

Roadmap of Green Methanol production from Biogas and Green Hydrogen in Paraná, Brazil

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Abbreviations

AACE	Association for the Advancement of Cost Engineering.
ATEX	Atmospheres Explosible
CAPEX	Capital expenditures
EPC	Engineering, Procurement and Construction
EPCM	Engineering, Procurement and Construction Management
ESIA	Environmental and social impact assessment
FEL	Front End Loading
FEED	Front End Engineering and Design
FID	Final Investment Decision
GHG	Greenhouse gases
HAZID	Hazard Identification report
ISBL	Inside Battery Limits
LPG	Liquefied petroleum gas
NOC	No Objection Certificate
O&U	Offsite and Utilities
OEM	Original Equipment Manufacturer
OPEX	Operating expenses or expenditure
OSBL	Outside Battery Limits
P&ID	Piping and Instrumentation Diagram
PEP	Project Execution Plan
PFD	Process Flow Diagram
PtX	Power to X
PPA	Power Purchase Agreement
Pre-FEED	Pre-Front End Engineering and Design
QRA	Quantitative Risk Assessment
RE farm	Renewable Energy Farm
RFNBO	Renewable fuels of non-biological origin
SPV	Special Purpose Vehicle

Purpose of document

The purpose of this document is to provide a roadmap to bring the project readiness closer to final investment decision (FID) along with FEL 2 feasibility study and to provide gap analysis from documents and engineering point of view. Table 1.1 represents the full life cycle of the project. The green methanol project is at FEL 1 stage and all the components of the project such as RE farm, biogas plants, water electrolysis and chemical synthesis plant, and pipeline infrastructure including offsites and utilities have to go through these phases.

Table 1.1. Full life cycle of the project

PHASE	FEL1	FEL2	FEL3	Detail Engineering and construction	Operation (O&M)
GOAL	Demonstration of Concept and business case Go/No Go Decision	Site Conditions and design basis Go/No Decision	Final Investment Decision Tender	Ensuring compliance with design, project execution	Ensuring high availability and efficiency
OBJECTIVE	<ul style="list-style-type: none"> • Technology Site Selection • Environmental assessment • Risk & Opportunities • Market Assessment • Business Plan Assessment • Review of legislative frameworks • CAPEX/OPEX 	<ul style="list-style-type: none"> • Layout • Conceptual design • Permitting • CAPEX/OPEX Iterations • Procurement Strategy • Overall program • Certification 	<ul style="list-style-type: none"> • Front End Engineering and Design • CAPEX/OPEX (Class 3) • Tendering for execution • O&M Strategy 	<ul style="list-style-type: none"> • Detailed Design (Select Services) • Planning and Implementation • Contract Management • Audits • HSE monitoring • Mechanical Completion • Pre-commissioning planning 	<ul style="list-style-type: none"> • O&M Planning / Review • Performance Audits • Performance KPIs • Technical Assistance

The purpose of this document is to clearly define the objectives, deliverables, tasks of FEL2/feasibility study and timeline of the entire project. It outlines the specific activities involved in the roadmap, ensuring that everyone has a shared understanding of what needs to be accomplished for the delivery of a FEL2/feasibility study on a 44,500 kg/h green methanol production facility from biogas and green hydrogen.

1 Project description

Mele Biogas GmbH in Germany and its biogas producing partners, potential chemical manufacturers and off-takers, possibly along with the German Society for International Cooperation (GIZ) could form an SPV and will be called as the “Client” in this document. Specific partners for the renewable energy and chemical synthesis and electrolyser plants have yet to be identified. These partners may consist of a single entity or a combination of multiple parties.

Client is planning to develop a green methanol production facility (referred as the “Project”) in the Western Paraná region in Brazil. The proposed Project will utilise green hydrogen, produced from renewable energy (RE), water and biogenic carbon and methane from animal and agricultural wastes.

