Third International Conference **CONSOLFOOD**2020

Advances in Solar Thermal Food Processing

22-23-24 January 2020

INSTITUTE OF ENGINEERING; UNIVERSITY OF ALGARVE; CAMPUS DA PENHA; FARO-PORTUGAL

PHOTOVOLTAIC SOLAR COOKER WITH NO BATTERIES USING ADVANCED ELECTRONICS

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INTRODUCTION
Why PV?

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Solar cooking:
- No pollution
- No deforestation

But:
- Outdoor cooking is not ideal
- Electrification is coming!

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Design
Main issues

PV panels offer:

- Possibility of transferring electricity to an indoor kitchen.
- Lower efficiency than “thermal” cookers $\sim 15\% \rightarrow$ high efficiency electric cooker.

PV panels need:

- A controller for power maximization.
- Batteries for the functioning of the commercial controllers (expensive and polluting)

Design:

- A controller circuit of high efficiency, low cost, and simple.
- A modified commercial electronic cooking utensil

Implementation
Installation: parts

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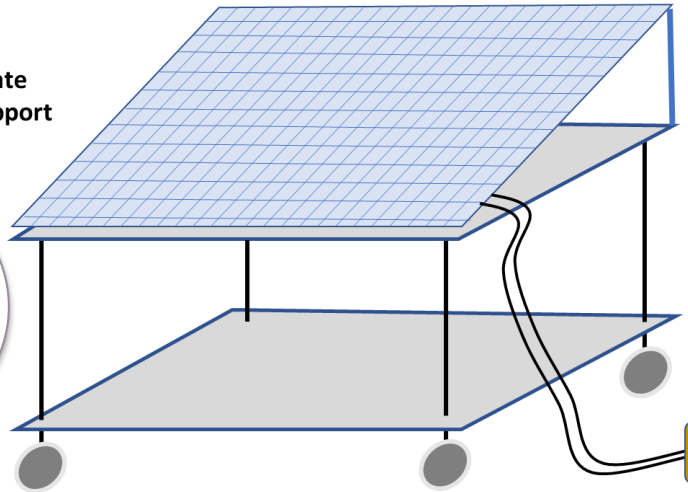
- Cooks food
- Thermal insulation
- Testing with water



Source of electric power needed for operation.

Obtains as much energy as possible from the PV panel without damaging.

Implementation
PV panel with structure

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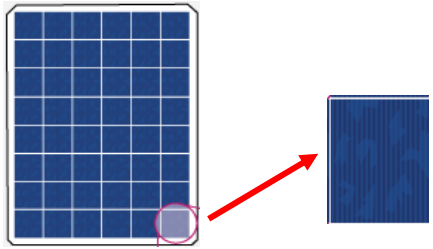
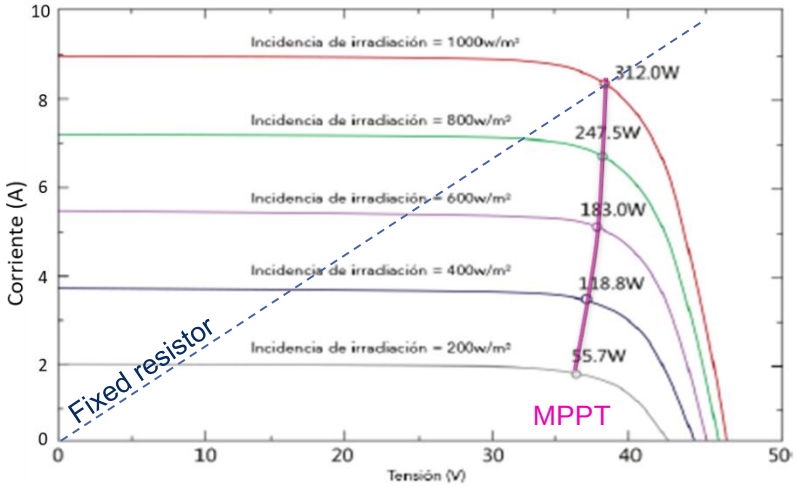
24V 300 W 2 m^2 PV panel

