//EU HYDROGEN RESEARCH DAYS

15-16 NOVEMBER

European Hydrogen Week

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REMOTE

Remote area Energy supply with Multiple Options for integrated hydrogen-based TEchnologies

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Project Overview

Call year:
[2017]

Call topic:
H2020-JTI-FCH-2017-1
FCH-02-12-2017 Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas

Project dates:
[01/01/2018 - 30/06/2023]

Total project budget:
6 740 031,40 €

REMOTE

% stage of implementation 01/11/2023: 100%

Clean Hydrogen Partnership max. contribution: 4 995 950,25 €

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Project Overview

7 countries, 11 partners from industry, research and university

POLITECNICO DI TORINO · PowiDian · Inycom innovation technologies · BALLARD · eps · CERTH Centre for Research & Technology Hellas · SINTEF · HYDROGENICS · TrønderEnergi · HORIZON S.A. · Grupo Capisa · itc Instituto Tecnológico de Canarias

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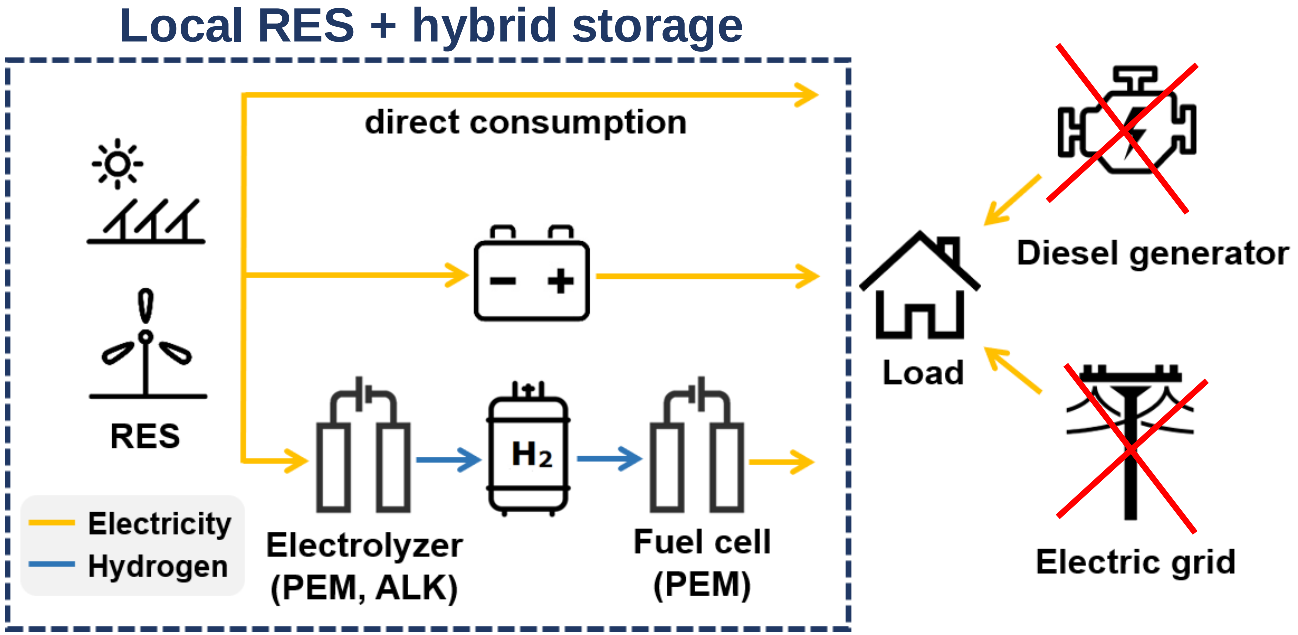
Project Summary

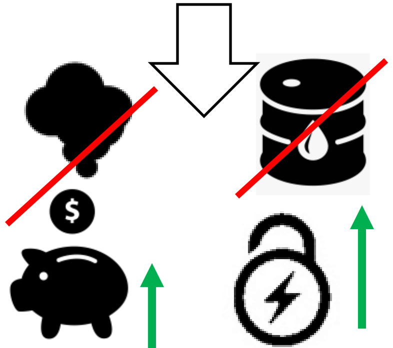
VRE-based P2P system for remote communities

