Newsletter

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ETN Global is a non-profit 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.

IN THIS ISSUE

Christer Björkqvist
Managing Director

Driving Growth and Progress in Carbon-Neutral Energy Solutions

I am delighted to share that ETN Global is making significant progress in identifying and exploring sustainable pathways for the gas turbine user community. Our dedication to accelerating technical advancements aligns with our roadmap towards carbon-neutral energy solutions.

Excitingly, ETN will release our new R&D Recommendation report and Roadmap at the end of this summer. These reports, along with an energy scenario and policy whitepaper, will provide guidance for achieving a cost-effective, secure, and timely energy transition. But our efforts go beyond reports and whitepapers. We are committed to further strengthen a coordinated voice of the gas turbine user community to build up specific market demand facilitating investment decisions for manufacturing and suppliers.

On this note, I am pleased to say that our aeroderivative, engine specific, user driven groups have made notable progress in enhancing fleet reliability and availability, and more users are joining our cause as the word is spreading of the benefits to be actively involved. Recently, the LM2500 meeting in London and the SGT-A35 group in Aberdeen successfully took place, impressively bringing together users from Australia, Canada, US, Azerbaijan and Europe.

Going forward it is our goal to bring together the wider gas turbine user community to attend our High-Level User meeting (HLUM) coming up in October, followed by our biennial International Gas Turbine Conference in Brussels. The HLUM will review the portfolio of identified pathways and further align user needs as well as discuss the timeline of development milestones and targets going forward.

To support the technical development of preferred pathways, ETN leverages on the expertise of our technical Working Groups, following an open innovation approach that places the users at the centre of the conversation. This user-centric collaboration approach to surmount technical barriers holds immense significance in today's rapidly evolving technological landscape.

As part of ETN's commitment to progress, we recognise the necessity of defining ambitious yet realistic pathways that can effectively achieve carbon and emission reductions by 2030 and 2050. In line with this, I am delighted to extend a special invitation to our renowned biennial International Gas Turbine Conference, themed "Dispatchable Technology & Innovations for a Carbon-Neutral Society". This highly anticipated conference will serve as a platform to showcase the vital role gas turbine technology plays in the energy transition and beyond. By bringing together major stakeholders in the energy sector and policymakers, the conference aims to explore net-zero pathways, market opportunities, required policy support, and present the latest state-of-the-art technological developments showcasing the already started transformation of our technology.

While we focus on sustainable technical advancements and industry growth, we must not overlook the critical importance of knowledge retention within our sector. As many experienced experts approach retirement, it becomes crucial to preserve their valuable insights while inspiring and incentivising the younger generation of engineers and technical staff to pursue careers in our industry. I am immensely proud of our growing Young Engineering Committee and Emeritus Club, both of which foster interconnections and contribute to progress on net-zero pathways, as well as inspiring the younger generation to pursue careers in our industry.

The commitment of our members and ETN staff to drive and facilitate progress towards carbon-neutral energy solutions is already impressive but working even closer together we can do and achieve more. Through collaboration, innovation, and engagement with all stakeholders, we are shaping a sustainable and prosperous future in the face of our changing energy landscape.

ETN's IGTC 2023: Registration is open!

ETN's 11th International Gas Turbine Conference (IGTC) titled "Dispatchable technology & innovations for a carbon-neutral society" will take place on 10-11 October 2023 at Tangla hotel in Brussels, Belgium. Registration is now open and we invite everyone to join us, the industry leaders, policymakers, and innovators from around the world at this prestigious event.

About IGTC

IGTC is a biennial conference organised by ETN Global. Recognised as a cornerstone conference in the field, the focus is on achieving net-zero power and heat pathways while balancing the key elements of the energy trilemma. With representatives from utilities, gas suppliers, technology manufacturers, researchers, and policymakers, this gathering is a hub for collaboration and knowledge exchange.

Programme

The conference is a two-day event, which will take place on 10-11 October, composed of 5 keynote sessions, 6 technical sessions with a total of 20 technical papers to be presented, an exhibition and plenty of networking opportunities.

Keynote sessions

Composed of **5 Keynote sessions** that explore net-zero pathways, presenting innovative solutions to tackle the energy trilemma. Discover how dispatchable and fully sustainable power and heat technologies play a vital role in a successful net-zero energy transition. Dive into insightful discussions on global market opportunities, paving the way for a sustainable future.

Engage with policymakers during dedicated panel sessions that address the crucial need for a supportive regulatory framework. Explore how incentives and investments can accelerate the development of essential technologies and drive the energy transition forward.

- Keynote session 1: Energy transition to a global carbon-neutral society
- Keynote session 2: Net-zero pathways
- Keynote session 3: National and regional gas turbine markets: opportunities and challenges towards a hydrogen economy
- Keynote session 4: R&D projects contributing to the energy transition
- Keynote session 5: Technology development pathways for a carbon-neutral society

Technical sessions

And **6 Technical paper sessions** that will showcase the latest research and ongoing developments. Leading equipment manufacturers will present their advancements, offering promising avenues to expedite the shift to sustainable energy systems. Explore a wealth of ongoing research and demonstration efforts, unveiling fully sustainable and affordable solutions that ensure the security of our energy supply.

- Technical session 1: Low carbon solutions
- Technical session 2: Product sustainability, performance & reliability
- Technical session 3: Product sustainability, performance & reliability
- Technical session 4: Energy efficiency improvements
- Technical session 5: Low carbon solutions
- Technical session 6: Integrated energy systems solutions

Accommodation

ETN Global has secured a preferential rate valid until 09 September 2023 at the venue where the event will be held – Tangla hotel, in Brussels, Belgium. Follow this link to book your stay.

Sponsorship and exhibition opportunities

This conference provides an exclusive opportunity to show your role and commitment in the energy transition as well as contributions to the development of a carbon-neutral society.

There are only 3 exhibition spots left! Secure your spot today by filling-out a sponsorship form found on the IGTC-23 event webpage.

Join us at the International Gas Turbine Conference and be at the forefront of dispatchable technology and innovations for a carbon-neutral society. Together, we will shape a cleaner, brighter future for generations to come.

For registration and more information visit our IGTC-23 event webpage. ■

4th European Micro Gas Turbine Forum event

4th European Micro Gas Turbine Forum (EMGTF) event will be held right after ETN's 11th International Gas Turbine Conference (IGTC) on 11-12 October at the same venue, the Tangla hotel in Brussels, Belgium. ETN Global is a media partner for this event and urges everyone who has an interest in micro gas turbines to register for this conference.

Programme

The event will include keynote speeches from industry experts, panel discussions and presentations of the latest findings from four years of research within the European Commission funded project, NextMGT.

NextMGT is a European Union's Horizon 2020 research and innovation programme under Marie Sklodowska-Curie grant agreement No 861079. The aim of the programme is to train 15 outstanding early-stage researchers in the field of micro gas turbine technology, economics, policy and regulations. They each have gone through an industrial and interdisciplinary training, which will contribute to realising the impact on the society and their career prospects.

