FLEXnCONFU PROJECT

NAME LAST NAME

LOCATION

DATE

This Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement N. 884157

PROJECT OVERVIEW

48 MONTHS | **9.8** MIL. € | **21** PARTNERS

1 APRIL 2020

2021
HYDROGEN/ AMMONIA COMBUSTION

2023
TRL 6
PILOT SITE

2023
TRL 7
DEMO SITE

2024

31 MARCH 2024

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IN A NUTSHELL

Power-to-X-to-power (P2X2P) solutions
Development and integration of novel solutions to enhance power plant flexibility.

Combustion of renewable gases
Combustion of Hydrogen and Ammonia to reduce the combined cycle environmental impact.

Energy storage integration
Increase the combined cycle efficiency enhancing load levelling via energy storage.

Smart, affordable and resilient power system
Real data from demo and pilot sites used to constitute an enhanced power system with an increased share of intermittent renewables.

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DRIVERS

		Project Response
DRIVER 1	• Major role of Natural Gas in the EU energy system • Natural Gas fueled power plants are the bridging technology to a 2050 decarbonized energy scenario	To demonstrate a cleaner and fast-responding solutions to be coupled with existing fossil fuel power plants, with a significant impact already in the short-term
DRIVER 2	• Hydrogen is an essential element in the energy transition • Hydrogen can achieve a remarkable importance in the future EU economy	To use hydrogen in fossil fuel power plant in order to accelerate the transition towards a decarbonized and energy efficient society
DRIVER 3	• Increasing share of Hydrogen and/or Ammonia combustion in gas turbines (target 100% Hydrogen by 2030) • Use of ammonia in gas turbine as energy carrier to unlock the potential Hydrogen and reduce the NO_x	To become a reference point in the short term for Hydrogen and P2X solutions, and in the long term for Ammonia as energy carrier.
DRIVER 4	• Rapid growth in variable generation is driving the need for a more flexible combined energy and storage technologies • P2X technologies are receiving particular focus in Europe as the next future best storage to be coupled with RES	Replication of FLEXnCONFU P2X solutions for future applications in other energy sectors in order to enable higher RES penetration.

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MAIN GOAL

- **Demonstrate up to TRL 7** in a real operative plant the **integration of power-to-X-to-power system** able to:
  - increase fossil-based power plant flexibility
  - reduce emissions of the power plant
  - converting surplus electricity to hydrogen or ammonia via P2X application, while in turn re-using the produced gases in the same power plant to produce power in times of demand (P2X2P)

- **Exploit the potential of NH_3** combustion to reduce CO_2 emissions by performing combustion tests injecting up to 100% Ammonia will be performed in a heavy-duty Gas Turbine (GT) combustion system (Cardiff University combustion lab).

FLEXnCONFU is promoting a closer RES/GT integration via Power-to-Gas solutions

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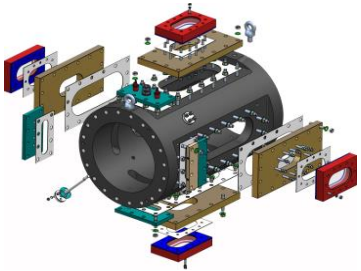
PILLARS

PILLAR 1

USE OF NON-CONVENTIONAL FUELS IN GAS TURBINE/COMBINED CYCLE FOR FLEXIBILITY NEEDS AND HIGHER ENVIRONMENTAL SUSTAINABILITY



