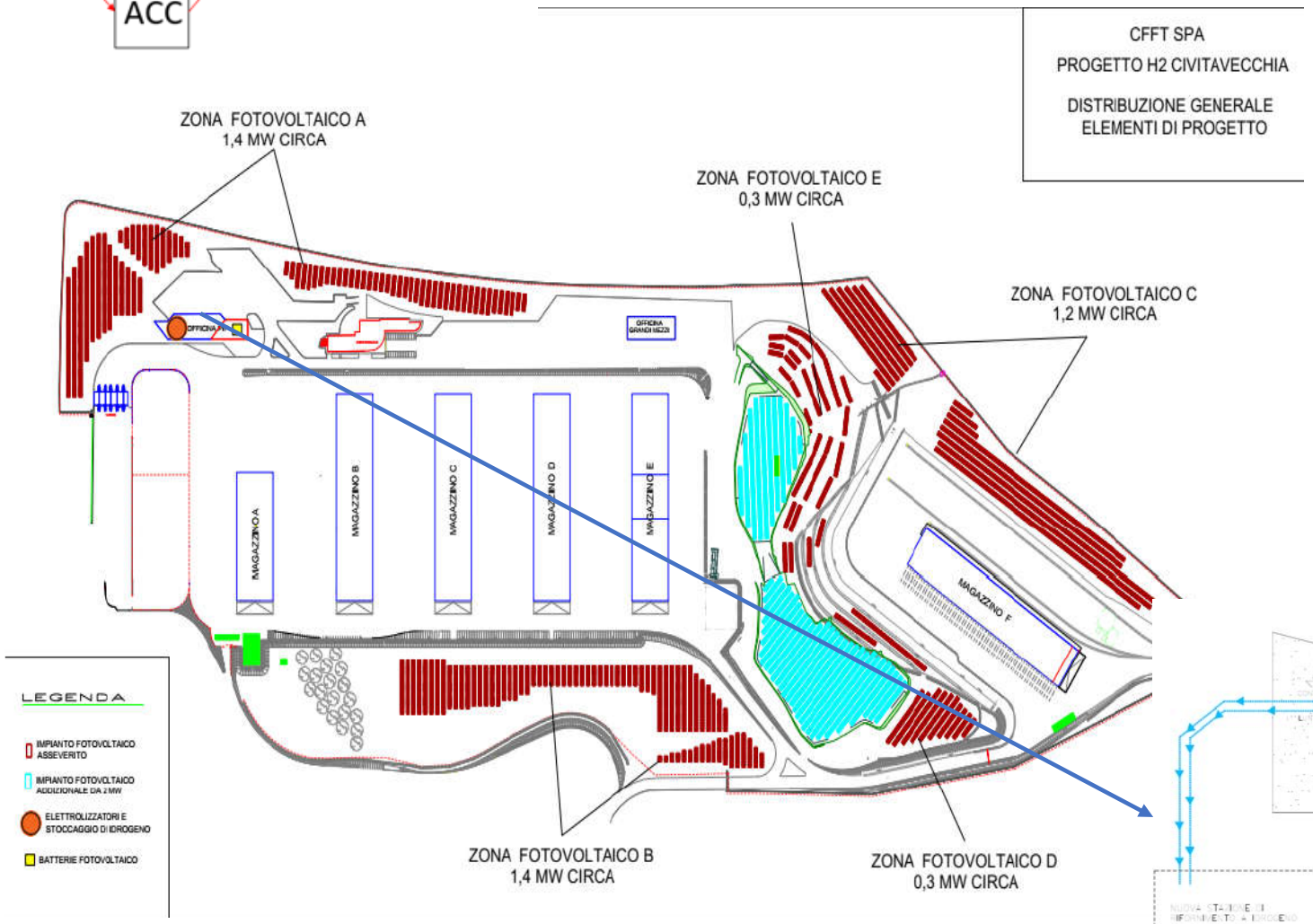
# CONTINUATION (replication, transfer, market uptake)

