ETN NEWS

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ETN is a non-profit association bringing together the entire value chain of the gas turbine technology community globally. Through cooperative efforts and by initiating common activities and projects, ETN optimises turbomachinery research and technology development and promotes the operation of environmentally sound gas turbine technology with high reliability and low cost.

In this issue

Christer Björkqvist
Managing Director

A secure, flexible and cost-competitive conversion technology that can provide carbon neutral solutions

Last month I participated in the ASME 2019 Turbo Expo in Phoenix which brought together impressive 2400 delegates from around the world to share the latest in turbine technology, research, development and application. No less than 1000 papers were presented in 400 sessions alongside panel and keynote sessions taking place. This year's keynote panels focused on turbomachines for clean power and propulsion systems and the importance of technology development that will enable further carbon emissions reductions. While the US has demonstrated in the past that a shift from coal to gas can provide large carbon reductions in the energy production and improvements of air quality, the carbon emissions rose by 3.4 percent in 2018, even though 14.3 GW of coal-fired power plant capacity was retired. This rise was mainly due to large increases in energy consumption in 2018, which highlights the need for further energy efficiency improvements and joint efforts for developing ultra-low or carbon neutral solutions. The race for the highest combined cycles efficiency continues, and while today's record is at an impressive 63.08% efficiency, it was highlighted at the ASME conference that the previous outlined target of 65% efficiency has now moved to no less than 67% efficiency! Impressive indeed, but the opportunities to use hydrogen to decarbonise the world energy supply were highlighted as the best way to mitigate climate change, and with that Carbon Capture and Storage (CCS) or CCUS (U=utilisation) is back on the table.

The interest in the panel sessions at the ASME conference was definitely higher than in the past years. This is promising as the R&D community needs clear directions, and the panel sessions, mostly populated with industry leaders and experts, can provide that guidance on the current trends and development needs.

In the sessions that I participated in, I was asked to provide my reflections on the future role of gas turbines. Based on a combination of stricter climate legislation, a gradually-climbing carbon price and carbon tax, an accelerated phase-out of coal plants, and increasing global electricity demand clear opportunities for flexible low carbon technologies like ours appears. However, many technologies under development are targeting this space so further focused research and development efforts and a wide cooperation within our sector is of vital importance to ensure competitive cost-efficient solutions. The majority in our sector would agree that we have a fantastic technology that we can build on, and with digitalisation and additive manufacturing opening up new opportunities, the future looks promising. However, as a constant increasing public environmental pressure is building up it is not enough that we believe in our technology. It is also not enough to highlight that our technology is a proven, reliable and efficient technology that can absorb the fluctuations of renewables in the grid. We have to showcase in a joint effort, to the general public, students, policy makers and the user community that turbomachinery is a secure, flexible and cost-competitive conversion technology that can that can be further developed in a step-wise approach to provide carbon neutral solutions. If we are able to do this I believe that gas turbine technology is set to play an increasingly important role in the energy transition and beyond.

Another interesting and important topic addressed in a panel session was the assessment of environmental impact on the life cycle for industrial gas turbines. The environmental impact assessment, as well as the preliminary lifecycle cost analysis, will represent critical drivers to develop a competitive product. This is something that we will also follow up on at the ETN platform. Looking ahead I am pleased to announce two important ETN meetings. First our High-Level User Meeting on 30 September, followed by our autumn Workshop on 1-2 October hosted by BHGE in Florence. This will be an important meeting not to be missed. Through a wide participation to this Workshop I believe we will take one step closer to ensuring a wide role for our sector in the energy transition and beyond.

ETN's October Workshop is here again

Our biennial October Workshop will take place on 1-2 October in Florence, Italy, with the kind support of our member BHGE. We would like to invite all our members to join us for two days full of interesting presentations, discussions and networking opportunities at BHGE's facilities in Florence Learning Center.

The Workshop will commence with a report from ETN's High-Level User meeting, presenting challenges and future development needs from the user community, followed by a panel discussion on developments and applications of sCO_2 power cycles for the future energy scenario. Other sessions will address "future fuels", such as hydrogen, methanol and ammonia; component life assessment; supercritical CO_2 cycles; additive manufacturing & future materials; and R&D projects and opportunities for new initiatives. Preliminary agenda for the event is now available on our website.

