



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



FLEXibilize combined cycle power plant through power-to-X solutions using non-CONventional Fuels

D8.6 – “First Stakeholder vision report”

Organisation name of lead contractor: European Turbine Network (ETN)



Project Contractual Details

| | |
|----------------------------|--|
| Project Title | FLEXibilize combined cycle power plant through power-to-X solutions using non-CONventional Fuels |
| Project Acronym | FLEXnCONFU |
| Grant Agreement No. | 884157 |
| Project Start Date | 01-04-2020 |
| Project End Date | 31-03-2024 |
| Duration | 48 months |
| Website | www.flexnconfu.eu |

Deliverables Details

| | | | |
|-----------------------------------|--|---------------------|------------|
| Number | D8.6 | | |
| Title | First Stakeholder vision report | | |
| Work Package | WP8 | | |
| Dissemination level ¹ | Public | | |
| Due date (M) | M24 | Submission date (M) | 31.03.2022 |
| Deliverable responsible | ETN | | |
| Contributing Author(s) | Simon Gianordoli (ETN) | | |
| Reviewer(s) | Alessandra Cuneo (RINA-C) | | |
| Final review and quality approval | 31/03/2022 | | |

Document History

| Date | Version | Name | Changes |
|------------|---------|------------------|--------------------------|
| 09/02/2022 | 1.0 | Simon Gianordoli | -- |
| 16/03/2022 | 2.0 | Simon Gianordoli | Edits and reviews |
| 31/03/2022 | 3.0 | Simon Gianordoli | Edits and pictures added |

¹ PU = Public
CO = Confidential, only for members of the consortium (including Commission Services)



Executive Summary

The Deliverable 8.6 “First Stakeholder Vision Report” reflects the undertaken activities by the consortium since the beginning of the project in April 2020 in line with Task 8.2 “Stakeholders’ engagement for future marketability of FLEXnCONFU concept”.

The main objective of the Deliverable 8.6 is to draw a first state-of-the-art of the FLEXnCONFU opportunities with valuable stakeholders (industrial players, policymakers, research and academia), the lessons learnt from the regulatory framework and the potential replicability of the project’s concept. This Deliverable will be updated at M48 as a positioning paper on policy and technology opportunities learnt from the FLEXnCONFU project.



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Abbreviations

AGM: Annual General Meeting

AIChE: American Institute of Chemical Engineers

ASME: American Society of Mechanical Engineers

CC: Combined-Cycle

ERCOFACT: European Research Community on Flow, Turbulence and Flow

EU: European Union

EUBCE: European Biomass Conference & Exhibition

EUSEW: EU Sustainable Energy Week

GT: Gas Turbine

H₂: Hydrogen

ICAE: International Conference on Applied Energy

IGTC: International Gas Turbine Conference

IGTI: International Gas Turbine Institute

IP: Intellectual Property

mGT: micro-Gas Turbine

OEMs: Original Equipment Manufacturers

P₂A: Power-to-Ammonia

P₂A₂P: Power-to-ammonia-to-power

P₂H: Power-to-Hydrogen

P₂H₂P: Power-to-hydrogen-to-power

P₂X: Power-to-X-to-power

TRL: Technology Readiness Level



1. Introduction

The FLEXnCONFU - FLExibilize combined cycle power plant through power-to-X solutions using non-CONventional Fuels- project is a H2020 project (Grant Agreement n.884157) funded by the European Union (EU) which started in April 2020 and will end in March 2024.

The use of alternative carbon-free fuels in existing power plants and a high penetration of renewable energy sources into the grid are required in order to meet EU 2030 and 2050 climate and energy goals. As such, combined-cycle gas turbine plants represent a crucial technology with the required flexibility to compensate for the intermittency of renewable energy sources like wind and solar.

The FLEXnCONFU project will develop innovative, economical, viable and replicable power-to-X (P2X) solutions to be integrated to existing and new power plant to level the load, and to un-tap their flexibility, converting electricity into hydrogen (H₂) or ammonia (NH₃) to be in turn locally re-used in the same power plant to respond to varying demand, thus reducing time their environmental impact. A 1MW scale power-to-hydrogen-to-power (P2H2P) system will be integrated in a real operational environment in Portugal (EDP's Ribatejo power plant) while a small-scale power-to-ammonia-to-power (P2A2P) solutions will be coupled with a micro gas turbine (mGT) properly modified to burn ammonia in Savona Smart Microgrid laboratory.

