CEN-CLC JTF H2qInd - Survey on hydrogen quality in industrial applications

(*Initiative of Sector Fora JTF 'Hydrogen quality needs for industrial uses' - H2qInd*)

Fields marked with * are mandatory.

Dear Operator of industrial sites,
Dear Manufacturer of equipment used on industrial sites,

European policies aim for a Green House Gas reduction of 55% by 2030 and climate neutrality by 2050. This means a step out of natural gas and the replacement by hydrogen (and biomethane) where technically appropriate and politically supported.
To ensure the further safe, reliable, and carbon neutral operation of your industrial facilities, the replacement of natural gas by hydrogen in industrial gas applications and in the gas supplying infrastructure needs thorough preparation by all parties and appropriate standards. The quality of the hydrogen here will be the key! The European hydrogen quality will be defined in CEN-CENELEC standards.

As a basis for these CEN-CENELEC standards we need your competency on hydrogen quality necessities and abilities of your industrial applications using natural gas/hydrogen as feedstock and/or combustion, especially:
- the impacts of trace components/impurities and other quality parameters on the industrial processes and equipment where hydrogen is used
- the identification of technical mitigation measures at the industrial sites in order to enable the use of the hydrogen from repurposed natural gas grids.

Therefore, we kindly invite you to support our work by filling-in this questionnaire, in the own interest of the natural gas and hydrogen consuming industry!

The contributions will remain anonymous unless you voluntarily share your coordinates with us (Section 5). The survey result will only be published as aggregated data in an informal CEN-CENELEC report and used in standardisation.

The contributions to this questionnaire will determine the future quality specifications for hydrogen and the actual suitability for the processes and equipment for industrial applications.

For any question, please use the contact form.

Thank you very much in advance for your preparedness to answer our questionnaire! It will be much appreciated!

Kind regards,
CEN-CENELEC Sector Fora Joint Task Force 'Hydrogen quality needs for industrial uses'
(a joint initiative of the three Sector Fora Energy Management WG H2, Gas infrastructure and Gas utilitisation)
Contact: Hiltrud Schülken, CEN-CENELEC SF JTF Secretary (for contact use CONTACT FORM above/on the right)

Section 1- Indication of the industry – industrial sector

* 1. What best describes the sector you are in? (multiple options allowed):
- [ ] a. Feedstock (H2 as raw material)
- [ ] b. Combustion
- [ ] c. Power generation
- [ ] d. Transportation
- [ ] e. Equipment manufacturer:
- [ ] f. Others (free text)

1.a. Feedstock (H2 as raw material) - Please select an option (multiple options allowed):
- [ ] 1. Production of ammonia
- [ ] 2. Production of methanol
- [ ] 3. Production of hydrogen peroxide
- [ ] 4. Food industry
- [ ] 5. Steel production (Reduction processes)
- [ ] 6. Refinery
- [ ] 7. Chemicals production (Hydrogenations)
- [ ] 8. Oxo-alcohols
- [ ] 9. Others (free text)

Please provide further details:

1.b. Combustion - Please select an option (multiple options allowed):
- [ ] 10. Chemical/ petrochemical plants
- [ ] 11. Metals/ Metallurgical and metal-working plants (steel and iron)

- [ ] 12. Ceramic manufacturing plants
- [ ] 13. Glass-making plants
- [ ] 14. Cement-, lime- and gypsum-manufacturing plants
- [ ] 15. Waste incineration
- [ ] 16. Food industry plants
- [ ] 17. Paper production plants
- [ ] 18. Oil and gas (e.g. refineries with cracking furnaces)
- [ ] 19. Drying plants for feed and food
- [ ] 20. Others (free text)

Please provide further details:

1.d. Transportation - Please select an option (multiple options allowed):

- [ ] 1. Maritime
- [ ] 2. Aviation
- [ ] 3. Others (free text)

Please provide further details:

1.e. Equipment manufacturer - Please select an option (multiple options allowed):

- [ ] 1. Oven
- [ ] 2. Furnace
- [ ] 3. Kiln
- [ ] 4. Dryer
- [ ] 5. Oxidiser
- [ ] 6. Boiler
- [ ] 7. Gas turbine
- [ ] 8. Engines
- [ ] 9. Others (free text)

Please provide further details:

Please provide further details:

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* 2. What is/are the relevant appliance(s) and/or equipment(s)? (multiple options allowed)