PILLAR 2

INTEGRATION AND DEMONSTRATION OF P2X SYSTEMS in REAL POWER PLANT

PILLAR 3

DEVELOPMENT OF PROPER GRID ORIENTED CONTROL STRATEGIES

PILLAR 4

PROMOTION OF A HYDROGEN AND AMMONIA ENERGY SOCIETY

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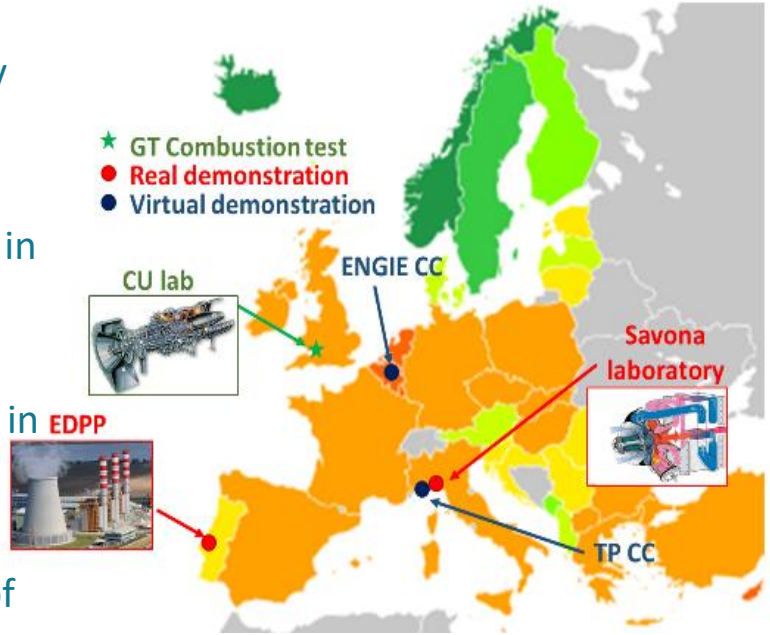
DEMONSTRATION

Demonstration at **four different levels**:

- Alternative fuel combustions in representative industrial scale gas turbine in Cardiff University laboratory
- TRL6 Power to Ammonia (P2A) demonstration in Savona pilot site
- TRL7 Power to Hydrogen (P2H) demonstration in Ribatejo power plant
- Virtual demonstration towards maximisation of the replication potential



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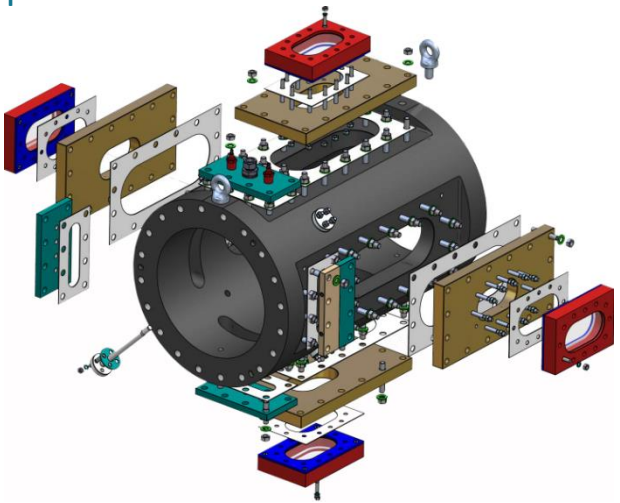
CARDIFF LABORATORY

Gas Turbine COMBUSTION TEST RIG

- The Cardiff University combustion laboratory enables novel research studies to be conducted into the functionality of new gas turbine combustion systems, components and fuels under elevated conditions of temperature and pressure as it would be experienced within a real gas turbine engine during operation.
- Non-intrusive measurement techniques enable a better understanding of the fundamental phenomena occurring within the combustion system.
- The Research Laboratories also enable advanced combustion diagnostics for complex gaseous blends using representative industrial geometries.