Thus, the main objective is to flexibilise Combined-Cycle (CC) power plants by developing Power-to-gas-to-power (P2G2P) technologies using non-conventional fuels, namely hydrogen (H₂) and ammonia (NH₃). This will be demonstrated at Technology Readiness Level 7 (TRL) in Ribatejo EDP CC Power Plant. The P2G2P system will be based on a Power-to-Hydrogen (P2H) solution developed, while a Power-to-ammonia-to-power (P2A) solution will be demonstrated within the Savona Smart Microgrid at TRL6. The P2G2P solution will be directly controlled by a grid driven/responsive management system. Gas Turbine (GT) combustion acceptability of different NG/H₂/NH₃ mixtures will be then studied. FLEXnCONFU is a demonstration to market project and upscale and replication of the demonstrate P2H/P2A will be studied in ENGIE Laborelec and Tirreno Power CC plants.

FLEXnCONFU has the objective to promote and disseminate its innovative concepts to the relevant stakeholders, ensuring a high-awareness and implementation of its technological opportunities. The consortium has conducted all the necessary activities in the first 2 years of the project, foreseeing real and pilot demonstrations in 2023. Under the supervision of ETN, the consortium fulfilled its communication and dissemination objectives during this period according to the phase of the project.

ETN Global, as the global association representing the entire turbines' supply chain (turbine manufactures, users, energy utilities, academia and suppliers), with an established expertise in EU research and legislation policies, leads the communication and dissemination activities to guarantee a wide, robust, market and policy-oriented spread of the project results. To achieve the best results all the



partners of the consortium support in the communications and disseminations activities. It must be noted that COVID-19 restrictions in Europe were a restraint and led to online activities.

During those first two years, the FLEXnCONFU project had the opportunity to liaise with a wide range of stakeholders: policymakers, scientific community, R&D, research and academia. As the project is in a pre-demo phase, the main objective was to create visibility and raise interest among stakeholders about the project and its expected outcomes. This will be addressed in a first part.

The FLEXnCONFU partners also started to work on the regulatory framework the project had to comply with and its potential replicability. The main part of this work was to understand which the best EU electrical markets are where to promote the potential of FLEXnCONFU concept. It is Deliverable D1.4 "Electrical market Assessment for enhanced FLEXnCONFU concept in CC". It will be addressed in a second part.



2. Task planning

2.1. Dependencies on other tasks

T8.2 activities are linked to other Work Packages and tasks within the project:

- **WP1 – ‘Scenario analysis & Requirements definition’** will disclose Deliverable 1.4 ‘Electrical market assessment for enhanced FLEXnCONFU conception CC’ in March 2022. It will contribute to understand which the best EU electrical markets are where to promote the potential of FLEXnCONFU concept.
- **WP6 – ‘Scale-up and replicability’** monitors the results from the demonstration phases on the P2H and P2A solutions. Those findings and results will be promoted and shared with industrial and energy stakeholders to assess the potential of FLEXnCONFU solutions.
- **WP7 – ‘FLEXnCONFU Impacts & Benchmarking’** will draw some lessons and inputs regarding environmental perspectives and social acceptance of the FLEXnCONFU solutions. Those will be promoted and showcased to relevant stakeholders.

2.2. Contribution from partners

ETN Global wrote the Deliverable.

RINA-C contributed to this Deliverable by reviewing and provided some content as Coordinator, WP1 and WP6 Leader and as the main involved partner into T8.2.



3. Engaging the FLEXnCONFU project

FLEXnCONFU project rose awareness on its key concepts and technologies since it started in April 2020. This has been done through communication channels and tools which are crucial to ensure a wide visibility and acknowledgment of the project (1). Thanks to its valuable partners, the project managed to participate and initiate key events and publications. It reaches scientific, industrial and policy-makers stakeholders and ensured a proper showcase of the project (2).

4.1 Raising awareness of the FLEXnCONFU concept

The FLEXnCONFU project has many communication channels that have been designed to reach and engage stakeholders. The communication materials correspond to [Deliverables 8.2](#) (1) and [8.4](#) (2).

