March 7, 2021

Dr. Reza Rizvi
York University
Toronto, ON M3J 1P3

Dear Mr. Rizvi

As requested on February 27, I am submitting the following report entitled *The Potential of Solar Photovoltaics as an Affordable Renewable Energy Source.*

This report documents the widespread problems regarding the United Nations' Goal 7, "Affordable and Clean Energy" and how solar photovoltaics have the potential to be a huge affordable renewable energy source that can solve these problems. It covers a few of the issues regarding lack of access to electricity, particularly in the South African region. As well as the various types of photovoltaic panels and which would be best applicable to this type of atmospheric conditions.

I hope you find this technical report satisfactory, and I would be glad to hear any questions, comments, or concerns that you have.

Sincerely,

John Doe

The Potential of Solar Photovoltaics as an Affordable Renewable Energy Source

John Doe

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Solar Energy Company

March 7, 2021

My signature below attests that this submission is my original work

Following professional engineering practice, I bear the burden of proof for original work. I have read the Policy on Academic Integrity posted on the Lassonde School of Engineering departmental web site (https://lassonde.yorku.ca/academic-integrity) and confirm that this work is in accordance with the Policy.

Signature: John Doe   Date: March 7, 2021

Executive Summary

Over 789 million people continue to lack access to electricity in 2018. Of this number of people, it is found that 85% inhabit rural areas and that this inaccessibility is highly concentrated in South Africa specially in Sub-Saharan region. Even by 2030, 2.3 billion people will continue to not have access to renewable fuels for cooking under existing and proposed policies. Almost one third of the global population, mainly children and women, will continue to be vulnerable to hazardous household emissions. To reach the United Nations' goal of universal access to clean and affordable electricity by 2030 needs to increase from the current 0.82% to 0.87% for every year until 2030.

Solar photovoltaics have the potential to be the energy source needed to help solve all these problems. This is because one of the best places on the planet to develop and harvest solar energy is South Africa. Majority of the region averages more than 2500 hours of sunlight per year. The decision is clear, but the next step would be to choose from all the different types of photovoltaics. In this case, Amorphous solar photovoltaic panels would be best suited for South Africa as they perform well in high temperatures while also keeping a low cost. The United Nations' goal of worldwide access to clean and affordable energy will be reached much quicker due to the inaccessibility to electricity being highly concentrated in Sub-Saharan Africa. Solar electricity will also act as a clean fuel to help cook food and as energy for water filtration and sanitation.

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1.0 Introduction

This report will provide insight about the United Nations' Goal #7, "Affordable and Clean Energy". It will dwell on many of the related problems occurring over the world and how reaching the UN's goal will help to solve them. The main topic will consist of solar photovoltaics, a conversion of the Sun's light into electricity. The purpose of this report is to explain and show how this emerging technology has the potential to become the solution to reaching Goal 7. It however will not explore other means of renewable energy or compare them in any way. The contents of this report consist of data illustrating the widespread problems to many individuals lacking access to affordable and clean energy, as well as explaining how solar photovoltaics can be used to combat these issues.

2.0 Background

Although society continues to make progress renewable energy objectives, they are too small to achieve the United Nations' goal of universal access to affordable and clean energy by 2030. Despite progress in increasing the availability and efficiency of electricity, this basic need is still inaccessible to millions of people all over the world. Because of this, the health of nearly 3 billion people are being affected due to the stagnated progress of clean cooking fuels and technologies. [1]

Photovoltaic, also known as solar cells, are electronic light converters that generate electricity. In 1839, a French scientist named Edmond Becquerel initially found the significance of photovoltaics, while Charles Fritts, 43 years later, would create the first working solar cell in 1882. This device was constructed of thin layers of selenium and covered in gold. While solar power may seem like a relatively new expansion, photovoltaics has been used to produce energy as far back as the 1900's. Bell Laboratories would be the first company to mass produce crystal silicon solar cells in 1954, this photovoltaic was about to convert 4 percent of the Sun's power to electricity. In comparison to early technologies composing of limited number of photovoltaic cells, present-day innovations consist of electricity grids fed by large scale photovoltaic systems and solar concentrated power. [2]

