

**Terms of reference (ToRs) for the procurement of services below the EU threshold**

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<b>Pre-Feasibility Study for 1000 tpd green ammonia production in India</b>	<b>Project number/ cost centre: 21.9016.3-015.00</b>
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## **0. List of abbreviations**

AVB	General Terms and Conditions of Contract (AVB) for supplying services and work 2022
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IGEF-SO	Indo-German Energy Forum Support Office
PTX	Power to X
RE	Renewable Energies
ToRs	Terms of reference
TPD	Tonnes per day

## 1. Context

To enhance and deepen the dialogue about the energy transition, the German Chancellor and the Indian Prime Minister established the Indo-German Energy Forum (IGEF) at the Hannover Fair in April 2006. The IGEF aims at initiating strategic cooperation projects between German and Indian governments, institutions, and the private sector. It aims at promoting cooperation in energy security, energy efficiency including energy conservation, renewable energy, investment in energy projects, and collaborative research and development in identified areas, considering the environmental challenges of sustainable development. The Support Office to the Indo-German Energy Forum is implemented by GIZ and has been tasked to support India in its ambition to become a global green hydrogen hub. Indo-German Energy Forum Support Office (IGEF-SO) is therefore implementing the H2-Uppp programme. The programme has been commissioned by the German Federal Ministry of Economic Affairs and Climate Action.

The H2-Uppp programme accompanies and supports efforts to ramp up the market for green hydrogen (H<sub>2</sub>) and Power to X (PtX) applications in India. Unlike other hydrogen support initiatives, H2-Uppp focuses on the early stages of green hydrogen project development. Green ammonia production has been identified as one of the first applications of green hydrogen to become commercially viable. This market study and location assessment for green ammonia production in India shall enable the development of this promising market segment in India.

## 2. Tasks to be performed by the contractor

The contractor is responsible for providing the following services:

A techno-commercially viable conceptual design in the form of a Detailed Project Report (DPR) specified by the tasks A. to H. for a green ammonia plant of initially up to 1,000 TPD.

### A. Site Requirements

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Compilation of necessary site requirements and information based on the production needs for a 1,000 TPD ammonia facility. Please note the intent is to provide an overview.

#### I. Location

- a) Climatic data
- b) Environmental data, with special precautions regarding natural disasters (e.g. earthquakes, floods), corrosivity, etc.

#### II. Process, Cooling, and Waste Water

- a) Volume and quality of the process, cooling, and waste water required or generated for the complete value chain (including hydrogen generation, cooling water, and service water, firefighting, drinking, etc.)
- b) Assessment of necessary water treatment steps and brine management for the different water sources under consideration in a cost-effective manner (desalination, borewell water, etc.)
- c) Proposed water balance diagram for production
- d) Operational requirement and safety stock storage requirement.

### III. Power

- a) Summary of energy storage options (e.g. batteries, banking, pumped-storage hydroelectricity) to ensure process stability and electrolyser full load hour extension
- b) Overview of the average and maximum electricity demand of the plant at full load and part load operation and its grid connection.
- c) Power tariff during the day, at different time periods, for design consideration will be provided.

### IV. Transport Infrastructure and Logistics

- a) Infrastructure required for supplying to domestic consumers (e.g. road, rail, pipeline);
- b) Required facilities for exporting to international consumers including storage bunkers at ports, based on varied parcel sizes (see section D);

### V. Area

- a) Building and plant areas of main sub-systems
- b) Site area (including safety and logistic spacing between sub-systems, piping corridors, access roads, etc.)

### VI. Profiling of Manpower (Numbers to be deployed, no of temporary household and the required area)

- a) Profiling for the construction duration at different phases of the project
- b) Profiling for the Regular Operation and Maintenance of the plant

## **B. System Design**

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A system for the hydrogen-to-ammonia value chain is to be developed within the framework of a 1000 TPD plant, consisting of:

- I. Electrical scheme (LT/HT)
- II. Electrolytic hydrogen production
- III. Process and cooling water provision and storage (e.g. through desalination)
- IV. Emergency backup battery storage system
- V. Air Separation Unit (ASU)
- VI. Intermediate hydrogen, nitrogen, and water storage
- VII. Compression system for Hydrogen, Nitrogen
- VIII. Ammonia synthesis via Haber-Bosch process or any other process
- IX. Ammonia storage and bulk transportation facilities
- X. Utilities and Effluent Treatment Plant

(Note dimensioning of the RE source is excluded from this assignment, electricity supply to the plant is given, power tariffs will be supplied to the consultant).