4.2 Engaging stakeholders with FLEXnCONFU

Communication materials are a first key to raise awareness and in engaging stakeholders towards the project. FLEXnCONFU reached out relevant group of stakeholders in the first half of the project thanks to ETN and its wide network but above all thanks to the coordination of the partners of the consortium.

4.2.1 The ETN network

ETN Global is a non-profit membership association bringing together the entire value chain of the gas turbine technology community. Through cooperative efforts and by initiating common activities and projects, ETN encourages and facilitates information exchange and cooperation to accelerate research, development, demonstration, and deployment of safe, secure and affordable carbon-neutral energy solutions by 2030. Its activities are mainly coordinated by working groups which deal with all the aspects of the gas turbine technologies developments. Through its extensive network encompassing gas turbines industrial users, R&D community and Original Equipment Manufacturers (OEMs) and its demonstrated dissemination experiences, ETN showcases FLEXnCONFU in its annual event and bi-annual conference also to collect yearly relevant insights from present stakeholders.

ETN Annual General Meeting (AGM)

The ETN AGM is a yearly conference open to ETN Members. The ETN community presents its results and activities achieved during the last year, details its agenda and priorities for the year to come and open the discussions on the current important topics related to the gas turbine technologies.

FLEXnCONFU was presented at the 2020 and 2021 editions where RINA-C and KTH presented the project to the ETN community. Those editions were held online due to COVID-19 restrictions which reduced the feedbacks from the ETN community.

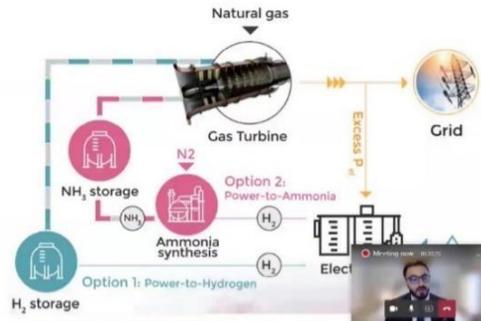


FLEXnCONFU H2020

FLEXibilize combined cycle power plant through Power-to-X solutions using non-CONventional FUEls



- April 2020 – March 2024. 21 partners.
- How to use non-conventional fuels to make CCGTs more flexible and enhance profits?
- 2 Demo sites (TRL4 -> TRL 6/7) integrating P2X components in system + 2 virtual replication sites
- 12.5M€ Budget (9.8M€ EU funding)



ETN AGM 2021 – Power to Ammonia for enhancing CCGT flexibility, March 2021

KTH Energy Department

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Figure 1: Presentation of FLEXnCONFU at ETN AGM 2021

The project was presented at the ETN Annual General Meeting and Workshop on 29-30th March 2022 in Brussels. ETN presented the project and first advancements to the ETN community and proposed a physical booth where attendees were able to get more from FLEXnCONFU. As the first in-person event held by ETN since March 2020, the event gathered more than 80 in-person attendees and was the place for fruitful discussions in various sessions of the programme. The attendees comprised gas turbines OEMs, users from Europe and North America as well as academia's and researchers. The opportunities of non-conventional fuels and particularly hydrogen for gas turbines in the next energy landscape were at core of the discussions.



Figure 2: ETN Annual General Meeting and Workshop, Brussels, 30 March 2022



ETN's International Gas Turbine Conference (IGTC):

The [International Gas Turbine Conference \(IGTC\)](#) (3) is a well-established and renowned biannual conference, organised by ETN, representing the whole gas turbine community. The objective is to raise the awareness of gas turbine (GT) and turbomachinery technology development needs – from operators' perspectives – and to explore and exchange ideas with GT experts from the whole value chain attending from all continents. The IGTC also provides the opportunity to meet and discuss with policymakers the role of gas turbines in future energy scenarios. The conference highlights the energy market outlook in Europe and in key markets globally, as well as presents and disseminates current R&D activities and latest achievements for flexible, efficient, reliable and environmentally sound gas turbine technology.

The 2021 edition "Gas turbines: an enabling technology for a carbon-neutral society" was a great opportunity to present the project. It was the case at the Technical Session "Alternative fuels and efficiency increases" where the joint paper "Ammonia Blended Fuels – Energy Solutions for A Green Future" (UORL, CU, BH, RINA-C, UCL, TU/e) was presented, highlighting P2A technologies of FLEXnCONFU. During the whole conference (11-15 October 2021), ETN provided an online booth for the project where attendees had the opportunity to chat directly the ETN team and have access to all relevant info of the project.



