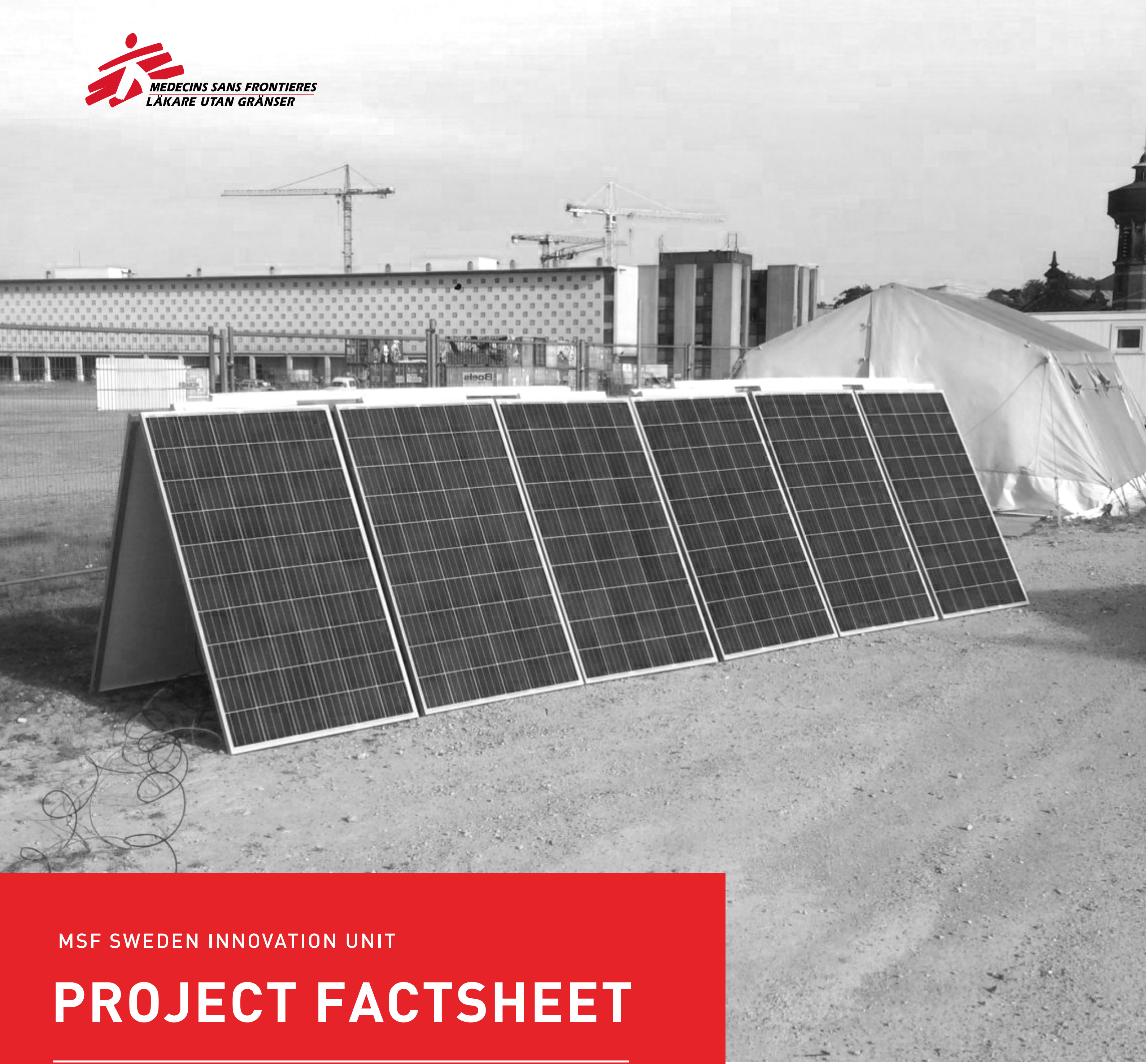


MSF SWEDEN INNOVATION UNIT

PROJECT FACTSHEET

SUSTAINABLE OFF-GRID OXYGEN CONCENTRATION WITH DIRECT SOLAR POWER

Table Of Content

This factsheet describes the possibility of producing concentrated medical grade oxygen with direct solar power during daytime, and storing it as compressed gas for night-time use.