- [ ] a. Oven

- [ ] b. Furnace
- [ ] c. Kiln
- [ ] d. Dryer
- [ ] e. Oxidiser
- [ ] f. Boiler
- [ ] g. Gas turbine
- [ ] h. Engines
- [ ] i. Sensors
- [ ] j. Measurement equipment
- [ ] k. Analytic equipment
- [ ] l. Burner
- [ ] m. Chemical reactors/synthesis
- [ ] n. Reformer
- [ ] o. Catalytic Bed and Tube Reactors
- [ ] p. Direct reduction iron technology
- [ ] q. Others or more specific information (free text)

Please provide further details:

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* 3. For which process do you need natural gas/ hydrogen? (multiple options allowed)

- [ ] a. Thermal production
- [ ] b. Melting and pouring
- [ ] c. Heating
- [ ] d. Heat treatment
- [ ] e. Surface treatment
- [ ] f. Coating
- [ ] g. Joining
- [ ] h. Surface pretreatment
- [ ] i. Drying
- [ ] j. Firing
- [ ] k. Direct reduction iron technology
- [ ] l. Chemical reactors/synthesis
- [ ] m. Haber Bosch Synthesis
- [ ] n. Syngas production
- [ ] o. Hydrogenations
- [ ] p. Desulfurisation
- [ ] q. Hydrocracking
- [ ] r. Electricity production and mechanical drives by reciprocating engines
- [ ] s. Electricity production and mechanical drives by gas turbines
- [ ] t. Others (free text)

Please provide further details:

* 4. What is the main output/product of the industrial site?

- a. Combustion
- b. Feedstock (H2 as raw material)
- c. Others (free text)

4.a. Please indicate output/product:

4.b. Feedstock - Please select an option (multiple options allowed):

- 1. Ammonia
- 2. Methanol
- 3. Oxo-Alcohols
- 4. Saturated oil, fats and fatty alcohols
- 5. Hydrogen Peroxide
- 6. Refined petroleum products (e.g. gasoline, petrol, jet fuel, kerosene, diesel)
- 7. Chemicals
- 8. Steel
- 9. Others (free text)

Please provide further details:

Please provide further details:

* 5. Which energy carrier is currently used for your processes?

- a. Natural gas
- b. Hydrogen
- c. Both
- d. Others (free text)
- e. Don’t know

Please provide further details:

* 6. Is the facility connected to a gas transmission grid, gas distribution grid, or storage or to a dedicated hydrogen grid?

- a. Natural gas transmission grid
- b. Natural gas distribution grid
- c. Dedicated hydrogen grid
- d. Storage (e.g. ammonia storage)
- e. Others (free text)
- f. Don’t know
- g. Not applicable

Please provide further details:

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7. What is the yearly consumption of natural gas and/or hydrogen of your industrial site(s) for combustion and/or feedstock? (multiple options allowed)

- a. Combustion – MWh
- b. Feedstock (H2 as raw material)
- c. Others/comments (free text)

Comments:

7.a. Combustion - MWh (multiple options allowed)

- 1. Throughput of natural gas
- 2. Throughput of hydrogen
- 3. Are there any other forms of energy expected to be replaced by hydrogen?
- 4. Don’t know

7.a.1. Combustion - MWh/ **Throughput of natural gas per year** - Please select an option:

- 1. Smaller than 2x10^3 MWh (< 2 GWh)
- 2. Between 2x10^3 and 1x10^4 MWh (2 - 10 GWh)
- 3. Between 1x10^4 and 2x10^4 MWh (10 - 20 GWh)
- 4. Between 2x10^4 and 1x10^5 MWh (20 - 100 GWh)
- 5. Between 1x10^5 and 5x10^5 MWh (100 - 500 GWh)
- 6. Greater than 5x10^5 MWh (> 500 GWh)
- 7. Don't know

7.a.2. Combustion - MWh/ **Throughput of hydrogen per year** - Please select an option:

- 1. Smaller than 2x10^3 MWh (< 2 GWh)
- 2. Between 2x10^3 and 1x10^4 MWh (2 - 10 GWh)
- 3. Between 1x10^4 and 2x10^4 MWh (10 - 20 GWh)
- 4. Between 2x10^4 and 1x10^5 MWh (20 - 100 GWh)

- 5. Between 1x10^5 and 5x10^5 MWh (100 - 500 GWh)
- 6. Greater than 5x10^5 MWh (> 500 GWh)
- 7. Don't know

7.a.3. Please select an option:

- 1. Yes
- 2. No

If so, how much per year?

