

## Tender Notification for Procuring

### Inter-disciplinary Center for Energy Research, Indian Institute of Science, Bangalore 560012

Quotations are invited to procure a bio-Hydrogen Gas Analyzer System on CIP Bengaluru Basis to quantify the contaminants in bio-Hydrogen as per ISO 14687 specifications for PEM fuel cell applications. The quotation should clearly indicate the terms and conditions of delivery, delivery schedule, entry tax, payment terms, warranty coverage etc. The quotation should be submitted in two parts: Part I (Technical bid) and Part II (Commercial bid).

The venue for all the meetings will be

**Conference room,  
ICER, Indian Institute of Science, Bangalore 560 012, India**

### Important dates

Sl.No	Item	Date
1	Final Specifications	10th June 2020
2	Two bid tenders last date The tenderer should submit Technical and Financial Bid separately in sealed envelope super scribing the envelope as 'Technical Bid' and 'Financial Bid'. Both these envelopes should again be put in a single envelope. The documents should reach;  <b>Chairman; ICER; Indian Institute of Science; Bengaluru 560 012.</b>	24th June 2020

### Background

Hydrogen economy in general and bio-hydrogen in particular are gaining significant traction in light of the environmental challenges. Standards have been established for contaminant limits in conventional Hydrogen generated from either SMR or Electrolysis route (ISO 14687). Towards qualifying bio-syngas generated from oxy-steam gasification for fuel cell applications, the generated gas is required to be analyzed for as per the ISO specification. In light of the same, H<sub>2</sub> gas analysis stream for quantifying contaminants as per ISO 14687 is sought to be procured. The following table provides the typical fuel requirement for the PEM fuel cell.

Standard reference	ISO-DIS14687-2
Characteristics (assay)	Type I, Type II, Grade D
Hydrogen fuel index (minimum mole fraction)	>99.97%
Maximum concentration of Impurities	
Total non-hydrogen gases	<300 µmol/mol
Helium (He)	<300 µmol/mol
Nitrogen (N <sub>2</sub> ), Argon (Ar)	<100 µmol/mol

Carbon dioxide (CO <sub>2</sub> )	<2 µmol/mol
Carbon monoxide (CO)	<0.2 µmol/mol
Water (liquid)	<5 µmol/mol
Water (Vapor)	-
Total hydrocarbons b (C1 basis)	<2 µmol/mol
Oxygen (O <sub>2</sub> )	<5 µmol/mol
Total sulfur compounds c	<0.004 µmol/mol
Formaldehyde (HCHO)	<0.01 µmol/mol
Formic acid (HCOOH)	<0.2 µmol/mol
Ammonia (NH <sub>3</sub> )	<0.1 µmol/mol
Total halogenated compounds	<0.05 µmol/mol
Maximum particulates concentration	<1 mg/kg
Max Particulate size	<10µm
Conductivity due to Max Inorganic Content	< 5 mS
Max Inorganic Content	< 0.01 % ash
Na Concentration	<0.05 mg/liter
K Concentration	<0.08 mg/liter

In regards to analysis of the contaminants as listed in the table, considering the cross interference of various sub components and the magnitude of contaminants and considering that concurrent measurements are required, a system consisting of parallel gas trains has been identified to analyse the amount of trace gases - O<sub>2</sub>/Argon, He, N<sub>2</sub>, CO, CO<sub>2</sub>, total hydrocarbons containing oxygenated organic species (measured as Methane) & total sulphur compound including H<sub>2</sub>S, COS, CS<sub>2</sub> and mercaptans. Concurrent measurement and cross interference within internationally accepted standards and within the limits as imposed by ISO 14687 are critical and the number of measurement trains themselves are flexible. The details of the analyzer train is described independently as below;

<b>Analyzer Train – Expected Performance</b>	
<b>Application</b>	Analyse O <sub>2</sub> /Argon, He, N <sub>2</sub> , CO, CO <sub>2</sub> , total hydrocarbons containing oxygenated organic species (measured as Methane) & total sulphur compounds including H <sub>2</sub> S, COS, CS <sub>2</sub> and mercaptans present in Hydrogen fuel gas.
<b>Sample gas feed</b>	Hydrogen (≈ 99.99% purity)
<b>Sample pressure</b>	1 bar absolute

<b>Sample temperature</b>	Ambient ( $\approx 25^{\circ}\text{C}$ )
<b>Equipment required</b>	Three GC Analyzers One FT-IR Spectrometer
<b>Software</b>	Compatible with computer and software: Windows 10 or latest.
<b>Instrumentation &amp; Controls</b>	Fully automated with programmable pneumatic/digital control.
<b>Quality Control</b>	<ul style="list-style-type: none"> <li>Fully factory tested, calibrated &amp; guaranteed for the mentioned applications. Shipment documents should come with related test certificates. Chromatograms (analysis results carried out in supplied Analyzers) for mentioned applications must be submitted along with shipping documents. Serial number of the Equipment to be mentioned in Chromatograms.</li> <li>ISO 9001 certification for the design, manufacture and service of the FTIR instrument required.</li> </ul>

## 1. Analyzer 1 Specifications

*Analyzer 1 is required to measure Helium (He) content in Hydrogen (H<sub>2</sub>) fuel gas.*

### Expected Performance:

- Minimum detection limit (MDL)  $\leq 10$  ppm.
- Analyzer 1 requires nitrogen carrier gas and a multifunction gas sampling valve.
- Analyzer 1 requires a Thermal Conductivity Detector (TCD) with suitable packed column, preferably Molecular Sieve 5A column.
- Basic system with EPC/AFC/PPC control for carrier/detector zone gases.
- EPC/PPC/AFC should provide optimum performance with all types of columns and detectors.
- All parameters should be stored as a part of method for better analysis reproducibility.
- Power Supply: 220 VAC  $\pm 10\%$ , 47 to 53 Hz.