From the above feedstock the facility will produce 44,500 kg/h of green methanol that is intended to be subsequently exported to the European Union (in particular Germany), to be used as green chemical or as potential fuel in hard-to-abate transport sectors. Regarding the latter, the subsequent conversion to SAF would need the implementation of a methanol-to-kerosene (MTK) production route. This SAF production pathway has not been certified yet by the ASTM as a valid sustainable alternative for aircraft fuelling. However, this production pathway is expected to receive the ASTM certification in a short- to medium-term, potentially enabling its industrial implementation.

For a better understanding, please refer to Figure 2.1.

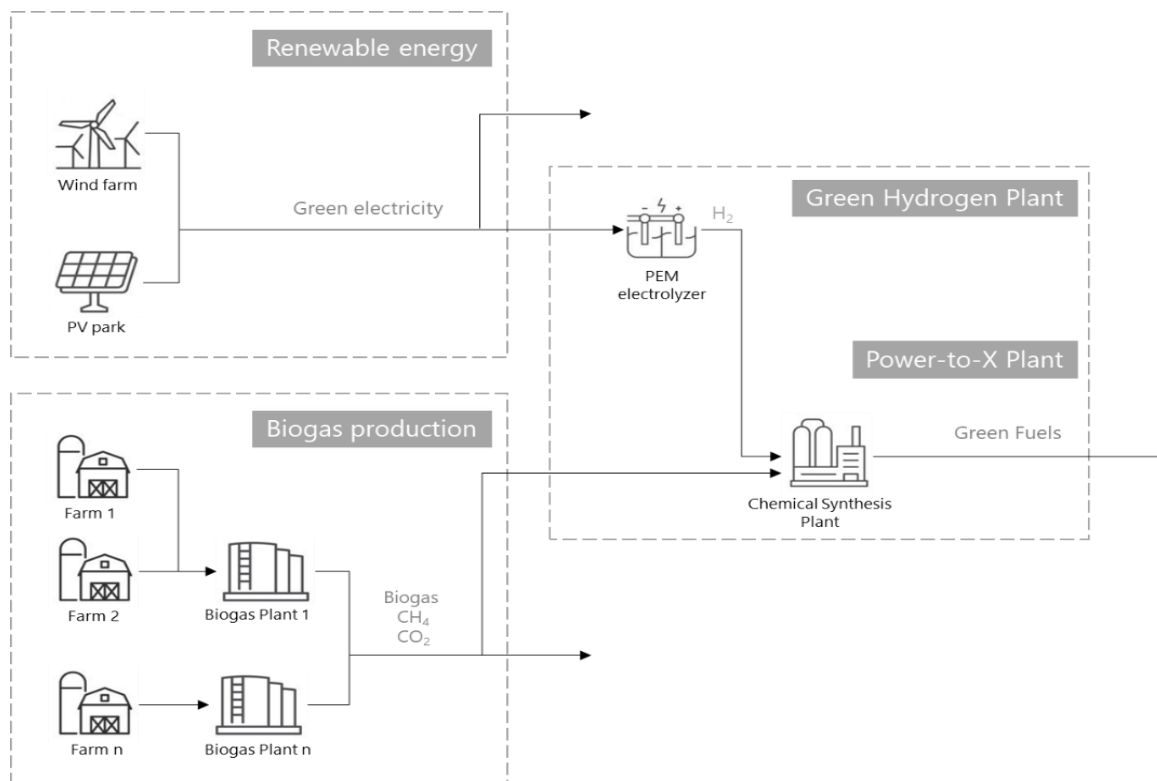


Figure 2.1: General plant concept

2 Roadmap to FEL2/feasibility study

The roadmap to FEL2/feasibility study will provide a structured project plan for the entire project life cycle. Studies, activities and deliverables to be produced to close the gap toward final investment decision of the project are found below.