The speakers will dive deeper into the findings of the four Work Packages (WP):

- WP1: Cycle Innovations and Optimisation
- WP2: Combustion and Emissions
- WP3: System Component Innovations
- WP4: Industry Links, IP Management and Commercialisation

About European Micro Gas Turbine Forum

European Micro Gas Turbine Forum (EMGTF), was launched to foster the commercial deployment of micro gas turbines by setting the scenario where all the stakeholders have a platform to share knowledge and experience, collaborate and discuss the roadmap to move the technology forward.

For more information and registration, please visit the registration page. ■

Photo credit @Najib Samatar

New members

We warmly welcome ADEX (Spain), Air Products (UK), ILT Technologie (Italy), Score Energy (UK), GLENSOL (Azerbaijan), SSE Thermal (UK), FW Marsh (UK), and Harbour Energy (UK) who recently joined ETN Global. ETN currently has 125 members from 22 countries.

ADEX develops self-tuning software technology specialized in optimisation, control, and regulation of Industrial Plants to increase performance, sustainability and flexible operation. ADEX has experience in the following industries: traditional power plants, combined cycle power plants, thermal power, wind, water, composite, and cement. The company operates in EU, US and India, among others, and the technology has been granted with different patents according to the region.

Air Products is a world-leading industrial gases company in operation for over 80 years with presence in more than 50 countries. The company serves customers in dozens of industries, including refining, chemicals, metals, electronics, manufacturing, and food. It operates some of the world's largest industrial gas and carbon-capture projects, supplying clean hydrogen for global transportation, industrial markets, and the broader energy transition. Additionally, Air Products also operates in the supply of liquefied natural gas process technology and equipment, and globally provides turbomachinery, membrane systems and cryogenic containers.

ILT Technologie focuses on the use of a wide range of sheet metals from nickel and cobalt-based superalloys to stainless steel, to make hot gas parts for the energy and aeronautical markets. It manufactures combustion chambers, combustion liners and transition pieces. The company also has an in-house team dedicated to repair and fully service hot gas turbine parts.

Score Energy, part of the Score Group, is a leading specialist in valves, fuel systems & accessories and component manufacture, providing complex engineering solutions to support customers in multiple markets including, energy, defence, nuclear, aerospace and utilities. The company also offers advanced and specialist testing procedures and facilities, ensuring that all parts overhauled and repaired meet the high level of quality.

Glensol is an energy services company focused on field operations and equipment maintenance providing services in the following industries: Oil & Gas, Water and Power Industries. Glensol is committed to adding sustainable value to customers' businesses relying on the years of experience and expertise, tested by local and global stakeholders.

SSE Thermal delivers the flexible energy needed today while powering the transition to net zero. The company operates an industry-leading fleet of flexible generation and energy storage assets, with over 600 direct employees across the UK and Ireland. SSE Thermal is developing carbon capture and storage projects and progressing plans for the world's first hydrogen-fired power station, as well as a major hydrogen storage facility.

FW Marsh is a global provider of highly skilled specialists and technical services for the Energy Industry. The company has over three decades of experience providing world-class engineering and customer service to organisations around the world, including OEMs, oil and gas companies, energy companies, generation utilities, independent power producers and rental/temporary power providers on the entire LM and SGT range of products. As an engine owner, operator, installer & service provider, FW Marsh is uniquely positioned to provide comprehensive engine services through the wealth of product knowledge and experience.

Harbour Energy is an oil & gas company with a leading position in the UK as well as interests in Indonesia, Vietnam, Mexico and Norway. Company's purpose is to play a significant role in meeting the world's energy needs through the safe, efficient and responsible production of hydrocarbons, while creating value for their stakeholders. ■

New record of attendees at ETN's Annual General Meeting (AGM) and Workshop 2023!

Figure 1: ETN's Managing Director making a welcome speech; joined on stage by ETN's President Pedro Lopez (Uniper) & Prof. Ricardo Martinez-Botas (Imperial College London)

ETN's 19th Annual General Meeting (AGM) and Workshop titled "Ambitious but realistic pathways to net zero" was held in London on 28-29 March 2023 generously sponsored by Imperial College London. It was a successful meeting with 155 participants who came in person, breaking our personal record for an AGM attendance.

We would like to thank our sponsors, exhibitors, speakers and all the members for their support and active participation, excellent presentations, and discussions as well as several ideas which will be further considered for implementation by ETN's Working Groups.

A fascinating 2-day programme

ETN's two-day event kicked-off with an AGM and a welcome message from the representative of the main sponsor Professor of Turbomachinery Ricardo Martinez-Botas from Imperial College London, followed by an opening speech by ETN President Pedro Lopez (Uniper).

The day continued with a policy briefing, providing latest relevant EU and US policy updates, annual report on performance, governance, and activities within ETN, such as the Working- and Engine-specific User Groups, EU- and industry funded projects, Young Engineers Committee and ETN's involvement in various European Commission research & innovation platforms. ETN members casted their votes in favour of a name change as well as changes required within the Articles of Association as stipulated by the new Belgian Code on Companies and Associations, which is mandatory as of 01 January 2024. The new name will be announced officially once the Belgian authorities have accepted the submitted changes.

The unforgettable evening event sponsored by Mitsubishi Power saw the three nominees for ETN Member of the Year 2023 with an announcement of the winner: Dr David Abbott, ETN's Emeritus Member. The nominees were:

- Giuseppe Tilocca (Universidad de Sevilla & NextMGT Project) - for his valuable contributions to ETN through his 3 months of secondment with us, dedicated support to the decentralised energy system working group, and impressive leadership skills in coordinating ETN Young Engineers Committee initiatives.
- Giacomo Persico (Politecnico di Milano) - for his active participation and cooperative approach in the ETN sCO_2 working group, particularly in leading the optimisation study and ASME paper "sCO_2 bottoming cycle for an off-shore application" which was accepted with a very high review score. But also, for his valuable contributions to the ETN's sCO_2 webinar series "R&D Activities on sCO_2 in Europe".
- Dr David Abbott (ETN Emeritus Member) - for his extraordinary efforts during the ETN report "Addressing the combustion challenges of hydrogen addition to natural gas" conception: guiding the team during their contributions, weighting the content, and tirelessly reviewing and altering, where needed.

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ETN's AGM was followed by a Workshop, moderated by ETN's esteemed members and split into two parallel sessions composed of four themes:

1) **Low carbon solutions** (covering alternative low carbon fuels, hydrogen combustion and gas turbine carbon capture and storage solutions)
2) **Energy Efficiency improvements** (covering sCO_2 solutions, operational flexibility, hybridisation solutions, and air filtration)
3) **Product circularity, performance and reliability** (covering high temperature additive manufacturing materials, gas turbine performance and reliability, life assessment and extension)
4) **Integrated energy system solutions** (covering integrated solutions for decentralised energy systems including storage)

Presentations from the AGM and Workshop are available to ETN members on event webpage (login required).