Registration

ETN members can register to the event by clicking here. Please use your website login credentials to access the registration system.

Accommodation

We would recommend reserving your rooms as soon as possible, as many hotels in Florence are already fully booked due to other events taking place at the same time. ETN has still some rooms blocked for our members at Starhotels Tuscany and NILHOTEL. These offers are valid until 30 August 2019 (a limited number of rooms available). Further details on accommodation are available on our website.

High-Level User Meeting

ETN's annual High-Level User Meeting will be held on 30 September at AC Hotel by Marriott Firenze. It provides an opportunity for users to contribute to and influence ETN's future strategy and activities. At this user-only meeting, each user will present 1-3 technical issues or development requirements of high relevance to them and the GT sector today. It will also be an opportunity to meet and discuss with senior colleagues and peers from the oil & gas and utility sectors. Agenda and more information about the meeting will be made available to our website.

IGTC-20 CAB

The first teleconference meeting of the Conference Advisory Board (CAB) of ETN's International Gas Turbine Conference 2020 was held earlier in July. The CAB continues their conference preparations and will hold a meeting in Florence in the morning on 1 October before the official start of the Workshop. ■

IGTC-20: save the date!

IGTC International Gas Turbine Conference

ETN's biennial International Gas Turbine Conference will be held on 14-15 October 2020 in Brussels, Belgium. The conference will mark the 10th anniversary of ETN's IGTC – the first edition of our conference took place already 20 years ago!

Call for Papers will be published this autumn; more information on the abstract submission will follow soon. This is a conference not to be missed! ■

New members

We warmly welcome our new members Alba Power (United Kingdom), Holland-Controls (Netherlands) and IDONIAL Technology Center (Spain) who joined our network.

Alba Power is an independent service provider for gas turbine maintenance, power turbine maintenance, turbine spare parts, package supply and renovation.

Holland-Controls is an independent specialist in gas turbine control systems headquartered in Hengelo, Netherlands.

IDONIAL is a Spanish technology centre specialised in additive manufacturing. ■

ETN User Group Meetings

ETN's SGT-A35 (formerly Industrial RB211) User Group Meeting took place on 7-9 May 2019 at Shell's Technology Centre in Amsterdam where constructive discussions between the users and independent service providers and suppliers took place over three days.

Our LM2500 User Group Meeting was held a month later at Equinor Business Centre in Stavanger on 5-6 June 2019. The users discussed prioritised technical issues with BHGE's technical experts and invited independent service providers and suppliers.

The meetings triggered some follow-up actions, such as a high interest from the users to collaborate on best practices of oil quality monitoring and sampling. This initiative will be discussed at ETN's upcoming High-Level User Meeting and Workshop this October. ETN will now follow up on the reported issues and actions that came out of the both events, in preparation for next year's SGT-A35 and LM2500 User Group Meetings.

We will also continue our work with ETN's new online platform of LM2500 and SGT-A35 engines that was launched earlier this year. This unique platform allows the users to share information about specific enquiries, such as operational issues and development needs directly with the ETN user community. If you are an operator and would like to receive information about ETN's User Group activities, please contact us. ■

New ETN brochure

New ETN brochure has been published! Read about the topics we cover and check all the benefits that the membership brings to our members. You can download a copy of the brochure at the following link: www.etn.global/ETN-brochure. ■

Hydrogen was discussed at ETN's AGM & Workshop in Pau

New Hydrogen Working Group

Following the high interest from ETN members on hydrogen as an energy vector, the new Working Group on hydrogen was launched at ETN's AGM & Workshop in March. The objective of ETN's Hydrogen Working Group is to enable and optimise the use of hydrogen and ammonia in gas turbines by identifying and addressing potential barriers. The Working Group consists of representatives from the OEMs, academia, users and service providers.

The new Working Group held their first teleconference meeting in May 2019 discussing the actions agreed during the AGM & Workshop. The group is currently holding regular teleconferences to work on the Hydrogen Summary document, with the objective to pave the way for hydrogen utilisation in the gas turbine based power plants. The WG members aim to complete the Hydrogen Summary by the end of September and present the document to the ETN members at our upcoming October Workshop in Florence. More information about the Working Group is available on ETN's website. ■

ETN's visit to Solar Turbines headquarters

Additively manufactured parts at the facilities of Solar Turbines

In conjunction with ASME Turbo Expo 2019, ETN's Managing Director Christer Björkqvist visited Solar Turbines facilities in San Diego. Ferenc Pankotai, Manager Combustion Engineering and Additive Manufacturing (AM) and also a member of ETN's Additive Manufacturing Working Group provided specific information to Christer Björkqvist about their AM facilities and capabilities besides a general tour.