1. **Diesel engines**
   high fuel cost, fuel dependence, CO_2 emissions
2. **Grid connection** (when feasible)
   high installation costs, invasive works, frequent outages

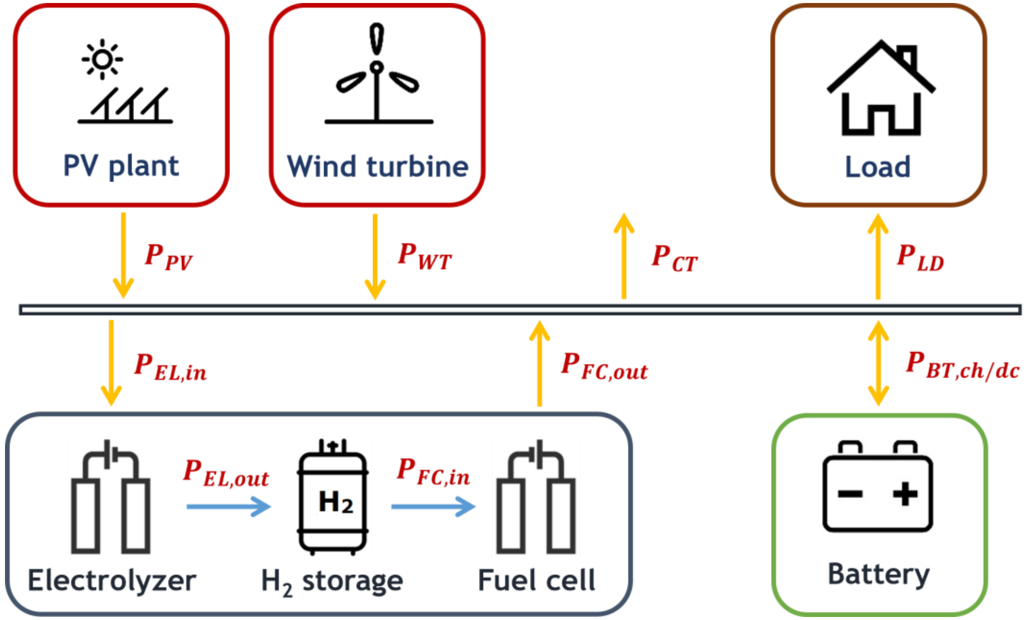
Why considering **P2P hybrid Power-to-Power (P2P) systems,** based on **hydrogen** in hybrid configuration with **closed batteries**?

