# IEEE IAS-IPCSD Engineering Student Chapter Design Contest (Africa) 2024.

PROJECT TITLE

## EcoCharge

DESIGN OF A SMART MPPT CHARGE CONTROLLER

**IEEE Section:** Zambia Section.

**Team Lead:** Zevyanji C. Nalungwe.

**Team Members:** Kangwa Mukuka; Taonga Mukobeko; Samson Tembo; Waza Banda; Didiana Kalobwe.

**Student Branch Name:** IEEE University of Zambia Student Branch.


BY TEAM

**PhotonPower**

## PROJECT SCOPE

This project proposes an innovative renewable energy power conditioning system. Basically, a Smart MPPT Charge controller divided into three (3) main parts.

Namely, the MPPT design, IoT Keylogging Module Design, Customised Web Server & Cloud Infrastructure.

## PURPOSE

- The motivation behind this project stemmed from the high costs of Commercial Charge Controllers in Zambia.
- The main purpose of the system is to enable the spark of rural electrification in Zambia and Africa at large. Our proposed design emphasizes on its low cost with the hope of reduce cost of rural electrification.

## BACKGROUND

- Based on data from the World Bank in 2021, approximately 84.5% of rural areas still lack access to electricity.
- The creation of the MPPT charge controller marks the initial phase of this project, which is now also aiming to address the ongoing power challenges being faced by the country.

## TEAM DESCRIPTION

[1] **MPPT Charge Controller:** Taonga Mukobeko & Samson Tembo.

[2] **IoT Keylogging Module:** Waza Banda & Zevyanji Nalungwe.

[3] **Web Server:** Kangwa Mukuka & Didiana Kalobwe

## PROBLEM TO BE SOLVED

Many rural farms and farmers struggle to adopt sustainable energy solutions due to the high costs associated with installing solar systems. This hinders the effective utilization of solar and wind power resources. Additionally, the country is currently facing a power deficit due to changing climatic conditions, mainly relying on hydroelectric power. To address these challenges, it is imperative to explore and utilize alternative energy sources to alleviate the situation. Therefore, we have initiated a project to develop localized MPPT charge controllers with prepaid features tailored specifically for small-scale farmers. This initiative aims to enhance accessibility to renewable energy, advocate for sustainable practices, and advance rural electrification efforts.

## DESIGN CRITERIA

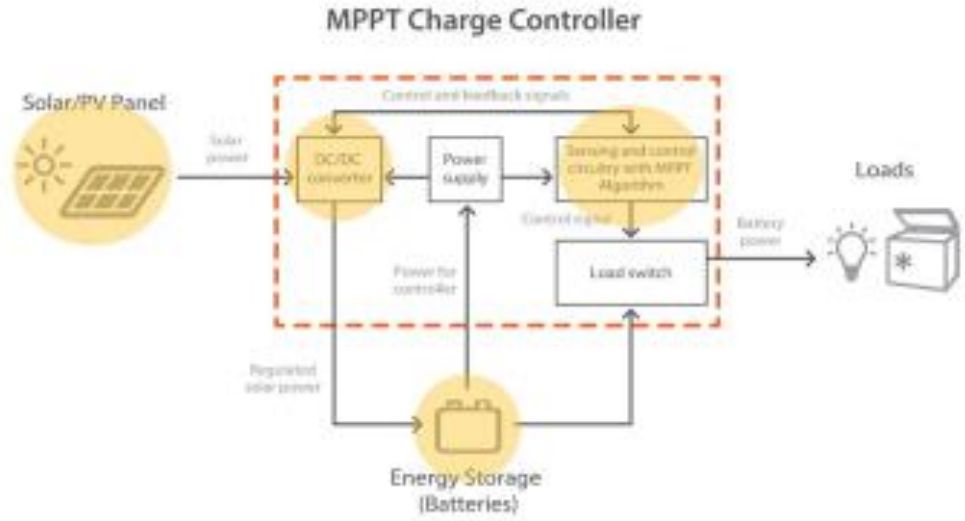
Technologies Used:

- Arduino Uno simulated in Proteus and Programmed in C++
- ESP32 Programmed in C++
- Custom Web Platform with Python, Django (MegaThings)

