MIT D-Lab Design Review + Dinner
Off-Grid Chick Brooder - Cameroon

With

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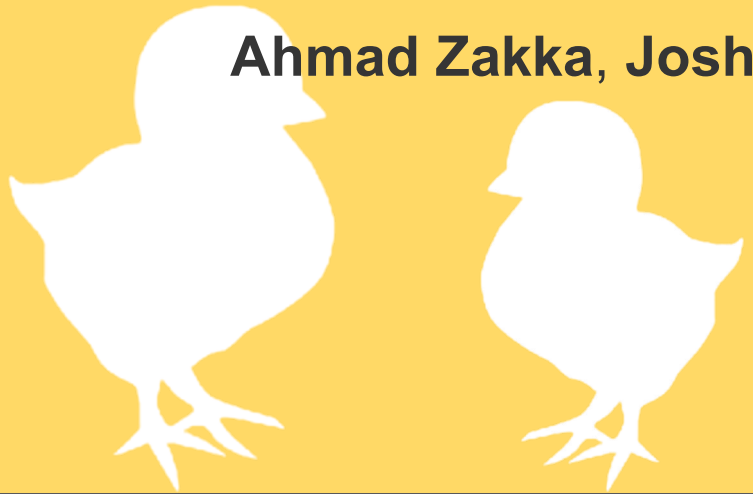
- Aly Kombargi, MIT PhD candidate

March 21, 2024

Off-Grid Brooder

Obala, Cameroon

Ahmad Zakka, Josh Maldonado, Aly Kombargi

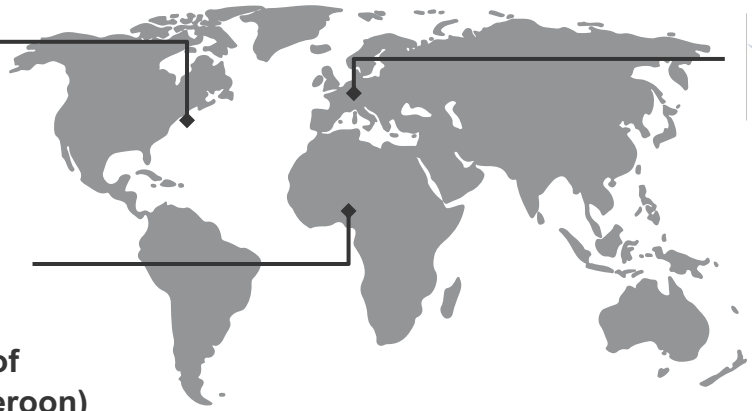


Our Partners

MIT D-Lab
designing for a more equitable world

AFRICAN SOLAR GENERATION

CDAS-BC
(African Diaspora Council of Switzerland – Branch Cameroon)



ANTENNA FOUNDATION

Swiss foundation committed to scientific research of technological, health, and economic solutions in marginalized population of developing countries

Community Contacts:

Joël Jeanloz (African Solar Generation, formerly Antenna Foundation)
Lionel Wassoumi (African Solar Generation)
Carole Erlemann Menguei (President CDAS-BC)
Kathrin Witschi (Secretary/ Treasurer CDAS-BC)

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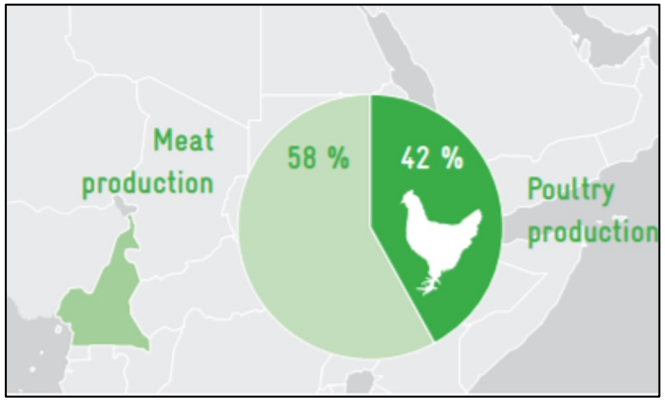
BACKGROUND

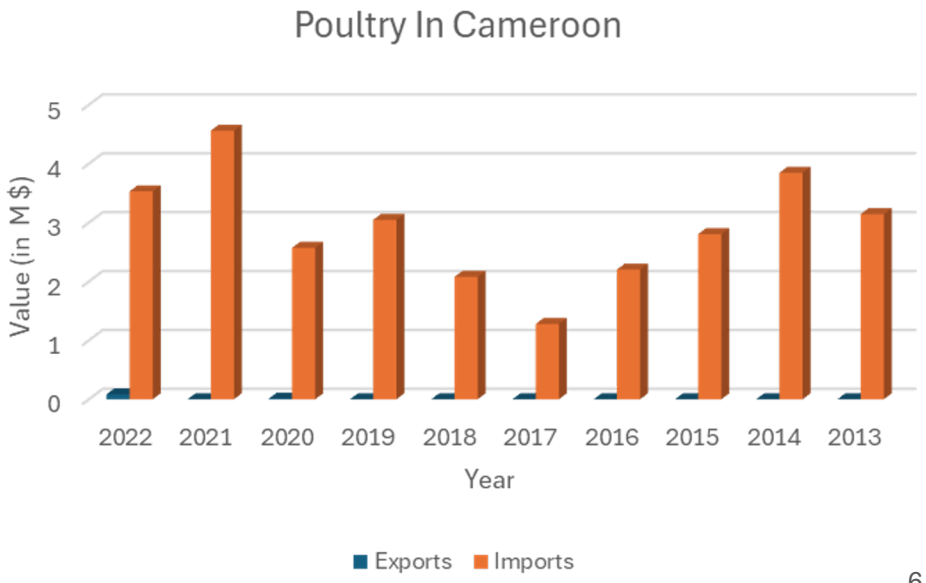
Poultry Sector In Cameroon

Poultry contributes **4% to Cameroon's GDP**

42% of all meat production

320,000 jobs created in recent years





Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, OEC.world

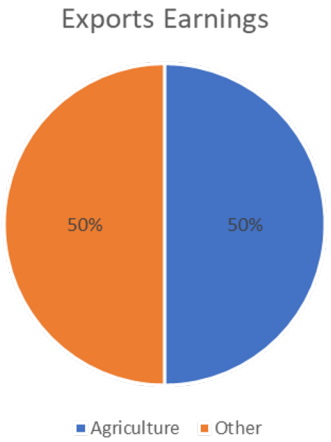
Agriculture Sector In Cameroon

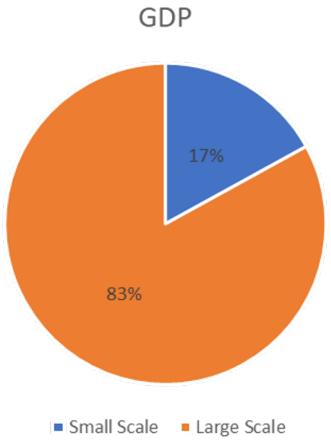
Agricultural sector **50% of export earnings**

