EFFICIENCY FOR ACCESS

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Efficiency for Access Design Challenge Final submissions

Summary of the designs submitted by the participants

2019-2020

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Foreword

The Efficiency for Access Design Challenge is a global, multi-disciplinary competition that empowers teams of university students to help accelerate clean energy access.

The Challenge invites teams of university students to create affordable and high-performing off-grid appliances and supportive technologies. To provide sustainable energy for all, we urgently need to enhance the efficiency and affordability of high performing appliances.

By bringing together and inspiring students, the competition aims to foster innovation in the off-grid appliances sector. It also seeks to help address barriers that limit market expansion and to forge beneficial partnerships between universities, researchers and industry partners at a global level. In this way, it will further strengthen academic capacity within the off-grid sector.

Student teams from nine universities in Bangladesh, Kenya, Uganda and the UK have spent the year designing appliances or improving existing appliances for off-grid settings. Please read more in this year's Challenge Brief.

Team 001 - Standalone solar load management system

Derrick Sibo, Innocent Weredwong, Peter Mukasa, Silivio Obeti

MAKERERE UNIVERSITY

Theme(s) – Power management

Proposal

We have designed a load management system for DC loads to be used in rural hospitals and health centres in Uganda. These DC loads will be categorized into priority, intermediate and non-priority loads. The micro-controllers were designed to cut off current supply to the intermediate and non-priority loads depending on the battery capacity.

Project Summary

Makerere University is looking forward to prototype a stand-alone solar load management system to be used in rural hospitals and health centres that have no access to the grid electricity but are powered by solar mainly. The rural health centres, particularly those in Uganda, face several challenges and inefficient use of energy is one of the major challenges they face in carrying out their operations.

Key design highlights

The micro-controllers and the ampere hour meter are the key parts of our design. the ampere hour meter measures the battery capacity and then relays the information to the main micro-controller which is programmed to cut off current supply to the different circuits depending on the battery capacity. Additional micro-controllers are connected to these different circuits and these are in communication with the main micro-controller through communication cables.

Cost

The most significant expense is the software to be used in prototyping which is proteus software. It accounts for over 20% of the total expenses. Other additional components are readily available and are thus cheap.

How does your design help to work towards the Sustainable Development Goals?

Ensure universal access to affordable, reliable and modern energy services is target 7.1. With this project implemented, therefore, there will be improved standards of living because of the efficient use of solar energy. Efficient use of solar energy makes it sustainable and reliable.

Social, environmental and economic considerations

Most of the components are readily available and thus making the project design less costly. Our product does not emit any hazardous waste and thus has no negative effect on the environment. Socially, we are improving the quality of people's lives as we are enhancing energy usage in these health centers.

Link to the full report

Team 002 - Solar energy efficient fish dryer

Evarest Ampaire, Ivan Musingo, Fred Wanjara, Reagan Massembe

Theme(s) – Agriculture

Proposal
To develop a low-cost energy efficient solar fish dryer for drying fish in off-grid fish landing sites.

Project Summary
Processing of fish in Uganda is still underdeveloped in spite of high amounts of fish caught leading to heavy losses due to spoilage of fish. Inefficient technology in the country and expensive yet inaccessible electricity in off-grid areas like at landing sites cannot allow fishermen to preserve their fish easily. These off-grid landing sites also cannot allow use of refrigerators and electric dryers. There are existing solar dryers however they are inefficient for the fishermen since losses are recorded because of long drying hours. This project focused on designing a dryer that efficiently uses solar energies to preserve fish.

Key design highlights
The solar energy efficient fish dryer is a post-harvest equipment for preserving small fish by drying it using solar energy from the sun. The solar energy is in two forms: heat radiation and solar DC electricity. The electricity improves the air flow by using a DC fan hence increasing the drying rate of the small fish. The solar dryer can hold 100 kilograms of small fish for drying, it takes 6-day hours to dry small fish at one go, it is lockable during operation hence minimal supervision. It is contamination free and has temperature and moisture monitoring for quality drying conditions.