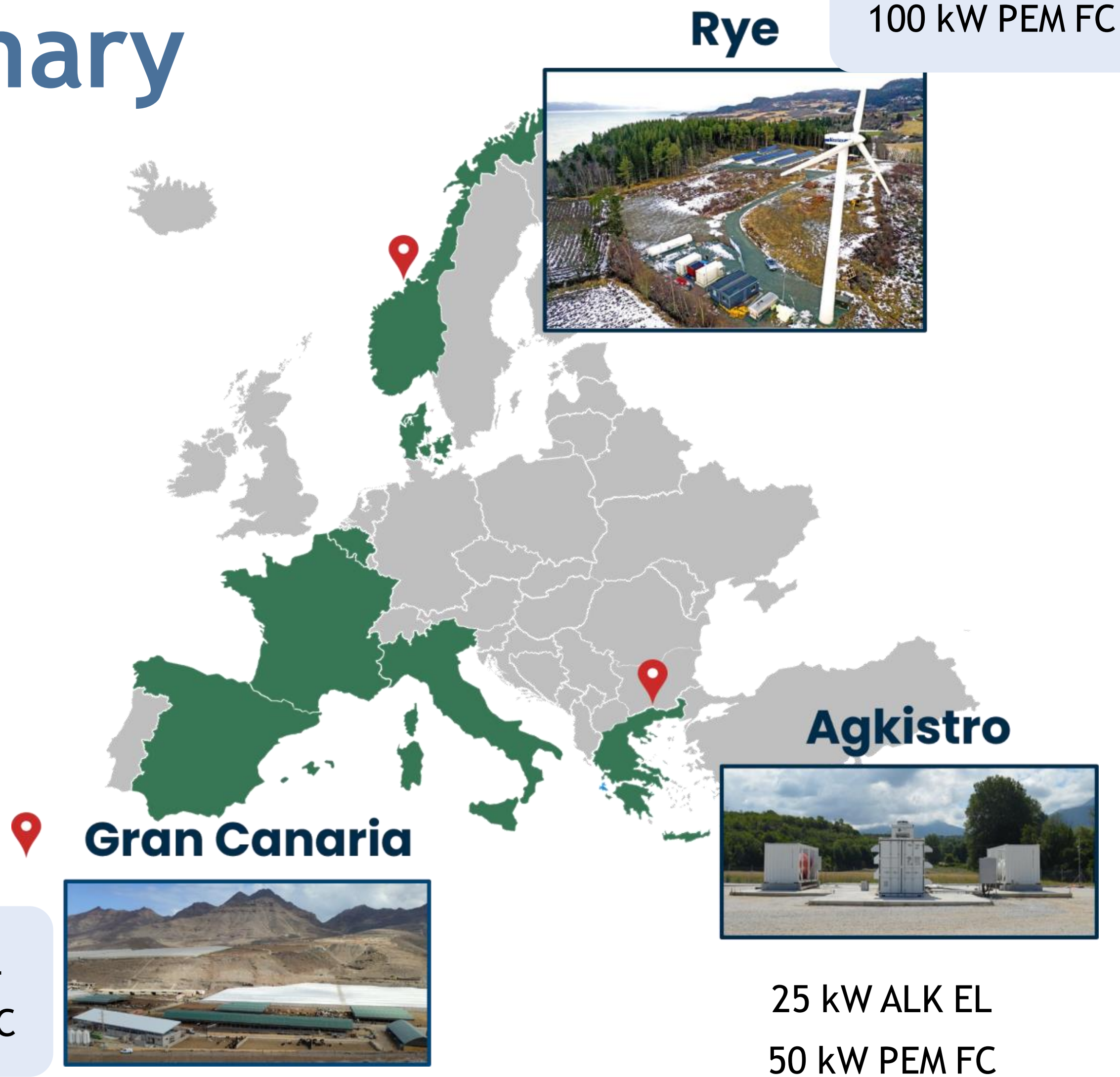
- To decrease **local pollution**
- To reduce the **cost of electricity**
- To enhance the **energy autonomy**
- To improve the reliability of the **electricity service**