3.0 Access to Clean and Affordable Energy

3.1 Inaccessibility to Electricity

While the percentage of the global population having availability to electrical energy has increased to 90% in 2018 compared to 83% in 2010. Over 789 million people still lack this essential service in 2018. Of this number of people, it is found that 85% inhabit rural areas and that this inaccessibility to electricity is highly concentrated in Sub-Saharan Africa (Figure 1). This affects over 548 million individuals, making up 53% of the population. [1]

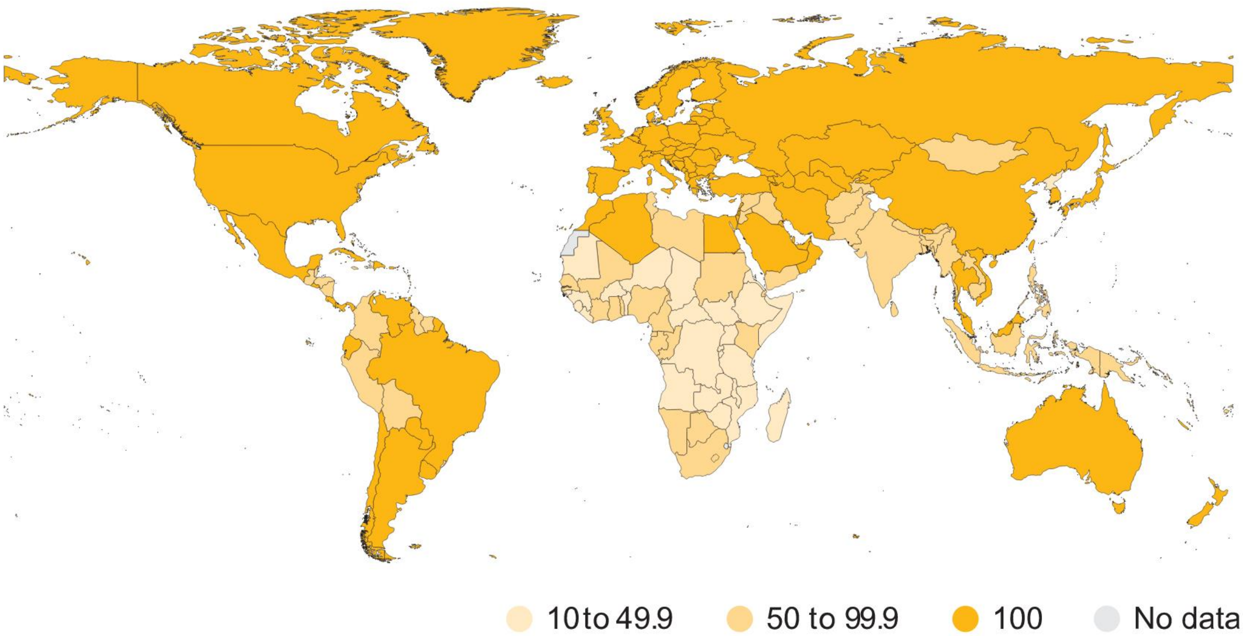

Figure 1. Percentage of population with access to electricity, 2018 [1]

To reach United Nations' goal of worldwide clean and affordable electricity before 2030, the yearly rate in gaining access to electricity needs to increase from the current 0.82% to 0.87% for every year until 2030. Otherwise, at the current pace, an estimated 620 million individuals will still be without this essential service throughout 2030. COVID-19 effects are also not factored into this prediction. [1]

3.2 Stagnated Progress on Clean Cooking Solutions

About 2.8 billion individuals continue to lack access to safe cooking fuels and technologies, a figure which has stayed largely stable for the last 20 years. Despite advancements in several Asian countries, population growth throughout Sub-Saharan Africa consistently outpaces access expansion by a total of 18 million people per year between 2014 and 2018 (Figure 2). [1]