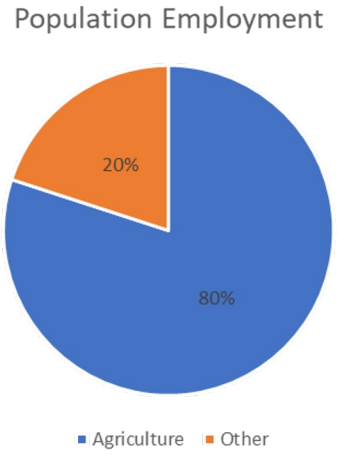
Agricultural sector **17% of the GDP**

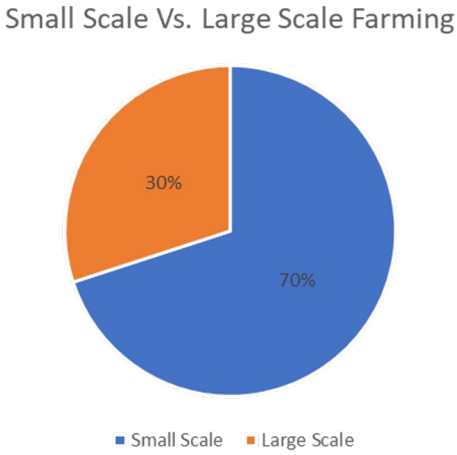
Employ between **70%–80% of the population**

Small scale farming 70% of agriculture sector





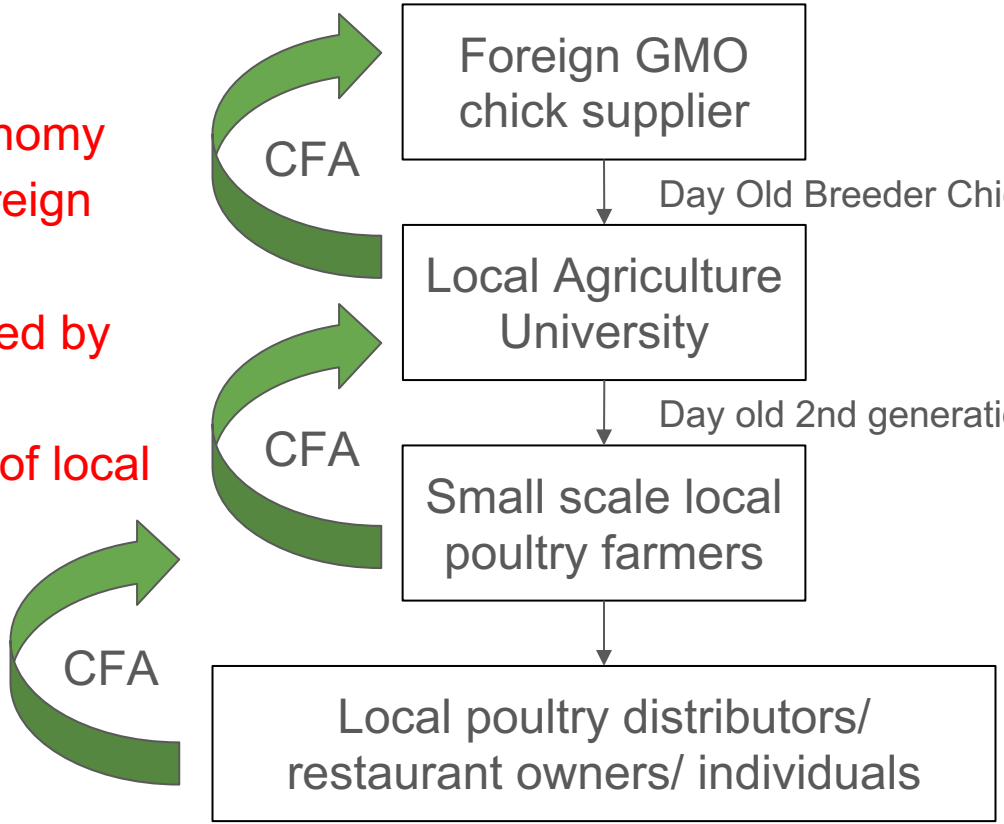




Current Poultry Market

Disadvantages:

- Weakened Economy
- Reliance on Foreign Market
- Market dominated by inferior product
- Disappearance of local breeds

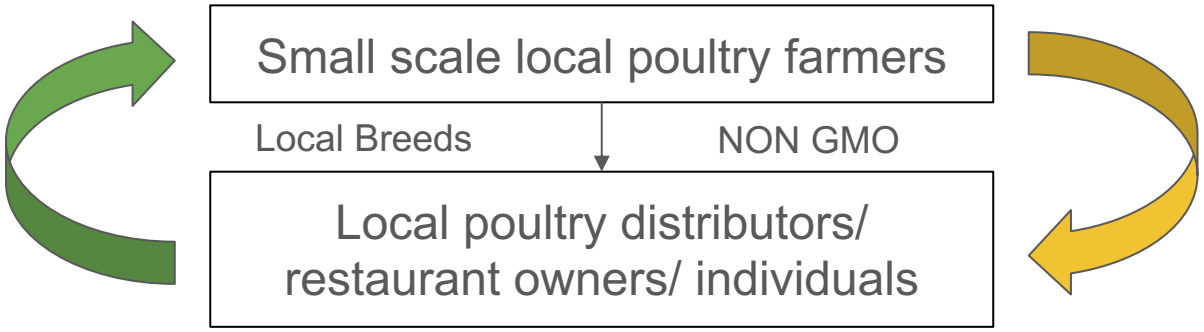


Advantages:

- Cheap and Quick supply of poultry

Road to Cyclical

- Not a sprint but a marathon
- Small scale/ Low cost egg incubation
- Cost efficient chick brooding



02
Designing the Brooder Box

Incumbent Solution

Burn firewood to keep chicks warm

- Disadvantages:
  - **Pollution** → Environmental/health concerns
  - **Inconvenient** → Farmers must rekindle fire several times a night
  - **Dangerous** → Farmers must sleep near chicks
- Advantages:
  - **Cheap** → Firewood easily sourced
  - **Familiar** → Farmers are accustomed and experienced in wood burning
  - **Reliable** → No reliance on external factors (grid, solar etc…)

