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HIGH EFFICIENCY LOW POWER COOKING AND/OR HEATING

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PATENT

HIGH EFFICIENCY LOW POWER COOKING AND/OR HEATING

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APPENDIX

[0002] This application is being filed with an appendix. Any appendices and all other papers filed herewith, including papers filed in any attached Information Disclosure Statement (IDS), are incorporated by reference. The appendix contains example data and results according to specific embodiments. Permission is granted to make copies of the appendices solely in connection with the making of facsimile copies of this patent document in accordance with applicable law; all other rights are reserved, and all other reproduction, distribution, creation of derivative works based on the contents, public display, and public performance of the appendix or any part thereof are prohibited by the copyright laws.

FIELD OF THE INVENTION

[0003] The present invention relates to heating apparatus, cooking apparatus and related methods and apparatus.

BACKGROUND

[0004] The discussion of any work, publications, sales, or activity anywhere in this submission, including in any documents submitted with this application, shall not be taken as an admission that any such work constitutes prior art. The discussion of any activity, work, or publication herein is not an admission that such activity, work, or publication existed or was known in any particular jurisdiction.

[0005] Well-established problems associated with cooking in the developing world include: household air pollution (Lim et al. 2013), deforestation, CO_2 emissions, and soot deposition (MacCarty et al. 2008). Additionally, it is the world's poorest socioeconomic class who cook with biomass (Smith and Dutta 2011), bearing the associated financial cost, time and vulnerability to violence (Andreae 1991). Some of these emissions and fuel demand may be reduced by fuel-efficient stoves, but not eliminated. While the use of solar cookers may be free of negative health or environmental impacts, solar cookers are often not readily adopted for reasons such as dissimilarity to traditional cooking technologies and inconveniences that include reliance on direct sunlight. Electrical cooking technologies have been quickly adopted in both off-grid regions (Millinger et. al 2012) and regions newly added to the grid such as in fourth and fifth tier cities in China. Electrical cooking, particularly with induction stoves (Subramanian 2014) has been suggested as an alternative to polluting biomass cook stoves. However, these induction cookers require well over 1000 W of grid electricity, which is too expensive or nonexistent in many areas.

[0006] While cooking is a particularly important use for heat in the developing world, effective or more efficient heat production could have many other applications in the developing world and elsewhere.

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SUMMARY

[0022] Most cooking apparatus and other heating apparatus have substantial energy loss between heat source and the heated material or volume, such as food. Specific embodiments described herein outline ways in which new cooking devices can be made which require far less energy input, and ways in which preexisting cooking devices can be retrofitted with insulation to boost their efficiency. Other embodiments describe apparatus that can produce primary or supplemental heating in a variety of systems.

[0023] Advantages include a decrease in the amount of energy required to cook or heat with and a decrease in the costs associated with purchasing the energy whether it comes from electricity, natural gas, solar, or biomass fuel. Advantages also include bringing cheap solar-electric energy to areas without stable power grid access, allowing safer, cheaper, more flexible, and less harmful cooking methods. According to specific embodiments where a PV (Photovoltaic) apparatus is effectively directly connected to a heating element are increased efficiency in heating for cooking or environmental (e.g., room heating or blanket heating) or medical/industrial (e.g., autoclaving, sterilization, clothes washing, or other household, commercial, or other processes requiring heat), advantages also include reduced system costs due to not having to buy an inverter or other hardware associated with converting PV current to more conventional grid AC current.

[0024] Specific embodiments of a cooking or heating apparatus and/or method described herein comprise of a heating or cooking chamber (which can be of any convenient shape). The insulation is structured in such a way as to surround the designated cooking or heating chamber or volume and to prevent heat loss. The insulation may either be directly mounted to the chamber or mounted to the housing containing the chamber.

[0025] According to specific embodiments, example cooking apparatus as described herein use a much larger amount of insulation than has customarily been used in cooking apparatus. Example apparatus use sufficient insulation such that a substantial majority of heat produced by a heating element is absorbed by the sample in the cooking or heating chamber rather than being lost to the external environment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating cost analysis of PV according to specific embodiments.

FIG. 2 is a photograph of a prototype cooking apparatus showing an inner cooking chamber, insulation, and an outer container according to specific embodiments. Insulation has been removed to expose the inner cooking chamber.

