Multiconsult

NOTE - TECHNICAL SPECIFICATIONS SOLAR POWER PLANT - PILOT PROJECT TROLL STATION, ANTARCTICA

PROJECT	**Integration of renewable energy in Troll Station, Antarctica**	DOCUMENT CODE	713055-RIEn-NOT-01
SUBJECT	Technical specifications solar power plant - Pilot project	AVAILABILITY	Open
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1 Introduction

The Norwegian Polar Institute is a directorate under the Norwegian Ministry of the Climate and Environment. The Institute's activities are focused on environmental management needs in the polar regions. In addition to collaboration on environmental protection in the Barents region, the Institute dedicates much effort to research on climate, long-range transport of pollutants and their impact on the environment, and biodiversity. Topographic mapping is also an important task. In Antarctica, the Institute is responsible for management of all Norwegian activities. This means that all Norwegian subjects planning activities in Antarctica must first contact the Norwegian Polar Institute. The Institute has arranged Antarctic expeditions regularly since 1976.

Troll is the Norwegian research station in Antarctica. Meteorological observations and measurements of radiation, including UV radiation, are undertaken, as well as field research programs on glaciology, biology and physics. Troll operates all the year round. The new station was opened in February 2005. It can accommodate eight people in the Antarctic winter and many more in summer (from October to February). Nowadays, transportation to and from Troll has been simplified by the Troll Airfield, a landing strip opened in connection with the extension in 2005. The station consists of prefabricated modules shipped from Cape Town to the ice edge, and has to withstand temperatures as low as -60 °C and wind speeds of up to 60 m/s.

The Norwegian Polar Institute is now conducting a feasibility study for the integration of renewable energy in Troll, with focus on solar power. The project is called "Troll Green Station". Considering the special conditions of the location, it has been decided to build a pilot solar power project on the roof of one of the buildings (Blåbo-I) before winter 2016 (Antarctic winter: from April to October) in order to build competence and collect data. The pilot project will give better understanding of the conditions and the system for a more efficient planning of the full project implementation.

2 General Requirements

The offer shall include design, procurement and documentation for a PV Plant of maximum 16 kWp. The PV Plant shall include all the required equipment such as PV modules, inverters, wiring, junction boxes, DC and AC switches, surge protection, operation monitoring and documentation.

The limits of the offer are:

- Electrical: general AC switch located in the main electrical switchboard
- Mechanical: existing completed and insulated container roof

The offer shall include every component for a fully assembled plant, without the construction. Due to special logistics linked to the location of the project, the employees in charge of the operation and maintenance of Troll Station will mount the PV plant themselves. Complete assembly instructions must be provided for every point listed in Chapter 5.2. Every component of the plant must fit in a container delivered in Aalborg, Denmark. The inverters must be pre-mounted on the walls of the container. Because of the extreme isolated location of the project, spare parts must be included in the offer (as described in Chapter 6).

The PV Plant shall not contain substances listed on the OBS list of the Norwegian Environmental Protection Agency and the list of particularly hazardous substances. This includes, between others, Cadmium (Cd) and BFRs (Brominated Flame Retardants).

The PV Plant shall comply with all applicable requirements regarding fire safety concerns.

The PV Plant shall be adapted to the connection to the local electrical grid (three-phase 400 V TN).

All documentation shall be delivered in English or Norwegian.

Prices in the offer shall be detailed (PV modules, balance-of-system, etc.) and shall be indicated in Euros (€) or in Norwegian Kroner (NOK), with and without value-added tax (VAT).

3 Option - training for installation

As an option, the supplier may offer installation training of a similar type of system to employees of the Norwegian Polar Institute in Norway. If the supplier should chose to offer this type of training, the offer must include a short description of the training and it must take place before they travel to Troll. The option must be priced separately.

4 Technical Description

4.1 Location, Building

Troll Station is around 235 km from the coast, at Jutulsessen in Dronning Maud Land. Located at 72° 01’ S, 2° 32’ E, Troll Station stands on bare ground 1270 m above sea level on the Jutulsessen nunatak, surrounded by the vast Antarctic ice cap, unlike most research stations in Antarctica, which are placed on snow.

An overview of Troll Station is shown in Figure 1.

Figure 1: Troll Station, from North. Source: Norwegian Polar Institute.