Ferenc Pankotai stated that a high number of the groundbreaking products of the future can only be made possible by the modern tools of digital manufacturing. As such additive manufacturing and advanced manufacturing technology is a high priority for Solar Turbines in order to continue its legacy of innovation. Metal additive manufacturing processes such as Laser-Powder Bed Fusion are being utilised to develop and manufacture components for Solar Turbines products.

"The breakthroughs in additive manufacturing have enabled Solar to develop and test new components faster, produce components at lower cost with improved quality, and remanufacture components at overhaul with increased yield and productivity", said Ferenc Pankotai. *"The expansion of the design space has also unlocked performance enhancing product improvements that were previously impossible to produce. Soon, the ability to manufacture parts on-demand with little to no tooling will enable us to better support our customers through improved parts availability and lead time reduction"*.

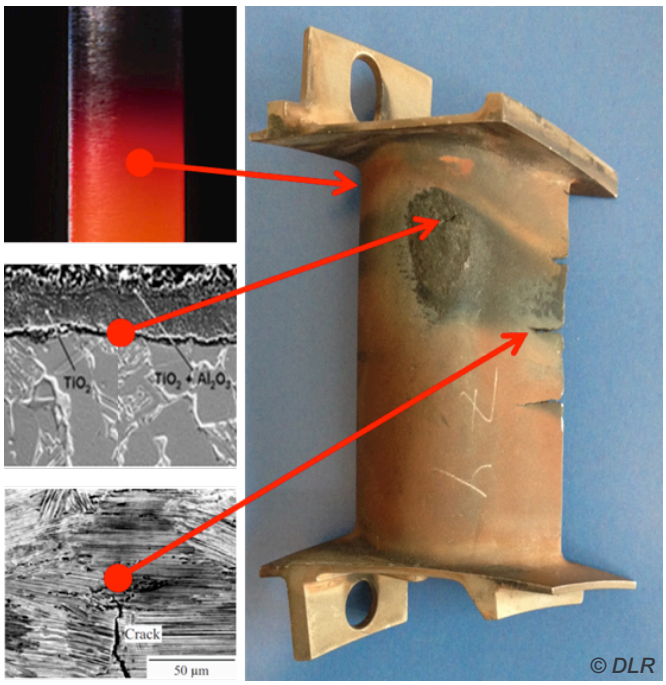
Ferenc Pankotai looks forward to a continued active involvement within ETN's Additive Manufacturing WG and plans to be present at the ETN October Workshop in Florence. ■

Component life assessment

Gas turbine component life assessment has been a topic of high interest for user companies within the ETN network. The Technical Committee (TC) 4 session at ETN's Annual General Meeting & Workshop in Pau earlier this year addressed the remaining life of gas turbine components and included presentations from utilities, universities and research institutes. Stefan Reh, Founding Director of Institute of Test and Simulation for Gas Turbines at DLR, joined our event and gave a presentation on Accessing Remaining Life of Critical Gas Turbine Parts. We asked Stefan to assess the topic and explain the issues discussed with the TC4 participants.

Like the thermodynamic performance or the fuel efficiency, the useful lifetime of critical gas turbine parts and the resulting overall lifetime of the entire gas turbine is one of the key performance characteristics for a gas turbine engine. The failure of critical parts directly has an impact on the operational reliability and availability of the gas turbine engine. The estimation and monitoring of the lifetime of critical gas turbine parts is therefore an ongoing challenge at all stages of the life cycle from the development and throughout operation.

Assessing the remaining useful life of critical parts after significant time of operation is additionally hampered by the fact that deteriorating effects like material creep, crack initiation and crack growth due to thermo-mechanical fatigue and chemical attack in form of corrosion and oxidation are not isolated, but act concurrently, interacting and emphasizing each other. For example oxidation and corrosion will weaken protective coatings and roughen the surface. This in turn will make crack initiation more likely, which after cracks have formed will provide an entrance door to more corrosion and oxidation and further deteriorate the material excessively, as illustrated in the figure below.



