# **Pre-Feasibility Study: Green Ammonia in Ethiopia – Workstream Overview**

**Summary:** This pre-feasibility study aims to evaluate the viability of establishing small-scale, renewable-powered green ammonia production facilities in Ethiopia. It comprises two core workstreams: a Techno-Economic Analysis (WS1), which will identify geographically suitable areas, model the technical performance and costs of various green hydrogen and ammonia system configurations (including solar, wind, and hydro inputs, and different electrolyzer technologies) to determine the Levelized Cost of Ammonia (LCOA) across approximately 24 scenarios; and a Fertilizer Market Analysis (WS2), which will examine Ethiopia's current fertilizer import supply chain, value chain costs, national and regional demand and price dynamics, and assess the competitiveness and potential impact of locally produced green ammonia. The integrated findings will culminate in a comprehensive report featuring suitability heatmaps and recommendations for potential pilot project locations, scales, and configurations, ultimately informing the decision to proceed with a full feasibility study.

**Total Cost:** $27,500

**Timeline:** 6-9 weeks pending data availability and deliverable structure

**Introduction:** This document outlines the core activities and objectives for the Techno-economic Analysis (WS1) and Fertilizer Market Analysis (WS2) for a pre-feasibility study on small-scale, renewable-powered green ammonia production in Ethiopia. The goal is to assess preliminary viability, identify key opportunities and challenges, and inform decisions for potential pilot project development.

## **Workstream 1: Techno-Economic Analysis (TEA)**

**Objective:** To identify geographically suitable areas for green ammonia production in Ethiopia, model the technical performance of renewable energy (RE) powered hydrogen and ammonia systems, and estimate the Levelized Cost of Ammonia (LCOA) under various scenarios.

### **High-Level Site and Resource Screening**

* **Renewable Energy Resource Assessment:**
  + Analyze 10-15 years of hourly solar irradiance (GHI/DNI) and wind speed data (0.25° resolution from ERA5/MERRA2/Global Atlases).
  + Compute P10, P50, P90 energy yield estimates to identify high-potential RE zones.
* **Land Suitability & Exclusion Criteria:**
  + Filter out: Protected areas, high population density, incompatible geographies (steep slopes), active conflict zones.
  + Data: ESA CCI, World Bank, OpenStreetMap (OSM).
* **Access to Enabling Infrastructure:**
  + Map proximity to: Existing electrical transmission lines/substations (EEP, OSM), reliable water sources (rivers, groundwater potential), and road networks (OSM, government data).
  + *Pending data availability*
* **Output:** National-level suitability map; selection of x zones/regions for detailed techno-economic scenario analysis.

### **1.2 Technology Configuration, Sizing, and Performance Modeling**

* **Renewable Energy Systems:**
  + Model hourly generation for Solar PV, Onshore Wind, and Hybrid (Solar+Wind) systems in archetypal zones using P50 resource data.
  + For Hydropower, model a Power Purchase Agreement (PPA) scenario with EEP: assume PPA price, capacity factor, and variability.
  + *Potentially* consider short-duration energy storage (BESS/H2) needs for intermittent RE.
* **Hydrogen Production (Electrolysis):**
  + SOEC based on partner specifications (kWh/kg H2, etc.)
  + Sensitivities can be run on other technologies such as PEM and alkaline electrolyzers.
  + Key inputs: Efficiency (kWh/kg H2), water consumption, CAPEX, OPEX, stack life, ramp rates.
* **Ammonia Synthesis (Modular Haber-Bosch):**
  + Based on AmmPower partner specifications.
  + Key inputs: Energy consumption (kWh/tonne NH3), N2 source (PSA from air), CAPEX, OPEX, catalyst life.
* **Plant Sizing:** Analyze 2-3 small-scale capacities (e.g., 1-20 tonnes NH3/day).
* **Balance of Plant (BoP):** High-level estimates for water purification, H2/NH3 storage, site infrastructure.
* **Key Scenarios:** Model 3 - 4 different renewable energy input types and potentially 1 - 2 different electrolyzer types across 1 - 3 different plant sizes. This leads up to a total of ~24 scenarios.

### **1.3 Cost Estimation (CAPEX & OPEX)**

* **CAPEX:** Partner data for Electrolyzer, BoP, NH3 synthesis loop, benchmarks for RE. Include estimates for installation, logistics, etc.
* **OPEX:** RE O&M, electrolyzer/ammonia unit maintenance, stack/catalyst replacement, water, local labor, PPA costs (for hydro).

### **1.4 Financial Modeling & Key Metric Calculation**

* Develop a Discounted Cash Flow (DCF) model.
* Assumptions: Discount rate (10-15%), project lifetime (20-25 years), construction period, inflation.
* **Outputs:** Levelized Cost of Energy (LCOE), Levelized Cost of Hydrogen (LCOH), **Levelized Cost of Ammonia (LCOA)**, cost component breakdown.