ETN Activity Update 2022-2023

ETN Activity Update document detailing associations activities which have been undertaken since the previous AGM held on 29 March 2022 in Brussels, Belgium, is available for download here (login required). ■

ETN launches a new Working Group: Gas Turbine Components Life Extension and Assessment

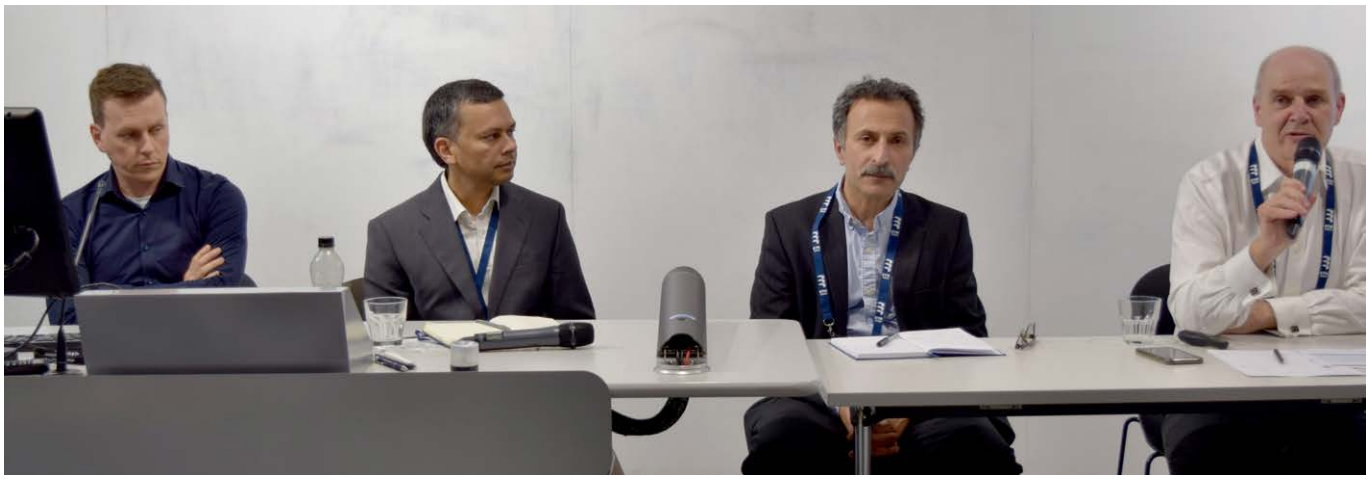

Figure 2: During the launch off ETN's GT components life extension and assessment working group at AGM (from left) - Luc Gooren (Engie), Yogiraj Pardhi (Sulzer), Siavash Pahlavanyali (RINA), Andy Williams (Chromalloy/ETN Board Member).

Gas Turbine Components Life Extension and Assessment Working Group was launched on 28 March 2023 at ETN's Annual General Meeting. The main aim of this Working Group is to tackle the challenges associated with extending the life of gas turbine components, with a specific focus on critical parts such as hot gas path components, rotors, and compressors.

The Working Group has identified three key initiatives it would like to work on:

1) **Enhancing Confidence in Life Prediction**: This initiative focuses on employing advanced non-destructive inspection techniques to improve confidence in predicting the remaining life of critical parts under cyclic duties.
2) **Rotor and Disc Lifing**: By developing an engineering platform and utilizing non-destructive inspections, this initiative aims to estimate the time to initiate creep and fatigue cracks in rotors and discs, enabling informed decisions regarding their life extension.
3) **Compressor Integrity and Reliability**: This initiative seeks to develop comprehensive inspection and risk assessment methods to address the integrity and reliability of compressor parts, minimizing the risk of unplanned outages and enhancing overall compressor performance.

Dr Siavash Pahlavanyali, from RINA Tech UK, the Chairman of the Working Group, emphasises the importance of collaboration in this initiative:

"The Gas Turbine Life Assessment and Extension initiative invites owners, operators, and service providers to join forces and contribute to these critical engineering analyses. By working together, we can expand our knowledge, effectively manage risks, and extend the useful life of gas turbine components."

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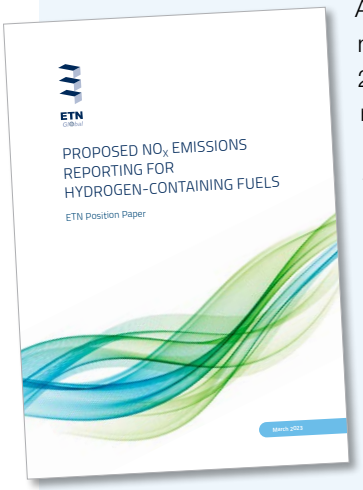
ETN Global warmly invites all interested parties to participate in the Gas Turbine Components Life Extension and Assessment Working Group. This initiative offers a valuable opportunity for collaboration, enabling us to overcome the significant challenges by working towards finding solutions associated with gas turbine life assessment in the face of evolving fuel options and increased cyclic operations.

For more information about the new Working Group, please visit ETN's website.

To express interest in joining the new initiative, please contact ETN's Senior Technical Manager Rene Vijgen. ■

ETN publishes a position paper "Proposed NOx emissions reporting for hydrogen-containing fuels"



A few days prior to ETN's Annual General Meeting held on 28 March 2023 at the Imperial College London, the association published a position paper titled "Proposed NOx emissions reporting for Hydrogen-containing fuels". The background for this paper is the current normalisation method that is being used for correcting emissions, in particular nitrogen oxides, to reference conditions, which adds a burden of up to 40% on hydrogen compared to natural gas.

This publication is authored by a group of experts from ETN's emissions correction for hydrogen task force working under the ETN's Hydrogen & Alternative fuels Working group. We would like to thank each contributor for sharing their knowledge and experience: Dr Adnan Eroglu (Siemens Energy), Rene Vijgen (ETN Global), Felix Güthe (Phoenix BioPower), Dr David Abbott (ETN Emeritus Member), Martyn Boden (EoN), Jon Runyon (Uniper), David Graham (Uniper), Bobby Noble (EPRI) Andreas Huber (DLR), Tobias Sieker (RWTH Aachen University), and Rob Bastiaans (Eindhoven University).

The position paper is freely available for download on ETN's website. ■

ETN's Project Board Chair and CCS Taskforce Chair visit Equinor and Northern Lights Project Site

Figure 3: (from left to right) Mohammad Mansouri (UiS), Peter Jansohn (Paul Scherrer Institut), Jon Jakobsen (Equinor), Arne Ulrik Bindingsbø (Equinor), Mohsen Assadi (UiS) and Olaf Brekke (Equinor) in front of the intermediate onshore CO_2 storage tanks

On May 24, 2023, Mohammad Mansouri (UiS), Chair of ETN's Carbon Capture and Storage (CCS) Taskforce, and Peter Jansohn (Paul Scherrer Institut), ETN Project Board Chair, embarked on a visit to Equinor in Bergen, Norway. The purpose of their visit was to exchange experiences, discuss opportunities, and explore challenges related to post-combustion CCS technologies. The visit also included a trip to the Northern Lights site, a groundbreaking project aimed at developing an open-source CO_2 transport and storage infrastructure.