The building chosen to host the pilot solar project is “Blåbo-I”, shown in Figure 2.

Figure 2: Location of Blåbo-I. Source: Google Earth.

Blåbo-I is composed of five 20-foot-long containers as shown in Figure 3 and Figure 4. The building's length is 12,2 m (walls oriented North-West and South-East) and its width 7,3 m (walls oriented North-East and South-West). The building is oriented South +20°.

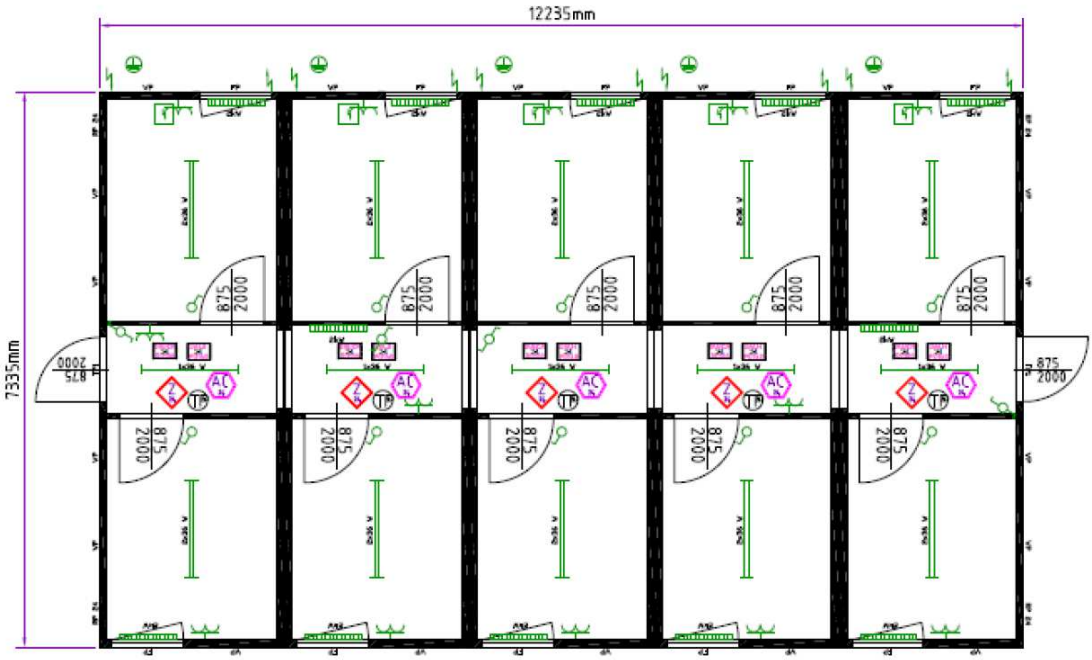

Figure 3: Blåbo-I. Source: Norwegian Polar Institute.

Figure 4: Blåbo-I. Source: Norwegian Polar Institute.

Drawings are enclosed to this document.

4.2 System Design

Because of the operation and maintenance of Troll's diesel generator, the pilot PV Plant shall not exceed 16 kWp.

The technical room will be the container in which the components are delivered, and the inverters must be pre-mounted on the walls of the container. The technical room will be installed South-West of Blåbo-I, freestanding on the ground, as seen in Figure 5.

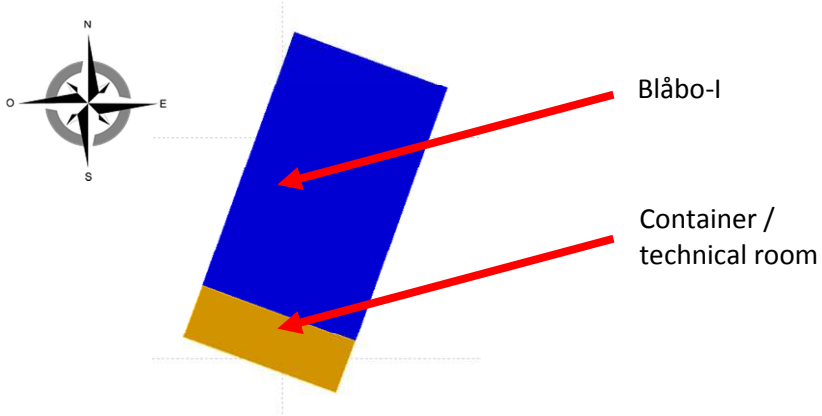

Figure 5: Location of the container / technical room. Source: Multiconsult.