TC4 session discussions at ETN's AGM & Workshop 2019

Concurrent and interacting degradation effects on a turbine vane (right) through high-temperature corrosion (top left), formation of an oxide scale with subsequent spallation of protective coating (middle left) and formation of cracks (bottom left)

At the TC4 session on "Gas turbine component life assessment" at ETN's AGM & Workshop in Pau these complex topics and the various methods to estimate the remaining life of critical gas turbine components were discussed. The state of the art, usual approaches, to address lifing of critical gas turbine components, range from pragmatic "quickly to deploy" methods, such as expert assessment of existing damage based on inspection observations to more involved and time consuming methods, such as numerical assessment of failure mechanisms based on a numerical calculation of the loads. The numerical methods itself range from heuristic estimates typically based on loads derived from linear-elastic Finite Element methods, more detailed Finite Element calculations, including elasto-plastic and creep models to sophisticated constitutive models that include non-linear material behaviour and material damage.

It is obvious that the time frame of an ongoing inspection leaves only a very small window to decide if an observed and apparently serious damage of the hot gas components should result in an immediate replacement of the damaged parts or if the components are still good enough to continue operation until the next planned outage. While operational guide-

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Component life assessment

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lines capturing expert opinion to assess the damage situation can be used to enable quick decisions, the lack of physical background and the shortcomings of guidelines to capture the specific damage situation at hand will cloud the resulting decisions with a fair amount of uncertainty. Numerical approaches are typically more accurate and reliable because they are physically motivated and include the load situation at the location of a damage based on calculation tools. But depending on the sophistication of the method the modelling effort far exceeds the time frame of inspections making it difficult to be useful on short notice.

A useful alternative combining an accurate physics based approach with short solution time was discussed at the ETN meeting as well. An upfront preparation of the necessary Finite Element models can be combined with on-the-fly updating of the operation loads to create a digital twin of the operated hardware. The assessment of the lifetime can be done with new physics-based models that can take also multi-physical damage due to combined thermal, mechanical and chemical loads into account. Recent developments of these methods also include damage progression in form of crack initiation and crack propagation without the need for continuous refining the Finite Element mesh. Together with the up-to-date nature of the digital twin of the operating hardware these methods can help to more quickly provide information for decision makers to assess observed damage during inspections. ■

Stefan Reh, DLR

Based on the discussions within Technical Committee 4 at ETN's AGM & Workshop in Pau, the participants decided to create a task force on what can be done for extending the lifetime. ETN held a teleconference at the end of May to discuss on follow-up actions within the task force and to find topics to be presented at our upcoming October Workshop, to be held on 1-2 October in Florence. The TC4 session in Florence will address again component life assessment – check out the Workshop agenda on our website.

NEXTOWER project

The EU funded NEXTOWER – "Advanced materials solutions for next generation high efficiency concentrated solar power (CSP) tower systems" project started in January 2017 and will run until December 2020. We interviewed the project coordinator Antonio Rinaldi from ENEA, who leads the consortium of 19 partners from 9 countries around Europe, including the ETN members ENEA (Italy) and KTH (Sweden).

> **"Hybrid solar gas turbines look like an attractive direction"**
>
> – Antonio Rinaldi –

What are the main objectives of the project?

NEXTOWER takes a comprehensive conceptual and manufacturing approach that will optimise bulk and joining materials for durability at the component level to achieve 25 years of maintenance-free continued service of the receiver and maximum thermodynamic efficiency at the system level. This is made possible through a unique combination of excellence in materials design and manufacturing, CSP full-scale testing facilities brought together in the consortium, supporting the making of a new full scale demo named SOLEAD.

Solar towers are atmospheric-air CSP systems that represent the best short-term option for large scale power generation. To make them competitive, new materials are needed to meet requirements in the following critical aspects (and specific objectives):

- High temperature receivers (durability & emissivity)
- Thermal fatigue and thermal shock (especially in joints)
- Thermal storage by liquid metals, e.g. lead-based systems (corrosion issues, efficiency and max working temperature)
- Standardisation and upscaling of new materials for fast uptake (shortening development cycle of innovative materials)

Why is the project relevant in the context of the energy transition scenario and in achieving the EU's long-term climate & energy targets?

