Utrecht University

Energy for Refugees: Tuyoor Al Amal school in Tripoli, Lebanon

Consultancy project

Marijn Vollebregt (6182127), Iris Floore (7243510), Inki Chae (8782652), Kenta Wakatabe (2034042), Linde Janssen (6443761)

ENERGY FOR REFUGEES

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Abstract

With the aim of providing sustainable energy solutions for refugees, the organization EfR is planning to install a solar PV system in order to power the water pump of the Tuyoor Al Amal school in Tripoli, Lebanon. Currently the school uses electricity from the national grid which is not a reliable source of energy and is expensive. When there is not enough electricity from the grid a polluting diesel generator is used to power the water pump. Hence, EfR intends to install a 4 kWp solar PV system with batteries so the water pump can be used via a reliable, clean, and cheap form of energy. Additionally, it can allow the water pump to be used more frequently improving access to water for the school. In order to secure funding for EfR, our project focuses on researching the environmental and societal impacts of installing the PV system for the school. For the environmental part two LCA's were carried out to determine the carbon footprint of the before – and after situation, i.e. the current energy system and the new energy system. Moreover, a social impact assessment was carried out in order to determine the impact on hygiene and health of the students and employees via a semi-structured interview with the headmaster and a survey dispersed amongst employees. The results indicate that a significant reduction in kg of CO2 equivalent will be achieved with installation of the solar PV system and also that there will be a significant improvement in hygiene and health due to an increased access to water.

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1. Introduction

1.1. Background information

Refugees and displaced people often suffer from poor access to affordable, safe, reliable, and clean energy. This affects many aspects of their lives, including water services, improved protection, health and sanitation, environmental protection, and education (Lehne et al., 2016). Most of them rely on inefficient and polluting sources of energy such as diesel generators, wood, charcoal, and kerosene. These sources are costly and harmful to the environment and human health, and often lead to conflicts over scarce resources (UNEPCCC, n.d.).

Renewable energy can offer a more sustainable and cost-effective solution for displaced people and humanitarian operations (IRENA, 2019). Renewable energy such as solar, wind, and hydro power can provide clean and reliable electricity for lighting, cooking, heating, cooling, communication, and other services (Gunning, 2014). Such green energy can also create income-generating opportunities for displaced people and host communities, such as selling excess power or providing maintenance services (UNEPCCC, n.d.). This issue is closely related to certain Sustainable Development Goals (SDGs), such as SDG 7 (Affordable and clean energy), 13 (Climate action), 3 (Good health and well-being) and 1 (No poverty). First, as mentioned before, renewable energy can help achieve SDG 7 by offering clean and cost-effective electricity for displaced people and humanitarian operations. Renewable energy can also help reduce greenhouse gas emissions and mitigate the effects of climate change by replacing fossil fuels with low-carbon sources of energy, which helps to achieve SDG 13. Regarding SDG 3, the health and well-being of displaced people can be improved with renewable energy by reducing exposure to air pollution, improving sanitation and hygiene, and facilitating access to healthcare facilities and services. SDG 1 is also interrelated with this issue, as green energy can help improve the livelihoods and income of displaced people and host communities by creating employment opportunities, enhancing productivity, and enabling access to basic services and markets.

1.2 Problem definition

Energy for Refugees (EfR) is an organization that aims to provide clean and sustainable energy solutions for refugees around the world. EfR is founded by students from TU Delft. Since 2017, they have started projects that aim to provide people who seek shelter or asylum with clean energy. EfR recognizes that access to energy is essential for meeting basic needs, such as cooking, heating, and lighting, as well as for accessing information and communication technologies. While improving the quality of life for refugees, EfR also promotes environmental sustainability and reduces the consumption of fossil fuels in refugee settings by installing green energy technologies such as solar PV systems. So far, EfR has completed two projects successfully in collaboration with several NGOs.

Currently, EfR is working on a project at a school in Tripoli, Lebanon. The Tuyoor Al Amal school serves around 2000 displaced Syrian children in Lebanon. The school gets their electricity from a diesel generator and from the national Lebanese grid. Currently, the school only receives one to two hours of electricity per day from the local utility. However, this supply is inconsistent and unreliable. The times at which the school can receive energy from the grid each day is unpredictable and random. Therefore, the generator is used when their existing sources of electricity are insufficient. However, the operation of the generator is expensive, as the school pays over 500 – 600 USD for its fuel each month, not to mention the negative impact it has in terms of carbon emissions.

As a solution to supplement the intermittent supply of electricity from the national grid without increasing dependency on the diesel generator, a local administrator with engineers installed a solar PV (photovoltaic) system with 18 panels and two batteries as of February 2023. It is estimated that solar PV panels with approximately 4 Kilowatt 'peak' (KWp) will be installed. KWp refers to the amount of energy solar PV panels can generate when the sun is shining directly overhead without any interference of, for example, clouds (Parida et al., 2011).

Unfortunately, the installation of these PV panels has not been enough to get the school off the national grid. One infrastructural feature of the school that is impacted by this insufficient energy supply, is the operation of the water pump that fills the two water tanks located on the rooftop of the school, which are 2000L and 3000L in capacity, respectively. Most standard water pumps are powered by either conventional electricity, diesel generated electricity, or both (Chandel et al., 2015). The latter is the case for the water pump of the Tuyoor Al Amal school. The water pump is the only three-phase load of the energy system in the school, meaning that it is powered by three wires. The current pulled by the water pump is approximately 3.7 - 3.8 Amps per phase, and the total operation time is 10 hours a day, accumulating an average of 24.2KW of energy consumed per day.

Currently, only the national grid and the generator can provide such three-phase load power. As the availability of three-phase power from the grid is at random hours each day, and the generator only runs whenever grid power is insufficient, the school does not have much influence on when they can use the water pump and have access to water. Therefore, the main focus of EfR's project is to install additional solar PV panels that are catered to provide three-phase load power specifically for the operation of the water pump. The additional solar PV panels, in combination with additional batteries to store energy that is produced by the PV panels but that is not immediately used, will be essential for overcoming the deficiency of electricity to power the water pump, as well as for providing a consistent source of energy. The capacity of the batteries that are planned to be installed is 12 KWh, which is estimated to be sufficient to provide electricity for the pump for all operations after sundown.

1.3 Research aim/ questions

The project is currently still in its designing phase, as EfR is focusing on the engineering details of the solar PV system for the water pump, such as the sizing and specifics of the solar PV panels and the batteries. Our task as consultants is to calculate the difference in carbon footprint between the current energy system (diesel generator + grid) that is powering the water pump and the new energy system (solar PV) that will power the water pump. Additionally, EfR has asked us to investigate the societal impact that the project could have, to get a clearer picture of how the project will impact the lives of the students and employees of the school. By estimating positive changes that the project will make environmentally and by investigating the social impact, EfR aims to gain validity in their proposal and secure funding. Hence, this consultancy is strategically fundamental to take this project from the drawing board to reality.

Research Question: *"What is the environmental and societal impact of replacing the use of the national grid and a generator for electricity generation for the water pump with solar PV panels at the Tuyoor Al Amal school?"*

Sub-questions

1. What is the current level of carbon emissions of operating the water pump through the diesel generator and national electricity grid?
2. What is the estimated level of carbon emissions by powering the water pump through the newly installed solar PV?
3. What is the current situation regarding access to water and hygiene with the water pump being operated through the diesel generator and national electricity grid?
4. How does the installation of the solar PV panels to power the water pump impact the hygiene and health of the school's students and employees?