Introduction

A multidisciplinary team within MSF has been pursuing a sustainable and efficient method for supplying field operations with medical grade, concentrated oxygen. They asked the question: *Can solar power be used for the task?* Applying a new approach through the development of a novel solar-powered oxygen compression and storage technology, helped to provide an answer.

PROJECT

Oxygen therapy can be a lifesaving intervention for children and neonates with pneumonia or hypoxaemia. It is also used for anaesthesia, and a range of other health conditions. The availability of medical grade concentrated oxygen is, however, limited in most low-resource health systems.

In MSF projects, it is an essential therapy for life-saving medical care and the use of oxygen concentrators is increasing exponentially. Since the concentrators consume a lot of energy, this is now the primary energy consumer in many projects, which also contributes to logistical challenges.

The aim of this project was to explore the possibilities of producing concentrated medical grade oxygen with direct solar power during daytime and storing it as compressed gas for night-time use. This could help facilitate solar power implementation in MSF by avoiding an extensive need for battery backup.

An increased use of solar power would be beneficial from an environmental and social sustainability perspective, the latter through an increased possibility for local actors to maintain healthcare facilities and provide critical care also after handovers. This innovation project was inspired by a conventional solar power installation for a project handover in Shamwana, Democratic Republic of Congo (DRC), in 2016.

MÉDECINS SANS FRONTIÈRES (MSF)

Médecins Sans Frontières (MSF) is an international medical humanitarian organisation, and was established in 1971 in France with the aim to establish an independent organisation that focuses on delivering emergency medicine aid quickly, effectively and impartially. Nowadays MSF operates all over the world and continues to be independent of both governments and institutions.

This autonomy is used to provide help to people irrespective of gender, race, religion, creed or political convictions. MSF advocates for improved medical treatments and constantly looks for ways to improve its own practices.

MSF SWEDEN INNOVATION UNIT

In the humanitarian sector, where responding quickly to rapidly emerging crisis situations is absolutely crucial, humanitarian organisations struggle to maintain a balance between addressing short-term needs and building the capability to meet long-term challenges.

The MSF Sweden Innovation Unit (SIU) explores a human-centered approach for promoting a culture of innovation within MSF, to more effectively co-create innovations that save lives and alleviate suffering.

For more information, visit msf-siu.org

Our Approach

The SIU takes a human-centered design approach. This means taking the needs and requirements from the potential users by involving them directly in the design process. In doing this, the product is more likely to fit the needs and wishes of the end-users and the processes in which it has to work.

INNOVATION PROCESS

The MSF SIU uses a three-phase innovation process of initiation, development and implementation. Although these phases principally follow each other, they also often overlap. It is important to highlight that an innovation process is not a linear one, but one that requires iterations in which steps are repeated to improve the product. Iterations improve the design solution to ensure it fits the scenario in which it has to be used.

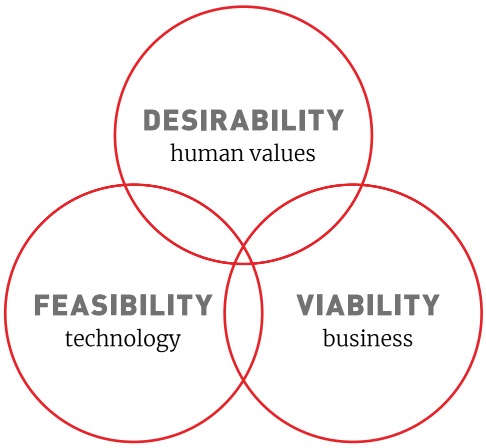
INITIATION
Framing the Challenge, performing research, analyzing insights, designing objectives

DEVELOPMENT
Generating and screening ideas, creating and testing concepts and prototypes

IMPLEMENTATION
Detailed implementation and design of solutions in the field, scaling up and diffusion

COLLABORATION

Most innovation processes are conducted collaboratively. This is done to balance desirability, viability and feasibility, which increases the value of the design solution. This is one of the reasons why the SIU operates on a collaborative and open basis. We believe that external actors have value to add through their expertise and aim to harness this added value throughout the design process.



In this project, collaboration with commercial suppliers of oxygen production equipment was necessary since equipment hardware adjustments were foreseen before any field implementation of the technology. All current suppliers were therefore approached to establish if they had any ongoing development work towards solar powered systems. Unfortunately this was not the case for any of the suppliers of high-pressure oxygen storage equipment and thus it was not possible to achieve any prototype test setup for this technology during the limited project time.

