1.4. TECHNICAL REQUIREMENTS

1.4.1 Scope of services

1.4.1.1 Design and alignment of design with related components

- Contractor is expected to carry out a site inspection prior to the start of all further activities
- Submission of:
  - Initial designs;
  - Post commissioning as-built drawings;
  - Technical documentation;
  - Operational and maintenance manuals including operational hours and internal power consumption of delivered equipment.
- Preparation and submission of detailed design for acceptance by beneficiary and UNDP based on plot properties, capacity of equipment and guaranteed performance to reach the specified output.
- Submission of time schedule and Gantt chart for the execution of the total job.
- Comprehensive maintenance plan for the complete project duration including elaboration on the OPEX.

1.4.1.2 Installation, commissioning and training **(please refer to amendments in red)**

- Supply of materials & equipment necessary for turn-key operation biogas plant; construction, fabrication, installation & commissioning.
- Relocation of the existing diesel generators
- Post commissioning operation of the plant including stabilization & performance monitoring & training on operation & maintenance of the biogas plant and the delivered components.
- Spare parts and consumables for the system guarantee period from start of biogas production. Spare parts and consumable usage after this period shall be specified in the maintenance plan.
- Site safety – The contractor will ensure that relevant safety regulations are complied with during the guarantee system guarantee period.
- A general safety plan shall be submitted with reference to NEN NTA 9766:2014, Fachverband Biogas (Guidelines for the safe use of biogas technology), or similar.
- A plan on the operation of the plant shall be provided, including:
  - Expected duration of labour on daily or weekly basis;
  - Roles, skills and expertise of operators;
  - Operational risk estimation and related mitigation measurements.
- The bidder has to give declaration in their offer to ensure compulsory use of all necessary Personal Protective Equipment like boiler suits, safety shoes etc. by all of his workmen.
- The responsibility of organizing and conducting a training of the beneficiaries will rest on the successful bidder. The training will be organized in consultation with both beneficiaries and UNDP. A training plan will be prepared and sent for approval by UNDP 2-months prior to the proposed training date. The training program will focus on operation and maintenance of the biogas plant. Technical documentation on operation, maintenance and safety instructions should be made available in English.

- The Contractor shall conduct an open training session (workshop) for all UNDP's engineers and technicians and interested professionals in the field on all related operation and maintenance issues of the systems.

1.4.2. Lot 1 Site 1: BGLB 1.1 Domaine Taanayel Arc En Ciel (Bekaa)

1.4.2.7.6 Switch board (please refer to amendments in red)

- A switchboard for the regulation of internal and external energy usage, as well as grid synchronisation equipment, shall be installed inside the CHP container. The sizes of the electrical groups for internal uses are to be defined by the bidder.
- All electrical equipment should be connected to a common grounding system, which is connected to ground electrode.
- The switch board shall be connected to the main bus at the Domaine. Supply and installation of a 420m ground cable (copper 4x70mm2) shall be included in the bid.

1.4.2.7.8 Mechanical separator (please refer to amendments in red)

- A mechanical separator shall be installed for post-processing of the digester effluent (estimated DM content 8-10%).
- Processing capacity: >3 tonnes/hour.
- DM content liquid fraction: <6%, DM solid fraction: >20%.
- If required for separator operation, a digester effluent tank will be installed with a capacity of holding 1 day production of digestate.

