CON20 Final Report

1.1 Project details

Project title:	EUDP 2016 CON20 RE-Smart
Project identification:	Journal 64016-0086, https://energiforskning.dk/da/project/eudp-2016-con20-re-smart
Name of the programme funder:	EUDP
Project managing company:	LOWENCO A/S
Project partners:	HEPKON ApS, Højgaard Teknik og Automation ApS
CVR:	34582424
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1.2 Short description of project objectives and results

Engelsk

In the Con20 VE-Smart project an innovative new industrial freeze design is developed and demonstrated, that combines ultra-low power consumption, with a modular design that offers significantly lower installation and operating costs than traditional cold stores. The system is powered by mounted solar cells and is Smart Grid integrated.

Dansk

Con20 VE-Smart projektet har til formål at udvikle og demonstrere et banebrydende nyt industrielt frysedesign, der kombinerer ultra lavt energiforbrug, med et modulært design der tilbyder markant lavere installations- og driftsomkostninger end klassiske frysehuse. Systemet drives af påmonterede solceller og kan Smart Grid-integreres.

1.3 Executive summary

The CON20 project was initiated to develop an energy efficient, optimal insulated, modular, high quality, reliable, stationary, aesthetic designed, ultra-low temperature freezer primarily for the food and medical industry. The design is based on a 20 foot container specifications, so transportation of the unit is easy. The temperature range varying from +10°C to -70°C and ambient from 32°C to 55°C specification wise making the concept usable within the whole world.

Optimizing freezers per specification will make the energy consumption minimal and energy efficiency optimal for the decided storage temperature.

1.4 Project objectives

The project objective was supposed to be achieved by:

• an optimized design with all heat-emitting components located outside the freezer compartment

• a redesigned evaporator and fan

• media tracing and defrosting based on syltherm oil

• integration of Lowencos new ultra energy-efficient door design, developed in an InnoBooster-funded project

• intelligent controls, balancing consumption to availability of solar power - in the development of controls, the project wants to go even further and expand functionality to incorporate use in the future Smart Grid, using control hardware developed in the EcoGrid project.

• a modular design where the future of cold storage will consist of interconnected freezer units, each with the dimensions of a 20-foot container, thereby providing maximum flexibility in capacity to avoid energy loss from periodic overcapacity

The project was initiated, and the design process started as scheduled. When looking back at the project the first major issue was to make an optimal insulated container for different temperature ranges. The solution was to specify several containers to a specific internal and external temperature. The design was also intended to make space for a compact and specific technical installation in one end and entrance in the other end of the container. The technical space was created so it could be assembled in a frame, where the frame afterwards could be pushed into the container.

Integration of the Delta150 InnoBooster door was also a complicated issue. The dimensions of the door were adjusted to the container, again depending on temperature difference specification of the container. This lead to four different sizes of the door, all with same insulation materials and specification according to the Delta150 project.

Another challenge was to fit all major components inside the small technical space. The installation was intended to include both an option for fully redundancy refrigeration setup, and possibilities for solar powering and Smart Grid connection and off grid functionality including battery backup. With a maximum depth of 500mm in the technical space, and temperatures ranging up to 55°C, technical restrictions for components and their dimensions was a large barrier in the project.

To move all heat-emitting components from inside the freezer to outside was not easy. Due to impossibilities such as defrost equipment without heat, and keeping doors unfrozen with temperatures below -40°C, it was decided to change the objective to minimizing the heat emitted from the components as much as possible.

These obstacles didn't affect the delivery of work packages or milestones in the project. All milestones were delivered according to the planned time schedule, only with these minor adjustments throughout the project.