Figure 3: Presentation of FLEXnCONFU, IGTC 2021



Figure 4: FLEXnCONFU Online Booth, IGTC 2021

ETN High-Level User Meeting

The High-Level User Meeting gathers high-management influence over ETN’s strategy, target, and fleet requirements. The audience are gas turbines end-users at senior management level. FLEXnCONFU project was presented online by Christer Björkqvist, Managing Director of ETN online in 2021 and rose the users’ interest. It was agreed that FLEXnCONFU concepts contribute to the key messages from ETN users to accelerate the energy transition, especially ‘*optimising existing assets to meet decarbonisation demands with required security of supply*’. Detailed outcomes of the meeting can be found [here](#). The outcomes of the meeting were presented at the IGTC 2021 by ETN President.



Figure 5: High-Level User Meeting 2021, FLEXnCONFU presentation

ETN Working Groups

ETN main activities are conducted through its Working Groups. As several partners of the consortium are also ETN Members (RINA, ENGIE, TU/e, KTH, Baker Hugues, CERTH, University of Genoa, CU) it enables a better connection between FLEXnCONFU and ETN.

As the project did not deliver concrete results insofar, the concepts have been presented to the Hydrogen Working Group and to the Young Engineers Committee. Those groups are currently developing a



comprehensive study on the potential of hydrogen in Europe in which FLEXnCONFU will appear. ETN enables to reach industrial stakeholders, energy companies, utilities, and underlines the high potential of the technologies proposed by FLEXnCONFU.

4.2.2 A coordinated dissemination strategy towards key stakeholders

From the beginning of the project, partners of the consortium followed a common dissemination strategy to reach key stakeholders. In the first two years, raising awareness and highlighting the innovative technologies and solutions proposed by FLEXnCONFU were the main goals achieved.

ETN's Series of webinar on flexible power generation

Between 2020 and 2021, ETN Global on behalf of FLEXnCONFU partners, with the support of [ETIP SNET](#) (4), and in cooperation with five EU Horizon 2020 projects: [FLEXnCONFU](#) (5) (grant agreement n. 884157), [HYFLEXPOWER](#) (6) (grant agreement n. 884229), [PUMP-HEAT](#) (7) (grant agreement n. 764706), [sCO₂-flex](#) (8) (grant agreement n. 764690), and [TURBO-REFLEX](#) (9) (grant agreement n. 764545) proposed a series of webinars on flexible power generation.

The objective of this series of webinars (7 episodes) was to shed the light on the actions taken by the EU and the industry to meet these challenges and pave the way for a carbon-neutral energy system that would ensure at the same time secure and affordable energy supply. A dedicated episode to FLEXnCONFU was proposed in November 2020 ([available on Youtube](#)) (10). FLEXnCONFU participated as well to the final episode of the series in April 2021 ([available on Youtube](#)) (11). It enabled high-level discussions between the projects and EU officials on the role of flexible power generation in the energy transition. It gave an increased visibility to FLEXnCONFU and reinforced the cooperation with other EU-funded projects.