7.b. Feedstock (H2 as raw material) - Please select an option (multiple options allowed):

- 1. Throughput of natural gas
- 2. Throughput of hydrogen
- 3. Are there any other forms of energy expected to be replaced by hydrogen?
- 4. Don’t know

7.b.1. Feedstock (H2 as raw material)/ **Throughput of natural gas per year**- Please select an option:

- 1. Up to 1 Mt
- 2. From 1 Mt to 25 Mt
- 3. From 25 Mt to 50 Mt
- 4. From 50 Mt to 100 Mt
- 5. More than 100 Mt

Feedstock (H2 as raw material)/ **Throughput of hydrogen per year** - Please select an option:

- 1. Up to 1 Mt
- 2. From 1 Mt to 25 Mt
- 3. From 25 Mt to 50 Mt
- 4. From 50 Mt to 100 Mt
- 5. More than 100 Mt

Please select an option:

- 1. Yes
- 2. No

If so, how much per year?

Section 2- Transition to hydrogen

8. If you are using natural gas, do you plan to convert from natural gas to hydrogen?

- a. Yes (fully or partially)

- b. No
- c. Don’t know

Comments:

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9. How long would the technical conversion of the facilities from natural gas to hydrogen take? (Planning/presumption) Please presume that hydrogen is available for all the timescale estimation.

- a. 1 year
- b. 2 years
- c. 3 years
- d. >3 years
- e. Don´t know

Comments:

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10. What is the acceptable and necessary exit pressure for the hydrogen delivered to your site?
Note: Please indicate at least one option. In case there are several pressure limits, please indicate this in the comment box.

- a. up to 1.5 bar
- b. > 1.5 bar - 5 bar
- c. > 1.5 bar - 16 bar
- d. > 16 bar - 20 bar
- e. > 20 bar - 30 bar
- f. > 30 bar - 40 bar
- g. Other (free text)
- h. Don't know

Comments:

Please provide further details:

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11. Do you participate in pilot projects?

- a. Yes
- b. No

- c. Don’t know

If possible, please provide further details:
e.g. a) Title, b) Organisation, c) Weblink

Comments:

12. Do you plan to produce and inject hydrogen into the public grid?

- a. Yes
- b. No
- c. Don´t know

Comments:

Section 3- Hydrogen quality considerations

3.1- Hydrogen content

* 13. A hydrogen concentration of ≥ 98 mol-% is the minimum value that is proposed in currently available hydrogen quality documents.
Is this value acceptable as the minimum?

- a. Yes
- b. No

Please provide additional information/comments (if needed):

Note 1: The values comes from the following hydrogen quality documents: CEN/TC 234 draft Technical Specification (WI 00234096), ISO 14687:2019 Grade A, EASEE-gas Common Business Practice 01/2022, Initiative European Hydrogen Backbone, Study Hy4Heat).

Note 2: The concentration of 98 % hydrogen is the expected minimum value of hydrogen that is supplied by repurpused natural gas grids. It is expected that the hydrogen quality will improve over time. The 98% takes into account the condition of existing piping with the possible presence of liquid and solid deposits influencing the hydrogen quality.

14. What would be the minimum value (if deviating from the 98%) that can be tolerated?
Please indicate the value in mol-% and indicate if it is in general or as peak amount.

Comments:

3.2- Possible trace components and impurities

* For questions 15-19, please download the Excel file below, fill the table in, and please upload it here again.
Note: the instructions to complete the table are given within the Excel file.

Please download the Excel file:

Questions_15_to_19_Impact_H2_quality_specifications.xlsm

Please upload your file(s):

If upload is not possible, please consider to send the file as attachment of the CONTACT FORM to us.

PLEASE read this instruction before answering the question 15 to 19.

Possible trace components, impurities and parameters	Reference values/tolerances (as maximum) taken from the available H2 quality proposals:	15. Is the given reference value / tolerance acceptable as a maximum?	16. Are there barriers if there are variations in the value up to the given maximum?	17. What would be the maximum value (if deviating from the reference value) that can be tolerated in your equipment/ process?	18. If you are already using hydrogen, are you already monitoring this parameter?
The values come from available H2 quality documents (CEN/TC 234 draft TS, ISO 14687:2019 Grade A, EASEE-gas CBP 01/2022, H2 Backbone, Hy4Heat)		Possible replies dropdown list: yes/no + don't know free text: for explanation	free text	free text, Please indicate if the value is in general or as peak amount.	Possible replies Dropdown list: yes/ no /no answer If yes, which technology is used? (add it as free text)
The following list gives possible parameter and their maximum values, that - summed up - are at a maximum of 2 mol-% of the gas (not additive!).					
Carbon monoxide CO	1 µmol/mol				
	20 µmol/mol				
Carbon dioxide CO_2	20 µmol/mol				
Total Sulphur	2 µmol/mol				
	5 µmol/mol				
	7 µmol/mol				
	10 µmol/mol				
	14,7 µmol/mol				
		15.a Is there a different sensitivity for the different sulphur components? If so, are the critical values known? Please indicate - free text			
	Hydrogen sulphide content H2S				
	Carbonyl sulfide COS				
	Carbon disulphide (CS2),				
	mercaptans (e.g. methyl mercaptan)				
	0,01 mol-%				
	1,5 mol-%				
	2 mol-%				