Solar DC enhances air flow to increase coefficient of heat transfer by powering the strategically positioned DC fan. A sensor system powered by solar DC monitors temperature and humidity in the drying cabinet in order to maintain the preferred drying conditions for higher quality.

Cost
The cost is derived from the cost of its components ($567). Installation labour takes $30, making the total cost of production of the fish dryer equal to $597-$600. Including a profit margin of 50%, the price of the fish dryer is expected to be 900 US dollars for the final customers.

How does your design help to work towards the Sustainable Development Goals?
The major problems faced by the customers tended to be solved by the solar dryer is:

- Loss of fish quality due to underdeveloped technologies to preserve it in off-grid regions thus it cannot easily be accepted in the market.
- Using solar electricity to aid in the drying of fish more efficiently than the existing sun drying method.
- The solar dryer will block contaminants from the fish as it dries.

Social, environmental and economic considerations
The fisher creates a free environment from usage of firewood to smoke and preserve food. From the cost analysis, a fisher will be able to save after purchasing the fish dryer. It includes charging ports that will help a user be able to keep connectivity while in an off-grid community. Fish dryer will contribute 95% to the health of lives, since to a greater extent, contamination of fish will be reduced. The design favors communities living on $2 per day as it is affordable in terms of purchase.

Link to the full report

Team 003 - Off-Grid Electric Pressure Cookers for Sub-Saharan African Communities

Joris Simaitis, Maryam Naqvi, Halaa Elhassan

Theme(s) – Cooking

Proposal
Communal DC electric pressure cooker powered by solar home system on a pay-as-you-go business model.

Project Summary
In pursuit of developing household level off-grid solar home system (SHS) electric pressure cookers (EPC), our studies determined that these were not feasible nor realistic for displacing biomass fuel cooking in low-middle income users. Hence, we developed a communal SHS EPC which showed not only much greater feasibility but would have cascading co-benefits. We developed a simple DC design, business model, supply chain and conducted an in-depth socio-economic analysis. The deployment of these would bridge transformative solutions for households, entrepreneurship, electrification, cooking and much more.

Key design highlights
- Communal Accommodation
- Off-grid DC
- Pay-as-you-go business model
- Cooperative customer route
- Entrepreneurship customer route
- Circular economy supply chain

Cost
- Solar Panels: $165, Batteries: $674, DC EPC: $70

How does your design help to work towards the Sustainable Development Goals?
- Bridges electrification + cooking indicators of SDG7
- Co-benefits to SDG1 No poverty (Providing productive activities and economic incentives)
- Co-benefits to SDG3 Good Health (Displacing toxic biomass fuels)
- Co-benefits to SDG8 Decent Work (Supporting productive activities and entrepreneurship route)
- Co-benefits to SDG5 Gender Equality (Women focussed design and empowering women)
- Co-benefits to SDG13 Climate Action (Displacing biomass fuels which have associated GHG emission supply-chains and using renewable energy)

Social, environmental and economic considerations
- Social: user-friendly interface, time savings, cost savings, opportunity-cost savings, gender equality, livelihoods, behavioural intervention strategies
- Environmental: displacement of biomass fuel, circular supply-chain of product, components and materials, general life cycle of the product, waste electronic and electrical equipment recycling
- Economic: cost savings, economies of scale, entrepreneurship, profitable and affordable PAYG schemes

Link to the full report

Team 004 - Design of a solar powered evaporative cooler

Kiraga Shafik, Ouga Moses, Tasobya Rollings

MAKERERE UNIVERSITY

Theme(s) – Refrigeration

Proposal
The designed machine is intended to preserve tomatoes and it is targeting farmers and other stakeholders in the preservation industry.

Project Summary
The idea is based on the concept of evaporative cooling. The increased post-harvest losses of tomatoes in sub-Saharan Africa are due to storage. Farmers, market vendors and other stakeholders use rudimentary methods of preservation which are inefficient because the other available methods are expensive, have high operational costs and run on A.C. As most areas have no access to power, there is a need to design an efficient system to preserve these items which is efficient and consumes less power, specifically through solar power.