2.1 Permits and authority approval for biogas, RE farm, PtX and water treatment

2.1.1 List of Permits/Clearances/Approvals

Detailed mapping and analysis of country-specific most relevant regulations, permits and authority approvals with emphasis on those specific to raw materials, utilities used, final product and effluents shall be carried out with the support of EPC/EPCM contractor or relevant third party consultants.

The approvals are required based on Project phase i.e.

- A) Pre-development phase
- B) Execution phase
- C) Commissioning/start up (if any)
- D) Before start of production

List of clearances/approvals/permits shall be identified along with approving authority, entity (Client or EPC/EPCM contractor) responsible for applying for the approval, phase of the project in which approval is required and timeline required for approval.

Table 3.1 is the examples of general approvals required during the project. This list is not green-methanol-project specific and therefore not exhaustive.

Table 3.1. General approvals required during the project

Sr.No.	Clearances/approvals/permits
1	Screening and EIA permit for project
2	Environmental approval
3	Building Permit
4	Exemption from the Agricultural Act
5	Any permits according to the Road Act
6	Exemption from beach protection line
7	Exemption from forest construction lines
8	Soil Pollution Act
9	No objection Certificate from Pollution control
10	Approval of unit wise equipment arrangement plans / Approvals of individual Plot plans
11	Approval of Electrical installation
12	NOC from Aviation Authorities
13	Allocation/approval of electric supply for bulk construction power
14	License from Labour Department
15	Electrical and Instrumentation approval for Flame proof enclosures/Equipment in hazardous areas in refinery/Petrochemicals/oil Pipelines and Jetty
16	Emergency Generator Environmental Approval
17	Cylinders used for fire extinguishers
18	Nitrogen storage, Hydrogen bullets
19	Storage of highly explosive chemicals and intermediate products exceeding quantities required for 2 months' consumption
20	License to Possess Compressed Gas Cylinder such as LPG, Hydrogen, Chlorine, acetylene etc.
21	Authorization for handling Hazardous Waste
22	Furnish information containing: a. Port of entry; b. Mode transport; c. Quantity of chemicals being imported, etc; d. Complete product safety information
23	Clearance for Lifting Equipment, e.g. Cranes, Hoist, Chain pulley blocks etc.

Methodology for the applications of statutory approvals/permits.

The following methodology can be utilized for the applications of statutory approvals/ permits.

- The applicable approvals/permits/clearances envisaged for the execution of Green Methanol Project shall be identified at the beginning of the Project, in order to meet the requirements of statutory regulations. Respective scope of Client & EPC/EPCM contractor shall be mutually agreed.
- For approvals which are to be taken by EPC/EPCM contractor, EPC/EPCM contractor shall take all statutory approvals/permits/ clearances for his scope. Preparation of required documentation, submission to respective authorities & expediting for timely approval, shall be in the scope EPC/EPCM contractor. Wherever applicable, only fees have to be deposited by Client for obtaining these clearances/permits/approvals, shall be borne by Client. The rest of the statutory fees have to borne by respective EPC/EPCM contractor . Whenever required, Client shall provide the covering letters, signed by authorized Client's personnel, to EPC/EPCM contractor to proceed with the approval formalities.
- For approvals which are to be taken directly by Client, EPC/EPCM contractor shall give technical support to Client for obtaining the statutory approvals either generating or providing the required technical documentation.

Client will further take necessary action for submitting the relevant documentation to the statutory authorities and coordination with the statutory authorities for obtaining these approvals. All expenses, including the fees to be deposited for obtaining these permissions, shall be directly dealt with by Client. If any third party certification/evaluation, is required, the same is to be carried out by Client.

- Whenever required by Client, EPC/EPCM contractor personnel shall accompany the Client for providing technical support for any clarifications, explanation or making presentation to Statutory Authorities. vi. EPC/EPCM contractor shall monitor the status of statutory clearances and keep Client informed of the same.