FIG. 3 is a close-up photograph of a prototype cooking apparatus showing a heating element configured with a cooking chamber according to specific embodiments.

FIG. 4 is a diagram showing a Temperature v Time profile for an experimental cooking according to specific embodiments.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Enhanced insulation

[0026] More efficient cooking apparatus are required worldwide to reduce energy consumption. Whether the energy comes from solar, electric, natural gas, or biomass fuel, users will benefit from a reduction of the amount required to effectively cook or heat food and water. Fitting insulation strategically around cooking apparatus will increase the apparatus efficiency and decrease the energy required for their purpose.

Increasing affordability of photovoltaic cells

[0027] According to specific embodiments, systems and methods as described herein take advantage of and anticipate that as the cost of photovoltaic cells continues to decrease, Photovoltaic Electric (PVE) systems will become increasingly cost competitive. According to specific embodiments, PVE cooking and heating is used in order to reduce cost while adapting and accommodating the technology to different community cooking practices so that as the appropriate PV solar panel price point is reached, cooking and/or heating apparatus that can effectively make use of the PVE systems according to specific embodiments are available.

[0028] Figure 1 shows the steady decrease in price of silicon-based photovoltaic power over the last 40 years (Swanson 2015, Samual 2015). Concerns that the recent price decrease (induced from Chinese companies selling below cost) is artificially deflated may be compensated by the emergence of new technologies (Green and Emery et al. 2014) including cadmium telluride (presently the least expensive PV technology) and experimental perovskite materials (Green and Ho-Baillie et al. 2014). In any case, the price of PV panels will certainly continue to decrease over time with the only uncertainty being the rate of decrease. The market price of these technologies, is about twice the cost of production, and we estimate a present purchase price of $0.70/W and project a 2020 price of $0.30/W. Additionally, the world's poor increasingly have access to more wealth. Recently, Pew reported the portion of humanity classified as "poor" decreased by nearly 50% between 2001 and 2011 (Kochhar 2015). Both the decreasing cost of PV technology and increasing wealth of the very poor make photovoltaic technology increasingly accessible to the poor. PV innovations in present industrial countries should also be expected with the decrease in PV cost.

Value of electricity

[0029] Typically, in converting sunlight to electricity and then to heat, we lose about 80% of the sun's available energy. However, according to specific embodiments, this loss may be well worth the added value gained by electrical conversion, for example due to one or more of:

1. Electrical transmission allows us to bring the sun's energy into the house, or wherever else it is needed.

2. Electrical transmission facilitates the use of insulation to lower the power necessary to cook, reducing costs. Most solar cooking and heating technologies require a significant surface area of reflector or glass, which is difficult to adequately insulate. Additionally the high temperatures and ventilation needs of combustion cooking and heating technologies make insulation difficult.

3. The power of a PVE cooking system could be increased over time with additional solar panels.

4. Electrical conversion enables energy storage in batteries for nighttime use.

5. Electrical power enables automated control of time and temperature.

6. PVE systems provide electricity for other domestic and commercial services.

7. Because combustion-free cooking is supported by carbon credits, PVE cooking systems lower the financial barrier to disseminate a resilient infrastructure of distributed PV. (Hogarth 2012) (Smith, 2010)

Direct PVE heating

[0030] According to further embodiments, a PV panel is connected directly to a heating element or device to be inserted as a retro fit to any other heating apparatus, either as a supplement to an original heat source or as the sole heat source. For instance, a small electric heater or heating element may be placed into a water heater (such as a gas, electric, solar or other water heater) and connected essentially directly to a PV panel. (As used herein connected directly or essentially directly in addition to a simple conductor, such as a wire, also comprises electrical connections that lose minimal power (e.g., <0.01-10%) due to the electrical connection between the PV panel and heating elements. Thus switches, circuit breakers, meters, thermostats, etc. might be between the PV panel and the heating element. However, energy conversion circuits, such as a DC to AC converter, are not generally considered to provide direct connection between the PV panel and the heating element.) With either no other connections between the PV panel and heating element, the PV panel can just heat the water during the day. Such a simple device to heat water when the sun is shining and the PV panel is active can provide hot water later for any use, such as home or commercial washing or room heating through a fluidic radiator system.