Aluminum Structure





Implementation
Control circuit

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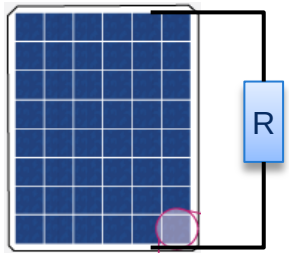
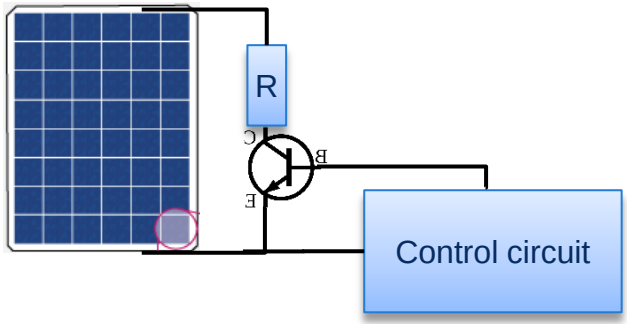
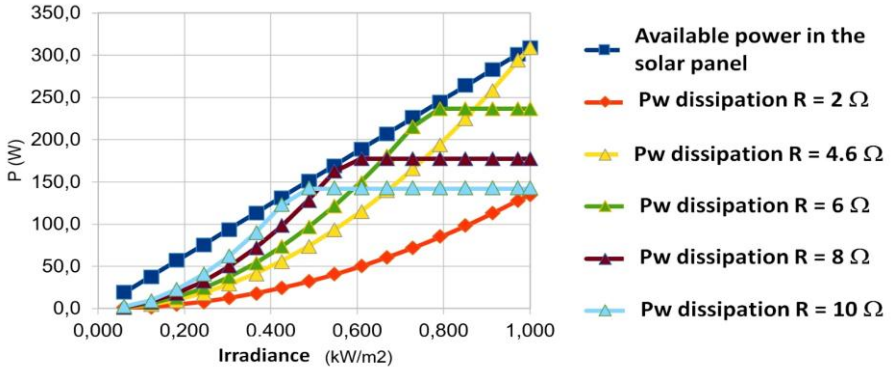
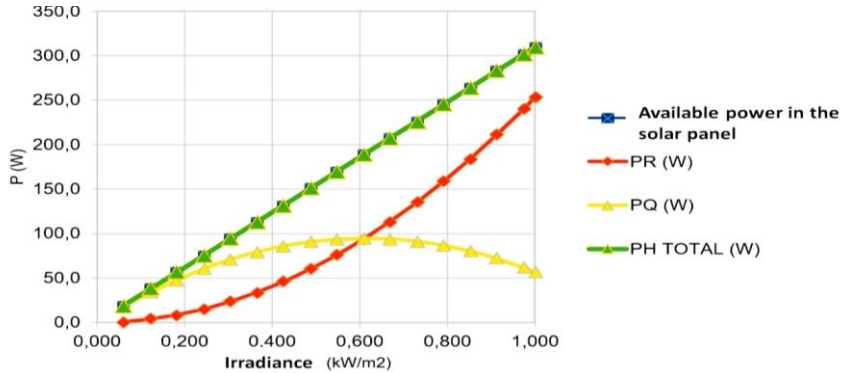
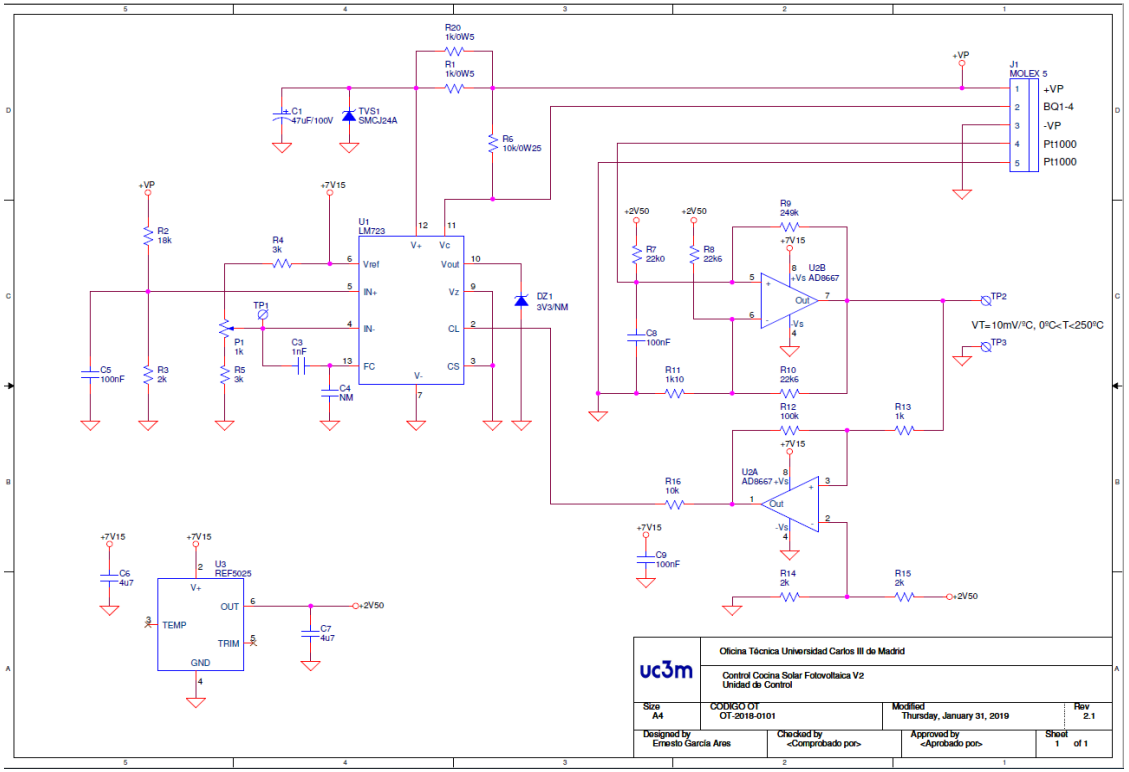