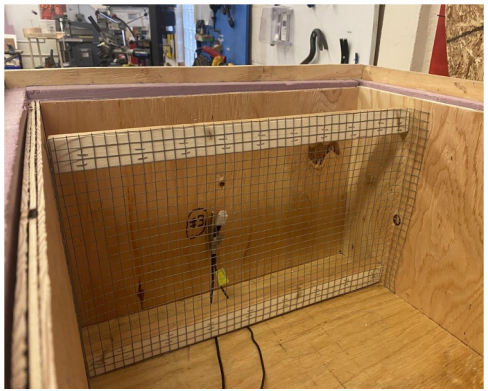
Design Requirements

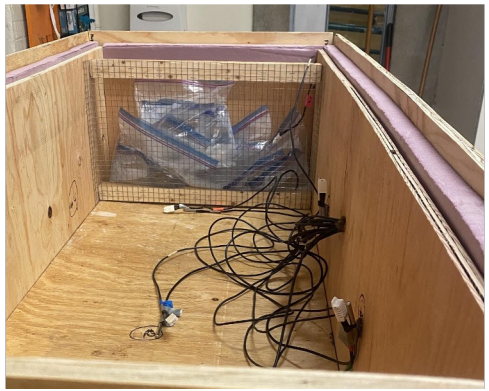
Design Requirement	What is measured?	How is it measured?	Target	Ideal	Reference
Interior Temperature	Temperature in the chamber	Temperature sensors	30-33 ˚C somewhere	30-33 ˚C everywhere	ASG
Time Between Maintenance	Time that temperature is in range	Temperature sensors	8 hrs	12 hrs	ASG
Humidity	Average humidity in box	Humidity sensors	40-60%	40-60%	Literature review
Ventilation	Volumetric air flow through box	Anemometer	12 CFM	12 CFM	Literature review
Operator Time	Time to maintain box	User experience, calculations	1hr	30min	Estimate

Building: The Box

Tasks Accomplished

1. Recreated the brooder box in Fusion 360 at **¼ volume**
2. Built the box from **½ in. plywood** and **1 in. XPS foam board**
3. Created barriers to mark potential locations to place the PCMs and protect them from the chicks

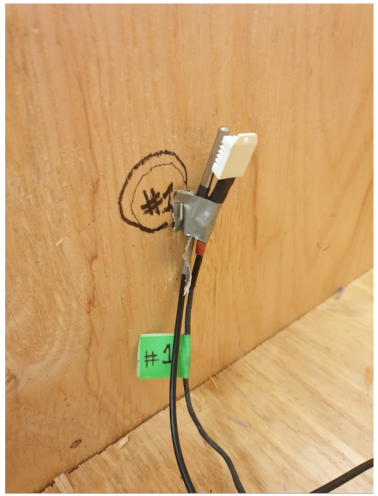


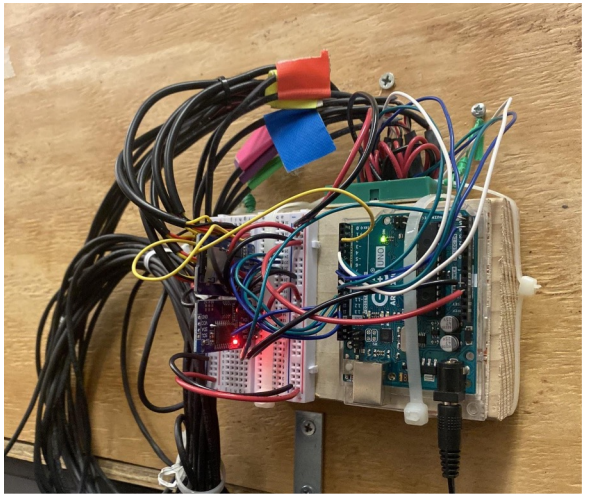


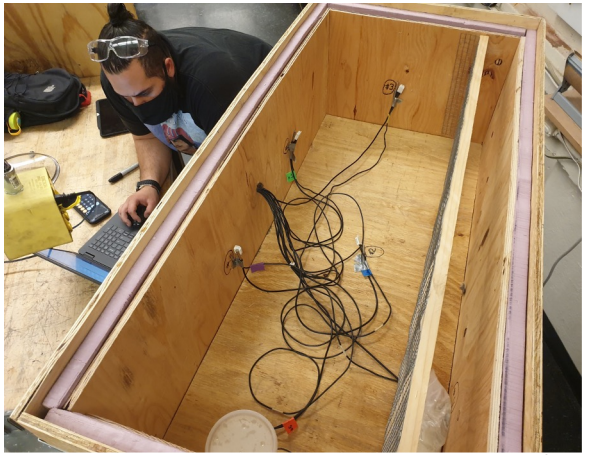
Building: The Sensors

Tasks Accomplished

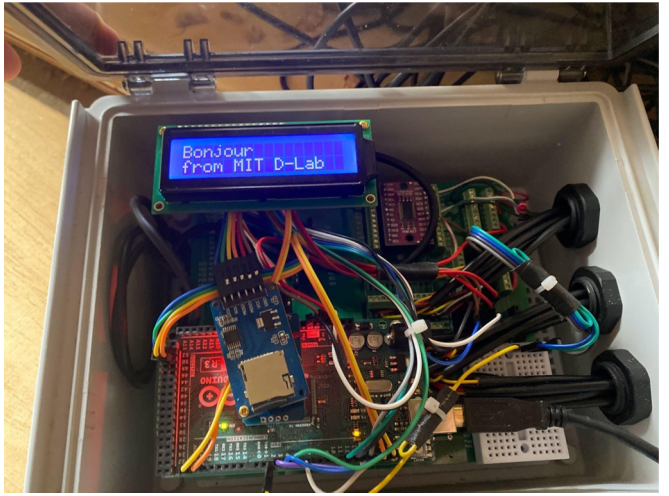
1. Installed **DS18B20 temperature sensors** and **DHT22 temperature and humidity sensors**
2. Monitored recorded sensor output using an **Arduino Uno**
3. Strategically placed sensors at measured distances from the PCM and within the PCM to monitor temperatures throughout the box