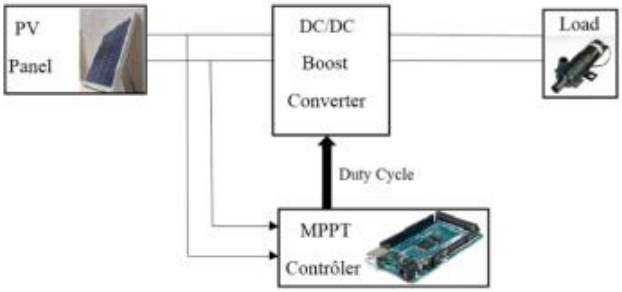
## PROPOSED SOLTION AND WHY IT IS NOVEL

Our design brings together the latest trends from Electrical and Electronic Engineering as well as Computer Science to create a low-cost energy solution for African farms to utilise.

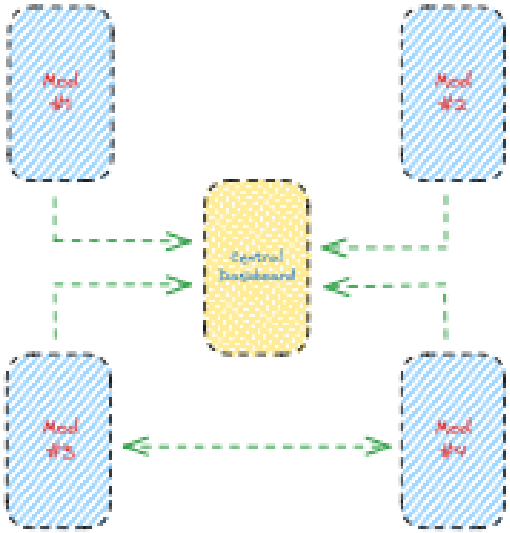
MPPT stands for Maximum Power Point Tracking. A solar panel has different electric output and different maximum efficiency levels. The efficiency depends on numerous factors, such as the time of day, cloud cover, and temperature of the panels. The MPPT identifies the point at which your system gets maximum efficiency. The MPPT solar charge controller is a DC-to-DC converter for your solar power system. It receives voltage from the solar panels and converts it to charge your battery at a more appropriate level. The optimization helps you avoid losing some energy your system captures and generates, maximizing what you can store and use.



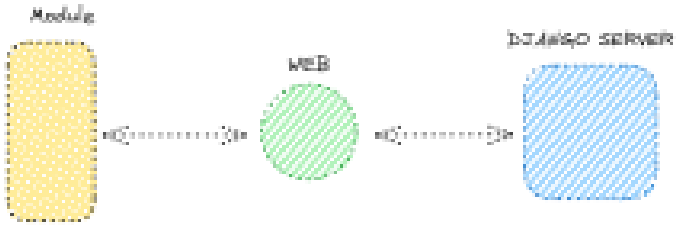

Currently, the most advanced solar charge controllers are those employing MPPT technology. While these controllers come at a higher cost than Pulse Width Modulation (PWM) charge controllers, they offer numerous benefits. MPPT controllers excel in maximizing the power harvested from solar panels to charge batteries, even in cloudy conditions. They are designed to extract the utmost available power from solar panels efficiently. The goal was to create a charge controller equipped with prepaid functionalities that could be utilized on farmer, with the potential to expand to rural areas for solar/wind power systems.



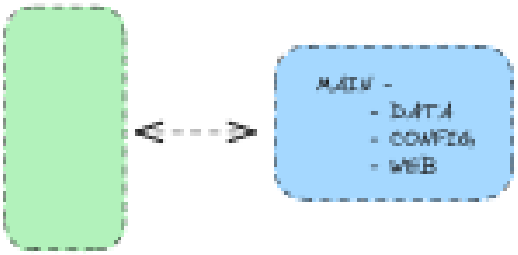

The IOT monitoring and automation system is intended to provide a streamlined and effective way of managing multiple ESP32 based devices with different functionality. This system aims to utilize existing Wi-Fi infrastructure on whatever site it is intended to be used or utilize ESP NOW to handle communication between the different modules and provide a centralized portal to observe each module.