The system design shall be balanced between optimization of production and security under extreme wind conditions (c.f. Chapter 4.4.4). The mounting system must then combine excellent aerodynamic according to the wind direction and speed, and good azimuth and tilt.

Example (only informative, the tenderer must propose and document his own offer):

PV plant oriented North-East (North -20°) tilted 10° with 2m pitch between rows, as shown in Figure 6. The whole roof area is not covered by the PV plant because of higher wind last on the North-East part. The South-West part of the roof have a lower form factor (c.f. Chapter 4.4.4).

Figure 6: Example pilot PV plant. Source: Multiconsult.

4.3 Minimum Performance Requirements

The power of the PV Plant shall be indicated in kWp at Standard Test Conditions (STC), according to IEC 60904-3 (Photovoltaic devices – Measurements principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data).

The simulation/calculation method shall be documented (complete software report and assumptions). The simulation/calculation shall be done with a validated software using hourly based calculation, such as:

- PVsyst;
- PV*SOL;
- Archelios;
- Polysun;
- Etc.

The simulation/calculation shall include every loss applying to this Solar Power Plant (DC, AC, LID, IAM, temperature, albedo, snow, shading, etc.) as well as the right component parameters (PV module, inverter, etc.).

Simple free simulation tools (for example PVGIS) will not be accepted.

4.4 Equipment

4.4.1 PV modules

The PV modules shall have a power warranty of minimum 80 % at STC (Standard Test Condition) after 25 years. The product warranty shall be at least 10 years.

The PV Plant shall consist on only one type of PV module and all the modules shall have the same rated power.

The flash test data shall be provided in order to minimize the mismatch losses in module strings.

The PV modules shall have a TÜV certification and, as a minimum, be in compliance with the standards listed in Chapter 8 of this document.

The PV modules shall meet the sales requirements of the EEA (European Economic Area) and be marked CE.

4.4.2 Inverters

The inverters shall be approved for solar photovoltaic applications.

The inverter design shall be adapted for the connection to the local electrical grid and the grounding system (three-phase 400 V TN).

The inverters' warranty shall be minimum 5 years. The offer shall include an extended warranty up to 10 years as an option.

The inverters will be mounted on the wall of the delivered container (technical room)

The inverters shall have a TÜV certification and as a minimum be in compliance with the standards listed in Chapter 8 of this document.

4.4.3 Wiring

All DC cables shall be approved solar cables for outdoor use, and otherwise meet the requirements of the standard IEC 60364 (Low-voltage electrical installations).

Interconnections between module cables and string cables shall be made with connectors type MC4.

The offer shall include DC cables long enough to connect the solar power plant to the technical room (South-West of Blåbo-I, see Chapter 4.2) and AC cables to connect the PV Plant to the general AC switch located in the main electrical switchboard.

The AC cable shall be connected to the grid on the upper right corner of the containers (angle North-East):

Figure 7: Location of connection to grid.

Figure 8: Detail of termination JB.

4.4.4 Mounting System

The PV modules are mounted on an existing completed and insulated container flat roof.

Due to the wind direction and in order to optimize the area on the roof, the PV modules shall be mounted on several rows with the same orientation as the building, i.e. North -20°.

The mounting system shall not impact the insulation neither the sealing of the roof. The mounting system must be welded to the steel container roof. A solution with a special steel sublayer fastened under the aluminum profiles must then be proposed in order to be able to weld it to the steel roof. The fastening system of the PV Plant to the existing roof shall be documented and cost estimated in detail and is a part of this deliverance.

Due to extreme wind conditions, the choice and design of the mounting system and its aerodynamic must be done with special care.

The mounting system shall meet the local requirements of wind loads according to the standards:

- NS-EN 1991-1-4:2005+NA:2009 (Eurocode 1: Actions on structures – Part 1-4: General actions - Wind actions)
    - Reference wind speed: 60 m/s

A wind rose made from wind measurements the last 10 yearsis shown in Figure 9.

