ALTITUDE'S IMPACT ON PHOTOVOLTAIC EFFICIENCY: AN IOT-ENABLED GEOGRAPHICALLY DISTRIBUTED REMOTE LABORATORY

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Universidad Privada Boliviana (UPB)

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Trujillo
Porto Velho
STATE OF ACRE
Brazil
Peru
Lima
STATE OF RONDÔNIA
STATE OF MATO GROSSO
Cusco
Cuiabá
Arequipa
Goiânia
STATE OF MATO GROSSO DO SUL
Antofagasta
Paraguay

La Paz

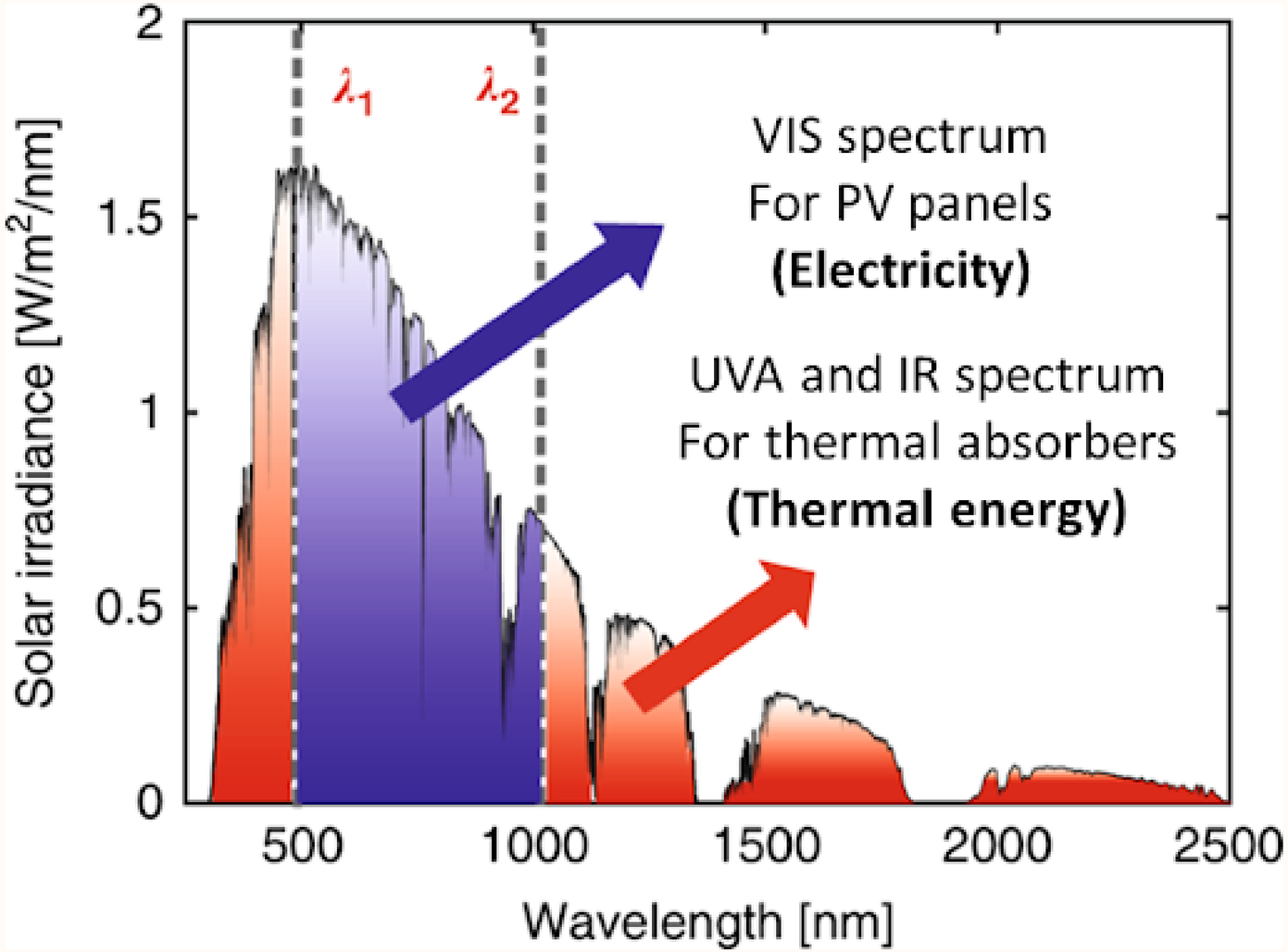
La Paz - Bolivia
3650 m.a.s.l.

Cochabamba - Bolivia
2558 m.a.s.l.

