Hydrogen Working Group

Minutes of the meeting

*26 October 2020, Teleconference*

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| Participants |
| Andrea Ciani | Ansaldo Energia  | Bernhard Winkelmann | ETN Emeritus Member |
| Marco Cioffi  | Ansaldo Energia | Elisa Todesco | ETN |
| Peter Stuttaford | Ansaldo Thomassen | Ugo Simeoni | ETN |
| Toni Hartikainen | Aurelia Turbines | Valentin Moens | ETN |
| Serena Gabriele | Backer Hughes  | Irfan Siddiqui | Frazer Nash Consultancy |
| Egidio Pucci  | Baker Hughes  | Michael Ladwig | GE Power |
| Stefano Rossin | Baker Hughes  | Ganesan Subbaraman | GTI |
| Marco Ruggiero | Baker Hughes | Renaud Le Pierres | Heatric |
| Giuseppe Bianchi | Brunel University | Ulrich Orth | MAN Energy Solutions |
| James Bain | Cardiff University | Colin Grady | Meggit |
| Jon Runyon | Cardiff University | Burak Kaplan | Mitsubishi Power  |
| Jafar Al-Zaili | City, University of London | Peter Breuhaus | NORCE |
| Sayma Abdulnaser | City, University of London | Peter Jansohn | Paul Scherrer Institute |
| Peter Griebel | DLR | Walt Steimel  | Shell |
| Peter Kutne | DLR | Adnan Eroglu  | Siemens |
| Eugenio Giacomazzi | ENEA | Konrad Meyer | Siemens |
| Stefano Sigali  | Enel | Alireza Kalantari | Solar Turbines |
| Andrea Belingheri | Enipower | Terry Tarver | Solar Turbines |
| Giuseppe Giannotti  | Enipower | Ferenc Pankotai | Solar Turbines |
| Rob Steele | EPRI | Rob Bastiaans | Technical University Eindhoven |
| Olaf Brekke | Equinor | Daria Bellotti | University of Genoa |
| Jon Jakobsen | Equinor | Marco Sorrentino | University of Salerno |
| David Abbott | ETN Emeritus Member | Geert Laagland | Vattenfall |

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# Introduction

U. Simeoni opened the teleconference and introduced the agenda of the teleconference. The meeting was chaired by P. Kutne.

# Hydrogen combustion position paper

A sub-group of the ETN hydrogen working group had been previously formed with the objective to produce a position paper *“Addressing the combustion challenges of Hydrogen addition to Natural Gas”*.

The purpose of this initiative is to inform and influence the European Commission (EC) and other relevant authorities on identified challenges associated with combustion of hydrogen & natural gas (H2NG) blends, and to recommend needed research topics to further enable the deployment of associated solutions. U. Simeoni noted that the paper would also be useful for discussions during the public consultation on EU ETS in 4Q 2020.

D. Abbott presented the preliminary table of content:

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| --- |
| Executive Summary 1. Introduction
2. Review of impact of hydrogen in natural gas on combustion behaviour
	1. Fundamentals
		1. Chemical kinetics

*Particularly NOx chemistry** + 1. Adiabatic flame temperature
		2. Fuel placement
		3. Air/fuel mixing

*Combustion modes, premixed, partially-premixed, non-premixed, mild combustion, ..** + 1. Flame speed
		2. *Others?*

*Looking for suggestions** 1. Impact of fundamentals on flame characteristics

*Should identify for each subsection whether there are adverse impacts that cannot be fully mitigated by improved design** + 1. Flame shape and position
		2. Residence time distribution
		3. Flashback
		4. Combustion acoustics (dynamics, pulsations, humming etc)
		5. Lean blow-out and CO emissions
		6. NOx emissions
1. Practical considerations

*Following content should be derived from the above** 1. Positive impacts and advantages of adding hydrogen
	2. Adverse impacts of adding hydrogen
		1. At what hydrogen concentration these impacts become significant.
		2. The impact of the range of hydrogen content
	3. Development efforts required to mitigate adverse impacts
	4. Modelling challenges, reduction of kinetics and turbulence
	5. Instrumentation and control
1. Recommendations
2. Conclusions

*This may include recommendations relating to relaxation of emissions and/or future research funding and support*References  |