Key design highlights
- Reservoir tank - stores water that is used to run the machine.
- Cooling chamber which stores the tomatoes to be preserved.
- Cooling pads - water from the tank drips through the pads. The enclosure of the four pads make up the cooling chamber.
- Water pump - water that drips through the pads is collected and pumped back to the tank.
- Suction fan - draws air to leave a cooler environment.
- Solar panel - solar radiation is collected and stored in the battery. This power is used to run both the pump and the suction fan.
- The system constantly runs therefore at any point the products will be preserved. The materials to be used shall be able to withstand the environmental conditions.

Cost
The machine design has components such as the suction fan which is 95 dollars, a solar panel at 55 dollars, a licensed version of solid works software at 150 dollars and a water pump at 20 dollars.

How does your design help to work towards the Sustainable Development Goals?
Increasing incomes of preservation stakeholders thus mitigating poverty, improve food security by reducing deterioration and ensuring access to affordable, efficient and sustainable energy which is an untapped resource; All these are in line with Sustainable Development Goal's 1,2 and 7. Therefore, this among others is a major contribution.

Social, environmental and economic considerations
In a social context, the stakeholders will be able to keep in touch with their customers with information regarding the level of ripeness of their products. It will change the status quo where buyers only come to buy and go. Secondly, the materials used have no impact on the environment. This is because the machine is not using any fuel powered components that could pollute the environment due to incomplete combustion. Lastly, the components are made from locally available materials which makes it cheaper to the stakeholders. This means, the stakeholders only need a little time to have a return on investment which helps to support the livelihood of families through an increase in their economic power.

Link to the full report

Team 005 - Design of a solar powered clay fridge refrigerator

Mark Musinguzi Musiimenta, Amati Dan Aggrey, Kasadha John Myles

MAKERERE UNIVERSITY

Theme(s) – Refrigeration

Proposal
Design and development of a solar-powered thermoelectric clay refrigerator.

Project Summary
We are looking to develop a dual cabin clay refrigerator that will use thermoelectric modules to provide the refrigeration effect. We will use the waste heat from these modules to cool the top cabin through evaporative cooling, thus increasing the refrigerated space with the same power input.

Key design highlights
We have introduced a double-walled top cabin that will increase the refrigerated space while efficiently using the waste heat generated from the hot side of the Peltier modules. This double-walled top cabin is similar to a pot-in-pot refrigerator and the evaporative cooling will be stimulated by the hot air being blown by the fan that dissipates waste heat. The stands lifting the top cabin from the bottom cabin allows air currents into the room to further improve the cooling effect produced by the evaporative cooling mechanism. Thermoelectric modules can directly use DC, which is the most common power source in off-grid areas.

Cost
Approximately 66 pounds. This cost can further be reduced by economies of scale in case of mass production of these units.

How does your design help to work towards the Sustainable Development Goals?
Our design could reduce the upfront and overhead costs incurred to run a refrigerator in the off-grid areas of Uganda. By using the comparatively cheaper clay cabinets, our system could be cost-effective and affordable to the majority of the rural farmers.

Solid-state thermoelectric coolers can operate with DC input hence making them adaptable solar which is a renewable energy source. Our local assembly of the refrigerator could provide employment to both the formal and informal sectors. This can increase income.

The use of solid-state coolers could reduce the emissions in the atmosphere because they involve no refrigerants. These refrigerators are also driven by solar energy, a renewable source. Ultimately, we will be offering more refrigerated space for the same upfront cost and the same power consumption, which will bring refrigeration to so many households.

Social, environmental and economic considerations
The use of clay as the main material and the decentralized manufacturing of our cabins will create many jobs along the supply chain. The decentralized manufacture of these cabins will reduce the emissions involved in the transportation of existing refrigerators from the point of sale to the consumer's residence. Clay refrigerators, at the end-of-life, can be remolded into bricks and other clay products offering us an advantage environmentally over existing plastic refrigerators.

Link to the full report

Team 006 - Solar Hob

Tom Eades, Tom Cosford, Lizaveta Ramanava, Barbora Mandatova

Theme(s) – Cooking

Proposal
A solar powered cooking unit utilising minimal materials in a cost-effective manner.