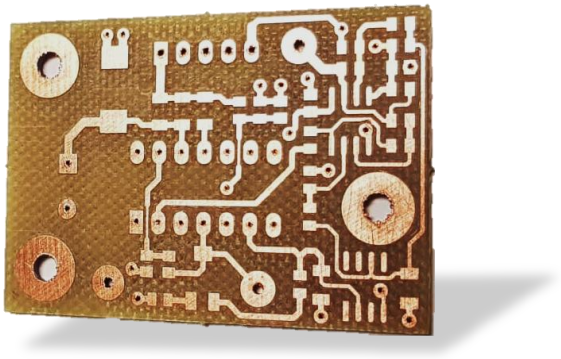


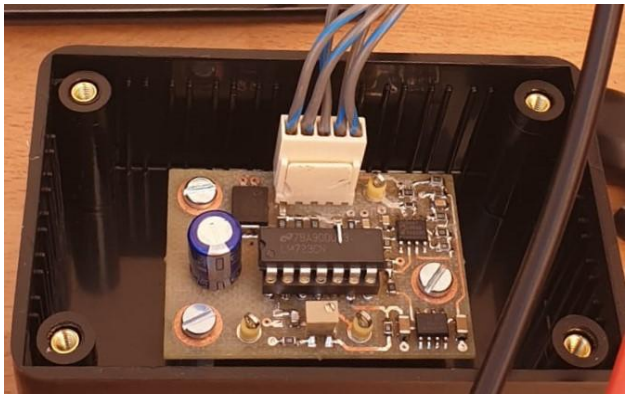




Implementation
Control circuit







Implementation
Cooking pot

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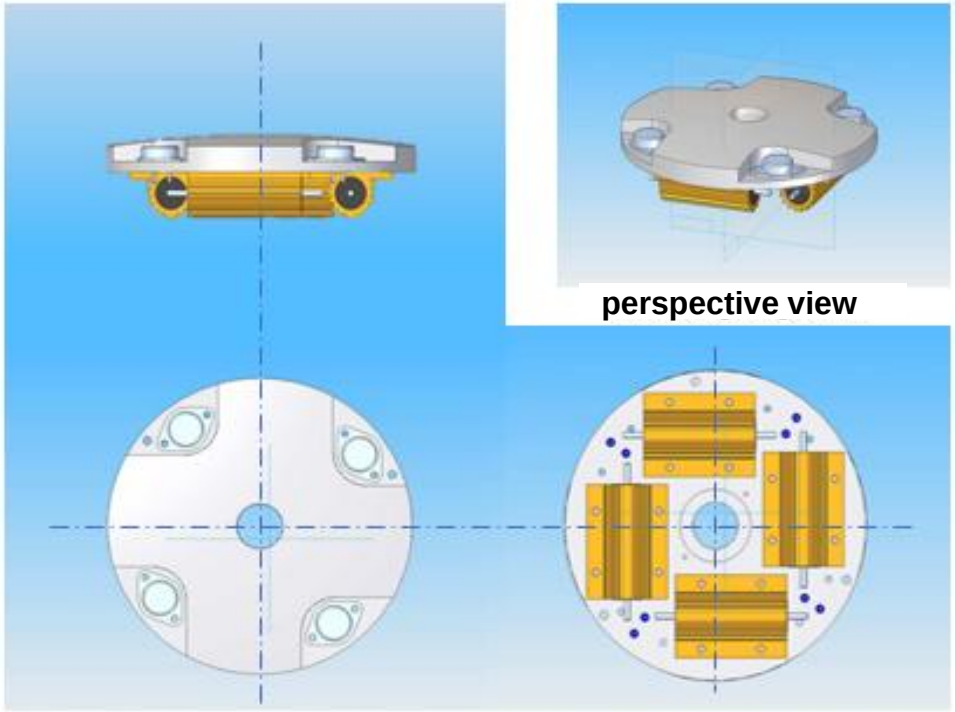
Heating plate

Electronic cooking utensil

Insulation



perspective view

Elevation & plan

y planta

bottom view

rior

Implementation
Cooking pot

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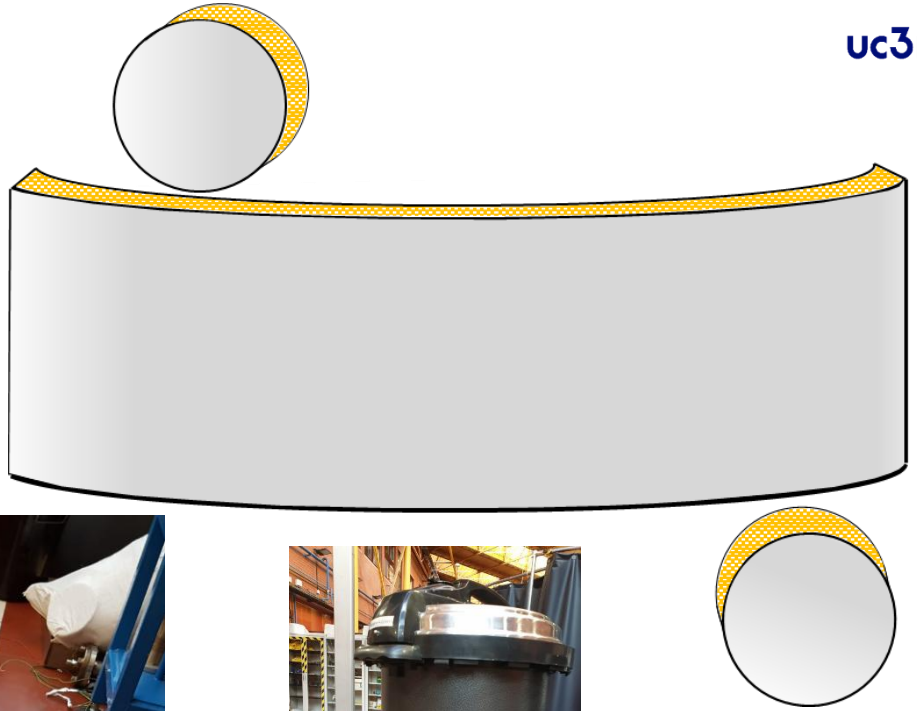
Heating plate