### Sub Components:

- Gas Flow Control:**
  - Carrier gas pneumatic program rates 0-100 psi/min or 0-100 ml/min or better.
  - Three-ramps pressure program for carrier gas.
  - Carrier pressure increment should be 0.1 psi or better.
- GC Oven Characteristics:**
  - Volume  $\geq 10\text{L}$ ; for easy fixing and removal of different column types/dimensions without compromising rate of heating or cooling of oven.
  - All temperature and time functions should be micro-processor controlled and displayed on the screen.
  - Column over-heat protection required.
  - Temperature set point resolution  $\leq 1^{\circ}\text{C}$ .
  - Oven Operating temperature: (Ambient+10) $^{\circ}\text{C}$  to 450 $^{\circ}\text{C}$ .
  - Temperature ramps  $\geq 3$ ; Maximum achievable temperature ramp rate  $\geq 45^{\circ}\text{C}/\text{min}$ .
  - Cool down time (from 250 $^{\circ}\text{C}$  to 50 $^{\circ}\text{C}$ )  $\leq 4.8$  min.
  - Time settings: 1 min increments for values 0 to 999 minutes or wider.
- Thermal Conductivity Detector:**
  - Operating Temperatures: 100 $^{\circ}\text{C}$  to 350 $^{\circ}\text{C}$ ; in 1 $^{\circ}\text{C}$  increments.
  - Minimum detectable quantity: <1ppm Nonane.
  - Sensitivity: 9  $\mu\text{V}/\text{ppm}$  Nonane at 160 mA.
  - Linearity: >105.
  - PPC pneumatics: Software flow control of gas.
- Software:**

- Software performing data analyses at least as per DIN/ISO/US-EPA, calibration, blank correction, data import, export, handling and reporting, quality control protocols, computer- based training.

## 2. Analyzer 2 Specifications

*Analyzer 2 is required to measure N<sub>2</sub>, O<sub>2</sub>/Argon, CO, CO<sub>2</sub> & total hydrocarbon containing oxygenated organic species (As Methane form) content in Hydrogen (H<sub>2</sub>) fuel gas.*

### **Expected Performance:**

- Minimum detection limit (MDL) for N<sub>2</sub>, O<sub>2</sub>/Argon, CO & total hydrocarbon containing oxygenated organic species (As Methane form) ≤ 50 ppb.
- Minimum detection limit (MDL) for CO<sub>2</sub> ≤ 0.1 ppm.
- Analyzer 2 requires three analytical channels which can run simultaneously or separately. Carrier gas to be used in analytical channels 1 & 3 is He.
- Analytical channel 1, for the analysis of N<sub>2</sub>, O<sub>2</sub>/Ar & CO, to feature an 8 port multifunction gas sampling valve with backflush to vent by mid-point pressure change, a PLOT capillary column system and a Discharge Ionization Detector (DID). The valve and all connections to the columns are contained in an unheated, purged box mounted on the side of the GC.
- Analytical channel 2, for detection of CO, CO<sub>2</sub> & CH<sub>4</sub>, to feature a multiple function Gas Sampling Valve, Methanizer, Flame Ionization Detector & suitable packed column.
- To optimize performance at the trace levels, the analyzer is plumbed with “passivated tubing”. The gas valve is mounted in a purged housing. The purged housing is filled with a positive pressure of carrier gas. Once CO<sub>2</sub> has fully eluted, column must backflush to vent.
- THC channel 3 to provide a guaranteed analysis of trace total hydrocarbons measured as methane. To maximize performance, treated tubing is used as needed throughout the analyzer.
- Analytical channel 3 to feature a Gas Sampling Valve and a Flame Ionization Detector (FID). FID to be used in common by Channel 2 & 3.
- Analyzer 2 requires Gas Sampling Valves, one Discharge Ionization Detector (DID), one Flame Ionization Detector (FID), Methanizer & Suitable columns.
- Analyzer 2 should consist of a 4 port valve configured with an auxiliary flow source to provide continuous flow while venting the majority of the matrix sample before the detector.
- The sample input for this analyzer should be VCR fitting; required in order to eliminate any air leakage into the sample when passed through the analyzer’s sample loop.
- Basic system with EPC/AFC/PPC control for carrier/detector zone gases.
- EPC/PPC/AFC should provide optimum performance with all types of columns and detectors.
- All parameters should be stored as a part of method for better analysis reproducibility.
- Power Supply: 220 VAC ±10%, 47 to 53 Hz.

### **Sub Components:**

- **Gas Flow Control:**
  - Standard with programmable pneumatic control; Digital Pneumatic Control for setting column flow with pressure, flow and linear velocity.
  - Carrier gas pneumatic program rates 0-100 psi/min or 0-100 ml/min or better.
  - Three-ramps pressure program for carrier gas.
  - Carrier pressure increment should be 0.1 psi or better.
- **GC Oven Characteristics:**
  - Volume ≥ 10L; for easy fixing and removal of different column types/dimensions without compromising rate of heating or cooling of oven.
  - All temperature and time functions should be micro-processor controlled and displayed on the screen.
  - Column over-heat protection required.
  - Temperature set point resolution ≤ 1°C.
  - Oven Operating temperature: (Ambient+10)°C to 450°C.
  - Temperature ramps ≥ 3; Maximum achievable temperature ramp rate ≥ 45°C/min.

- Cool down time (from 250°C to 50°C) ≤ 4.8 min.
- Time settings: 1 min increments for values 0 to 999 minutes or wider.
- **Flame Ionization Detector (FID):**
  - Operating Temperatures: 100°C to 350°C; in 1°C increments.
  - Minimum detectable quantity: <math>3 \times 10^{-12}</math> g C / s with Octane.
  - Sensitivity: >0.015 Coulombs / g C.
  - Linearity: > 107.
  - Makeup gas: Not required.
  - PPC pneumatics: Software flow control of hydrogen and air.
- **Software:**
  - Software performing data analyses at least as per DIN/ISO/US-EPA, calibration, blank correction, data import, export, handling and reporting, quality control protocols, computer- based training.

### 3. Analyzer 3 Specifications

*Analyzer 3 is required to measure total sulphur compounds including H<sub>2</sub>S, COS, CS<sub>2</sub> and mercaptans content in Hydrogen (H<sub>2</sub>) fuel gas.*

#### **Expected Performance:**

- Minimum detection limit (MDL) ≤ 10ppb.
- Analyzer 3 requires Gas Sampling Valve (GSV), a sulfur capillary column, and a Sulphur Chemiluminescence Detector (SCD).
- Analyzer 3 requires passivated tubing to avoid corrosion by H<sub>2</sub>S.
- Basic system with EPC/AFC/PPC control for carrier/detector zone gases.
- EPC/PPC/AFC should provide optimum performance with all types of columns and detectors.
- All parameters should be stored as a part of method for better analysis reproducibility.