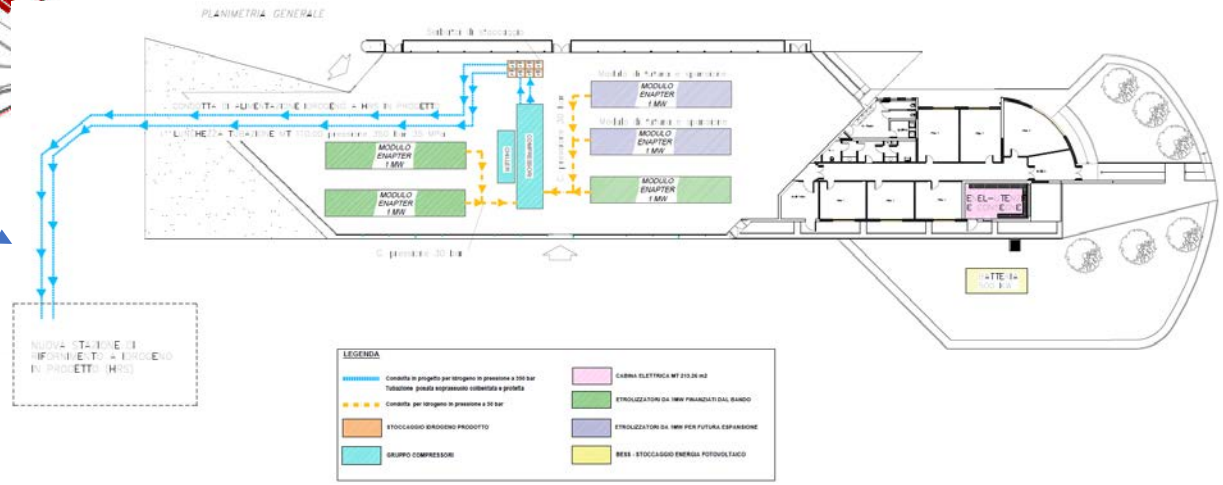
**LIFE3H is the first project to introduce Hydrogen Valleys in the center of Italy as well as H2 extra-urban public transport.**



# H2 Civitavecchia




## M2C2I3.1 Produzione in aree industriali dismesse

- Name of the project “H2 Civitavecchia”
- Total funded 7,469,000 €
- Description: 3 MW of electrolysis powered by 4.5 MW of off-grid photovoltaics with electrical storage, followed by hydrogen compression and storage. Total annual production 145 t (estimated).
- Plant completion time by 2026

# H2 Civitavecchia Model

## Model explanation

$$E_{PV\_plant}[Wh] = I[Wh/m^2] \cdot S_{PV}[m^2] \cdot \eta_{PV}[\%] \cdot N_{PV} \cdot BOP_{plant}\ [\%]$$

$$E_{curtailment} = E_{PV\ plant} - E_{EL\ dir}$$

$$E_{EL} = E_{EL\ dir} + E_{discharge}$$

$$kg_{H2} = E_{EL} \cdot \frac{LHV_{H2}}{\eta_{EL}}$$

Energy and Hydrogen production

$$CAPEX = \frac{€}{kWp} \cdot PV_{size} + \frac{€}{kW} \cdot EL_{size} + \frac{€}{kWh} \cdot Storage_{size}$$

$$CRF = \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

$$CAPEX_{year} = CAPEX \cdot CRF$$

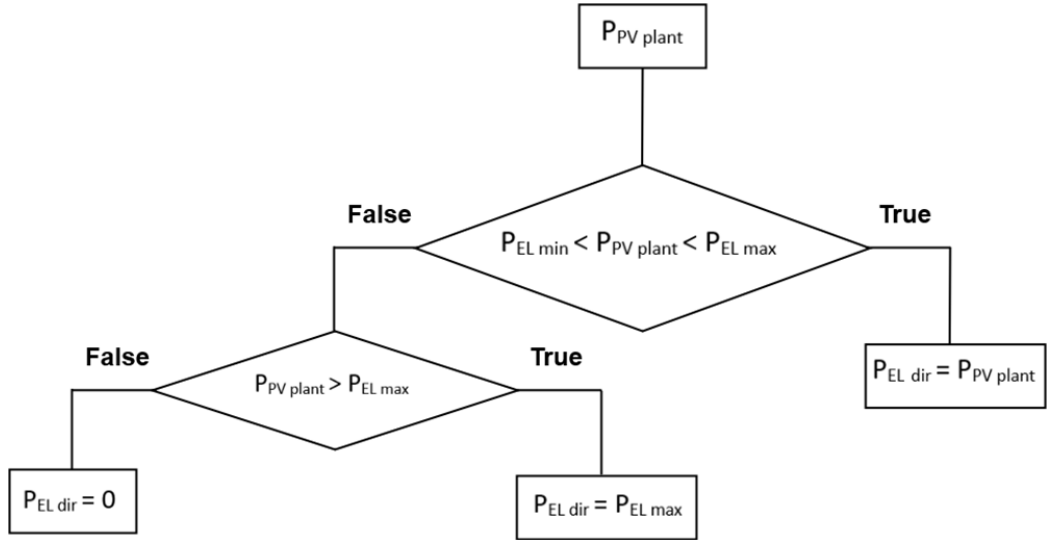
$$OPEX = \frac{€}{kWp} \cdot PV_{size} + 2\% EL_{cost} + \frac{€}{kWh} \cdot Storage_{size}$$