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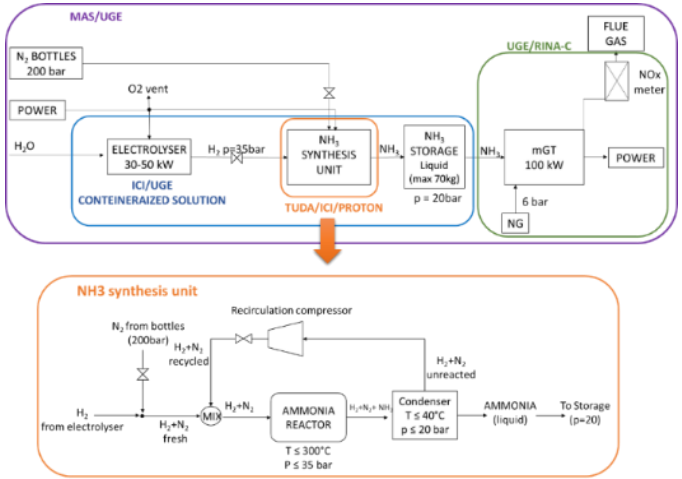
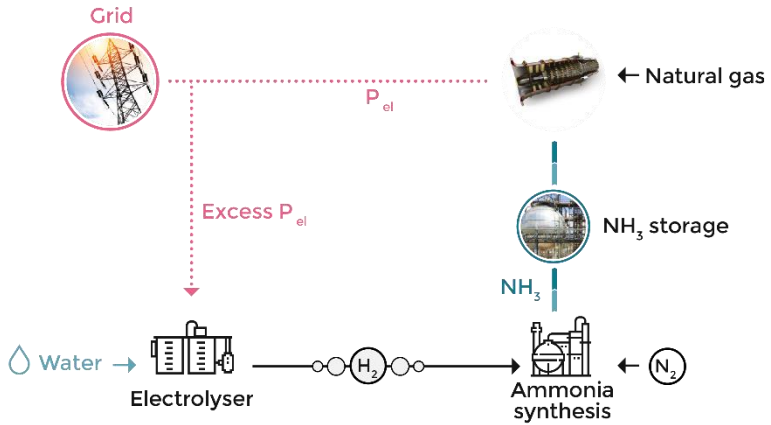
SAVONA LABORATORY

POWER TO AMMONIA TO POWER TEST RIG

- Study the use of ammonia as hydrogen carrier, using a micro Gas Turbine (mGT).
- A modular and containerized solution will be connected to an existing mGT, installed within a smart grid, properly modified for ammonia combustion.





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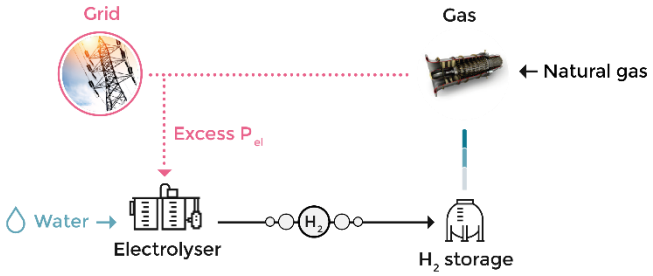
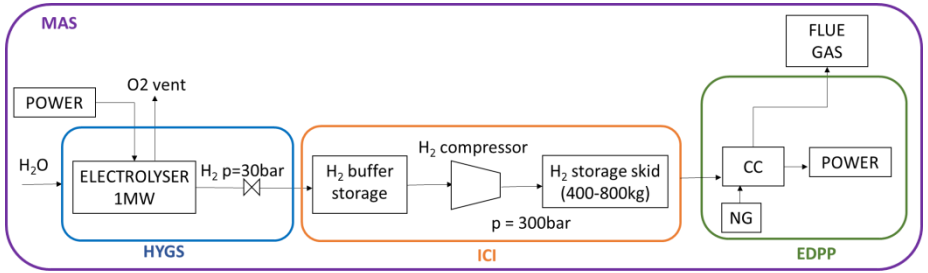
RIBATEJO GT COMBINED CYCLE

POWER TO HYDROGEN TO POWER TEST RIG

- A complete system composed by 1MW fast-cycling electrolyser, gas compressor and pressurized hydrogen storage will be installed to demonstrate the potential of FLEXnCONFU concept in a real environment
- The hydrogen produced will be firstly accumulated in a storage and re-used to produce power when is more convenient.





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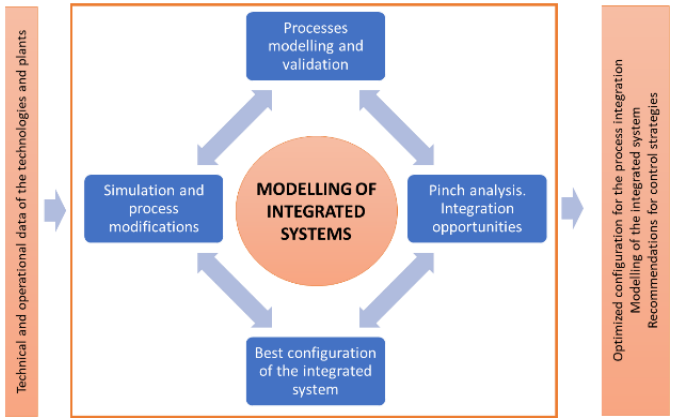
GRID ORIENTED CONTROL STRATEGIES

Dynamic modelling:

- Dynamic models for both P2A and P2H systems will be developed
- Thermal integration approach based on Pinch analysis is selected
- Dynamics will be based on Reduced Order Models (ROM) as a solid way to predict the dynamic behaviour of P2X technologies.