Building: The Sensors



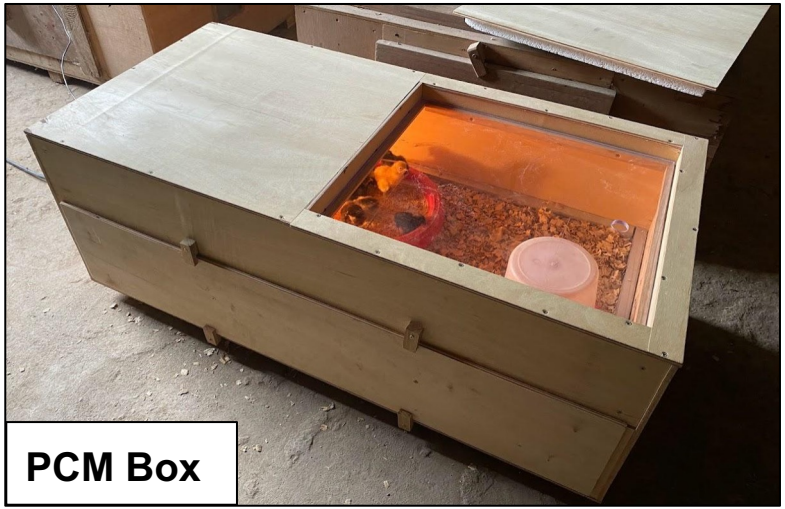
Building: The Heat Source

1. Replaced initial firewood technique
2. Thermally-insulated wooden cabinet
3. Solar panels that store energy in batteries for heating with lamps

Building: The Heat Source

Solar Box

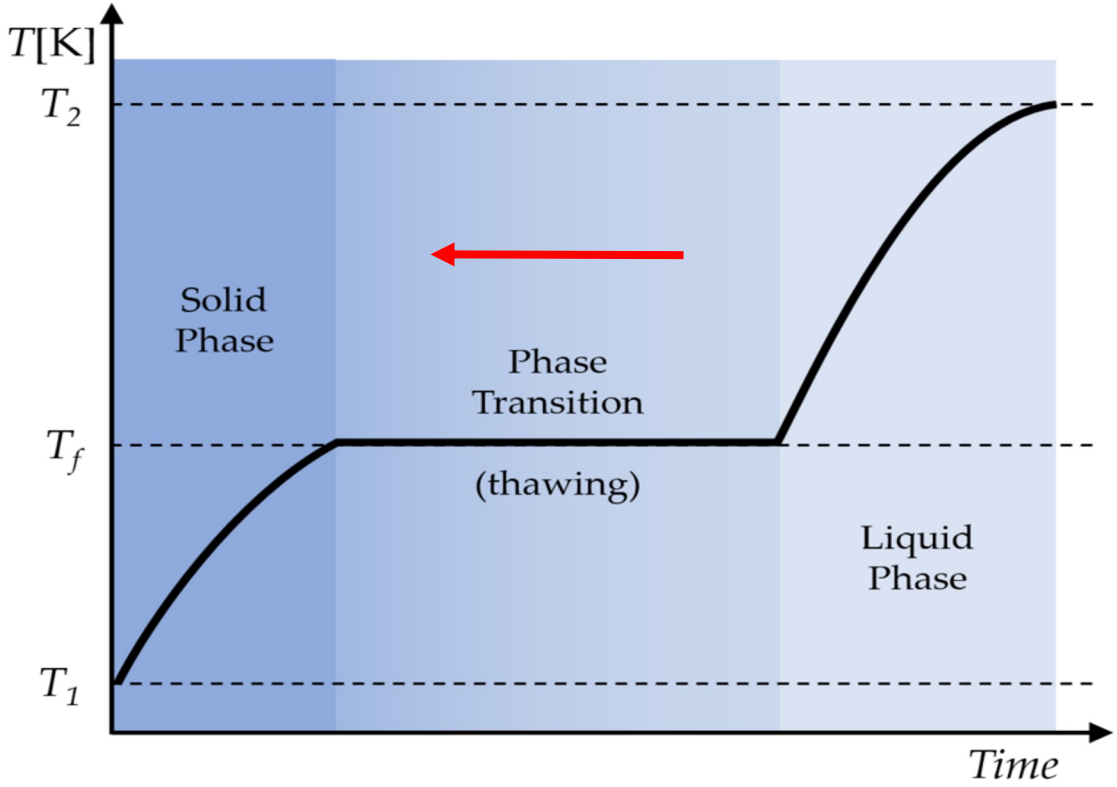
1. Replaced initial firewood technique
2. Thermally-insulated wooden cabinet
3. Solar panels that store energy in batteries for heating with lamps



PCM Box

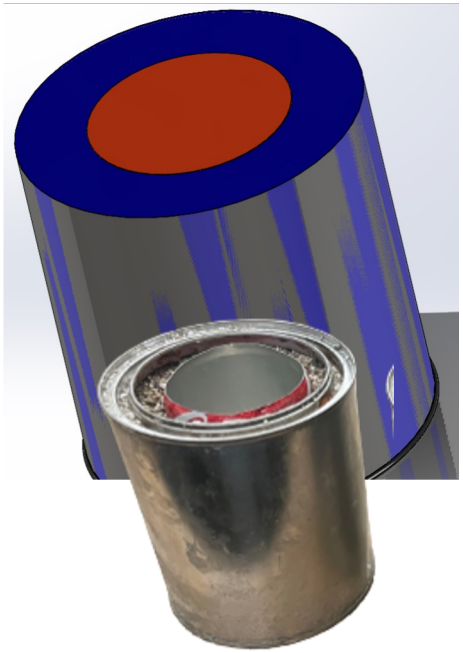
1. Replaced lamp warming with heat released from phase-changing materials (PCMs)
2. Thermally-insulated wooden cabinet
3. PCMs : sodium sulfate decahydrate, tetradecanol, paraffin wax

Building: The Heat Source



03
Designing the Thermal Battery

Design - Thermal Batteries

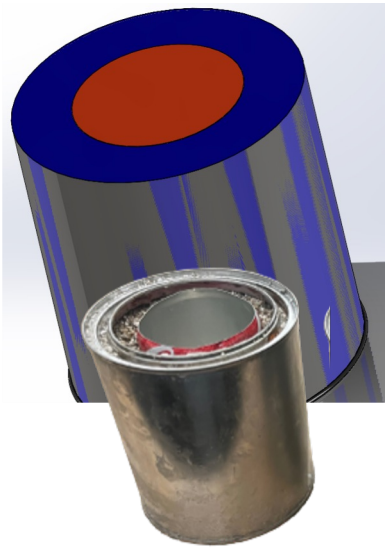


Design - Thermal Batteries

Sodium sulfate & Tetradecanol

Water

Beeswax



Hybrid

04

Designing the Egg Incubator Box

Design - Egg Incubator

Controls:

- Temperature
- Humidity
- Rocking motion

The Project Today

New Partners

CDAS-BC (African Diaspora Council of Switzerland – Branch Cameroon)

Kathrin Witschi
Secretary/ Treasurer

Carole Erlemann Mengue
President/Founder

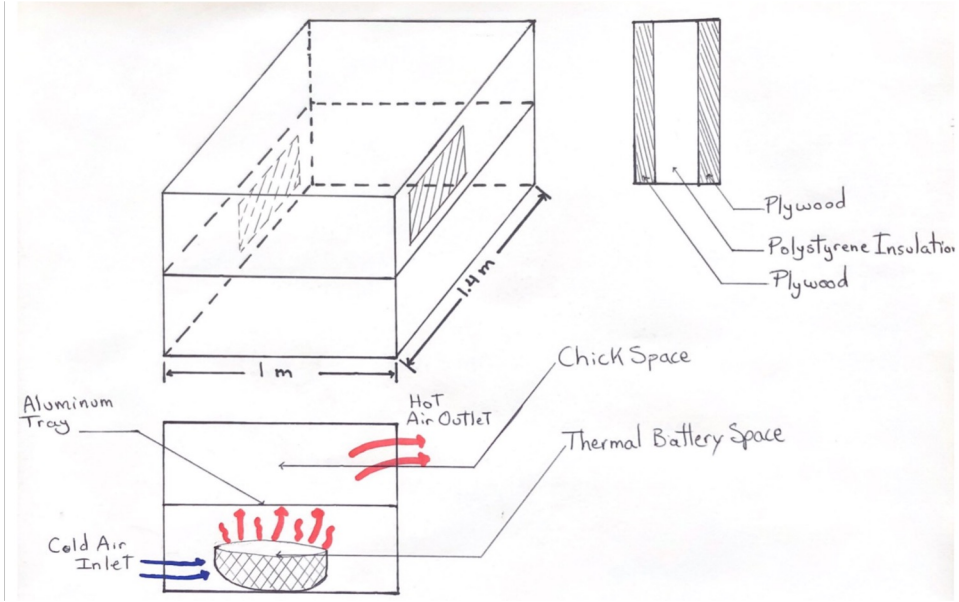
Interests

- Permaculture & Biological Agriculture
- Cultural Exchanges & Travelling
- Experimenting Small Scale Agro-Business