2. Conceptual research design

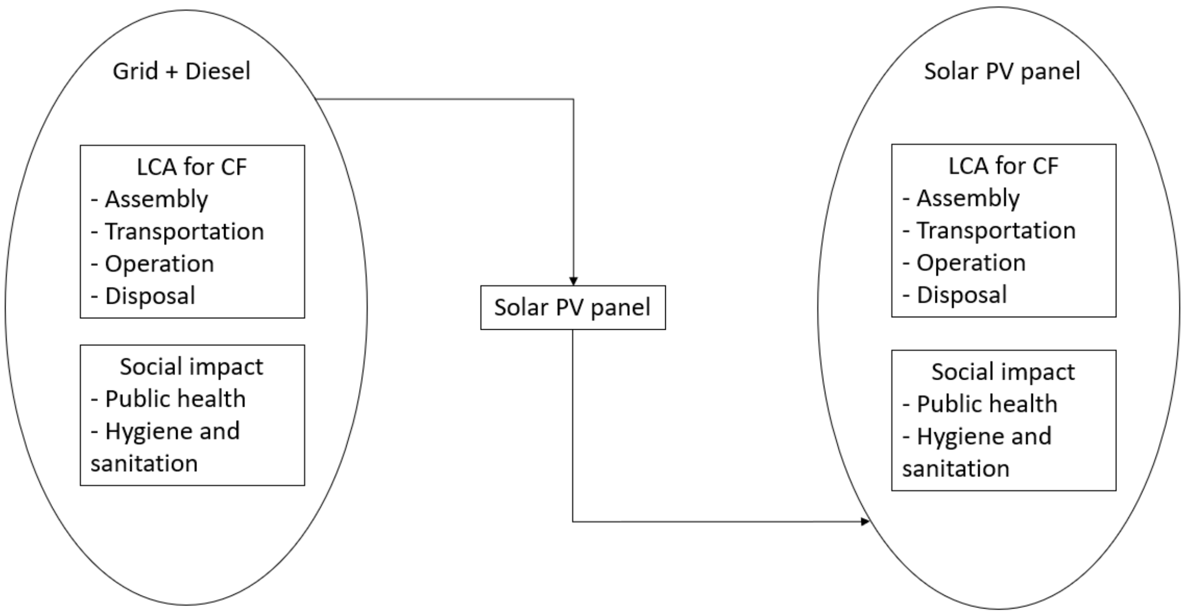

Figure 1*:* Conceptual Framework showing the before and after scenarios researched in this project

The aim of this research is to assess the environmental and social impact of installing solar PV panels to power the water pump. To measure these impacts, a carbon footprint was calculated via the method of Life Cycle Assessment (LCA) for the environmental part. For the societal part, the impact on hygiene and health of the school's students and employees was researched by conducting a semi-structured interview with the headmaster of the school and by conducting surveys amongst employees. Figure 1 visually depicts the concepts that will be used in this consultancy project to compare the before and after scenario of the installation of additional solar PV panels for the water pump. In the following subchapters the concepts carbon footprint, LCA, and several social impact theories will be further explored.

2.1 Carbon Footprint and Life Cycle Assessment framework

The carbon footprint may be viewed as a hybrid concept, deriving its name from 'ecological footprint', which is a concept used to measure the capacity of natural capital that an average person can consume given the resources restraint of their economies (GFN, 2023), as well as being a potential indicator for global warming (Pandey et al., 2011). The carbon footprint focuses on the total level of direct and indirect carbon dioxide emissions that an organization, company, country, product, or individual emits (Wiedmann & Minx, 2007).

The concept of 'embodied energy' clarifies the full scope of the environmental impact of a product. Embodied energy is the energy consumed in the extraction and processing, assembly, transportation, operation, and disposal of instruments (Ding, 2004). In order to identify these variables in our research, the LCA framework was used. LCA is a method that aims to give a full and complete view of the environmental impacts and energy consumption of a product (Ludin et al., 2018). A major strength of the LCA method is that it takes into account all life stages of a product or system, i.e., a life cycle perspective, including the assembly of the product, transportation, operation, and disposal (Bjorn et al., 2017). This is important because it prevents burden-shifting between different life stages, meaning that the environmental impact of a product must be calculated considering its whole life cycle and not just one or several of its life stages (Bjorn et al, 2017). Additionally, LCA takes into account various environmental issues and has a quantitative nature, meaning that it is a good method to compare environmental impacts of products or processes (Bjorn et al., 2017). LCA is a fit method for this research in which the carbon footprint of the current and new energy system for powering the water pump was calculated.

2.2 Social Impact

A change in the current energy situation for the water pump of the school could impact the students and employees in various ways. For this project, the focus was on researching the impact of improved access to water on the hygiene and health of the school's students and employees. A social impact assessment, which can be defined as **"***the process of identifying the future consequences of a current or proposed action which are related to individuals,* *organizations and social macro-systems"* (direct citation from Becker, 2001), can help in studying how the hygiene and health of the school's students and employees will be impacted by the project.

As the generator and the grid provide energy to power the water pump at random times during the day, the installation of the solar PV panels will increase the water security at the school. The relationship between access to water and health has been widely studied. As access to water is crucial for good hygiene, this is inevitably linked to overall health and wellbeing (Jasper et al., 2012). Plenty of research has been done on the relationship between washing hands and disease outbreaks among school children. These studies showed that the number of children with infectious diseases such as diarrhea, conjunctivitis, soil transmitted helminths (worms), and influenza could be significantly reduced by regularly washing hands (Joshi, 2013; McMichael et al., 2020). A high prevalence of these types of infectious diseases (including cholera, typhoid, and polio) in school communities is almost always related to sufficient access to water, hygiene and sanitation (Adams et al., 2009; WHO, 2022). Some studies show that asthma, rhinitis, and eczema are common in schoolchildren (5-14 years old) across Lebanon (Waked & Salameh, 2006; Waked & Salameh, 2008). Good hygiene practices such as washing hands help prevent the spread of germs and infections that can cause those diseases (Ferrandiz-Mont et al., 2018). As a result, the absence rates among school children can also be reduced, which in turn improves numerous educational benefits (Joshi, 2013; Poague et al., 2022). As the Tuyoor Al Amal school counts approximately 2000 students (employees excluded), there is a lot of person-to-person contact, which can increase the risk of how susceptible the students and employees are to various environmental health hazards if the access to water is insufficient (Adams et al., 2009).

A quite recent study on the perspective of school children on the importance of water for hygiene showed that children are often aware of the importance of access to water, and they value proper hygiene in their school. Besides that, they often feel a certain responsibility for maintaining their own personal hygiene during school time, regardless of the school's quality of sanitary facilities and access to water. This creates a willingness of the school children to sustain and improve their personal hygiene when facilities and access to water improve (McMichael et al., 2020). This research used schools in the Philippines as a case study but should represent the overall attitude and perspective of children on access to water and hygiene in schools. When the water pump in the Tuyoor Al Amal school can be powered and used throughout the whole day by the school's students, and if the students are aware of the importance of access to water for the school, this will impact the children's hygiene and health positively.

3. Methodology

3.1. Life Cycle Analysis

In this section, the environmental impact of replacing the diesel generator system with the solar PV system will be analyzed. To measure these impacts, a Life Assessment Cycle (LCA) will be used. As explained earlier, LCA is a method aiming to give a full and complete view of the environmental impacts and energy consumption entailed in a product (Ludin et al., 2018). The ISO has set a standard for calculating LCA into 4 phases: goal and scope, life cycle inventory, life cycle impact assessment, and interpretation (ISO, 2014). The results of our findings will be presented in this order.

3.2. Goal and Scope of Analysis

The goal of this part of this study is to calculate and compare the environmental impact of operating the water pump through two different systems: 1) diesel generator and national electricity grid of Lebanon, and 2) an independent solar PV system. The scope of an LCA helps to demarcate the boundaries and determine standards on which the research is conducted upon.

Table 1. Scope of LCA calculation

Category	Definition
Product system	Within the product system falls the processes that include the activities that transform inputs to outputs (Palsson, 2011). For this research, we have categorized the system into four processes: assembly of the products, transportation of the products from the country of origin to Lebanon, operation of the products during its lifetime, and waste disposal at its end.
Functional Unit	Functional unit defines exactly what will be used for the calculations of the LCA for each of the two distinctive systems and how it will be quantified as 'environmental impact' (Rebitzer et al.,2004). The specifics of the materials and their quantities (e.g., steel for the assembly of generators, silicon for the PV panels, the source of electricity used for the during the assembly process etc.) will be covered in detail in the following Life Cycle Inventory section. Another factor that must be defined to determine the functional unit is the time in which the environmental impact must be calculated (Rebitzer et al.,2004). Due to the fact that there were large gaps in the data on electricity usage of the school and the water pump, the research used data from May 2023, which was the month with the most complete and consistent data. Moreover, data on the amount of diesel fuel usage for the generator was available on daily and weekly terms. Therefore, this research unified the temporal window of the measurements to not a year or its entire life cycle, but to one week.

	Finally, for the location of the collected data, Lebanon and countries of manufacture (all in Europe) of the machines in the two energy systems were used where data was available. Where not, Lebanon's alternative data was gathered from Simapro's data labeled as 'rest of the world' and countries of manufacture as Europe. With all this in mind, we can state the following functional unit for both systems: '*generation of one week of electricity*'.
System Boundary	This will set the boundaries in which the study assumes the aforementioned activities to be taking place, which is critical in LCA calculation as the procedure's innate nature includes byproducts or co-products that must be accounted for within the product system (Finnveden, 2009). Within this boundary, researchers LCA must 'allocate' the share of inputs and emissions to the intended product and the byproducts (Ecoinvent, 2023). This research used the method of Allocation at the Point of Substitution (APOS).
Assumptions & Limitations	The assumptions made for the scope have been specified in the Life Cycle Inventory section, and the consequent limitations have been listed in the discussions.
Data Quality Requirements & Documentation of Data	Collection of the data has been done on the Simapro program and following validification and documentation of the data has been confirmed by the data library available on the program.
Impact Assessment	The goal of this LCA calculation mandates that the focus of the results will be the environmental impact, and for the purpose of the client, the scope of impact focused on CF. This narrowed down the classification of the impact categories of the life cycle of each energy system to Climate Change. The calculation was then indicated in kilograms of CO2 equivalent (kg CO2 eq). The calculation used an existing LCA model of EF 3.0 Method V1.01.