1.5 Project results and dissemination of results

1.5.1 Mechanical prototype (WP1 and WP2)

The design result was a 20 foot container, where only the corner fitting are similar to a standard 20 foot container. Due to high demand for precise tolerances during assembly of the container, Lowenco decided to make the frame themselves. This left the container within +-3mm at the longest measurement of 6 meters. The design of the CON20 frame has been coordinated with DNV GL in Hamburg, and applies with the applicable sections of ISO 668, ISO 1496 and the International Convention for Safe Containers (CSC) 1972 (2012 edition). A physical test will indicate whether the frame is strong enough to withstand the forces for a complete CSC approval. The physical test was postponed, since a strength calculation through computer simulation indicated deviations up to the maximum allowable. It left the bare container frame with no safety margin, and an optimization was needed. To keep track of the schedule, it was decided to move forward with the designed frame. The optimization will be done after the project is complete which also is a part of the perspectivation of the project.

A result in the design. Four different insulation classes were needed to create the optimal thermal barrier depending on outside temperature and operating temperature. The different classes of insulation also made the internal dimensions optimal, creating maximum space for storage inside the container.

Space for batteries depends weather the container needs to go as low as -70°C or 0°C. The higher demand for power in a -70°C container, requires a larger battery bank. Space for this larger battery bank isn't possible to fit within the tiny space for the compressor skid including the cooling equipment and electrical panels. A dedicated technical container is a possible solution to solve the problem, but in case of changing a setup, the technical container would also need an update. We decided to proceed with the technical container, but with possibilities to connect and disconnect each container from the solar panels supply.

1.5.2 Refrigeration prototype (WP3 and WP4)

To get as low energy consumption as possible, ten different ranges for the compressor system was made. The range was from +10°C to -70°C with optimal performance and power consumption as low as 1kW at the 0°C with dimensioned ambient of 32°C.

A prototype plant was designed and tested. The simplified control system used for the prototype was a Carel UltraCella and pumpdown operation. P&ID´s and equipment lists for a one-stage and cascade plants were completed, and a 3D layout was completed.

Trials were made with auto cascade -50°C plants, but proved inefficient compared to cascade plants at these capacities (1-1.5 kW).

Experiments were conducted with media tracing (thermal oil) for defrosting purposes. The used thermal oil is a heat transfer fluid which is pumpable at temperatures as low as -112°C. None of our preferred supplier would accept the thermal stress, so we customized a standard evaporator coil ourselves to test the thermal oil. An evaporator coil was modified with an additional circuit of 10 pcs. ½" Cu pipes, evenly distributed in an evaporator. Workshop testing were carried out with a standard Metro Therm electrical water heater, a fixed displacement pump and Cu pipework. The electrical heating element thermostat was set at 60°C. A defrost was carried out by manually starting the pump forcing the thermal oil through the additional circuit and slowly heating the evaporator coil. The test was successful but the actual control, design and certification of a circuit for operation requires more R&D. Thermal stress seems to be the biggest issue. The materials in the coil ranges from -60°C to +60°C within few seconds.

To optimize space and performance Lowenco created a compact, insulated, optimized evaporator design proven to work in -70°C. Lots of standard evaporators works fine until -40°C to -50°C, the problems occur when the evaporator fan stops during defrost. After a defrost the fan has difficulties to start again. By various optimizations and insulating vital parts of the fan, Lowenco made an evaporator fan reliable even at -80°C.

1.5.3 Simple prototype of control and software (WP5, WP6 and WP7)

Initially a mock-up was created of the solar-setup to drive one container at 0°C. The setup had a peak power production of 130 Wp x 12 panels = 1560 Wp, and during November/December/January the production were 50-750W (actual values). The battery bank contained 8 pcs. 12V/130Ah Gel Deep Cycle Batteries only using 60% of the capacity.

One CON20 0-10°C test setup/prototype were operated by battery and solar package alone (off grid) and managed to operate for 2.5 days straight at a room setpoint = 0°C. Indicative the compressor on/off cycle was 60/40. Beside the temperature controller a bucket of water was placed inside the freezer to indicate when the temperature reached 0°C or below. Within the first 8 running hours the water was frozen.