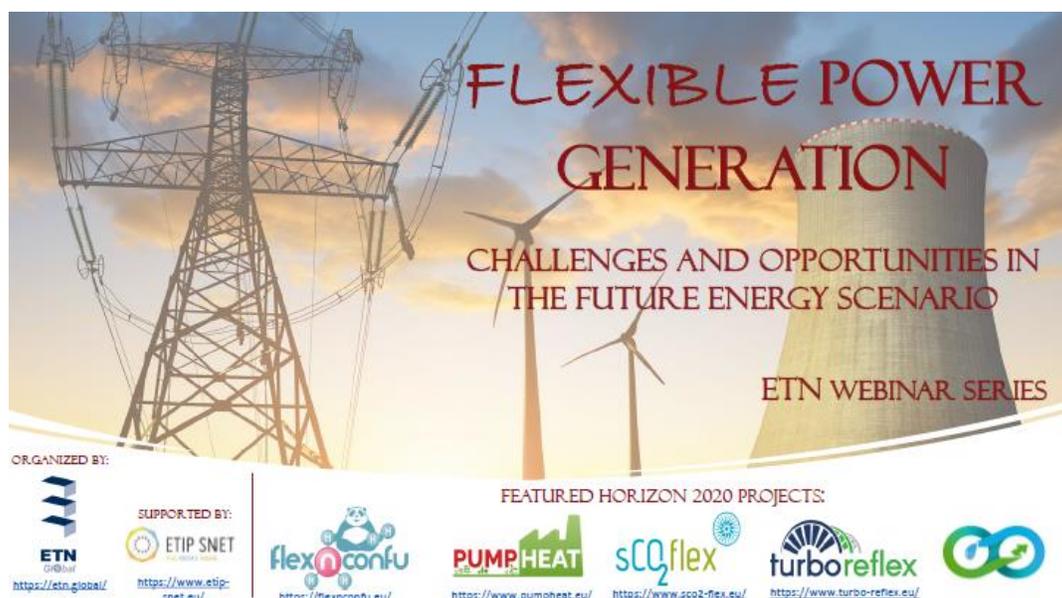


Figure 6: Banner of ETN's Series of Webinar



Moreover, the project participated in several key policy events and EU-platforms showcasing its added-value to energy policymakers:

- **INEA Workshop (2020):** In line with the willingness to cluster EU-funded projects as it was the case for the ETN's Series of Webinar, FLEXnCONFU and related projects participated to a [Workshop \(12\)](#) organised by the former Innovation and Networks Executive Agency (INEA) of the European Commission. The workshop has been a unique opportunity for the projects to discuss and compare the status quo of the different research initiatives, analyse and share best practices on how to overcome potential challenges, and to find new ways to cooperate and leverage synergies.
- **ENLIT (2020-2021 editions):** FLEXnCONFU exhibited online at ENLIT Europe conference, which is one of the major energy events in Europe. It was a great opportunity to increase the visibility of the project.



Figure 7: Enlit Europe EU Projects Zone Banner 2021

- **EU Sustainable Energy Week (2021):** The European Sustainable Energy Week (EUSEW) is a series of activities aimed at building a secure energy future for Europe. It brings together public authorities, private companies, NGOs, researchers and consumers to promote initiatives to go green and digital for Europe's energy transition. Launched in 2006 by the European Commission, EUSEW is organised by the European Climate, Infrastructure and Environment Executive Agency (CINEA), in close cooperation with Directorate-General for Energy. FLEXnCONFU and other EU-funded projects participated to the "[Energy Storage Systems: Key Players for The European Energy Transition](#)" (13) extended session. The proposed workshop session aimed to demonstrate how Energy Storage Systems are key components to reshape European Energy Systems in the next decade and to reach the EU sustainable targets.



#EUSEW2021

Figure 8: Banner to the EUSEW Workshop 2021

- **SET PLAN Conference 2021:** This hybrid conference brought together high-level speakers, policy makers, industry, researchers, academia and general public on important Energy related topics in the new post-COVID policy realities. It was jointly organised by the European Commission and the Presidency of the European Council. FLEXnCONFU had the opportunity to [virtually exhibit](#) (14) with 9 other exhibitors. It gave the project a unique visibility during the conference.



Figure 9: SET PLAN Conference, FLEXnCONFU Exhibition page, 2021

- **BRIDGE:** BRIDGE is a European Commission initiative which unites Horizon 2020 Smart Grid, Energy Storage, Islands, and Digitalisation Projects to create a structured view of cross-cutting issues which are encountered in the demonstration projects and may constitute an obstacle to innovation.



Based on its Power-to-X technologies both with hydrogen and ammonia, the FLEXnCONFU project joined major scientific and technical events to put the project's ambitions under the spotlights:

- **American Society of Mechanical Engineers (ASME) - International Gas Turbine Institute (IGTI) (2021):** ASME is one of the most acknowledged engineering organisations, encompassing engineering disciplines and skills. ASME events are amongst the most followed in the engineering world at global scale. The project was presented online by Christer Björkqvist, Managing Director of ETN, during the ASME Electrical Power Committee under a European perspective (March 2021) and was of interest of other participants and speakers, mainly from the gas turbine industry and high regulatory bodies (ex: U.S Department of Energy).