The Exchange at Equinor

On 24 May 2023 Mohammad Mansouri, Chair of ETN's CCS Taskforce, and Peter Jansohn, ETN's Project Board Chair, visited Equinor in Bergen, Norway. They met with Equinor's representatives, including Hege Rognø (Vice President of the ETN Board), Olaf Brekke (ETN Project Board member), Lars Bergersen, Gelein De Koeijer, Bente Johannessen, Jon Jakobsen, and Arne Ulrik Bindingsbø, as well as Mohsen Assadi from the University of Stavanger. The group engaged in fruitful discussions centred around post-combustion Carbon Capture and Storage (CCS) and CCGT's (Combined Cycle Gas Turbines). These exchanges allowed for valuable knowledge sharing, assessment of opportunities, and identification of challenges within the realm of CCS technologies.

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Exploring the Northern Lights Site

Following the technical deliberations at the Equinor office, Mansouri, Jansohn, Assadi, and members of the Equinor team proceeded to the Northern Lights project site, located near Bergen, Norway. Northern Lights, a joint venture owned by Equinor, Shell, and TotalEnergies, is at the forefront of developing the world's first open-source CO_2 transport and storage infrastructure. During their visit, Sverre Johannesen Overå, the Project Director, presented an overview of the project and provided a guided tour of the site, which is scheduled to commence operations in 2024. The project aims to offer a safe and reliable CO_2 transport and storage service to industrial emitters in Norway and across Europe, with an initial storage capacity of 1.5 million tonnes of CO_2 per annum.

Implications for the ETN CCS Taskforce

The insights gained from the visits to Equinor, and the Northern Lights project site hold immense significance for the future work of the ETN CCS Taskforce. By engaging with industry leaders, project directors, and experts in the field, the taskforce gains valuable knowledge that can be applied to their ongoing initiatives. The exchange of experiences, discussions on challenges, and exploration of opportunities are instrumental in advancing the development and adoption of CCS technologies within the energy sector.

As projects like Northern Lights pave the way for CO_2 transport and storage infrastructure, it is imperative for industry leaders and taskforces alike to collaborate and leverage these advancements for a greener and more sustainable future. ■

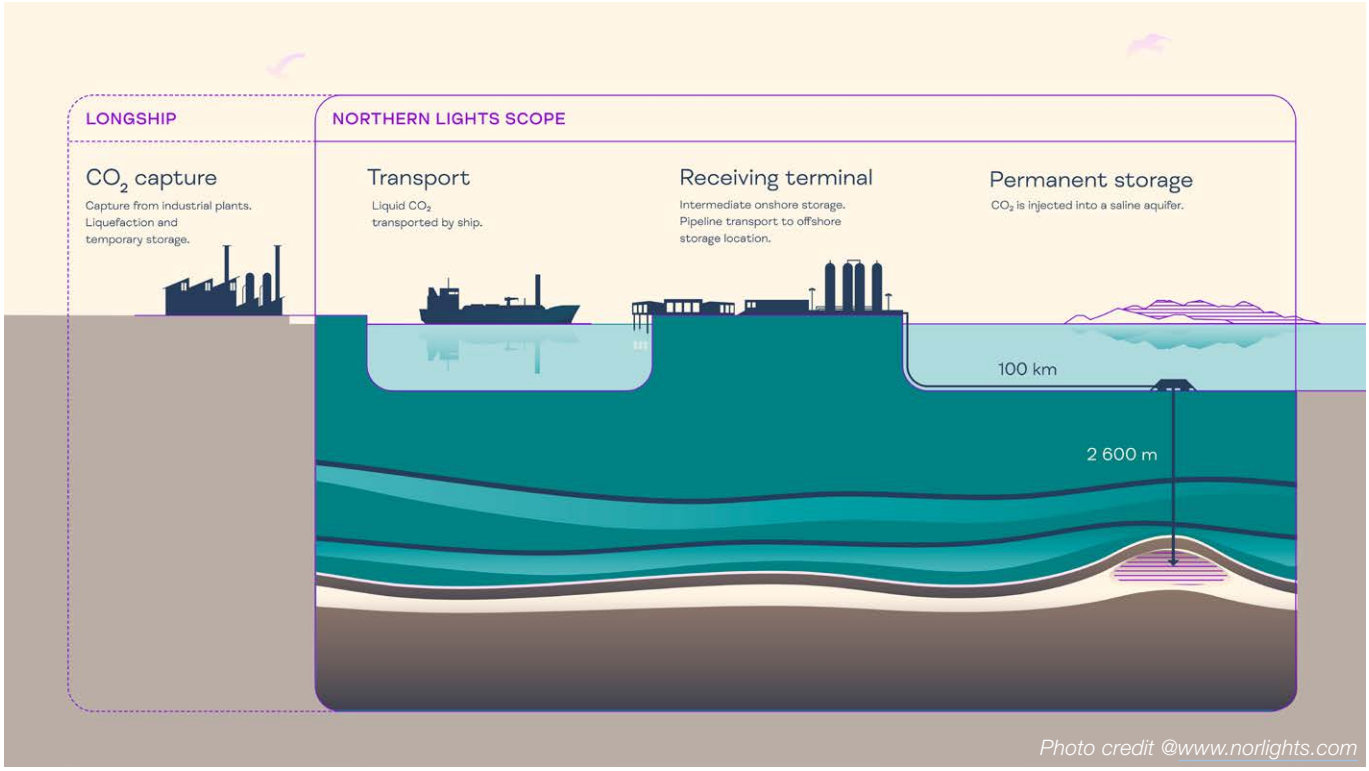

Figure 4: The Longship CCS value chain

If you are interested to learn more, visit the project website: www.norlights.com
and get the project updates on &

ETN's SGT-A35 & LM-2500 User Group Meetings

ETN's SGT-A35 User Group Meeting was be held on 10-11 May 2023 in Aberdeen, United Kingdom. The meeting had a record participation of 53 people representing 22 companies!

Figure 5: SGT-A35 User Group Meeting attendees

ETN's LM-2500 User Group Meeting was be held on 06-08 June 2023 in Sunbury-on-Thames, United Kingdom, generously hosted by British Petroleum. Another successful meeting with a great turnover of 61 attendees representing 24 organisations in the industry.

Both events are user-driven, resulting in fruitful discussions with the respective OEMs, allowing for amazing networking opportunities for both users and Independent Service Providers.

ETN would like to thank all the sponsors and attendees for making these two meetings a success. ■

Figure 6: LM-2500 User Group Meeting 2023 attendees

ETN's webinar series: "R&D activities on sCO_2 in Europe"

ETN's fourth episode in the webinar series "R&D activities on sCO_2 in Europe" was held virtually on 12 June 2023 at 14h00-15h30 CET. This session was part of the European Sustainable Energy Days and focused on sCO_2 heat exchangers: primary heaters.

The following experts spoke, presenting challenges they encounter in their research and daily business:

- Maxime Rouzes (John Cockerill Renewables) – *"Development of a high-efficiency particle-sCO_2 heat exchanger for CSP applications"* - representing COMPASsCO_2 project;
- Damien Serret (Temisth) *"How additive manufacturing will help the energy sector: application to the primary heat exchanger in a sCO_2 cycle"* – representing Desolination project;
- Panagiotis Drosatos (Centre for Research & Technology Hellas - CERTH) – *"CFD-aided conceptual design of a cooler in sCO_2 cycles for novel waste heat to power (WH2P) plant layouts"* - representing the CO2OLHEAT project.