2.2 Site selection for RE farm, green hydrogen and green methanol plants

RE farm location shall be selected based on wind and solar energy potential. Green hydrogen and methanol plant location shall be evaluated based on water utilization potential and electrical grid connection capacity along with logistic organization involving transport of biomass to the plant site and transport of the green fuel product to a potential off-taker location.

It is also important to note that production and sales at the selected site for the Methanol plant may vary considerably. Costs associated with electricity, raw materials, labour, equipment, and utilities are particularly vulnerable to change based on selected site.

Thus it is advised to initiate the sites selection process, considering all aspects of technical, safety and economic feasibility. Specialized agency can be appointed to identify potential barriers to development, including development of criteria for site selection and recommendations for the preferred project site enabling the Client to make an informed decision regarding the site chosen to pursue for development.

Site selection shall also include Site Survey, Topographic Survey and Geotechnical Investigation.

2.3 GHG emission estimation

Regarding the emissions limit of RFNBO production, the European RED II/RED III directives establish a minimum emissions savings threshold of 70% with respect to a fossil fuel alternative, after considering the full lifecycle of the fuel. Equivalent to the GHG emissions calculation of biofuel production, the regulation defines a specific methodology for the measurement of the carbon intensity of the RFNBO, covering its value chain from electricity generation to the end use of the fuel.

GHG emission calculation helps organizations stay compliant with environmental regulations and reporting requirements. During the next phase of the project, a study conducting approach, methodology and calculation of GHG emissions shall be carried out. Study report shall provide a detailed breakdown of the factors and considerations involved in the emission calculations, including exceptions, and shall also offer a transparent and rigorous approach to understanding the environmental impact of these fuels.

2.4 Basis of design for RE farm and water treatment plant

Basis of design for RE farm and waste water treatment plant shall be reevaluated during FEL2 study to optimize the RE farm and waste water utilization along with optimized CAPEX estimate.

2.4.1 RE farm

Based on early study, considering the plant location conditions, for methanol, a mix of 200MW solar, 200MW wind and an additional-PPA with small-hydro/biogas plants would be needed.

The facility could be powered by long-term RE PPAs in an indirect grid connection scheme with lower CAPEX compared to deploying new RE plants. However, in scenarios where green-H₂ is incorporated into the product, the green fuel might be partially classified as RFNBO. Even in the high renewability grid area where the plant will be located (>90% RE), if meeting this certification is desired, it's recommended to finance new RE plants based on local and/or remote self-production grid-tied schemes assisted by smart metering. Power Purchase Agreements (PPAs) are recommended due to the importance of renewability, additionality, and time/geographical correlation within EU certificate directives, RED II/III, to reduce electricity OPEX costs.

The idea of additionality is to ensure that the increased hydrogen production goes hand in hand with new renewable electricity generation capacities and hydrogen producers to conclude power purchase agreements (PPAs) with new renewable electricity generation capacity.

It is advised to finalise RE farm capacity along with its basis of design in next phase of the project depending on location of the plant, direct or indirect connection scheme and power purchase agreement.

2.4.2 Water treatment plant

Conceptual design phase demanded 237 m³/h of raw water considering ~70% recovery rate (i.e. 169 m³/h of treated water) from raw water treatment processes (superficial water quality) for methanol production including electrolysis.

Electrolyzer manufacturers' demand high purity deionized water for hydrogen production. Most electrolyzer's manufacturers offer an integrated solution that include a water treatment station to bring treated water to deionized water within purity requirements for their stacks.

Within electrolysis plant, there are other sub-processes such as gas separation, cooling and processes in steam Methane reforming, Methanol plant that require water with less treatment intensity than electrolyzer plant. Therefore, these water streams, for electrolysis and Methanol plant, will require water quality treatment processes.

Demand of raw water can be met from surface and underground water sources which implies lower CAPEX/OPEX for water treatment compared to effluent usage. Farming, agroindustry, and even urban wastewater could also help reach the plant's water demand. However, this would require additional costs due to advanced treatment and infrastructure needs. To improve sustainability, the rainfall pattern can be exploited alongside recirculation methods.