#### 1. Broad Design Concept

- a) Selection and assessment of suitable technology options (e.g. electrolyser types AEL or PEM) for the individual sub-systems based on techno-economic data and site-specific circumstances including design assumptions (corrosion class, input power source, etc.), advantages/disadvantages, technology readiness level (TRL) and suitable technology suppliers
- b) Operation management and storage concept based on the type and duration of renewable power sources and regulatory framework conditions

- c) Arrangement of sub-systems on the available areas under consideration of (a) explosion protection zones and safety distances, (b) an economic flow of materials and personnel and (c) possible future expansions

## 2. Dynamic Simulation and Optimization

Based on (a) the day and night energy tariffs from renewable energy (tariffs will be provided) , and (b) the established design concept, a dynamic simulation and optimization of the complete Hydrogen-to-Ammonia value chain is conducted to determine a cost optimum.

Based on the predetermined size of the ammonia plant of 1,000 TPD, this section should provide the optimal size of the sub-systems, of which the electrolysis, battery and hydrogen storage and synthesis are the most interesting results. The dimensions of other sub-systems (e.g. air separation unit, water & ammonia storage) are subject to a more linear dependency, and can be determined based hereupon.

The simulation and optimization should deliver the following key performance indicators amongst others:

- I. Dimension of the individual system components in the cost optimum
- II. Production quantity
- III. Relevant energy and material flows
- IV. Overall efficiency

## 3. Description of Sub-Systems and Equipment

- a) Techno-economic details about all relevant sub-systems and storages
- b) Techno-economic details about electrolyzer stacks and ammonia synthesis catalyst (e.g. operating conditions, lifetime, exchange interval, impurity resistance)
- c) Ammonia plant material and energy balance in flow chart
- d) Process flow scheme detailing all processes, equipment, interconnections
- e) Risk and Safety Studies e.g. HAZID, HAZOP, QRA etc
- f) Utilities
  - i. All plants and equipments including their capacities required for utility supply (e.g. compressed air, nitrogen).
  - ii. Feasibility of arranging necessary utilities other than power and water at the project site for the life of the project (e.g. compressed air).
- g) Offsite Systems
  - i. Cooling system (preferably air-cooled system)
  - ii. Hydrogen storage facilities on-site and at transport terminal.
  - iii. Ammonia storage tanks on-site and at transport terminal, including boil-off gas compression and refrigeration systems, flare, and supporting infrastructure.
  - iv. Oxygen handling system, including assessment of potential end-use cases.
- h) Effluent List and Effluent Treatment Plant (ETP)
  - i. Composition of effluent generated from the plant.
  - ii. Details like philosophy, size, etc about ETP
  - iii. Effluent Summary and ETP requirement.
  - iv. Solid and Hazardous Waste Generation and Management Plan.

#### 4. Material and Energy Balance

The main material and energy flows are named, quantified and characteristic operating conditions (pressure, temperature, concentrations, etc.) are identified.

- a) Overall material and energy balance
  - a.1.1. Overview of essential energy and material flows
  - a.1.2. Inventory of operating resources (e.g. catalysts) and utilities
- b) Hydrogen Balance
  - i. Configuration of hydrogen generation, compression, and storage units
  - ii. Operation management of hydrogen storage
- c) Nitrogen Balance
  - i. Configuration of nitrogen generation, compression, and storage units
  - ii. Usage of N<sub>2</sub> for Ammonia production
  - iii. Usage of N<sub>2</sub> in the Hydrogen circuit for purging activities
  - iv. Operation management of nitrogen storage
- d) Water and Steam Balance
  - i. Configuration of steam generation and heat exchangers
  - ii. Volume of possible steam generation from waste heat from ammonia synthesis, including the impact of process variance on steam production profile
  - iii. Assessment of waste heat utilization through heat pumps or power production
- e) Energy Balance
  - i. Power required by different equipment/systems in part and full load
  - ii. Differentiation between main system and BOP

#### **C. Safety and Risk Mitigation**

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1. Safety provisions for operating overall ammonia production complex including storage and transport facilities.
2. Template for Risk and Safety Studies (eg. HAZID, HAZOP, QRA etc)
3. Emergency provisions

#### **D. Operation Management**

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1. Turn down philosophy
  - a) Comparison of turning down the plant vs bigger storage of hydrogen and energy
  - b) Effect of turn down on equipment life and OPEX
2. Hot and cold start-up philosophy
3. Basic open loop and closed control systems (with control logic) involved
4. Operation - Control and Monitoring, level of automation
5. Performance Guarantee clauses

#### **E. Personnel and Manpower**

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1. Indicative staffing needs for operation (Operation, Technicians, Supervision, Engineering, Administration)
2. Maintenance requirements
3. Local availability of personnel
4. Training and qualification needs
5. Local training institutes

## **F. Financial Analysis and Techno-Economic Assessment**

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### **1. Capital Cost Estimate**

Breakup of the capital cost estimate for all major sub-systems and auxiliary facilities of the Hydrogen-to-Ammonia value chain including relevant direct costs (e.g. equipment costs, site development), indirect costs (e.g. EPC) and others (e.g. contingency, contractor fee).

