Energetic modernisation of the German Neumayer-Station III

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***Information Paper submitted by Germany***

**Introduction**

Climate change due to increased anthropogenic CO2 emissions is one of the most important and increasingly obvious factors influencing the state of the Antarctic environment. Reports like the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate and the updates provided by SCAR of its Antarctic Climate Change and the Environment report[[1]](#footnote-1) show that the climate of the Antarctic and Southern Ocean is undergoing rapid change, which is expected to continue into the future.

ATCM and CEP have over the last years adopted several Resolutions[[2]](#footnote-2) and programmes[[3]](#footnote-3) in order to combat and mitigate climate change.

In the light of this, Germany has investigated the energetic modernisation of the German Neumayer-Station III with a view to increasing the utilisation of renewable energy sources, thereby enhancing renewable energy technologies and reducing operational costs.

**1. Characteristic of Neumayer-Station III**

Neumayer Station III is the third German research station to be operated as a year-round station in Antarctica at about 70°35'S / 8°20'W on the Ekström shelf ice at the eastern exit of the Weddell Sea near Atka Bay[[4]](#footnote-4). While the first two stations were built in a tubular tunnel construction submerged into the shelf ice, a fundamentally different construction principle has been implemented since 2009 with the Neumayer Station III (NM III). The station was built as a free-standing island station above a roofed garage on top of the drifting ice shelf. As a result of snow accumulation, the ground level at the site experiences an annual elevation of approx. 100 cm. In order to avoid submersion, the station building and all outdoor installations have to be lifted at regular intervals. The corresponding technologies have been developed. The NM III itself can be lifted via its 16 hydraulic stilts / legs. For all other equipment, such as wind turbines, special lifting and crane facilities are available at the station. All structures are built on firn ice, which despite special foundations limits their overall size and height (e.g. of new wind turbines).

**2. Energetic modernisation of Neumayer-Station III**

A modern energy concept was already developed and installed during the construction of NM III[[5]](#footnote-5). The energy efficiency of the diesel fuel used at NM III was significantly increased compared to that of Neumayer-Station II (NM II). Although the new station has more than twice as much usable space as its predecessor and is also directly exposed to the weather (i.e. wind and low temperatures), the additional specific fuel requirement (litres/year/m²) is only about 54 percent compared to NM II (see Table 2).

|  |  |  |
| --- | --- | --- |
|  | **NM II in 2006** | **NM III averaged per year (2011 -2021)** |
| Total consumption [litres] | 190.152 | 242.020 |
| Heated floor space [m²] | 914 | 2.118 |
| Specific consumption [litres/year/m²] | 208 | 114 |

**Table 2:** Fuel consumption comparison Neumayer-Station II and Neumayer-Station III

These favourable operating values are achieved in the combination of:

- efficient energy management to utilise the electrical and thermal energy of the combined heat and power plant (CHP) units;

- heat recovery from the exhaust air of the container modules and the power station;

- use of a special wind turbine suitable for the specific Antarctic conditions at NM III.

After 12 years of safe operation of the NM III station, the energy technology is to be successively renewed in the coming years. After a detailed inventory of the energy flows and requirements, a feasibility study (FS) was carried out to assess the potential and practicability of new alternative and environmentally friendly technologies to be used under polar conditions. The main target parameters of the subsequent optimisation investigations and calculations were the CO2 emissions and the total annual costs. In addition, the concept variables were dynamically simulated and analysed in detail using a Transient System Simulation Tool (TRNSYS), which allowed examination of concept variants and expansion states as well as dedicated parameter studies.

**3. Key statements of the feasibility study**

Economic and environmental optimum: In order to achieve an economic and environmental optimum when upgrading the operating technology, a balance between available renewable energy, thermal and electrical energy consumption and the respective installation costs has to be achieved. In the case of NM III, new combined heat and power plants (CHPs), additional wind turbines, photovoltaic (PV) plants and thermal and electrical storage systems are recommended.

A battery electrical storage system (BESS) and a heat storage system: Both systems will primarily be used to optimise the running time of the CHP units. The feature to shift energy quantities from times of wind power generation to times of demand is very limited. The evaluation of the available wind field around NM III shows that the duration of lulls (times with small wind speeds or no wind) would require a BESS in the MWh range to ensure a high level of self-sufficiency of the station.

Power-to-heat technologies: With an increasing shift of the primary energy source from fossil energy to renewable electrical energy, the capacity of the heating register to generate thermal energy, to melt snow and heat the building, needs to be increased.

Combined heat and power plants: In order to provide a safe energy supply, the provision of thermal and electrical energy from CHP units will continue. However, 2 module sizes are used in order to cover the energy demand (above the yield generated by renewable energy) adequately.

General: With increasing contribution of renewable energy, the electric power demand in the system increases, whereas the share of CHP units in covering the heat demand decreases from approx. 100% to a maximum of 56%. The heat demand is covered by power-to-heat technologies (e.g. electric heating coils) and no longer only by recuperating the waste heat from the CHP units. The share of renewable energy in the total electricity demand increases from currently 5% to up to 73% (depending on the chosen options and configuration levels).

**4. Start of upgrade**

The feasibility study clearly showed that the wind turbine is the most important component of the conversion to renewable energy production at NM III. For this purpose, a suitable Vertical Axis Wind Turbine VAWT was identified on the market and modernised for polar operation. In addition to replacing adhesives and resins in the generator and using steel suitable for use in low-temperatures, the characteristic power curve of the turbines was adapted to the actual air density conditions at NM III. The turbine proved its suitability during a trial run in a climate-controlled test chamber.

In order to compensate for the annual increase in snow level of around 100 cm, the wind turbine has to be raised once a year. The new design of the foundation in the snow/firn and the mast ensures this process.

It is planned to test the operation of the new wind turbine plant, which has the nominal power of P=50 kW, after its installation in January 2023 for at least one year.

The implementation of further steps in the energetic modernisation of NM III are planned once the new wind turbine has demonstrated its reliability in the test operation.

1. see ATCM XLIV Agenda Item 16 and CEP XXIV Agenda Item 7 and SCAR Lecture at ATCM 2022 [↑](#footnote-ref-1)
2. e.g. Resolution 8 (2021) "Antarctica in Changing Climate" [↑](#footnote-ref-2)
3. e.g. the CEP Climate Change Response Work Programme [↑](#footnote-ref-3)
4. See <https://www.awi.de/en/expedition/stations/neumayer-station-iii.html> [↑](#footnote-ref-4)
5. XXXII ATCM IP 114: Neumayer Station III Completion of construction and start of pilot operation in February 2009 [↑](#footnote-ref-5)