EFFICIENCY FOR ACCESS

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EFFICIENCY FOR ACCESS RESEARCH AND DEVELOPMENT FUND: INNOVATOR SERIES

RETROFITTING REFRIGERATORS TO CREATE AN AFFORDABLE, ENERGY EFFICIENT COOLING SOLUTION

In Sub-Saharan Africa, there are low rates of access to rural electrification, and consequently, refrigeration. People living in rural areas and remote communities are especially affected – in 2021, Sustainable Energy for All estimated that a combined 389 million people among the rural and urban poor on the African continent lack access to cooling solutions.

Lack of access to refrigeration can cause numerous issues. Food has to be prepared for each meal since it cannot be stored safely. This increases the physical burden on women, who are typically responsible for tasks such as preparing meals and shoping for groceries. As a result, limited access to refrigeration means that women need to spend longer preparing meals, and food may be wasted.

Refrigerators can allow families to save money, reduce food waste, and help women by reducing the amount of time that they spend preparing food. However, the initial cost of refrigeration, including the solar system to power it, is around $1000. Therefore, affordability is still a very significant barrier to access that needs to be addressed.

DID YOU KNOW?

In Sub-Saharan Africa, only 3% of the total agricultural output is refrigerated at the last mile.

INSTITUTE OF SYSTEMS AND ROBOTICS

The Institute of Systems and Robotics is based in the University of Coimbra (ISR-UC) in Portugal. ISR-UC is a private, non-profit research institution founded in 1992. Its purpose is the creation of a first class, multi-disciplinary research team, able to carry out leading-edge research in several important areas of science and technology, with a special emphasis in systems and robotics. ISR-UC promotes advanced multidisciplinary research and development in the off-grid appliance sector.

The Efficiency for Access Research and Development Fund supported ISR-UC to develop an affordable, highly efficient refrigeration system for low-income families in Sub-Saharan Africa.

ISR-UC :

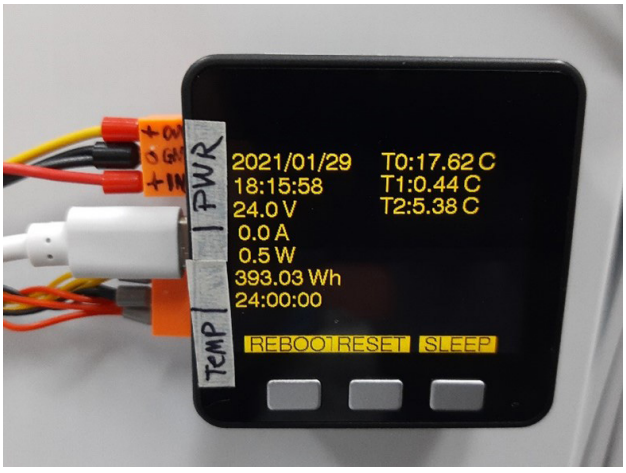
" Support from the Efficiency for Access Research and Development Fund has made an important contribution to driving the off-grid market towards cost-effective, energy efficient refrigerators. We believe our research could be an important step to improving the living standards of people in remote communities without access to modern energy services, by helping to reduce food and energy poverty in these regions."

– Nuno Quaresma, Researcher, Intelligent Energy Systems, Institute of Systems and Robotics, University of Coimbra

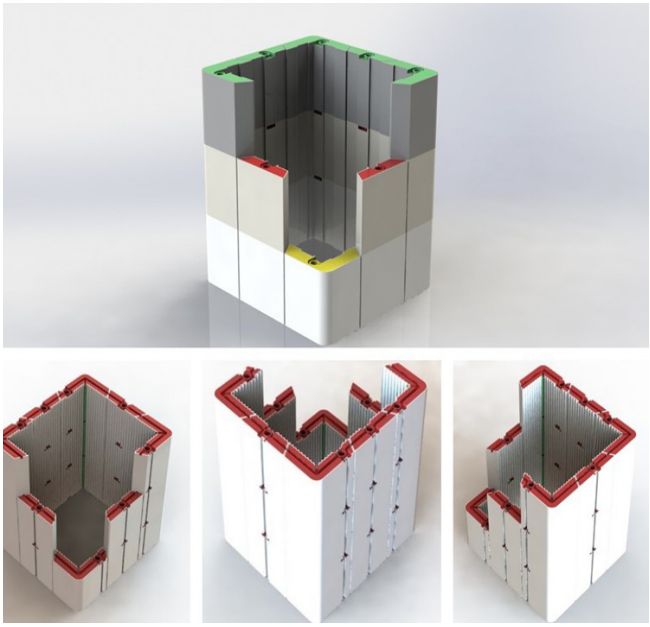
RETROFITTING AC APPLIANCES TO BECOME SOLAR-POWERED