Total Hydrocarbons		15b. Is there a different sensitivity for different hydrocarbons? If so, are the critical values known? Please indicate - free text			
	Hydrocarbons such as - methane - propane -				
Total Inerts	2 mol-%				
		15c. Is there a sensitivity for specific inerts? Please indicate the maximum values, if known.			
	Nitrogen				
	Argon				
	Helium				
	Others Please indicate which the inerts and the maximum value.				
Oxygen O_2	0,0001 mol-% (10 µmol/mol (ppm))				
	1 mol-% (10000 ppm)				
	0,2 mol-% (2000 ppm)				
Halogenated compounds (Chlormethane, Chloride, Fluoride, etc) e.g. relevant for the corrosion effects of exhaust gas	0,05 µmol/mol				
		15d. Are other effects than corrosion to be considered? Please indicate - free text			
Other trace components, impurities, parameters which cause barriers (e.g. iron (Fe), particulates, contaminants)					
Formic acid HCOOH	10 µmol/mol				
Formaldehyde H_2CO	10 µmol/mol				
Ammonia NH_3	10 µmol/mol				

	13 µmol/mol				
Water content (The water dewpoint is relevant for infrastructure but rather not for application; For the time being no formula for the conversion of water content to dew point for hydrogen is commonly available.)	250 µmol/mol at maximum operating pressure < 10 bar				
	60 µmol/mol at maximum operating pressure > 10 bar				
Hydrocarbon dewpoint	-2 °C				
Wobbe Index (The wobbe index calculation is based on 100% and 98% of hydrogen plus 2% Nitrogen (the case of 2% Ar is not realistic and therefore out of these considerations)) at ISO standard reference conditions of 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m^3 .	40,09 - 45,88 MJ/m^3 ($5,79\ MJ/m^3$)				
	40,09 - 45,88 MJ/m^3 ($5,79\ MJ/m^3$)	15f. What are the acceptable tolerances within this range? Please indicate - free text			
		15g. Do you need a Wobbe Index range for your business? Please indicate yes / no and free text			
Gross calorific value at ISO standard reference conditions of 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m3	11,86 - 12,61 MJ/m^3				
		15h. Is the specification of a GCV significant for your industrial business? If, so please explain why? - free text			

PLEASE read this instruction before answering the question 15 to 19.

Possible trace components, impurities and parameters	Reference values/tolerances (as maximum) taken from the available H2 quality proposals:	19a. What are the effects for each of the indicated equipment if the reference value/ tolerance is exceeded?	safety	performance	efficiency (%)	product quality	furnace integrity	other effects	comments on effects on equipment
The values come from available H2 quality documents (CEN/TC 234 draft TS, ISO 14687:2019 Grade A, EASEE-gas CBP 01/2022, H2 Backbone, Hy4Heat)		Select the relevant equipment from list - Please select the equipment using the plus bottom on the left (close to the number of the row)	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	free text	free text
The following list gives possible parameter and their maximum values, that - summed up - are at a maximum of 2 mol-% of the gas (not additive!).									
Carbon monoxide CO	1 µmol/mol	Oven							
		Furnace							
		Kiln							
		Dryer							
		Oxidiser							
		Boiler							
		Gas turbine							
		Engines							
		Sensors							
		Measurement equipment							
		Analytic equipment							
		Burner							
		Chemical reactors/synthesis							
		Reformer							
		Catalytic Bed and Tube Reactors							
		Direct reduction iron technology							
		Others or more specific information (free text)							
	20 µmol/mol	Oven							
Carbon dioxide CO_2	20 µmol/mol	Oven							
Total Sulphur	2 µmol/mol	Oven							
	5 µmol/mol	Oven							
	7 µmol/mol	Oven							
	10 µmol/mol	Oven							
	14,7 µmol/mol	Oven							
	Hydrogen sulphide content H2S	Oven							