$$Total\ annual\ costs = CAPEX_{year} + OPEX$$

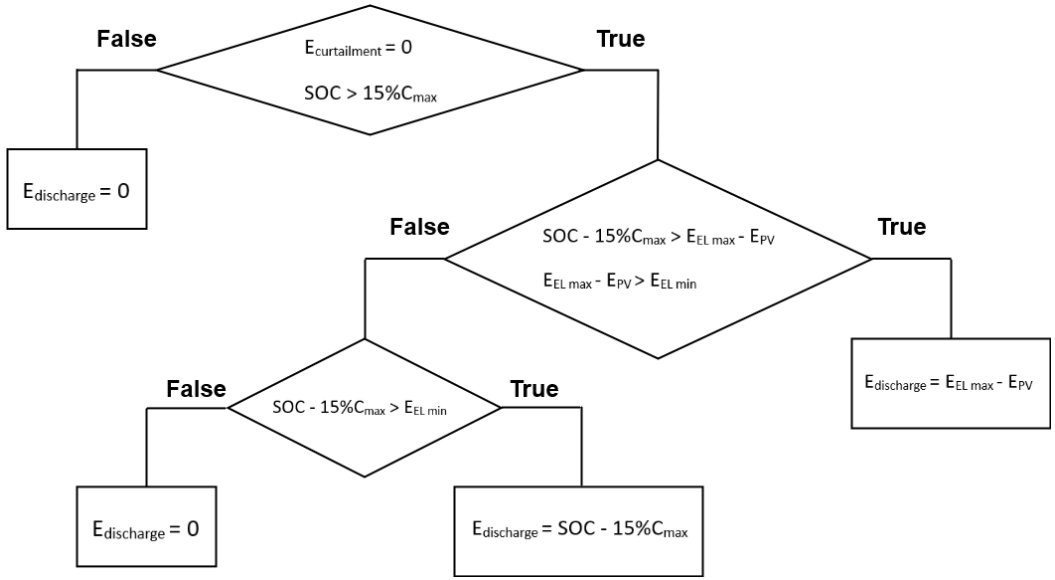
Costs

$$LCOH = \frac{Total\ annual\ costs}{kg\ H2\ /year}$$

Power flow from photovoltaic to electrolyzer



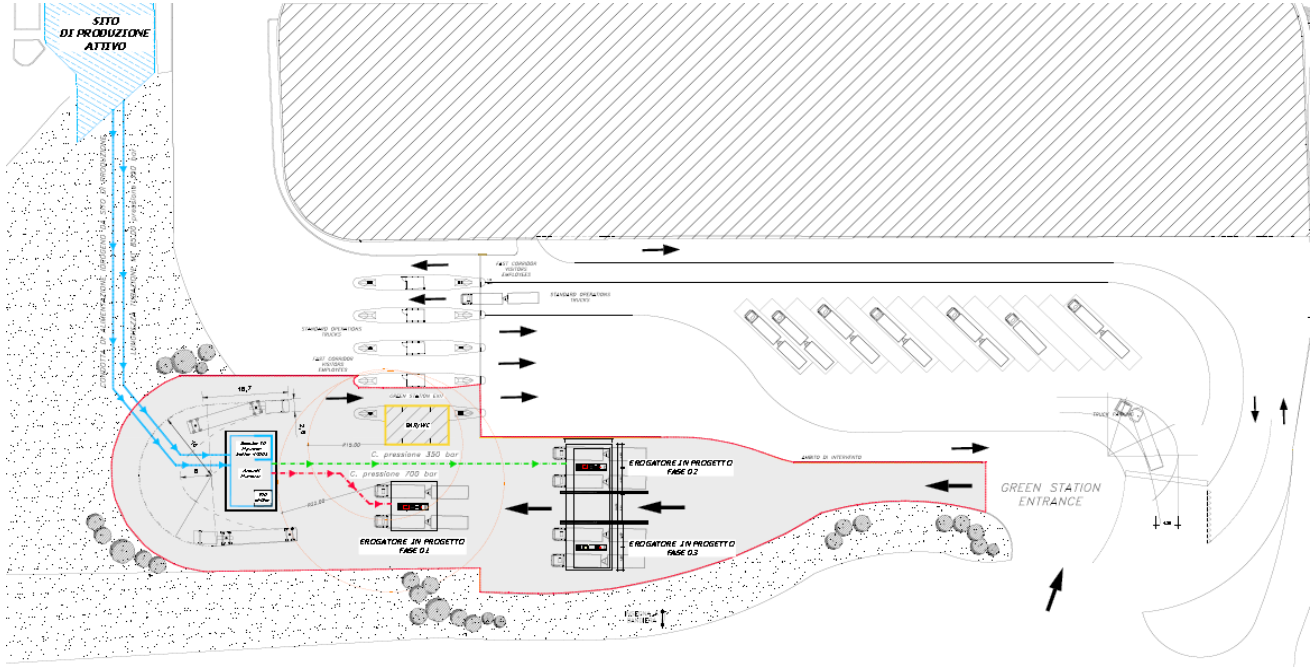

Battery discharging strategy

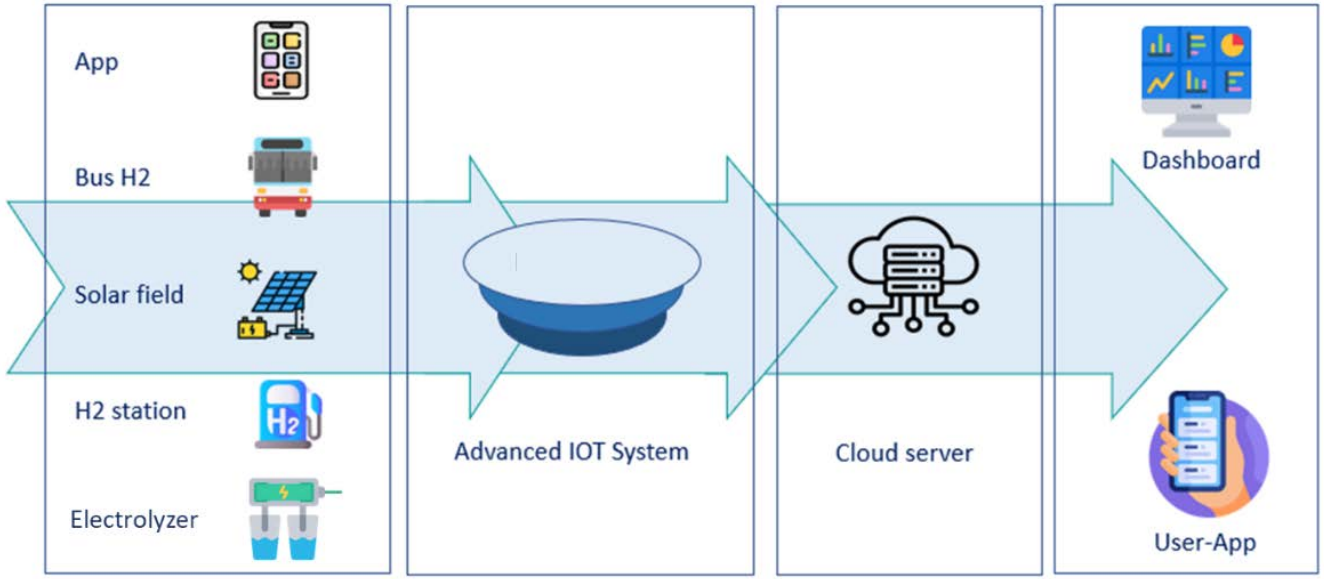


# H2 Civitavecchia Model Conclusions

- The conducted analysis has highlighted that in an off-grid configuration, the **proper sizing** between the **photovoltaic** system and the **electrolyzer** plays a fundamental role in the hydrogen production cost and that the analysis have to be conducted at least on **hourly base**.
- Due to the low annual equivalent hours of photovoltaic, its nominal size must be overestimated compared to that of the electrolyzer and the **optimal ratio is around 2** (depending on $P_{EL\ min}$, irradiation, cost and efficiencies).
- **Electrical storage** have to be sized according to size variation and it proves to be economically viable for **high PV and electrolyzer ratio** and **high minimum acceptable electrolyzer power** ($P_{EL\ min}$).
- Another important finding is that the **cost decrease and lifespan extension** has a **more significant effect** than the increase in efficiency in the reduction of the LCOH values.