### **2. OPEX estimate**

Detailed breakup of fixed (e.g. taxes, insurance, plant overhead) and variable (e.g. raw materials, utilities, labour) operational expenditures.

### **3. Feasibility of utilizing Oxygen, generated from Electrolyser operation, for achieving a second revenue stream**

### **4. Financial analysis to include Levelized Cost of Hydrogen and Ammonia, cash flow calculation, IRR, and payback period.**

### **5. Cost sensitivity analysis of LHOC and Ammonia, including key risks such as offtake, WACC. Basic assumptions for financial analysis shall be taken from a market study contracted by GIZ running in parallel (information to be shared at a later date)**

## **G. Vendor/Bidder Selections**

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This section is to prepare next steps, should a positive investment decision be taken.

### **1. Potential OEMs**

### **2. Potential FEED Contractors, technology providers, LEPC players etc.**

## **H. Project Implementation Strategy**

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This section is to inform of necessary regulations requirement to be observed, should a positive investment decision be taken, and to establish an indicative timeline.

### **1. Level of indigenisation required by authorities**

### **2. Licensing and statutory clearance required for Producer, EPC, and other third parties.**

### **3. Project Schedule: GANTT chart, showing lead times**

### **4. Long lead items in the project**

### **5. Quality control recommendations**

### **6. Assessment of statutory and environment clearances/permissions required for setting up the plant, operations, and storage, including the timeline required to acquire these.**

In addition to the description as per the ToR above, the following documents to be delivered

Figures:

### **1. Green Hydrogen-to-Ammonia pilot project – a itemized breakdown of CAPEX and OPEX, incl. import duties, transport / shipping cost and considering alternative technologies available in India**

### **2. Green Hydrogen-to-Ammonia pilot project - Sensitivity and Risk Analysis for LCOH and LCoA**

### **3. Green Hydrogen-to-Ammonia pilot project - Carbon Footprint Analysis**

Tables:

### **1. Green Hydrogen-to-Ammonia pilot project – Project Details**

### **2. Green Hydrogen-to-Ammonia pilot project – Sizing of Main components**

Annexes: Green Hydrogen-to-Ammonia pilot project

### **1. Plant layout and configuration**

2. Energy balance diagrams
3. Process and instrument diagrams
4. Basic bill of material and cost sheet
5. Specifications of major components (Electrolyser, Ammonia loop etc.)
6. Overall project timelines with milestones

Certain milestones, as laid out in the table below, are to be achieved by certain dates during the contract term:

<b>Milestone</b>	<b>Deadline</b>
Technical Assessment – input analysis, system design, safety provisions, operations, and personnel	31. January 2023, 1 <sup>st</sup> draft and presentation
Financial and Execution Assessment – financial analysis, vendor and bidding strategy, project implementation strategy, presentation	15. March 2023, 1 <sup>st</sup> draft and presentation
Final Report	30 April 2023

The detailed report is for internal use. Once approved, a simplified version is to be released to the public.

Period of assignment: From 15 November 2022 until 30 April 2023.

### 3. Concept

In the bid, the bidder is required to show how the objectives defined in Chapter 2 are to be achieved, if applicable under consideration of further specific method-related requirements (technical - methodological concept). In addition, the bidder must describe the project management system for service provision.

#### Technical-methodological concept

**Strategy:** The bidder is required to consider the tasks to be performed with reference to the objectives of the services put out to tender (see Chapter 1). Following this, the bidder presents and justifies the strategy with which it intends to provide the services for which it is responsible (see Chapter 2).

The bidder is required to present the actors relevant for the services for which it is responsible and describe the **cooperation** with them.

The bidder is required to present and explain its approach to **steering** the measures with the project partners and its contribution to the results-based monitoring system.

The bidder is required to describe the key **processes** for the services for which it is responsible and create a schedule that describes how the services according to Chapter 2 are to be

provided. In particular, the bidder is required to describe the necessary work steps and, if applicable, take account of the milestones and contributions of other actors in accordance with Chapter 2.

### **Project management of the contractor**

The bidder is required to explain its approach for coordination with the GIZ project.