The introduction of "enabling materials" for more competitive CSP systems and power cycles is at the basis of the roadmap for sustainable low-carbon footprint in Europe. CSP is a key renewable resource largely untapped that can contribute in the transition from a fossil fuel based industry towards a circular and green economy. The possibility to produce electricity as well as high temperature "heating power" is a signature feature of CSP as flexible renewable source able to power manufacturing industry and reduce CO_2.

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NEXTOWER project

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What are the main outcomes of the project so far?

The main outcomes are associated to the eight tech areas (see "Ceramic solar receiver" and "Thermal storage architecture and materials"). Noteworthy and of sure industrial interest also outside the CSP community, the standardisation work undertaken for SiC components and the scaling up of FeCrAl steels, along with the development and qualification of welding/manufacturing process, will allow the deployment or fast-transfer of these results to the market.

Do you have any follow-up plans once the project is completed?

The exploration in this area is at the beginning before the materials and engineering propositions are fully ripe for a real technological shift. But there is no doubt that the results and the approach will appeal to a broader audience. NEXTOWER has to be understood also as an "ambitious proof-of-concept playground" poised to fuel the effort to go passed current paradigm and develop radically new pathways. Our connection with ETN as well as ESTELA association will help us critically evaluate what is achieved and steer the new endeavours after the project is over. Hybrid solar gas turbines look like an attractive direction. ■

Plataforma Solar de Almeria

Ceramic solar receiver

Innovative ceramic for high-temperature open volumetric receivers based on all-SiC honeycomb design by VPS for more durability to oxidation.	Innovative ceramic for high-temperature open volumetric receivers based on more flexible multiparts Si-SiC 3D printed design for higher toughness, higher thermal conductivity, and more open design. Optimised joining technique with proven scalability based on two steps methodology (Si coat on SiSiC disk and Mo-Wrap joining).	Coating and surface treatments to improve thermo-mechanical properties and emissivity: ◆ For increased thermal conductivity and thermal shock resistance: introduction by CVI of highly thermal conductive aluminium nitride (AIN) ◆ For reduced emissivity: ▪ *innovative metal-oxide coating by sol-gel deposition* ▪ *engineering surface roughness by micropatterning* ▪ *engineering surface coatings filled with nanocavity by plasmonic technology based on nanoparticles*	A proposal of amendment to the current standard on thermal diffusivity determination with the Laser Flash Method (LFA) has been drafted and submitted to the ISO Standardisation Body. The objective is to propose to employ a single standard and only the LFA method to characterise the whole thermal behaviour of the ceramic materials under investigation, in terms of thermal diffusivity, specific heat and thermal conductivity.

Thermal storage architecture and materials

Liquid lead as heat transfer fluid as technology transfer from nuclear fission to CSP of high-temperature lead-based thermal fluid.	Corrosion resistant alumina forming steels: innovative FeCrAl-alloys with better performance than reference commercial ones (good corrosion resistance in liquid lead at 750°, minor oxidation, self-healing properties) used for the construction of steel piping and plates of the CSP full-scale demo.	Optimised robotic GMAW welding procedures and SAW Strip Cladding to be used with NEXTOWER innovative alloy at high temperature strength of the welds: defect free coatings on NiFeCr high temperature resistant steels (no liquation cracks, nor solidication cracks).	Up to 100 kW demo pilot plant including: ◆ the improved open volumetric receiver ◆ an innovative single-tank thermocline indirect thermal energy store (TES) system using liquid lead as heat storage medium installed and tested at Plataforma Solar de Almeria

Find out more about the project on the NEXTOWER website: www.h2020-nextower.eu

Aftermath of the EU election

In the European Parliament election at the end of May, the mainstream political groups European People's Party (EPP) and Social Democrats (S&D) who have traditionally dominated as the biggest parties in the EU lost seats to the Greens and far-right parties but still remain as the largest parties. The liberal ALDE group, who recently joined forces with Emmanuel Macron's French "En Marche" party and named the group as "Renew Europe", gained also more seats for their MEPs. The next five years of the new EU Parliament's mandate will be interesting when it comes to energy policy, not only because of the "green wave" that passed over Europe, but also because of the agendas of other parties who highlighted climate issues in their campaigns. How these campaign promises will lead to concrete actions remains to be seen.