During the FEL2/feasibility study phase, finalisation of water sources along with water treatment concept to optimise the best possible option for water treatment of various water sources shall be considered as important task.

2.5 Biogas collection and distribution network analysis along with permits

Methanol production module along with green Hydrogen will involve an electrolysis plant and a chemical synthesis plant, as well as various structures for transporting biomethane and CO₂ from biogas plants to the synthesis site.

Gas pipelines between the biogas producing units transporting Methane and CO₂ to the chemical synthesis plant for producing methanol. These will include metal pipework and accessory structures. A total of 45 biogas production units are planned, so it can be assumed that there will be 45 interconnection pipelines. These pipelines could certainly be connected to each other along the site, forming branches connected and joined to a central pipeline, depending on the geographical positioning of the plants.

It is recommended to perform route survey of gas pipeline collection and distribution network to ascertain the exact alignment of the pipeline route, to identify number of crossings and to verify the ownership details along the pipeline route. Soil Stratification survey and Corrosion survey need to be carried out to ascertain the ground soil data and corrosivity of the soil. Route survey shall be conducted with the help of specialized agency to finalize the best route possible.

Also permission from various authorities are required to be obtained to lay the pipelines.

2.6 Methanol synthesis design improvement

The FEL2/feasibility study shall conduct optimizations analysis related to process efficiency and heat integration of methanol production facility.

The primary recommendations regarding process optimization requirements during feasibility shall include but not limited to the below points.

2.6.1 Water utilization

The methanol synthesis process generates significant quantities of water as a by-product. Consequently, it is imperative to conduct thorough and optimized water treatment and reuse processes to minimize the overall water consumption. This would not only contribute to reducing the costs associated with this demand but also serve to mitigate some of the environmental impacts.

Water scrubber units or other water-using process units operating performance need to be optimized in order to reduce water consumption. Reduction of water need would be highly beneficial for the process economics and water demand. The effect of variables such as pressure, temperature, and the input of some recycle could be assessed. Additionally, it is crucial to examine various processes for conducting biogas upgrading and separating CH₄/CO₂. Given the elevated CO₂ content in the mixture, alternative technologies should be explored, including chemical absorption using amines, pressure swing adsorptions, or even a membrane separation system.

2.6.2 Utility types and conditions

During conceptual design phase, simple utilities were chosen due to time constraints. Overall, water usage was considered. Thermal fluids such as heating oil were only chosen in the equipment where the water consumption would be really high, resulting in high equipment size besides the water demand. Thus, utility optimization must be performed, by considering different types of utilities and the equipment needed to generate them in the economic analysis. It is also important to analyse the best conditions (temperature, pressure, phase) for each chosen utility to minimize the overall costs.

2.6.3 Heat integration

Explore additional potential heat integration opportunities and assess whether modifications to the initially proposed scheme are warranted. Moreover, it is crucial to investigate the feasibility of generating utilities, such as steam, from the surplus heat generated by the plant. If feasible, this could significantly diminish the demand for the required utilities.

2.6.4 Methanol plant purge and recycle

The usual syngas to methanol conversion is quite low which causes great amounts of unreacted species to be present in the product stream. Recycle strategies need to be implemented for the process to be economically viable, but since the conversion is low, high recycle rates will ultimately imply in non-reacting species accumulation in the system and convergence issues.

Clearly, for commercial applications, careful optimization must be performed so global carbon efficiency is increased, and the purge rate is decreased. Since the purge stream has a high hydrogen and carbon monoxide content hydrogen recovery units should be considered. In the present project, it is especially important to address this stream since high-cost green hydrogen is being introduced in the process, and environmental footprint is a special concern.

Strategies to enhance recycle rate were not implemented in the initial study, but they are required in future project refining to enhance the process economics and to assess the impact of higher recycle rates in process costs. Potential strategies to address this purge stream could be the implementation gas separation units or more than one methanol reactor.