1.4.3. Lot 1 Site 2: BGLB 1.2 Masri Livestock Aabdeh (Akkar)

1.4.3.1 Site description (please refer to amendments in red)

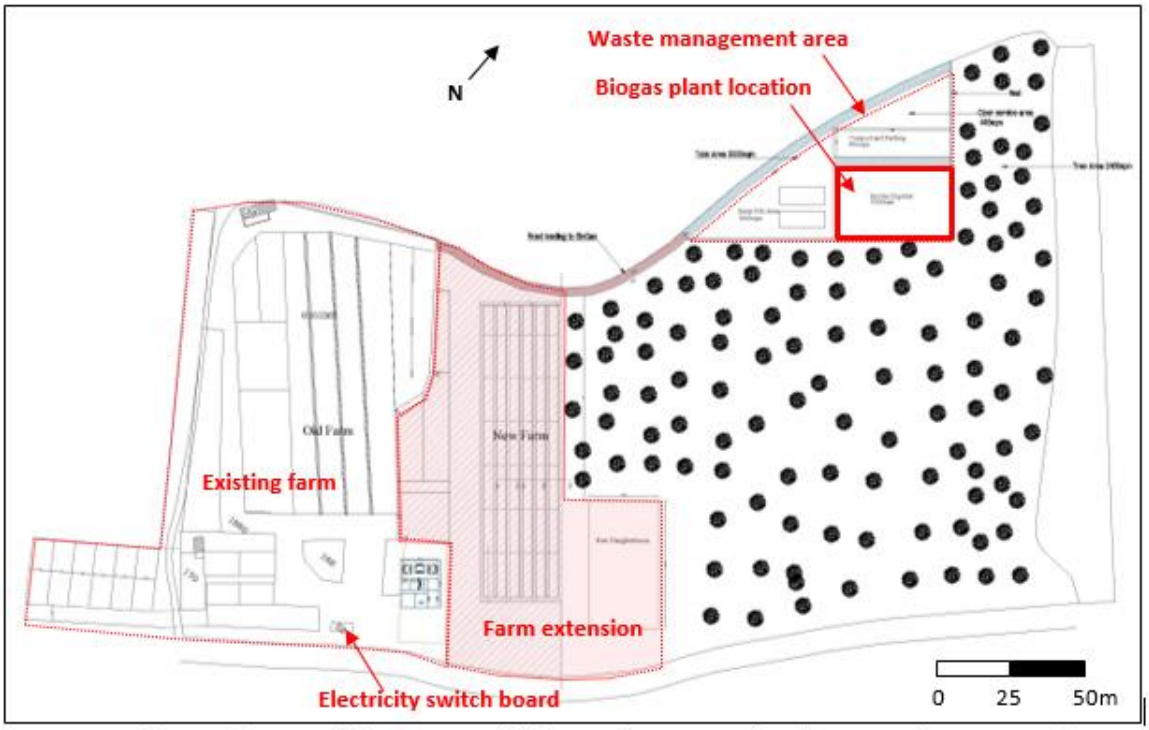
The project Beneficiary is Masri livestock, a family-owned cattle rearing farm located in Abdeh, Akkar. The company is located some 1km from the coast, approx. 15km Northeast from Tripoli. It is well accessible, a few hundred metres from a main road.

The farm currently has a holding capacity of approx. 2000 heads of cattle, and also has a small slaughtering unit on the premises. They are planning for an extension of the stables and the slaughterhouse (see figure below).

On the basis of the available feedstock, Masri could cater a medium-scale biogas plant that could produce a multiple of the energy consumed at the farm. However, the owner has indicated not to consider supplying electricity to the grid, but rather to cover the energy demand of the farm only. Due to the weak grid, electricity for the farm is presently being produced with diesel generators.

The company has decided to develop a new plot for the management of farm wastes (see map below). A new manure tank and separator will be constructed there, as well as a composting area. For the biogas plant, an area of 25x40m has been reserved.

GPS: 34°31'46.8"N, 35°59'56.9"E, altitude 0 metres



Overview of Masri livestock (existing and planned extension), indicating the proposed biogas plant location

Annual average temperature at the site is approx. 20°C. Monthly averages are highest in the months of July and August (27°C) and lowest in January (13°C).

1.4.3.3 Feedstocks (please refer to amendments in red)

The main feedstock available at Masri is cattle manure, mixed with small quantities of slaughterhouse waste (rumen contents). At present, the waste is collected in an underground pit, and subsequently mechanically separated in a solid fraction and a liquid fraction. The solid fraction is sold or used as bedding on the farm; the liquid fraction is flushed away. In the new waste management location, this will be similar.