This episodes proceedings are available on ETN's event webpage.

The next episode in the series will focus on *"Components challenge: expanders"* and it will be held in September 2023. Please visit our events page to learn about the upcoming episode's speakers and exact date.

The webinar series are free and open to both ETN members and non-Members but require a registration. They were launched in September 2022 bringing together eight participating projects: CARBOSOLA (German national project), COMPASsCO_2, CO2OLHEAT (coordinated by ETN), DESOLINATION, SCARABEUS, sCO_2-Efekt (Czech national project), sCO_2-4-NPP, ISOP, and SOLARSCO_2OL. ■

ASME Turbo Expo 2023

ASME Turbo Expo 2023 (Turbomachinery Technical Conference & Exposition) with the title *"Collaborate, Innovate & Empower – Propulsion & Power for a Sustainable Future"* was held in Boston, US on 26-30 June. It was a 5-day conference and a 3-day exhibition event. This year the aim was to find the pathways addressing the 2050 sustainability goals cutting across disciplines and geography, demanding for multi-disciplinary and diverse teams.

ETN Global was once again a media partner at the conference, had a virtual booth at the exhibition and was present at the panel and technical sessions.

ETN's Managing Director Christer Björkqvist co-chaired two sessions on 28 June 2023:

- 08:00-10:00 GMT-4: 08-10 Voice of the Customer: User Experience with Gas Turbine Technology, together with Robert Steele (EPRI).
- 13:30-15:30 GMT-4: 08-09 The Pathway Forward: Future Gas Turbine Products & Technologies– OEM Perspective, together with Peter Jansohn (Paul Scherrer Institut).

Christer Björkqvist was also one of the speakers, representing our **FLEXnCONFU project**, at the session showcasing various projects within energy storage solutions on 30 June 2023:

- 08:00-10:00 GMT-4: 09-11 Energy Storage projects funded by European Commission, with other speakers:
  - Dr.-Ing. Benjamin Witzel, Siemens Energy: HYFLEXPOWER Project
  - Marco Astolfi, Politecnico di Milano: RESTORE Project
  - Silvia Trevisan, KTH Royal Institute of Technology: HYBRIDplus project & SUSHEAT project
  - Rafael Guedez, KTH Royal Institute of Technology: SHARP-sCO$_2$ Project
  - Marco Bicchi, Baker Hughes: SOLARSCO$_2$OL Project
  - Ben Bollinger, Malta Inc.: Sun2Store project

The **FLEXnCONFU project** was also part of other presentations by project partners at the following sessions:

- 27 June 2023:
  - 08:00-10:00 GMT-4: 04-13: Combustion modelling – *Numerical Modelling of Swirl Stabilised Lean-Premixed H2-Ch4 Flames With the Artificially Thickened Flame Model*, presented by Simone Castellani, Baker Hughes & *University of Florence*
  - 12:00-13:30 GMT-4: Student poster session: *The Role of Combined Cycle Gas Turbines as an Energy Storage Solution in a Hydrogen Economy*, presented by Jose Angel Garcia Frediani, KTH Royal Institute of Technology
- 28 June 2023:
  - 13:30-15:30 GMT-4: 04-49 Emissions V: *Influence of Variable Swirl on Emissions in a Non-Premixed Fuel-Flexible Burner at Elevated Ambient Conditions*, presented by Daniel Pugh, Cardiff University (Figure 7)

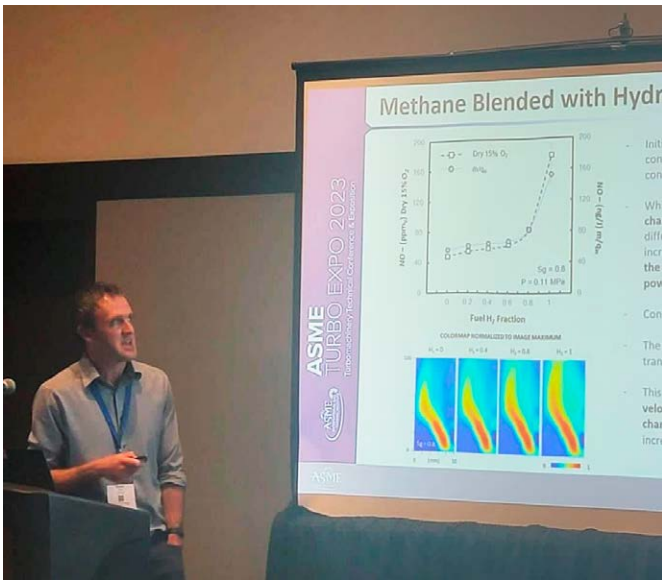

Figure 7: Daniel Pugh (Cardiff University) during his presentation

- 30 June 2023:
  - 10:30-12:00 GMT-4: 06-09 Innovative GT Cycles: *Green Ammonia for Gas Turbine Application*, presented by Loredana Magistri, University of Genoa

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Our **ROBINSON project** was featured in a presentation on 29 June 2023:

- 08:00-10:00 GMT-4: 06-06 Optimization Strategies: *Energy Management System for Smart Grids Including Renewable Sources and Industrial Symbiosis*, presented by Simone Maccarini, University of Genoa

Our **CO2OLHEAT & ISOP projects** were part of the same session on 26 June 2023:

- 08:00-10:00 GMT-4: 31-31 Panel - sCO_2 Projects in the International Community
  - *CO2OLHEAT: Supercritical CO_2 power cycles demonstration in Operational Environment Locally valorising industrial Waste Heat* by Renaud Le Pierres, Heatric
  - *ISOP: Innovation in Supercritical CO_2 Power generation systems* by David Sanchez, University of Seville

The work of selected members from **ETN's sCO_2 Working Group** was presented by the leading author Giacomo Persico from Politecnico di Milano on 27 June 2023:

- 8:00-10:00 GMT-4: 31-10: Cycle Modelling & Economics: *sCO_2 Bottoming Cycle for Off-Shore Applications – an Optimization Study*. The paper is a result of almost a year's work by the team comprising of authors from academia and from industrial partners.

ETN's Young Engineers Committee members were also present and involved in the Turbo Expo 2023 by co-chairing and presenting their work:

- 26 June 2023:
  - 13:30-15:30 GMT-4: 06-15 The role of GTs as part of Decentralised Energy Systems to address the Energy Trilemma, co-chaired by Giuseppe Tilocca, University of Seville (Figure 8)
  - 16:00-17:30 GMT-4: 03-11 Hydrogen & Alternative fuels: *Performance, Emissions, and Decarbonization of an Industrial Gas Turbine Operated With Hydrotreated Vegetable Oil*, presented by Jon Runyon, Uniper
- 27 June 2023:
  - 8:00-10:00 GMT-4: 19-03 Radial High Speed Compressors & Turbines: *Performance Investigation of Stator-Less and Blade-Less Radial Expander*, presented by Avinash Renuke, Mälardalen University
  - 13:30-15:30 GMT-4: 06-01 microGT Innovation and Potential: *A System Dynamics Approach to Assess the Impact of Policy Interventions on the Market Penetration of Micro Gas Turbines*, presented by Kirti Sharma, City, University of London (Figure 9) ■

Figure 8: Giuseppe Tilocca (University of Seville) co-chairing a technical session on decentralised energy systems

Figure 9: Kirti Sharma (City, University of London) during her presentation at ASME Turbo Expo 2023

ETN High-Level User Meeting 2023

ETN's High-Level User Meeting (HLUM) "Efficient, flexible and low carbon pathways towards net-zero solutions" will take place on 09 October 2023 at the Tangla hotel, in Brussels, Belgium.

