SGT-A35 USER GROUP 2021 MEETING

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This event is supported by:

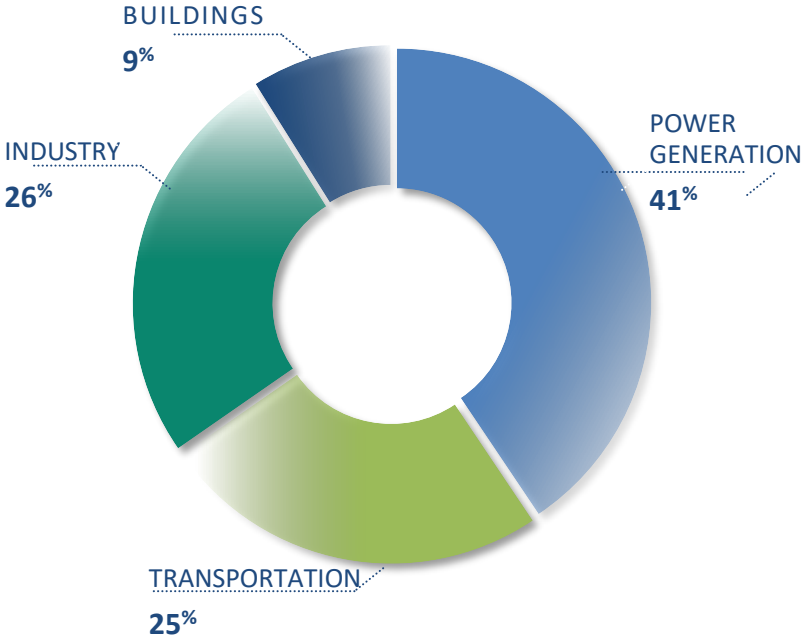
SIEMENS energy

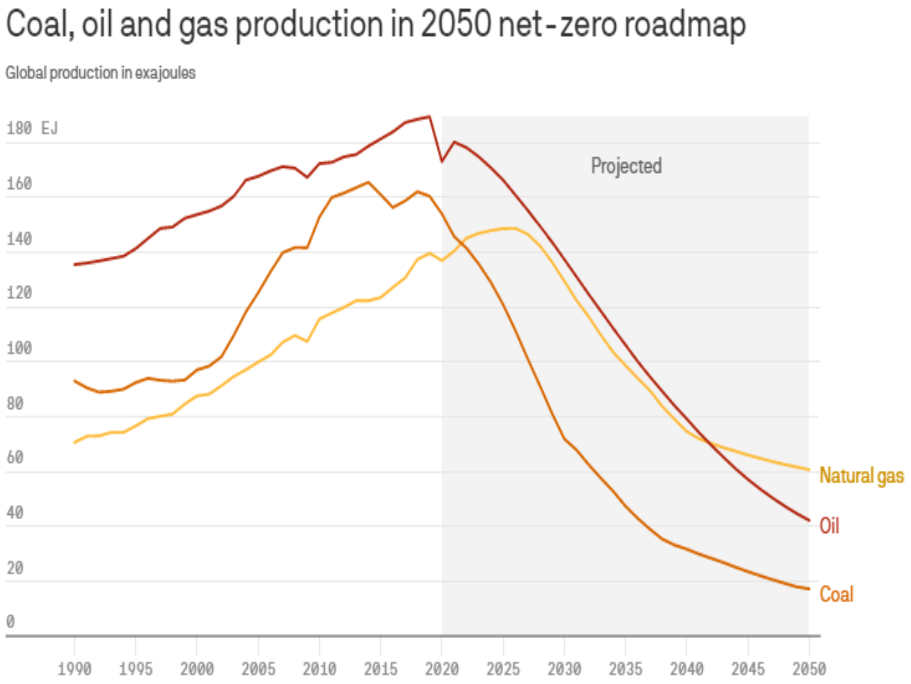
RWG
REPAIR & OVERHAUL EXPERTISE

→ Link to slide 32 – SGT-A35 2021 virtual meeting

Global carbon emissions today and decarbonisation needs to reach Net-Zero by 2050

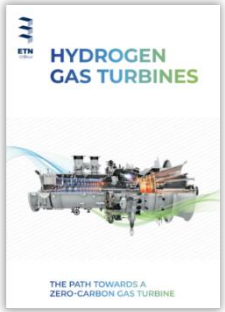
Global CO_2 emissions (33.7 gigatons)