Project Summary





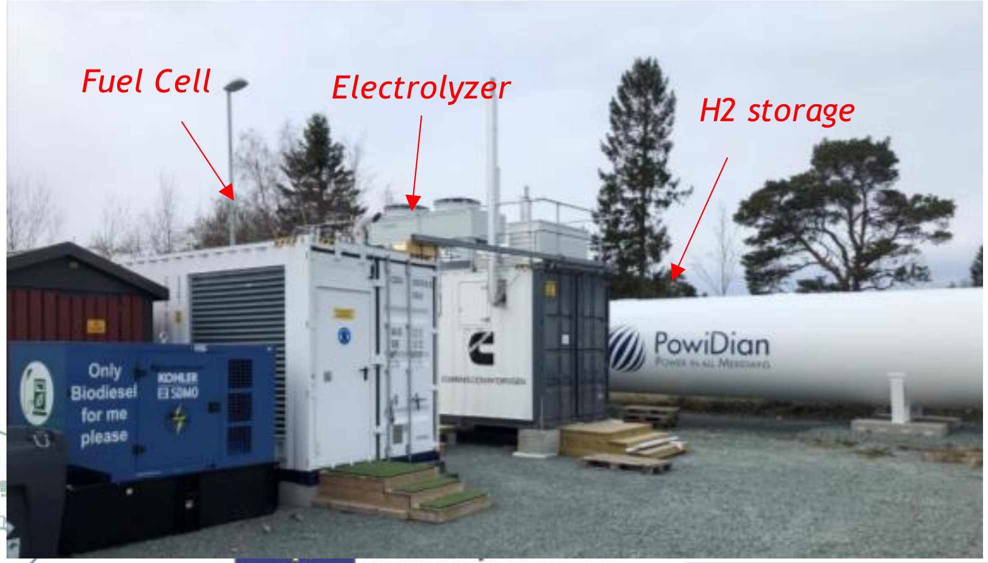
50 kW PEM EL
100 kW PEM FC

80 kW ALK EL
100 kW PEM FC

25 kW ALK EL
50 kW PEM FC

Project Results

Rye (N)
Off-grid
Non-Integrated P2P
RES: PV (85 kW) + wind (225 kW)
P2G: 50 kW (PEM)
G2P: 100 kW (PEM)
Hydrogen storage: 37 m^3 (30 bar)
Battery: 550 kWh (Li-ion)
Biofuel generator: 45 kW

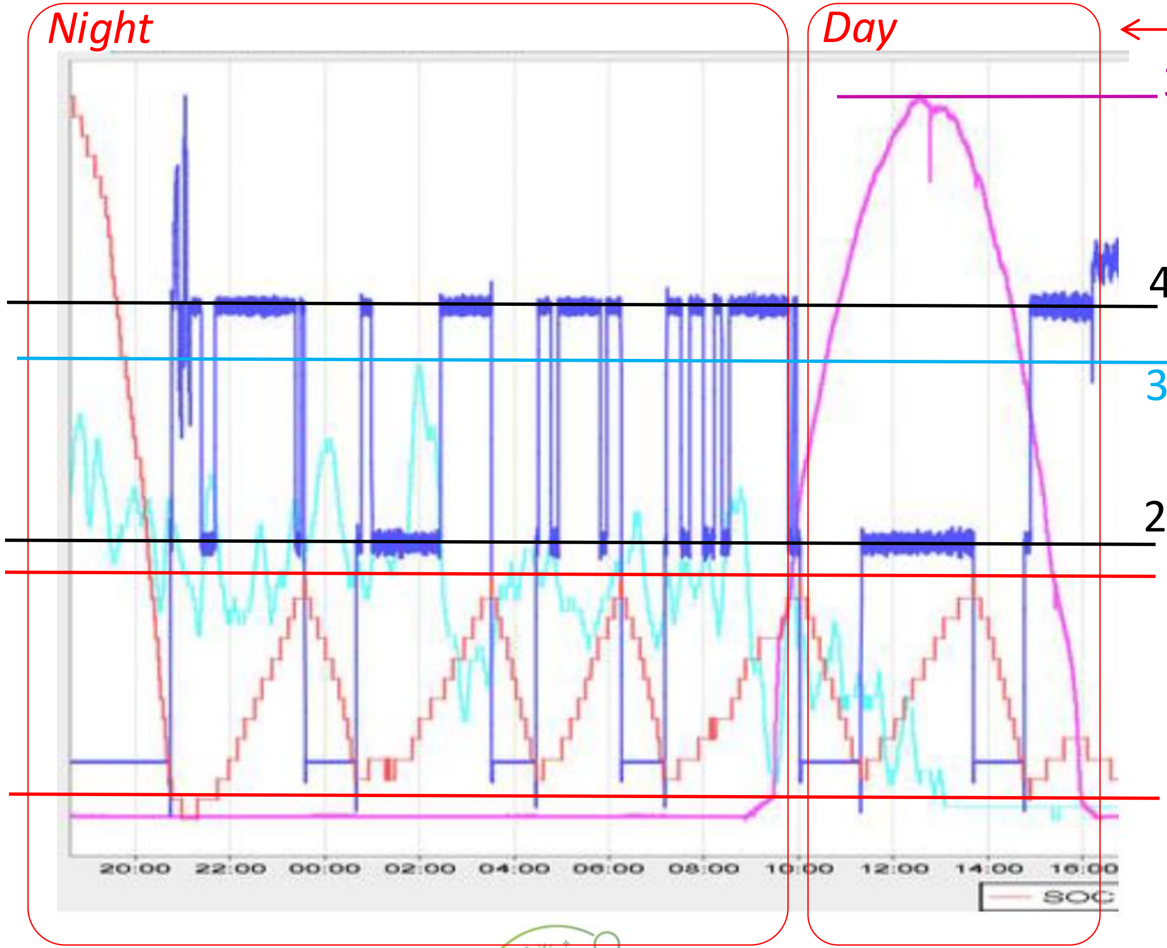


Project Results

Example of operation DEMO-Norway: night&day in Feb 2021

During night:

- WT is producing @ low power (< 30 kW)
- FC is producing when SOC is < 30%.
- FC setpoint can be fixed (cycle charging) or adapted to the load (load following)



During day:

- PV produces during the day (short period, it's February in Norway) and WT production decreases
- Battery is discharged and then excess PV is used to recharge it. The FC is set at lower setpoint (20 kW) thanks to PV.

Battery SOC: 25%-30%
FC Power: 0-20-40 kW
Wind Turbine Power: 0-37.5 kW

PV Power: 0-30 kW
Genset Power: 0 kW

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Project Results

Agkistro (GR)
Micro-grid
Integrated P2P
RES: Hydroelectric 0.9 MW
P2G: 25 kW (ALK)
G2P: 50 kW (PEM)
Hydrogen storage: 12 m^3 (30 bar)
Battery: 92 kWh (Li-ion)

Project Results

Avg. FC efficiency up to 51%

Avg. EL efficiency up to 58%

KPI: round-trip efficiency in DEMO-Greece

	η_{EL} *	η_{FC} *	$\eta_{RT,total}$ **
Oct (2020)	55%	43%	41%
Nov (2020)	0%	0%	-
Dec (2020)	55%	0%	84%
Jan	0%	0%	-
Feb	57%	51%	86%
Mar	57%	42%	87%
Apr	53%	43%	47%
May	53%	46%	59%
June	53%	0%	72%
July	54%	47%	58%
Aug	56%	0%	80%
Sept	55%	44%	-
Oct	0%	0%	-
Nov	55%	48%	66%
Dec	0%	0%	-
2022	58%	0%	93%

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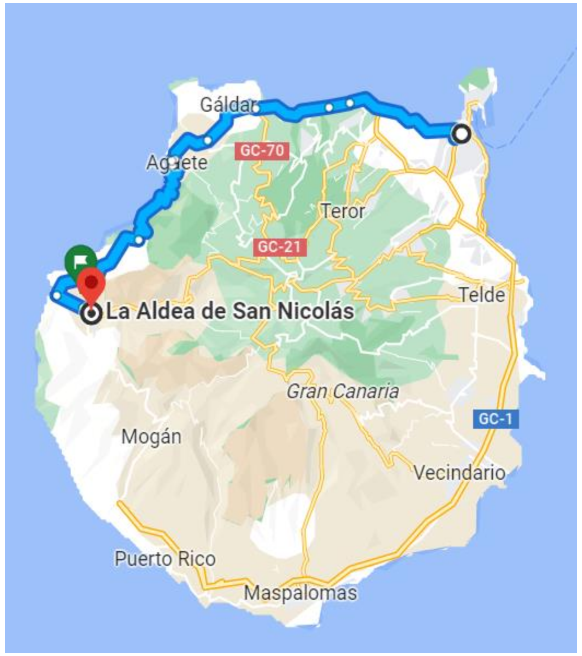
Project Results

Gran Canaria (ES)
Micro-grid
Non-Integrated P2P
RES: PV (100 kW) + wind (20 kW)
P2G: 80 kW (ALK)
G2P: 100 kW (PEM)
Hydrogen storage: 50 kg (200 bar)
Battery: 200 kWh (Li-ion)