HLUM is an annual event for users-only upon receival of an invitation.

The objective of the meeting is to bring together the wider gas turbine user community including utilities, oil & gas, industrial users, gas transporters and distributors. The meeting aims to facilitate discussions on potential pathways in the energy transition, identify technology development needs, and address policy and public acceptance barriers that may arise.

If you are a user and have received an invitation, please register through our event page.

Please note that ETN's 11th International Gas Turbine Conference (IGTC) titled "Dispatchable technology & innovations for a carbon-neutral society" will take place at the same venue the day after the HLUM on 10-11 October 2023. We therefore invite all the attendees to stay on and register for the IGTC 2023 on the event webpage. ■

25th GTEN 2023 Symposium

Gas Turbines for Energy Network (GTEN) in Canada is gearing up for its 25th biennial Symposium "Gas Turbines and the Energy Evolution" at the Fairmont Banff Springs Hotel!

GTEN is a Canadian Technical Advisory Group to the energy industry and governing bodies, with this Fall marking 50 years of service. This is your chance to join forces with over 100 gas turbine experts from around the globe as we come together to ignite the latest ideas and cutting-edge advancements in gas turbine technology and applications.

Efficient gas turbine energy systems using natural gas and hydrogen can be developed together with renewable energy to achieve long term diversity and resilience, while minimizing the lifecycle impacts on the environment. This event will have several training modules and 20 technical papers, based on themes of decarbonization for pipeline and power applications, CO_2 capture, hydrogen, operations and maintenance, and air/GHG emission solutions.

ETN Global is a supporting organisation and will be present at the event:

- ETN's MD Christer Björkqvist will give a keynote speech on 16 October 2023.
- ETN's Project Engineer Antonio Escamilla will give a presentation "Prerequisites for Use of Low-Carbon Alternative Fuels in GT Power Generation" on 17 October 2023.

ETN Members are entitled to a discounted registration fee. For more details, please contact us.

For more information on the event and registration, please visit the event webpage. ■

DGTA's GE Frame 6B, Frame 7E & Frame 9E User Conference 2023

International & Independent GE Frame 6B, Frame 7E & Frame 9E User Conference 2023 organised by the Dutch Gas Turbine Association (DGTA) will be held on 07-10 November 2023 at Crowne Plaza CS in Utrecht, the Netherlands.

The conference is tailor made and the program encourages participants to engage with fellow users, the official equipment manufacturer GE and selected ISP's (Independent Service Providers), allowing everyone to actively participate in sharing knowledge, experience and best practices.

ETN Global is one of the partners and will be present at the conference.

For more information and registration, please visit the conference webpage. ■

13th International Gas Turbine Congress by GTSJ

13th International Gas Turbine Congress 2023 Kyoto (IGTC2023) organised by the Gas Turbine Society of Japan (GTSJ) will be held on 26 November-01 December 2023 at the Kyoto International Conference Center.

About IGTC

The International Gas Turbine Congress (IGTC) is an international congress held in Japan to exchange information on the latest research and technology trends in gas turbine, propulsion, and energy systems.

Since the 1st congress in 1971, IGTC has been held twelve times until the last one in Tokyo in Nov. 2019. The IGTC 2019 was successfully held at Toranomon Hills, located in the central part of Tokyo with 493 participants and 226 presentations.

Papers related to any aspects of gas turbine, aero-engine, turbomachinery and energy conversion turbine systems are invited from all over the world. Keynote Speeches, Invited Lectures and Panel Discussions are arranged in addition to the Paper Sessions.

An exhibition related to gas turbines, energy systems, turbochargers, accessories, parts, materials, instrumentation, software, etc. is also held at the Congress site. Technical tours, a welcome reception, and a banquet are also part of the programme.

Set-up and congress dates

- Welcome Reception: Nov. 26 (Sun)
- Technical Sessions: Nov. 27-30 (Mon-Thu)
- Banquet: Nov. 29 (Wed)
- Technical Tours: Dec. 1 (Fri)

About GTSJ

GTSJ intends to provide a global platform for engineers, researchers and users to exchange ideas and results as well as to promote personal networking, with a focus on gas turbines, propulsion, and energy systems. With increasing demand for CO_2 reduction, our global collaboration in the energy sector is one of the most important factors for ensuring environmental sustainability in the future.

For more information on the event and registration, please visit the event webpage.

ETN Global is one of the collaborating societies and will be present at the conference. ETN Members are entitled to a discounted registration fee. For more details, please contact us. ■


Photo credit @Cosmin Georgian

Interview with Andrea Ciani and Vasileios Stefanis from Ansaldo Energia: FLEX4H$_2$ project coordinators

Andrea Ciani, Ansaldo Energia

Vasileios Stefanis, Ansaldo Energia

What is the role of Ansaldo Energia in the FLEX4H$_2$ project?

Ansaldo Energia, as FLEX4H$_2$ project coordinator, will integrate all activities, aiming at the best exploitation of expertise and skills within the consortium.

The key to success of this project lies in the very well-balanced multidisciplinary composition of the consortium, bringing together one of the world's leading players in the sector of power generation plants with renowned leading research partners, a gas turbine industry stakeholder representative association as well as a major power plant operator. All consortium partners have a long and successful history of collaborating in European, national and other research projects.

Figure 10: FLEX4H$_2$ Consortium

Ansaldo Energia will use its extensive experience in developing advanced combustion technologies from early concept generation to product implementation and commercial deployment. The newly developed combustion systems will be tested in full-scale at their dedicated rigs for atmospheric and high-pressure tests, fully reproducing the engine operating conditions.

Ansaldo Energia is leading two work packages and is responsible for the development of the combustion system design enabling operation with natural gas, hydrogen and every blend in between. Additionally, Ansaldo Energia will develop the design for manufacturing and coordinate the production of combustor prototype hardware, as well as their tests and validation.

What are the main goals of the FLEX4H$_2$ project?

The FLEX4H$_2$ project fully supports the Paris agreement and EU Green Deal climate targets. In this context, utilisation of hydrogen offers a unique chance to decarbonise the power generation sector reliably, independently from weather or seasonal conditions, contributing to the ongoing effort in the fight against climate change, enabling CO_2-free, dispatchable power generation.

Consequently, the main FLEX4H$_2$ goal is to design, develop and validate a safe, efficient, and highly fuel-flexible gas turbine combustion system capable of operating with any concentration of hydrogen blend up to 100% hydrogen. Crucially, this objective will be pursued at the most challenging hydrogen combustion conditions, i.e., at H-Class operating temperatures and pressures, required for highest cycle efficiency, while still meeting emission targets without any use of diluents.