[0031] According to specific embodiments, and in general unless the context demands otherwise, a cooking or heating chamber or apparatus as described herein can be used for any purpose served by the heating provided, such as, without limit, cooking food for consumption, canning any consumables for preservation, water purification, and/or autoclaves for hospitals, and/or any commercial or industrial or household use.

Example Embodiments

[0032] According to specific embodiments, projected prices of photovoltaic panels indicate that a 1000 W electric stovetop capable of boiling a liter of water in 5 minutes requires an investment in solar panels of $700 now, projected to be $300 in 2020. However, the PV panel costs for a 100 W system, capable of boiling a liter of water in 50 minutes would only be $70 now or $30 in 2020. A 100 W conventional stovetop would likely never reach boiling because of heat losses but heat loss can be reduced with insulation. Thus, specific embodiments focus on optimizing an insulated cooker with a 100 W photovoltaic solar panel directly connected to the heater. However, other embodiments can equally make use of the present invention.

[0033] Figure 2 is a photograph of an example prototype system according to specific embodiments. In this example, a 5-gallon steel drum insulated from the surrounding 55-gallon plastic drum, with some insulation removed from around the inner drum to better visualize the design. 100 W is provided by a heating element, thermally connected to the lid of the inner metal drum, as illustrated in Figure 3.

Example calculations

[0034] An example of thermal and financial calculations related to specific embodiments on the available spreadsheet. We calculate the equilibrium temperature for a 5-gallon drum heated with 100 W and insulated with 13.5 cm of fiberglass to be 358°C (676°F). Also, 100 W should be sufficient power to boil a liter of water in under an hour. In the financial calculations, we do not include the cost of the outer, plastic containing device with the assumptions that locally sourced materials could provide this with little expense. Additionally, the heating element of correct resistance to optimize the power output of the solar panel could be replaced with something less expensive such as nichrome wire. These engineering challenges will likely find different solutions depending on local interests and resources.

Experimental Trial:

[0035] One example embodiment was used for proof of concept testing. In the tests, we cooked ~ 2 kg chicken with ~ 1.6 kg of vegetables in a 5-gallon steel drum using 100 W from a heating element. Poultry's minimum safe internal temperature of 74°C (165°F) was reached in about 2 hours. After 5 hours, the chicken's internal temperature was over 100°C, and the air temperature inside the steel drum was 111°C (232°F). The chicken was thoroughly cooked, as were the vegetables inside the chicken. We can calculate that the expected time necessary to heat 3.6 kg of water from 20.5°C to 100°C is almost 3 hours 20 min, roughly consistent with our experimental results allowing for some heat loss through conduction and boiling. (See the spreadsheet in the Appendix for other related calculations.)

Further Embodiments

[0036] Further embodiments of highly insulated and/or PVE cooking technologies are directed to hardware improvements and adaptations to reduce costs as well as accommodate different cultural practices and norms and material availability. Because the electric element is contained and controlled, the risk of fire and burns is less than for biomass fires. The oven technology we prototyped can be modified to accommodate a wide range of cooking styles including insulated pots and broilers with thermostat-controlled automation. According to specific embodiments, cookers as described herein are appropriate for collaborative development and dissemination in the developing world.

Conclusion

[0037] Photovoltaic-electric and/or highly insulated cooking and heating offers a new paradigm in developing countries that is safer for the users, as well as the local and global environment. Use of insulation significantly reduces power demand and therefore operating cost. In further embodiments, additional benefit will come from making use of the available photovoltaic electricity to power other appliances such as lights and cell phones. Finally, using photovoltaic electricity to displace biomass combustion would allow carbon credits to lower the cost of photovoltaic panels, thus facilitating dissemination of solar technology in developing countries.

[0038] Thus, according to specific embodiments, the present invention is involved with methods and/or systems and/or devices that can be used together or independently to provide efficient heating and/or cooking as described herein. This description introduces a selection of concepts that are further described or can be further understood from other papers submitted with this application. Key features or essential features of the claimed subject matter are discussed throughout this submission including in the appendix, thus no individual part of this submission is intended to determine the scope of the claimed subject matter.

[0039] It is well known in the art that systems and methods such as described herein can include a variety of different components and different functions in a modular fashion.