As the biogas plant is intended for the production of farm electricity only, only part of the available feedstock will be used. As such, it is the intention to use (part of) the liquid fraction for the production of biogas.

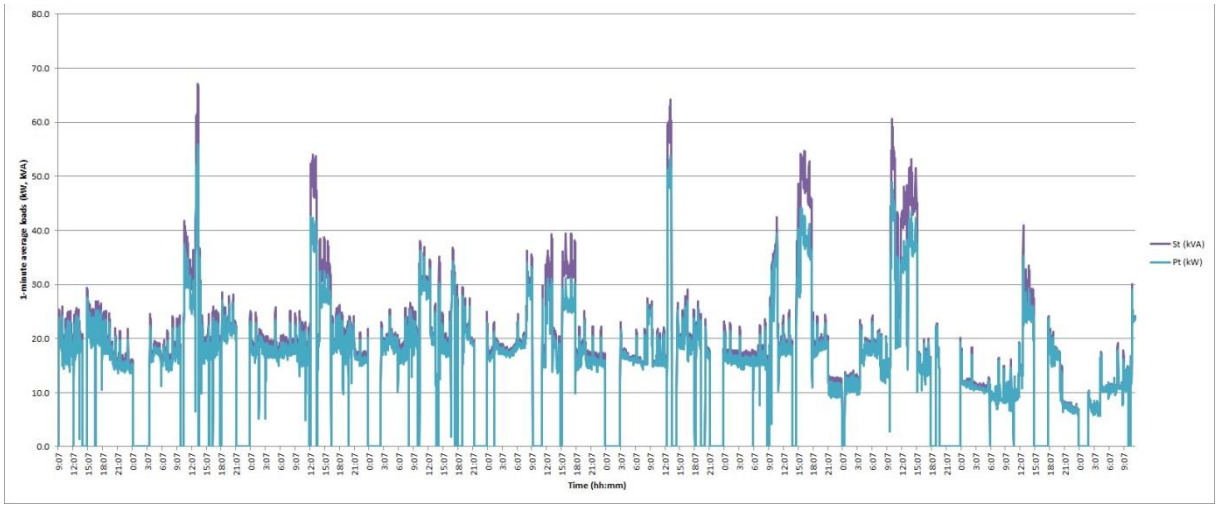
The feedstock properties are as follows:

- Maximum available quantity: approx. 50 t/d
- Dry matter content: 6%
- Organic dry matter content: 85%
- Estimated biogas production potential: 400 Nm^3/tODM

On the basis of the electricity / biogas demand on the farm (see below), the feedstock requirements for de biogas system are estimated at 15.1 t/d.

1.4.3.4 Energy demand

The average total electricity demand on the farm is approx. 450 kWh/d, which is mainly used for pumping, refrigeration and feed preparation. A load graph showing 1-minute averages during 9 days of operation is shown in the figure below.



1-minute average active and apparent load at Masri livestock (5-14September 2017)

Analysis of the data shows the following:

- Maximum 1-minute average load is approx 67kVA (56kW)
- Average load is 18.9 kW (corrected for downtime – 17% of the time)

The farm uses diesel for electricity production, as the grid is too weak for covering the electric loads. Most of the day and night a 60kVA generator is running; when heavier equipment (for feed production) is being used, a 100kVA generator is used. This is typically less than 2 hours per day. Average total diesel consumption is 200 litres per day

1.4.3.5 Project functionality **(please refer to amendments in red)**

It is proposed to use the biogas for covering the smaller farm loads only, and to continue using diesel for supplying the high loads. The diesel generators will be moved to the new site; when heavier equipment is to be operated (i.e. the feed mill), one of the diesel generators will be synchronised with the biogas generator, increasing the generating capacity to the required level. This way, more than 90% of the electricity demand can be produced using biogas. The biogas generator will thus be used continuously. When the diesel generator is running, some biogas can be supplied to the engine with the combustion air, thus reducing the diesel consumption.