They will also utilize a custom server written in the Django web framework to handle communications outside the network from any remote location. This will use web sockets to allow for Realtime communication between the server and the esp32 when sending data from the server to the esp32. When the esp32 is talking to the server it only sends data in set intervals based on how the device is configured at the moment as well as the data source (For instance since weather conditions don't drastically change every 30 seconds. Having a module send data out every 30 minutes to an hour would be way less task intensive and allow us to put the esp32 to sleep to save on a bit of power).



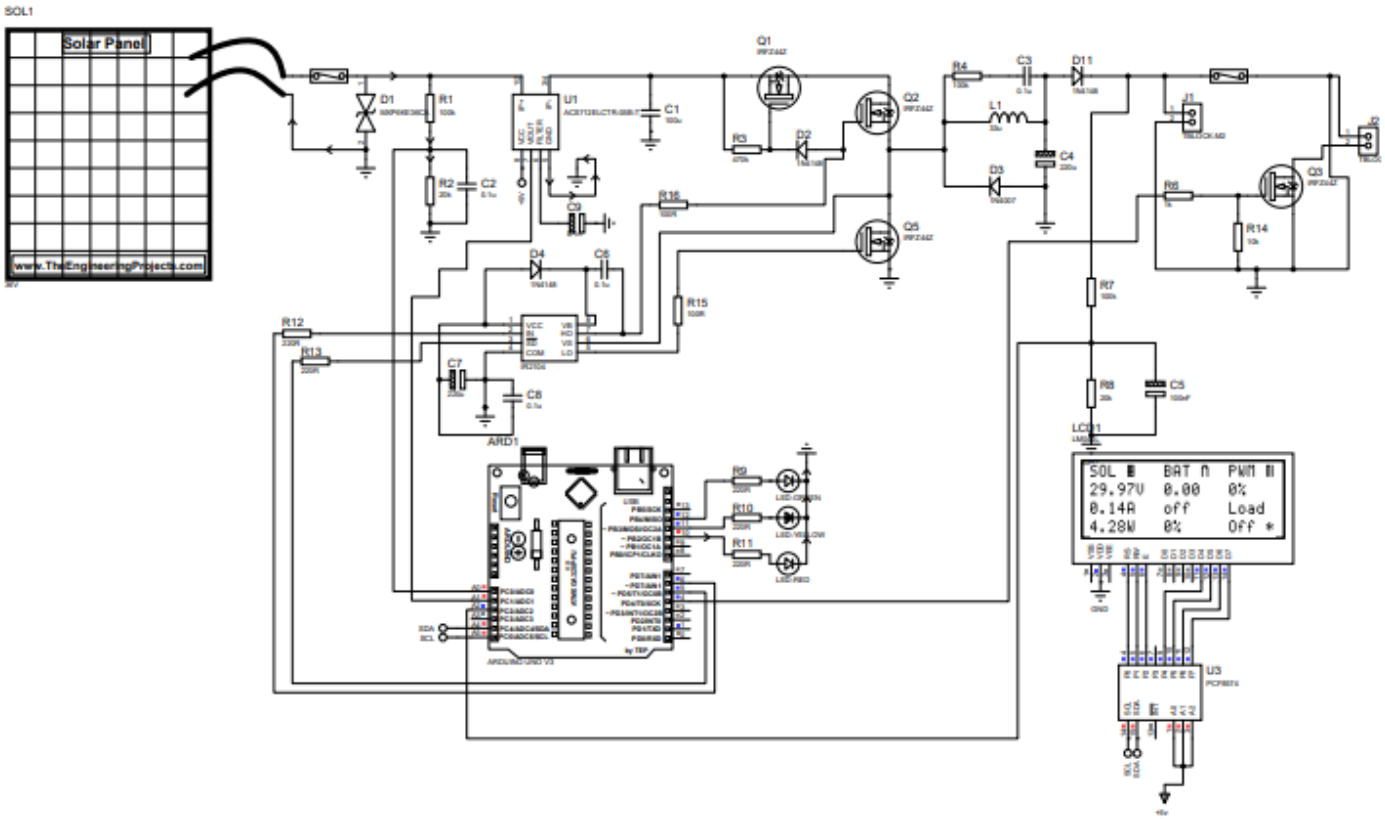
Every module on the network will also require a data storage extension not just for storing configurations and its Webserver files but also if it is used to log data then said data will need to be locally cached and or recorded at a higher resolution locally, that way if there is a network disconnect from the internet the system will still maintain any data recorded and can easily bulk upload any data that wasn't uploaded during down time.