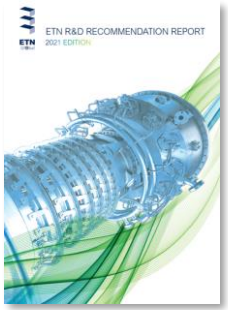


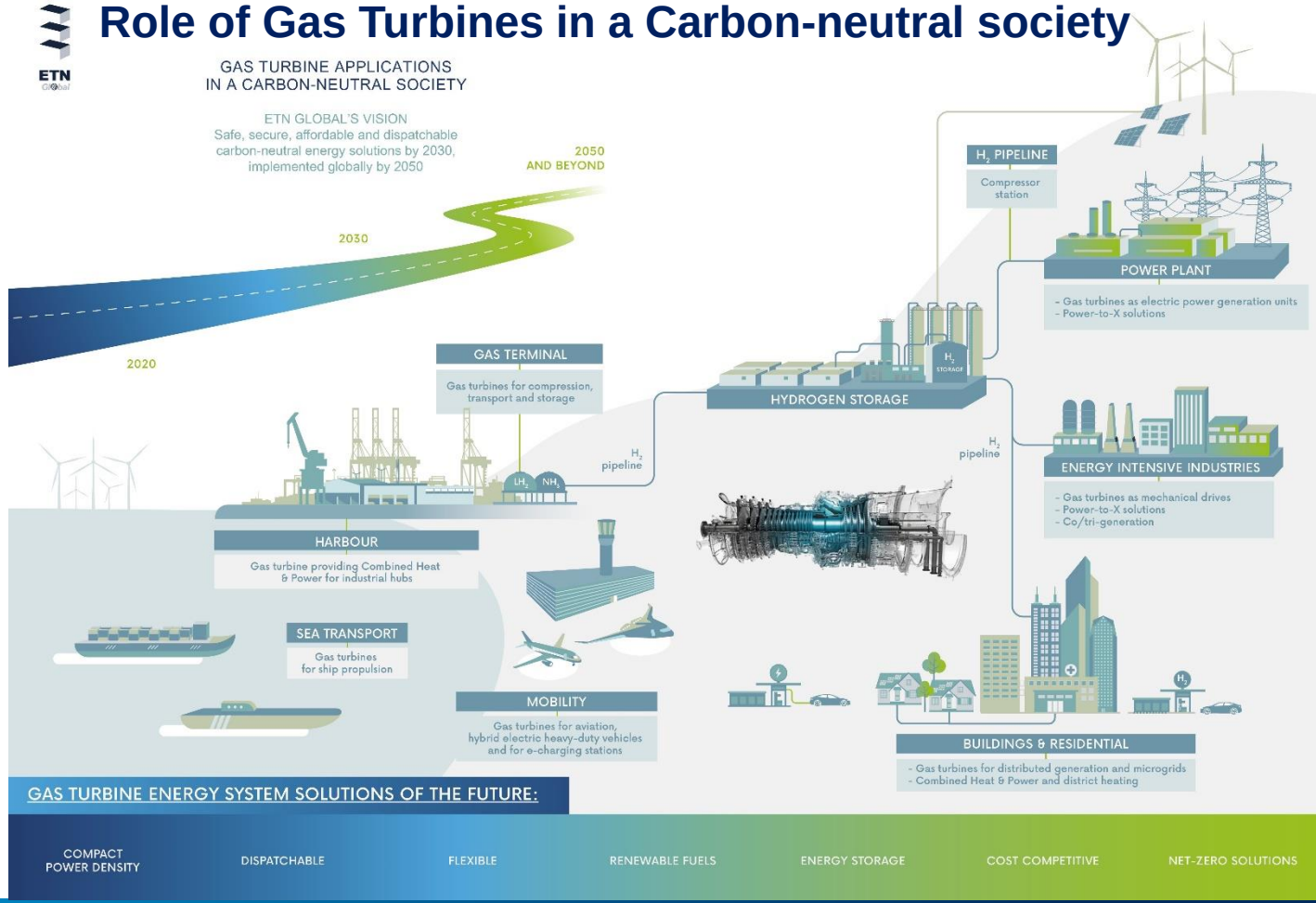


*Decarbonization as used herein is intended to mean the reduction of carbon emissions on a kilogram per megawatt hour basis | Source: IEA WEO 2020