The required electricity production from biogas is as follows:

- Island operation (approx 20/7)
- Synchronised operation with diesel generator (base loading, approx 4/7)
- Average load in island mode: 17.2 kW (typically varying between 15-25kW)
- 1-minute average maximum load is approx 30kVA (27kW)

- Expected incidental peak loads upto 40kVA (35kW)
- Average daily electricity production is 420 kWh/d

On the basis of the above, daily biogas demand (including 10% margin) is estimated at 308Nm^3/d.

Because of the mild climate, the space availability and the nature of the feedstock, it is proposed to use one or several bag type digesters without agitation, but with a rudimentary floor heating system for keeping the digester temperature above 20°C at all times. Indicative total digester volume would be 900m^3.

The digester inlet should be directly connected to the outlet of the mechanical separator, which will be located next to the new waste collection pit on the new location. The liquid fraction from the separator can then be piped directly into the digester under gravity. The digester outlet shall be connected to the existing disposal system for the liquid fraction coming from the separator.

1.4.3.6 System components (please refer to amendments in red)

Over-all, the scope of supply concerns the provision, installation and startup of a turn-key biogas electricity plant, including the following plant components:

1. A low-cost anaerobic digester in PVC or HDPE, running in the mesophilic temperature range, with internal gas collection / storage.
2. A biogas CHP unit operating in island mode and synchronised with one of two existing diesel gensets, producing on average 17.2 kW with incidental peaks upto 35kW.
3. Biogas treatment system capable of bringing the biogas to the generator at the conditions required by the generator engine.
4. An underground collection tank for liquid cattle manure, a manure separator, and a pump for pumping the liquid manure from the tank to the separator
5. An underground digester effluent collection tank, connected to the existing wastewater disposal system by underground pipe
6. A generator house for installing the biogas CHP unit and the existing two diesel generators, with a switch board and synchronisation equipment for synchronising the biogas CHP with one of the diesel generators.
7. System monitoring and control facilities required for controlling biogas plant equipment and for measuring and recording of gas production and electricity production.
8. A flare for burning off excess biogas.
9. All piping and cabling required for interconnecting the plant components, and for connecting the new switch board to the existing switch board in the farm.
10. Spare parts and consumables for 2 years of plant operation.

Note that the site will be cleared and made accessible by road by the farm owner before the start of the installation works.

Bidder shall include in his bid full data sheets of all components, in particular:

- CHP unit
- Digester bag, liner and/or cover material
- Pumps
- Flare and gas blower
- Control and monitoring equipment

1.4.3.7 Technical Specification

1.4.3.7.1 Operating conditions

- The biogas plant shall be fully operational in the following climate conditions:
  - Temperature: -10 to 45°C
  - Relative humidity: 90-95%
  - Wind speeds: up to 120 km/h
  - High ultraviolet radiation
  - Rural environment with presence of dust and insect.
- In case of biogas CHP shutdown, the system shall operate on an (existing) diesel generator. However, the system should operate such that no unsafe situations can occur in case of power interruptions upto 2 hours.
- Incidental stray bullets could potentially hit the digester. Bidder should indicate in the design how the digester would be protected from damage and/or how damage can be repaired.

