UNIVERSITY OF ILLINOIS CHICAGO ENGINEERING
Electrical and Computer Engineering

Electrical Design For A Stored Thermal Solar Energy

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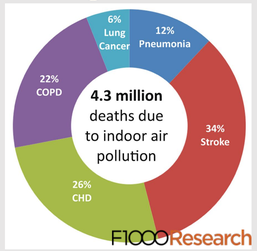
EXPO

Abstract

According to The World Health Organization, approximately 2.4 billion people worldwide cook with biomass and coal. As of 2020, approximately 3.2 million die annually due to household air pollution associated with cooking. A safer alternative to biomass cooking is using solar energy. Solar energy can provide a safe, smoke-free alternative method of cooking and facilitate auxiliary functions like water purification and lighting. Although solar cooking is a very safe cooking alternative, there are a lot of companies that make their solar cooking products too expensive or would inefficiently use the gathered solar energy. Our task was to design the electrical system for a stored solar thermal energy system that uses its energy optimally and is affordable to consumers in low-income countries. We created an intelligent switching system for heating and charging our expandable battery. We also designed an auxiliary power system with 1 type A and 1 type C usb port, providing 15 watts of DC output power. We've also done preliminary work on integrating an open source maximum power point tracking system into our device. Additionally, it has an easy to use interface with temperature and power monitoring and controls to adjust features. Therefore, with the design, we can efficiently use the solar energy of the thermal storage system.

Background

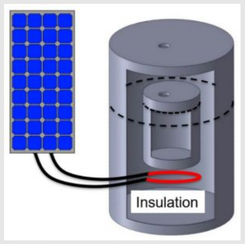


Apte K and Salvi S. Household air pollution and its effects on health [version 1]. F1000Research 2016, 5:2593 (doi: 10.12688/f1000research.7552.1)

Indoor air pollution is a crucial factor in daily life, and one of the causes is biomass or solid fuel cookings. Which caused the CO2 and polluted air emission.

According to World Health Organization
- around **2.4 billion** people worldwide cook with biomass fuel and coal
- household air pollution caused around **3.2 million** deaths per year in 2020
- both ambient and household air pollution are associated with **6.7 million** death annually

The models of thermal storage system:

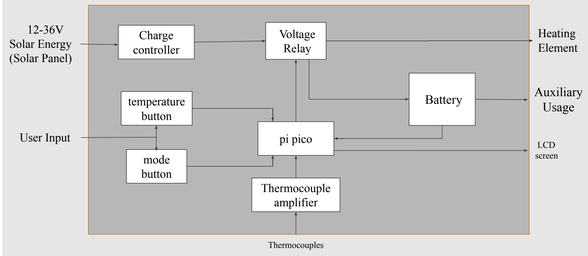


ISEC (Insulated Solar Electric Cooker) Sunbuckets: thermal storage system (heat container)

Engineering Requirements

- Accept generic solar load (12-36V, 100-300W)
- Expandable battery pack and 5V auxiliary power
- Must have a redundant temperature control system (100-500C, overheat protection)
- must have a user interface
- Power level of the system should be monitored
- The cost of material should be below $150
- Should track usage for potential carbon credit schemes