	Carbonyl sulfide COS	Oven								
	Carbon disulphide (CS2),	Oven								
	mercaptans (e.g. methyl mercaptan)	Oven								
Total Hydrocarbons	0,01 mol-%	Oven								
	1,5 mol-%	Oven								
	2 mol-%	Oven								
	Hydrocarbons such as - methane - propane -	Oven								
Total Inerts	2 mol-%	Oven								
	Nitrogen	Oven								
	Argon	Oven								
	Helium	Oven								
	Others Please indicate which the inerts and the maximum value.	Oven								
Oxygen O_2	0,0001 mol-% (10 µmol/mol (ppm))	Oven								
	1 mol-% (10000 ppm)	Oven								
	0,2 mol-% (2000 ppm)	Oven								
Halogenated compounds (Chlormethane, Chloride, Fluoride, etc) e.g. relevant for the corrosion effects of exhaust gas	0,05 µmol/mol	Oven								
Other trace components, impurities, parameters which cause barriers (e.g. iron (Fe), particulates, contaminants)		Oven								
		Oven								
		Oven								
Formic acid HCOOH	10 µmol/mol	Oven								
Formaldehyde H_2CO	10 µmol/mol	Oven								
Ammonia NH_3	10 µmol/mol	Oven								
	13 µmol/mol	Oven								
Water content (The water dewpoint is relevant for infrastructure but	250 µmol/mol at maximum operating pressure < 10 bar	Oven								

rather not for application; For the time being no formula for the conversion of water content to dew point for hydrogen is commonly available.)	60 µmol/mol at maximum operating pressure > 10 bar	Oven							
Hydrocarbon dewpoint	-2 °C	Oven							
Wobbe Index (The wobbe index calculation is based on 100% and 98% of hydrogen plus 2% Nitrogen (the case of 2% Ar is not realistic and therefore out of these considerations)) at ISO standard reference conditions of 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m^3	40,09 - 45,88 MJ/m³ (5,79 MJ/m^3)	Oven							
	40,09 - 45,88 MJ/m³ (5,79 MJ/m^3)								
.									
Gross calorific value at ISO standard reference conditions of 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m3	11,86 - 12,61 MJ/m³	Oven							

PLEASE read this instruction before answering the question 15 to 19.

Possible trace components, impurities and parameters	Reference values/tolerances (as maximum) taken from the available H2 quality proposals:	19b. What are the effects for each of the indicated process if the reference value/ tolerance is exceeded?	safety	performance	efficiency (%)	product quality	furnace integrity	other effects	comments on effects on the process
The values come from available H2 quality documents (CEN/TC 234 draft TS, ISO 14687:2019 Grade A, EASEE-gas CBP 01/2022, H2 Backbone, Hy4Heat)		Select the relevant process from list - Please select the process using the plus bottom on the left (close to the number of the row)	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	Possible replies Dropdown list: yes / no	free text	free text
The following list gives possible parameter and their maximum values, that - summed up - are at a maximum of 2 mol-% of the gas (not additive!).									
Carbon monoxide CO	1 µmol/mol	thermal production							
		melting and pouring							
		heating							
		heat treatment							
		surface treatment							
		coating							
		joining							
		surface pretreatment							
		drying							
		firing							
		direct reduction iron technology							
		chemical reactors/synthesis							
		Haber Bosch Synthesis							
		syngas production							
		hydrogenations							
		desulfurisation							
		hydrocracking							
		electricity production and mechanical drives by reciprocating engines							
		electricity production and mechanical drives by gas turbines							
		others (free text)							
	20 µmol/mol	thermal production							
Carbon dioxide CO_2	20 µmol/mol	thermal production							
Total Sulphur	2 µmol/mol	thermal production							
	5 µmol/mol	thermal production							
	7 µmol/mol	thermal production							
	10 µmol/mol	thermal production							
	14,7 µmol/mol	thermal production							
	Hydrogen sulphide content H2S	thermal production							