3.3 Life cycle inventory analysis – diesel generator and national grid

The national grid to which the Tuyoor Al Amal school is connected, is a low-voltage grid (220 V at 50 Hz). The diesel generator is from Perkins Motors originating from Italy with a voltage of 380 V. The specific type of model is unknown, since the generator is quite old, and the label is scratched. Since we do not have all the information about the diesel generator and specific electricity usage information of the national grid and generator, several assumptions had to be made. In the following section, the life cycle inventory analysis of this current energy system has been carried out, examining data from each life cycle stage. As mentioned earlier, the results will be expressed in kg CO2-eq emissions per week. See explanation in table 1 under 'functional unit' why we chose the temporal scope of one week.

3.3.1 Assembly

For the assembly (=materials) of the diesel generator, we looked at a study executing an LCA on a typical standby diesel generator set (Benton et al., 2017). Here, a percentage of the mass per material of the total generator was given, along with the mass per material (kg). Based on the voltage of the school's generator (380 V), we could get an idea of the weight of such Perkins generators, which is around 508 kg (Manel Service, 2023). With the information described above, the weight per material of the generator was calculated. Since this is the weight of the materials over the whole lifetime, we divided this weight over the lifetime. We assumed the lifetime of the generator to be 20 years, which is the same as in the study by Benton et al. (2017). Next, the output of this was divided by 52 in order to obtain the mass per material per week. This information is summarized in table 2.

Table 2: Mass per material of diesel generator

Material	**% of total mass generator**	**mass of specific material (kg)**	**mass of specific material/week**
Aluminum alloy	2.50	12.7	0.0122
Cast aluminum	2.50	12.7	0.0122
Cast iron	12	60.96	0.0586
Copper	3	15.24	0.0147
Epoxies	0.20	1.016	0.0010
Ferromanganese (Fe-Mn)	0.20	1.016	0.0010
Ferrosilicon (Fe-Si)	27	137.16	0.1318
Lead	0.20	1.016	0.0010
Low Alloy Steel	25	127	0.1221
Low carbon steel	16	81.28	0.0782
Molybdenum	0.20	1.016	0.0010
Nickel	0.20	1.016	0.0010
PCB (printed circuit board)	0.20	1.016	0.0010
Stainless steel	0.20	1.016	0.0010
Steel, bar, & rod	10	50.8	0.0488
Tin	0.20	1.016	0.0010
Titanium Alloys	0.20	1.016	0.0010
Zinc	0.20	1.016	0.0010
Total	**100%**	**508 kg**	**0.4885**

The assembly of the materials also requires a certain amount of energy. Hence, we also calculated the energy required to assemble the materials of the diesel generator. For this, information from Benton et al. (2017) was utilized again. Here, the values of the embodied energy per material of the generator were taken and multiplied by the mass of each material. Then, these results were transformed into the amount of kWh using the following formula (1):

(1) Embodied energy of material (kWh) = embodied energy of material (MJ) / 3.6

A summary of this information can be found below in table 3. Finally, with this information the total embodied energy of the diesel generator per week was calculated (see table 3) with the following formula (2):

(2) 7272.8 kWh / 20 years / 52 weeks = 7 kWh per week

This value was then put into SimaPro.

Table 3. Embodied energy per material in the diesel generator based on values from Benton et al. (2017)

Material	Embodied energy value (MJ/kg)	Embodied energy of material in generator (MJ)	Embodied energy of material (kWh)
Aluminum alloy	72	914.4	254
Cast aluminum	51	647.7	179.9
Cast iron	25	1524	423.3
Copper	34	518.16	143.9
Epoxies	133.5	135.6	37.7
Ferromanganese (Fe-Mn)	23	23.4	6.5
Ferrosilicon (Fe-Si)	15.88	2178.1	605.0
Lead	16	16.3	4.5
Low Alloy Steel	28	3556	987.8
Low carbon steel	25	2032	564.4
Molybdenum	151	153.4	42.6
Nickel	142	144.2	40.1
PCB (printed circuit board)	12101	12294.6	3415.2
Stainless steel	68	69.1	19.2
Steel, bar, & rod	22	1117.6	310.4
Tin	321	326.1	90.6
Titanium Alloys	471	478.5	132.9
Zinc	52	52.8	14.7
Total		**26182.1**	**7272.8**

We did not consider the materials of the power supply for the national grid, since this is beyond the scope of this research and not possible to consider due to time constraints.

3.3.2 Processes

For the operation and transport of the diesel generator, a total of three processes were included: (1) the energy used to supply the national electrical grid, (2) the energy used to power the diesel generator, and (3) the energy used to transport the diesel generator. According to the information that EfR provided us with, the water pump consumes 24.2 kW/day and runs 10 hours per day for 6 days in total, since the school is open for 6 days a week. This results in a consumption of 1,452 kWh per week. Of these 10 hours/day, we assumed that the water pump is powered for 2 hours per day by the national grid and for 8 hours per day by the diesel generator. In table 4, the amount of electricity that is utilized by the water pump is allocated per source.

Table 4: Source of power utilized to power water pump

Source	kWh/week
National grid	290.4
Diesel generator	1161.1
Total	**1,452**

For the first process, the energy used to supply the national grid is based on the grid type and the fuel mix. In SimaPro, we were able to select 'Electricity, low voltage {LB}| market for electricity, low voltage | APOS, S' which describes the electricity available on the low voltage grid level of Lebanon in 2017. Here, we input the 290.4 kWh from table 4, which is the electricity from the national grid that directly powers the water pump.

For the second process, we know that 1161.1 kWh is attributed to powering the water pump by the diesel generator (table 4). Hence, this is the electrical output of the generator. However, we need to know what the diesel fuel input is of the generator to calculate its operational emissions. Unfortunately, there was no option for diesel fuel input in our database. Hence, we chose a fuel with a similar emission factor to diesel, which is natural gas (CBS, 2023). It was calculated that 1161.1 kWh is equal to 110 m^3 of natural gas (LearnMetrics, 2021) and that 1 m^3 of natural gas is equal to 0.829 kg (CBS, 2023). With the following calculation, an input of 91 kg per week into the generator was determined:

110 m^3 * 0.829 kg = 91 kg of natural gas

The diesel generator was shipped from Italy to Lebanon, which is a total distance of 3707 km over land. Since the generator weighs roughly half a ton, transporting this over this distance is equal to around 1853 tkm (ton-kilometers). Due to the weight and size of the generator, we assumed the transportation mode to have been road freight.

Transport of electricity from the national grid is excluded from the calculation since this lies outside the scope of this research and due to time constraints.

3.3.3 Waste disposal

Approximately 94% of waste in Lebanon ends up in landfills which is why we assumed that, after the completion of its lifetime, the diesel generator will 100% end up in a landfill (Kiwan, 2018).

3.4 Life cycle inventory analysis – solar PV and battery

To power the water pump with solar PV panels, a certain number of panels and batteries must be installed. The batteries are used in conjunction with a solar PV panel that serves as a means of energy storage (Muteri, 2020). Its primary function is to store the excess electricity generated by the solar panels during periods of high sunlight or low energy demand. This stored energy can then be utilized when the solar panels are not producing electricity, such as during nighttime or periods of low sunlight.

According to the information provided by EfR, the size of the solar PV system that needs to be installed is approximately 4 kWp of solar PV panels and 12 kWh of batteries. This translates to 9 solar PV panels and 8 batteries in total. In the data retrieved from EfR, we learned that the model type of the solar PV panels are monocrystalline (Single-Si) modules with a weight of 23.5 kg per panel, and with an efficiency of 20.66%. In addition, the battery type for the solar PV panels (Battery BS DYN/DLC6-420 Lead Carbon 6V) consists of a nominal battery capacity of 420 Ampere-hours, with a weight of 23.5 kg, and with an efficiency of 90-92%. In figure 2, the solar PV system is illustrated schematically. In addition to the solar PV panel and the battery, an inverter is added to the system. The inverter is a device that converts direct current (DC) electricity, which is what a solar panel generates, to alternating current (AC) electricity, which the electrical grid uses (Muteri, 2020). In consultation with EfR, we assumed a lifetime of 25 years for every compartment within the solar PV system.