Cochabamba

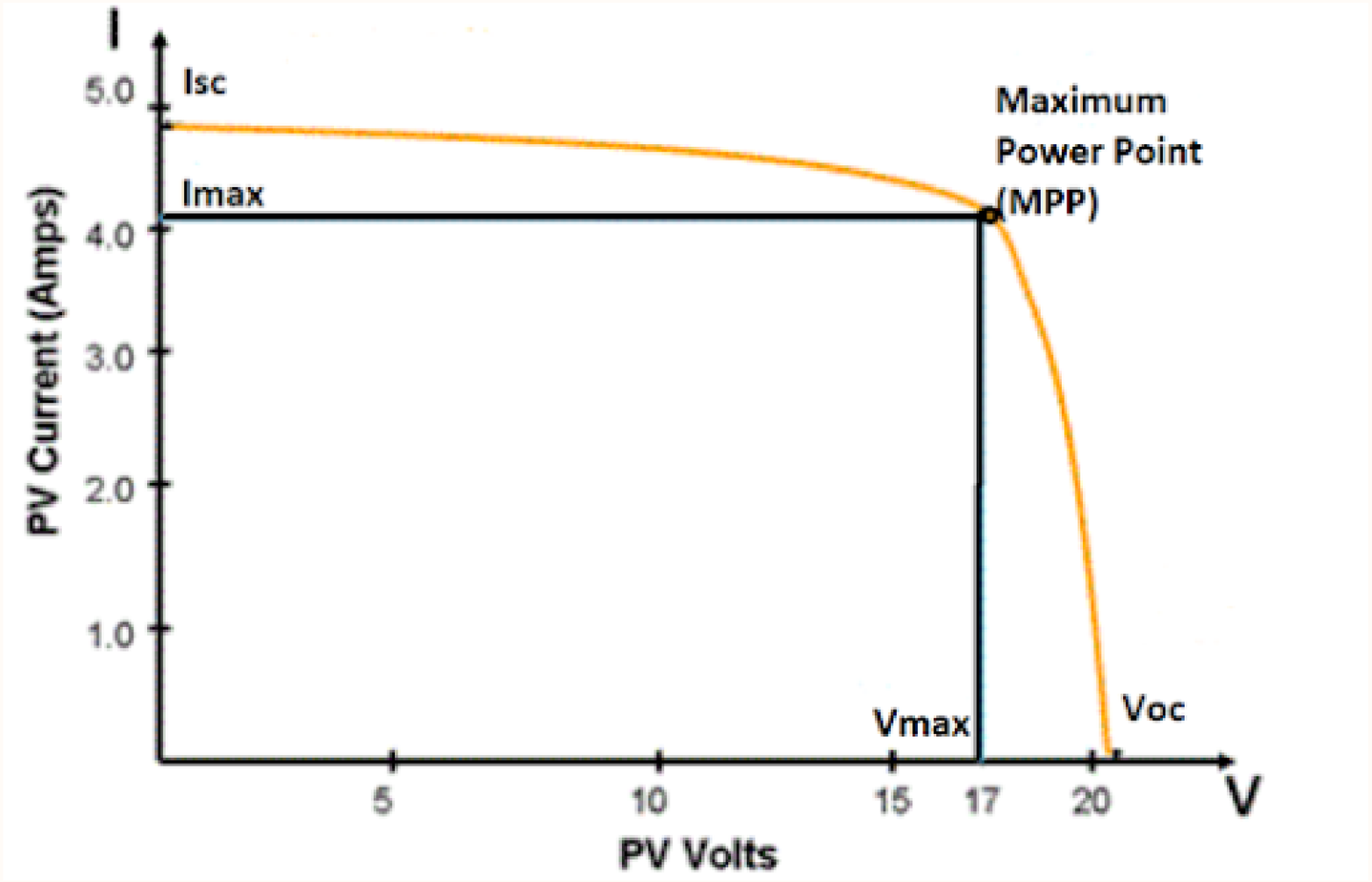
Santa Cruz de la Sierra - Bolivia
400 m.a.s.l.