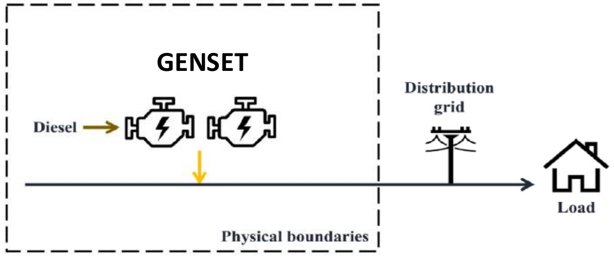


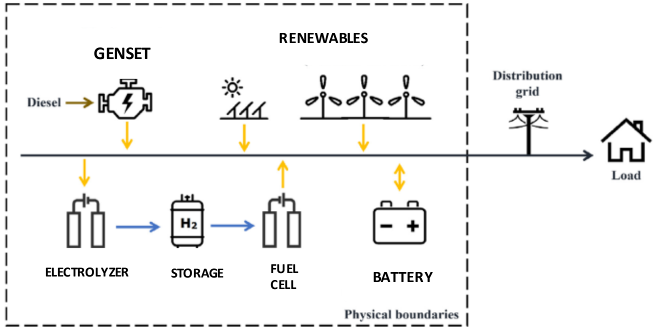
Some conclusions

Technical and Environmental (e.g. Norway)

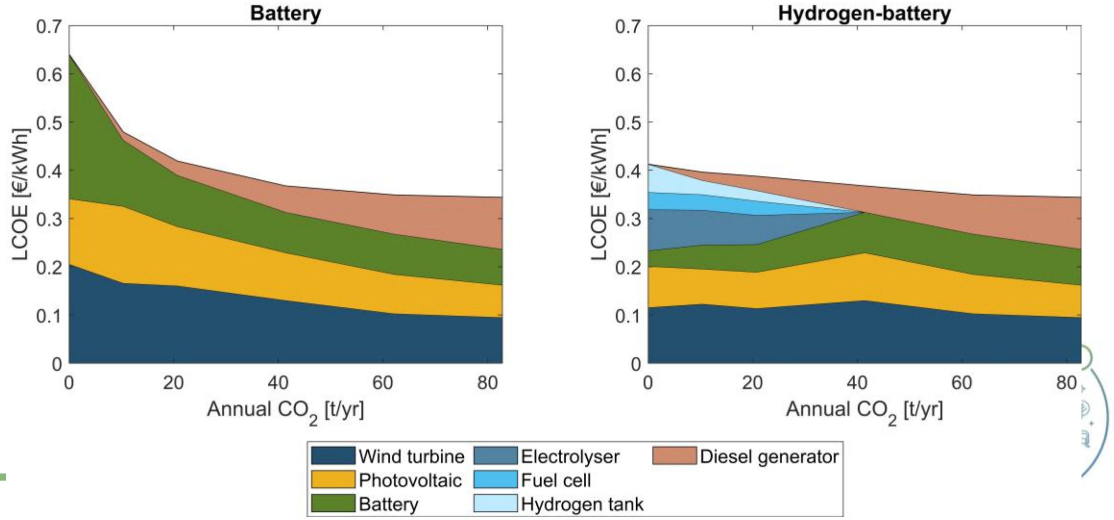
- ✓ 13 months, 7691 hours of data recorded
- ✓ RES production: 158 MWh (104 wind + 54 PV) + biofuel genset 60 MWh
- ✓ RES use:

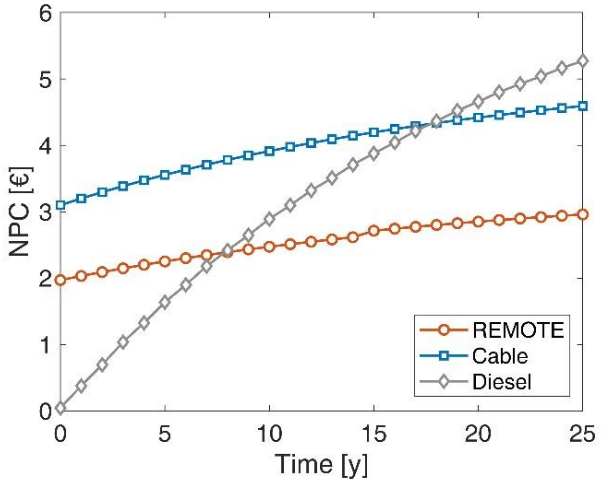
  Directly to load: 38 MWh (24%)
  To battery: 96 MWh (61%)
  To electrolyzer: 18 MWh (12%)
  To auxiliary: 6 MWh (4%)





System	DEMO Norway ($kgCO_{2eq}/MWh$)
REMOTE scenario	603.3
Reference scenario	1574.8
Emissions savings vs. reference	**971.5**