### **1.5 Sensitivity and Scenario Analysis**

* **Sensitivity:** Analyze impact of +/- 20% changes in key variables (RE/electrolyzer/ammonia CAPEX, PPA price, discount rate, capacity factor) on LCOA.
* **Scenarios:** Compare LCOA for different RE sources, plant scales, cost assumptions (optimistic/base/pessimistic), and grid interaction models.
* **Output:** LCOA ranges, identification of critical cost drivers, and most promising configurations/locations.

### **WS1 Timeframe**

Approximately **four weeks**, pending data availability/collection time.

### **WS1 Cost: $15,000**

## **Workstream 2: Fertilizer Market Analysis in Ethiopia**

**Objective:** To understand Ethiopia's current fertilizer market structure, pricing, demand drivers, regional variations, and the potential impact of increased local green ammonia supply. This will inform commercial viability and optimal project positioning.

### **2.1 Current Fertilizer Market Structure & Value Chain Analysis**

* **Map Import Supply Chain:** Identify source countries, port of entry (Djibouti), inland transport routes, storage.
* **Key Market Players:** Profile importers (e.g., Ethiopian Agricultural Business Corporation - EABC), distributors, retailers (cooperatives), Ministry of Agriculture (MoA), development partners.
* **Value Chain Costs & Margins:** Estimate cost build-up: CIF, port/clearing, duties, transport, storage, distributor/retailer margins. Analyze and investigate current fertilizer subsidies.
* **Data Sources:** AfricaFertilizer, MiDA, UN Comtrade, industry reports.

### **2.2 Fertilizer Demand Analysis (National and Regional)**

* **National Demand:** Quantify historical and current demand for nitrogenous fertilizers (Urea, DAP focusing on NH3 equivalent); identify seasonality.
* **Regional Demand (County/Woreda level if possible):**
  + Identify high-consumption/potential agricultural zones using proxies (crop production, cultivated area for key crops).
  + Data: TBD
* **Data Sources:** MoA, EABC, FAOSTAT, CSA, research institutes.

### **2.3 Fertilizer Price Analysis (National and Regional)**

* **Import Parity Price (IPP):** Calculate landed IPP for Urea/ammonia using international benchmarks and import costs.
* **Domestic Price Monitoring:** Collect current/historical wholesale, retail, and (crucially) farm-gate prices for Urea in key agricultural regions.
* **Regional Price Differentials:** Analyze and map price variations across Ethiopia; identify drivers (transport, market power). **This helps identify regions where local production offers a competitive advantage.**
* **Price Volatility & Affordability:** Assess historical volatility and impact on smallholders.
* **Data Sources:** Commodity reports, MiDA local network for price collection (MoA/EABC, cooperatives, market surveys).

### **2.4 Competitiveness and Market Entry Assessment for Local Green Ammonia/Fertilizer**

* **Price Competitiveness:** Compare estimated LCOA (from WS1) with IPP, domestic prices, and SOE target offtake prices. Consider forex savings benefit.
* **Non-Price Factors:** Reliability of local supply, reduced logistics, "green" attributes.
* **Target Market Segments & Offtake Potential (TBD, based on time and availability):**
  + Confirm SOE (e.g., EABC) interest, volumes, procurement criteria.
  + Assess potential from large commercial farms, farmer cooperatives.
* **Impact of Local Supply:** Estimate potential market share and influence on regional prices/imports.

### **2.5 Potential Impact of Increased Fertilizer Availability on Crop Yields & Food Security**

* **Estimate Yield Response:** High-level estimate of yield increases for key crops (teff, wheat, maize) from improved nitrogen application (sub-optimal to optimal).
* **Contribution to Food Security & Livelihoods:** Qualitatively describe benefits for national food security and smallholder incomes.
* **Data Sources:** FAO, IFPRI, Ethiopian agricultural research. (Note: High-level assessment, no detailed agronomic modeling).

### **WS2 Timeframe**

Approximately **three to four weeks**, pending data availability/collection time.

### **WS2 Cost: $12,500**

## **Overall Deliverables from WS1 & WS2**

* A comprehensive pre-feasibility report integrating:
  + TEA findings: Suitable project zones, LCOA for various scenarios, key cost drivers.
  + Market Analysis findings: Value chain, demand/price dynamics, regional opportunities, competitiveness.
* Heatmaps illustrating RE resource potential, land suitability, infrastructure, fertilizer demand, and price variations.
* Recommendations for potential pilot project locations, scales, and configurations, highlighting key risks and next steps for a full feasibility study.
* ***Total required time*: 6-9 weeks pending data availability and deliverable structure.**
* ***Total cost*: $27,500**