#### **Sub Components:**

- **Gas Flow Control:**
  - Standard with programmable pneumatic control; Digital Pneumatic Control for setting column flow with pressure, flow and linear velocity.
  - Carrier gas pneumatic program rates 0-100 psi/min or 0-100 ml/min or better.
  - Three-ramps pressure program for carrier gas.
  - Carrier pressure increment should be 0.1 psi or better.
- **GC Oven Characteristics:**
  - Volume ≥ 10L; for easy fixing and removal of different column types/dimensions without compromising rate of heating or cooling of oven.
  - All temperature and time functions should be micro-processor controlled and displayed on the screen.
  - Column over-heat protection required.
  - Temperature set point resolution ≤ 1°C.
  - Oven Operating temperature: (Ambient+10)°C to 450°C.
  - Temperature ramps ≥ 3; Maximum achievable temperature ramp rate ≥ 45°C/min.
  - Cool down time (from 250°C to 50°C) ≤ 4.8 min.
  - Time settings: 1 min increments for values 0 to 999 minutes or wider.
- **Sulphur Chemiluminescence Detector (SCD):**
  - SCD detection limit < 0.3p gram sulfur per sec or better.
  - Selectivity: 107 g S / g C or better.
- **Software:**
  - Software performing data analyses at least as per DIN/ISO/US-EPA, calibration, blank correction, data import, export, handling and reporting, quality control protocols, computer - based training.
- **Accessories Required:**

- Extra 1 set of columns for each analyzer.
- Installation kit - Qty 3.
- Gas Sampling Valve Kit - Qty 3.
- 1/4 - 1/8 Union Reducing Kit - Qty 10.
- Two port manual toggle valve Brass - Qty 3.
- Tubing Nickel 1\16 -10 feet - Qty 10.
- 1\16 Std. ferrule - Qty 10.
- 1\16 Std. nut - Qty 10.
- REDUCING FERRULE 1/8" X 1/16" GRAPHITE - Qty 10.
- UNION REDUCER 1/8 X 1/16 STEEL- Qty 10.
- UNION REDUCER 1/4 X 1/8 STEEL - Qty 10.
- UNION REDUCER 1/4 X 1/16 STEEL - Qty 10.
- RDCR-TBG PORT 1/16 TB ¼ - Qty 10.
- 2 Micron In-line Filter - 1/8 in. Stainless Steel - Qty 10.
- 1/8 DIA .003 2SR2 2U Screen - Qty 10.
- 1 ml Gas tight syringe.

#### 4. FTIR Spectrometer Specifications

*Computer controlled, High performance, Research grade, High resolution FTIR system capable of analyzing Gaseous compounds.*

##### **Expected performance:**

- Spectral range: 7800-350cm<sup>-1</sup> or better with KBr beam splitter. System should be upgradable to NIR region (upto 14700cm<sup>-1</sup>) or FIR region (upto 30cm<sup>-1</sup>).
- Signal to Noise ratio should be 50000:1, peak to peak for 1 min & 4 cm<sup>-1</sup> resolution.
- Wavenumber precision: 0.008cm<sup>-1</sup> at 2000cm<sup>-1</sup>.
- Wavenumber accuracy: 0.02cm<sup>-1</sup> at 2000cm<sup>-1</sup>.
- Resolution: 0.4cm<sup>-1</sup> or better.
- Atmospheric compensation: Effect of atmospheric water, CO2 etc. to be minimized on sample spectra without the need for reference or calibration spectra.
- Helium; Hydrogen; All Sulphur compounds; Argon; Oxygen; Nitrogen; Methane; Carbon Monoxide detection limits to be mentioned.
- Desiccants pair to be quoted additionally.
- FTIR system to utilize high reflectivity, gold coated reflecting optics incorporating low angle off-axis design for optimal throughput.
- FTIR system to have upgradability features like upgrade with FTIR Microscope/Imaging and upgrade to evolved gas analysis.

##### **Sub Components:**

- ***Michelson Interferometer (sealed & desiccated)***
- ***High sensitivity DTGS detector:***
  - With temperature control mechanism.
  - Up to 2 detectors should be supported. Second detector to be quoted as MCT.
  - Software selectable.
  - Facility required in place permanently in detector compartment.
- ***Integrated methane gas cell:***
  - Ensure high instrument-to-instrument stability and line-shape calibration technology.
- ***Software controlled validation wheel:***
  - Contains a polystyrene reference material, traceable to a NIST standard for wavenumber accuracy and a Schott NG11 filter for ordinate repeatability.
- ***7-position automated optical filter wheel:***

- Contains traceable validation materials to allow instrument performance verification on the Mid spectral regions.
- **Multi-layer potassium bromide beamsplitter:**
  - Required for the Mid-IR spectral region.
- **Large sample area:**
  - Provides plug-and-go capabilities for a wide range of Mid sampling accessories.
- **Accessories:**
  - 10m Tornado Fixed, long path length cells to be quoted.
- **Software:**
  - Should have self diagnostic after initialization.
  - Provision for creation of library.
  - Provision for search functions like spectral search, peak search, text search.

## 5. Interfaces Required

- GC Analyzer systems must have touch screen user interface for easy instrument operation.

## 6. Control and Automation Features if any

- The functions should allow the user to operate the automation system in manual and automatic mode.
- GC analyzers to be fully automated with programmable pneumatic/digital control.

## 7. Measurement Data Acquisition & Storage

All quantities acquired in measurement requests and the derived results to be stored permanently in a well-managed way.

## 8. Multi-Level Safety Monitoring

A tool for multi-level safety monitoring is required to ensure the optimal safety of operator, unit under test and test bed in all operating states.

## 9. Services to be supplied on various aspects related to the installation:

### i. Electrical Engineering:

- Electrical integration of all test system components at IISc test cell environment.
- The electrical engineering has to be carried out according to EN-60204-1 - Safety of machinery  
Electrical Equipment of machines
- All documents listed are to be provided.