The project started by retrofitting two standard alternating current (AC) cooling units to become a solar-powered, direct current (DC), one-door, vertical refrigerator and a horizontal freezer. ISR-UC incorporated new features into the refrigerator and freezer to improve overall efficiency, and therefore reduce operating costs. These included:

- **Installing super-efficient variable speed compressors (VSC)** using permanent magnet technology instead of the typical fixed-speed compressors. Permanent magnet motors can make refrigerators more efficient, and are often smaller compared to standard motors, making installation and maintenance much easier.
- **A smart controller** to manage the entire system (refrigerator/freezer and the solar system including the storage system charging/discharging). This allows the end-user to monitor and manage the system's power, making the cooling system more reliable and alerting the end-user to any maintenance issues.



- **A solar home system that uses Lithium Iron phosphate (LiFePO4) batteries.** Compared with typical lithium batteries, LiFePO4 batteries have a higher charging and discharging efficiency, higher battery safety performance and capacity, longer life-cycles, and perform better at higher temperatures. This makes them incredibly well-suited to use in Sub-Saharan Africa.
- **The use of phase change materials (PCMs).** For this project, ISR-UC used water and salt to work as a thermal battery. This material is used to collect thermal energy during the equipment freezing cycles and releases the same energy during the melting cycles. This means that the VSC needs to run for a shorter period of time, increasing the overall energy efficiency of the equipment with the same temperatures inside the refrigerator/freezer.



The project also tested the impact of using new insulated materials – Vacuum Insulated Panels (VIPs) – as a way to improve the equipment's energy efficiency. VIPs have a significant impact on the overall energy consumption, improving the energy performance by 30%.

ISR-UC also included a number of features to enable disabled people, especially those in wheelchairs, to use the refrigeration units more easily. The refrigeration unit features an easy-grip handle, which can help people reach food items, and an anti-fog mirror to help locate them. The dimensions of the existing refrigerator and freezer were also taken into consideration, to make the refrigerator as accessible as possible at varying heights.

WHAT DID THE PROJECT ACHIEVE?

ISR-UC conducted extensive tests on its prototypes in controlled environment chambers and used the standards from the 2019 Global LEAP Awards refrigerator competition. The company concluded that:

- This prototype has an energy consumption of 0.418 kWh/day. As a result, the refrigerator prototype could rank in the top three energy efficient, off-grid refrigerators, according to the 2019 Global Leap Award results.
- In this case, it was hard to compare the results of the freezer with other products since the 2019 Global LEAP Awards do not have a specific category for freezers. The freezer prototype consumes 0.506 kWh/day. However, considering that the energy consumption of the winner of the Refrigerator-Freezer Combination Unit category was 1.091 kWh/day, ISR-UC's prototype consumes consumes 0.506 kWh/day, 50% less power than the category winner.

WHAT DID WE LEARN?

Using PCMs can significantly improve the energy efficiency and affordability of refrigeration units. Using PCMs in the project significantly increased the efficiency of the refrigerator and freezer by reducing the required on-time of the VSC. This is an important outcome, as the project is helping to showcase the benefits of using PCMs for the off-grid appliance sector. Using cost-effective materials in the PCM container and in the PCM itself, is extremely important to make the equipment affordable for the consumer. Using salt and water as the PCM allows the user to replace the PCM if any accidents occur, such as spills. Additionally, the mass production of containers is important to reduce their price, allowing the consumer to replace them if any problem occurs.

Using VIPs can increase the performance of cooling technologies. ISR-UC found that the performance of the VIPs was far higher than initially expected, with a reduction of energy consumption close to 30%. Although VIPs are not the standard material used in insulation, this project showed their efficacy, and ISR-UC plans to demonstrate this to manufacturers of off-grid appliances through the use of its pilot refrigeration units.

USING CUTTING-EDGE INSULATION MATERIALS TO FURTHER IMPROVE ENERGY EFFICIENCY IN COOLING

During this project, ISR-UC researched a new material, aerogel, which can be used for insulation, and is up to three times more effective than traditional expanded polystyrene. The company plans to explore its potential to improve the overall efficiency of refrigerators.

ISR-UC also plans to develop a cold storage room, informed by the findings from this project. These community-sized "refrigerators" can help entire villages to store fresh produce for longer, which will improve the living standards of rural communities. ISR-UC is also analysing the refrigeration controls for these large cold rooms to enhance the overall energy efficiency of the equipment.

GET IN TOUCH:

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