It should be noted that these strategies will ultimately and, probably importantly, impact the CAPEX and the OPEX, and a detailed evaluation should be performed to evaluate if they are economically attractive.

2.7 Technology evaluation/selection and plant configuration study

Study for evaluation and selection of Electrolysis technology for Hydrogen production and Methanol synthesis technology for Methanol production shall be conducted in Pre-FEED engineering.

Technological characteristics combined with economic analysis must be considered when making a final decision. Refer below to the methodology for the technology evaluation and selection.

2.7.1 Electrolysis for hydrogen production

Study to provide early comparison to select one technology based on anonymised generic techno-economic information for the three technologies shall be performed.

- Proton Exchange Membrane (PEM)
- Atmospheric alkaline
- Pressurised alkaline

Electrolyser vendors selection via extensive engagement of the OEM's shall be done at the end of Pre-FEED engineering.

2.7.2 Methanol synthesis for methanol production

Screening and evaluation of various licensed technologies of Methanol, followed by selection of the best suited technology for this kind of renewable power-based production facility shall be conducted.

Evaluation of the most optimal configurations of the Methanol plant shall be done considering several key factors such as:

- Renewable energy production profile and associated hydrogen production/storage from electrolysis plant.
- Biomethane and CO₂ production profile and quality characteristics.

2.7.3 Evaluation of configurations of the full project

Evaluation of optimal configuration of the full project (i.e., Water treatment, electrolysis, methanol synthesis) shall be performed considering:

- A technical point of view (e.g. assessment of total production or total power consumption versus time)
- An economic point of view (e.g. assessment of total cost vs time or levelized cost of a kg of product)
- Or environmental (e.g. assessment of CO₂ emissions)
- Optimization of the sizing of a plant configuration based on the selection of economic, technical and/or environmental criteria (e.g. minimize the levelized cost of product) and the selection of parameters to be sized (e.g. size of the wind farm, size of the electrolyser, size of the H₂storage).
- Hydrogen storage sized to support shutdown of the integrated plant in instances of inadequate renewable energy supply
- Realization of sensitivity analyses: calculation of the influence of one or more parameters of the system on technical, economic and/or environmental indicators of interest

Configuration with different choices of technologies, e.g. different electrolyser technology, different type of storage or different operating philosophies can thus be compared from a technical, economic and environmental point of view, to allow the selection of the most appropriate configuration for the plant.

Evaluation of up to three (3) technologies/vendors for electrolysis and methanol synthesis shall be done as part of the concept refinement. Set of criteria for down-selection of a single technology/vendor in each category shall be established. Technologies will then be incorporated into the FEL2/Feasibility Study report.

2.8 Cost estimate

Once the plant configuration study is completed, it is proposed carry out EPC cost estimate based on the unit sizes determined for the ISBL and OSBL units. This is a more accurate basis than scaling the OSBL cost as the factor of ISBL cost.

The CAPEX costs, along with the product pricing assumptions and OPEX costs shall be used to produce levelized cost assessments.

Identification of associated capital and operating financial risks and associated method of mitigations shall be internally evaluated by project financial partners.

2.8.1 CAPEX

The EPC Cost Estimate of AACE Class 3 (-20%/+30%), or lower class, shall be developed from the project specific Equipment List and plot plan.

The EPC estimates shall include the cost of Licensor Package of Hydrogen and Methanol synthesis unit, equipment and overall construction & project management costs. Cost estimation methodology shall be mutually agreed between Client and contractor.

When necessary Critical/High Value Equipment shall be estimated on the basis of enquiry floated to the market and vendor quotations.

Cost Breakdown Structure shall be composed as follows:

- RE farm
- Electrolysis
- Methanol synthesis
- Water treatment
- Offsite and Utilities
- Methanol Storage
- Hydrogen Storage

OPEX

OPEX analysis for the Methanol Chain based on cash flows projections through the life cycle of the Project and account for key economic metrics covering feedstocks costs and capital investment shall be performed. Other costs, such as fixed and variable expenses (cash and non-cash), shall also be estimated.