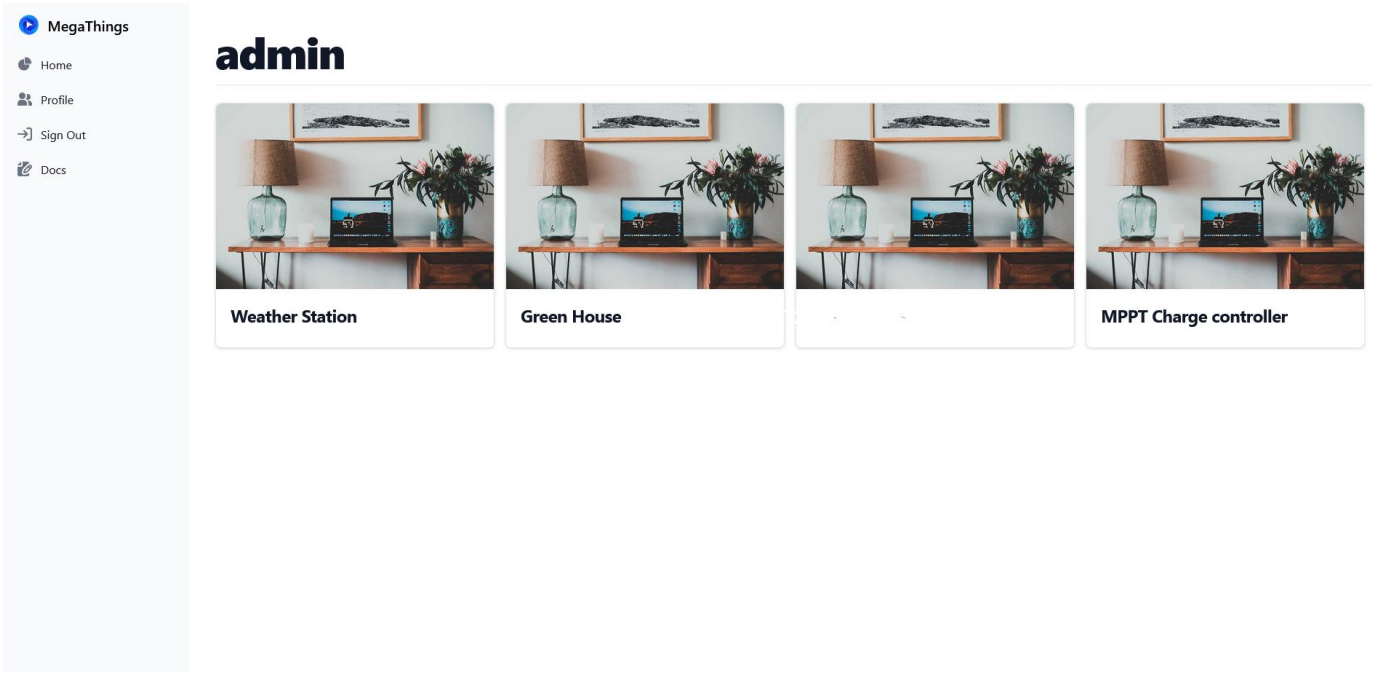
So on our farm we intend to produce most of our own electricity to insure enough machinery can operate effectively. The power monitoring module should allow us to monitor power usage from different connected services and also allow us to control which connections receive power and also set priority in case of low power to allow only essentials should be active.