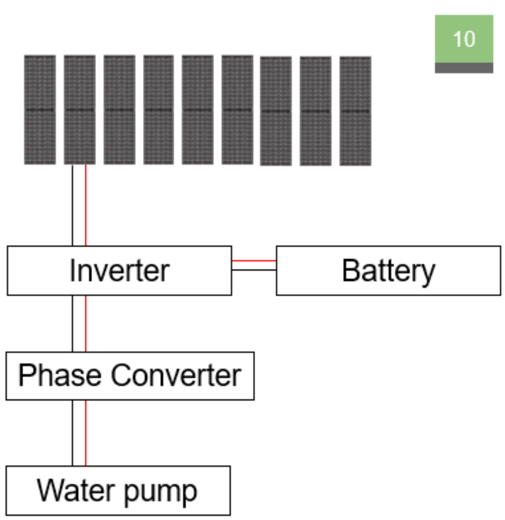

Figure 2. Schematic framework of the solar-PV system (EfR, n.d.)

3.4.1 Assembly

The input resources such as raw materials and energy and the output emissions for both the solar PV panels and the batteries are considered in the assembly part of the LCA inventory. An assembly is formed using all the unit processes of the solar-PV system, which is then used to assess the individual impacts of each process element. Likewise, another assembly is built using all unit processes of the batteries for the solar-PV system to find the effects from each element. For the solar PV panel, we included four components: PV panel, inverter, converter, control unit electronics, and cable. The photovoltaic panel includes the following processes in the Simapro dataset: the production of the cell matrix, cutting of foils, washing of glass, production of laminate and production of the aluminum frame of the panel. The inverter and converter were chosen in Simapro to match the wattage of the solar panel system. The inverters were 37 kg in total and had an overall efficiency of 93.5%. The included process in the dataset is the production of this inverter. A converter's weight and carbon footprint were also based on the most approximate unit available within the Simapro database. The rest of the electronic components would in reality include various equipment such as a power meter, adapter, electronic display etc. A comprehensive solar PV system model was chosen from Victron Energy to approximate the total weight. Within the Simapro, this paper chose "Electronics for control units", which consisted of 46% steel, 32% plastic, 14% printed wiring boards and 8% cable. For the battery, we included the following compartments in the LCA calculation: the rechargeable Lithium-ion battery. As the lead-carbon battery is not included in the Simapro dataset, we decided to choose the Lithium-ion battery. This choice is based on similarities in properties in terms of chargeability, energy density and voltage output (Monahov, 2012). It is estimated that a typical Li-ion battery back (with the casing included) will emit approximately 73 kg CO_2 eq /kWh. This figure was then adapted to the total power storage capacity of the model designed by the EfR (8 batteries of 428Ah, 6V batteries).

3.4.2 Processes

The transportation of the produced materials to the solar plant area at the school, installation, and operation of the plant are considered in the processes part of the LCA inventory. For the project, the components of the solar PV system will be acquired from local sellers and transported to the school within a domestic boundary. Therefore, we estimated that the carbon footprint that could arise from the transportation of the equipment was minimal compared to other scenarios, considering that they were shipped from overseas manufacturers.

3.4.3 Waste/Disposal

The waste treatment methods for solar PV panels, including end-of-life management, can vary depending on the specific region and the available infrastructure for recycling and disposal. According to the American University of Beirut, approximately 94% of solid waste in Lebanon goes to open dumps or landfills (Kiwan, 2018).

Data for the solar PV system (panels + batteries) for working with SimaPro are given in table 5 and were obtained through literature research and data provided by our client. The data below were put into the SimaPro software to prepare for the life-cycle impact assessment.

Table 5. Data collection for assembly, processing, and waste/disposal of the solar-PV panels

Assembly	Unit	Amount
Solar PV panel	Single-Si PV panel	19.56 m2
	3-phase cable	12m
	Converter encompassing 5kW	4.5kg
	Inverter encompassing 5kW	37 kg
	Control unit electronics	15 kg
Solar PV Battery	Rechargeable Li-ion battery	20.5 kWh
Waste/Disposal		
Disposal of the solar PV panel	Treatment of municipal solid waste, landfill	Municipal solid waste (landfill)
Disposal of the solar PV battery	Treatment of municipal solid waste, landfill	n/a

3.5 Societal impact assessment

In order to find an answer to the question of how the project could have an impact on the hygiene and health of the school's students and employees, a social impact assessment has been conducted. To answer the third sub-question of this research ("what is the current situation of access to water and hygiene when the water pump is operated through the diesel generator and national electricity grid?") and the fourth sub-question ("How could the installation of the solar PV panels to power the water pump impact the hygiene and health of the school's students and employees?"), a semi-structured interview with the school's headmaster, Mustafa Alhaj, has been conducted. By doing this, we aimed to gain more insight into the school's current situation regarding access to water and hygiene. The interview questions can be found in Appendix 1. If possible, we would have liked to come in contact with the school's students, as well, but this was difficult to realize as there is a strict university protocol that needs to be adhered to when involving a minor in research. Besides that, a translator would have been necessary. A semi-structured interview was chosen because this forms a basic outline for an interview, so you do not get lost on the main aim of the interview, whilst there being a chance for taking unexpected side paths if desired (Magaldi et al., 2020). The purpose of the interview was to 1) gain understanding of how the current situation regarding access to water affects the personal hygiene and health of the school's students and employees and 2) to look into the student's perspective and see how they think the project will impact their hygiene and health. Here, it is important to realize that the school has previous experience with solar PV panels being installed, but this did not impact their access to water as these panels are not connected to the water pump. After conducting the interview with Mustafa, the interview has been transcribed and analyzed with the knowledge previously gained from the literature research in mind.

Furthermore, a survey has been conducted among the school's employees. The aim of the survey was to gain insight into the perspective of the employees and help to answer the third and fourth sub-questions. The survey asked the employees questions about how they experience the current situation in the school regarding access to water. Moreover, the survey analyzed how the employees think that improved access to water will impact their health and hygiene, as well as that of the students. The survey questions as well as the link to the survey can be found in appendix 2. The survey was conducted online via Google Forms and was spread among employees by Mustafa. Once we had the responses, we analyzed them in order to identify how the project could have an impact on the hygiene and health of the school's students and employees.

4. Results

4.1 Environmental Impact Assessment

The objective of the LCA was to calculate the environmental impact of changing the current diesel generator and grid electricity system of powering the water pump, to solar PV system. The first step was to determine the impact categories, indicators and characterization model. To this end, this research used the EF (Environmental Footprint) 3.0 Method V1.01. This model was specially designed to incorporate carbon footprints into the larger scheme of environmental footprint while using the LCA method (Simone et al., 2018). Furthermore, one of the categories within this model is climate change, indicated as 'Radiative forcing as global warming potential', which is measured in kilograms of CO2 equivalent (kg CO2 eq).

The comparison of the two systems to power the water pump is presented in figure 3.

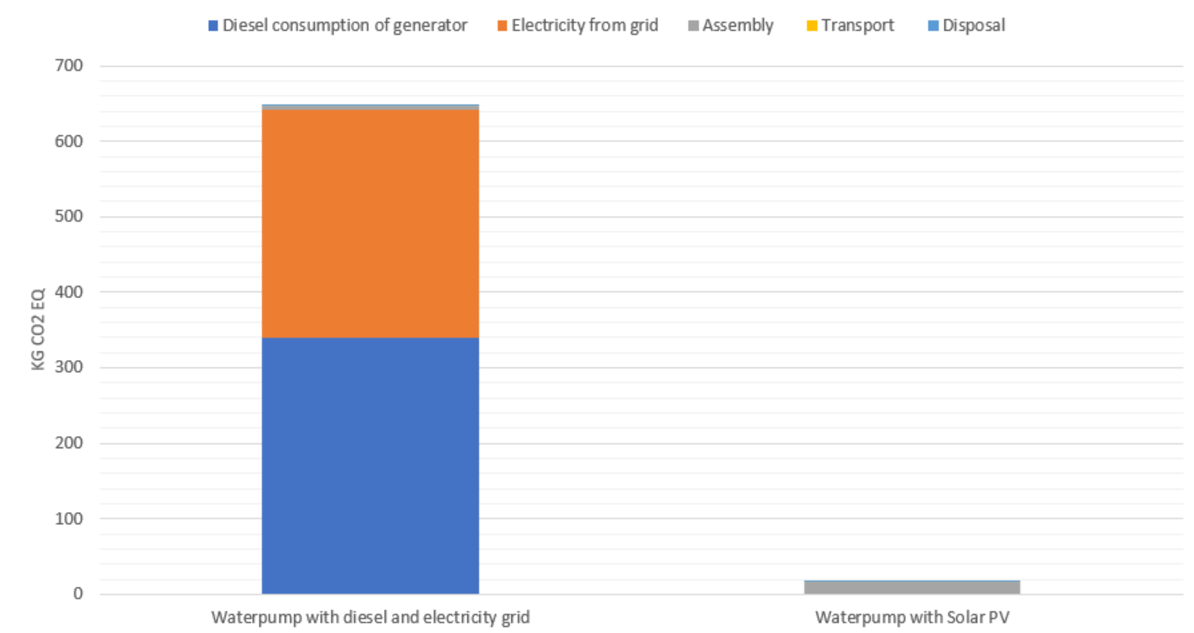

Figure 3. Comparison of carbon footprint of two systems

The results showed a drastic change in the estimated carbon footprint between the two systems. The diesel/electricity system showed that the system will emit 647.88 kg CO2 eq each week, whereas the solar PV system only emitted 23.89 kg CO2 eq/ week. Although this research found that the carbon footprint in the assembly, transportation, and disposal of the generator system is approximately 40% lower than the solar PV system, the overwhelming bulwark of the CO2 came from the weekly operation of the diesel/electricity system. The amount of diesel consumed emitted 339 kg CO2 eq, and based on the electricity grid system of Tripoli, electricity used for the water pump resulted in 30 kg CO2 eq. Therefore, it is possible to conclude that the largest environmental impact that this project will bring to the school is that with the solar PV system, the school's dependency on polluting sources of energy, such as diesel and electricity generated in the conventional way, will be negated. Table 6 presents the specific figures in CO_2 eq/ week.