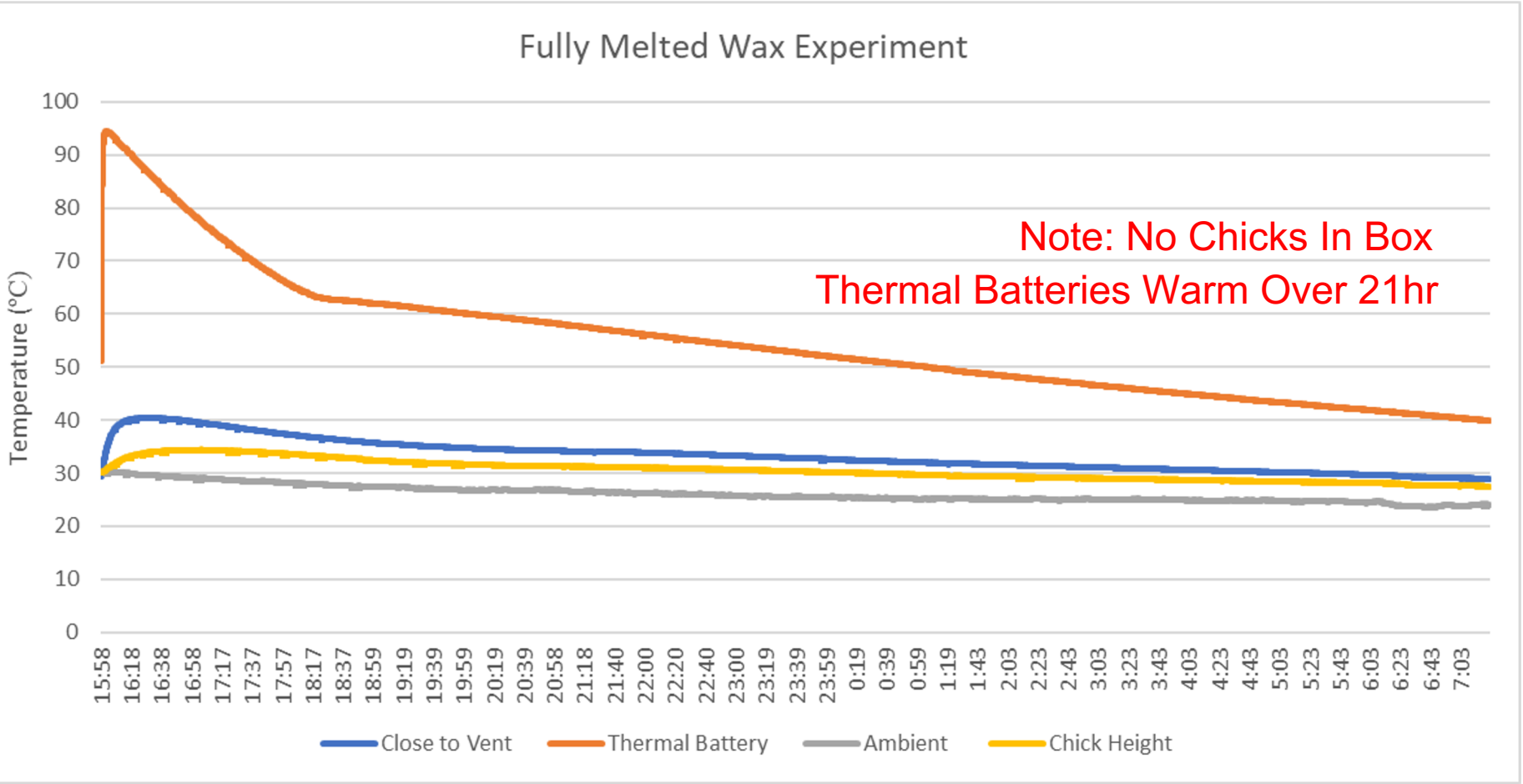
Interests

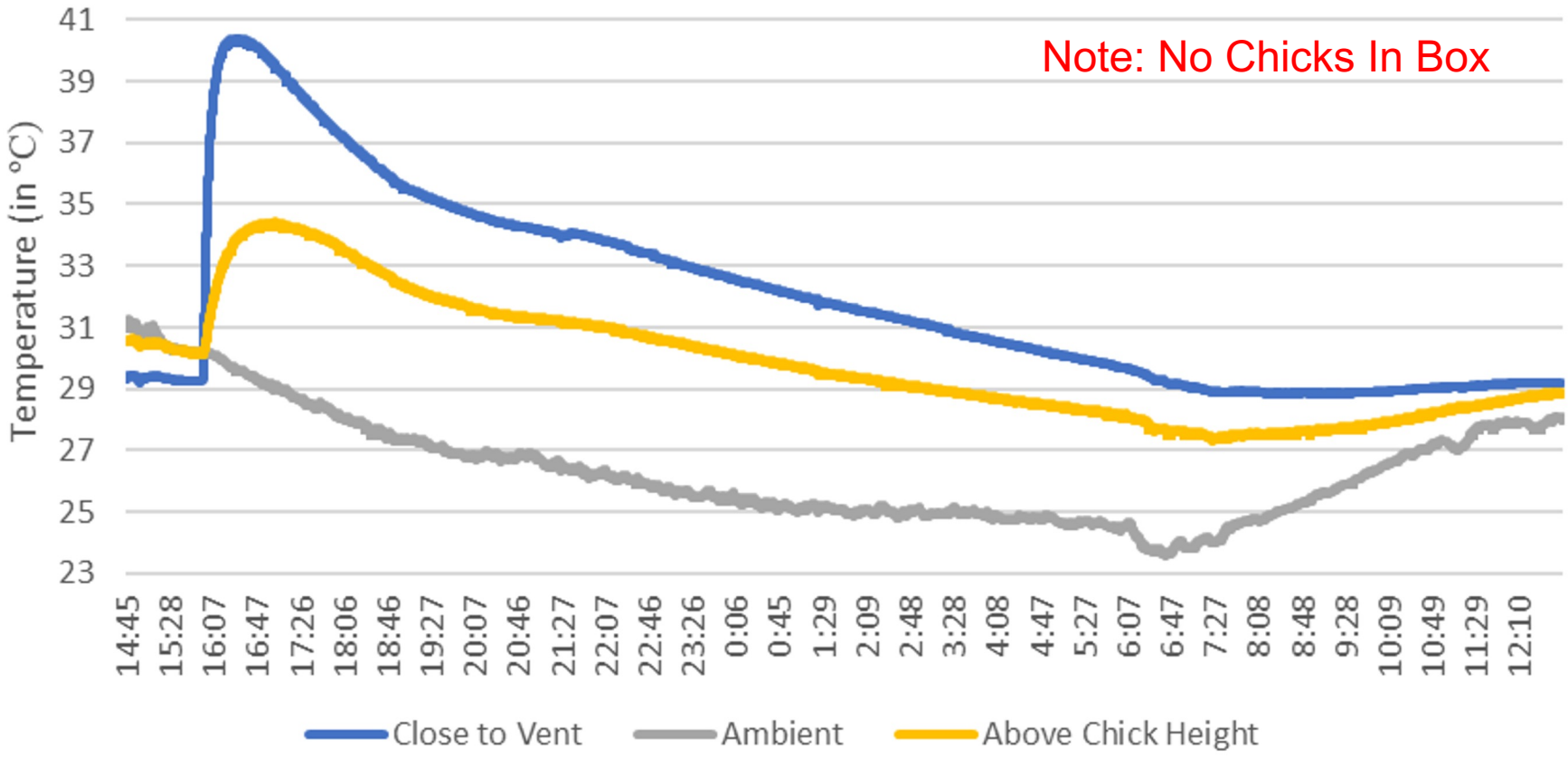
- Agriculture
- Professional Exchanges
- Social Reintegration

Data Collected In Research Box



- Styrofoam Insulation
- Stacked Design (floor heating)
- Aluminum Base Tray
- 10 Kg of Beeswax Thermal Batteries


Fully Melted Wax Experiment
Temperature (°C)
100
90
80
70
60
50
40
30
20
10
0
15:58
16:18
16:38
16:58
17:17
17:37
17:57
18:17
18:37
18:59
19:19
19:39
19:59
20:19
20:39
20:58
21:18
21:40
22:00
22:20
22:40
23:00
23:19
23:39
23:59
0:19
0:39
0:59
1:19
1:43
2:03
2:23
2:43
3:03
3:23
3:43
4:03
4:23
4:43
5:03
5:23
5:43
6:03
6:23
6:43
7:03
Close to Vent
Thermal Battery
Ambient
Chick Height
Note: No Chicks In Box
Thermal Batteries Warm Over 21hr

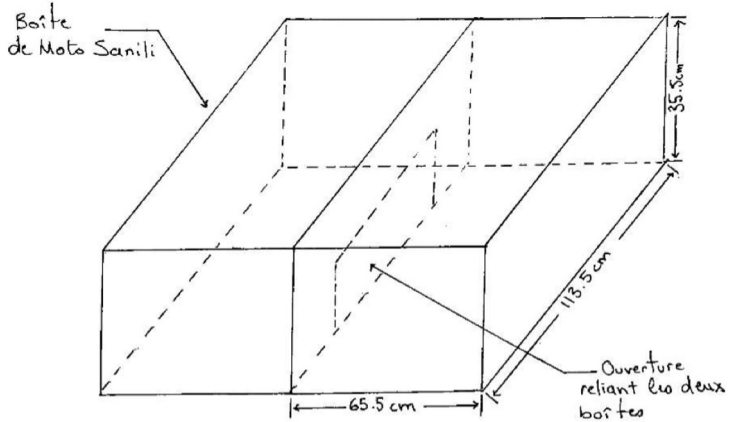

Note: No Chicks In Box
Temperature (in °C)
41
39
37
35
33
31
29
27
25
23
14:45
15:28
16:07
16:47
17:26
18:06
18:46
19:27
20:07
20:46
21:27
22:07
22:46
23:26
0:06
0:45
1:29
2:09
2:48
3:28
4:08
4:47
5:27
6:07
6:47
7:27
8:08
8:48
9:28
10:09
10:49
11:29
12:10
Close to Vent
Ambient
Above Chick Height

Key Takeaways

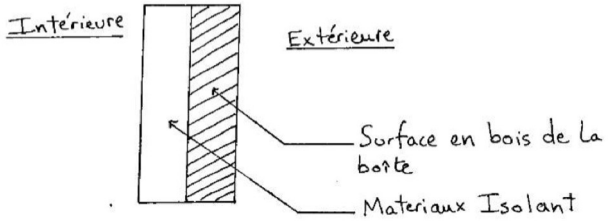
Chick Space Over 30°C	Chick Space Over 29°C	Thermal Batteries Over 30°C
7h 48min	12h	+21h