The project also aims at a demonstration of the system in a rig (see figure 11 featuring the rig) fully reproducing engine operating conditions (mass-flows, temperatures, pressures) thus achieving a technology readiness level (TRL) of 6, paving the path towards commercial deployment shortly after project completion.

Likewise, the improved combustor design should be fully retrofittable to existing gas turbines, thereby providing significant opportunities for refurbishing existing assets.

Ultimately, FLEX4H$_2$ will present credible pathways for comprehensive exploitation of the project's results and thus providing the basis for a firm contribution to the EU Green Deal towards decarbonisation of the electric power sector by 2030 and beyond.

What will be the main tools and methods used to achieve the project goals?

The development of the sequential combustion system to achieve 100% hydrogen operation at H-class conditions will be supported by advanced numerical modelling and simulations. These activities will combine state-of-the-art modelling tools for the simulation of turbulent reactive flows and the computational power of modern high-performance computers. High-resolution calculations of both combustor stages will reveal detailed insights and trends about flame stabilisation and emission formation in each stage. Additionally, a reduced-order model of both stages

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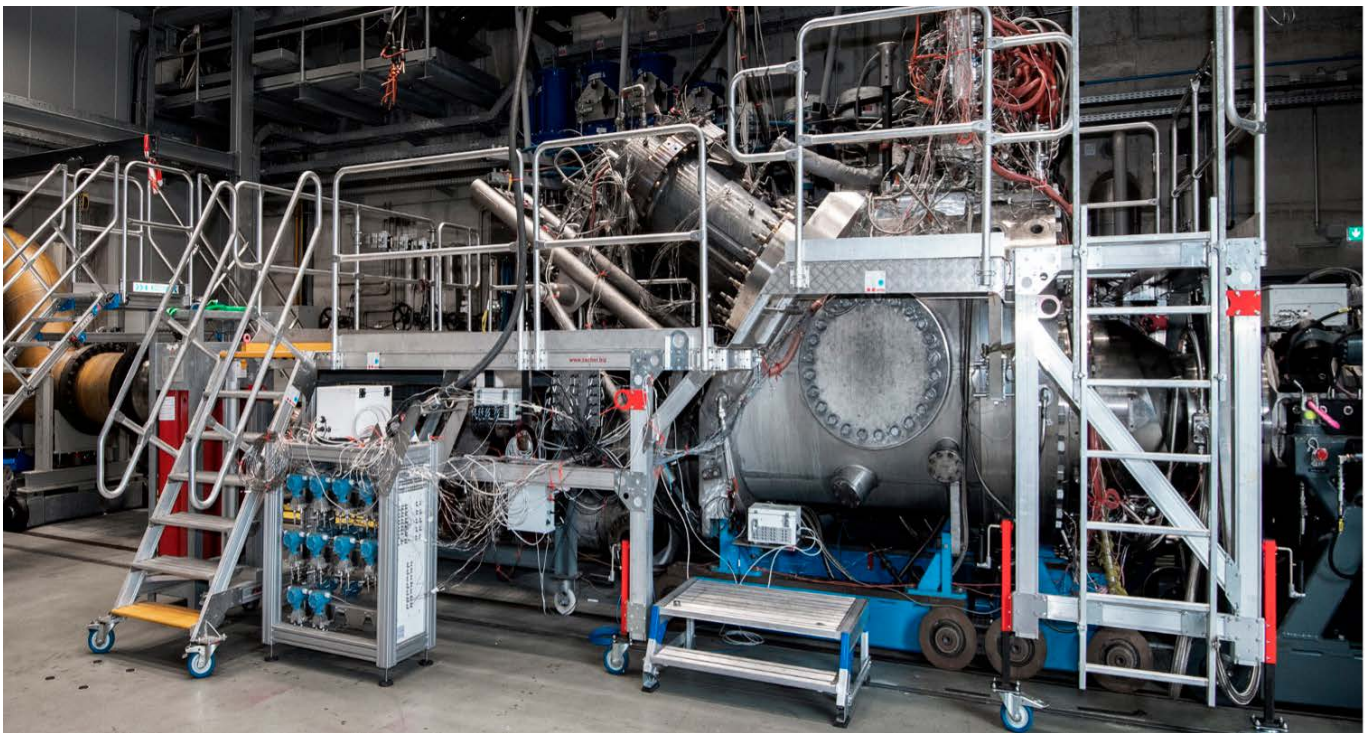

Figure 11: High pressure combustion rig, fully reproducing engine operating conditions

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will be constructed to investigate their interaction and map the boundaries of their stability. The numerical results will be used to design the combustion system, with the aim of maximising combustion testing efficiency and improving the operational window, specifically regarding fuels containing up to 100% hydrogen.

Stable combustion will be ensured by advanced thermoacoustic models derived from the numerical simulations and refined by acoustic measurements in the rigs.

The numerical simulations will also be complemented by dedicated tests of a simplified sequential combustor geometry at GT relevant operating conditions in an optically accessible rig, providing experimental data for both numerical modelling validation and optimisation of the engine operation concept.

Finally, the full-scale single-can combustor prototypes will be manufactured and tested both at atmospheric conditions for validation of ignition procedures and at full engine operating conditions to ultimately validate the combustor operation up to and including 100% H_2.

Could you tell us more about the game-changing technology cutting down NOx emissions that you will employ in the project?

To maximise cycle efficiency, while keeping emissions at very low levels, modern gas turbines must target ultra-high firing temperatures, robust flame stabilisation and the widest flexibility both in respect to engine operation and fuel type. Sequential combustion has demonstrated its advantages towards such extremely ambitious targets. Therefore, the design of the combustor will be based on Ansaldo Energia's Constant Pressure Sequential Combustion (CPSC) technology.

The sequential combustion technology is implemented in Ansaldo Energia's state-of-the-art commercial heavy-duty gas turbines such as the GT36 and represents the most promising technology to achieve stable, clean and efficient hydrogen-firing of H-class gas turbines (the largest and most efficient engines).

The use of two combustion stages, one utilising aerodynamic flame stabilisation, driven by flame propagation, and the other stabilised by autoignition, provides outstanding performance in terms of both NOx emissions, turn-down capability and fuel flexibility.

The intrinsic flexibility of sequential combustion technology has already been shown to enable clean and efficient operation on a wide variety of fuels with very high hydrogen contents. NOx emissions can be brought down to very low levels thanks to the short post-flame residence time achieved in the sequential combustor as well as the advantage of an auto-ignition stabilised flame burning into the hot products of the first stage, characterised by lower oxygen content, thus inhibiting NOx formation. ■

If you are interested to learn more, please visit our webpage www.flex4h2.eu and follow us on &

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101101427

Interview with Jose Angel Garcia Frediani from KTH Royal Institute of Technology: FLEXnCONFU project partner

Jose Angel Garcia Frediani, KTH Royal Institute of Technology

What is the role of KTH Royal Institute of Technology in the FLEXnCONFU project?