	Carbonyl sulfide COS	thermal production							
	Carbon disulphide (CS2),	thermal production							
	mercaptans (e.g. methyl mercaptan)	thermal production							
Total Hydrocarbons	0,01 mol-%	thermal production							
	1,5 mol-%	thermal production							
	2 mol-%	thermal production							
	Hydrocarbons such as - methane - propane -	thermal production							
Total Inerts	2 mol-%	thermal production							
	Nitrogen	thermal production							
	Argon	thermal production							
	Helium	thermal production							
	Others Please indicate which the inerts and the maximum value.	thermal production							
Oxygen O_2	0,0001 mol-% (10 µmol/mol (ppm))	thermal production							
	1 mol-% (10000 ppm)	thermal production							
	0,2 mol-% (2000 ppm)	thermal production							
Halogenated compounds (Chlormethane, Chloride, Fluoride, etc) e.g. relevant for the corrosion effects of exhaust gas	0,05 µmol/mol	thermal production							
Other trace components, impurities, parameters which cause barriers (e.g. iron (Fe), particulates, contaminants)		thermal production							
		thermal production							
		thermal production							
Formic acid HCOOH	10 µmol/mol	thermal production							
Formaldehyde H_2CO	10 µmol/mol	thermal production							
Ammonia NH_3	10 µmol/mol	thermal production							
	13 µmol/mol	thermal production							
Water content (The water dewpoint is relevant for infrastructure but	250 µmol/mol at maximum operating pressure < 10 bar	thermal production							

rather not for application; For the time being no formula for the conversion of water content to dew point for hydrogen is commonly available.)	60 µmol/mol at maximum operating pressure > 10 bar	thermal production							
Hydrocarbon dewpoint	-2 °C	thermal production							
Wobbe Index (The wobbe index calculation is based on 100% and 98% of hydrogen plus 2% Nitrogen (the case of 2% Ar is not realistic and therefore out of these considerations)) at ISO standard reference conditions of 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m^3	40,09 - 45,88 MJ/m³ (5,79 MJ/m^3)	thermal production							
	40,09 - 45,88 MJ/m³ (5,79 MJ/m^3)								
.									
Gross calorific value at ISO standard reference conditions of 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m3	11,86 - 12,61 MJ/m³	thermal production							

20. What is the max. acceptable change of hydrogen quality properties (Wobbe Index and fraction of hydrogen) at your site per unit of time (rate of change) your facility can tolerate?

Note: Please specify also the required time resolution of the measurement

Rate of Change (RoC) = speed of change

Change of the value of a gas quality property at a location per unit of time

- a. Answer (free text)
- b. Don't know

Please provide your answer:

21. Are there any other impacts or related topics that you want to address?

- a. Yes
- b. No

Comments:

22. Are technical studies on hydrogen quality needs available for the industry category?

- a. Yes
- b. No
- c. Don´t know

If possible, please provide further details:
e.g. a) Title, b) Author(s)/organisation(s), c) Year

If possible, please upload the studies:

Section 4- Purification and mitigation measures

* 23. Are there hydrogen purification facilities or natural gas treatment facilities on your site?

- a. Yes, please indicate which type and technology
- b. No
- c. Don´t know

23.a. Please indicate which type/ technology:

Comments:

* 24. If there are hydrogen purification facilities or natural gas treatment facilities on your site, can these be adapted to remove trace components/impurities from the hydrogen quality that affect your facility?

- a. Yes - please indicate which impurities can be removed
- b. No
- c. Don´t know

24.a. Please indicate which impurities can be removed (multiple options allowed):

- 1. Carbon monoxide (CO)
- 2. Carbon dioxide (CO2)

- [ ] 3. Total sulphur
- [ ] 4. Total hydrocarbons
- [ ] 5. Total inerts
- [ ] 6. Oxygen (O2)
- [ ] 7. Halogenated compounds (Chlormethane, Chloride, Fluoride, etc.) e.g. relevant for the corrosion effects of exhaust gas
- [ ] 8. Other trace components, impurities (e.g. Iron (Fe), particulates, contaminants)
- [ ] 9. Formic acid (HCOOH)
- [ ] 10. Formaldehyde (H2CO)
- [ ] 11. Ammonia (NH3)
- [ ] 12. Water content

Comments:

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* 25 - If hydrogen is already used, are there technical measures (other than purification) to adapt/ mitigate for unrequested hydrogen trace components/ impurities? (multiple options allowed)

- [ ] a. Existing equipment/ technology – please indicate which and how
- [ ] b. New equipment - please indicate which and how
- [ ] c. Hydrogen is not used

25.a. Existing equipment/ technology – please indicate which and how:

25.b. New equipment - please indicate which and how:

Comments:

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26. Can you please indicate the (potential) adaptation costs for the purification/treatment facilities and/or in processes/equipment on site?
Note: please specify, in case of presumption, the approach in the comment box.

Comments:

Section 5- Further information

27. Indication of company name:

28. Indication of interest in resulting report:

- a. Yes
- b. No

29. Indication of contact: