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INNOVATION PILOT – LOOP 1 – ENGINEERS WITHOUT BORDERS
TECHNICAL UNIVERSITY OF DENMARK

INNOVATION REPORT

ADRESSE DTU
Anker Engerslunds vej 1
2800 Kongens Lyngby

TLF +45 45 25 25 25
FAX +45 45 87 02 16
WWW dtu.dk

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INNOVATION REPORT

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INDHOLD

1 Executive summary (short summary)

This proposal report addresses the problems formulated by Engineers without borders (EWB) and Water4Ever.
Based on conversations with a representative from Water4Ever, we learned that they had a maintenance worker coming to the nexus every 2-3 days to ensure that the chlorine tank was filled amongst other things. If the chlorine tank was to run dry, the water would not be drinkable, and either the water supply had to be closed, or the inhabitants could end up getting sick from drinking contaminated water.

The solution to this problem can be to mount a level gauge in the chlorine container, which sends a signal to a resistance sensor with a built-in Wi-Fi modem. This allows you to remotely read the level in the container, as well as sending an alert to the responsible party when the container is about to run dry.

The motivation for Water4Ever to implement this solution is to reduce the downtime of the pump running. This will produce increased revenue for Water4Ever as well as those employed at the kiosks. The social and health benefits for the inhabitants should not be downplayed, as access to clean water is both a human right as well as an important developmental factor for both children and adults. Our solution would solve a big problem, as a lot of time is spent checking the containers. In the future there will probably be more water kiosks, here it will make it much easier to keep an eye on all the containers.

2 Introduction to the problem/ background

The company who is working on this case is Engineers Without Borders – DK.
The project is described in short terms below.
Project 134: Community Kiosk Water Supply (Sierra Leone)
Provide safe water to an area inhabited by internally displaced persons with no urban planning or state provision of safe water.

Women's empowerment

Addresses women's empowerment insofar that the BM is designed to engage and economically empower local women as vendors and managers of the water kiosks.

Women will be commercial vendors of water backed by a not-for-profit local organization to secure maintenance and business support.

What has been done already?

EWB-DK has engaged strategic local partners in order to enhance sustainability economically, socially and technically.

Components

1. Construction of water supply infrastructure (tower, submerged pump based on solar energy)
2. Distribution of water to 5 local kiosks
3. Training of basic maintenance
4. Training in business model for water sale

Objectives

1. Provision of access to safe water for up to 4000 inhabitants in the suburb Grafton.
2. Women's empowerment through income generation - the creation of a sustainable BM to secure community access to water.
3. Training and capacity building of Fuorah Bay engineer students in sustainable water supply provision.[1]

The project described above is already working well. The object of this report is to find out where there is an opportunity to improve the project.

The water supply is delivered by the local company Water4Ever and here is a couple of things we know about the technical aspect of the water supply.

We know the chlorine runs out every 2-3 days

- If the chlorine runs dry, the water could become dangerous to drink

[1] The Project is copied from the Case study course material.

- We know that the chlorine is liquid and that it is stored in a drum that feeds into the chlorinator

- We know that there is a chance of overflow in the water tanks at the "nows" if the safety valve breaks.

From these known facts we found "the hard nut" to be:

How do we secure safe water and reduce maintenance through increased automation and monitoring?

This is important because it might be able to reduce the cost of maintenance and increase the reliability of the system.

3 Problem Owner

The Problem Owner is Engineers Without Borders – DK (EWB-DK). EWB-DK is a technical-humanitarian organization of volunteers with technical skills of different kind. They collaborate with local and international NGOs to help citizens in less developed countries suffering from deprivation, and they ensure local empowerment. Their vision states the following:

"Engineers Without Borders – DK works to develop strong and sustainable communities and to support development processes, based on equal and fair distribution of the world's available resources."

For this project EWB-DK has received 873,305 DKK. from The Ramboll Foundation.
The project is also supported with groundwater pumps from Grundfoss.
In this case study EWB-DK works close together with the European research project Water4Ever.

Water4Ever

Water4Ever has already implemented more than 400 water projects in different places. Some of the projects were failing due to poor sustainable solutions. This is where EWB-DK and the students following the Innovation Pilot Course might be able to help.

Water4Ever's Aim is to:
- Ensure a safe delivery of pipe-born water to our vending and private points.
- Making sure that our services are accessible, affordable and sustainable

Water4Ever began testing the kiosk systems in 2016 and in 2019 they started expanding the systems throughout Waterloo, Sierra Leone. In total they have implemented 123 kiosks, 101 private connections, and over 400 portable wells so far[2]

The goal is to ensure safe water to the population in Grafton, Sierra Leone. The focus is not to earn money but to make it economically sustainable. There are no competitors.

