Camps in the Arctic

FOREWORD

This paper discusses the Danish Ministry of Defense focus on the Arctic, as described in the Ministry of Defense's *Environment and Energy Strategy*. This topic coincides with theme of the U.S. Army Corps of Engineers January 2020 "Thermal Energy Systems Resilience in Cold Art Climates Consultation Forum" in Alaska.

As larger and larger areas of the Arctic Sea areas have become navigable, the requirement to have stations / camps to carrying out rescue operations at sea is increasing. Due to the cold climate, this effort will require significant energy production for electricity and heat. It will also require buildings and electricity and a heating infrastructure with very high resilience. At the same time, the level of ambition of the Danish 2030 plan has been raised significantly. This means that the Danish are not interested only in reducing energy consumption, but also in replacing fossil fuels with non-fossil energy. To this end, the Ministry of Defense in Denmark has initiated a construction project on a smaller Danish island where electricity was previously produced on the CHP diesel engine and residual heat on an oil-fired boiler, that now produces all its energy in the form of electricity from a wind turbine. The surplus production of electricity is stored in the form of hydrogen and is used as a backup for use in fuel cells. The heat is produced with heat pumps.

Denmark is currently establishing a professional collaboration between the Ministry of Defense, universities, and private companies to inverstigate and develop camps in the Arctic. This is being attempted by applying for an EUDP (Danish Energy Technological Development and Demonstration Program) project that similar to the International Energy Agency (IEA).

CONTENTS

1 INTRODUCTION

The contents of this document are drawn from experience gained from past experience from the Greenland military bases. This document is not intended as the finished article, but as a starting point for a form of instruction manual for bases/future bases in the Artic. It is a matter of fact that Denmark uses large amounts of fossil based fuel in keeping the Artic bases functional. Denmark has recently passed new parliamentary laws, meaning that Denmark shall become 70% fossil fuel free by 2030. With this in mind, we must with every new installation/building, investigate the possibilities of achieving a fossil fuel free solution. Electricity and heat can always be produced without using fossil fuels, whereas at present aircraft transportation is a further step into the future.

Control of smaller electricity networks has been shown to be a challenge under low load conditions. Investigations should be made into how much harmonic and load factors cause problems with these smaller networks, as this will be relevant to these types of remote encampments.

Communal heating networks, where use of heat produced from other processes such as burning as communal waste, exhaust heat from diesel motors / generator units etc. are points that the Danish delegation will take up.

The indoor environment in the Artic area is another large challenge. An uncontrolled internal environment can result in considerable problems with illness both in the short and long term. However, relieving these problems in the form of increased ventilation has an inevitable need for more energy. However, this is a cost that one cannot ignore in such a remote environment.

The production of environmentally friendly green electricity must have a high priority. The Property agency is a present in the starting phase of a new project called “Green Christiansø” where all electricity usage on the small island will be provided by a windmill placed slightly offshore, with backup energy being produced by stored hydrogen used in fuel cells. Experience gained from this project will be very relevant and important for us, not alone because of the energy production aspects, but also regarding control of network stability etc.

1.1 ELECTRICITY AND HEATING, AND HEATING CONSUMPTION COMPONENTS

Electricity and heat consuming components refer to all components that require energy. also Included are components that use aviation fuel (unifuel).

1.2 Buildings

This includes:

- Hospitals
- Cafeterias
- Offices
- Residential accommodations
- Hangers
- Airport building
- Other.

For all buildings in the artic area, where the internal and external temperature can vary by up to 80°C, it is obviously extremely important that floor, walls, ceilings and windows are insulated sufficiently with the components having correct U-value. Particular attention should be given to avoiding cold bridges, these are often seen with doors, windows and points of entry of services (heating and electrical). In addition it is extremely important that there is a very effective damp course/ membrane, in our Danish camps we have seen examples where the damp air enters the roof construction causing ice to form, giving large problems when it thaws out.

1.3 Technical Installations

Technical installations refers to:

- Ventilation / air-conditioning equipment
- Compressed air units
- Pumps
- Streetlights
- Runways
- Harbors / ports
- Other.