As a leading research university in Stockholm, Sweden, the KTH Royal Institute of Technology (KTH) has a significant role in the FLEXnCONFU project consortium. It heads the development of techno-economic models that evaluate innovative layouts in power-to-x-to-power (P2X2P) systems. KTH combines technical, economic, and environmental key performance indicators to create predictive models, assessing potential feasibility. KTH also contributes dynamic modelling and control. These tasks complement the initial models by incorporating the dynamic behaviour of P2X2P systems and establishing control strategies for system management across varied conditions. This work ensures system reliability, resilience, and enhances overall performance. KTH also validates models using operational data from pilot tests on demonstration sites, as well as conducts feasibility studies using partially validated models to identify profitable market conditions and scenarios for P2X2P system deployment. In addition, KTH participates in the project's dissemination and exploitation activities, communicating results to stakeholders and fostering awareness and adoption of P2X2P systems. Through these roles, KTH helps advance P2X2P technology and supports the European Union's energy transition and carbon neutral goals.

KTH has recently carried out research on techno-economic models, which play a key role in the project implementation. Can you provide some information on the objectives and results of your work?

The immediate goal of the techno-economic model studies is to assess the performance of proposed project layouts and to guide the operational decision-making process. Essentially, these models serve as tools to estimate optimal operational conditions, including the timing and volume of hydrogen and/or ammonia production and utilisation. Long-term objectives involve modelling the project layouts under varying boundary conditions (fuel and electricity markets), with the aim of identifying the most suitable system configuration (size of electrolyser and storage), depending on the stakeholders' objectives.

The picture below (see Figure 12) shows an example of one of the analyses performed. In this occasion the model was set to minimize the specific CO_2 emissions from the power plant by producing hydrogen with green low-cost electricity from the grid, and then using it to replace natural gas, whilst maximizing the net-present value of the project (the project here is understood as retrofitting a Combined Cycle Gas Turbine with a Proton Exchange Membrane and its respective hydrogen storage).

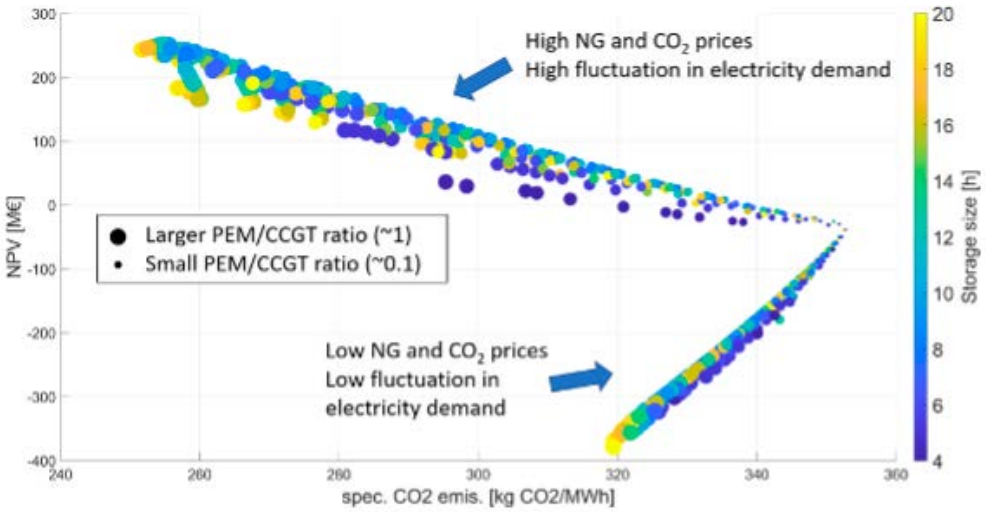

Figure 12: NPV and specific CO_2 emissions of different system configurations under different market conditions

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The analyses have underscored the significance of market conditions. In areas characterized by relatively consistent daily electricity demand and lower natural gas prices (below 50 €/MWh), the P2X2P system appears unprofitable due to the substantial upfront investment required for hydrogen and/or ammonia production and storage. However, scenarios with higher fuel prices (exceeding 200 €/MWh, as forecasted over 25 years by EEA, BloombergNEF, EU ETS, and others), alongside greater fluctuating electricity prices, show that increased revenue from fuel diversification and enhanced energy shifting flexibility can offset the necessary investment. Moreover, the modelling tool effectively determines the ideal electrolyser and storage size based on fuel and electricity prices.

What are the main challenges and opportunities that have been identified during the research?

One of the primary challenges encountered in the project has to do with remote collaboration between consortium partners. Although today's work culture has adapted to online meetings and global collaboration, back in 2020 when the project commenced, this remote working model was not as prevalent. The significance of in-person general assemblies and meetings became evident when we finally started meeting two years later, providing an invaluable space to truly get to know each other and exchange ideas.

This leads to the primary opportunities discovered during the research. Building a network of like-minded colleagues, unified by common goals and interests, can significantly propel research and technological advancements. Our participation on behalf of KTH in FLEXnCONFU has given us a unique opportunity to merge theoretical knowledge with practical insights from our industrial partners and manufacturers. This fusion of knowledge is beneficial in fostering innovative research and expanding technological horizons. ■

Subscribe to our newsletter and follow the updates on: www.flexnconfu.eu

Follow us on &

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 884157

Upcoming meetings and events

Meeting/Event*	Date	Location
ETN's High-Level User Meeting	09 October 2023	Brussels, Belgium
ETN's 11th IGTC "Dispatchable technology & innovations for a carbon-neutral society"	10-11 October 2023	Brussels, Belgium
4th European Micro Gas Turbine Forum event	11-12 October 2023	Brussels, Belgium
GTEN's 25th Symposium	16-18 October 2023	Banff, Canada
DGTA's GE Frame 6B, Frame 7E & Frame 9E User Conference 2023	07-10 November 2023	Utrecht, the Netherlands
13th International Gas Turbine Congress by GTSJ	26 November - 01 December 2023	Kyoto, Japan

** Please note that full list of ETN's meetings and events can be found on our website.*

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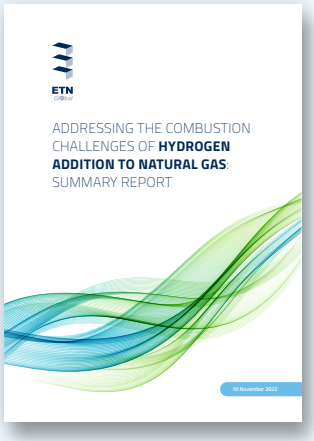
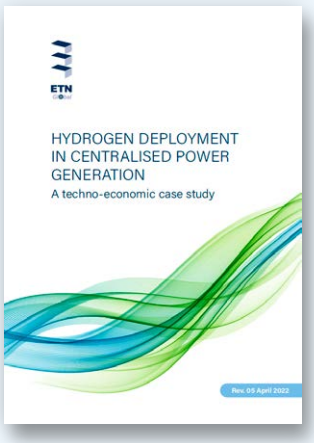
ETN at a glance

Download our latest publications:

A summary report – Addressing the combustion challenges of hydrogen addition to natural gas



Hydrogen deployment in centralised power generation



Download the three pager and learn more about ETN's vision.