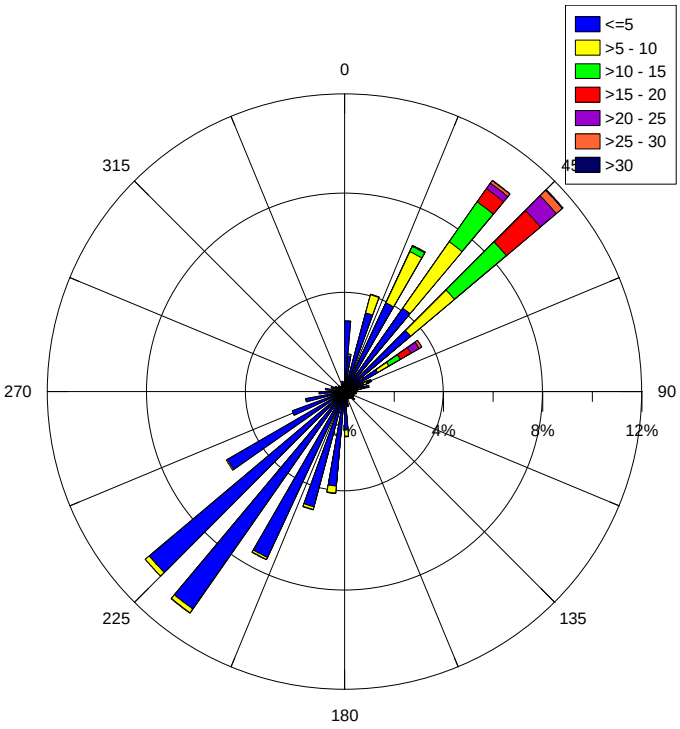

Figure 9: Wind directions and speed Troll station, Antarctica. Source: Multiconsult.

The compass rose shows that the strongest wind comes from North-East.

The extra weight per m² due to the PV Plant on the roof (including the mounting system and the PV modules) shall not exceed 25 kg/m².

Wind load calculations for the fastening of the mounting system, the mounting system itself and the PV modules must be documented. It is recommended to offer special fastening and aerodynamic measures (ex: closed mounting system, extra rails, etc.).

According to the wind load standard, giving the form factors for flat roofs, it is suggested to limit the installation area to the south end of the building were the form factors are the lowest. This given, the available area for the PV plant is approximatley 7,9 x 5,9 m as shown in Figure 10. This calculation is indicative and must be validated and documented by the supplier.

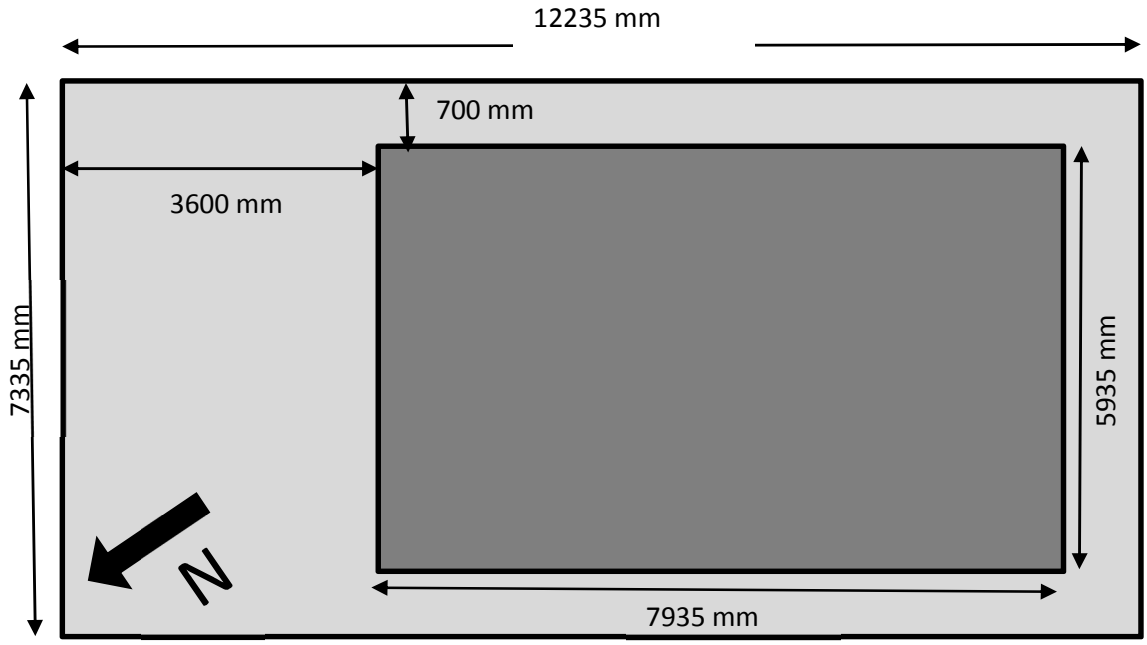

Figure 10: Indicative available are for PV plant in area of roof with minimum for factor according to wind load standard. Source: Multiconsult.