The overview of the app was initiated early in the project, and later improved for implementation to the plc control of larger compressor units for -70°C. It was decided to connect the app through a raspberry pi and visualized through a LED screen directly on each container. The solution only requires a Wi-Fi network to monitor online.

1.5.4 Final prototype (WP8)

Test of incorporated Delta 150 door was a success. It performs optimal at the tested temperature of -65°C inside and +35°C ambient. No moist, indicating cold bridges, was found. The door heating was replaced with electrical heating on the tested doors. This also worked fine.

The final prototype of the evaporator seemed to get issues starting at cold condition, even with the optimizations, so the final improvements was ceramic bearings with low temperature grease. The bearings made the unit able to rotate even when cooled down to -80°C.

The final prototype of the complete container is still being tested, to make sure all performance criteria are met.

1.5.5 Commercial milestones

After this project partnership have been established, we have made a lot of commercial activities, to be able to promote and sell our CON20 products.

August 1st 2017 we established a sales department, with fully focus and responsibility of all commercial activities within Lowenco – including establishment of a distribution network for the CON20 products.

We have been traveling several times to Dubai, primarily to get market knowledge and establish contacts to partners, who can act as distributors for us. Additional we have establish contacts to partners, where the CON20 park can be placed and put into operation. We have found to potential locations by logistic companies, who can allow us to enter their premises even with our distributors and potential clients. Additional we needed to establish contact to the Danish Trade Council, to be inform about the Dubai trading laws and rules, as well to get more knowledge about the market.

We have been participated with a booth at the ArabLab exhibition in Dubai in March 2018, for meeting potential distributors located throughout the MENA region. Many contacts have been made, and some have moved to distributor agreements.

From January 2nd 2018 we have had an intern from IBC, Kolding for a three month internship, working intensively on a deep market analysis of the Middle East and African markets, where we see a potential for the CON20 products.

The result shows, that there is a huge potential and requirements for products like ours on those markets.

In addition, the analysis shows that markets like India, Egypt and Iran has a huge concentration of pharmaceutical production companies, local as well as international players. These kinds of companies can be potential for the CON20 as well our larger product the LSSU. The CON20 will properly be of most interest due to price.

As well some of the countries in the MENA region shows a high concentration of people in areas with very long to distances to the next area with a concentration of people. This indicates for us a potential for a need for decentral distributing centers for medicine around in those kinds of countries. At the same time, those countries often have a bad infrastructure and a lot of main-power issues. Since we with the CON20 are offering the possibility to run the units partly or even fully on solar-power with battery back-up, we are a perfect solution for them and their application. Exact those issues have been mentioned by some potential clients in the region – both in Middle East and Africa, and we have been in dialogue and even sent offers for a total of 273 units for more clients in more countries.

We have now got a man-on-the-ground in Dubai, still an external person – a Danish man living in Dubai for more than 10 years. He is very interesting to promote our product in Dubai, as well taking care of further developing the distribution network in the MENA region. Over time he could be a full-time employ for us.

1.6 Utilization of project results

Even though the project it complete, Lowenco keeps develop the CON20 concept together with Hepkon and HTOA as subcontractors. Lowenco currently receives a lot of interest for the product, therefore the further development is important.

1.7 Project conclusion and perspective

A conclusion of energy consumption is that during a 24hour period running at 0°C the container consume 16,5kWh. The average is below 1kW consumed each hour. Comparing our values to a standard reefer container consuming an average of 9,1kW[1] at same running conditions, it is above 80% more efficient at storing at 0°C.

The project requires further test before clear conclusions of solar driven ultra-low temperature (-70°C) containers can be given. These further testing will be completed the following period after the end of this project.

After the establishment of contact and slowly setup of a distributor network in the MENA region, the focus will now be on the American market, as we see a huge market here as well.

Twenty – thirty years back, the world used more energy on heating as on cooling. Now the situation has changed, and today we use more energy on cooling as on heating. And this will only increase.

[1] http://www.containerhandbuch.de/chb_e/wild/index.html?/chb_e/wild/wild_08_01_02.html