Role of Gas Turbines in a Carbon-neutral society



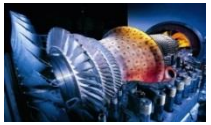




ETN Global 2021

A Global Gas Turbine Association





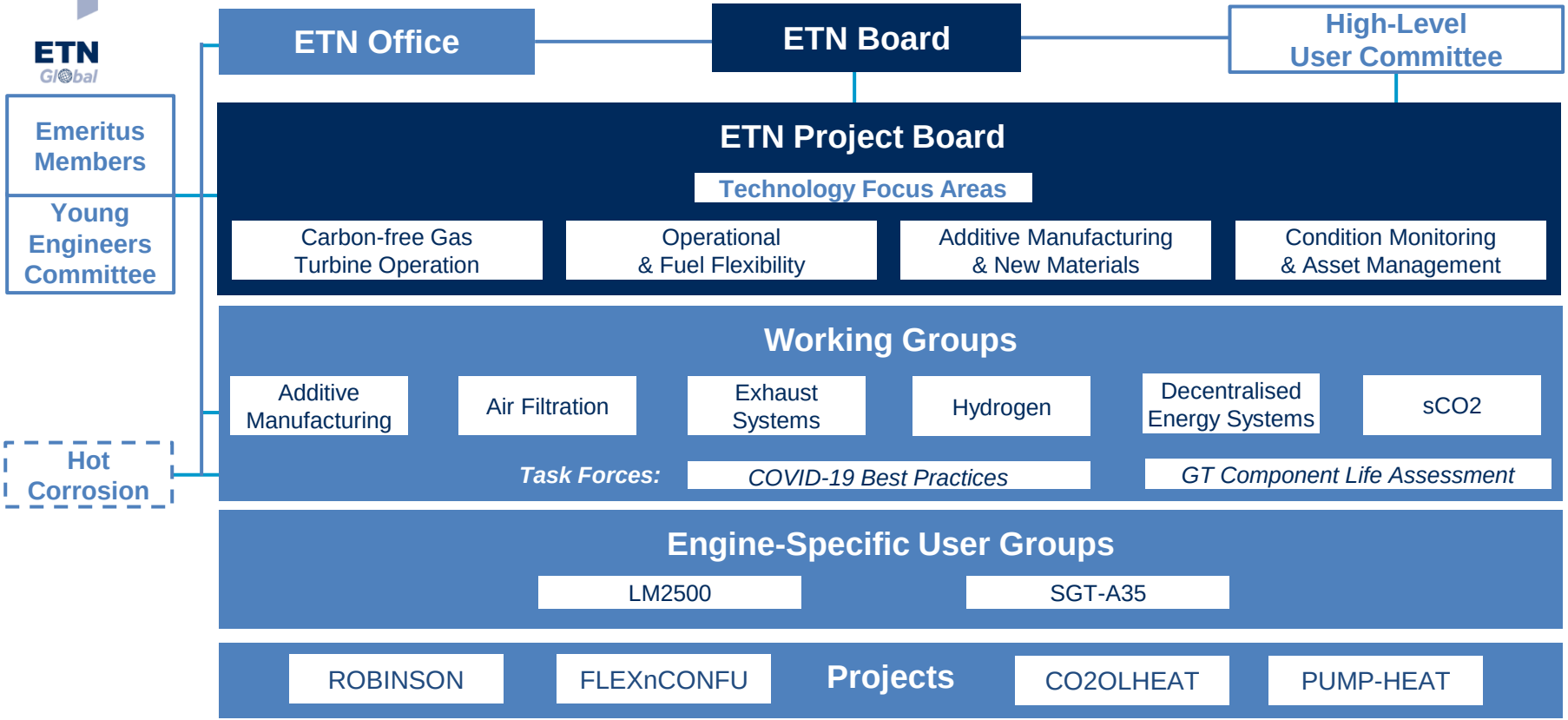

Membership-based, non-profit association
Coverage: Gas Turbine and Turbomachinery Technology

111 Member organisations
22 countries: Europe, Asia, North America, Middle East
+800 persons from member companies involved in different ETN activities

President: Pedro Lopez, Uniper
Vice President: Hege Rognø, Equinor


Platform for Information exchange, R&D cooperation and technology development

Organisational Structure



Vision and Strategy 2021

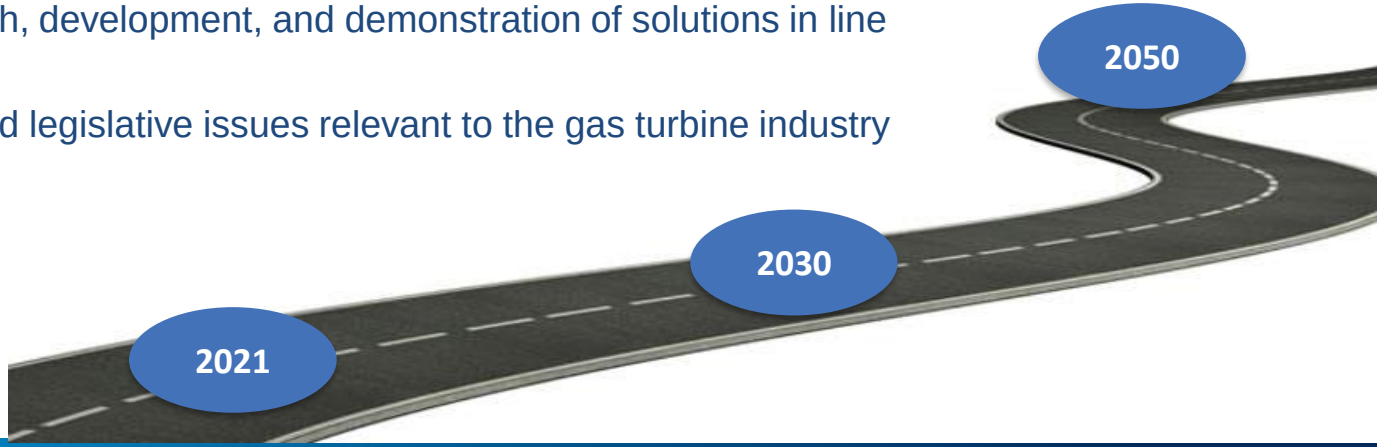
ETN Global

Vision

Safe, secure, affordable and dispatchable carbon-neutral energy solutions by 2030, implemented globally by 2050