Different example specific embodiments and implementations can include different mixtures of elements and functions and may group various functions as parts of various elements. For purposes of clarity, embodiments of the invention are described in terms of systems that include different innovative components and innovative combinations of innovative components and known components. No inference should be taken to limit the claimed invention to combinations containing all of the innovative components listed in any illustrative embodiment in this specification.

[0040] All references, publications, patents, and patent applications cited herein are hereby incorporated by reference in their entirety for all purposes.

[0041] The general structure and techniques, and more specific embodiments that can be used to effect different ways of carrying out the more general goals are described herein. Although only a few embodiments have been disclosed in detail herein, other embodiments are possible and the inventor(s) intend these to be encompassed within this specification. The specification describes specific examples to accomplish a more general goal that may be accomplished in another way. This disclosure is intended to be exemplary, and the claims are intended to cover any modification or alternative that might be predictable to a person having ordinary skill in the art.

[0042] The inventors intend that only those claims which use the words “means for” are intended to be interpreted under 35 U.S.C. § 112, sixth paragraph. Moreover, no limitations from the specification are intended to be read into any claims, unless those limitations are expressly included in the claims.

[0043] Where a specific numerical value is mentioned herein, it should be considered that the value may be increased or decreased by 20%, while still staying within the teachings of the present application, unless some different range is specifically mentioned. Where a specified logical sense is used, the opposite logical sense is also intended to be encompassed.

WHAT IS CLAIMED:

1. An apparatus for heating comprising:

a photovoltaic solar cell substantially directly connected to a heating element.

2. An apparatus for heating a chamber for cooking or other uses comprising:

insulation surrounding a heating chamber, wherein the insulation increases efficiency thereby decreasing the amount of power required to heat a volume in the chamber, wherein the insulation volume is larger to substantially larger than the chamber volume.

3. The apparatus of claim 1 further comprising:

insulation surrounding a heating chamber, wherein the insulation increases efficiency thereby decreasing the amount of power required to heat a volume in the chamber, wherein the insulation volume is larger to substantially larger than the chamber volume or wherein the power to heat the food or other material in the chamber is large compared to the amount of heat dissipated.

4. The apparatus of claims 1, 2, or 3 further wherein the chamber is a generally horizontal volume, such as a horizontal cylinder or horizontal rectangular volume or any other shape.

5. The apparatus of claims 1, 2, or 3 further wherein the chamber is a generally vertical volume such as a vertical cylinder or vertical rectangular volume or other shape.

6. The apparatus of claims 1, 2, or 3 further wherein the chamber is a sphere, +/- 20%.

7. The apparatus of claims 1, 2, or 3 further wherein the chamber comprises an approximately 1-10 gallon drum or similar container of any shape which is contained within an approximately 15-100 gallon drum or similar container or any shape with insulation between the two structures.

8. The apparatus according to any combination of the above claims further comprising a thermostat for controlling temperature in the chamber.

9. The apparatus according to any combination of the above claims further wherein the apparatus is configured as a retrofit to be inserted into a preexisting electric, gas, biomass, or solar heating or cooking apparatus.

10. The apparatus of claim 9 wherein the heater and/or controls of the preexisting apparatus are used to control operation of retrofit components.

11. The apparatus according to any combination of the above claims further wherein the heater is located inside the chamber.

12. The apparatus according to any combination of the above claims further wherein the heater is located outside the chamber.

13. The apparatus according to any combination of the above claims further wherein the heater is in thermal contact with the chamber.

14. The apparatus according to any combination of the above claims further wherein the heater is not in thermal contact with the chamber.

15. The apparatus according to any combination of the above claims further comprising a tube inserted into the chamber to allow venting.

16. The apparatus of claim 15 where the venting tube is connected at the lowest point of the chamber to drain away excess liquids from the cooking volume without losing excess heat.

17. The apparatus according to any combination of the above claims further comprising:

thermal storage to hold thermal energy, such as one or more of a phase change material or pieces of cement, ceramic and/or metals; or electrical storage through the use of a battery for instance.

18. The apparatus according to any combination of the above claims further wherein the chamber is configured as an oven for cooking food not generally submerged in liquid.

19. The apparatus according to any combination of the above claims further wherein the chamber is configured as a pot for cooking food generally submerged in liquid.