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Future ambitions

Hydrogen Valleys

Optimal sizing and operation

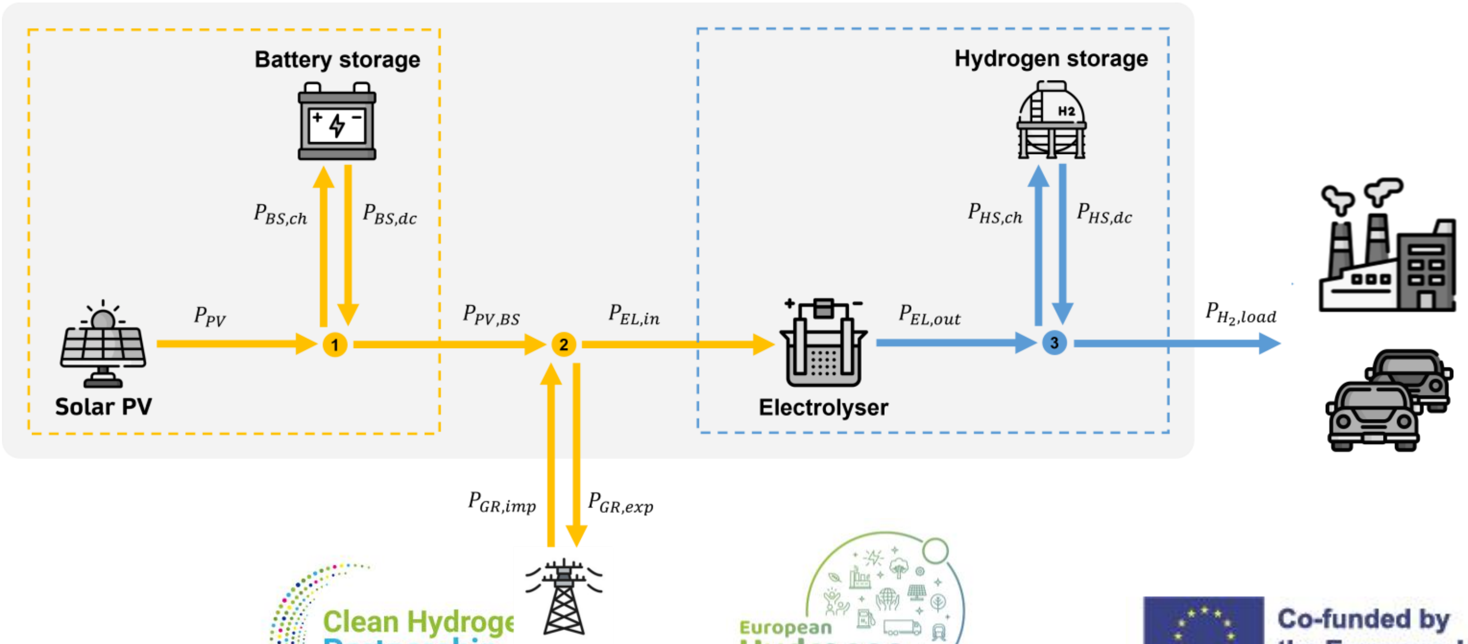
Reliably cover the load demand while minimizing a certain objective function

Single Objective optimization

Multi-objective optimization

Objective function estimation

Economic (LCOE) and environmental impact (CO_2)



P. Marocco, D. Ferrero, E. Martelli, **M. Santarelli**, and A. Lanzini, "An MILP approach for the optimal design of renewable battery-hydrogen energy systems for off-grid insular communities," Energy Convers. Manag., vol. 245, p. 114564, 2021, doi: 10.1016/j.enconman.2021.114564.