## MODELLING AND SIMULATED RESULTS/FUNCTIONALITY OF PROPOSED SOLUTION

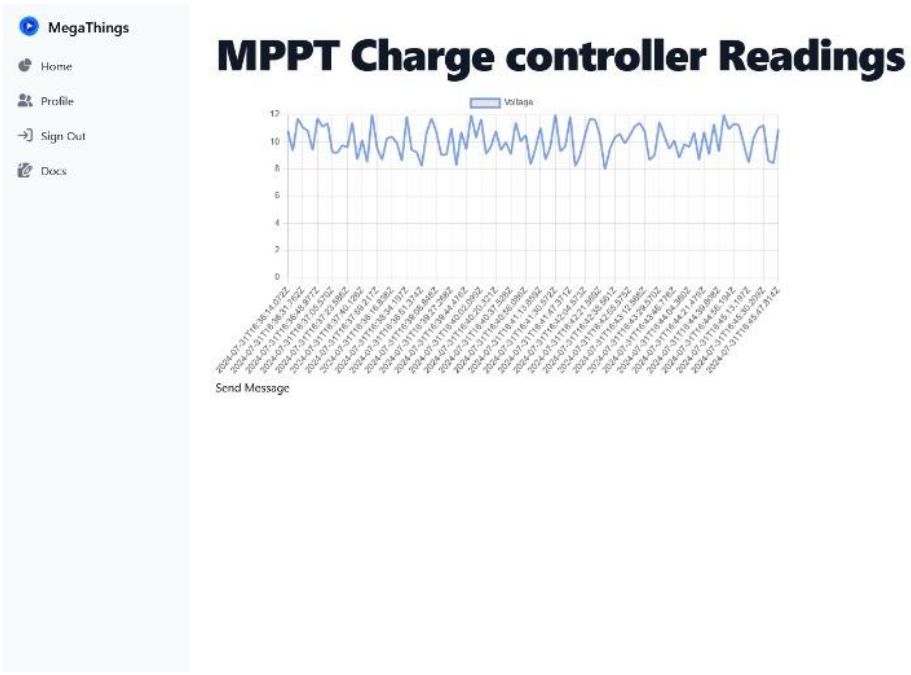
Simulation of the MPPT design in the Proteus Design Tool:



User Dashboard of the Custom-made Server given the name of “MegaThings”.