MEASURING SOLAR RESOURCE



ENERGY EFFICIENCY OF PV PANELS

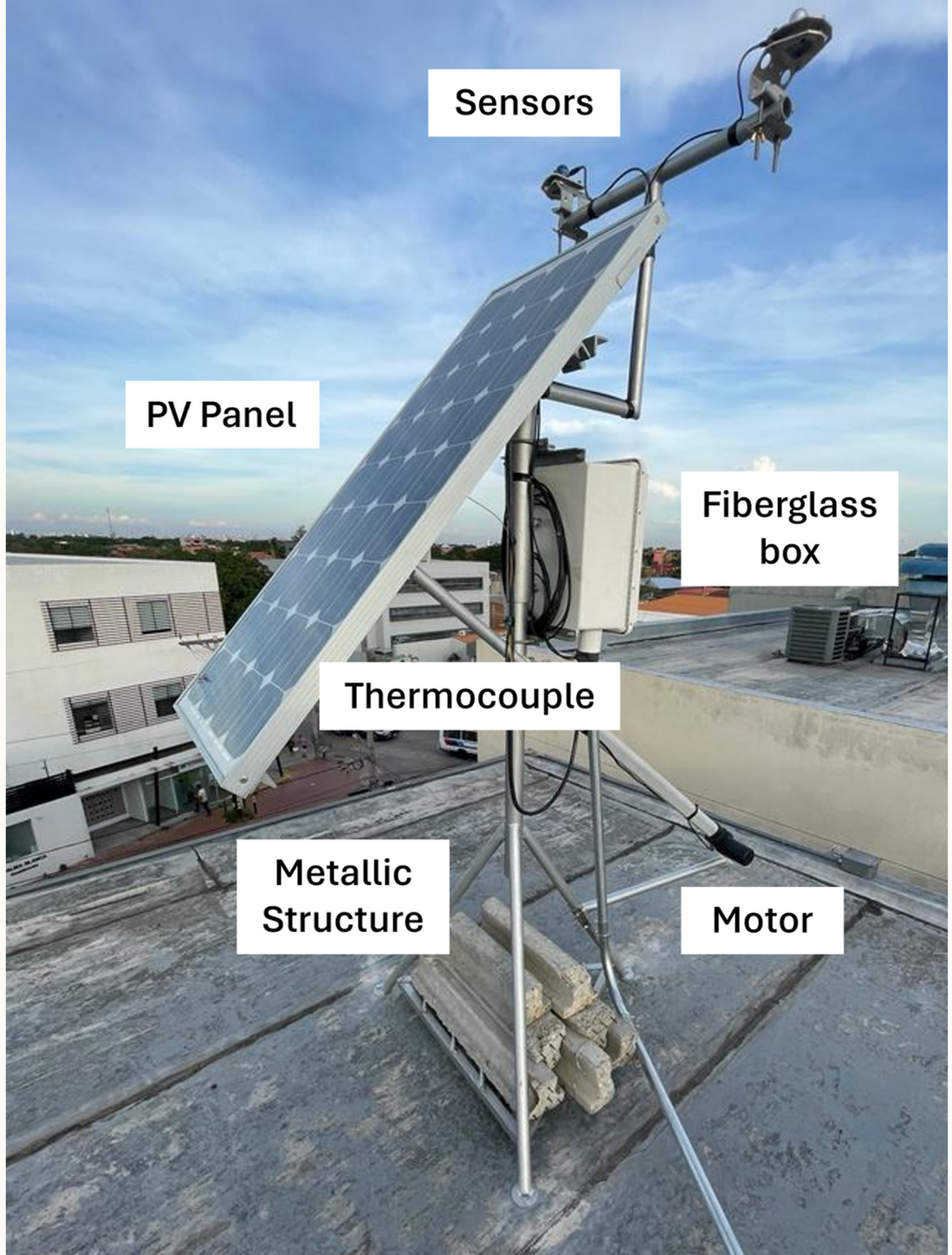
I-V (Current- Voltage) Curves



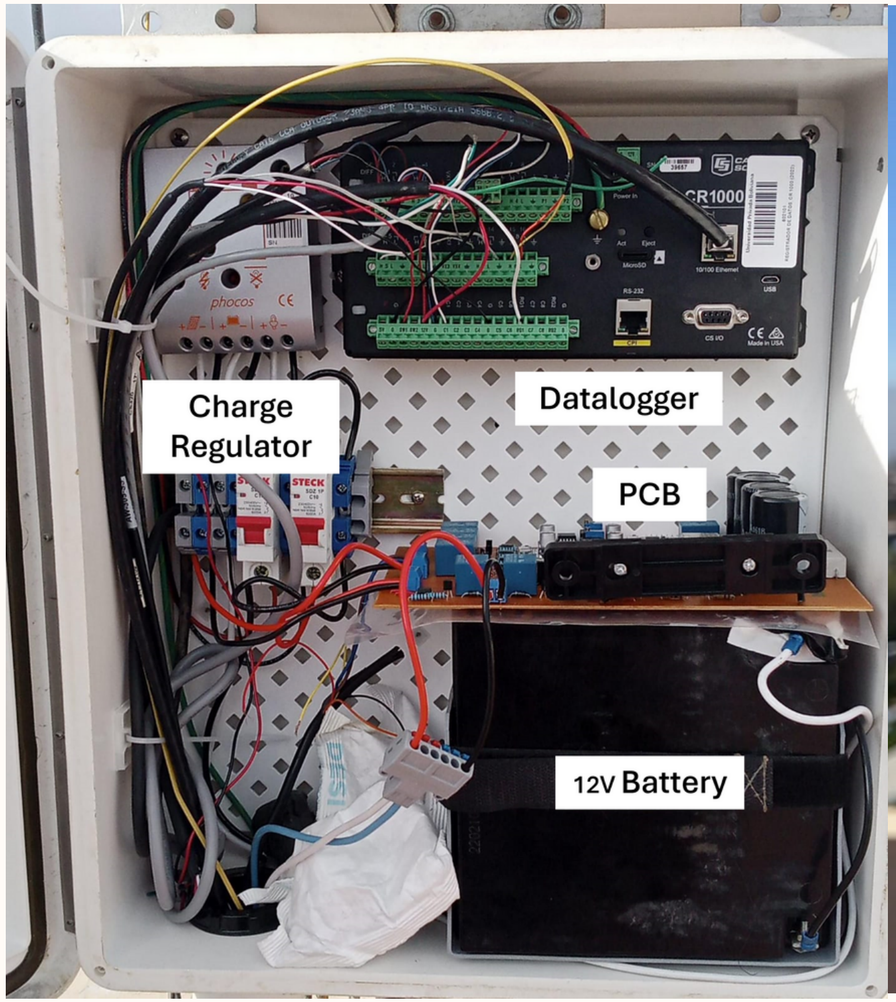
MAIN REQUERIMENTS

- [ ] Design a complete PV Remote Lab Kit (Hardware Components)
- [ ] Replicate the PV Remote Lab kits as exact as possible.
- [ ] Control and monitor real-time status of the kits and make experiments.
- [ ] Develop a user-friendly web platform where users can put in practice theoretical knowledge.

HARDWARE (KITS)



HARDWARE (KITS)