Table 6. Carbon Footprint comparison of two systems in kg CO_2 eq/ week

Source of CO2	**Water pump with diesel and electricity grid**	**Water pump with Solar PV**
Diesel consumption of generator	339 kg CO2 eq/ week	0
Electricity from grid	302 kg CO2 eq/ week	0
Assembly	6.31 kg CO2 eq/ week	28.8856 kg CO2 eq/ week
Transport	0.39 kg CO2 eq/ week	N/A
Disposal	0.183 kg CO2 eq/ week	0.0114 kg CO2 eq/ week
Total	647.883 kg CO2 eq/ week	28.8969 kg CO2 eq/ week

To visualize the contribution of each life cycle process more clearly, figure 4 illustrates the share of emission for each product stage of the diesel generator. Since diesel consumption, electricity from the grid, and transport do not apply for the solar PV system, we did not include a pie chart for that system.

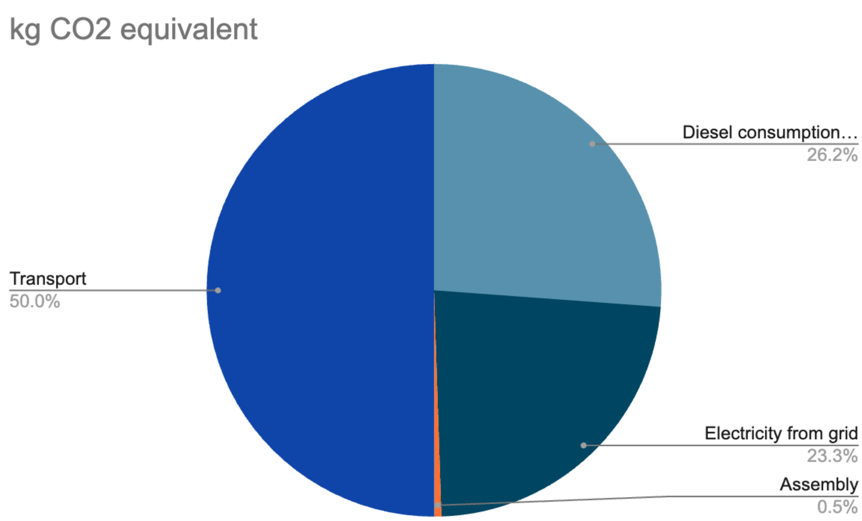

Figure 4. Process contribution diesel generator

4.2 Social Impact Assessment

4.2.1 Social Impact Interview

The questions of the semi-structured interview as well as a literal transcription can be found in the appendix.

The interview with Mustafa was useful for gaining insight into the school's current situation regarding access to water and the impact that the project could have on the school's students and employees. Currently, the school is highly dependent on the national grid and fuel generator for keeping the water tanks full. As the school has so many students, the consumption of water is high. Besides drinking water, other usages of the water are cleaning, washing hands, and flushing toilets. All of these usages are related to health and/or hygiene. It regularly occurs that the tanks are empty, and the school cannot use water until they have power again. This also depends on when the school gets cleaned, as this often uses a lot of water. Maintenance workers regularly check whether there are any places where water gets spilled, and they also check on the cleanliness of the water in order to ensure that the water is safe to drink and use. Moreover, Mustafa mentioned the importance of water for the health and hygiene of the students and employees of the school. Access to water is crucial for good health and hygiene, so a lack of it results in a decrease of these factors. Furthermore, Mustafa stated that the cause of a lack of access to water has never been the water well. The climate in Lebanon is rather humid, and the well has never fallen dry. However, since the school does not have access to water all the time, Mustafa could not say with complete certainty that the well will always hold enough water, even when the school would be able to access the water from the well 24/7. However, this has not yet appeared to be an issue before.

When asking Mustafa about the student's perspective on the importance of access to water for health and hygiene, he stated that the students are very aware of this. The school has two health advisors, whose task is to educate the students on hygiene practices. Besides that, the health advisors also educate the students on other health issues, such as the importance of vaccines. Therefore, the students value good hygiene practices.

Overall, when asking Mustafa about the impact that EfR's project would have on the health and hygiene of the school's students and staff, he answered that it would change everything: "*You cannot imagine life without water, and you cannot imagine a school with 2000 children without water… This is essential to the lives of the kids…"* The most urgent challenge that the school is currently facing, is a lack of energy to power the water pump and keep the tanks filled. If this problem can be solved, the health and hygiene of the students and employees will also improve.

Lastly, the school does not currently collaborate in projects with NGOs or other stakeholders regarding access to energy and water. Mustafa's main goal for the future of the school is to get an energy system that is able to power the water pump 24/7, as this would solve the lack of access to water, as well as providing power for e.g., lighting in the school. Furthermore, Mustafa stated that in the future, it would be great to collaborate with stakeholders to work on the school's development and, for example, renovate the bathrooms and purchase showers.

4.2.2 Social Impact Survey

The survey questions can be found in the appendix, as well as a link to the online Google Forms.

In total, 44 employees of the Tuyoor Al Amal school have filled in the survey. The answers to the questions sometimes differed quite a lot, but overall, it provided us with more insight into how the employees of the school perceive the situation regarding access to water. The answers to the first question *"On a scale of 1 to 10, how would you rate the school's current situation regarding access to water?"* can be seen below in figure 5.

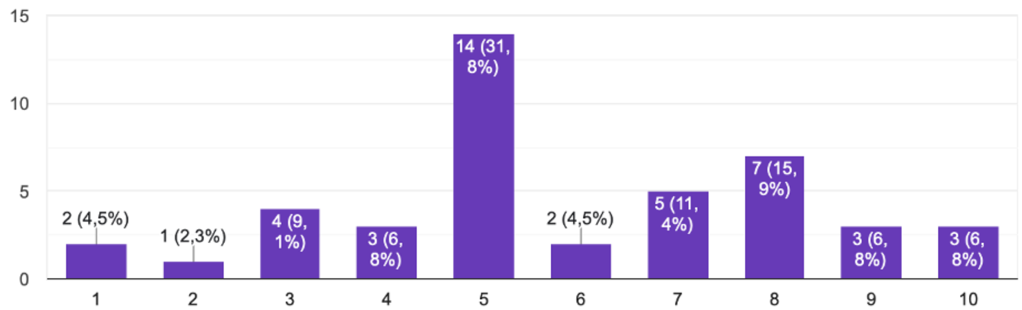

Figure 5. Survey answers to question 1

On average, the current water situation was rated a 5. However, the answers range from 1 all the way to 10. When looking at the second question *"What is, for you, the most important use of water in the school? Order the following options from least important to most important",* the answers are as follows (figure 6):