The economic evaluation shall be performed for the selected case and shall be based on the following factors:

- Feedstock prices and products price;
 - Investment cost, as defined by the cost estimate evaluation.
 - Operating cost (staff, maintenance, royalties, insurance, catalyst & chemicals, effluent disposal, and general expenses)
- The projections shall be provided for the project lifetime, typically 20 years of operation after start-up.

2.9 FEL2/ Feasibility study package

FEL2/ Pre-FEED/Feasibility study shall be performed by assigning engineering consultancy contractor. The Deliverables to be prepared by contractor and to be included in the documentation of the Services are as follows.

Sr. No.	Deliverable	Deliverable content/description
1	Concept Study Report	Overarching study report that contains all below deliverables
2	Plant configuration optimization study	Plant configuration optimization study for assessment of performances of a defined configuration shall be performed. Refer chapter 3.7.3
3	Design Basis	The Design Basis principally contains information on: <ul style="list-style-type: none"> • Plant capacity, • Design scope and battery limit, • Feed stock specification, • Product specification, • Utilities specification, • Consumable and catalyst specification, • Codes and standards relevant for the Plant and • Climatic information
4	Plot plan for specific site	2D Layout Arrangement Drawing, considering topography of site showing process, utility and offsite units, roads, railroads, interconnecting pipe racks, storm water drains, reference coordinates, battery limits, plant North
5	Process Flow Diagrams (PFDs)	The Process Flow Diagrams principally contain: <ul style="list-style-type: none"> • Overall process flow of facility • Inlet and outlet streams
6	Overall Proces Description	Process Description Principally containing <ul style="list-style-type: none"> • General description of process, • General description of process units, • Essential operation conditions and • Chemical reactions.
7	Conceptual Piping and Instrumentation Diagrams (P&IDs)	The Process and instrumentation Diagram contain: <ul style="list-style-type: none"> • Equipment with pipe lines , it's piping components • Inline and non-inline instruments along with safety valves
8	Heat and material balances	The Heat and Material Balance containing <ul style="list-style-type: none"> • Flow rates for streams from the PFDs, • Temperature and pressure for streams from the PFDs, • Compositions from streams from the PFDs.
9	Utilities specifications and consumption	Consumption Figures for the Process Plant and O&U (list summarizing the Block Flow Diagram figures)

10	Emissions List	The List of Emissions for Principally containing the following: <ul style="list-style-type: none"> • Sources of emissions • Substances emitted (gaseous), discharged (liquid) • Concentration and mass flows
11	Overview of battery limits	The B.L. Interface Table includes: <ul style="list-style-type: none"> • Flow conditions (normal; design) • Line size, material
12	Overview of main equipment, size, and long lead items	Equipment list containing details for main equipment
13	Plant performance guarantees	Typical plant performance guarantees
Sr. No.	Deliverable	Deliverable content/description
14	Materials selection concept	Material selection criteria and general requirements applying to the specific materials are mentioned, e.g. material types, requirements for specific services
15	Conceptual single line diagram	The Single Line Diagram shows the paths for power flow between the different systems / equipment for the Process Plant and O&U.
16	Electrical load list	Overview List of all electrical consumers such as motors, lighting and tracing summary loads (panels),
17	Instrumentation and control concept	Typical Overview with principle interconnection lines: DCS, ESD, HMI, PLCs of PUs, PLC of ET (if any), machine monitoring MMS, fire & gas detection sys., marshalling, principal field equipment
18	Safety systems design Concept	Basis for the overall process safety, plant safety and environmental safety design and provides the minimum requirements that are applied in the plant including ATEX philosophy, ATEX area classification, HSE strategy, noise protection concept, flare and blow down concept.
19	Fire protection design concept	Design standards covering basic requirements for design and materials for Fire Protection Systems, applicable codes and standards
20	Environmental and Social Impact Assessment (ESIA)	ESIA study to be included in Pre-FEED
21	Hazard Identification (HAZID) report	HAZID Study workshop to be facilitated. Deliverable is a HAZID Report.
22	Quantitative Risk Assessment (QRA)	QRA study to identify the Hazard and quantify the onsite and offsite risk to personnel
23	Erection & commissioning philosophy	Construction concept covering the permanent plant as well as the temporary site facilities. Information to be provided on site