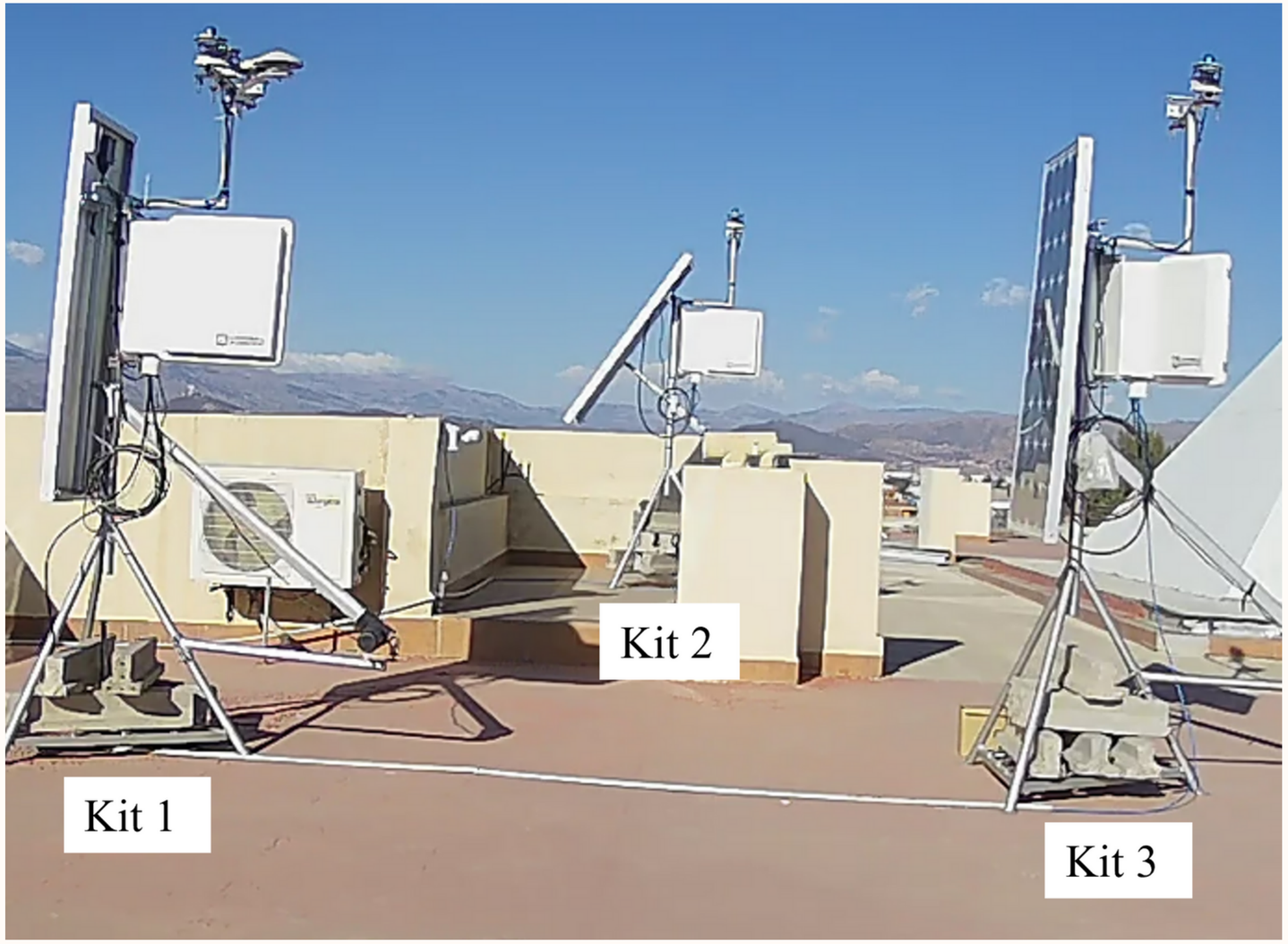


Inside of the Fiberglass Box

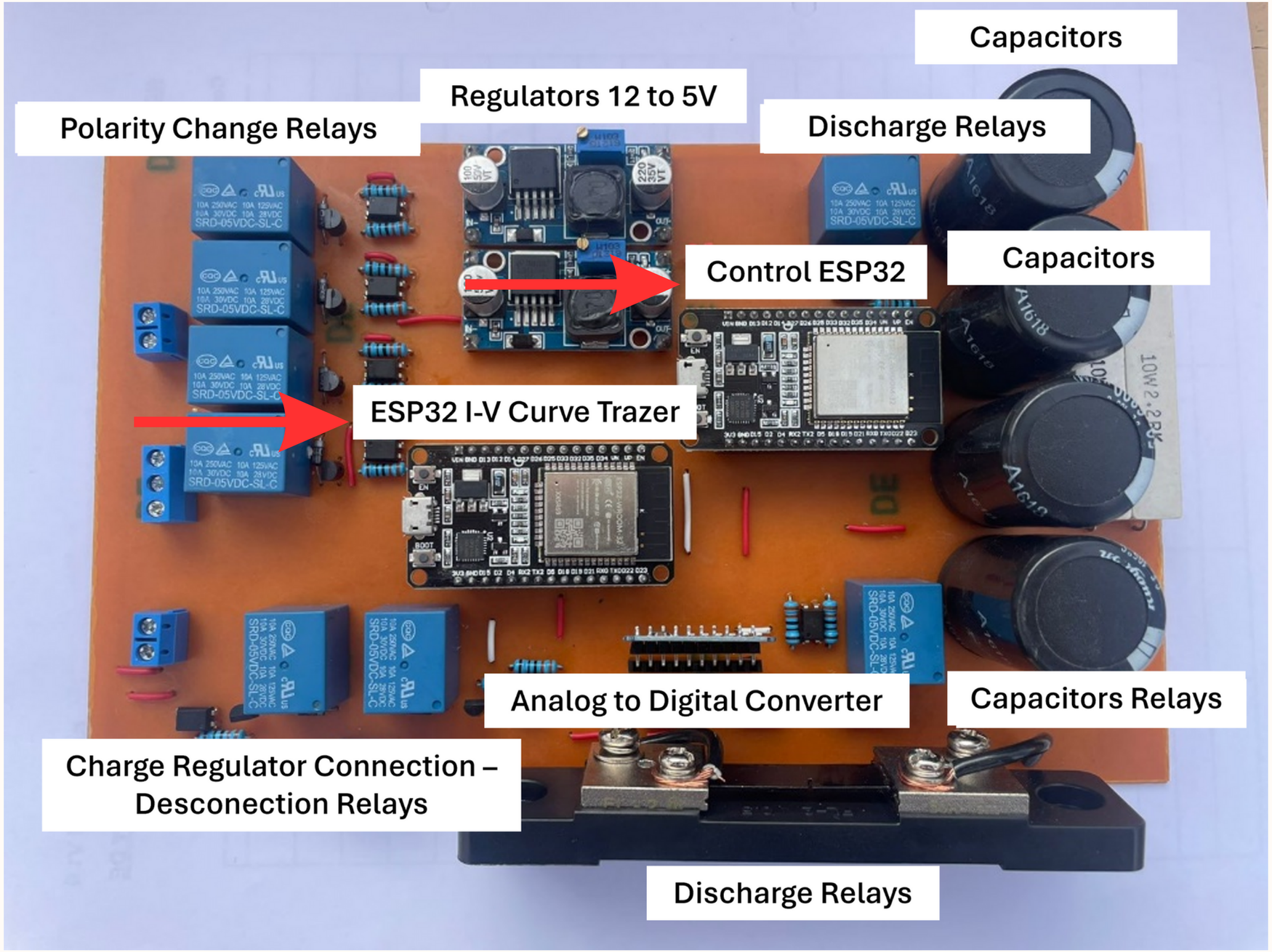
Sensor CS320

Sensor SU-200

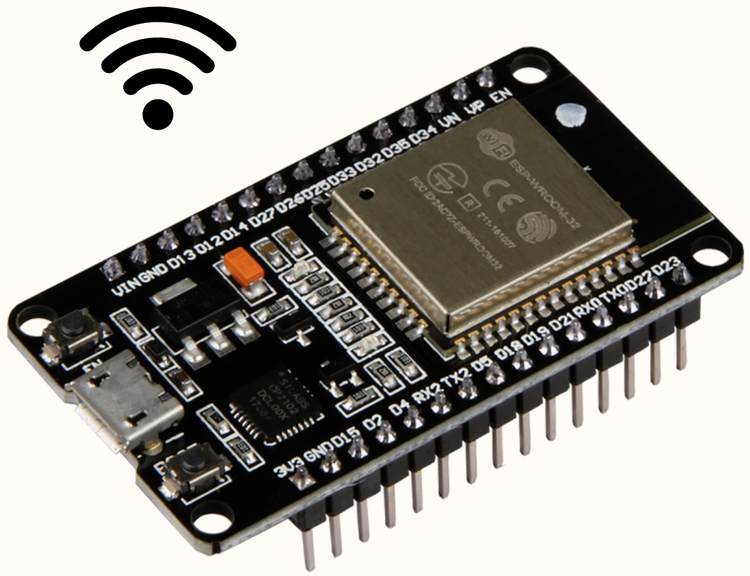
KITS ASSEMBLY



PCB


Capacitors
Regulators 12 to 5V
Polarity Change Relays
Discharge Relays
Control ESP32
Capacitors
ESP32 I-V Curve Trazer
Analog to Digital Converter
Capacitors Relays
Charge Regulator Connection – Desconection Relays
Discharge Relays