- In summary, by optimizing the **sizes of PV and EL**, lowering the admissible **minimum electrolyzer power levels** and so the **battery size** and realizing the plant with **reduced cost**, a LCOH less than 5 €/kg can be achieved also with irradiation values similar to Rome.
- The ongoing trend of cost reductions and efficiency improvements is making hydrogen production from photovoltaic systems increasingly competitive compared to fossil fuels and while the cost of the latter is expected to rise, the advancements in hydrogen technologies are moving towards cost reductions and efficiency improvements, thus the **hydrogen production at less cost than fossil fuel can be achieved by the off grid PV-Battery-EL systems**.

# HRS Civitavecchia & H2System




## M2C2I3.3 Sperimentazione dell'idrogeno per il trasporto stradale

- Name of the project "HRS Civitavecchia"
- Total budget 2,363,500 €, total funded 1,173,000 €
- **First phase from 4,5 MW FV+3 MW ele. ->11-450 Nm3/h (average 185=16,5 kg/h), 397 kg/day, 9000 l of hydrogen storage at 500 bar (300 kg), 1 350 + 1 700 bar dispenser, 31 refueling/day, 7 h/day, 145 t/year.**
- Second phase from 4,5 MW FV+Grid+3 MW ele. ->600 Nm3/h (54 kg/h), 1300 kg/day, ), 1 350 + 1 700 bar dispenser, 65 refueling/day, 20 h/day, 500 t/year + 1150 kg/d LNG, 520 kg/d HCNG
- Third phase from 4,5 MW FV+Grid+12 MW ele. ->2400 Nm3/h (229 kg/h), 5400 kg/day, 2 350 + 1 700 bar dispenser, 200 refueling/day, 20 h/day, 2000 t/year + 3450 kg/d LNG, 1560 kg/d HCNG
- Hydrogen delivery at 350-700 bar
- Plant completion first phase time by 2025

## Bandi a cascata PNRR

- Name of the project "H2System"
- Total budget 320,879.83 €
  Total granted 202,670.77 €
- Description: The project aims to design and develop a software application dedicated to the collection, monitoring, and analysis of data related to hydrogen production and refueling facilities
- Completion time by 2024

# Phase 1 2025 , Phase 2 2030, Phase 3 2035

## Phase 1 2025

| Hydrogen demand | |
|---|---|
| **kg/day** | **400** |
| day/year | 317 |
| **t/year** | **127** |

| Electrolyzer | | |
|---|---|---|
| CF | 28% | |
| SEC (Mean) | 58.00 | kWh/kgH2 |
| Eel | 7,354.40 | MWh/year |
| Eel | 7.35 | GWh/year |
| **Pel** | **3.00** | **MW** |

| Photovoltaic | | |
|---|---|---|
| PV/EL ratio | 2 | |
| **Ppv** | **4.50** | **MW** |
| heq | 1500 | h |
| Epv | 6,750.00 | MWh/year |
| Epv | 6.75 | GWh/year |