Figure 10: Introduction slide (ETN), ASME IGTI, 2021

- **International Conference on Applied Energy (ICAIE) 2021:** ICAIE aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Applied Energy. Partners jointly presented three papers encompassing the FLEXnCONFU technological added value:
 - "Ammonia/Hydrogen/Methane Characteristic Profiles for Atmospheric Combustion Applications" (CU, UORL).
 - "Power-to-fuel energy storage systems comparison for Combined Cycles flexibility" (UNIGE, EDP).
 - "A new small-scale time-flexible containerized power to ammonia solution" (TUDA, UNIGE, PROTON).

Despite ICAIE was online, it was an important contribution to partners in this well-known conference.

- **Ammonia Energy Conference (2021):** This conference is held by the Ammonia Energy Association which is a global non-profit industry association that promotes the responsible use of ammonia in a sustainable energy economy. In 2021, this major conference was held under a hybrid format and co-located with the American Institute of Chemical Engineers (AIChE) general



meeting. FLEXnCONFU had the great opportunity to virtually present its P2A solutions through a poster presentation led by TUDA ([available on YouTube](#)) (15).

- **The European Biomass Conference & Exhibition (EUBCE) 2021:** EUBCE is the largest biomass conference and exhibition in the world. FLEXnCONFU partner CIRCE presented a paper entitled “Integration of hydrogen and ammonia energy into combined cycles: the FLEXnCONFU project” under the topic “*Bioenergy integration, Alternative renewable fuels and hydrogen*”.
- **Institution of Mechanical Engineers (2021):** Institution of Mechanical Engineers is one of the most recognised associations that represents mechanical engineers and the engineer profession. FLEXnCONFU partner CU presented the project during the seminar, “[Engineers fuels for the future: Climate neutral fuels for 1.5°](#)” (16), giving additional awareness to FLEXnCONFU solutions.
- **European Research Community on Flow, Turbulence and Flow (ERCOFTAC) Course (2022):** ERCOFACT and FLEXnCONFU partner TU/e proposed an international [5 days-course on “Combustion towards Carbon-Neutral Combustion Systems”](#) (16) in which the project was showcased by ETN, giving the opportunity to reach PhD students, postdocs and also industrial researchers needing education in experimental and modelling approaches to both laminar and turbulent flames. Discussions took place following this in-person presentation, raising interest from the audience.



4. First lessons learnt from FLEXnCONFU

FLEXnCONFU, covering the whole value chain, is a pioneer “*demonstration to market*” project which will contribute to the valorisation of European gas turbines and Power to Gas scientific and technological competencies, and to the creation of a clean hydrogen/ammonia society. The technical activities are then supported by transversal work on scalability, replication and impact assessment, including the operational regulatory framework. After 2 years, some preliminary results can be drawn despite the demonstration periods will only begin in 2023.

5.1 Lessons learnt on the regulatory framework

The FLEXnCONFU partners started to work on the regulatory framework the project had to compel with and its potential replicability. The main part of this work was to understand which the best EU electrical markets are where to promote the potential of FLEXnCONFU concept. It refers to Deliverable D1.4 “Electrical market Assessment for enhanced FLEXnCONFU concept in CC’.

The project is still in the pre-demo phase. Lessons learnt will be provided at the end of the project in 2024 in D8.7 ‘Final Stakeholder vision report and outcomes from the final dissemination event’

5.2 The replicability and scale-up of FLEXnCONFU

The project is still in the pre-demo phase. Lessons learnt will be provided at the end of the project in 2024 in D8.7 ‘Final Stakeholder vision report and outcomes from the final dissemination event’.



5. Conclusions

Since it started, FLEXnCONFU concepts and objectives have been promoted and disseminated to key audiences (policymakers, industrial actors, gas turbines users, energy utilities, scientific community) through insightful communication materials, organisation and participation in dedicated conferences and events.

Through the ETN network and the coordinated approach of the partners, the project showcased its technological opportunities and concepts for the future energy landscape. As such, combined-cycle gas turbine plants represent a crucial technology with the required flexibility to compensate for the intermittency of renewable energy sources like wind and solar.

D8.7 'Final Stakeholder vision report and outcomes from the final dissemination event' will be proposed in March 2024 and deliver all the results and findings from FLEXnCONFU once the demonstrations of P2H and P2A technologies will be performed.

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