Mission

- ✓ To encourage and facilitate information exchange about carbon-neutral solutions
- ✓ To bring together and to foster cooperation among the stakeholders of the gas turbine industry, its associated equipment providers and users
- ✓ To accelerate research, development, and demonstration of solutions in line with our vision
- ✓ To influence policy and legislative issues relevant to the gas turbine industry



Strategy

Key pillars supported by ETN Working Groups and projects

Market Trends, Policy, Legislation

Technical issues and optimised operations

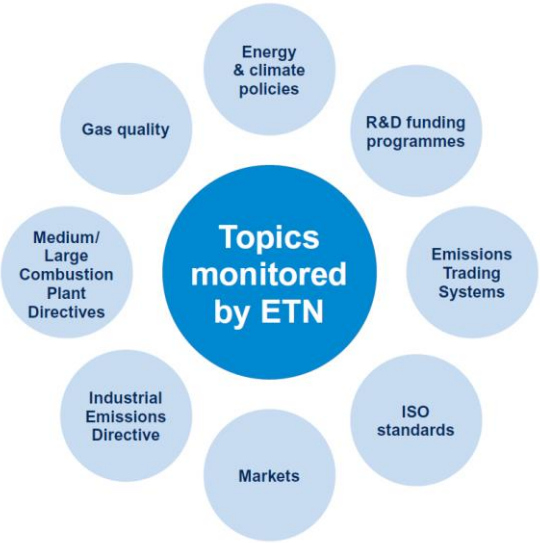
Research and Development

Working Groups and Projects

Pillar 1

Market Trends, Policy, Legislation

- Promotion of net-zero gas turbine energy solutions for future energy and industrial markets
- Influence energy, climate and research policy and legislative issues relevant to the gas turbine industry
- Monitor and inform on market trends



COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

Pillar 2

Optimised operations, maintenance and retrofit solutions

- Risk mitigation and technical solutions:
  - To improve energy efficiency and performance
  - To improve operational flexibility
  - To improve reliability and availability
- To reduce emissions
- Digitalisation/Condition Monitoring/Life Assessment
- Standardisation
- Exchange of best practices

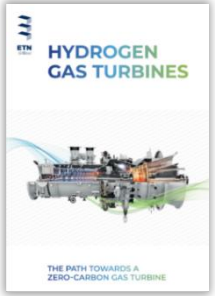
Pillar 3

Research and Technology Development

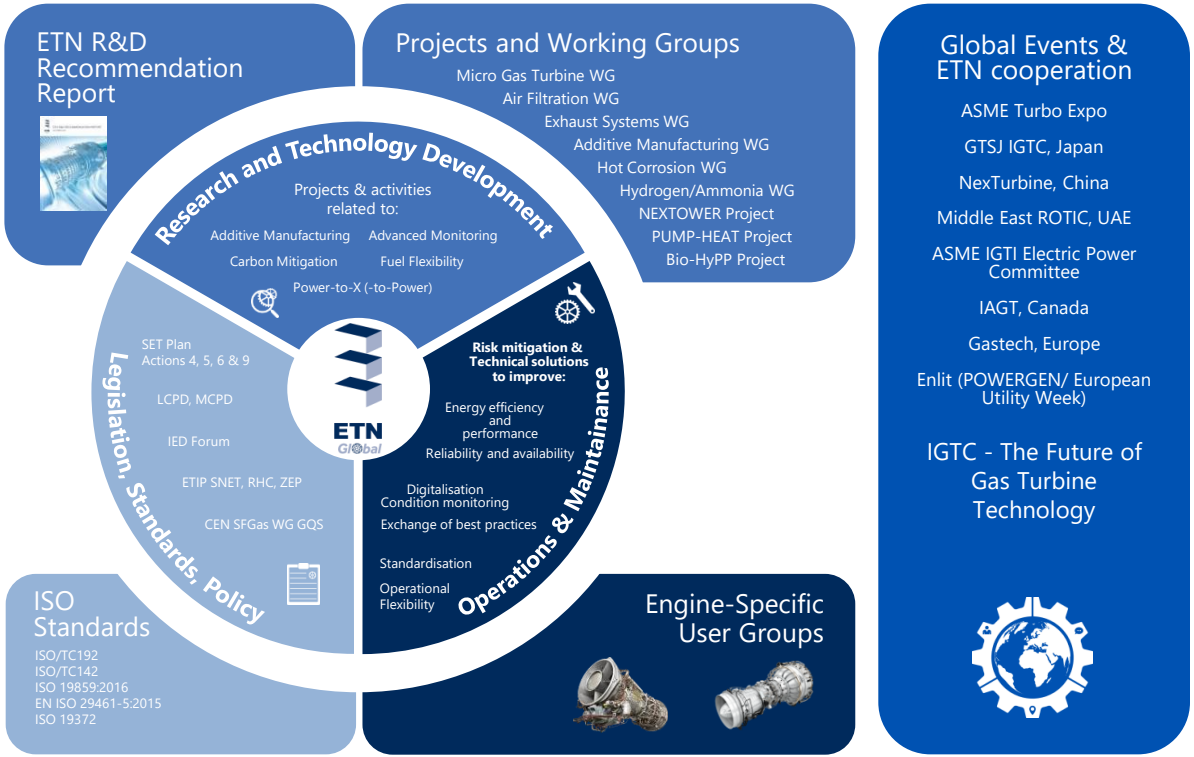
Development of turbomachinery systems to meet future low carbon market needs