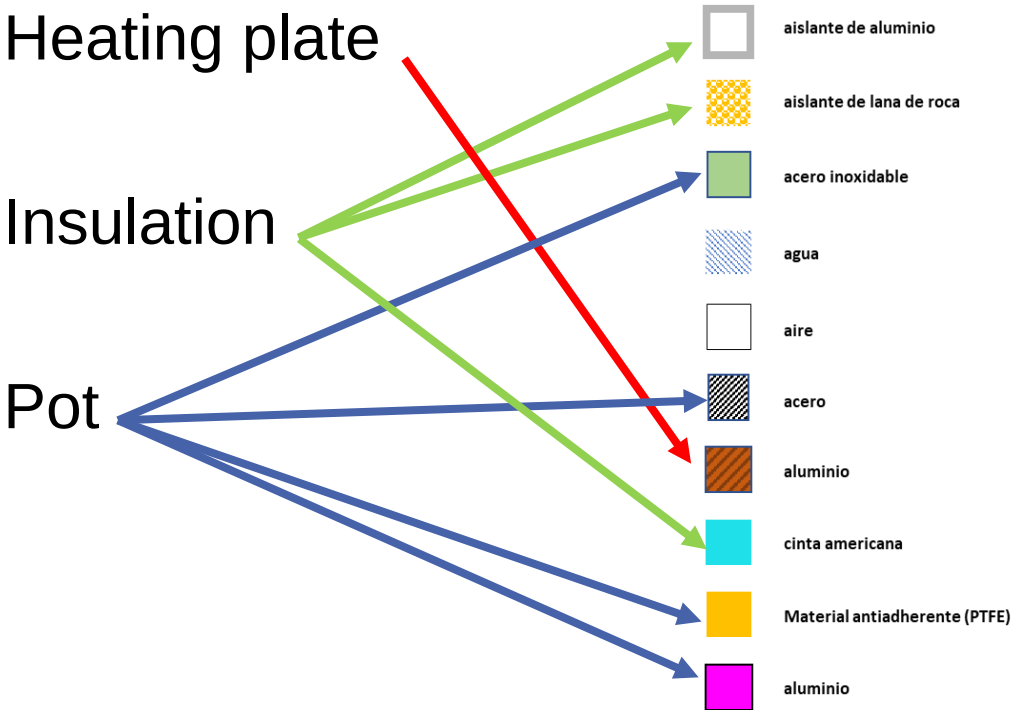
Pot

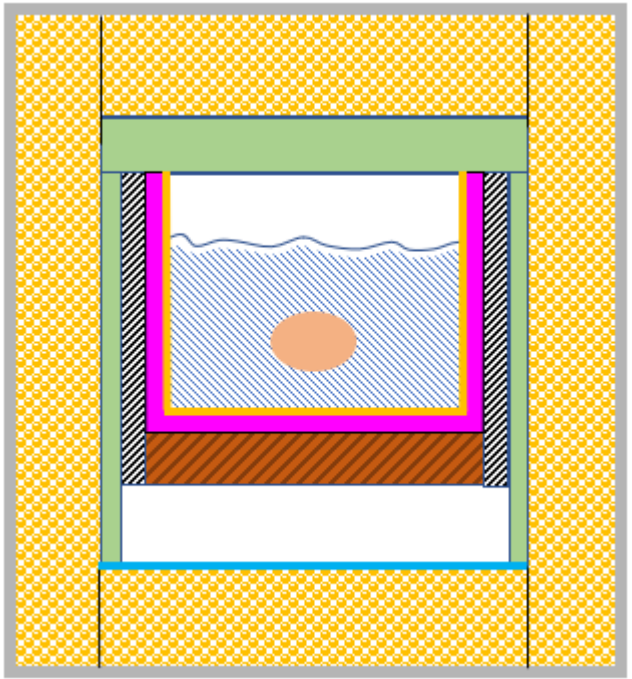
Insulation



Modified electronic cooking utensil without lower and lateral skins

Implementation
Cooking pot





Implementation
Cost estimate

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THEORICAL ESTIMATE	REAL ESTIMATE
432,69 €	300 €

↓ 25% or almost 100€ !!