Control strategies development:

- Development of advanced controls combining predictive capabilities while respecting the plant operational constraints.
- Considering the grid constraints to develop strategies to follow CC needs on the electrical market.

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METHODOLOGY

M1-M18

Assessment Phase

M1-M43

Development and pre-demonstration phase

M24-M48

Demonstration phase

1st April 2020

31st March 2024

Environmental assessment

Replication

Promotion and policy

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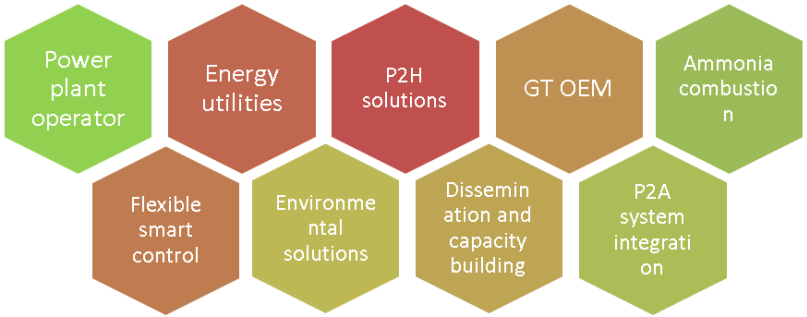
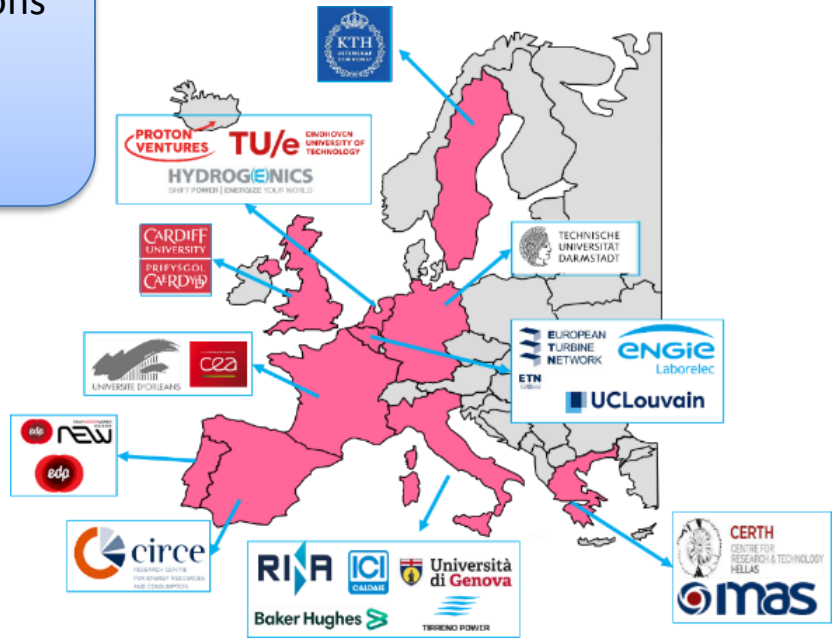
CONSORTIUM

Industrial driven consortium:

- 10 top level Academic Polytechnic Institutions
- 7 Large Enterprises
- 3 Small and Medium Enterprises
- 1 association





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IMPACTS

Impacts 1:

Contribute to a smart, secure and more resilient power system through the integration of energy storage for the purpose of load levelling in fossil fuel power generation

- FLEXnCONFU will enlarge Combined Cycle (CC) possibility of offering services on the ancillary services market guaranteeing a more secure, clean and resilient power system.
- FLEXnCONFU solution will stimulate electric/gas grid interaction and increase EU energy independence enabling EU CC plants to act as hub of gas/electric grid flexibility services.