[2] According to PowerPoint presentation that was presented the 9th February

4 Your proposal and the reasons for it

Through discussions with the representative from Water4Ever we identified several different problems that could be helped with increased monitoring and automation. We took a narrow approach and identified an issue where a maintenance worker had to manually check and monitor the level of chlorine in the chlorine drum.
Our solution to this problem is to develop a way to measure the level of chlorine with a remotely read control. This will make it possible to see the level in the chlorine tank and therefore be able to get a warning before the container is empty. This ensures that the water quality is as desired. This also means that no one must check the level every second day. With this solution, the problem in our opinion will be solved.
We know that this method of measuring the level works. It has been used to measure fuel levels in tanks on boats, cars and motorcycles. And the innovative part of our solution is the combination of the measurement tool and a remote signal.
The measuring device itself is simple. It consists of few components. This means that there is not much that can break. The sensor for measuring and sending information about the amount of chlorine consists of more complicated parts, as it must be able to be read remotely.
The technology is easy to use, and reminiscent of tools already used by the local stakeholders, this means that very little training of maintenance personnel is required. EWB-DK saw an even greater potential for use in future projects where personnel are further removed from the nexus and keeping the maintenance to an absolute minimum is therefore crucial.

5 The Prototype

Figure 1 - Prototype part 1 – Floater

Figure 2 - Prototype part 2 – Wifi-module and resistance sensor

The prototype consists of 2 parts.

One is a float, which can measure the chlorine level in the container.
A prototype has been made in the workshop, which will be mounted in the chlorine container. The plastic part moves on the meter according to the amount of chlorine. When the floater moves, it changes the resistance of the pipe.
The other part to this is a wi-fi module with an ohm meter built-in. It can measure the resistance as the floater moves up and down the pipe.
This solution makes it possible to remotely read the level in the container. This ensures that the container does not run out of chlorine.
For this solution to work, there must there be internet in the area for connecting the Wi-Fi-module. This can be done by having mobile internet device with a sim card.

6 Economic perspectives

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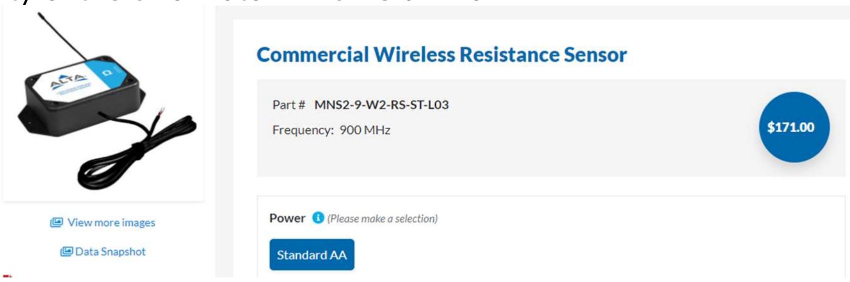
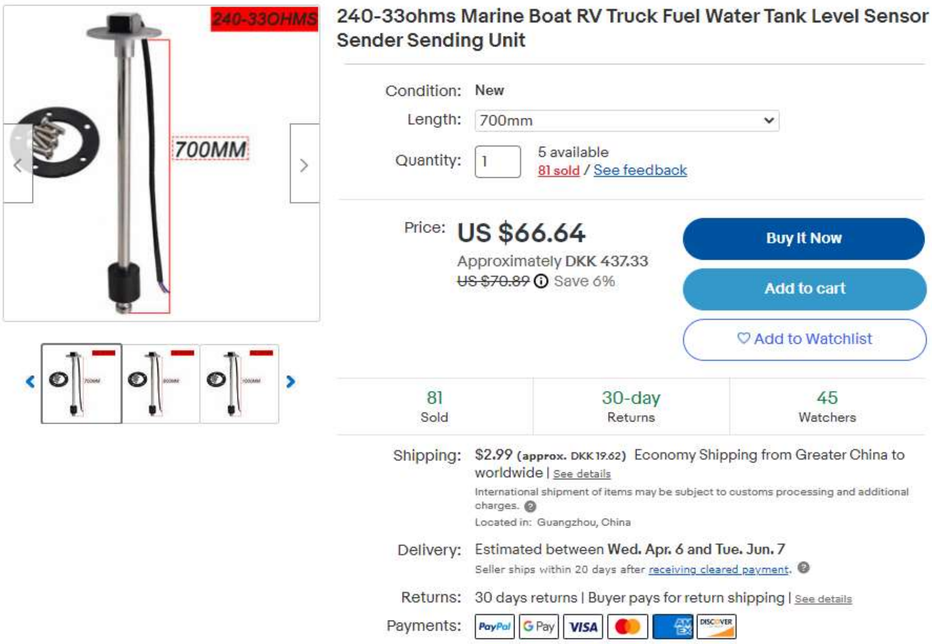
A tank level sensor sending unit has a price of approximately 67[3] USD and the Wireless Resistance sensor has a cost of about 172[4] USD. The cost of the technology overall is less than 240 USD. This product helps keeping the water safe and the process is more reliable with it. It also makes it possible to gather data of the use of chlorine compared with the use of water. It is difficult to put a specific price on these benefits. However, since this is a very cheap technology to implement it seems like a "no brainer" and with time it might be able to save money if it helps reduce the workload of the maintenance crew. It is not possible to calculate a specific payback time because this depends on the performance and reliability of the chlorinator which is unknown.