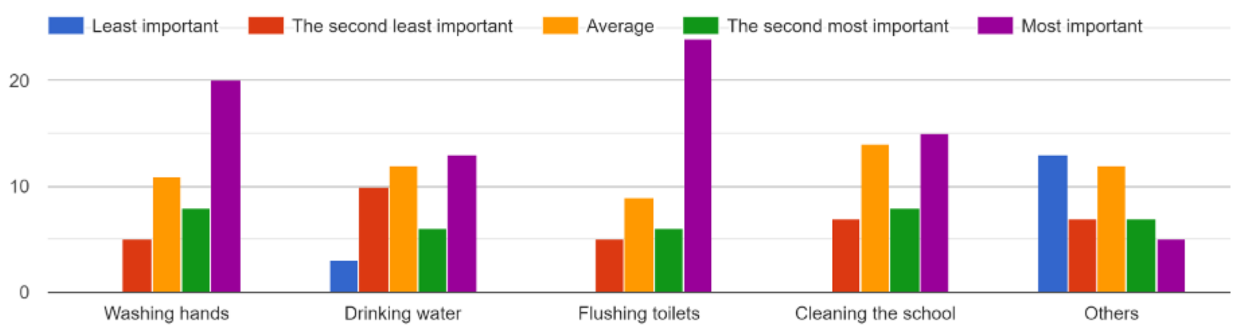

Figure 6. Survey answers to question 2

Flushing toilets and washing hands were perceived as the most important usages of water in the school, with 24 and 20 votes, respectively. As the other options have also been voted as most important by some of the employees, this indicates that some employees have voted multiple options as most important. When looking at the answers on question 3 *"How often and what kind of difficulties and inconveniences related to water access in the school do you face?"* The answers are mostly in agreement. Even though some employees state that they do not experience any issues with water access in the school, most of the answers state serious problems. Not being able to wash hands and flush toilets is named often, as well as a lack of water in general. Some employees state that they do not drink the water, as it does not always seem clean and is not always available. One employee explained that he/she drinks bottled water instead. Students complaining about not being able to wash their hands or clean themselves is also mentioned. When looking at question 4 *"Do you feel like the school's current access to water prevents you (and students) from participating in hygiene practices?"* the answers are as follows (figure 7):

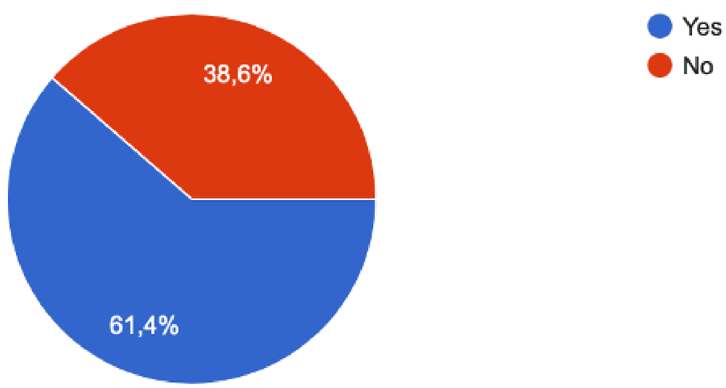

Figure 7. Survey answers to question 4

A majority of 61.4% voted 'yes', and 38,6% voted 'no'. When looking at the answers to question 5 *"How do you think improved access to water would impact your personal hygiene and the hygiene of the students?"*, many employees mentioned the importance of water for hygiene practices to halt the spread of infectious diseases. Even though 38.6% voted 'no' for question 4, almost everyone agreed in question 5 on the importance of water for improving personal hygiene and improving the health of the students. As most employees already included the aspect of health in their answer to question 5, their answer to question 6 "How do you think improved access to water would impact your health and the health of the students?" were very similar. When looking at question 7 "If you have any suggestions or recommendations to improve access to water in the school, please feel free to share", the suggestions ranged from having more taps and faucets to wash hands and access water, to finding a way to improve the access to water. Finding a solution to the energy problem in the school was mentioned multiple times, and one employee even mentioned the use of solar energy to power the water pump. Moreover, it must be stated that finding a way to have cleaner water was also mentioned a few times. Two employees suggested using a water filter, and others simply stated that they wanted the water to be cleaner and more sterile for the purpose of drinking water.

5. Discussion

5.1 Environmental part

For the environmental part, several limitations are important to take into account. First, there was limited information on the exact use of the water pump by the school. Therefore, we had to make assumptions about how many hours per day it is on average powered by the diesel generator and by the grid. This is also because the school simply does not know and does not track this data. Due to this EfR made an estimation of this use and also the amount of kWh it takes for the water pump to be powered and we followed this accordingly.

Secondly, there are some constraints to consider with regard to the diesel generator. We did not know the exact model of the generator and had to make assumptions about materials, size, weight, and capacity, which could have affected the results of our research and made it less context specific. Additionally, the lifetime of the generator is assumed to be 20 years, while in reality the lifetime is probably higher but working with lower efficiency and producing less electricity. As long as the generator provides electricity, it is likely to continue running which could be up to approximately 40 years depending on how well it is maintained (Petersen, 2020). Also, in the utilized software, SimaPro, we ran into an issue. For the operational stage of the chosen generator, the database did not provide an option for diesel input and therefore we had to use gas instead. Although gas has a similar emission factor, this is a significant limitation since in the results around half of the emissions coming from the current energy system is attributed to the fuel input of the generator.

Another important limitation for calculating this LCA is that our temporal scope was one week. Unifying the temporal window to one week allows for a more detailed analysis of the impact, particularly for the variables such as electricity and diesel fuel usage. However, this approach also presents limitations, as it restricts the assessment to a shorter time frame, potentially overlooking seasonal variations and long-term trends that may affect the overall environmental performance of the school and water pump. This way, it can perhaps represent an incomplete system boundary coverage. This adds to the criticism by Hellweg & Canals (2014), as they state that there is a lack of consensus regarding the methods and variables, as a single product's 'environmental impact' can vary according to the researcher's perspectives and scope of the analysis, resulting in a different LCA calculation for every researcher.

Finally, although the mode of transport for the generator is plausible to be road freight due to its size and weight, there is no absolute certainty in this.

Regarding the limitations for the solar PV system scenario, the waste management of the solar PV system assumed that the waste scenario of the solar PV panel and battery as 100% landfill waste, but this requires further research into the actual recycle percentage of renewable energy technology in Lebanon. If there are policies and social infrastructure to properly reuse the solar panels at the end of its life cycle, the carbon footprint of the solar PV system will be reduced compared to our estimates. For now, the data on end-of-life treatment options and their associated environmental impacts are limited, which affects the accuracy of the LCA results.

Furthermore, the CO2 emitted through the transportation of the components of the solar PV system, including the batteries, was not included in this calculation process. As the EfR project is planning to acquire this equipment from local sellers in Lebanon, the carbon footprint from this process is estimated to have a minute impact on the overall carbon footprint of operating the water pump with the solar PV system. A more accurate LCA could be possible once determining the sellers, and therefore the transportation distance from the manufacturers to the school, however this would warrant further research to be made clear.

Lastly, it is important to highlight that solar PV panels and battery technologies are rapidly evolving. The LCA calculations are based on data and assumptions from 2016, which therefore might not capture future advancements or improvements in the technology, such as efficiency, lifetime or recyclability rate.

5.2 Societal part

There are some limitations that need to be considered regarding the survey and interview. First of all, the interview and survey rely on self-reported information, which may be subject to bias or inaccurate information. This can be due to, for example, memory lapses or personal interpretations of the questions we prepared. Respondents may have overstated or understated the severity of their water access issues, either intentionally or unintentionally, resulting in an incomplete or inaccurate understanding of the current situation (Althubaiti, 2016).

Besides that, some answers to the survey were not logical answers to a certain question, which can mean that some questions were misunderstood by some employees. Furthermore, the results of the survey and interview are based on a limited sample size of respondents. As we only interviewed the headmaster and as the survey covered 38 employees, we cannot be certain that the questions on the students' perspective were accurately answered (Faber & Fonseca, 2014).

After all, we did not conduct an interview or survey with students of the school. In addition, social desirability bias can influence participants' responses. The respondents may have felt pressured to provide answers that they believe are socially acceptable, or they could have been hesitant to share negative experiences or feelings rather than their true opinions (Althubaiti, 2016). For example, if the employees were asked whether they have access to water at the school, they may have provided positive feedback even if they do not have sufficient access to water because they believe that having access is socially desirable. Language and cultural barriers may also have hindered effective communication during the interview or survey. Even though we prepared the survey questions in English, some participants gave their answers in Arabic. This indicates that their preferred language is Arabic, and this could have influenced how some employees understood the questions of the survey. Despite these limitations, survey and interview remain valuable tools for gathering qualitative data and capturing firsthand experiences and perspectives (Hecht et al., 2017). By acknowledging and addressing above-mentioned limitations, efforts can be made to enhance the validity and reliability of the data collected, leading to a more robust assessment of the current situation regarding access to water and the potential societal impacts the project has.

6. Conclusion

In conclusion, the new solar PV system installed by EfR is expected to have a significant positive environmental and societal impact. For the environmental part of this research, two LCAs were conducted examining the transition from the national grid and diesel generator to a solar PV system for powering the water pump. Through the database of SimaPro and data retrieved from the client, it was made possible to answer the first two sub-questions on the CO_2 emissions of the current system, and the CO_2 emissions of the future system involving solar PV. After completing the calculation, we indeed noticed a significant reduction in CO_2 eq emissions (-618.94 kg CO_2 eq/week) when implementing the solar PV system to power the waterpump of the school. By comparing the two energy systems, the decision-makers involved can make informed choices based on the quantified environmental performance, potentially leading to a reduction in greenhouse gas emissions and other environmental burdens associated with electricity generation.