- The contractor is responsible for selecting, preparing and steering the experts (international and national, short and long term) assigned to perform the tasks.
- The contractor makes intensive use of relevant studies and assumes the associated costs involved for making use through publishing of permitted study results.
- The contractor manages costs and expenditures, accounting processes and invoicing in line with the requirements of GIZ. The contractor reports regularly to GIZ in accordance with the AVB of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH from 2022

The bidder is required to draw up a **personnel assignment plan** with explanatory notes that lists all the experts proposed in the bid; the plan includes information on assignment dates (duration and expert days) and locations of the individual members of the team complete with the allocation of work steps as set out in the schedule.

### **4. Criteria for eligibility of firms**

The bidder must have the following administrative and financial requirements for conducting the assignment

- Be a registered as national organization or entity
- References on reports and market studies are required
- Average annual turnover for the last three financial years should be at least 100,000 EUR
- The agency should have minimum 25 employees as of 31.12.2021
- The agency must have handled at least 3 reference projects with focus on areas of Market studies with at least 3 projects in in the last three years with minimum commission value of Euro 30,000.
- The organization must be experienced in the areas of
  - 1. Energy transition
  - 2. Hydrogen, renewable energy or chemical industry
  - 3. Feasibility studies
- The agency must have regional experience in India
- Agency must have experience of development projects (ODS financed)

## **5. Personnel concept**

The bidder is required to provide personnel who are suited to fulfil the tasks described, on the basis of their CVs (see Chapter 7), the range of tasks involved and the required qualifications.

The below specified qualifications represent the requirements to reach the maximum number of points.

### **Team leader**

#### Tasks of the team leader

- Overall responsibility for the tasks to be performed by the contractor (quality and deadlines)
- Coordinating and ensuring communication with GIZ and others involved in the project
- Personnel management, in particular identifying the need for short-term assignments within the available budget, as well as planning and steering assignments and supporting local and international short-term experts
- Regular reporting in accordance with deadlines

#### Qualifications of the team leader

- Education/training (2.1.1): University qualification ('Diplom'/Master) in Economics, Business Administration or Engineering
- General professional experience (2.1.3): 10 years of professional experience in consultancy
- Specific professional experience (2.1.4): 3 years in the chemical or renewable energy sector
- Leadership/management experience (2.1.5): 4 years of management/leadership experience as project team leader or manager in a company
- Development cooperation experience (2.1.6): proven experience in feasibility studies in India

### **Expert 1 – technical expert**

#### Qualifications of expert 1 - technical expert

- Education/training (2.1.1): University qualification ('Diplom'/Master) in Engineering
- General professional experience (2.1.3): 5 years of professional experience in ammonia plants
- Specific professional experience (2.1.4): proven experience in the feasibility studies and/or project design

### **Expert 2 - financial expert**

#### Qualifications of expert 2 - financial expert

- Education/training (2.1.1): University qualification ('Diplom'/Master) in Economics, Business Administration or Engineering
- General professional experience (2.1.3): 5 years of professional experience in market analytics

- Specific professional experience (2.1.4): proven experience in the chemical or fertilizer sector

### **Short-term expert pool**

A short-term expert pool is to be established with 2-4 experts, with minimum 1 international and 1 national expert, maximum 4 members.

#### Qualifications of the short-term expert pool

- Education/training (2.6.1): 2-4 experts with university qualification in technical engineering, feasibility studies or similar
- General professional experience (2.6.3): 2-4 experts with 5 years of experience in the ammonia market, electrolysers, or chemical industry

Specific professional experience (2.6.4): 2-4 experts with practical involvement in minimum 1 green ammonia project, The bidder must provide a clear overview of all proposed short-term experts and their individual qualifications.

## **6. Costing requirements**

### **Assignment of personnel**

Team leader and national experts: On-site assignment for up to 220 national expert days

Short-term international expert pool: total up to 25 international expert and 40 national expert days.

### **Travel**

The bidder is required to calculate the travel by the specified experts and the experts it has proposed based on the places of performance stipulated in Chapter 2. and list the expenses separately by daily allowance, accommodation expenses, flight costs and other travel expenses.

### **Other costs**

Costs for required third party studies which need to be procured are to be borne by the bidder. In case visas are required the costs for the same are to be borne by the bidder.

**The total maximum budget is INR 76.5 lakhs for the said assignment.**

## **7. Requirements on the format of the bid**

The structure of the bid must correspond to the structure of the ToRs. In particular, the detailed structure of the concept (Chapter 3) is to be organised in accordance with the positively weighted criteria in the assessment grid (not with zero). It must be legible (font size 11 or larger) and clearly formulated. The bid must be drawn up in English language.