However, a collaboration was started with Diamedica Limited (UK), a medical equipment manufacturer specialising in product development for challenging environments. They had done some initial development work for a lower pressure oxygen storage solutions and agreed to lend us equipment for a prototype for testing in the SOX project.

01 Initiation

In November 2016 the MSF Sweden Innovation Unit and the OCA (Operational Centre Amsterdam) jointly undertook the SOX project to seek out an effective way to use solar energy to power oxygen concentration and storage.

Step 1 of Innovation process
Initiation

Framing the challenge, performing research, analyzing insights, defining objectives

04|2016
Shamwana Hospital, DRC, installs solar panels and batteries to power concentrators after OCA hands over the project to local MoH.

08|2016
Shamwana Hospital project finalised and handed over. The solar power system indicates the potential of non-battery solar systems to supply oxygen.

11|2016
OCA and SIU receive funding for the innovation project from the MSF Sapling Nursery Fund.

01|2017
Project initiation by SIU, OCA and Biomed Working Group. Market research for available equipment, assessment of oxygen needs in OCA field projects and fuel consumption and running cost of current oxygen supply equipment.

01 Defining objectives

The primary objectives of the project were to:

- Survey available equipment on the market;
- Design a solution that would serve a selected, typical project setting;
- Assemble and evaluate potential candidate equipment for a prototype system.

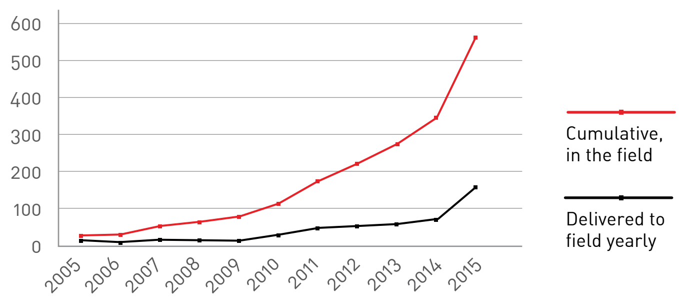
If a prototype could be assembled from off-the-shelf components, the project would aim to plan a test under field conditions in a suitable project.

02 Perform research

Some of the first steps were to clearly define: the current levels of oxygen usage in MSF field projects; the current challenges and costs for oxygen provision; as well as the market availability and costs for oxygen storage solutions. In order to provide medical grade oxygen to their patients, MSF operations in the field primarily rely on small, moveable oxygen concentrators originally designed for patient home-use. High-pressure bottles of oxygen delivered to the projects by external suppliers complement the supply in some projects.

The current oxygen usage in some MSF field projects was investigated using Logistics Reporting System data up until 2016 and a specific follow-up at the Mweso hospital project in DRC in March 2017. In addition, data was collected in the Shamwana project 2016 to evaluate current challenges and costs for oxygen provision.

OXYGEN CONCENTRATION IN OCA



03 Analyse insights

Current oxygen supply in MSF field projects is mainly through an estimated 2000-3000 oxygen concentrators, based on extrapolations from OCA data. Our investigation showed that concentrators are used approximately 50% of the time at 75% of their capacity, which would mean 200-300 m³/hour consumption of medical oxygen globally in MSF. This is, however, an uncertain figure based on extrapolations.

The operation of oxygen concentrators (currently done by using diesel generators), consumes a great deal of energy. An estimated 1 kWh is consumed per m³ of oxygen produced. In a remote location like Shamwana, DRC, the fuel cost is 1€/m³ with concentrators powered by diesel generators. 1 m³ would supply a child with oxygen for roughly 8 hours and an adult for about 3 hours. Based on this the team determined a small rural hospital would require approximately 0.6 m³/hour or 10 litres per minute (LPM) continuously.

After thorough research on available equipment on the market, it was concluded that none of the equipment suppliers that were interviewed had thoroughly considered the possibility of using solar power for their equipment. This absence of any off-the-shelf solution that could be integrated into a system for using solar energy to power oxygen concentration and storage, meant setting up a prototype would be a more complex process than initially anticipated. In addition, the costs of equipment for oxygen generation combined with high-pressure compression (bottle filling stations) from manufacturers superseded the cost of current MSF systems by as much as 3 or 4 times.