Deployment

Following the completion of the R&I project, ***next stages*** *(deployment)*

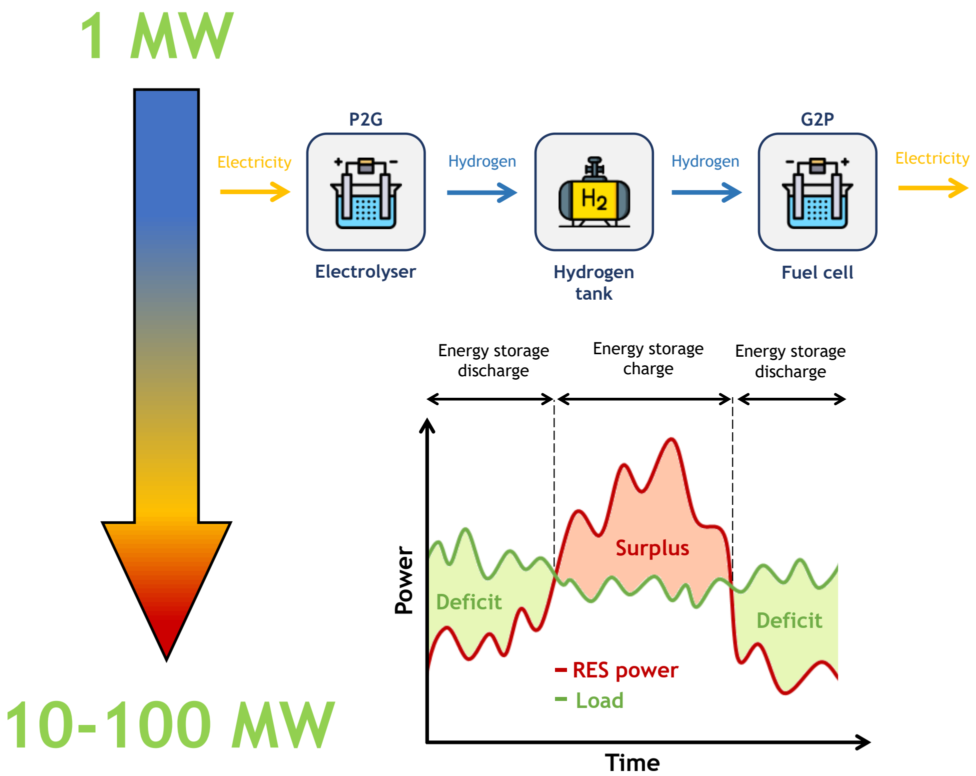
Technology available and demonstrated at small-medium scale (around 1 MW)

Large potential market(s)

- Off-grid solutions (e.g., islands, remote areas)
- Isolated-micro-grids (RES-based areas with connection to the electric grid)
- Smart energy districts inside municipalities
- Grid balance in smart-grid solutions (mainly, inside municipalities)

In different areas of the World

Support for scale-up of the technologies and system integration



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Prospects

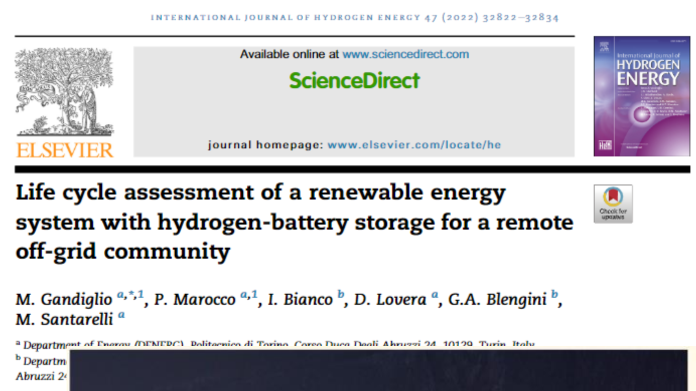
Global business allowing large emission saving

Thousands of populated islands and mountain communities around the World that **rely on diesel** generators to produce electricity

Only considering islands, around **750 million inhabitants** around the World are involved.

Save the emissions of **1.5 GtonCO$_2$/year**

Dissemination and Awards


INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 47 (2022) 32822–32834

Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/he

Life cycle assessment of a renewable energy system with hydrogen-battery storage for a remote off-grid community

M. Gandiglio [a,*,1], P. Marocco [a,1], I. Bianco [b], D. Lovera [a], G.A. Blengini [b], M. Santarelli [a]

European Sustainable Energy Week 2020

Winner of the Innovation Award

SIOS Innovation Award 2023

Develop an Automatic Climate Station prototype for remote sites observations in the Arctic

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Thanks REMOTE Team!!

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