Impacts 2:

Smoother operation of these plants at optimal efficiency and environmental performance

- *Reduction of minimum load*: - 10%
- *Increase of yearly efficiency*: - 5%
- *Increase yearly Equivalent Operating Hours*: + 5/10% according to the location of the CC
- *Reduction of yearly start-up numbers*: -10%
- *Quicker ramp up/down* with load gradient +10/15%
- *Reduction of natural gas consumption* and related emissions: -10/20% of GHG_{eq}

Impacts 3:

Better adapt to an energy system that will increasingly be dominated by intermittent renewable energy

- Promotion of P2X2P solutions for GT/CC, exploiting excess of power to produce potential GT fuels like H_2/NH_3 are the best option to flexibilise the cycles, guaranteeing a smoother operation than a traditional battery to be then coupled and releasing power to the grid.

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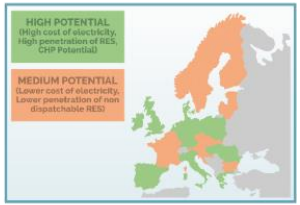
ROADMAP

Key Exploitable Results	TRL
Distributed modular scale P2A reactor:	5
Modified mGT for non-conventional fuels (H2/NH3):	5
CC GT for non-conventional fuels (H2/NH3):	4/5
Grid responsive controller for P2H/P2A:	4/5
Simulation ROM for alternative fuel combustion:	4
FLEXnCONFU layout	5

Key Exploitable Results	TRL
Distributed modular scale P2A reactor:	6
Modified mGT for non-conventional fuels (H2/NH3):	6
CC GT for non-conventional fuels (H2/NH3):	6
Grid responsive controller for P2H/P2A:	5/6
Simulation ROM for alternative fuel combustion:	5
FLEXnCONFU layout	6

Key Exploitable Results	TRL
Distributed modular scale P2A reactor:	7
Modified mGT for non-conventional fuels (H2/NH3):	7/8
CC GT for non-conventional fuels (H2/NH3):	7
Grid responsive controller for P2H/P2A:	7
Simulation ROM for alternative fuel combustion:	6
FLEXnCONFU layout	7

Key Exploitable Results	TRL
Distributed modular scale P2A reactor:	8
Modified mGT for non-conventional fuels (H2/NH3):	9
CC GT for non-conventional fuels (H2/NH3):	8
Grid responsive controller for P2H/P2A:	8
Simulation ROM for alternative fuel combustion:	7/8
FLEXnCONFU layout	8



PROJECT STARTS 2020 TRL 5 — 2022 TRL 6 — PROJECT ENDS 2024 TRL 7 — 2025 TRL 8 — 2027 TRL 9

Project Starts

Project Drivers

- Flexibilization of Natural Gas Based Power Plants to increase their role in electrical market
- Fast-Response Back-up Capacity for fluctuating RES
- Increase the efficiency and the performances at minimum and part load of the plants
- Consolidate power-to-X technological solutions
- GTs are required to reduce their emissions

Intermediate Achievements

CH_4/H_2/NH_3 mixed combustion in mGT and GT in CU and UGE labs

TECH NON-TECH BARRIERS	• Definition of regulatory and HSE framework to have relevant quantity of H_2/NH_3 in power plant areas • Guarantee a correct injection of H_2/NH_3 in already existing GTs as well • Reducing the capital costs of the components • Standardization of control protocol for P2X2P solutions
MARKETING	• Use the P2X2P system to flexibilize both gas and electric grids • Selection of the first entry markets: EU countries with high RES penetration and good presence of CC • Assessment of the final business model for the commercial exploitation of the FLEXNCONFU system

MAIN APPLICATIONS:

Combined cycle operating close to RES Plants and areas demanding high grid flexibility

MARKET DRIVERS:

- De-Moothballing of Combined Cycle
- Increasing of RES penetration
- Need for an Increased Back-Up Capacity of Flexible Power Plants
- Reduced emissions of Combined cycles in part load thanks to alternative environmental friendly gases
- Promotion of P2Gas solutions also for Gas Grid injection

ADDITIONAL MARKETS:

Distributed P2X2P solutions

Aggregation with RES via VPP

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MANY THANKS!

CONTACT
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