When looking at the societal impact that EfR's project could have on the school's students and employees in terms of hygiene and health, the results are promising. Both the headmaster of the school and the employees stated the importance of sufficient access to water for hygiene practices, which also has health impacts. Even though the survey results showed that the employees were sometimes not all in agreement for every question, the overall conception is that the current situation regarding access to water is seriously lacking. A water pump that works properly would bring a lot of benefits to the overall hygiene and health in the school and stands at the top of the list of things that employees want to see change in the school.

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Appendix

1. Semi-structured interview questions

Interview with Mustafa (headmaster of the Tuyoor Al Amal)

Questions to get more insight in the current situation regarding access to water:

5. What is the current situation in the school regarding access to water?
   - What are all the different types of water usages in the school?
   - How predictable are the times during the day at which water is accessible?
   - Is the water pump also used for obtaining drinking water?
6. If the water pump can be powered 24/7, do you think that the well will be able to provide enough water?
   - What is the climate in the area? Is the well being replenished enough?
7. How does the school manage its water consumption and waste and what measures are taken to conserve water and prevent contamination?
8. How often does the school experience water shortages and how do you think the lack of access to water impacts the school?
   - Especially regarding hygiene and health?
9. What are the main challenges or risks associated with accessing water in the school and how are they addressed or mitigated?

Questions to get more insight in the student's perspective regarding access to water:

10. How much do you think the students value good hygienic practices such as washing hands?
    - Do you think the students are aware of the importance of access to water for good hygiene?
11. How aware and engaged are the students (and staff) in water-related issues and what initiatives or activities are carried out to educate and empower them?
12. Finally, how do you think improved access to water will influence the school, its students, and its employees?
    - How do you think this will impact the overall hygiene within the school?
    - How do you think this will impact the student's and employees' health / overall wellbeing?

Other related questions

13. How does the school collaborate with other stakeholders such as NGOs, local authorities, or communities to improve access to water and what are the main opportunities or barriers for cooperation?
14. What are the short-term and long-term goals or plans of the school regarding access to water and management and what resources or support are needed to achieve them?

2. Survey

The following survey was conducted amongst employees of the Tuyoor Al Amal school. The survey was conducted online using Google Forms. The link to the survey: https://forms.gle/5BYG2gDKLb4kHaAy7

[Questions on the current situation regarding access to water]

15. How would you rate the school's current situation regarding access to water on a scale of 1 to 10 (1 being extremely poor and 10 being excellent)?
16. What is, for you, the most important use of water in the school? Order the following options from least important to most important.
17. How often do you face difficulties and inconveniences related to water access in the school?
18. Do you feel like the school's current access to water prevents you (and students) from participating in hygiene practices? (yes or no question)

[Questions on the impact of improved access to water]

19. How do you think improved access to water would impact your personal hygiene and the hygiene of the students? (open question)
20. How do you think improved access to water would impact your health and the health of the students? (open question)

[Other related questions]

21. What suggestions or recommendations do you have to improve access to water in the school?

3. Transcription of the interview

L: Yes, so I'm recording it now. And I'm also recording it on my phone so this time it should go right. So maybe Kenta if you can also record it then we are just sure that it is going to be okay.

Okay, perfect.

Okay, so we prepared 10 questions for you, and they are a little bit different than last time but the first questions are about getting more insight in the current situation regarding access to water in your school. So, the first question is what is the current situation in the school regarding access to water. So, what are all the different types of water usages and how predictable are the times that you can get water each day?

M: Okay, you are asking me about the water, how we get the water in the school for the whole day right?

L: Yes, and also, for what types of usages you all use the water so for washing hands, toilets, do you also drink it?

M: Well, first we have two water tanks and we have water pump with which we use the water and fill the tanks and these tanks get the water to the school. And usually we are depending on the water to keep the tanks full because there is a huge number of kids. The school is big and the school is used by hundreds of kids everyday so that means, like, we use water more than the normal schools. We have the morning shift and the afternoon shift and each shift sometimes, like it has up to 1000 students, so the water is maybe sometimes just somedays for 2000 people who are using the school for toilet, for drinking water, for washing hands and for cleaning, like, for the cleaners. You know, this is the main like usage for the water, which is the drinking and the… we have also the toilets that kids are using to wash their hands and also we have for washing the, like the, and for cleaning the school. So these are the reasons when we, why we are using the water.

L: Yes, and how predictable are the times during the day at which the water is accessible? So you have water in the tank, so is that accessible 24/7 or not?

M: No, sometimes it depends on time of, like, it depends all of the system of power, because the tanks are nearly 5000 liters which is sometimes it is empty after one hour or two hours, so we cannot like have a fixed time for how many, like, hours or minutes we are using the tanks and when they are empty. It depends on consuming the water from the kids. But I can say that we have been using the, like the water, like coming to the water pump we were using the fuel generator and depending on the government power like ….. In general we are using the fuel ?like the tanks? because when we run the pump, the pump needs three phases. So this is how it works, like before we had a solar panel, last february the school we tried to connect like the water like like the system to the previous system because it somehow was expensive and we were depending on the mainly on the fuel generator, so now we are using the fuel generator with the previous system so we have two sources for the generating power. The first and the main one is the biggest system which gives the lights and turning on the light bulbs and using different machines in the school and the other one is the fuel generator. We are using it to run the pump when the water is empty. So the other source which is the government power, we don't have specific time for how many hours, but generally as an average it's average about two hours per day.

L: Yes, so that is not a lot of time, times per day.

M: No, the water consuming is more than the like the usual like when we have one ?shift? So it depends on how many children and how many people are using the school and if also we have the cleaning sometimes it depends on the cleaners when they will clean the school so they have a system where they are cleaning the school like sometimes when the kids are there, so that also consumes water. So that's how it works.

L: Okay, that's very clear, thank you. Then i would like to know the well that the water comes from, does this provide enough water, so i don't know what the climate is in Tripoli but is it very dry and is the well filled enough with water? Replenished enough?

M: Okay, the water pump, the well is depending on the water pump like to take the water out and give it to the tanks. However, i mean, the weather in Tripoli it is humid weather but generally the water the water pump is enough to generate water i mean we did not face any troubles regarding the dry and? of the water and we're very happy with using the school now since 2014 because the school is not ours we are hiring it.

L: Ah, okay.

M: We have a rental contract with the owner so now we are hiring it for the second the next two more years and maybe more in the future. But generally we are using the water from the well and we did not see any troubles regarding the like the dry well. The water is on the surface however if you would have the like a guy who is working for the government i can ask him the ? of water generally in the area.

L: Yeah, but you have never, oh sorry, you have never experienced that the well fell dry? It was always just filled with enough water?

M: Yeah.

L: Okay, that is good to hear.

M: We have been using the school and it is providing enough water. We did not get in trouble with the water well.

L: Okay, perfect. So, how does the school manage it's water consumption and waste and what measures are taken to conserve water? And prevent contamination of the water?

M: Well, regarding your question you are asking about how we stop consuming extra water like for no reason? Right?

L: Like, how do you manage how much water you use and make sure that it is also clean water?

M: Yes, first regarding the, like, like? the school to see about the situation of the tanks and these things at the beginning of the school year which is like this is the water usually we don't have any trouble regarding this. And also for the for the water we have someone who's job in this school is in addition to like to making or to do maintenance work in case we need like maintenance repairs on the doors and everything is up to control the water and to the like the power at the same time make sure there is no extra usage of the water in some cases. And we do maintenance for the for the power for the everything like just in case we have anything just to fix it.

L: Okay, yes okay thank you. Then how often does your school experience water shortages and how do you think the lack of access to water impacts the school?

M: Yes it happens many times, the shortages of water. Sometimes like it happens like before we had the solar panels and things we were depending mainly on the fuel generator as a first source for like generating power for everything. So when we have like a problem in the generator that means we don't have water and we don't have power. Like, we experienced this a couple many times. Then the expert comes to fix the problem with the generator and it works again.

L: So, is this something that occurs daily or weekly?

M: No, like sometimes. Like once in two months. But now these days because we are depending on the fuel, we need to like sometimes we check that there is water because the tanks can be empty so we like the maintenance worker he has to do and bring fuel and you know run the generator it takes some time. But it is not for a long time maybe 10 minutes maybe 20 minutes sometimes it depends on the problems. Because we we that all depends on the also the government power which helps to give power for the water pump and to bring power for that otherwise we are depending on the generator and we like consume more fuel for the generator.

L: Yeah, and I forgot to ask; is the water also for drinking water? Is it the same water?

M: Yes.

L: Okay. Yeah, okay so how do you think the lack of water impacts for example health and hygiene practices?