Finland took over the rotating presidency of the Council of the EU in the beginning of July, aiming to strengthen the EU's role as a global leader in climate action with its "Sustainable Europe – Sustainable Future" presidency programme. The Nordic country announced just ahead of the presidency to set its own target to reach net-zero emissions already by 2035, and wants now to sign a deal on the 2050 net zero emissions for the whole EU.

At the recent summit in June, the EU leaders already voted on making the EU economy climate-neutral by 2050. 24 member states backed the proposal, but four countries (the Czech Republic, Estonia, Hungary and Poland) blocked the deal referring to economic reasons, hinting that they would need more financial support to make the transition to happen.

The next opportunity for the heads of states to sign the deal will be at the next EU summit in October. In the meantime the UN Climate Action Summit, convened by the UN Secretary-General Antonio Guterres, will take place in New York this September.

As reported in the January edition of our newsletter, the EU member states were invited to submit their national energy and climate plans (NECPs) to the European Commission and elaborate on details how the countries plan to achieve the long-term targets in line with the Paris Agreement. In its assessment the Commission stated that the draft plans for 2021-2030 are "falling short both in terms of renewables and energy efficiency contributions", and urged the member states to submit the final plans by the end of this year with "an adequate level of ambition". ■

Warmest June in Europe recorded

New records were measured in parts of France, Switzerland, Austria, Germany, the Czech Republic and Spain in June as temperatures rose around Europe. According to the World Weather Attribution group, the heatwave in France was made "at least five times" more likely to happen by global warming. The EU's Copernicus Climate Change Service reported that the temperatures in June were more than 2°C above normal in Europe. A long-term comparison shows that the average temperature in Europe this June was more than 3°C higher compared to the average between 1850 and 1900. ■

EU Industrial Emissions Directive evaluation

European Commission has opened an evaluation of the Industrial Emissions Directive (IED) for all stakeholders. ETN is a member of the IED Forum and monitors the IED developments and updates, as well as participates in the Forum meetings. The ongoing IED evaluation will assess how the EU rules on industrial emissions are working and how they benefit the public and industry. The online questionnaire closes on 4 September 2019. Further information about the evaluation and a link to the questionnaire is available here. ETN has also been invited to provide input to the Targeted Stakeholder Survey. More information will be circulated to our members in the upcoming weeks. ■

EU's CO_2 emission regulation compliance criteria

As reported in the last edition of our Quarterly Newsletter, ETN is working with other associations in the sector contributing to the guidance document on CO_2 emission limits for capacity remuneration mechanisms in the EU's Electricity market design regulation. The regulation on the internal market for electricity establishes two CO_2 emission limits for generation capacity seeking to participate in capacity remuneration mechanisms. In order to apply these standards, appropriate methodologies to calculate the compliance of these plants need to be developed. The guidance document is currently being reviewed by the participating organisations before its submission to ACER (Agency for the Cooperation of Energy Regulators). ■

Upcoming meetings and events

Meeting/Event	Date	Location
SUstainable PolyEnergy generation and HaRvesting – SUPEHR 2019 conference	4-6 September 2019	Savona, Italy
International Charles Parsons Turbine Conference	16-18 September 2019	Cranfield, United Kingdom
ETN High-Level User Meeting**	30 September 2019	Florence, Italy
IGTC-20 Conference Advisory Board meeting	1 October 2019	Florence, Italy
ETN October Workshop**	1-2 October 2019	Florence, Italy
Middle East Rotating Machinery Technology and Innovation Conference*	15-17 October 2019	Dubai, United Arab Emirates
European Utility Week & POWERGEN Europe*	12-14 November 2019	Paris, France
GTSJ International Gas Turbine Congress*	17-22 November 2019	Tokyo, Japan
ETN Project Board meeting	10-11 December 2019	Brussels, Belgium
ETN Board meeting	11-12 December 2019	Brussels, Belgium
International Gas Turbine Conference 2020	14-15 October 2020	Brussels, Belgium

** ETN members are entitled to a discounted registration fee | ** Only for ETN members*

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ETN at a Glance!

Download the ETN Brochure and find out more about our mission & objectives, activities, events and more!

Are you interested to become an ETN member? Download the one-pager showcasing the benefits of being part of ETN's global turbomachinery community.

Keep in contact and updated with ETN's most recent news.

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