The complete bid shall not exceed 20 pages (excluding CVs & other supporting company documents)

The CVs of the personnel proposed in accordance with Chapter 5 of the ToRs. The CVs must clearly show the position and job the proposed person held in the reference project and for how long. The CVs should be submitted in English (language) only.

If one of the maximum page lengths is exceeded, the content appearing after the cut-off point will not be included in the assessment.

## 8. Annexes

Mandatory list of studies and papers to be analysed.

Opportunities for green hydrogen production in petroleum refining and ammonia synthesis industries in India by Joydev Manna, Prakash Jha, Rudranath Sarkhel, Chandan Banerjee, A.K. Tripathi, M.R. Nouni

<https://www.sciencedirect.com/science/article/abs/pii/S0360319921035448>

Innovation Outlook: Renewable Ammonia by Irena

<https://irena.org/publications/2022/May/Innovation-Outlook-Renewable-Ammonia>

Harnessing Green Hydrogen: Opportunities for Deep Decarbonization in India by NITI Aayog, RMI

<https://rmi.org/insight/harnessing-green-hydrogen/>

Accelerating Green Hydrogen Economy: Prepared for Green New Energy for a Net Zero India by EY

[https://www.ey.com/en\\_in/news/2022/06/india-needs-approx-115-gw-of-renewable-power-generation-capacity-and-approx-50-billion-litres-of-demineralized-water-supply](https://www.ey.com/en_in/news/2022/06/india-needs-approx-115-gw-of-renewable-power-generation-capacity-and-approx-50-billion-litres-of-demineralized-water-supply)

A Green Hydrogen Economy for India by CEEW

<https://www.ceew.in/sites/default/files/CEEW-A-Green-Hydrogen-Economy-for-India-14Dec20.pdf>

Greening Steel: Moving to Clean Steelmaking Using Hydrogen and Renewable Energy

<https://www.ceew.in/sites/default/files/ceew-study-on-clean-and-carbon-neutral-hydrogen-based-steel-production.pdf>

Harnessing Green Hydrogen by IH2A and Niti Aayog

[https://www.niti.gov.in/sites/default/files/2022-06/Harnessing-Green-Hydrogen\\_V21\\_DIGITAL\\_29\\_06.pdf](https://www.niti.gov.in/sites/default/files/2022-06/Harnessing-Green-Hydrogen_V21_DIGITAL_29_06.pdf)

Building India's Hydrogen Economy: Proposed 25/25 Development Plan for National Green H2 Projects, Hubs by IH2A / FTI Consulting

Hydrogen Market & Opportunity in India by Eninrac Consulting

<https://store.eninrac.com/reports/hydrogen-market-and-opportunity-in-india>

The Potential Role of Hydrogen in India by TERI

[https://www.teriin.org/sites/default/files/2021-07/Report\\_on\\_The\\_Potential\\_Role\\_of\\_%20Hydrogen\\_in\\_India.pdf](https://www.teriin.org/sites/default/files/2021-07/Report_on_The_Potential_Role_of_%20Hydrogen_in_India.pdf) The Potential Role of

Global Hydrogen Review 2021 by International Energy Agency

<https://www.iea.org/reports/global-hydrogen-review-2021>

Ammonia Technology Roadmap: Towards more sustainable nitrogen fertiliser production by International Energy Agency

<https://www.iea.org/reports/ammonia-technology-roadmap>

Blue Hydrogen. The greatest fossil fuel scam in history? by Just Have a Think

<https://www.youtube.com/watch?v=2EA4tDYwNYo>

International Market Consultation on the 1st H2Global Tender by BMWK

[https://www.bmwk.de/Redaktion/DE/Downloads/h2global/international-market-consultation-on-the-1st-h2global-tender.pdf?\\_\\_blob=publicationFile&v=2](https://www.bmwk.de/Redaktion/DE/Downloads/h2global/international-market-consultation-on-the-1st-h2global-tender.pdf?__blob=publicationFile&v=2)

H2Global Term Sheet: Hydrogen Purchase Agreements (Draft 7 July 2022) by BMWK

[https://www.bmwk.de/Redaktion/DE/Downloads/h2global/draft-term-sheet-hpa-market-consultation-h2global.pdf?\\_\\_blob=publicationFile&v=2](https://www.bmwk.de/Redaktion/DE/Downloads/h2global/draft-term-sheet-hpa-market-consultation-h2global.pdf?__blob=publicationFile&v=2)

Hydrogen – 10 Predictions for 2022 (Prediction 9) by BNEF

<https://about.bnef.com/blog/hydrogen-10-predictions-for-2022/>