M: Well, I mean that is a difficult question. Because for me it is a very important question. You know, as we like depending now on the system which was before us as a school owner and how it works like depending mainly on the water pump to … the kids they are missing it for drinking, so like we we are also like checking about the tanks and the cleanliness sometimes to make sure that the water is healthy.

L: Yeah, okay perfect. So then what are the main challenges do you think with accessing water in the school? Do you think there are any obstacles that need to be overcome before it can be realized to have enough water?

M: You mean in the future or before?

L: Yeah, yeah, yeah, so what are the main obstacles regarding getting more access is it just the only problem is getting enough power to generate the water pump?

M: Yesthat is the main problem i think which is so far we are experiencing this problem which is considered the main problem that is lacking the power which provides the pump to work and to run. So, one of the main obstacles now is converting the system from three single phase or i mean from three phases to one single phase.

L: Yeah.

M: which helps now the like to the main thing and like sustain the water for twenty four hours that the solar panels are working then the water pump is working and you know this is the easiest because we have now two buildings as schools as we are many schools and two buildings we have many shifts. However, i mean in the other school we are working on one phase of single phase system for the water pump which is working on the solar panel and we did not have any trouble regarding water i mean in this building we have a water pump we have a solar panel in the previous system but the problem is that we in the in the system here is not connected to the to the pump because of technical issues like ? and the the like the water is on one phase and the previous system is ?

L: Yeah, okay, yeah that is very clear. So then we will move on to the question on the students' perspective. So do you think that the students value good hygienic practices such as washing washing hands like are they aware of the importance of access to water for good hygiene?

M: Well as a school as a school system in the school we have someone called the like a type of health advisor. His job is to help the kids to teach them about the hygiene and help to make them self cleaning and -

L: Nice.

M: - how they make their school clean. Their job is to teach the kids hygiene and the cleanliness and help to be clean enough.

L: Oh great, that is great.

M: Like that is what we are doing.

L: Okay, perfect, yeah. That sounds great, good initiative. So the students are educated on this by this health-

M: Yeah, they are aware about this.

L: Yeah, okay great.

K: Uhm

L: Oh, yes, Kenta?

K: Yeah, sorry how many how many health advisors do you have in the school? It is kind of a… do you hire from the… how to say this. municipality? Or are they sent by other organizations?

M: How many, sorry I didn't get what you-

K: sorry, how many health advisors do you have in your school?

M: I have two ones. In two different shifts, the main shifts. It is like we hire them as it is their job to teach like that hygiene and to warn for different things and to give lectures about the importance of like giving vaccines and taking vaccines and also for the parents and reconnect them with the local clinical our clinics like they come and visit the school if possible and having these.. We have two ones so far. We have shifts and we have two ones. And the municipality is they are connected to this we are responsible for this as a school.

K: Alright thanks.

L: Okay so then how do you think improved access to water will influence the the school and the students and the employees? So do you think that improved access to water will impact the overall hygiene and health of the students and staff?

M: Of course, yes. Because you can't imagine life without water. And you cannot imagine a school with 2000 children without water.

L: Yeah

M: And like they come to school everyday sometimes you know let's give an average like the school is occupied by mainly 1000 children daily and by 1000 people let's say. These 1000 people they want water and they want to clean themselves sometimes they want to go to the bathroom. And all of these things it needs water. I mean we never ? problem of lacking of water here or some days before and we are having these problems and they happen every week now for some minutes for like let's say and it is a disaster because you know the situation is because we cannot control the cleanliness if the system is not working for us. And I mean the the - This is essential to the lives of the kids and one of the main challenges is to solve the problem of the water for to make sure that 100% is is solved.

L: Yeah, yes so it is very important for the overall health and overall hygiene of course. Yeah, okay so then I think we are finished with the students' perspective questions. So we have two final questions to end the interview. So how does the school collaborate with other stakeholders such as NGOs, or local authorities or communities to improve the access of water and what are the main opportunities and barriers for cooperation? So I believe you already cooperation with an NGO for the previously installed solar PV? But do you have other projects or cooperation with NGOs or other stakeholders?

M: As a main like point here in Tripoli there is water like everywhere like we have water because we are very close like we are a coastal area and the water is not so far from the environment. And every institution we have like a well and this flow depends on having the power to generate or to work to run the pump. However, as a problem we did not mean the problem mainly before only because of lack of power. And lack of power like something we cannot do anything here with the government you know since 2019 we lived in a kind of darkness for the whole country. Like only a few hours the government power came and some months like for instance sometimes for many months there were no like power from the government for many months.

L: That is terrible.

M: We were depending mainly on the local generators like like asking was demanding and very very expensive. We like we were paying a lot for fuel and it was because if you want …. We want to cooperate with the locals here they are all having the same problem so it is impossible to find like a solution and answer to all of this trouble of this main problem.

L: Yeah, it is just too big.

M: ? And they did not help because they have the same problem. So i contacted my stakeholders and the people who are interested to help with the like helping the solar panels as solving the problem so we… Now because the problem was not only the water, you know we believe that is the main problem, but the problem it was like essential for us which is the ?

L: Sorry, the..?

M: Afternoon shift for the kids. So the kids usually in the winter coming from 3 or 2 PM until 7 sometimes 7:30 PM which means after 5 it is dark.

L: Oh, really

M: So, the kids, 1000 kids are in the school until 7

L: Without lights.

M: It happens many times. The kids are in the school and then the power switches off because of the main the problem in the fuel generator.

L: And then you cannot really do anything.

M: Yeah. When we solve the problem of the previous system, like the power for the previous system we still have this main problem but we can't solve it. It needs more like power it needs more maybe resources for the to install and more batteries because you know. We got like, this is the main concern for us as we if you will use the previous system to reduce water and to run the pump than that means we will have to like the consumption of the of the power will be more during the day than the batteries will be empty very soon. So we need more batteries and we need more like more solars.

L: Yes, but you do not have any other projects now with stakeholders or NGOs?

M: Regarding water?

L: No, yeah. Yeah regarding water.

M: No.

L: No, okay.

M: I mean, i mean we have the - because I'm looking for a stakeholder to help us to do like a system for hygiene. A hygiene system for maintenance for the bathroom by replacing the everything with something of more quality. You know, we are working according to our possibilities and we are doing according to our capacity.

L: Yeah.

M: I mean one of the NGOs we are interested in last year the year before them I did not hear from them to do some maintenance work for the bathroom and for the water system. But yeah, i mean we did not hear from them anymore. I mean so it is fine it is good for us like we are controlling things if we are to do this kind of helping as ? water resources for the school, like 90% of the problem will be solved. Like then we are able to use water more then.

L: Okay, so then we arrived at the final question. So, what do you think the short-term and long-term goals or plans are regarding access to water and what resources do you need to achieve these goals for the school?

M: Okay, as a long-term, I think we need to find first we find a solution for power, which is related directly to the water. So, if a plan happens next August by converting the system and the PV like the pump from being 3 phases into one like connecting it with water, with the water pump of the previous system then like the main problem will be solved. And a strategy for the future we think like that will solve the problem. Then, we are working on maintenance for the bathrooms and different things in the schools. We are doing it as I said on our own possibilities. So, in the future we have to find stakeholders or partners or we maybe we ourselves find enough budget to maybe to turn the system in the bathroom like to have like maybe more like have a shower for the kids to clean -

L: Ah, nice.

M: You know, this, it depends on the future how we can make that happen. But at the moment we are thinking about to solve the main problem which is connecting the power to the water system. Then like we make sure the water will be here. The other concern may be drying the well. I mean I did not hear from anybody that it happened but, it may happen. But we don't know because it is something we cannot like figure out about it.

L: Yeah, and maybe if - oh sorry

M: It is not our main concern now, but it could be here.

L: Yeah, so maybe if the water pump gets powered by solar PV, so you have access to the to water 24/7, then maybe you will use more water so maybe you also do not know whether the water well will actually hold enough water for that.

M: Yeah, that is the issue. A different story. But I mean I did not hear from anybody here that… Sometimes the problem is it happened in the pump itself because it is under the ground and it costs a lot of money to replace the pump. That is one of the things that we are working to solve. But I mean if I want to like make the concern as priority, I feel like the first priority for us is to connect the PV system to the pump.

L: Yes, that is the main goal. The main thing.

M: Yes, this is our first and main -

L: Priority, yeah. Okay, those were all the questions. I think you gave very very long and very clear answers to yeah I think we can definitely continue now with our research. Yeah, so I would like to thank you again for your time. It was really interesting, so.

M: Yeah, I am sorry again for last Friday.

L: Oh, no it is okay. It is okay, it is okay.

M: However, nice to meet you and it was a pleasure. If you would like to know some more about the school I am here. You can contact me or Whatsapp.

L: Okay, great. Thank you. Okay. Have a nice day. Bye bye.

M: Thank you.