[3] Wireless Resistance Sensor with Auto Data-Logging (monnit.com) (last visited March 4th 2022)
[4] 240-33ohms Marine Boat RV Truck Fuel Water Tank Level Sensor Sender Sending Unit | eBay (Last visited March 4th 2022)

6 Further perspectives

Next part of the innovative proses would be to implement the solution. This would ideally be done by the local maintenance personnel, or a student from a local technical university. The maintenance personnel could most likely install it, since it isn't very technical. If a student from the local technical university, did it, it would create value for further learning. Universities in Serre Leone don't have enough opportunities to work with the things they learn. This would give a student an opportunity to work with a level-gauge and Wi-Fi transmitter and learn from the experience without the university paying for it.
Furthermore, there needs to be researched materials used in the floater and check their compatibility with the liquid chlorine in the tank. Some plastics and most metals reactive to chlorine solutions, while some plastics are completely resistance to it. The positive thing with the simple design chosen is that no part that are touching the chlorine needs to be metal.

When data starts flowing in from the chlorine gauge, it can be used in collaboration with the sensors measuring the waterflow. With these data, it can be confirmed that the chlorinator is mixing the right ratio. It can also start predicting time of use, and time of maintenance/need of refill. Data collection is a very powerful tool, when it comes to safe drinking water and maintenance. This would become significantly more important when Water4Ever plans to scale the solution to many cities. Here data collection will save a lot of man-hours and increase reliability.

Another problem Water4Ever had with their nodes was their water tower. The locals have experienced the tower flowing over with water. This is quite bad since clean water is a valuable as well as scarce resource. The reason the tower is flowing over with water, is that the regulating valve either broke or the sensor that detects the water level in the tower wasn't working properly. Innovation briefs were made for this problem, and some different solutions were discussed.
One solution was to make a bypass-system, which required the following resources. Another regulating valve, a by-pass pipe, an independent sensor, a program to initiate the bypass. The advantage of this solution was that the system would not stop working, and that the fixing of the regulator valve could happen while the system was running. The disadvantage is that there would be two systems doing the same thing. This would not be cost-effective, since the problem was quite rare, and the integration into the existing water pumps would be equivalent to a repair of the problem.

Another solution was to implement the solution for the chlorine tank into the water tower. This would have a similar sensor, with a kill-switch to the power of the pump when water reached a certain point. This had the advantage of being cheap and easy to install. The disadvantage is that it was only preventing water from overflowing, but not preventing the problem. When doing a cost-benefit analysis, it became clear that the water saved wouldn't be significant to the amount cost, since water is so cheap.

Inhabitants filling dirty containers with clean drinking water

Initially it was discussed that it could be a problem that the containers brought would be clean, and the locals could get sick. There was considered a solution involving integrating the Danish "pant" system to the Jerry-cans used. After doing more research it became clear that the locals were aware and had set up systems to make sure their jerry-cans weren't dirty.

Alternative ideas

In the process of finding the right "hard nut", different "hard nuts" and innovative ideas were discussed and worked on. In the process we were looking at weaknesses and improvements on the existing concept. Here the first part of the research (the first step in the double diamond), was done with help from experts from Sierra Leone. With this research different "nuts" came about.

7 Conclusion

The goal of our project was to secure safe water and reduce maintenance through increased automation and monitoring. One of the elements that could make the system more reliable was monitoring of the chlorine level in the chlorine storage container. The monitoring is done by using a floating unit inside the chlorine container with the liquid chlorine and a wireless sensor connected with the floating device and able to communicate with a computer or a smartphone. This makes it possible to check the chlorine level from a computer far from the nexus and also to collect data on the chlorine usage compared with the usage of water. This data could help avoid contamination of the drinking water because of an critical amount of chlorine in the cleansed water. The data could also make it possible to decide if the specific chlorinator in the system is the right for the job and when it should be replaced. From an economic point of view these benefits makes the product worth investing in because it is very cheap to implement.