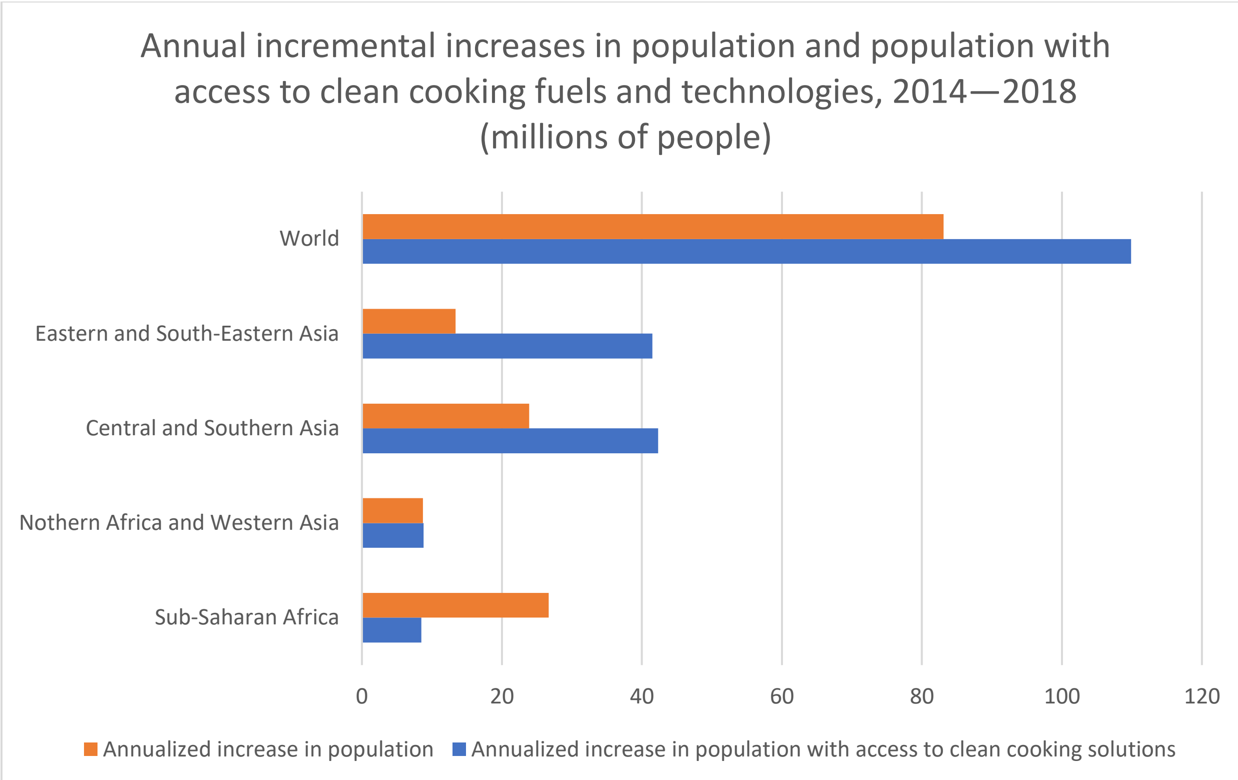

Figure 2. Annual incremental increases in population and population with access to clean cooking fuels and technologies, 2014—2018 (millions of people). [1]

This slow progress in clean cooking technologies is a major source of concern around the world, posing a threat to both human health and the environment. By 2030, 2.3 billion people will already be without access to renewable cooking fuels and technology under existing and proposed policies. As a result, almost one third of the global population, mainly children and women, will remain vulnerable to hazardous air emissions. [1]

4.0 Solar Photovoltaic (PV) Technology

The growth of solar energy in recent years has skyrocketed due to supportive government policies on the development and operation of renewable energy, as well as the technological improvements that help to reduce costs. Yet this same growth is affected by two factors; consumers being uninformed about the technology of solar power, and the quality of solar products in the market. [2]