20. A method for configuring a cooking/heating/autoclaving apparatus comprising:
configuring a photovoltaic solar cell to be substantially directly connected to a heating element associated with the apparatus.

21. A method for configuring a cooking/heating/autoclaving apparatus comprising:
configuring insulation surrounding a cooking or heating chamber, wherein the insulation increases efficiency thereby decreasing the amount of power required to heat the cooking or heating chamber volume, wherein the insulation volume is substantially larger than typically associated with cooking/heating/autoclaving apparatus.

22. The method of claim 20 further comprising:
configuring insulation surrounding a chamber volume, wherein the insulation increases efficiency thereby decreasing the amount of power required to heat the chamber volume, wherein the insulation volume is substantially larger than typically associated with cooking apparatus.

23. The method of claims 20, 21, or 22 further wherein the chamber is a generally horizontal volume, such as a horizontal cylinder or horizontal rectangular volume.

24. The method of claims 20, 21, or 22 further wherein the chamber is a generally vertical such as a vertical cylinder or vertical rectangular volume.

25. The method of claims 20, 21, or 22 further wherein the cooking or heating chamber is a sphere, +/- 20%.

26. The method of claims 20, 21, or 22 further wherein the chamber comprises an approximately 1-10 gallon drum or other 1-10 gallon volumetric shape which is contained within an approximately 15-100 gallon drum or other 15-100 gallon volumetric shape with insulation between the two structures.

27. The method of claims 20, 21, or 22 further wherein the chamber comprises an approximately 1-10 gallon drum or other 1-10 gallon volumetric shape with approximately 15-100 volumetric gallons of insulation substantially surrounding the shape.

28. The method according to any combination of claim 20 to the preceding claim further comprising configuring the apparatus as a retrofit to be inserted into a preexisting electric, gas, biomass, or solar cooking/heating/autoclaving apparatus, such as stoves, ovens, water heaters, other commercial or industrial heaters.

29. The method according to any combination of claim 20 to the preceding claim further comprising:

configuring heater and/or controls of an original device to control heating to the heating chamber.

30. The method according to any combination of claim 20 to the preceding claim further comprising:

configuring the heater inside the heating chamber.

31. The method according to any combination of claim 20 to the preceding claim further comprising:

configuring the heater outside the heating chamber.

32. The method according to any combination of claim 20 to the preceding claim further comprising:

configuring the heater in thermal contact with the heating chamber.

33. The method according to any combination of claim 20 to the preceding claim further comprising:

configuring the heater not in thermal contact with the heating chamber.

34. The method according to any combination of claim 20 to the preceding claim further comprising:

configuring thermal storage to hold thermal energy, such as one or more of a phase change material or pieces of cement, ceramic and/or metals; and/or

configuring electrical storage to hold electrical energy, such as one or more of a battery or a gravity based energy storage system.

HIGH EFFICIENCY LOW POWER COOKING AND/OR HEATING

ABSTRACT OF THE DISCLOSURE

Cooking and/or heating apparatus using one or both of substantial insulation and a photovoltaic heating element provide new energy efficient cooking and/or heating options particularly effective for less developed areas.