- Fuel flexibility: hydrogen, ammonia, full operability of different fuel compositions
- Carbon mitigation: CCUS, CSP, advanced cycles
- Storage solutions
- Digitalisation, Additive Manufacturing
- Advanced monitoring, component life management

Details in ETN's R&D Recommendation Report and ETN Hydrogen report



Summary of Activities



High-Level User Meeting

4 October 2021

Yearly strategic meeting in October for coordination of priorities and to review progress

Discussions

- Topics of strategic importance
  - Operational issues and needs for the current fleets
  - Requirements for the next generation GT fleets
  - Highlight engines with a high amount of issues
- Outcome reported to the ETN Community

ETN's High-Level User Meeting 2020

"Operational optimisation and technology development needs for the transition to a carbon-neutral society"

Key messages from ETN Users

- Decarbonization trend is accelerating
- Carbon neutrality is the ambition
- Many decarbonization options for GTs…
- …but commercial viability still unclear
- GTs paying a key role in the energy transition today
- Lower carbon dispatchable technology towards carbon neutrality
- Turbine based solutions as cornerstone technology for carbon neutrality
- Collaboration across whole value chain more important

Users call OEMs and the R&D community to join forces, contribute and continue enabling cost-efficient operations of the current asset base, while investing in solutions to respond to the decarbonization challenge – ETN as Key Enabler

Key inputs into ETN strategy from ETN users

Vision for the Energy Transition

Decarbonisation
Improve the carbon footprint of new and existing assets towards carbon-free generation

Energy Efficiency
Explore new and more efficient options

Transition to new energy systems
Expand the solutions portfolio in the transition to new energy systems

Strategic Areas and Goals

Affordable decarbonised gas turbine-based solutions

Fleet improvements towards the most efficient and cost-effective solutions for the energy system

Decarbonisation and security of supply solutions through expanded fuel flexibility and system integration

User Groups, Working Groups, Projects and other activities

ETN Global

Engine-specific User Groups

LM2500 & SGT-A35

Objective

Develop strong, independent and knowledgeable user communities, by:

- Providing a **continuous and focused dialog** between the user community, OEMs, service providers and suppliers
- Sharing **user experience at site**.
- Defining, developing and implementing solutions in order to **improve gas turbine operations**.
- Bringing together and coordinating the **user's voice community**.

Engine-specific User Groups

LM2500 & SGT-A35

Process

- **Collect** issues and requirements reported by the user community
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- **Meet** at the annual user group meeting, where solutions & developments are being presented and discussed with technical experts from the OEM and the invited ISPs
- **Trigger** dedicated response from OEMs, ISPs and R&D community, and follow-up on implemented recommendations and proposed solutions

Supercritical CO_2 Working Group

Chair: Marco Ruggiero, Baker Hughes
Co-Chairs: David Sánchez, University of Seville
Albannie Cagnac, EDF

Working Group

Objective

Develop, enable and optimise the use of supercritical CO_2 power cycles by:

- Highlighting potential use, applications and benefits
- Addressing operational issues/effects on components (turbomachinery, heat exchangers and combustion systems) related to the use of sCO_2
- Assessing and addressing operational safety aspects of sCO_2-cycles based power plants
- Creating a database of European open test beds
- Exploring market opportunities
- Exploring strategic alliances internationally to gain economies of scale worldwide
- Paving the way for funding opportunities by highlighting the research needs on sCO_2 based power cycles, to contribute to their deployment in the future energy system

Business case for sCO_2 Waste Heat Recovery System
Published in October 2020

Download at
etn.global/sco2-whrs-case

Working Group

Air Filtration Working Group

Chair: Olaf Brekke, Equinor
Co-Chair: Dominique Orhon, TotalEnergies

Objective

Improve the quality and flexibility of Air Filtration systems by:

- Allowing the users to have a single point of reference for state-of-the-art filtration technology
- Addressing air filtration issues through projects of common interest

ETN liaison members of ISO/TC142

Testing Activities

Hydrogen Working Group

Chair: Peter Kutne, DLR
Co-Chair: Geert Laagland, Vattenfall

Working Group

Objective

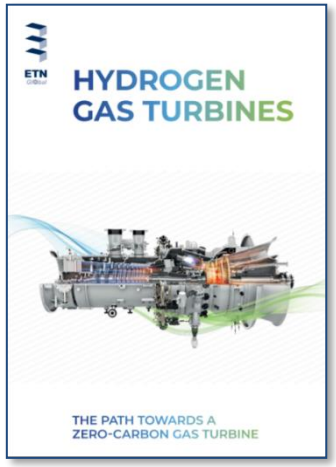
Accelerating the development and use of hydrogen-based gas turbine technology by:

- Identifying potential barriers, and exploring:

Economic aspects & business cases	**Demonstration projects**	**Operational issues/effects on GT components**
Retrofit solutions for high hydrogen-content fuel	**Safety aspects**	**Research needs**

- Exploring cooperation opportunities to ensure safe, reliable and cost-efficient solutions for existing and future fleets

The path towards a
Zero-Carbon Gas Turbine
Published in January 2020



Download at
etn.global/hydrogen-report

Working Group

Additive Manufacturing Working Group

Chair: Christian Haecker, Oerlikon

Objective

Strengthen the cooperation between stakeholders of the turbomachinery value chain on additive manufacturing (AM) topics by:

- Exchanging knowledge and experiences focusing on the added value of AM
- Cooperating on AM practices for applications in the energy sector

AM Best Practices
Published in 2019

Download at
etn.global/ETN-AM-Best-Practices

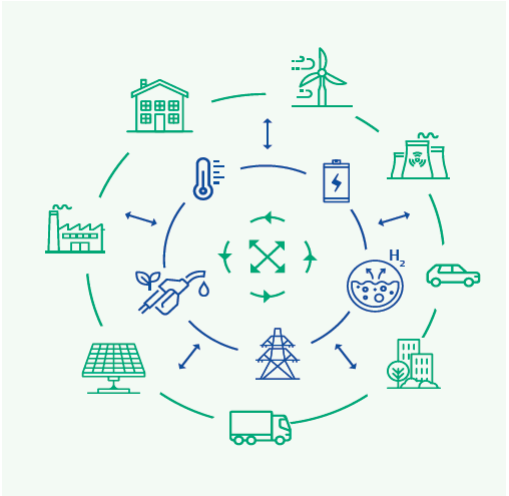
Decentralised Energy Systems Working Group

Widen the scope of the MGT Working Group by:

- Covering Micro GTs and Small GTs
- Aligning with the user community needs

Way forward

- ❑ Launch on 23 September 2021
- ❑ Explore markets opportunities and solutions, Pave the way for funding opportunities, Initiate R&D projects



Source: EU strategy on energy system integration, July 2020

ETN Key R&I topics of interest

etn.global/RDRR

Energy Efficiency and Emissions
- Load flexibility and part load operation
- Reliability
- Bottoming cycle

Decarbonisation
- Blend of H2, Biogas
- Full fuel flexibility (from 0 to 100%) H_2, ammonia

Advanced Cycles
- ORC and Wet Cycles
- Supercritical CO_2 and Pressure Gain Combustion

System integration and Energy Storage
- Integration with storage solutions (battery, CAES, LAES, thermal)
- Integration with different energy conversion systems

Cost Optimisation
- CAPEX & OPEX
- Overhaul cost

Digitalisation
- Condition monitoring
- Unmanned plant

Material
- Hot-Corrosion
- Additive Manufacturing

Short-term
Long-term

Participation to European Technology and Innovation Platforms

Highlighting GT R&D development opportunities

Smart Networks for Energy Transition

Governing Board - Rob Versteirt (ENGIE)

WG3 Flexible Generation: Peter Jansohn (PSI),

Olaf Bernstrauch (Siemens), Yiguang Li (Cranfield University)

Renewable Heating and Cooling

Biomass panel representative: Peter Kutne (DLR)

Zero Emission Platform

Key priorities

1. Deployment and commercialisation of CCUS; 2. CCU; 3. Engagement with EU and MS; 4. Influence stronger policy support; 5. CCUS financing.

Involvement in the Strategic Energy Technology (SET) Plan

- SET-Plan Action 4 – Increase the resilience, security and smartness of the energy system
- SET-Plan Action 5 – New materials and technologies for buildings
  Increase efficiency of heating and cooling technologies for buildings
- SET-Plan Action 6 – Energy efficiency for industry
- SET-Plan Action 9 – Carbon Capture Utilisation and Storage

Ongoing EU projects

2017-2021
NEXTOWER aims at demonstrating high-performance durable materials for the next generation of CSP air-based tower systems, making them commercially competitive in the energy market beyond 2020.

h2020-nextower.eu

2017-2021
PUMP-HEAT project proposes the demonstration of an innovative concept based on the coupling of a fast-cycling highly efficient heat pump (HP) with CCs. The integrated system features thermal storage and advanced control concept

pumpheat.eu

2020-2024
The goal of the FLEXnCONFU project is to develop and demonstrate in a combined cycle (CC) power plant an innovative, economically viable and replicable power-to-X-to-power (P2X2P) solution.

flexnconfu.eu

2020-2024
ROBINSON aims to help decarbonise (industrial) islands by developing an intelligent, robust and flexible energy management system that integrates technologies across different energy vectors (electricity, heat and gas)

robinson-h2020.eu

These projects have received funding from the European Union's Horizon 2020 research and innovation programme:
NEXTOWER: GA 721045; PUMP-HEAT: GA 764706; FLEXnCONFU: GA 884157; ROBINSON: GA 957752

Young Engineers Committee (YEC)