Ventilation units are often not designed for artic conditions. The extreme low temperatures, down to -60°C means that when the air is warmed up the relative

humidity is reduced to 10%, as such a fine spray of warm should be introduced to the unit to raise the humidity to 50%. The reverse of this problem arises when we remove air from the building, in this instance air humidity is raise to nearly 100% (after removal of heat from the air). This meaning there is a great risk of the creation of ice at the exit point. Naturally it is extremely expensive to heat this cold air up to the desired temperature, as such it is very important to only heat up that air that is necessary. As such the units shall be controlled by monitoring of CO2 and relative humidity. It should be noted that the more airtight the building becomes the more the need for ventilation.

- Pumps are often frequency regulated, there are many good reasons for this, among other things, energy savings. However, this can have other unwanted side effects, for example, harmonic distortion in the electrical network, causing instability, as was mentioned earlier.

1.4 Vehicles and Machinery

Vehicles and machinery are included because they use unifuel. In the future it will/may be possible to use electric vehicles / hydrogen driven vehicles as will be covered under point 3.

2 ELECTRIC AND HEAT PRODUCING UNITS

In the Artic electricity and heat is generally produced by motor / generator units using aircraft fuel (unifuel).

2.1 Motor/Generator Units (Traditional Diesel Driven)

It is often seen that generators are used as pure power units, thus is a very ineffective way of producing energy, with only at best a 30-35% efficiency. It is possible to utilize exhaust gases for warming of water, this then brings the efficiency up to 90%, but only if this hot water can be stored in accumulation tanks. These motors are able to operate at very low rpm, which is the case under low electrical load, unfortunately at these low rpm conditions the motors, which are not designed for such operations, are quickly worn out. It is therefore advisable in such operations to have a battery bank that can be charged in such operations, thus, by using alternating charging/ discharging cycles always keeping the motor in its optimum operating range. The battery can have additional functions such as balancing of load and use during network blackout.

2.2 Sun/Wind Using Hydrogen as a Backup Fuel Cell Source

Production of electricity by using sun and wind can be made directly using can be provided by Sun/wind as a substitute for fossil fuels. In the area around Station Nord has an average yearly wind of 5m/s, this being ideal for smaller windmills up to 800 kW. In the light summer months there are many hours of sunshine, as such the combination of wind and sun could be very effective, although an emergency backup would be essential, and in such cold climates with low temperatures and RF, storage of hydrogen would be optimal proposition. The heat produced by the process of electrolysis, could further be used to heat the buildings and the inherent low temperatures used to cool fuel cells.

3 WASTE AND WASTEWATER

3.1 Waste

Waste is defined as both regular household waste and human waste. In cold regions it is difficult to compost waste, as such waste could be burnt and the resulting heat used to heat buildings etc. However, a limited amount of material will not be reusable, and will needed to be transported away.

3.2 Wastewater

Waste water could sensibly be used in place of clean water in the electrolysis process, as waste water has a higher hydrogen content than pure water.

4 DISTRIBUTION OF ELECTRICITY AND HEAT

4.1 Heating Infrastructure

It is important to protect the communal heating piping structure and associated pumps. Breaks and other damage can be disastrous, as one often does not have personnel present to repair the damage immediately. The buildings cannot function without heating for very long without heat. Here one must have special control systems to identify problems before they develop into catastrophic failure.

4.2 Electrical Infrastructure

This is possibly the most vital element, without electricity a camp in such conditions cannot function for any length of time. Failures can be caused by various events:

- Usage overload followed by too low a production
- Load being too low.
- Buildup of harmonic current and voltage
- These problems need to be addressed further.

5 RESILIENCE – MISSION CRITICAL FACILITIES

5.1 Control – Regulation – Overview

SRO systems must be developed for the Arctic

5.2 Battery Backup

Battery backup can be used as:

- Balance Sheet Management
- Engine optimization
- Local battery backup at the building or process level
- This needs to be further investigated.

5.3 Fuel Cell as Emergency Generator

Instead of local batteries, comressed hydrogen can be used with fuel cells.

5.4 Electricity Quality

Electricity quality is important, which is why there should always be measurement:

- Voltage
- Frequency
- Peaks
- Harmonic current
- Harmonic voltage
- Other things.