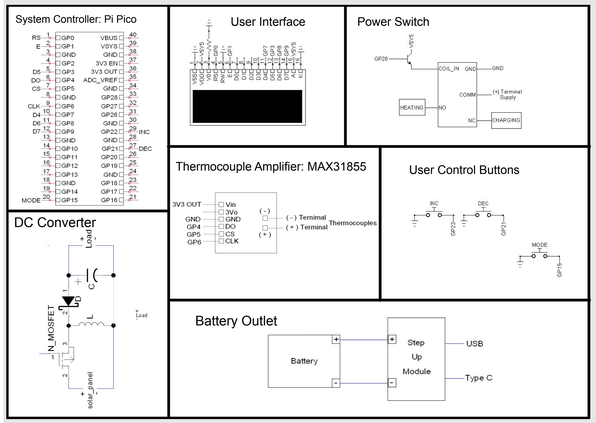
System Overview



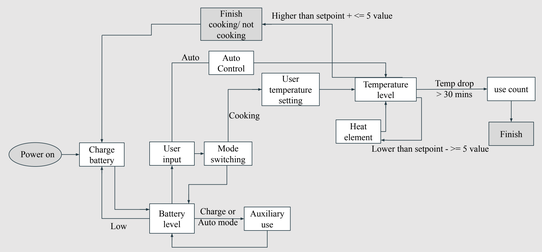
Design alternative

Design Alternative	Control Algorithm	Microcontroller	Temperature Sensor	Heating Element
	Manual switch	Raspberry pi	Thermocouple (voltage)	Nichrome wire
	Auto switch	Tiva c	Thermistor (resistance)	Power Resistor
	Manual & auto switch	Arduino	Thermopile IR (infrared)	PTC Cartridge Heater

Curcuit Diagram

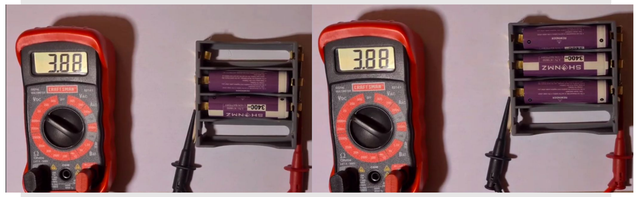


Software Design

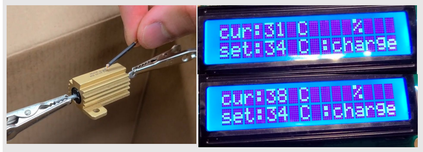


Testing and Results

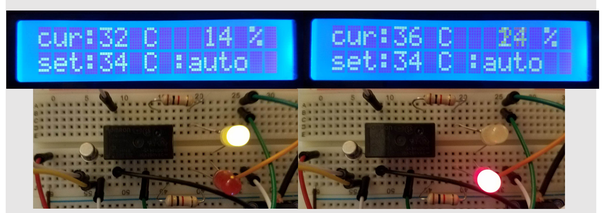
Graphs of Test Results and Pictures of PCB



expandable battery, by adding more battery cell the voltage output is not affected



Thermocouple sensor in contact with heater, results in the rise of temperature



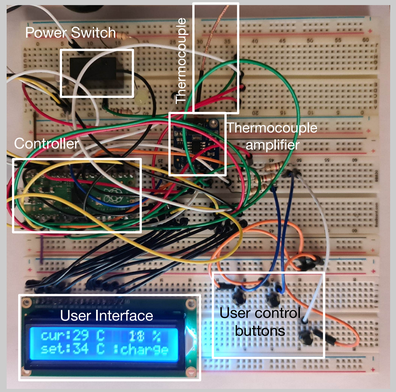
Relay switch using "curr" value as a trigger

yellow LED: charging battery mode
red LED: heating mode

A use count mode, by pressing all 3 buttons, to adjust the interval cooking time to be counted as one use

There are 3 mode:
charging the battery
cooking
auto (automatically charge and heat)

Final Design



The assembled circuit components using breadboard and jumper wires for connection. Following the circuit schematic of pin connections of each components. We derived with this generic circuit assemble on the breadboard

Conclusion

As the air pollution is a concern matter of the public health. many groups has risen the awareness of biomass fuel use. There are development in reducing the air pollution. Cooking with solar energy remains a fuel-saving technique, which can provide definite help in situations of fuel scarcity. Also, it helps us making the environment less polluted, less household air pollution. When there is an unlimited supply of the resources like solar energy, it is better to cook with solar energy.

Therefore, the electrical design for thermal storage system with an intelligent switching system and auxiliary expandable battery pack. Also, an easy to use interface with power monitoring and control features. With this design, we can reduce the carbon emission and household air pollution and efficiently use solar energy

Acknowledgements

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