Project Summary
Solar Hob is a cooking intervention that has the potential to improve cooking methodologies for over 800 million people. Solar Hob utilises a solar powered hot plate design to reduce the negative effects of biomass cooking, whilst maintaining similar cooking techniques

Key design highlights
Reduced material consumption, minimal effort in use and minimised alteration to cooking methodologies

Cost
Minimised costs through the use of cheap materials and the potential for implementation of metal recycling schemes to further reduce costs

How does your design help to work towards the Sustainable Development Goals?
Improvements in public health, gender equality, life on land etc.

Social, environmental and economic considerations
Reduced pollution through the removal of need for biomass cooking, reduced deforestation, gender equality development etc.

Link to the full report

Team 007 - Solar Powered Water Pump - Carbon Nanotube filters

Holly Tree, Jordan Williams, George Moon, Holly Currier

Theme(s) – Cooking

Proposal
A solar-powered water pump which uses carbon nanotubes to purify water.

Project Summary
To ease water collection and cleaning to assist with cooking.

Key design highlights
Innovative Carbon Nanotube technology.

Cost
N/A

How does your design help to work towards the Sustainable Development Goals?
This is outlined within the concept note.

Social, environmental and economic considerations
See concept note.

Link to the full report

Team 011 - Design and Implementation of a Solar Powered Smart Irrigation System

Patrick Odong, Jordan Wasswa Nyombi, Yunus Bwambale, Joel Kalemba

MAKERERE UNIVERSITY

Theme(s) – Agriculture

Proposal

The conventional irrigation systems provide unnecessary irrigation to a given part of a field while leading to a lack of irrigation in other parts. Changing environmental conditions and shortage of water have led to the need for a system which efficiently manages irrigation of fields hence we have proposed a design of a smart irrigation system to use soil moisture content sensors to ensure effective and efficient irrigation

Project Summary

The aim of this project is to propose and design a system that addresses the need of soil moisture sensors in irrigation scheduling, a system we will be called a smart irrigation setting. This project was set out to eliminate human control. We have developed a low-cost PV smart water pumping system using a permanent magnet brushless DC motor drive coupled to a pump load. It costs $416 and has a payback period four months.

Key design highlights

- DC brushless motor to ensure efficient use of solar energy as the major power supply to an automatic irrigation system.
- Soil moisture sensor for continuous monitoring of the amount of soil water available to plants.
- Water level sensors to determine if watering was required for the plants based on the information obtained from monitoring the soil water content.
- Micro-controller unit to manage the autonomous system.

Cost

Our design costs an estimate of $416 and has a payback period four months.

How does your design help to work towards the Sustainable Development Goals?

Agriculture is the major user of fresh water, consuming 70% of the fresh water i.e. 1,500 billion m3 out of the 2,500 billion m3 of water is being used each year. One of the major problems in agriculture is non-optimal usage of water. It is estimated that 40% of the fresh water used for agriculture in developing countries is lost either by evaporation, spills, or absorption by the deeper layers of the soil, beyond the reach of plants roots.

The problem of agricultural water management is today widely recognized as a major challenge that is often linked with development issues. Therefore, our design ensures efficient and effective water use hence conserving water and wetlands at larger. Our design allows for the use of natural energy source which is a relief to off-grid areas.

Social, environmental and economic considerations

Our design directly addresses community livelihoods and economic problems by being affordable in the long run. Our design also helps conserve the environment by managing water requirement for agriculture.

Link to the full report

Team 012 - An Efficient Solar Irrigation System for Off-grid Areas of Bangladesh

Md Iftadul Islam Sakib

Theme(s) – Agriculture

Proposal
Low cost irrigation system for small scale farmers of off-grid areas.

Project Summary
Developing an irrigation system using local technology to ensure the winter vegetable irrigation as well as the pure and clean drinking water for the poor farmers of off-grid areas in Bangladesh.

Key design highlights
Low cost solution and high energy efficient.

Cost
A complete irrigation system under $200 for small farmers.

How does your design help to work towards the Sustainable Development Goals?
We have proposed a design which is using solar energy to ensure the water requirement of a farmer in off-grid areas. Overall system price is comparatively lower than the alternative solutions. The system can fulfil the water requirement of drinking as well, meeting the goal of affordable clean energy and water.