COMMUNICATION INFRASTRUCTURE



MQTT Protocol

MODBUS Protocol

Booking System (Book4RLab)

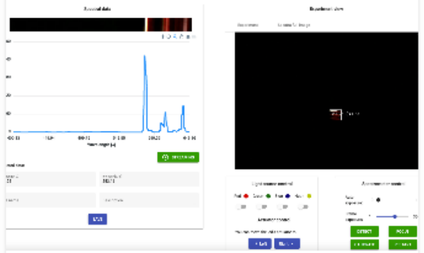
Book4RLab | My Laboratories | New Booking | Public Rooms | My Reservations | Profile | Logout

Welcome

Search for a lab by name and select an available time slot to make a reservation:

Laboratory

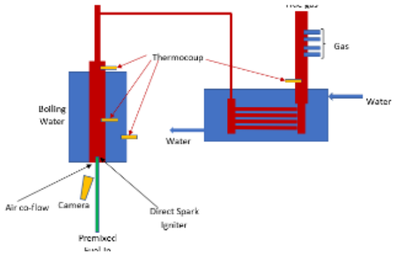
Spectrometry Remote Lab
Universidad Privada Boliviana



Course: Optics
Instructor: Omar Ormachea
Description: Low-cost Spectrometry Remote Lab

NOT AVAILABLE MORE INFO >>

Combustion Remote Laboratory
University of Moratuwa



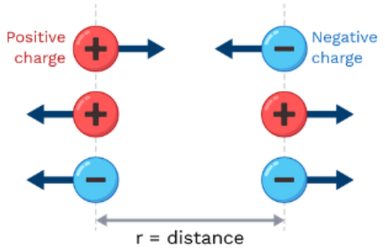
Course: Master of Science in Energy for Circular Economy
Instructor: Mahinsasa Narayana
Description: Combustion is a chemical process between substances, usually including oxygen, and accompanied by the generation of heat and light in the form of flame. This remote lab is focused on the analysis of gas phase fuel

Wind Energy Remote Online Lab
University of Ruhuna

Course: Renewable Energy Technologies
Instructor: Dr. K. Jayawickrama C. Kumara
Description: WEROL and University of Ruhuna funded by EU Erasmus+ EUSL EnergyProject

NOT AVAILABLE MORE INFO >>

Coulomb Lab
Universidad Privada Boliviana



Course: Physics
Instructor: Omar Ormachea
Description: The Coulombs Law remote lab is an interactive online experiment designed to demonstrate and explore the principles of electrostatic force between charged particles.

NOT AVAILABLE MORE INFO >>

Wind Energy
Universidad Central "Marta Abreu" de las Villas, Cuba

Course: How to use the wind energy unit remote lab
Instructor: Leonardo Agustín Hernández Pérez
Description: The Wind Energy Unit, "EEE", contains an aerogenerator, in laboratory-scale, and is used to study the conversion of kinetic wind energy into electrical energy and to study the influence of some factors on this

ONLINE LEARNING MATERIAL (TUTORIAL)

SA301-T01L04CM01 Solar PV Remote Lab Platform Tutorial

Activity 5: Laboratory

This is the Page where you can make the experiments that you want. What can you do?

- Activity 5a: City Selection
- Activity 5b: Live Camera Monitoring
- Activity 5c: PV Panel Movement
- Activity 5d: Start IV-Curve Experiment
- Activity 5e: Hands-On Activities
- Activity 5f: Save Experiment
- Activity 5g: Radiation Data
- Activity 5h: Laboratory Summary Video

ONLINE LEARNING MATERIAL (LEARNING GUIDE)

SA301-T01L04CM02 UPB Solar PV Remote Lab Learning Guide

Activity 4: Optimum Tilt Angle

It is known that the tilt angle of the PV panel, largely determines the received solar irradiance and is the primary factor that governs the power output of the panel. As the position of the sun on the celestial sphere changes during the day and follows a different path each day of the year, it becomes apparent that the determination of an optimal tilt angle is essential for the optimal operation of every PV system.

- Activity 4a: Determination of the Optimum Tilt Angle
- Activity 4b: Summary Video

DEMO

UPB
UNIVERSIDAD PRIVADA BOLIVIANA

Solar Remote Lab

Andres Gamboa Baldi

Cities to Display: Cochabamba La Paz Santa Cruz

Remaining Time: 36:30

Cochabamba

Local Time: 15:23 (America/La_Paz)

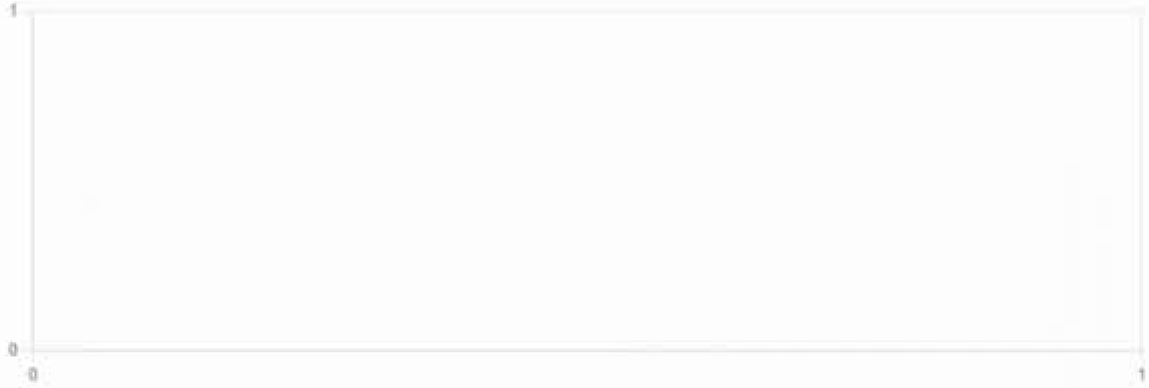
Actual Angle: 9°

Move to:

Sync all Panels

Move

Activity 1 Activity 2 Activity 3



X: Voltage (V)

Y: Current (A)

Start Download

Procedure

Take the IV-Curve and calculate its MPP, then verify your result:

Maximum Power Point: 0 W

Actual Radiation: 898.17 W/m2

Panel Temperature: 41.32 °C

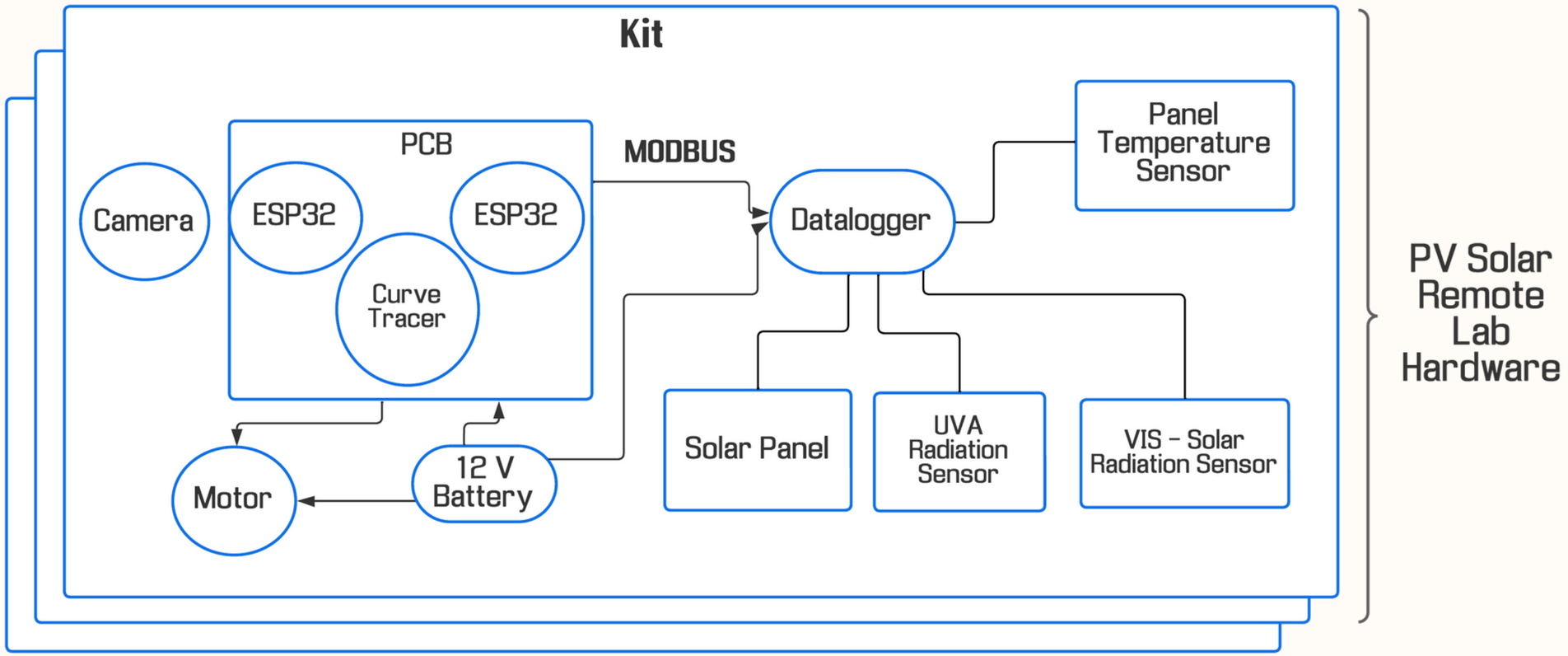
Actual UVA Radiation: 53.48 W/m2

Welcome Back!