### ii. Mechanical Engineering:

Mechanical / physical integration of the test system components at IISc test cell environment comprising of the following but not limited to:

- Creation of a 3D layout of the test cell, the operator area and –if applicable – the technical area. Note: Drawings of the concerned part of the building will be provided in a suitable digital format by IISc.
- Detailed Engineering and specification of specific components and subsystems as specified in the technical specifications.
- Arrangement of the equipment / components / devices to be supplied and incorporation of them into the 2D-layout.
- Design drawings are to be delivered.
- Fuel storage guidelines must be clearly specified for a variety of liquid and gaseous fuels along with safety aspects.

### **iii. Mechanical Installation and Commissioning:**

Ensuring correct erection of the mechanical parts of the system (according to the scope of supply) and to guarantee compliance to installation specifications prior to test system commissioning and productive operation.

- Positioning and mounting of all equipment in cooperation (if necessary with local subcontractor)
- Removal of protection coatings and transport locking device(s)
- Alignment of equipment at designated location
- Commissioning of mechanical system elements

### **iv. Commissioning:**

Well trained, qualified and certified engineers shall perform all required steps to get the single equipment and complete test system ready for the acceptance test as defined in the particular agreement. Following activities are to be included:

- Check of power & media supply, data, measurement and sampling connections.
- Installation, configuration and parameterization of all software.
- Allocation and verification of used I/O and measurement channels according to engineering.
- Interfacing of peripheral equipment based on scope of supply.
- Commissioning work is carried out with one fully functional single cylinder research engine.
- Controller set-up and basic tuning for the given UUT/Load System combination as a preparation for the Final Acceptance Test.

## **10. Documentation:**

Includes a compilation of following documents (digital format); user manuals included typically:

- Operating manual
- Maintenance instructions and schedules
- Spare and wear parts lists as well as a list of consumables, safety instructions and a troubleshooting guide.
- Emergency measures according to the safety matrix.
- Documentation of third party products (language as available).
- System engineering drawings.
- Description of the test bed layout and functionality
- Trouble shooting and emergency measures

**The documentation shall be provided in English language.**

## **11. Other Items**

- The cost of the Hydrogen Gas Analyzer System and that of each equipment/accessory to be quoted separately.
- The vendor must submit a signed compliance document mentioning whether their equipment meets each and every specification detailed above.
- The award of the tender will be decided by the institute as per price of the complete system. All insurance charges shall be borne by the vendor.
- Technical and financial bids should be submitted separately.
- All prices of the Hydrogen Gas Analyzer System and accessories should be quoted in currency of respective country of origin of the equipment.
- The specifications mentioned shall be understood to be the minimum required. Additional technical and research features suitable to our requirements shall be given due reference.
- Vendors that submit qualifying technical and financial bids are required to send competent representatives from the sales and technical divisions for further negotiations.



**All the communication in this regard should be addressed to:**

The Chairman  
ICER,  
Indian Institute of Science  
Bangalore 560 012  
India

With attention to Prof. S Dasappa.

The email communication should be to [dasappa@iisc.ac.in](mailto:dasappa@iisc.ac.in).

## **SPECIFIC TERMS AND CONDITIONS**

The following requirements should be specifically adhered to by the vendor, and express indication should be given regarding adherence.

### **1. GUARANTEE PERIOD**

- The equipment should be guaranteed for a period of 12 months from the date of handing over the fully functional unit to the Institute, against manufacturing defects of material and workmanship.
- Separate list of spares desirable for an R and D lab along with costs to be provided separately with individual costs.

### **2. POST GUARANTEE ANNUAL MAINTENANCE CONTRACT(AMC)**

Annual maintenance contract (AMC) for the complete system will be start after expiry of the warranty period as per agreed terms and conditions. The contract will also include the recommissioning of the system for what so ever reasons.

- Costs for the post-guarantee 3 years of annual maintenance contract for the complete system which includes all the accessories supplied during the installation. One annual visit by relevant subject expert(s) must be scheduled during the period of AMC.
- The amount due every year on account of the AMC will be paid at the beginning of theyear to the vendor.

### **3. WARRANTY**

- The complete system is to be under warranty period of 36 months including free supply of spare parts, and labour from the date of functional installation, commissioning and acceptance.
- During the period of warranty the supplier is required to take full responsibility to recommissionthe system in the event of failure whatsoever reasons.

### **4. DOCUMENTATION**

- Two sets of operational/service/application manuals are to be provided along with the Equipment in English.
- Detailed documentation on various sequences, application software and evaluation software etc. are to be provided and the same must be updated regularly for next 10 years as and when these are released.
- Supplier is required to ensure mailing of product/research newsletters released from their R&D sites to the our site on a regular basis. This is to keep this centre abreast of the latest developments taking place in system technology and research techniques.
- The vendor is to provide a tender compliance sheet by giving all the necessary specifications, which should be supported by printed documentation sheets and certification of each item. In the absence of such documentation, a letter from the principals of the company should be provided.
- The vendor must provide at least one USER SATISFACTION CERTIFICATE for equivalent / similar kind of supply and installations.

### **5. SOFTWARE UPGRADATION**

Software upgrades for the core system and all related applications for next 10 years to be provided free by the firm as a matter of routine as and when these are released, inclusive of minor hardware changes.

### **6. RESEARCH COOPERATION (Optional)**

- The vendor is required to provide work in progress packages to us for research trial as for their

- other research sites. The firm should provide an exhaustive list of performance of various engines which will help the research and cooperation.
- The vendor should extend demonstrated cooperation regarding design and implementation of novel hardware and software inputs as required by the user, such as newer analysis techniques, emissions standards, post-processing, synthesis of data.
- Specific proposal regarding research collaboration will be submitted subsequently for consent and counter signatures of the principals on the research proposal.

## **7. DELIVERY, INSTALLATION & COMMISSIONING OF THE SYSTEM**

The facility should be built and the Hydrogen Gas Analyzer System should be delivered, installed and functionally commissioned within 6 months from the date of receipt of confirmed supply order. The supply of the items will be considered as effected only on satisfactory commissioning and inspection of the system by the institute. After successful installation and inspection, the date of taking over of the entire complete running of the Hydrogen Gas Analyzer System system by the institute shall be taken as the start of the warranty period.