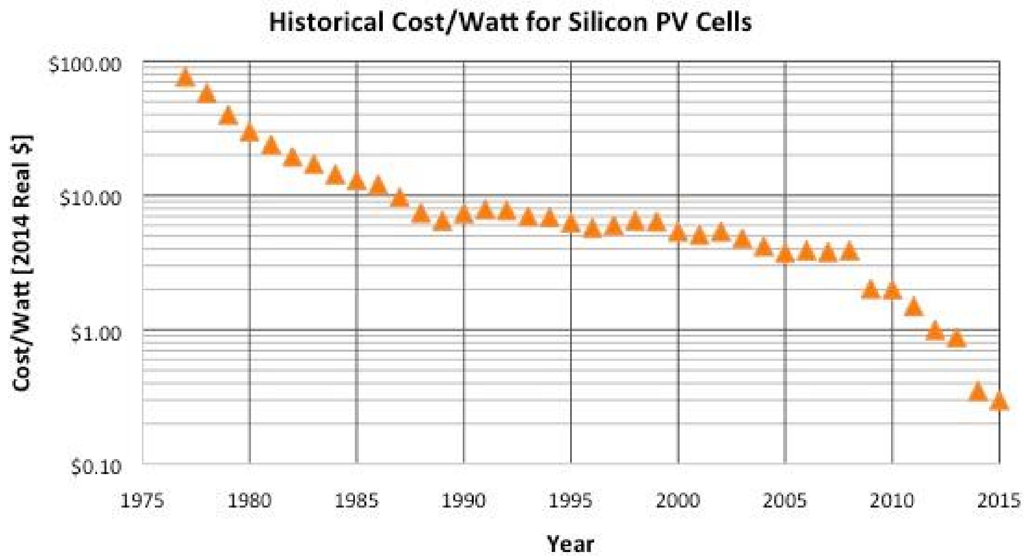


FIG. 1
(The steady decrease in cost of photovoltaic panel in $/Watt.)

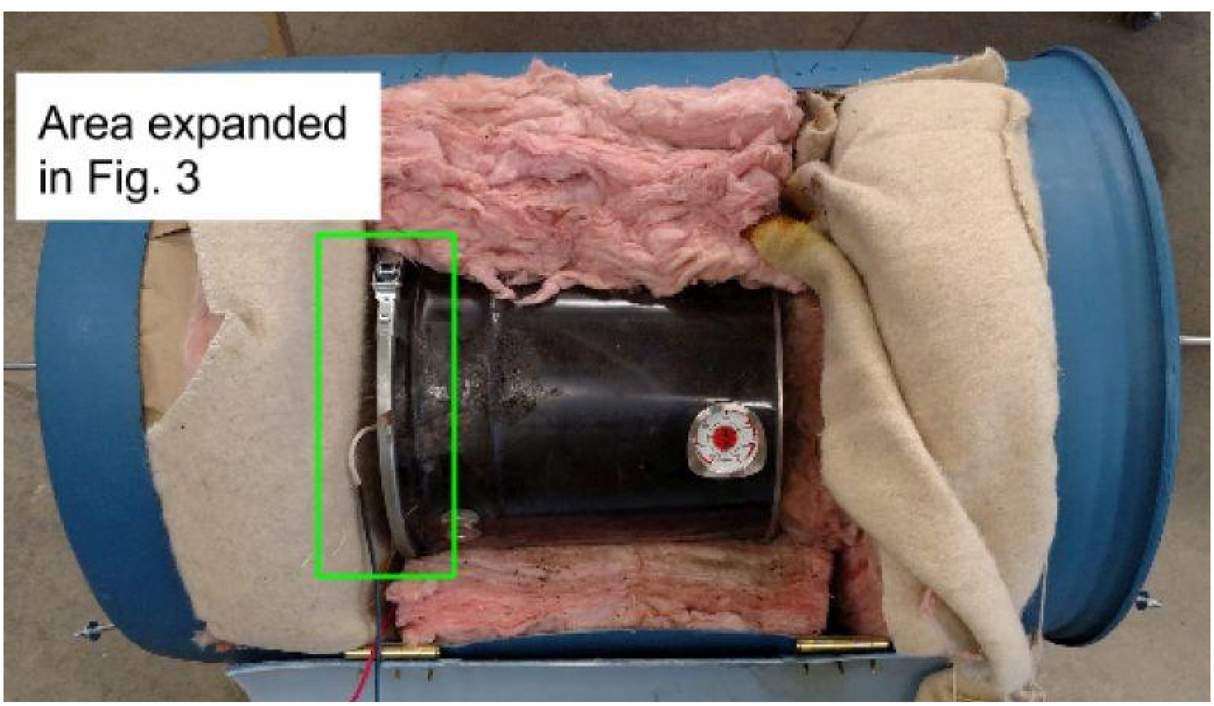


FIG. 2
(Placement in insulation)