The following points were discussed and clarified:

* The purpose of this initiative is to publish a position paper, supported by a literature review and the state of the art. Future challenges and/or research gaps should be highlighted, in particular if they are not yet recognised by legislators.
* The paper will look at identifying fundamental challenges of H2NG blends combustion. Design considerations influencing NOx emissions (boundary conditions, size and location of the GT, etc.) are therefore considered to be out of scope and under control of the manufacturer. Further discussion of this point could be addressed in an appendix.
* Participants agreed to include a content section to ease the transition between chapters addressing theoretical and practical limits.
* When addressing retrofitting, practical limits and economics should both be addressed. Relaxation of NOx limitations should be included in the cases considered.
* Participants agreed that the paper should point out the difficulties in achieving current NOx emission limits and what the trade-offs would be.
* Factors impacting operability of the machine should be addressed in a dedicated section, with links to other sections detailing the points listed when relevant.
* R. Steele offered to contribute to the document by providing a summary of the US perspective, based on conclusions of a publication on hydrogen released last year by EPRI and GTI

**Action**: WG Members to provide feedback on the hydrogen combustion paper’s table of content

**Action**: WG Members to identify sections of the hydrogen combustion paper to which they could contribute

**Action**: R. Steele to draft a summary of the US perspective on identified challenges and research gaps

# YEC Techno-Economic study

*Presentation available on the ETN website:* [*Link*](https://etn.global/wp-content/uploads/2020/11/ETN-YEC-Hydrogen-WG_2610202_v4_etnmembersonly.pptx) *(login required)*

D. Bellotti, University of Genoa, presented the work carried out by the Young Engineers Committee on the techno-economic analysis for hydrogen deployment in centralised power generation.

The following points were discussed:

* Suggested title options:
	+ *Centralized Hydrogen Power Generation: A techno-economic analysis of low-carbon gas turbine utilization in the energy transition and beyond*

*Comments:*

* + - *Not ideal as we mention low-carbon utilization in the energy transition and beyond: may be misinterpreted as a lack of commitment*
	+ *Cost-Effective Hydrogen Gas Turbine Power Generation: Enabling renewables now and delivering net-zero by 2050*

*Comments:*

* + - *Not ambitious enough as the vision is to have carbon-neutral solution in place by 2030 in line with the ETN vision and GT manufacturers’ common statement*
	+ *Techno-Economic Analysis of Hydrogen Gas Turbines for Net-Zero Centralized Power Generation*
* The preliminary table of content is open for feedback from the Working Group.
	+ The report will start with a literature review providing background on considered costs related to hydrogen and CO2.
	+ Case studies will then be developed for different scales of GTs
	+ Policy support and R&D funding are then addressed
* First results of the analysis of the OCGT case were presented
	+ Glossary (green, blue, grey hydrogen) should be aligned with the EC’s hydrogen strategy.
	+ Cost of electricity will be taken into consideration as part of the LCOE analysis
	+ Clarification of centralised / decentralised power generation should be included
	+ Participants agreed that CO2 transportation and storage costs associated to CCS could be further discussed depending on the narrative taken into consideration (e.g. methane reforming at natural gas extraction site reduces those costs)
* Several WG Members offered to provide further feedback, contribution, and revision to the study. They were invited join the next (and future) meeting(s) dedicated to this initiative (currently organised every Thursday at 16:00, Brussels time).

**Action**: WG Members to provide feedback on suggested titles for the YEC techno-economic study

**Action**: WG Members are invited to provided further feedback on the presented preliminary analysis of the YEC techno-economic study

# Actions list

| # | Actions | Resp. | Deadline |
| --- | --- | --- | --- |
| 1 | WG Members to provide feedback on the hydrogen combustion paper’s table of content | All | 30 November 2020 |
| 2 | WG Members to identify sections of the hydrogen combustion paper to which they could contribute | All | 30 November 2020 |
| 3 | R. Steele to draft a summary of the US perspective on identified challenges and research gaps | R. Steele (EPRI) | 15 December |
| 4 | WG Members to provide feedback on suggested titles for the YEC techno-economic study | All | 30 November 2020 |
| 5 | WG Members are invited to provided further feedback on the presented preliminary analysis of the YEC techno-economic study | All | 30 November 2020 |