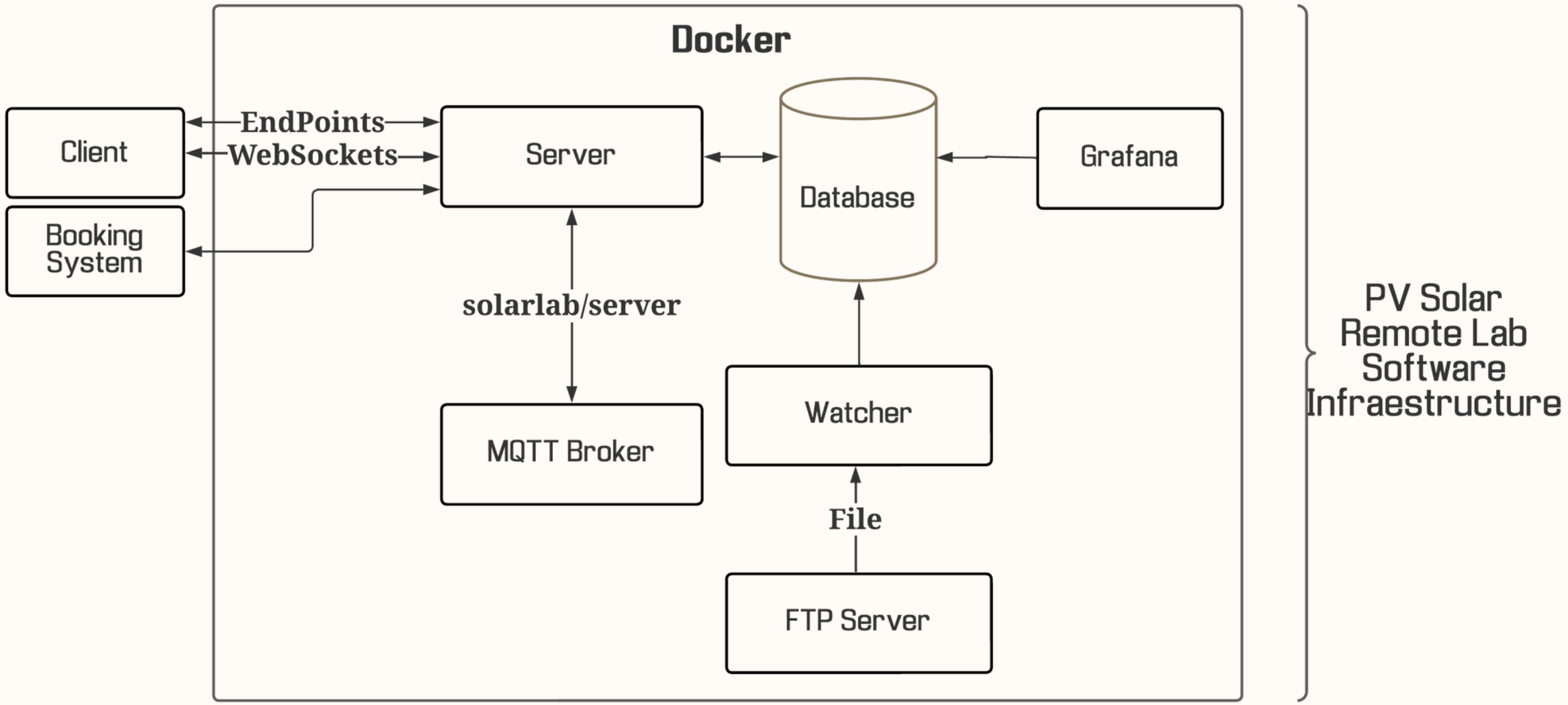
Save Current Experiment

Load Previous Experiments

ARCHITECTURE



ARCHITECTURE




RESULTS

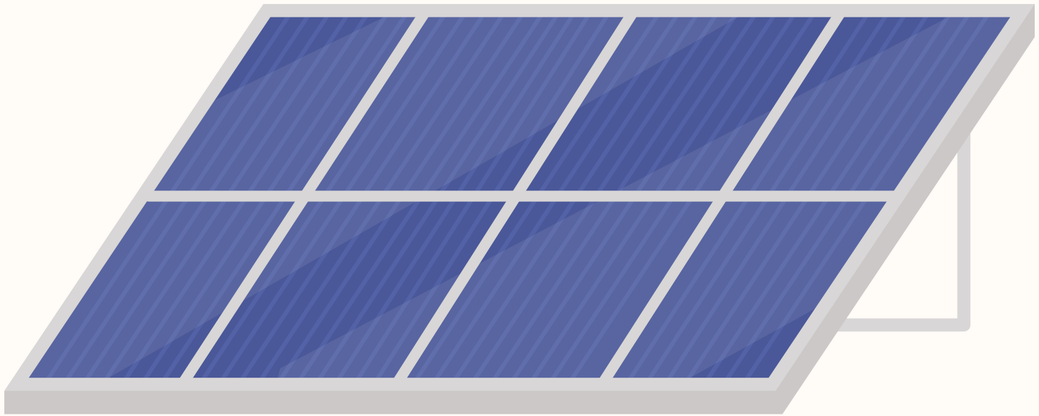
KIT DEPLOYMENT

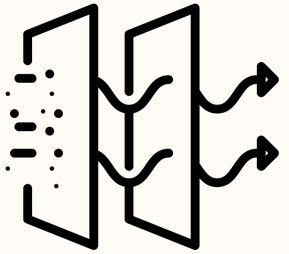
Cochabamba (2658 masl)

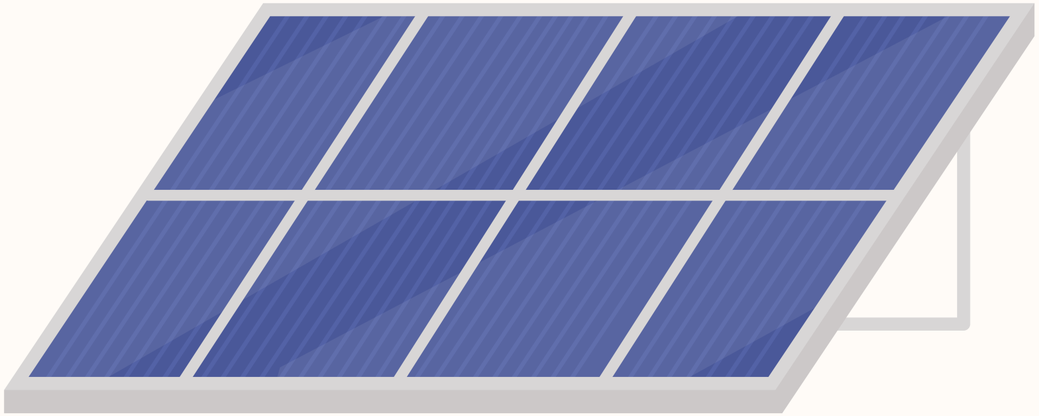
La Paz (3625 masl)

Santa Cruz (400 masl)