		preparation, transport to/from the site, traffic on the site, key quantities and manpower requirements. First indication on a commissioning concept focusing on the handover from construction to commissioning
24	Proposals for critical equipment (e.g. electrolyser)	Budget Quotations from Electrolyser suppliers
25	Electrolyser and Methanol synthesis technology selection and supplier qualification and shortlist	Study to provide early comparison to select one technology for the Pre-FEED engineering. Refer Chapter 3.7
26	Project Risk Assessment	Project Risks analysis
27	Project Execution Plan (PEP)	Generic PEP incl. engineering plan, construction plan, mobilization and de-mobilization plan, logistics and procurement plan, pre-commissioning and commissioning plan and contracting/sub-contracting plan
28	Preliminary CAPEX & OPEX estimate (AACE Class 3 estimate. expected)	<p>1. Chapter in the Report summarizing the results of the EPC cost evaluation, considered assumptions and exclusions</p> <p>2. Accuracy of EPC cost estimate to AACE Class 3 (-20%/+30%) shall be provided, broken down into key areas:</p> <ul style="list-style-type: none"> • RE farm • Electrolysis • Methanol synthesis • Water treatment • Offsite and Utilities • Methanol Storage • Hydrogen Storage <p>List of inclusions and exclusions</p> <p>3. High level Operating costs for on-going operations and Maintenance.</p> <p>Refer chapter 3.8</p>
29	Project Execution Schedule	<p>Suggest Level 1 for Execution schedule to include information, such as:</p> <ul style="list-style-type: none"> • Overall time estimate for the complete build and commissioning of the plant, • Time estimate of key engineering phases (feasibility, FEED, detailed design), • Project implementation plan and project development timeline.

2.10 Entire Project implementation timeline

This paragraph presents the current preliminary project implementation timeline, developed in FEL1 design phase.

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Biogas Expansion Plant												
Design	█											
Design FEL2/FEL3		█	█									
Licenses and permits	█	█	█	█								
Construction			█	█	█							
Licenses and permits 2nd phase				█	█							
Construction 2nd phase					█	█	█					
Licenses and permits 3rd phase						█	█					
Construction 3rd phase							█	█	█			
Licenses and permits 4th phase							█	█				
Construction 4th phase								█	█	█	█	
Commissioning												█
Renewable Energy farms												
Design FEL2				█								
Design FEL3					█	█						
Licenses and permits					█	█	█					
Construction							█	█	█	█		
Commissioning										█		
Chemical Synthesis & H2 Plant												
Design FEL2				█								
Design FEL3					█	█						
Licenses and permits						█	█	█				
Construction								█	█			
Commissioning										█		█

FEL2 / feasibility design phase will add a layer of detail to the present preliminary project timeline, specifying time estimates for detailed activities relative to each phases, licenses and permits, engineering (design), construction and commissioning. Additional information regarding project timeline for biogas expansion plan is in particular required as well as in coordination with the financial structure of the project, potentially to be included in the Level 1 project timeline, given the extensive amount of biogas plants, 45 new plants, and the connected complexity in terms of site selection, license and permits and additional infrastructure, e.g. manure and biogas pipelines.



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The International Hydrogen Ramp-up Programme (H2Uppp) of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) promotes projects and market development for green hydrogen in selected developing and emerging countries as part of the National Hydrogen Strategy.