## **8. CUSTOM CLEARANCE**

The Institute will furnish the necessary papers for the import of items into India, necessary custom duty exemption certificate and other supporting documents to facilitate the import of the items.

**Note: Institute has got into an agreement with M/S FEI Cargo for custom clearance of all imported equipments to the Institute.**

## **9. TRAINING**

The supplier, at their expense, will arrange for an application specialist, immediately after the installation and commissioning of the Hydrogen Gas Analyzer System, to demonstrate the capabilities/features of the system and also to impart training to staff members. The supplier, at their expense, shall provide initial specialized training at our site by a research scientist and a research engineer from the supplier's international R&D Centre or from an internationally renowned centre; the training shall cover the state of art research application, together with system operation and first line maintenance of the system, system and application software, along with developmental aspects for modifications and development of user defined sequences, for various application purposes, etc. The travel, boarding and lodging expenses of the above personnel, scientist and engineer shall be borne by the vendor and this training should be completed before handing over the Hydrogen Gas Analyzer System to us.

## **10. MODE OF SHIPMENT**

The consignment must be air-lifted, insured and transported to the installation site by the supplier.

## **11. PAYMENT TERMS**

A confirmed irrevocable and divisible letter of credit will be opened with the bank designated by the vendor with 80% of the total cost payable against confirmed proof of dispatch and the remaining 20% balance on successful installation against a bank guarantee of 10% of the total cost for the 3 years warranty period.

## TERMS AND CONDITIONS FOR SUBMISSION OF BIDS

Both the Technical and Commercial bid should be put in separate sealed envelopes and both the envelopes should be put in another cover subscribing “**Bio-Hydrogen Gas Analyzer System**” and should reach “*The Chairman, Interdisciplinary centre for Energy Research, IISc, Bangalore-560012*” on or before **24<sup>th</sup> June 2020**.

The Technical bid must include all the details of technical specifications of the equipment, compliance certificate along with commercial terms and conditions, **however, without the price component**. The bill of materials printed technical brochure and any other documents to help the technical evaluation of the bid may be enclosed.

1. The commercial bid must include the price of the item(s) in Indian/Foreign currency indicating the breakup of

a) For Goods manufactured within India

- (i) The price of the goods quoted Ex-works including taxes already paid.
- (ii) GST and other taxes like excise duty, entry tax and other applicable taxes which will be payable on the goods if the contract is awarded.
- (iii) The charges for inland transportation, insurance and other local services required for delivering the goods to IISc, Bangalore.
- (iv) The installation, commissioning and training charges including any incidental services, if any with applicable service taxes.

(b) For Goods manufactured abroad

- (i) The price of the goods should be quoted on CIF/DAP Bangalore, India basis.
- (ii) The charges for insurance and transportation of the goods by Air/Sea up to Bangalore India.
- (iii) The agency commission charges, if any.
- (iv) The installation, commissioning and training charges including any incidental services, if any.

2. The invoice to be billed at applicable GST and for concessional GST rates, GST concession certificate(s) shall be provided.

3. Please indicate the import code of the items.

4. Goods found to be defective by the committee during installation and warranty have to be replaced / rectified. Items found not acceptable or missing have to be replaced / rectified. Replacement of parts to be at the cost of the supplier (including all incidental charges), within 15 days from the date of receipt of written communication from us. If there is any delay in replacement / rectification, the warranty period should be correspondingly extended.

5. The terms FOB, FCA, CIF, CIP, etc., shall be governed by the rules prescribed in the current edition of the Incoterms published by the International Chambers of Commerce, Paris.

6. The purchases made by the purchaser for scientific purpose are exempt from excise duty and Custom Duty at a concessional rate is leviable.
7. Conditional tenders shall not be accepted.
8. Bids shall remain valid for minimum of 90 days after the date of bid opening prescribed by the Purchaser.
9. The Purchaser reserves the right to accept or reject any bid, and to annul the bidding process and reject all bids at any time prior to award of Contract, without thereby incurring any liability to the affected Bidder or Bidders.
10. The bidder should have established track record of Design, Manufacturing and supply of Rotor Balancing Machines.
11. Technical support for 3 year must be provided.
12. Onsite inspection of the machine will be done by IISc before the dispatch at IISc cost.

## Annexure-I

Note: Compliance Certificate to be enclosed with the technical bid

Description	Comply	Non-comply	Deviation from specifications	Remarks
<b>Analyzer Train - Expected Performance</b>				
<b>Application</b>				
<ul style="list-style-type: none"> <li>Analyse O2/Argon, He, N2, CO, CO2, total hydrocarbons containing oxygenated organic species (measured as Methane) &amp; total sulphur compounds including H2S, COS, CS2 and mercaptans present in Hydrogen fuel gas.</li> </ul>				
<b>Sample Gas Feed</b>				
<ul style="list-style-type: none"> <li>Hydrogen (<math>\approx 99.99\%</math> purity)</li> </ul>				
<b>Sample Pressure</b>				
<ul style="list-style-type: none"> <li>1 bar absolute</li> </ul>				
<b>Sample Temperature</b>				
<ul style="list-style-type: none"> <li>Ambient (<math>\approx 25^{\circ}\text{C}</math>)</li> </ul>				
<b>Equipment required</b>				
<ul style="list-style-type: none"> <li>Three GC Analyzers</li> <li>One FT-IR Spectrometer</li> </ul>				
<b>Software</b>				
<ul style="list-style-type: none"> <li>Compatible with computer and software: Windows 10 or latest.</li> </ul>				
<b>Instrumentation &amp; Controls</b>				
<ul style="list-style-type: none"> <li>Fully automated with programmable pneumatic/digital control.</li> </ul>				
<b>Quality Control</b>				
<ul style="list-style-type: none"> <li>Fully factory tested, calibrated &amp; guaranteed for the mentioned applications. Shipment documents should come with related test certificates. Chromatograms (analysis results carried out in supplied customized Gas Analyzers) for</li> </ul>				