4.1 Types of Photovoltaics Panels

Although photovoltaic cells comprise of at least 2 fine sheets of a semiconductor, usually silicon. Different procedures can be applied to the silicon to produce several types of panels. [2], [3]

4.1.1 Monocrystalline

Monocrystalline panels are constructed from silicon cells cut out of an individual cylindrical crystal. This photovoltaic is the most efficient technology, turning about 15%

of solar energy into electricity. Monocrystalline silicon has a more complex processing procedure, leading to significantly increased costs compared to other panels. [3]

4.1.2 Polycrystalline

Polycrystalline silicon cells, also known as multi-crystalline cells, are made up of individual cells that have been cut from a recrystallized and melted ingot. Very fine wafers are then cut from the ingots using a saw, which are then formed into full cells. Because of the simplified manufacturing procedure, they are usually less expensive to manufacture than monocrystalline cells, but they are marginally less effective, with an overall efficiency of about 12 percent. [3]

4.1.3 Thick-film

A type of multi-crystalline manufacturing in which silicon is continuously dispersed onto a base material, resulting in a fine-grained, gleaming look. The material is usually encased inside a clear insulating polymer with a toughened glass enclosure, and then bound into a module with a metal construct. [3]

4.1.4 Amorphous

Amorphous silicon cells are made by dispersing silicon over a substrate in a fine homogeneous surface. This silicon absorbs solar energy more efficiently than crystalline silicon, allowing the cells to be narrower, which is why it may also be referred to as "thin film". It can also be deposited onto a variety of hard and versatile substrates, making it appropriate for non-linear exteriors or direct binding to materials used for roofing. The process is less effective compared to crystalline silicon, due to an overall average efficiency of about 6 percent, but it is simpler and less expensive to manufacture. An amorphous substance may be a good choice if roof capacity is not a concern. Crystalline technology should be chosen if maximum performance per square meter is desired. [3]

Table 1 below gives compares the properties of all the different types of solar photovoltaic panels and what each excel and fall behind in.

Property	Monocrystalline	Polycrystalline	Amorphous
Efficiency	Highest	Moderate (13-15%)	Lowest
Cost	Highest	Moderate	Lowest
Area occupied per kW	Lowest	Moderate (approx. 9.3 square meter)	Highest
High temperature performance	Poor	Poor	Better
Generation in diffused light	Average	Average	Better

Table 1. Comparison of Solar Photovoltaic Technologies [2]

4.0 Discussion

The South African region is one of the of the best locations on the planet to establish and utilize photovoltaics, as majority of the region has an average of over 2500 hours of daylight per year while the solar-radiation levels range from 4.5 to 6.5k Wh/m^2 per day (Figure 3). In comparison to places such as Europe only having 1000 hours of sunlight per year but leading the solar industry through installing majority of the world's solar power. This speaks volumes about the potential that South Africa has. [4]