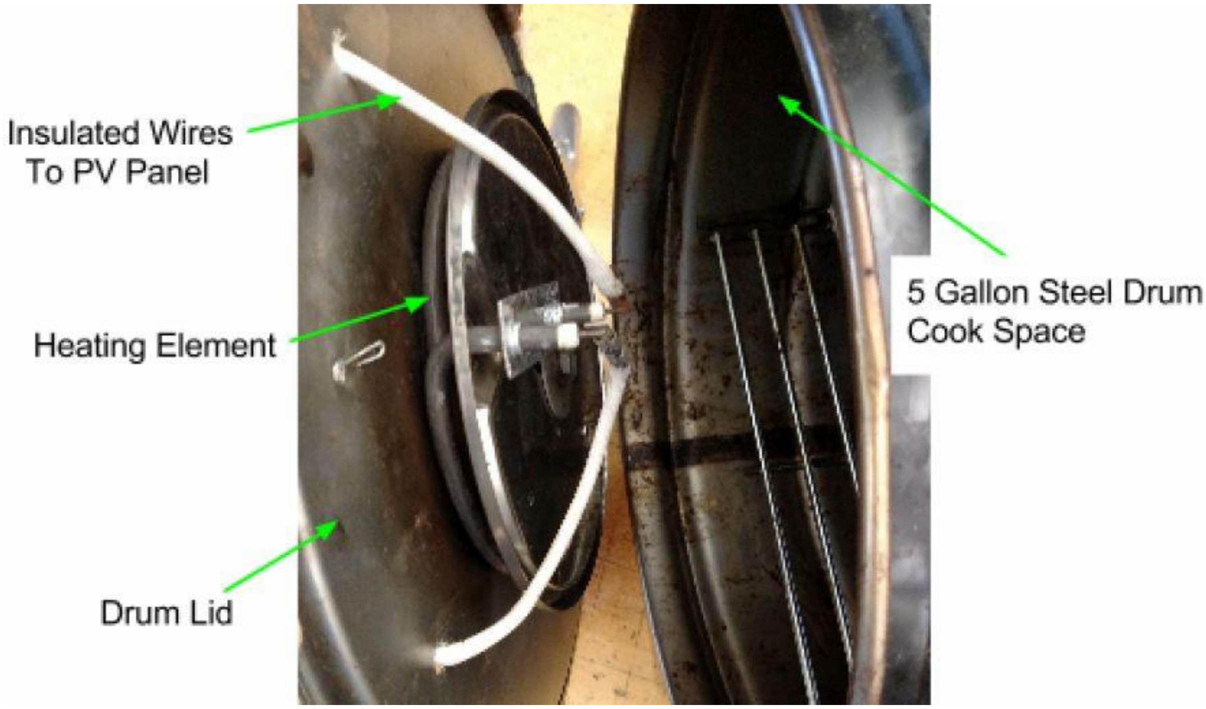
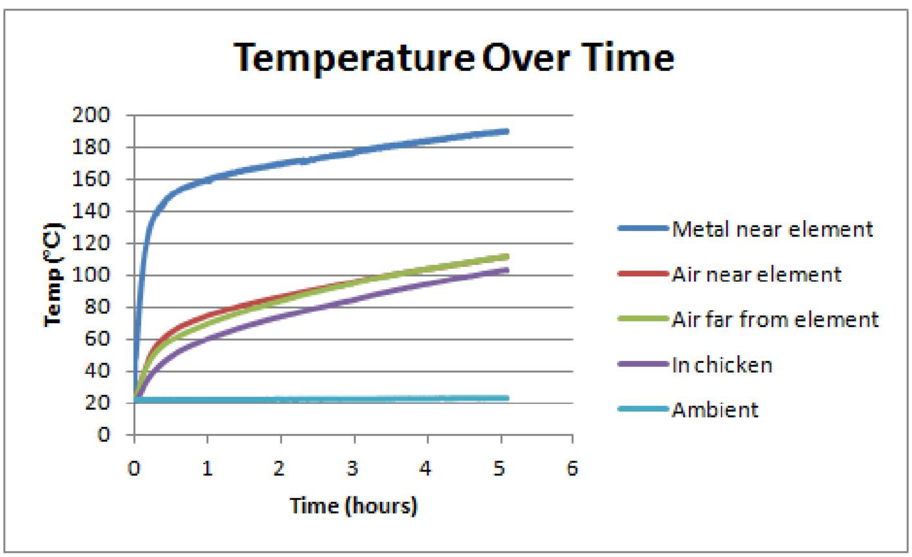


FIG. 3

(Cooking area with heating element)



(The Temperature v Time profile for the chicken bake)

FIG. 4