1.4.3.7.2 Digester including (internal) gas storage (please refer to amendments in red)

- Bag- or (fully closed) lagoon type digester operating in the mesophilic temperature range (20-38°C). The digester can be a single unit or multiple smaller units.
- Materials: flexible fibre- reinforced PVC (UV resistant), >1.2kg/m^2, or HDPE sheeting (thickness 1mm). High-frequency welded.
- Minimum retention time 60 days (~900m^3 digester volume).
- Digester heating system for maintaining temperature above 20°C at all times, by means of Digester floor heating using PEX tubing. A layer of 100mm PUR plating will be placed between the hot water tubes and the earth for minimising direct heat losses to the ground. The required heat will be supplied by the CHP unit. Maximum water temperature 50°C.
- Active/mechanical mixing in the system for heat distribution and for avoiding scum layer formation. Submersible agitators and submersible pumps should be intrinsically safe according to DIN EN 50020:2003-8, and have a degree of protection IP68 according to EN 60529.
- Gas storage capacity inside the digester, sufficient for storing all gas for 12 hours in case of generator standstill (>180m^3). Working pressure 0-5mbar, allowable maximum pressure 20mbar.
- The digester inlet will be connected to the manure separator outlet, allowing the liquid separator fraction to flow into the digester by gravity.
- The digester outlet will be connected to the effluent storage tank, allowing the effluent to flow out of the digester by gravity.
- Air dosing system for biological desulphurisation.
- (Mechanical) overpressure valve.

1.4.3.7.3 Biogas CHP unit

- Electrical capacity 42.5-45kVA (34-36kW prime power rating).
- Minimum acceptable biogas methane content 55%.
- Electrical efficiency at rated maximum load >30%.
- CHP engine should be an original gas (spark plug) engine. It shall be fit for continuous (24/7) island operation.

- Gas blower for increasing the gas pressure to minimum level specified by CHP and the flare. Minimum flow rate at required pressure 30m^3/h. ATEX rating Ex II 2G.
- CHP heat from engine water jacket will be made available for digester heating, in order to assure the required digester temperature (>20°C). Any excess heat will be dissipated by cooling unit and/or made available for use on-site.
- An emergency shutdown button outside the generator housing shall be provided as well as a valve to close the gas supply. This closing valve should automatically close when engine is shut down.
- The system shall have adjustable over- and under voltage protection. Operational limits shall be set in accordance to generator requirements (to be specified in the bid).
- The generator should record at least cumulative generator operating hours and cumulative gross electricity production (kWh).
- Exhaust emission limits according to German TA luft (2002) or similar.
- The CHP system shall be installed in the existing generator house. Noise insulation measures will be applied to the CHP unit, such that the noise level at 7 metres is below 80 dB.

1.4.3.7.4 Biogas treatment

- Gas shall be pre-treated to fully comply with the stated requirements of the CHP engine. Gas treatment shall include at least:
  - Desulphurisation by biological means (i.e. immobilisation in the digester by air injection) and physical means (i.e. adsorption with activated carbon).
  - Condensate removal unit.
- Quantities of consumables required for operation of biogas treatment systems will be specified in the bid.

1.4.3.7.5 Control and monitoring equipment

- Electrical control panel for delivered installation for CHP unit, pumps and other electrical equipment.
- Electricity meter (kWh), (400V, I_{nom} >65A, accuracy <1%) measuring the net electricity generated by the biogas plant.
- Gas flow meter (m^3), measuring the cumulative gas produced by the biogas plant (before split to generator and emergency flare). The gas flow meter should have a measuring range between 3-30 m^3/h and an accuracy of ±2%. Compliant with EN12261:2002. ATEX classification Ex ia IIC T4 Gb
- Gas analyser for determining the main biogas constituents: CH_4 (0-100%vol), CO_2 (0-100%vol), O_2 (0-25%vol), H_2S (0-2000ppm or higher). Accuracy ±1.5% from measuring range (CH_4/CO_2), ±3% of measuring range (O_2/H_2S). ATEX classification II2G Ex d e ib IIB T4 Gb.