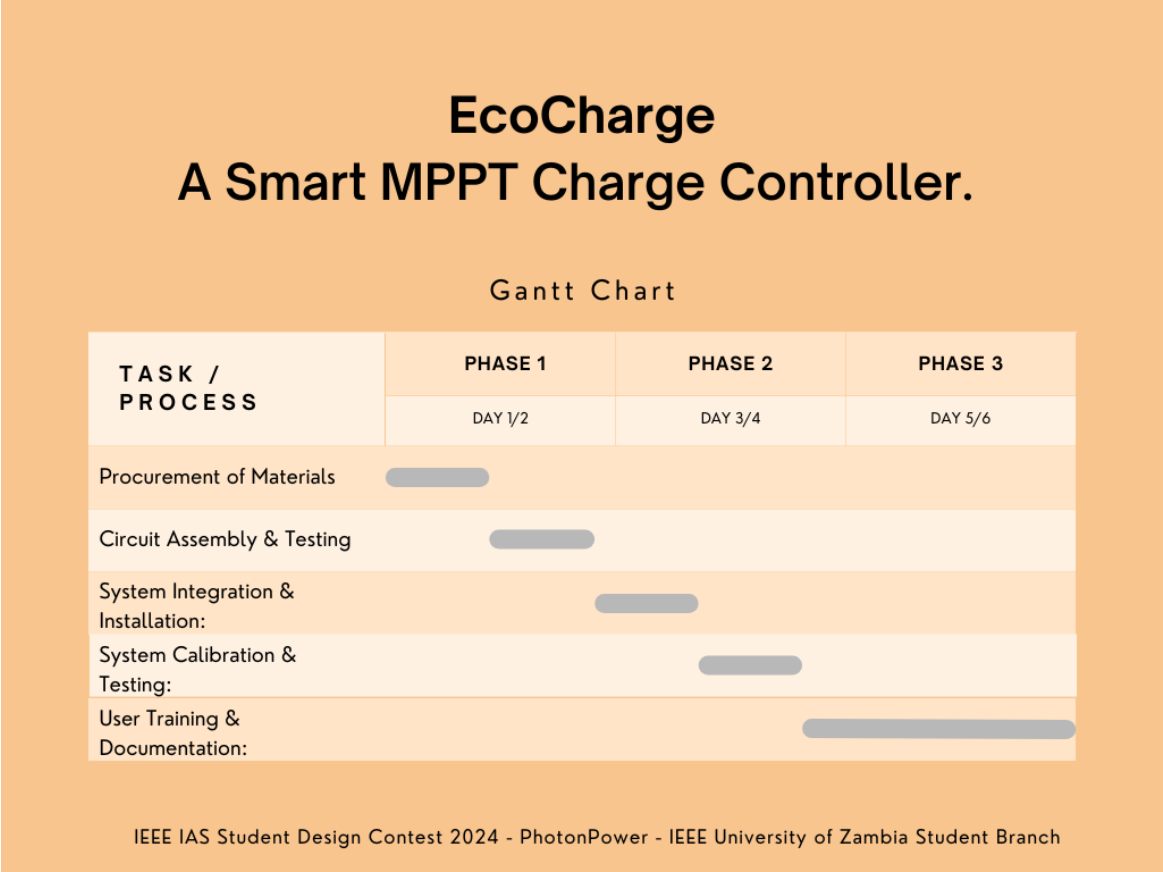

Real-time data analytics of the dedicated Web-sever.



## DESCRIPTION OF DESIGN AND PROPOSED PLAN FOR THE CONSTRUCTION OF A PROTOTYPE

As shown in the video, given that the system comprises of three parts. The IoT Keylogging module and the Web-Server have already been built physically and have been prototyped. However, the MPPT Charge Controller was simulated in proteus and requires a physical construction.

A summary of the proposed construction of the MPPT charge controller is shown below:




According to the Gantt Chart above, it should take about a week to implement a prototype of the proposed solution.

## IMPACT INLINE WITH THE UN SDGs

This project falls inline with SDG 7 and 13 respectively. Which are “Affordable and Clean Energy” and “Climate Action”.

The Impact can be further illustrated by the infographics below:

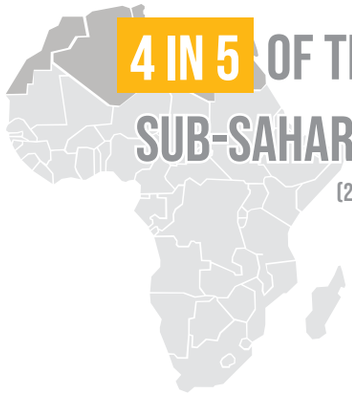
7 AFFORDABLE AND CLEAN ENERGY

# ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

## LIGHTS OUT:

**675 MILLION PEOPLE**

STILL LIVE IN THE DARK



**4 IN 5** OF THEM ARE IN SUB-SAHARAN AFRICA

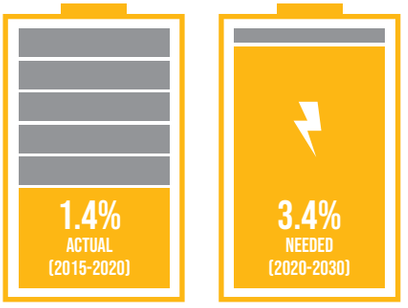
(2021)