mentioned applications must be submitted along with shipping documents. Serial number of the Equipment to be mentioned in Chromatograms.				
<ul style="list-style-type: none"> <li>ISO 9001 certification for the design, manufacture and service of the FTIR instrument required.</li> </ul>				
<b>I. Analyzer 1 Specifications</b>				
<ul style="list-style-type: none"> <li>Analyzer 1 is required to measure <u>Helium (He) content in Hydrogen (H2) fuel gas.</u></li> </ul>				
<b>Expected Performance</b>				
<ul style="list-style-type: none"> <li>Minimum detection limit (MDL) <math>\leq 10</math> ppm.</li> <li>Analyzer 1 requires nitrogen carrier gas and a multifunction gas sampling valve.</li> <li>Analyzer 1 requires a Thermal Conductivity Detector (TCD) with suitable packed column, preferably Molecular Sieve 5A column.</li> <li>Basic system with EPC/AFC/PPC control for carrier/detector zone gases.</li> <li>EPC/PPC/AFC should provide optimum performance with all types of columns and detectors.</li> <li>All parameters should be stored as a part of method for better analysis reproducibility.</li> <li>Power Supply: 220 VAC <math>\pm 10\%</math>, 47 to 53 Hz.</li> </ul>				
<b>Sub Components</b>				
<b>Gas Flow Control</b>				
<ul style="list-style-type: none"> <li>Carrier gas pneumatic program rates 0-100 psi/min or 0-100 ml/min or better.</li> <li>Three-ramps pressure program for carrier gas.</li> <li>Carrier pressure increment should be 0.1 psi or better.</li> </ul>				
<b>GC Oven Characteristics</b>				
<ul style="list-style-type: none"> <li>Volume <math>\geq 10L</math>; for easy fixing and removal of different column types/dimensions without compromising rate of heating or cooling of oven.</li> </ul>				

<ul style="list-style-type: none"> <li>• All temperature and time functions should be micro-processor controlled and displayed on the screen.</li> <li>• Column over-heat protection required.</li> <li>• Temperature set point resolution <math>\leq 1^{\circ}\text{C}</math>.</li> <li>• Oven Operating temperature: (Ambient+10)<math>^{\circ}\text{C}</math> to 450<math>^{\circ}\text{C}</math>.</li> <li>• Temperature ramps <math>\geq 3</math>; Maximum achievable temperature ramp rate <math>\geq 45^{\circ}\text{C}/\text{min}</math>.</li> <li>• Cool down time (from 250<math>^{\circ}\text{C}</math> to 50<math>^{\circ}\text{C}</math>) <math>\leq 4.8</math> min.</li> <li>• Time settings: 1 min increments for values 0 to 999 minutes or wider.</li> </ul>				
<b>Thermal Conductivity Detector</b>				
<ul style="list-style-type: none"> <li>• Operating Temperatures: 100<math>^{\circ}\text{C}</math> to 350<math>^{\circ}\text{C}</math>; in 1<math>^{\circ}\text{C}</math> increments.</li> <li>• Minimum detectable quantity: &lt;1ppm Nonane.</li> <li>• Sensitivity: 9 <math>\mu\text{V}/\text{ppm}</math> Nonane at 160 mA.</li> <li>• Linearity: &gt;105.</li> <li>• PPC pneumatics: Software flow control of gas.</li> </ul>				
<b>Software</b>				
<ul style="list-style-type: none"> <li>• Software performing data analyses at least as per DIN/ISO/US-EPA, calibration, blank correction, data import, export, handling and reporting, quality control protocols, computer-based training.</li> </ul>				
<b>II. Analyzer 2 Specifications</b>				
<ul style="list-style-type: none"> <li>• Analyzer 2 is required to measure N<sub>2</sub>, O<sub>2</sub>/Argon, CO, CO<sub>2</sub> &amp; total hydrocarbon containing oxygenated organic species (As Methane form) content in Hydrogen (H<sub>2</sub>) fuel gas.</li> </ul>				
<b>Expected Performance</b>				
<ul style="list-style-type: none"> <li>• Minimum detection limit (MDL) for N<sub>2</sub>, O<sub>2</sub>/Argon, CO &amp; total hydrocarbon containing oxygenated organic species (As Methane form) <math>\leq 50</math> ppb.</li> <li>• Minimum detection limit (MDL) for CO<sub>2</sub> <math>\leq 0.1</math> ppm.</li> <li>• Analyzer 2 requires three analytical</li> </ul>				