4.5 Overvoltage and Grounding System

The PV Plant, including the mounting system, shall be grounded in accordance with requirements from the suppliers of PV modules, inverters and mounting system.

4.6 Monitoring

4.6.1 Data Logging

The PV Plant shall include a simple solar radiation measurement (reference cell) and temperature sensors on the modules.

The PV Plant shall include a surveillance system that enables live monitoring and logging. An Ethernet cable is available in Blåbo-I for the connection to internet. The solution must be documented.

The monitoring shall include, as a minimum, data from every single string. The monitoring solution shall include option alarms notifying the operator of production disruptions via emails or SMS.

5 Documentation

5.1 General

All documentation, product information and datasheet of every component of the PV Plant shall be delivered, according to the standard EN 62446 (Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection). The documentation shall be in English or Norwegian.

The complete documentation, including the instruction manuals and drawings (one-line diagram and mounting system), shall be delivered in both hard copy and electronic format. The hard copy must be included in the container. A folder with the complete operation and maintenance instructions must also be included.

5.2 Assembly Instructions

Complete assembly instructions must be provided for every step of the work:

- Fastening of the mounting system to the roof
- Assembly of the mounting system
- Fastening of the PV modules to the mounting system
- Fastening of the inverter(s)
- DC and AC electrical connections and security equipment
- Connection of the monitoring system
- Operation and mintenance

6 Warranty and spare parts

A document giving an overview of the different components, warranties and warranty terms shall be delivered.

Additional spare parts shall be provided in order to optimize the operation and maintenance of the PV power plant. Amount of spare parts must follow the following list:

- Solar panels: 20% extra (2 extra panels for a solar power plant of 10)
- Inverters: 35% extra (with 1 pc. minimum)
- Cables: 25% extra (DC and AC)
- Electrical components: 1 pc. extra of each
- Sensors: 1 pc. extra (both radiation and temperature)

7 Delivery

The complete equipment must be delivered in Aalborg, Denmark, before Thursday December 3, 2015.

The inverters and other relevant electrical components must be pre-mounted on the walls of the container.

8 Standards

The offer shall meet the requirements of the following standards:

General:

- IEC 60364 (Low-voltage electrical installations)

PV modules:

- IEC 61215 (Crystallin silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval)
- IEC 61730-1 (Photovoltaic (PV) module safety qualification – Requirements for construction)
- IEC 61730-2 (Photovoltaic (PV) module safety qualification – Requirements for testing)
- IEC 62716 (Photovoltaic (PV) modules – Ammonia corrosion testing)
- IEC 61701 (Salt mist corrosion testing of photovoltaic (PV) modules)

Inverters:

- IEC 61727 (Photovoltaic (PV) systems – Characteristics of the utility interface) or EN 50438 (Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks)
- DIN V VDE 0126-1 (Automatic disconnection device between a grid-parallel generator and the public low-voltage network)
- IEC 62103 (Electronic equipment for use in power installations)
- EN 50178 (Electronic equipment for use in power installations)
- IEC 61173 (Overvoltage protection for photovoltaic (PV) power generating systems – Guide)
- EN 62109-1 (Safety of power converters for use in photovoltaic power systems – General requirements)
- EN 62109-2 (Safety of power converters for use in photovoltaic power systems – Particular requirements for inverters)

Mounting system:

- EN 1991-1-3:2003+NA:2008 (Eurocode 1: Actions on structures - Part 1-3: General actions - Snow loads)
- EN 1991-1-4:2005+NA:2009 (Eurocode 1: Actions on structures – Part 1-4: General actions - Wind actions)

System:

- IEC 60364-7-712 (Electrical installations of buildings – Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems)
- EN 62446 (Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection)

9 Attachments

- Drawings of the building