IF CURRENT TRENDS CONTINUE,

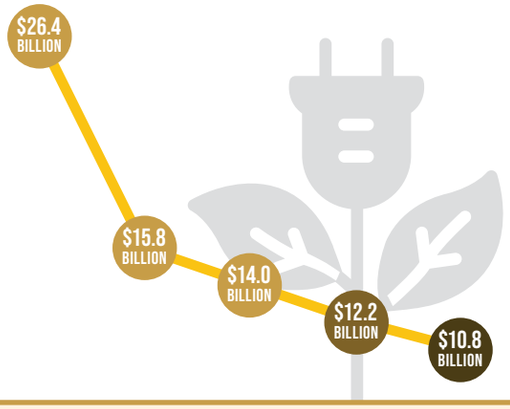
**1 IN 4 PEOPLE WILL STILL USE UNSAFE AND INEFFICIENT COOKING SYSTEMS BY 2030**

## ENERGY EFFICIENCY IMPROVEMENT MUST MORE THAN DOUBLE ITS PACE

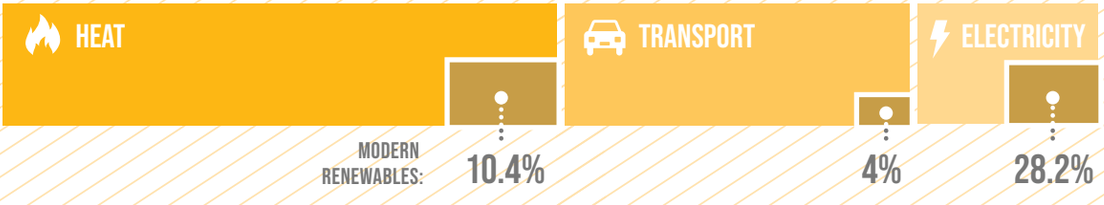
ANNUAL ENERGY-INTENSITY IMPROVEMENT RATE




## INTERNATIONAL PUBLIC FINANCING FOR CLEAN ENERGY FOR DEVELOPING COUNTRIES CONTINUES TO DECLINE




## MODERN RENEWABLES POWER NEARLY 30% OF ELECTRICITY, BUT REMAIN LOW IN HEATING AND TRANSPORT (2020)

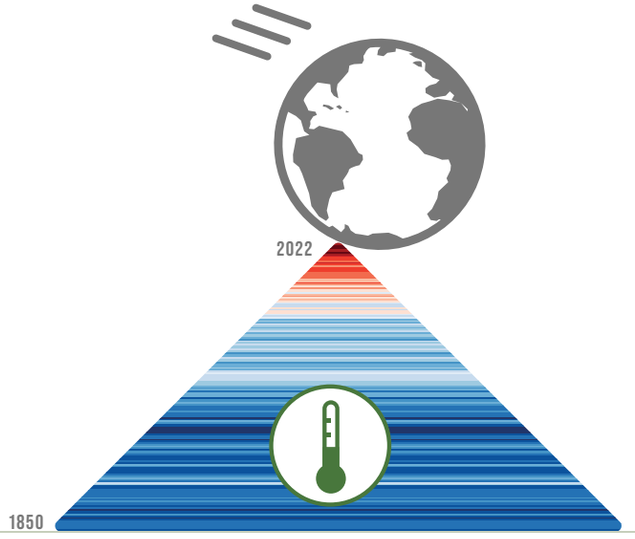


13 CLIMATE ACTION

# TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS

## EARTH'S TIPPING POINT

### STANDING AT THE BRINK OF CLIMATE CALAMITY




**WHERE WE ARE**

THE WORLD WILL EXCEED 1.5°C BY 2035 AND FACES A 2.5°C WARMING BY 2100

**WHAT WE NEED**

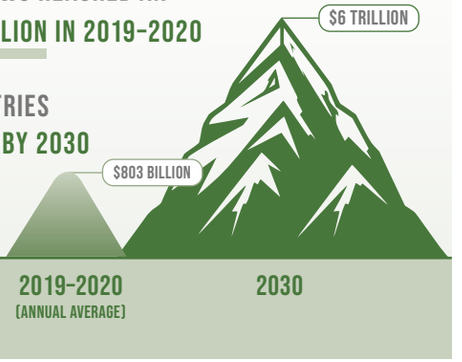
$CO_2$

DEEP, RAPID AND SUSTAINED GHG EMISSION REDUCTIONS BY 43% BY 2030 AND TO NET ZERO BY 2050

**BILLIONS TO TRILLIONS:**

GLOBAL CLIMATE FINANCE FLOWS REACHED AN ANNUAL AVERAGE OF $803 BILLION IN 2019-2020

HOWEVER, DEVELOPING COUNTRIES REQUIRE NEARLY $6 TRILLION BY 2030




THE RATE OF SEA-LEVEL RISE HAS **DOUBLED** IN THE LAST DECADE

**HIGHLY VULNERABLE REGIONS**

EXPERIENCE **15X HIGHER MORTALITY RATES** FROM DISASTERS

COMPARED TO VERY LOW VULNERABILITY REGIONS (2010-2020)