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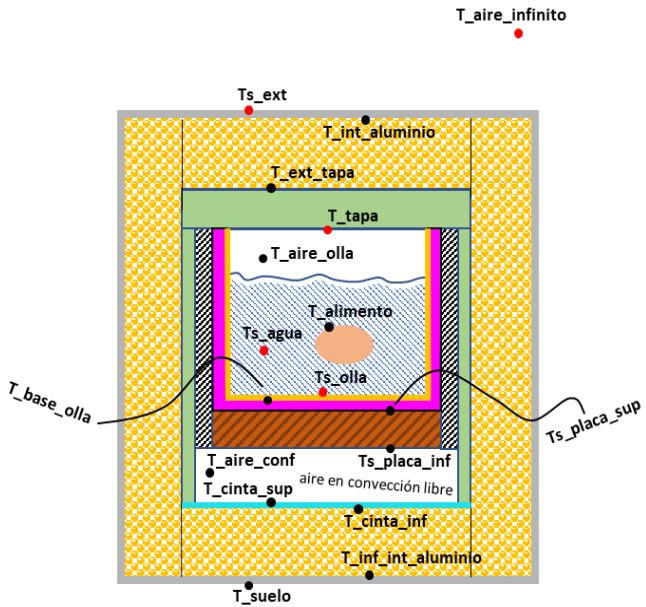
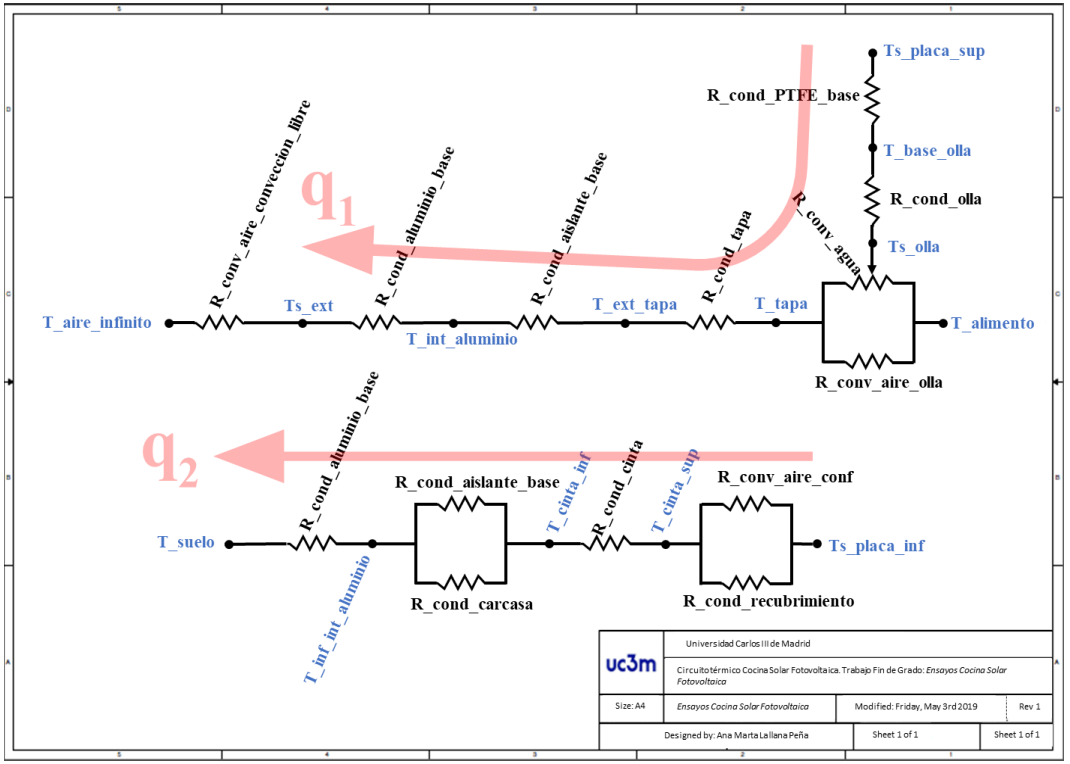
TESTING CAMPAIGN
Theoretical modeling