Social, environmental and economic considerations
Rural economy of the off-grid area will be benefited and it also helps to keep the environment clean.

Link to the full report

Team 013 - Design of an efficient battery charger for solar powered electric rickshaw for operating in the off-grid areas of Bangladesh

Khan Farhan Ibne Faruque, Nazmus Sakib Mustak, Pritam Azra Hassan, Debaleena Datta Gupta

Theme(s) – Power management

Proposal
A charger is designed that will efficiently charge li-ion battery pack with solar panel which is to be used from electric rickshaw

Project Summary
In the rural area, electric rickshaw is main source of income. Huge numbers of electric rickshaw charging at the same time overnight can put a toll on the grid, so using solar panels, efficient battery pack and efficient charger may increase income and decrease grid load.

Key design highlights
A highly efficient charger, lightweight in design, using full-bridge topology. Li-ion battery pack with high energy density with longer runtime.

Cost
See full report.

How does your design help to work towards the Sustainable Development Goals?
It would help the people living in places with no access to electricity.

Social, environmental and economic considerations
Less carbon footprint, less pressure on the national grid, and green energy.

Link to the full report

Team 014 – Jua Pot Pressure Cooker

Rachel Burstow, Tianzhu Lu, Tom Downey, Max Mackie

Theme(s) – Cooking

Proposal
The Jua Pot is a five-litre electric pressure cooker that can run off a typical solar 12 V DC supply. It has been designed for seamless integration with solar home systems (SHS).

Project Summary
The design of the Jua Pot achieves the design brief to create a super-efficient electric pressure cooker capable of operating from a 12 V solar-powered DC supply. Technically, the device will provide users with a clean energy and sustainable alternative to traditional, inefficient and polluting biomass cookers. By integrating safety valves, a lid locking mechanism, and programmed safety control features, the cooker design will mitigate user risks and will be capable of safely reaching an absolute pressure of two bar and a temperature of 121°C.

Key design highlights
Design features include insulation in both the cooking pot walls and lid to ensure minimal heat loss, creating an efficient cooking process. Low voltage requirements mean it can easily integrate with SHS.

Cost
£45 sold to businesses

How does your design help to work towards the Sustainable Development Goals?
- Goal 3: Ensure healthy lives and promote well-being for all at all ages
- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all
- Goal 13: Take urgent action to combat climate change and its impacts

Social, environmental and economic considerations
The device would directly help to address UN Sustainable Development Goals (SDG) 3 ‘Good Health and Well-being’ and SDG 7, to ‘ensure access to affordable, reliable, sustainable and modern energy for all.

Used as an alternative to carbon-based biomass fuel sources that approximately three billion people currently rely on, it would significantly improve household living standards. Particulate and chemical pollutants released from inefficient household stoves contribute to multiple diseases such as stroke, ischemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer. The World Health Organisation states exposure to this kind of household air pollution is responsible for 3.8 million premature deaths per year.

Link to the full report

Team 016 - eCook for Developing Countries

Calum Watkins, Wei-Wen Tan, Iain Wright, Elliot Wilson, James Thompson

Theme(s) – Cooking

Proposal
Development of a diode electric cooker prototype for a Zambian social enterprise called Zayohub.

Project Summary
In developing countries across the world people cook using open fires that burn solid biomass fuels such as coal, charcoal and wood. Cooking in this way leads to a plethora of issues, both locally and globally, such as severe health problems and deaths caused by fumes, significant environmental damage, and various socio-economic problems that stem from the collection and use of solid fuels. The report outlines the design process and development of an easy to use, user-orientated solar powered electric cooking (eCook) device that could serve as a potential replacement to open-fire cooking in areas where it is widely practiced.

Key design highlights
The cooker relies on low power diode electric heating technology with energy monitoring capability. It has a simple, robust construction, energy efficient insulated design and should be easy to maintain. An affordable business model was created to work for low users.

Cost
The project costs were around £410 but subsequent cooker designs would be in the region of £50. Major costs included metal work for the casing, diodes of different specification to test their performance and the pots.