- Inlet vent temperature > Chick height Temperature indicate heat losses
- ~8hr above target temperature on one charge (~2h charge time)
- ~5°C gain in box throughout night
- Thermal Batteries still warm after 21h

Data Collected In Low Cost Box



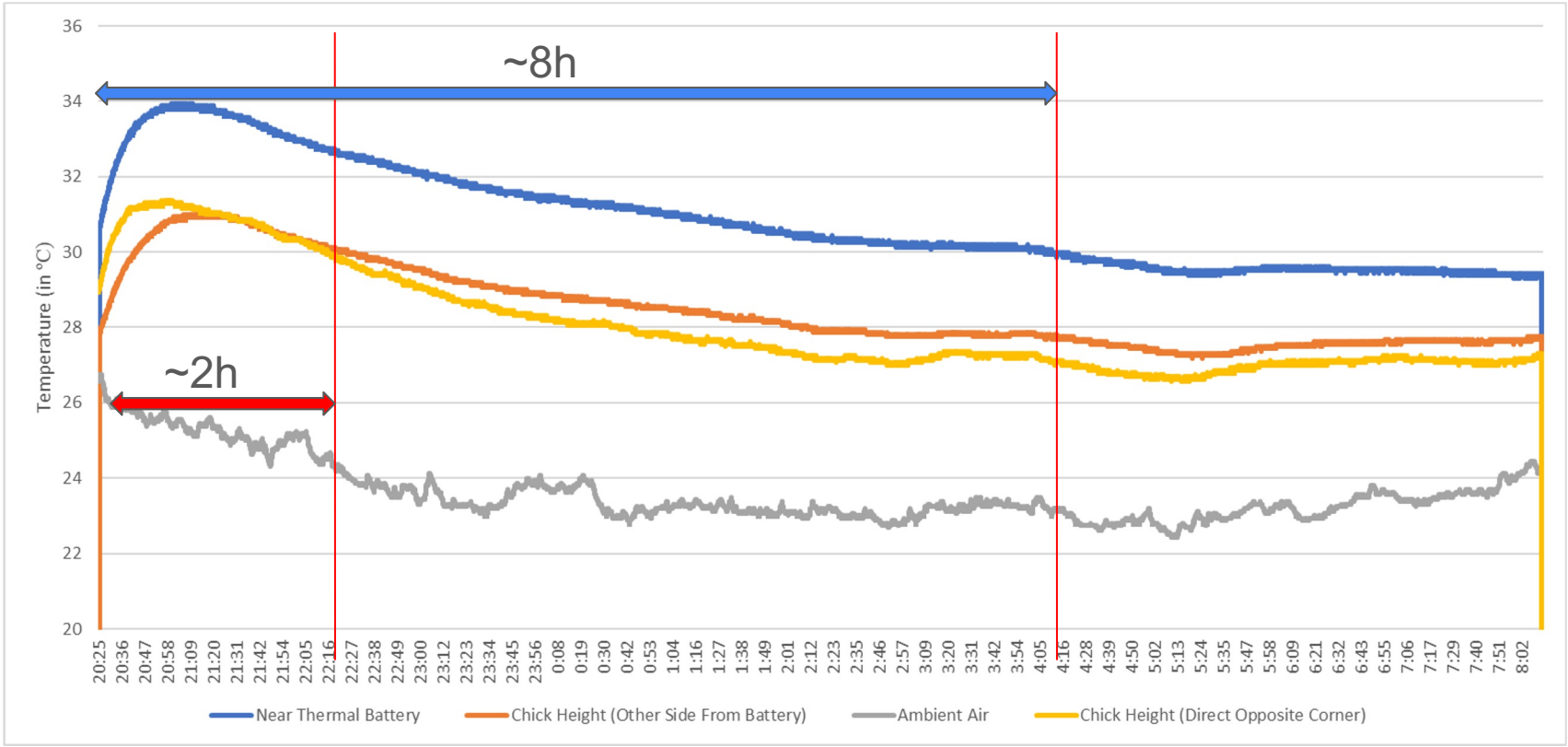
Boite Couveuse de Poussins



Coupe Transversale des Parois de la Boite

- Taped Polypropylene Bags Insulation
- Flat Design (heat source with chicks)
- No Floor Insulation