- Known temperature
- Calculated temperature





TESTING CAMPAIGN
Theoretical calculations

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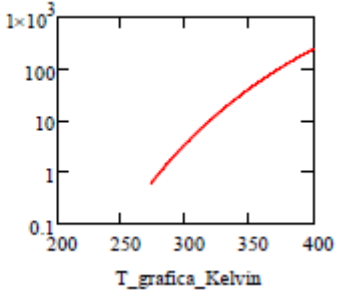
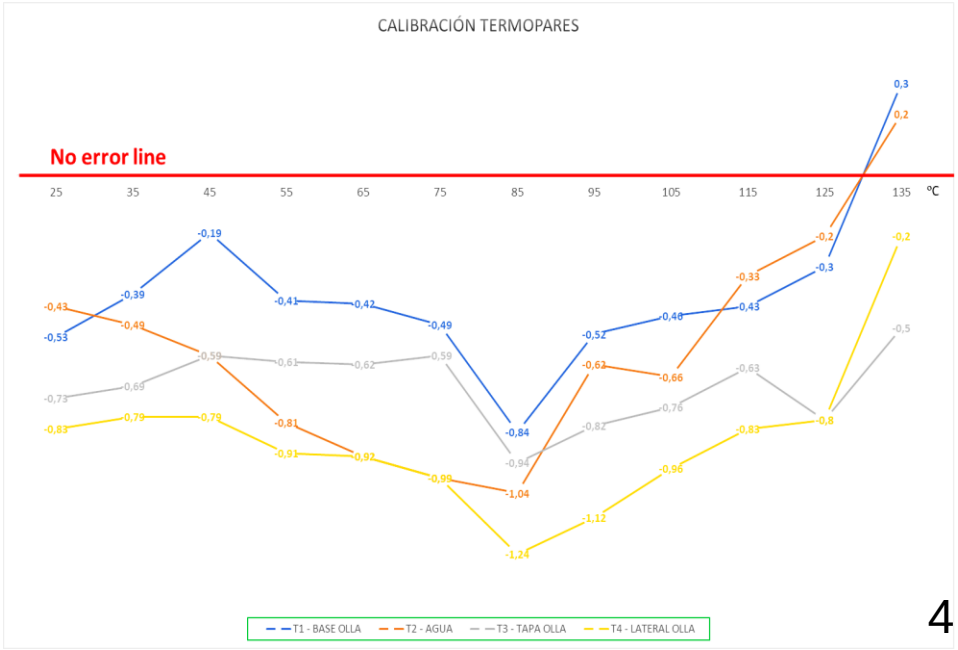
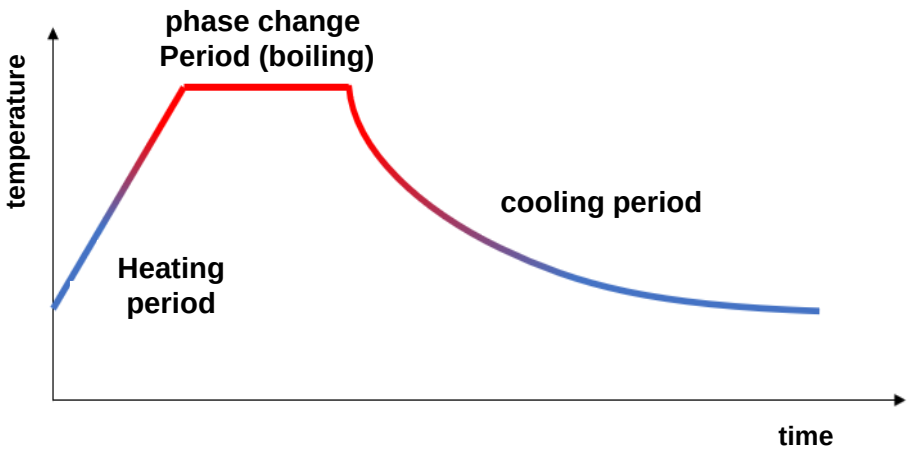
1. Initial data and hypothesis
2. Areas and **R_cond**
3. Antoine's Correlation: **Tsat** in Madrid? → FluidProp("P","Q",1,"T",T_grafica_Kelvin,"water")
4. **R_water_conv**
   - Free convection: *vertical cavities*
   - Phase change: *nucleated boiling*
6. **R_air_conv_Pot**
7. Heat balance in the inferior part
8. **R_conv_infinite**
   - Free convection: *Churchill and Chu*
   - Forced convection: *Hilpert*
9. **T_aluminum_int**: energy balance ← Energy balance: RETAINED heat
10. **R_air_conv_conf**: *free convection in confined volumen with ↓ (H/L)*