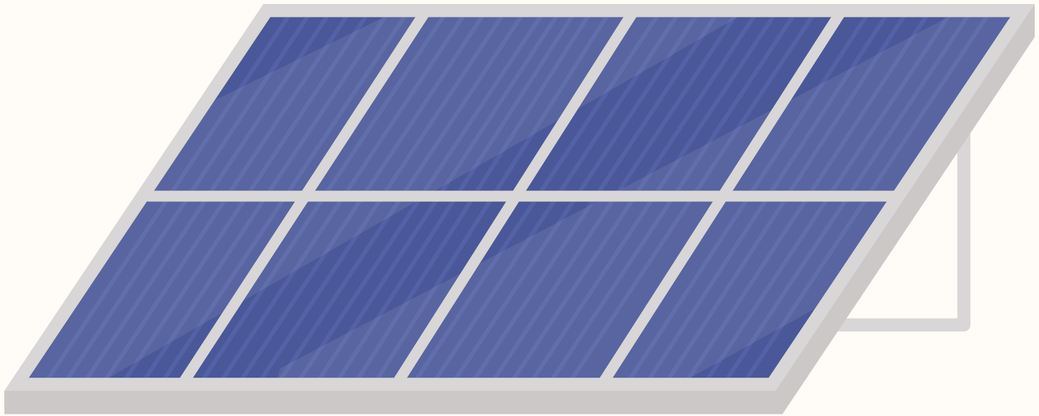
EXPERIMENTAL VALIDATION



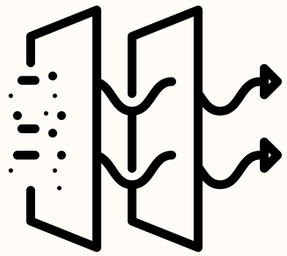


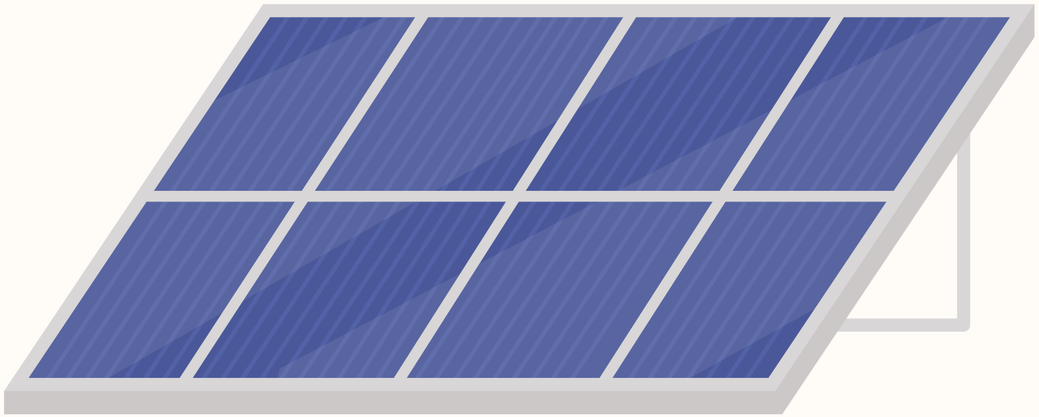


EXPERIMENTAL VALIDATION



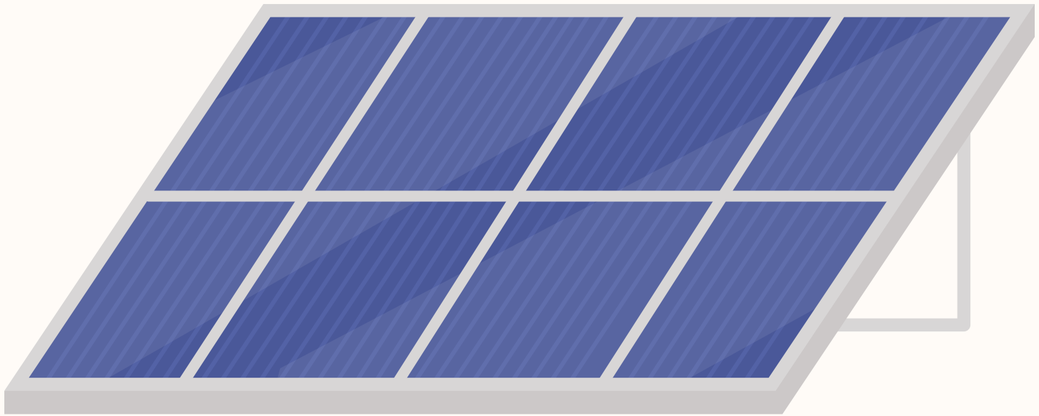
11 %





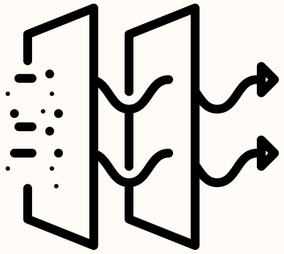
11.8 %

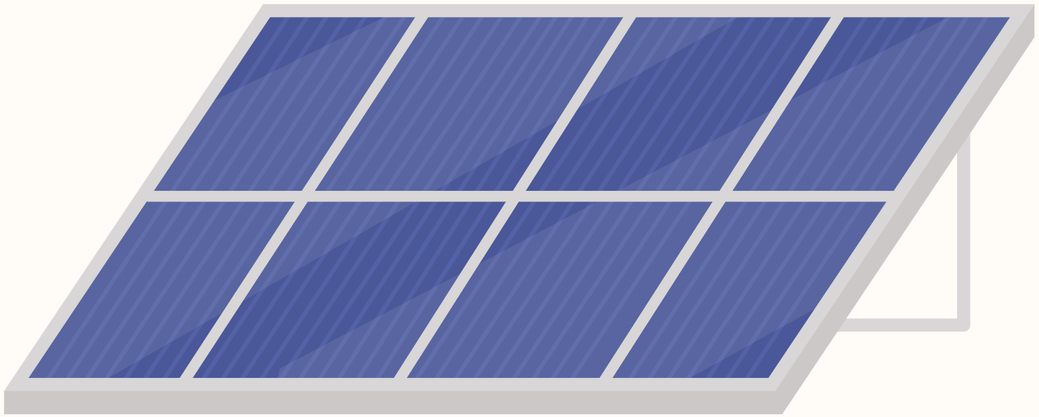
EXPERIMENTAL VALIDATION



11 %

68 °C





11.8 %

63.5 °C

ERASMUS+ PROJECT EUBBC-DIGITAL

CONCLUSIONS

- Fully operational distributed PV Solar Remote Laboratory deployed at **various altitudes**.
- We fill the **gap** between **theory and practice** of PV efficiency with simultaneous measurements at **different real-world conditions**.
- The application of **IoT technology** has been **crucial** for the proposed PV Solar Remote Laboratory, by enabling **real-time data collection**, remote control, and synchronization of experiments.
- The PV Solar Remote Laboratory software and hardware components are available as **open-source in Github**,

THANK YOU
Q&A

Andres Gamboa Baldi