Low Cost Brooder Box Empty Test

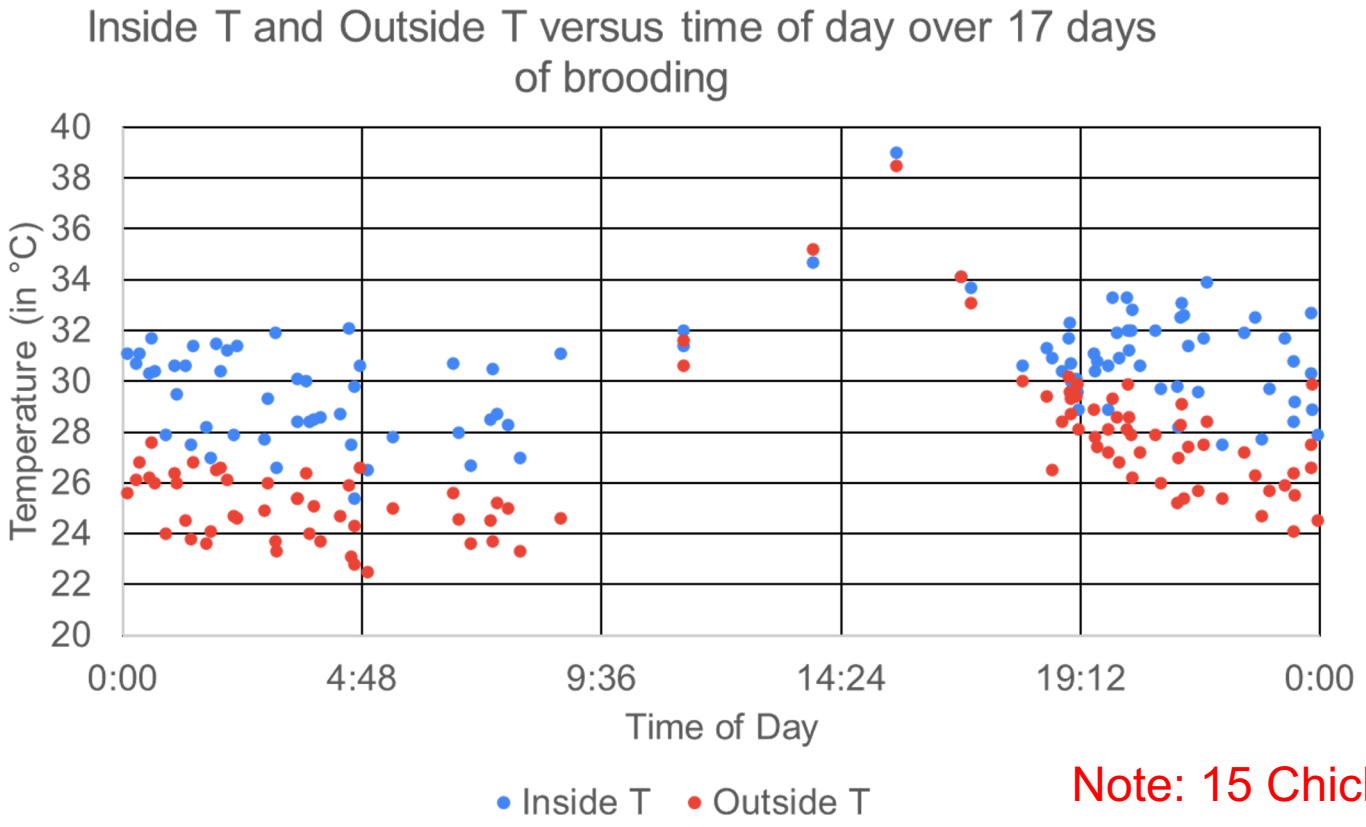


Key Takeaways

Chick Space Over 30°C	Chick Space Over 29°C	Near Thermal Batteries Over 30°C
2h	3h	8h

- Temperature near batteries > Chick height Temperature indicate heat losses
- ~2hr above target temperature on one charge (~2h charge time)
- ~5ºC gain in box throughout night

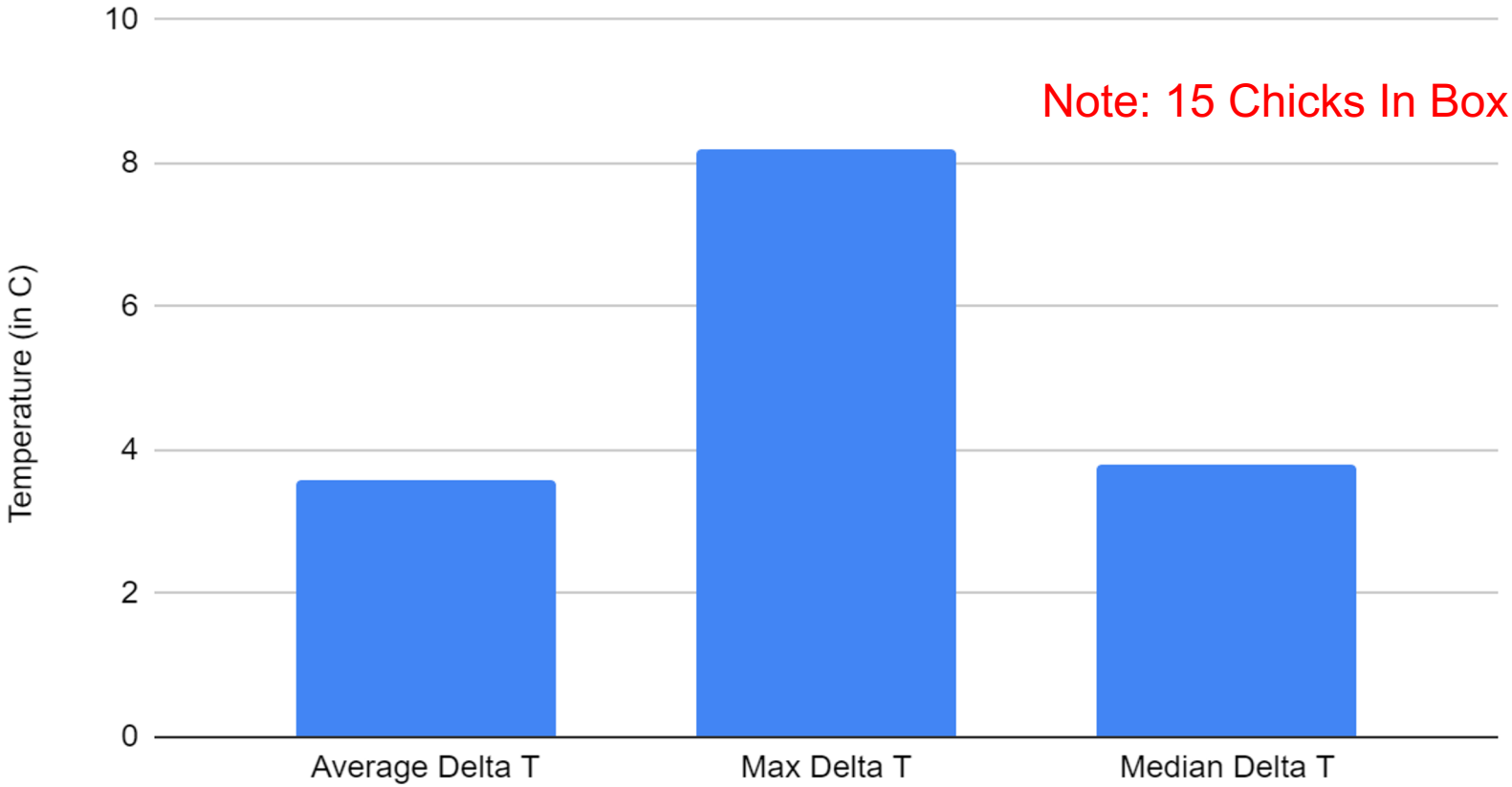
Low Cost Brooder Box Live Chicks Test



Note: 15 Chicks In Box

Data Collected By CDAS-BC

Temperature Gain In Brooder Box



Note: 15 Chicks In Box

Data Collected By CDAS-BC

- Survived Brooding process
- Weight comparison at 45 day

Brooder Box Comparison

Low Cost Box

- Price: ~10 USD
- Thermal Batteries(10kg): 40 USD - 70 USD
- Minimal build time
- ~2h @ chick height T > 30ºC on single charge
- 1.5 m2 chick surface area

Research Box

- Price: >200 USD
- Thermal Batteries(10kg): 40 USD - 70 USD
- Significant build time
- 8h @ chick height T > 30ºC on single charge
- 1.4 m2 chick surface area

Similar Technology Already In Use

Moving Forward

Commercial Dissemination

- Identify local entrepreneurs
- Determine appropriate business model and price point
- Procure backstock of beeswax for rapid distribution

Educational Dissemination

- Identify trainers
- Run a ToT (training of trainers)
- Procure backstock of beeswax for rapid distribution