$$R = \frac{e}{k}$$



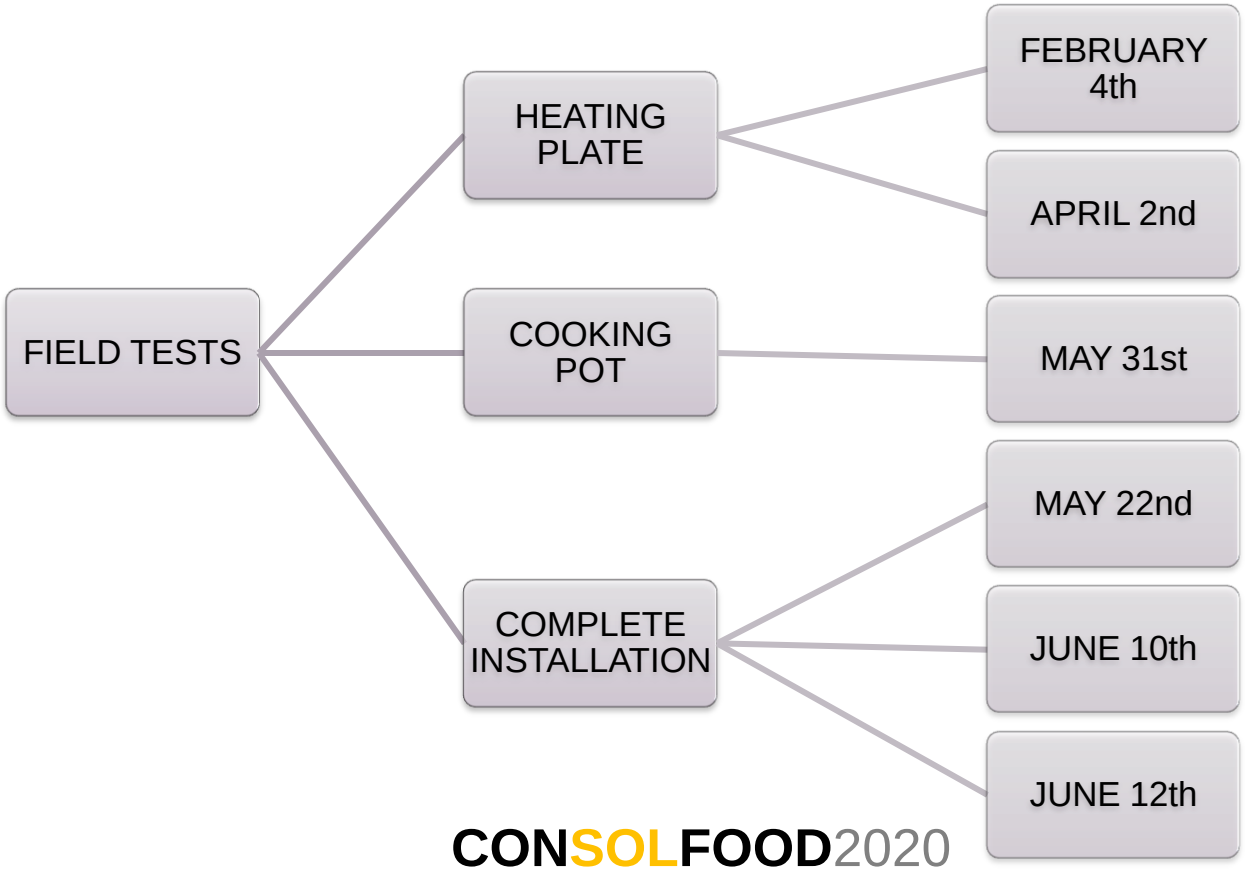
TESTING CAMPAIGN
Theoretical behavior





4 type K thermocouples implemented:
Pot base, water, lid, and pot lateral

TESTING CAMPAIGN



TESTING CAMPAIGN

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FEBRUARY 4th

APRIL 2nd

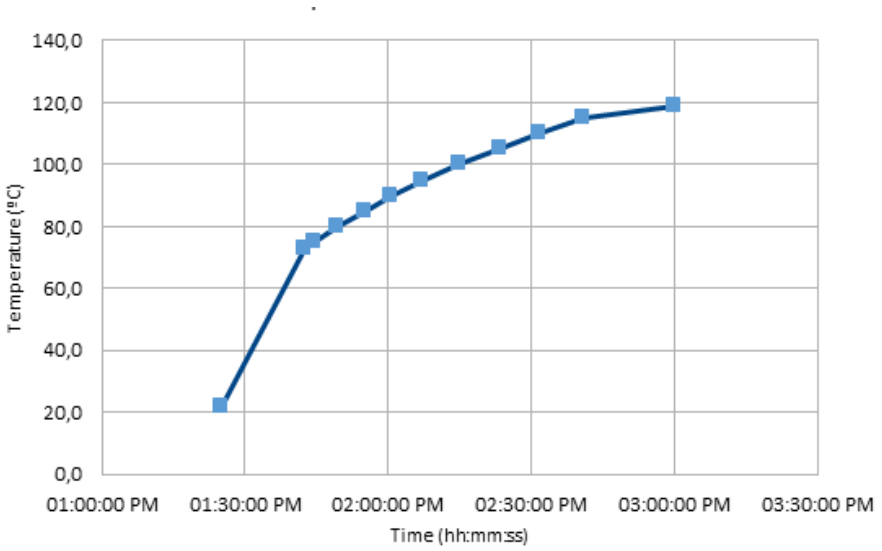
MAY 22nd

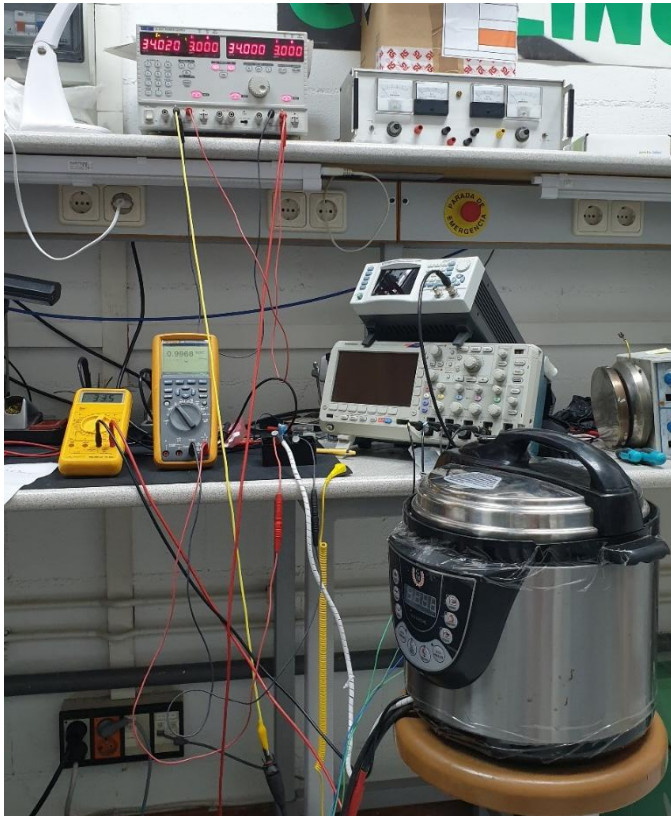
MAY 31st

JUNE 10th

JUNE 12th

Overheating protection





TESTING CAMPAIGN

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Heating and cooling testing, 2 l water