1.4.3.7.6 Digestate storage tank (additional equipment to the original design to cater for the beneficiary's future plans and safety concerns)

- An underground digestate tank with a gross capacity of >50m3 shall be installed on the new site.
- Approximate dimensions 3x6x3m (WxLxD).
- Construction of foundation, walls and cover (with manhole) in reinforced concrete.
- A submersible pump (capacity >15m3/h) will be installed for transferring the digestate from the collection tank to the wastewater disposal system, or optionally into a removal truck or drying bed (not to be included in the bid)

- An underground pipe connecting the digestate tank to the wastewater disposal system (approx 200m)

1.4.3.7.7 Liquid manure tank (additional equipment to the original design to cater for the beneficiary's future plans and safety concerns)

- An underground manure tank with a gross capacity of >50m3 shall be installed on the new site.
- Approximate dimensions 3x6x3m (WxLxD).
- Construction of foundation, walls and cover (with manhole) in reinforced concrete.
- A long shaft macerator pump will be installed for transferring the liquid manure to the separator. The pump capacity should match the capacity of the separator (>15m3/h).

1.4.3.7.8 Manure separator (additional equipment to the original design to cater for the beneficiary's future plans and safety concerns)

- A mechanical separator shall be installed next to the liquid manure tank, for separating the liquid cattle manure (estimated DM content 10-12%) before digestion.
- Processing capacity: >15 tonnes/hour.
- DM content liquid fraction: 5-7%, DM solid fraction: >25%.
- Installation on a steel frame, height approximately 2m.
- A reinforced concrete floor of approx 4x4m shall be constructed on which to deposit the dry separator fraction.
- The liquid separator output will be directly connected to the digester inlet, and to the underground pipe leading to the wastewater disposal system. A three-way valve will be installed with which the liquid can be directed to the digester or to the disposal system.

1.4.3.7.9 Generator House (additional equipment to the original design to cater for the beneficiary's future plans and safety concerns)

- The new generator house will host the biogas CHP unit, as well as the two existing diesel. generators, the new switch bard, and all biogas plant control equipment.
- Approximate dimensions: 8x4x3m (WxLxH), open on one of the long sides.
- Armed concrete foundation, cement stone walls, corrugated iron roofing.
- Ventilation slots to avoid buildup of biogas in case of leakage.
- The relocation of the diesel generators will be part of the bid.

1.4.3.7.10 Switch board and synchronisation panel (additional equipment to the original design highlighted in red to cater for the beneficiary's future plans and safety concerns)

- A switchboard for the regulation of internal and external energy usage shall be installed. The sizes of the electrical groups for internal uses are to be defined by the bidder.
- The switch board will include a synchronisation panel for synchronising the biogas CHP and either of the existing diesel generators. Speed and voltage control units of the existing diesel generators are outdated and may require replacement in order to accomplish synchronisation.
- All electrical equipment should be connected to a common grounding system, which is connected to ground electrode.
- The switch board shall be connected with the nearest switch board of the project beneficiary. Supply and installation of 300m ground cable (copper 4x150mm2) shall be included in the bid.

1.4.3.7.11 Flare

- A (manually operated) emergency flare should be equipped to flare biogas in case of CHP unit shutdown or biogas over production. The capacity of the flare should be dimensioned to handle the expected biogas production rate (>15 m^3/h) at the rated pressure of the gas blower that is supplied with the CHP unit.
- The flare should be equipped with a flame arrester.
- It must be possible to operate the flare independently from grid- or generator power, i.e. it should have battery powered ignition.
- The flare should be placed at least 10 metres from the biogas system and at least 5 metres from other buildings.

1.4.3.7.12 All related/required infrastructure e.g. cables, pipes etc. (please refer to amendments in red)

- Gas piping shall be resistant to corrosion (e.g. PE or PVC) and dimensioned to handle occurring pressure (max 50mbar). Characteristics of used piping should be defined by bidder e.g. material, dimensions, overpressure, specific colour, flow direction.
- An additional gas connection will be installed inside the generator house, for (optional future) dual fueling of the diesel generators.
- All gas piping shall be pressure-tested prior to be taken into operation according to NEN 2088 or similar standard.
- Gas sampling ports will be placed for sampling of raw biogas and treated biogas.
- All cabling shall be dimensioned according to their design current, length and overload protection devices, according to NEN 1010 or similar standard. Calculations to be provided by bidder.