## Phase 2 2030

| Hydrogen demand | |
|---|---|
| **kg/day** | **1,300** |
| day/year | 317 |
| **t/year** | **412** |

| Electrolyzer | | |
|---|---|---|
| **CF** | **96%** | |
| SEC (Mean) | 61.30 | kWh/kgH2 |
| Eel | 25,261.73 | MWh/year |
| Eel | 25.26 | GWh/year |
| **Pel** | **3.00** | **MW** |

| Photovoltaic | | |
|---|---|---|
| PV/EL ratio | 2 | |
| **Ppv** | **18.00** | **MW** |
| heq | 1400 | h |
| Epv | 25,200.00 | MWh/year |
| Epv | 25.20 | GWh/year |

## Phase 3 2035

| Hydrogen demand | |
|---|---|
| kg/day | 5,400 |
| day/year | 317 |
| t/year | 1,712 |

| Electrolyzer | | |
|---|---|---|
| CF | 96% | |
| SEC (Mean) | 61.30 | kWh/kgH2 |
| Eel | 104,933.34 | MWh/year |
| Eel | 104.93 | GWh/year |
| Pel | **12.48** | **MW** |

| Photovoltaic | | |
|---|---|---|
| PV/EL ratio | 2 | |
| **Ppv** | **75.00** | **MW** |
| heq | 1400 | h |
| Epv | 105,000.00 | MWh/year |
| Epv | 105.00 | GWh/year |

# Civitavecchia potential: 2050 zero emission scenario

- **Corridoio mondiale ovest-est** Europeo E80 Lisbona –Gürbulak (Turchia) - Tokyo Asian Highway AH1
- **Corridoio europeo nord-sud** Helsinki-La Valletta/Napoli/Bari-Instanbul
- **Comune di Civitavecchia: 72,3 km²**, circa 50.000 abitanti
- **Porto: 200 ha** di banchine, 34 attracchi, 16 km di accosti, 500 ha di aree retroportuali (comprendendo limitrofe nel comune di Tarquinia): 3 milioni di persone e 11 milioni di tonnellate di merci (potenziali 30), 30 km in BT, 10 km in MT, 3x9,3 MW e 11x0,5 MW, PV, Cold Ironing, GNL, Idrogeno.
- **CFFT: 50 ha**, 200 transiti medi al giorno di camion al parcheggio e 30 camion al giorno (con picchi di 300) tra banchina ed interporto (movimentando in media 50 container al giorno)
- **Mezzi interni al porto e CFFT**: 6 bus interni, crane/forklift/crube, yard truck, treno porto-interporto (500 t/anno)
- **Mobilità pesante-media** (massa 30-15 t, capacità del serbatoio 10-40 kg; autonomia 300-800 km: 200x35=7000 kg al giorno, 200 rifornimenti annui, 1400 t/annue senza contare, centri limitrofi come Conad, Mondo convenienza, etc.)
- **Mobilità media-leggera** (massa 15-2 t, capacità del serbatoio 5-10 kg; autonomia 200-600 km: il comune di Civitavecchia, i bus COTRAL e i bus turistici della zona ammonterebbe a più di 300 t/annue senza contare i limitrofi camion rifiuti Porcarelli i mezzi della limitrofa autostrada A12.
- **PV**: in area tirreno nord installati impianti per circa 1 GW, domande per circa 2 GW
- **Eolico**: 6 domande di autorizzazione per impianti OFFSHORE per circa 4 GW
- **Centrali di potenza**: E.g. Torrevaldaliga sud 2,2 GWt (turbine al 5% di idrogeno: 111,1 MW 1500 ore annue 5.000 t/anno)

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# Thank you for your attention


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ETIP bioenergy WG2 conversion member: https://www.etipbioenergy.eu/about-ebtp

Energies Bioenergy and H2 sections editor member: https://www.mdpi.com/journal/energies/editors

EU-National projects coordinator: BLAZEwww.blazeproject.eu, GICOwww.gicoproject.eu, ZEPHYRUS,

EU-National projects participant: LIFE3Hwww.life3h.eu, LIFE2Mwww.life2m.eu, SO-FREEwww.so-free.eu, AIRE, H2C.

Affidatario RdS (Ricerca Di Sistema Elettrico Nazionale 2022-24): Tema 1.3 Idrogeno Linea 2.17 Power to Gas