FEBRUARY 4th

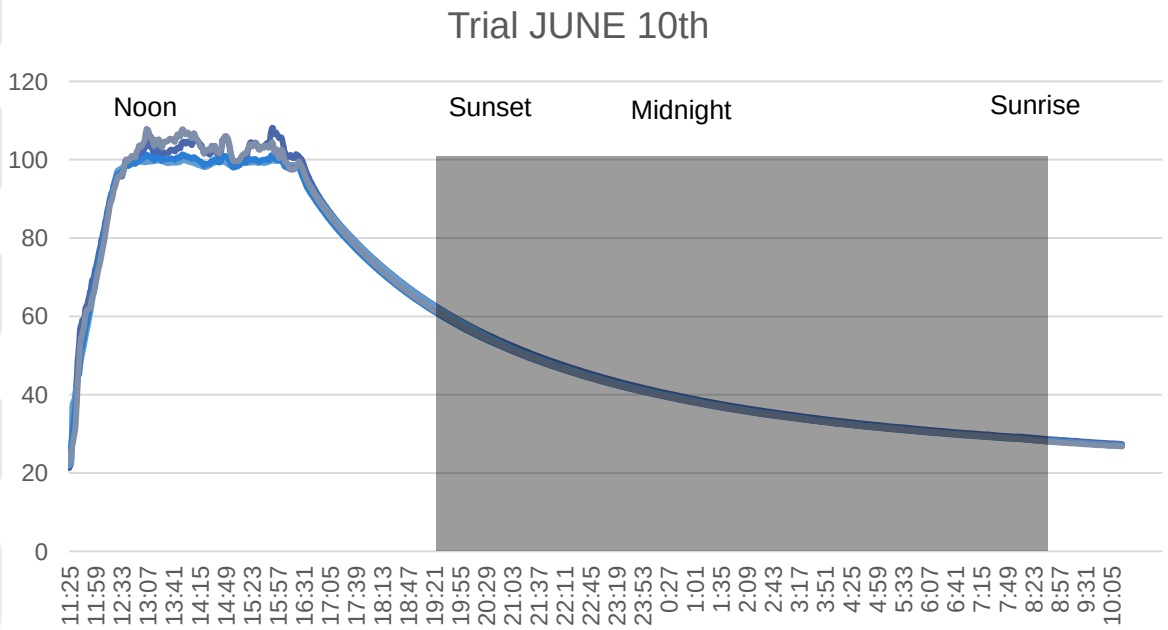
APRIL 2nd

MAY 22nd

MAY 31st

JUNE 10th

JUNE 12th

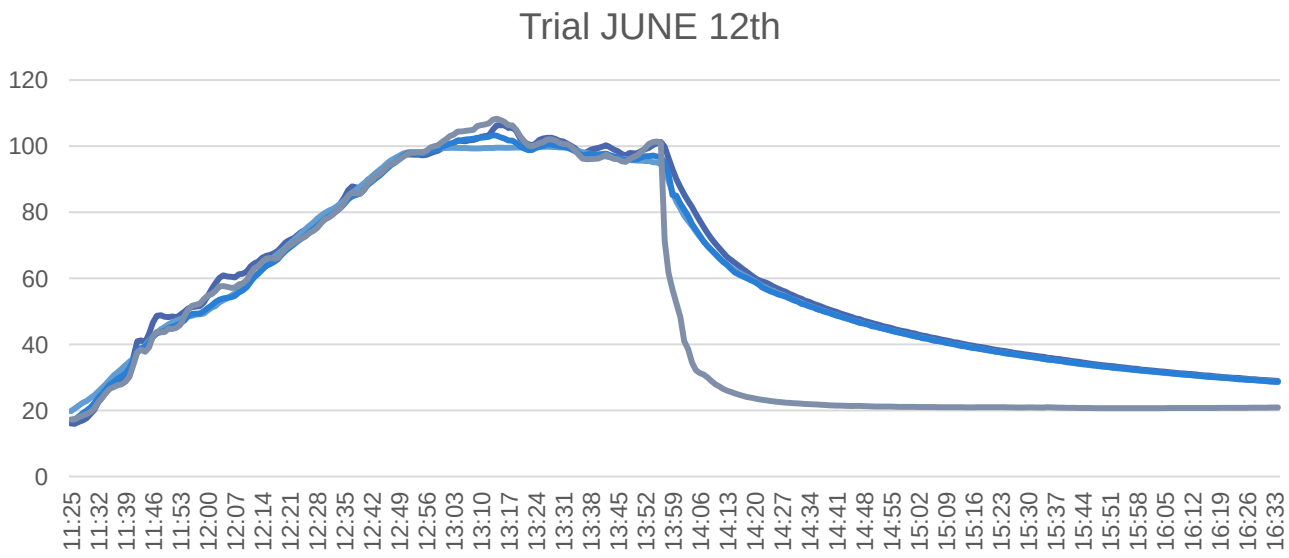


MEASURES 12:25	VALUE
T_multimeter	1,204 V
I_PVpanel	7,51A
I_Sun	1058W/m^2
T_PVpanel	48,6ºC
T_ambient	26,1ºC
V_wind	0,8 m/s

MEASURES 14:27	VALUE
T_multimeter	1,215V
I_PVpanel	6,05A
I_Sun	425W/m^2
T_PVpanel	34,3ºC
T_ambient	26ºC
V_wind	0,8 m/s

TESTING CAMPAIGN

Cooking test:
Egg and 30×1 cm^3 potato



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CONCLUSIONS

- Electronic utensil modified for high efficiency PV cooking.
- Low temperature cooking is possible (tender boiling).
- Low cost ~ 300 € off-the shelf in Madrid.
- Robust design.
- Inner heat dissipation allows high efficiency.
- Insulation optimizes heat retention.
- Theoretical calculations and experimental validation.

Further work

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- Pre-commercial prototype development
- Laboratory testing under realistic conditions (day and year-round)
- Testing at field conditions, user experience
- Low temperature cooking experience by users
- Electrification user experience
- Possible “commercialization”

Thanks!