Current member organisations

Vision

Facilitate a successful energy transition

Mission

A network of committed young engineers promoting fresh perspectives for a sustainable world and society

Objectives

- Develop future leaders in the turbomachinery field by enabling cross-sector collaboration and knowledge sharing
- Ensure continuity of involvement in ETN
- Pass on experience in cooperation with ETN's Emeritus Members
- Provide valuable contributions in collaboration with ETN's Working Groups and Technical Committees
- Promote low-carbon technologies

ETN contact
Valentin Moens (vm@etn.global)

LinkedIn
ETN Young Engineers Committee

ETN's 10th International Gas Turbine Conference

11-15 October 2021

"Gas turbines in a carbon-neutral society"

5 keynote sessions

Technical sessions: 30 technical papers to be presented

IGTC International Gas Turbine Conference

More details will be updated to our website: etn.global/events/igtc-21

Communications

www.etn.global website

Main communications platform and database for member information

Social media

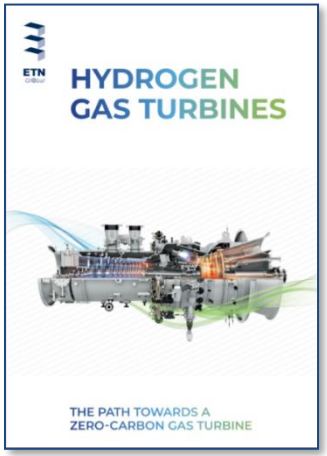
ETN publications

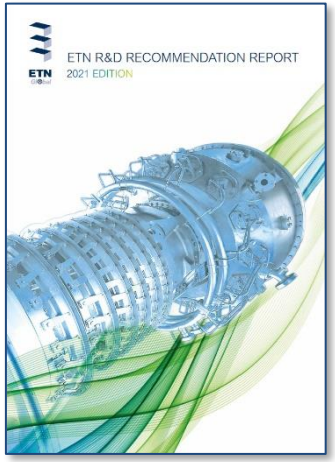
Monthly News Summary: distributed internally to ETN members every month (800 subscribers)

Quarterly Newsletter: sent to more than 1500 contacts (members and external contacts) four times a year

Recent Publications

All publications: etn.global/research-innovation/rd-reports





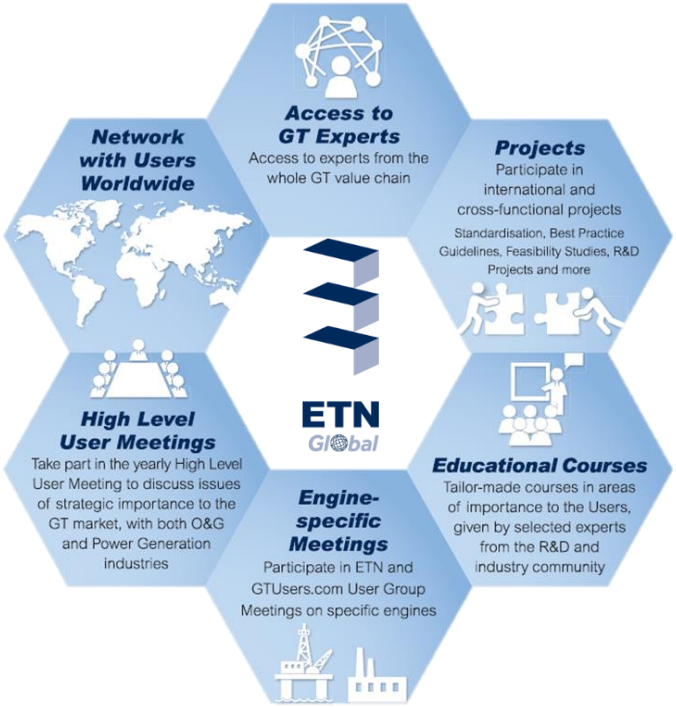
ISO 21905 – Gas turbine applications – Requirements for exhaust and heat recovery unit

A need for Global Cooperation

to accelerate the Energy transition and ensure a wide role for dispatchable clean turbine technology in the energy transition and beyond

Mission to:

- ✓ encourage and facilitate information exchange
- ✓ foster cooperation among the stakeholders of the turbine industry
- ✓ accelerate research, development, and demonstration of sustainable energy solutions
- ✓ Regulatory and market framework that will incentivise the required investments