How does your design help to work towards the Sustainable Development Goals?
- SDG3: Health - Each year, 3.8m people die prematurely from illness attributable to household air pollution from inefficient cooking
- SDG7: Energy - Around 3b people cook using open fires or simple stoves causing 1.2% of global CO2 emissions
- SDG8: Economy - More than 40m worker years are wasted each year on fuelwood gathering and biomass cooking.
- SDG10: Equality – Pollution exposure is particularly high among women and young children.
- SDG15: Environment - In Africa, approximately 50% of all trees removed are used for cooking.

Our Solution
- Provide an affordable, efficient, user-friendly and reliable diode electric cooker.
- Provide a clean energy solution which would reduce mortality rate attributed to household air pollution.
- Enable through innovative financing and modelling, the increased usage of electricity and solar power systems.
- Focus on rural off-grid Zambian communities.

Social, environmental and economic considerations
- Provide an affordable, efficient, user-friendly and reliable diode electric cooker.
- Provide a clean energy solution which would reduce mortality rate attributed to household air pollution.
- Enable through innovative financing and modelling, the increased usage of electricity and solar power systems.
- Focus on rural off-grid Zambian communities.

Link to the full report

Team 017 - Kijiji

Raymond Kiyegga, Fredrick Amariati, Alex Osunga

Theme(s) – Business models

Proposal
A solar powered container with essential services for empowering rural communities and extending battery supply to distant homes.

Project Summary
Kijiji seeks to provide access to energy together with societal development to contribute to poverty reduction as well. Our business case is based on building and thereafter the communities can own and operate the solution on their own using a solar powered container. Rural communities are strengthened by togetherness and having such a collaborative solution would harness the power of synergy to bring together these communities to actions of development. The materials for this prototype shall be sought locally and therefore contributing to the local talent.

Key design highlights
Power is generated by a solar photovoltaic system. The system sizes ranges from 15kW to 50Kw, with a battery storage ranging from 4000 - 8000AH able to power the applications. The range provides flexibility such that if the rural market needs change, the system capacity can be varied accordingly. The system also comprises of charge controllers connected in parallel to regulate the charging and discharging of batteries. Direct current generated by the solar photovoltaic system is converted into alternating current by inverters that are connected in parallel.

Cost
See full report

How does your design help to work towards the Sustainable Development Goals?
Ensuring universal access to affordable electricity means investing in clean energy sources such as solar energy. This will reduce the cost of electricity to the small households

Kijiji has a component of a medical facility powered by the solar energy to ensure that rural area populations have access to affordable general medical care for all. This will ensure that mortality rates go down. Our focus will be on indigenous and vulnerable rural households, particularly female headed families and children.

Kijiji has a component of an educational facility driven by new technologies that will offer access to the internet where the youth can learn through access to quality digital content.

Social, environmental and economic considerations
- Minimize post-harvest losses through cooling / refrigeration facility, which should result in increased yields and enhanced revenues that can be used on other components to improve lives.
- Lengthen operating hours, beyond the current 6 to 8 hours, with the ultimate goal of 24 hours service.
- With the spaces for renting / leasing, women and youths will be prioritized and supported with capacity to run own enterprises.
- Provide space for women and youths to nurture their ideas within their settings without having to travel to the urban centres.

Link to the full report

Team 020 - Off-grid Refrigeration Solution (ACE)

Jey Ashokkumaar, Javier Klatovsky-Buey, Llyr Jones, Eliot Serrano-Davey, Thivinesh Pathmanathan

Theme(s) – Business models

Proposal
Fridge powered by ethanol adsorption to a carbon bed.

Project Summary
Fridge powered by ethanol adsorption to a carbon bed.

Key design highlights
Low electricity usage as all is needed is to heat up the carbon bed to provide refrigeration.

Cost
Difficult to estimate, estimated at £86 pounds for the cooling unit alone.

How does your design help to work towards the Sustainable Development Goals?
Very low energy usage in design.

Social, environmental and economic considerations
Payment schemes being considered to account for low income of target market.

Link to the full report