02 Development

Building upon the results of the initiation phase, the project entered the prototyping and testing phase of the innovation process. By combining existing off-off-the-shelf components, the project was able to devlop a working prototype. The process is detailed below.

Step 2 of Innovation process
Development

Generating and screening ideas, creating and testing concepts and prototypes

03|2017
Prototype for testing high-pressure storage of oxygens encounters severe problems due to a lack of available off-the-shelf system components and is aborted.

04|2017
A solar powered system for testing is set up at EBC, Brussels. A low-pressure storage prototype product is developed and suppllied by Diamedica.

05|2017
Testing solar powered production and low-pressure storage of oxygen is performed with and without a minimal amount of battery back-up

09|2017
The Sapling Nursery project is finished and recommendations for continued development are agreed by OCA and Biomed WG.

01 Generating ideas

The price and energy obstacles led the team to consider low-pressure storage technology. Prototyping showed that a promising solar oxygen solution might combine low-pressure storage with oxygen produced with standard concentrators. This would, however, require a pipe delivery system to the patients. Although an obstacle, this would also have advantages in terms of patient comfort as well as infection control, since the concentrators would not be moved between, and operated close to, patients.

02 Creating prototypes

To create the prototype used for the test, Diamedica adapted a low-pressure oxygen generation and storage system from the company's product line. After establishing the three necessary components of a prospective oxygen generation system: solar power, a small battery bank or a supercapacitor (for stabilizing the solar power output), and a low-pressure system for oxygen-generation and storage; each was tested and optimised.

03 Testing phase

The testing was carried out at the Espace Bruno Corbé (EBC). Established by the MSF Belgium, EBC provides medical, technical and logistic support for the humanitarian activities through training and innovation. The EBC can be described as a place that is as close to the field as possible without being in the field.

Testing began with the setup of the solar power system. To help optimizing the system, SAM (an open access tool made available by the US National Renewable Energy Laboratory) was used to make performance predictions and thus to estimate the cost of the solar energy generated.

The tests verified that the prototype system, with an initial investment cost of roughly 16,000€, can produce up to 5,300 m3of oxygen per year with no continuous operation cost. Potentially, such a system might thus be cost-saving after 3 years, compared to oxygen produced with generator power.

MSFers in training at EBC inspect the SOX equipment.

03

Step 3 of Innovation process
Implementation

Detailed implementation and design of solutions in the field, scaling up and diffusion

- Develop pipe distribution system for oxygen to patients in field hospitals.
- Partner with supplier of tested storage prototype to resolve remaining development issues.
- Perform field project test of solar powered low- pressure storage and pipe distribution.
- Test small scale high pressure storage oxygen storage solution

- Project Completion

Implementation

The low-pressure oxygen storage system described, has the potential for application in remote settings. The primary challenge in implementing this solution would be the higher initial investment but the payback period is relatively short. Implementation of outcomes was not a part of the original feasibility study project and due to human resource constraints at the OCA field support unit, a follow-up project could not be carried out there.

A thorough description of the tests and results of the project can be found in the full project report, published at the MSF Sweden innovation Unit web page under **Cases**.

Next Steps

We are currently looking for other potential stakeholders within and outside MSF for next phase with the following recommended activities, agreed by the intersectional MSF biomedical working group:

- Develop pipe distribution system for oxygen to patients in field hospitals.
- Partner with supplier of tested storage prototype to resolve remaining development issues.
- Perform field project test of solar powered low- pressure storage and pipe distribution.
- Test small scale high pressure storage oxygen storage solution

There are two different contexts where the project findings could be particularly valuable:

- A small standalone unit, comparable to standalone solar fridges, that could significantly increase the availability of medical oxygen in rural, low and medium income regions. This would also be interesting for outpost health centres within MSF projects with no energy supply.
- A larger solar powered oxygen production unit in hospitals currently powered by diesel generators for medium and long-term cost savings and improved environmental sustainability.

Solar installation in Shamwana, DRC

Acknowledgements

The financial support from the **MSF Sapling Nursery fund** is gratefully acknowledged, as is the support from the OCA stakeholder group for the project, the intersectional biomedical working group. We are also very grateful to the OCB staff at the Espace Bruno Corbé in Brussels for making the space available and for helping with many practical bits and pieces around the testing as well as to **Diamedica (UK) Limited** for developing and providing the low-pressure oxygen storage prototype for the tests.

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safe anaesthesia and respiratory solutions for limited resource settings

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