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Brussels, Belgium

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Web: www.etn.global

SGT-A35 User Group

– 2021 virtual meeting

ETN Global

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LM2500 & SGT-A35

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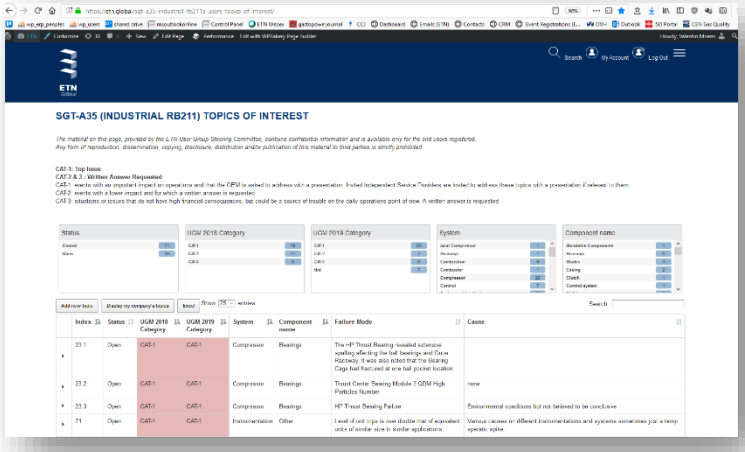
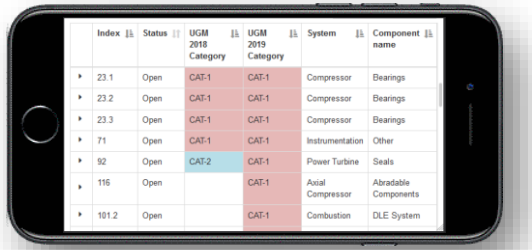
Online platform for Users

Online platforms and databases developed by the ETN Office to gather topics of interest on LM2500 and SGT-A35 (RB211) gas turbines

https://etn.global/rb211topics

https://etn.global/lm2500topics





Agenda

Wednesday 22 September 2021				Participants *[U = Users]*
Brussels (UTC+2)	*New York (UTC-4)*	*Sydney (UTC+10)*		
13:00 - 14:30	07:00 - 08:30	21:00 - 22:30	**User Session 1 – Prioritised Reported Topics,** Discussion	U
15:00 - 16:30	09:00 - 10:30	23:00 - 00:30	**User Session 2 – Prioritised Reported Topics,** Discussion	U
Thursday 23 September 2021				
11:00 - 12:30	05:00 - 06:30	19:00 - 20:30	**RWG Session –** MRO Presentation & Discussion	U + RWG
14:00 - 15:30	10:00 - 11:30	22:00 - 23:30	**Siemens Energy Session –** Aero-derivative Gas Turbines Products Update	U + SE
Friday 24 September 2021				
13:00 - 14:30	07:00 - 08:30	21:00 - 22:30	**SE Technical Session (1/2) –** Updates on progress related to highlighted technical topics and issues	U + SE
15:00 - 16:30	09:00 - 10:30	23:00 - 00:30	**SE Technical Session (2/2)**	U + SE
16:30 - 17:30	10:30 - 11:30	00:30 - 01:30	**User Closing Session –** Prioritised Topics ● Follow-up Actions ● Feedback & Recommendations	U

Prioritised topics - 2021

PART A – Update or follow-up on existing topics

The following topics have been introduced in previous edition(s) of the ETN SGT-A35 User Group meeting.

An update discussion was requested to the partners:

- update on active programs,
- observation of new occurrences in the fleet (statistics, trends),
- experience with the implementation of solutions (incl. relevant SB),
- changes regarding capabilities (expanded servicing capacities, upgrade in capabilities, changes in tooling, etc.)
- reporting on root cause analysis
- improvements suggestions (new solutions, collaboration proposal, etc.)

Prioritised topics - 2021

PART A – Update or follow-up on existing topics	
Topic	**Index**
Oil leakage from IPC front	82
HP Thrust Bearing material review update	23
Feedback on the FMV design released in March 2019	66
HPT blade failure event (2018), and risk for the fleet	123
IP turbine blade failures, and risk for the fleet	103
Power Turbine disk & rotor inspection and life extension criteria	115
HPC Stg1 blade - high cycle fatigue crack	127

Prioritised topics - 2021

PART B – New topics	
Topic	**Index**
Collaboration with ETN Members - Review of Alba Power's proposal	-
Siemens support performance	138
Experience with RT62X upgrade	137
Clarification regarding lube oil specification change	136
PT depot capability & capacity	135
Frequent failed starts	130
Cracking on HP compressor rotor disk stg 1-2	132
PT RT56 rim cooling measurement fault	131
Energy efficiency improvements solutions	-

Alba Power proposal

ETN Request

Testing facility

- Please develop Alba Power's testing facility scope and capabilities.
- Does it cover liquid fuel, gas fuel, both ?
- Is the test bed calibrated? If yes please elaborate on the procedure followed. If not, users have questioned the value it would bring.

Engineering capability

- Has there been a change in engineering capability since the merging with Sulzer? (expansion, cross-collaboration between organisation, etc.)
- What is the experience in dealing with non-conformance ? Clarifications on the team's expertise and presenting use cases would be beneficial

Alba's response – proposed Agenda

- Test Facilities
- DLE Upgrade performance & reliability
- PT Life extension
- Sulzer impact and engineering capability
- New Parts Manufacture
- Open discussion – Current issues being faced, potential concerns using ISP

Speakers

- Ian, owner of Orbital
  -> DLE and controls
- Charles Soothill, Head of Technology, Sulzer
  -> Reverse engineering & manufacturing
  -> Hydrogen ?
- Mike Johnston
  -> PT