<p>channels which can run simultaneously or separately. Carrier gas to be used in analytical channels 1 &amp; 3 is He.</p> <ul style="list-style-type: none"> <li>• Analytical channel 1, for the analysis of N2, O2/Ar &amp; CO, to feature an 8 port multifunction gas sampling valve with backflush to vent by mid-point pressure change, a PLOT capillary column system and a Discharge Ionization Detector (DID). The valve and all connections to the columns are contained in an unheated, purged box mounted on the side of the GC.</li> <li>• Analytical channel 2, for detection of CO, CO2 &amp; CH4, to feature a multiple function Gas Sampling Valve, Methanizer, Flame Ionization Detector &amp; suitable packed column.</li> <li>• To optimize performance at the trace levels, the analyzer is plumbed with “passivated tubing”. The gas valve is mounted in a purged housing. The purged housing is filled with a positive pressure of carrier gas. Once CO2 has fully eluted, column must backflush to vent.</li> <li>• THC channel 3 to provide a guaranteed analysis of trace total hydrocarbons measured as methane. To maximize performance, treated tubing is used as needed throughout the analyzer.</li> <li>• Analytical channel 3 to feature a Gas Sampling Valve and a Flame Ionization Detector (FID). FID to be used in common by Channel 2 &amp; 3.</li> <li>• Analyzer 2 requires Gas Sampling Valves, one Discharge Ionization Detector (DID), one Flame Ionization Detector (FID), Methanizer &amp; Suitable columns.</li> <li>• Analyzer 2 should consist of a 4 port valve configured with an auxiliary flow source to provide continuous flow while venting the majority of the matrix sample before the detector.</li> <li>• The sample input for this analyzer should be VCR fitting; required in order to eliminate any air leakage into the sample when passed through the analyzer’s sample loop.</li> <li>• Basic system with EPC/AFC/PPC control for carrier/detector zone gases.</li> <li>• EPC/PPC/AFC should provide</li> </ul>				
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<p>optimum performance with all types of columns and detectors.</p> <ul style="list-style-type: none"> <li>All parameters should be stored as a part of method for better analysis reproducibility.</li> <li>Power Supply: 220 VAC <math>\pm</math>10%, 47 to 53 Hz.</li> </ul>				
<b>Sub Components</b>				
<b>Gas Flow Control</b>				
<ul style="list-style-type: none"> <li>Standard with programmable pneumatic control; Digital Pneumatic Control for setting column flow with pressure, flow and linear velocity.</li> <li>Carrier gas pneumatic program rates 0-100 psi/min or 0-100 ml/min or better.</li> <li>Three-ramps pressure program for carrier gas.</li> <li>Carrier pressure increment should be 0.1 psi or better.</li> </ul>				
<b>GC Oven Characteristics</b>				
<ul style="list-style-type: none"> <li>Volume <math>\geq</math> 10L; for easy fixing and removal of different column types/dimensions without compromising rate of heating or cooling of oven.</li> <li>All temperature and time functions should be micro-processor controlled and displayed on the screen.</li> <li>Column over-heat protection required.</li> <li>Temperature set point resolution <math>\leq</math> 1°C.</li> <li>Oven Operating temperature: (Ambient+10)°C to 450°C.</li> <li>Temperature ramps <math>\geq</math> 3; Maximum achievable temperature ramp rate <math>\geq</math> 45°C/min.</li> <li>Cool down time (from 250°C to 50°C) <math>\leq</math> 4.8 min.</li> <li>Time settings: 1 min increments for values 0 to 999 minutes or wider.</li> </ul>				
<b>Flame Ionization Detector (FID)</b>				
<ul style="list-style-type: none"> <li>Operating Temperatures: 100°C to 350°C; in 1°C increments.</li> <li>Minimum detectable quantity: <math>&lt;3 \times 10^{-12}</math> g C / s with Octane.</li> <li>Sensitivity: <math>&gt;0.015</math> Coulombs / g C.</li> <li>Linearity: <math>&gt; 107</math>.</li> <li>Makeup gas: Not required.</li> <li>PPC pneumatics: Software flow</li> </ul>				

control of hydrogen and air.				
<b>Software</b>				
<ul style="list-style-type: none"> <li>Software performing data analyses at least as per DIN/ISO/US-EPA, calibration, blank correction, data import, export, handling and reporting, quality control protocols, computer-based training.</li> </ul>				
<b>III. Analyzer 3 Specifications</b>				
<ul style="list-style-type: none"> <li>Analyzer 3 is required to measure total sulphur compounds including H<sub>2</sub>S, COS, CS<sub>2</sub> and mercaptans content in Hydrogen (H<sub>2</sub>) fuel gas.</li> </ul>				
<b>Expected Performance</b>				
<ul style="list-style-type: none"> <li>Minimum detection limit (MDL) ≤ 10ppb.</li> <li>Analyzer 3 requires Gas Sampling Valve (GSV), a sulfur capillary column, and a Sulphur Chemiluminescence Detector (SCD).</li> <li>Analyzer 3 requires passivated tubing to avoid corrosion by H<sub>2</sub>S.</li> <li>Basic system with EPC/AFC/PPC control for carrier/detector zone gases.</li> <li>EPC/PPC/AFC should provide optimum performance with all types of columns and detectors.</li> <li>All parameters should be stored as a part of method for better analysis reproducibility.</li> </ul>				
<b>Sub Components</b>				
<b>Gas Flow Control</b>				
<ul style="list-style-type: none"> <li>Standard with programmable pneumatic control; Digital Pneumatic Control for setting column flow with pressure, flow and linear velocity.</li> <li>Carrier gas pneumatic program rates 0-100 psi/min or 0-100 ml/min or better.</li> <li>Three-ramps pressure program for carrier gas.</li> <li>Carrier pressure increment should be 0.1 psi or better.</li> </ul>				
<b>GC Oven Characteristics</b>				
<ul style="list-style-type: none"> <li>Volume ≥ 10L; for easy fixing and removal of different column types/dimensions without</li> </ul>				

<p>compromising rate of heating or cooling of oven.</p> <ul style="list-style-type: none"> <li>• All temperature and time functions should be micro-processor controlled and displayed on the screen.</li> <li>• Column over-heat protection required.</li> <li>• Temperature set point resolution <math>\leq 1^{\circ}\text{C}</math>.</li> <li>• Oven Operating temperature: (Ambient+10)<math>^{\circ}\text{C}</math> to 450<math>^{\circ}\text{C}</math>.</li> <li>• Temperature ramps <math>\geq 3</math>; Maximum achievable temperature ramp rate <math>\geq 45^{\circ}\text{C}/\text{min}</math>.</li> <li>• Cool down time (from 250<math>^{\circ}\text{C}</math> to 50<math>^{\circ}\text{C}</math>) <math>\leq 4.8</math> min.</li> <li>• Time settings: 1 min increments for values 0 to 999 minutes or wider.</li> </ul>				
<b>Sulphur Chemiluminescence Detector (SCD)</b>				
<ul style="list-style-type: none"> <li>• SCD detection limit &lt; 0.3p gram sulfur per sec or better.</li> <li>• Selectivity: 107 g S / g C or better.</li> </ul>				
<b>Software</b>				
<ul style="list-style-type: none"> <li>• Software performing data analyses at least as per DIN/ISO/US-EPA, calibration, blank correction, data import, export, handling and reporting, quality control protocols, computer - based training.</li> </ul>				
<b>Accessories Required</b>				
<ul style="list-style-type: none"> <li>• Extra 1 set of columns for each analyzer.</li> <li>• Installation kit - Qty 3.</li> <li>• Gas Sampling Valve Kit - Qty 3.</li> <li>• 1/4 - 1/8 Union Reducing Kit - Qty 10.</li> <li>• Two port manual toggle valve Brass - Qty 3.</li> <li>• Tubing Nickel 1\16 -10 feet - Qty 10.</li> <li>• 1\16 Std. ferrule - Qty 10.</li> <li>• 1\16 Std. nut - Qty 10.</li> <li>• REDUCING FERRULE 1/8" X 1/16" GRAPHITE - Qty 10.</li> <li>• UNION REDUCER 1/8 X 1/16 STEEL- Qty 10.</li> <li>• UNION REDUCER 1/4 X 1/8 STEEL - Qty 10</li> <li>• UNION REDUCER 1/4 X 1/16 STEEL - Qty 10.</li> <li>• RDCR-TBG PORT 1/16 TB 1/4 - Qty 10.</li> </ul>				