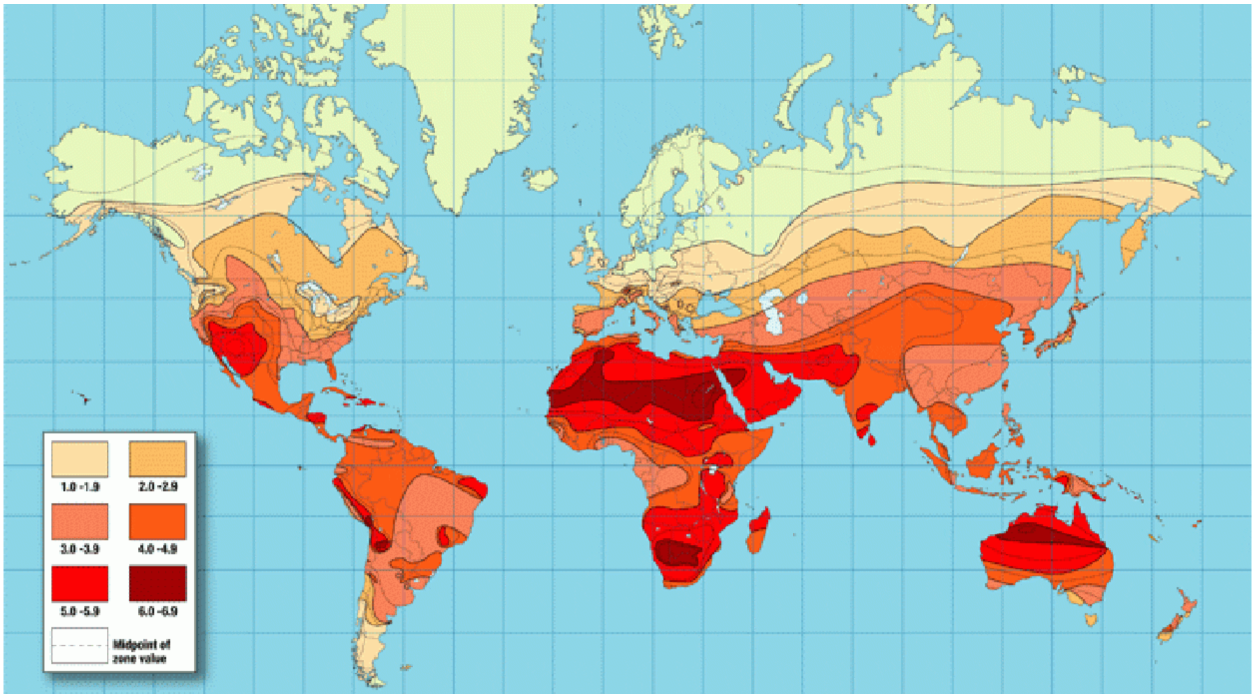

Figure 3. Average solar-radiation level [4]

With a mean yearly precipitation of only 464 millimeters, compared to the global average of 806 millimeters, South Africa is classified as a "relatively dry" region. This represents another significant benefit as the operation of solar photovoltaic cells does not necessitate the use of water and with less rainfall, there will be more sunlight. This will result in more solar photovoltaic energy being produced. [4]

Referencing Table 1, the type of photovoltaic panel that best benefits South Africa would be Amorphous panels as they and perform well in high temperature while also keeping a low cost. These panels will require more area, but this will not be a problem due to the amount of unused land and although the efficiency of Amorphous panels is low, this will be compensated through the amount of sunlight and solar-radiation South Africa receives.

By installing Amorphous solar photovoltaic panels in South Africa, the United Nations' goal of worldwide access to clean and affordable energy will be reached much quicker due to the inaccessibility to electricity being highly concentrated in Sub-Saharan Africa. Solar electricity will also act as a clean fuel to help cook food and as energy for water filtration and sanitation.

5.0 Conclusions

In 2018, over 789 million people will be without electricity. 85 percent of this population lives in rural areas, with Sub-Saharan Africa having the highest concentration of inaccessibility to electricity. Under existing and proposed initiatives, renewable cooking fuels and technology will still be inaccessible to 2.3 billion individuals by 2030. Almost a third of the global population, primarily children and women, will remain subject to unsafe household emissions. To meet the United Nations' goal of universal access to affordable and renewable electricity before 2030, the annual current speed of access to electricity needs to increase from 0.82 percent to 0.87 percent each year until 2030.

Solar photovoltaics have the potential to be the energy source that will aid in the resolution of all these issues. This is because South Africa is one of the best places on the planet for solar energy development and harvesting. Most of the region receives over 2500 hours of sunlight per year on average. The choice is clear, but the next step is to narrow down the various types of photovoltaics. In this case, Amorphous solar photovoltaic panels would be the best option for South Africa because they can withstand high temperatures while remaining cost-effective. Because electricity inaccessibility is concentrated in the Sub-Saharan Africa region, the United Nations' goal of universal access to clean and affordable energy will be achieved much faster. Solar photovoltaics can also be used as an energy source for clean cooking fuel as well as water filtration and sanitation.

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