<ul style="list-style-type: none"> <li>• 2 Micron In-line Filter - 1/8 in. Stainless Steel - Qty 10.</li> <li>• 1/8 DIA .003 2SR2 2U Screen - Qty 10.</li> <li>• 1 ml Gas tight syringe.</li> </ul>				
<b>IV. FTIR Specifications</b>				
<ul style="list-style-type: none"> <li>• Computer controlled, High performance, Research grade, High resolution FTIR system capable of analyzing Gaseous compounds.</li> </ul>				
<b>Expected performance</b>				
<ul style="list-style-type: none"> <li>• Spectral range: 7800-350cm-1 or better with KBr beam splitter. System should be upgradable to NIR region (upto 14700cm-1) or FIR region (upto 30cm-1).</li> <li>• Signal to Noise ratio should be 50000:1, peak to peak for 1 min &amp; 4 cm-1 resolution.</li> <li>• Wavenumber precision: 0.008cm-1 at 2000cm-1.</li> <li>• Wavenumber accuracy: 0.02cm-1 at 2000cm-1.</li> <li>• Resolution: 0.4cm-1 or better.</li> <li>• Atmospheric compensation: Effect of atmospheric water, CO2 etc. to be minimized on sample spectra without the need for reference or calibration spectra.</li> <li>• Ammonia, H2O, Formaldehyde, Formic Acid, Methane; Carbon Monoxide detection limits to be mentioned.</li> <li>• Desiccants pair to be quoted additionally.</li> <li>• FTIR system to utilize high reflectivity, gold coated reflecting optics incorporating low angle off-axis design for optimal throughput.</li> <li>• FTIR system to have upgradability features like upgrade with FTIR Microscope/Imaging and upgrade to evolved gas analysis.</li> </ul>				
<b>Sub Components</b>				
<ul style="list-style-type: none"> <li>• <i>Michelson Interferometer (sealed &amp; desiccated).</i></li> <li>• <i>High sensitivity DTGS detector:</i> <ul style="list-style-type: none"> <li>- With temperature control mechanism.</li> <li>- Up to 2 detectors should be</li> </ul> </li> </ul>				

<p>supported. Second detector to be quoted as MCT.</p> <ul style="list-style-type: none"> <li>- Software selectable.</li> <li>- Facility required in place permanently in detector compartment.</li> </ul> <ul style="list-style-type: none"> <li>• <i>Integrated methane gas cell:</i> <ul style="list-style-type: none"> <li>- Ensure high instrument-to-instrument stability and line-shape calibration technology.</li> </ul> </li> <li>• <i>Software controlled validation wheel:</i> <ul style="list-style-type: none"> <li>- Contains a polystyrene reference material, traceable to a NIST standard for wavenumber accuracy and a Schott NG11 filter for ordinate repeatability.</li> </ul> </li> <li>• <i>7-position automated optical filter wheel:</i> <ul style="list-style-type: none"> <li>- Contains traceable validation materials to allow instrument performance verification on the Mid spectral regions.</li> </ul> </li> <li>• <i>Multi-layer potassium bromide beamsplitter:</i> <ul style="list-style-type: none"> <li>- Required for the Mid-IR spectral region.</li> </ul> </li> <li>• <i>Large sample area:</i> <ul style="list-style-type: none"> <li>- Provides plug-and-go capabilities for a wide range of Mid sampling accessories.</li> </ul> </li> <li>• <i>Accessories:</i> <ul style="list-style-type: none"> <li>- 10m Tornado Fixed, long path length cells to be quoted.</li> </ul> </li> <li>• <i>Software:</i> <ul style="list-style-type: none"> <li>- Should have self diagnostic after initialization.</li> <li>- Provision for creation of library.</li> <li>- Provision for search functions like spectral search, peak search, text search.</li> </ul> </li> </ul>				
<b>Interfaces Required</b>				
<ul style="list-style-type: none"> <li>• GC Analyzer systems must have touch screen user interface for easy instrument operation.</li> </ul>				
<b>Control and Automation Features</b>				
<ul style="list-style-type: none"> <li>• The functions should allow the user to operate the automation system in manual and automatic mode.</li> <li>• GC analyzers to be fully automated with programmable pneumatic/digital control.</li> </ul>				
<b>Measurement Data Acquisition &amp; Storage</b>				

<ul style="list-style-type: none"> <li>All quantities acquired in measurement requests and the derived results to be stored permanently in a well-managed way.</li> </ul>				
<p><b>Multi-Level Safety Monitoring</b></p>				
<ul style="list-style-type: none"> <li>A tool for multi-level safety monitoring is required to ensure the optimal safety of operator, unit under test and test bed in all operating states.</li> </ul>				

## **Annexure-II**

### **MANUFACTURERS' AUTHORIZATION FORM**

*[The bidder shall require the manufacturer to fill in this form in accordance with the instructions indicated. This letter of authorization should be on the letterhead of the Manufacturer and should be signed by the person with the proper authority to sign documents that are binding on the Manufacturer.]*

Date: [insert date (as day, month and year) of Bid Submission]

Tender No.: [insert number from Invitation for Bids]

To: **The Chairman, Interdisciplinary Centre for Energy Research, IISc, Bangalore-560012.**

#### **WHEREAS**

We [insert complete name of Manufacturer], who are official manufacturers of [insert full address of Manufacture's factories], do hereby authorize [insert complete name of Bidder] to submit a bid the purpose of which is to provide the following Goods, manufactured by us [insert name and or brief description of the Goods], and to subsequently negotiate and sign the Contract.

We hereby extend our full guarantee and warranty with respect to the Goods offered by the above firm.

Signed: [insert signature(s) of authorized representative(s) of the Manufacturer]

Name: [insert complete name(s) of authorized representative(s) of the Manufacturer]

Title: [insert title]

Duly authorized to sign this authorization on behalf of: [insert complete name of Bidder]