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EFFICIENCY FOR ACCESS RESEARCH AND DEVELOPMENT FUND: INNOVATOR SERIES

DEVELOPING AN AFFORDABLE, HIGH-PERFORMING SOLAR-POWERED FRIDGE FOR SUB-SAHARAN AFRICA

Reducing cost and increasing performance in off-grid refrigeration using phase change materials and innovative design

Solar refrigeration solutions are critical to the livelihoods of many people living in rural, off- and weak-grid areas of Sub-Saharan Africa. These help to keep food, drinks, medicines, and other produce fresh for longer and provide a much-needed source of income. However, two key issues of solar-powered refrigerators on the market today are cost and efficiency.

With an average cost of around $1,300-$2,000 for a medium-sized system, solar fridges are too expensive for much of rural Sub-Saharan Africa. While current low-energy options have been awarded for high efficiency (Global LEAP 2019-20), they tend to struggle with maintaining the required cold temperatures when dealing with a high turnover of newly added produce, especially when ambient temperatures are particularly high. This challenge of producing a world-leading cost-effective and high-performing refrigerator was taken on by Amped Innovation, with support from the Efficiency for Access Research and Development Fund.

Headquartered in the USA, Amped Innovation (Amped) specialises in off-grid solar products and appliances. Recognising that battery costs are the biggest contributor to the price of current solar fridges, Amped opted to test a phase change material (PCM) 'ice battery' approach. PCMs absorb heat as they melt and can be 'recharged' through cooling until they crystallise and release the stored energy back into the environment. Amped has used a combination of PCM geometry, a hybrid PCM alongside a LFP (Lithium Ferro Phosphate) battery and customised air circulation to develop a revolutionary, affordable high-performing solar fridge.

AMPED INNOVATION

We don't see multinational appliance companies developing off-grid solar fridges for use in rural Africa or Asia. No doubt it's a challenging market. However, at Amped Innovation, we have found that the reward is worth the risk, especially given the impact we can create, namely, local green jobs with the final assembly of fridges in Africa and new sources of income generation for small businesses.

Andrea Kleissner, Co-CEO at Amped Innovation

Customer feedback leads to continuous improvement

The company's approach to product development involves 'building up' from a minimally viable product, which is improved upon by gathering customer feedback and incorporating the learnings into future iterations.

Further to this, the first solar fridges were modular, enabling the team to test different configurations with end users and in different use cases.

Allowing for a range of 20-200Wh of LFP battery and 40-160W of solar panels, the initial product developed with support from the Efficiency for Access Research and Development Fund was powerful but had a limited runtime after sunset. Customer feedback informed the team that users needed more power than the maximum 200Wh provided by the battery. This led Amped to test the integration of a PCM 'ice battery' which would complement the electrical storage and meet customers' runtime demands and cost constraints.

DID YOU KNOW?

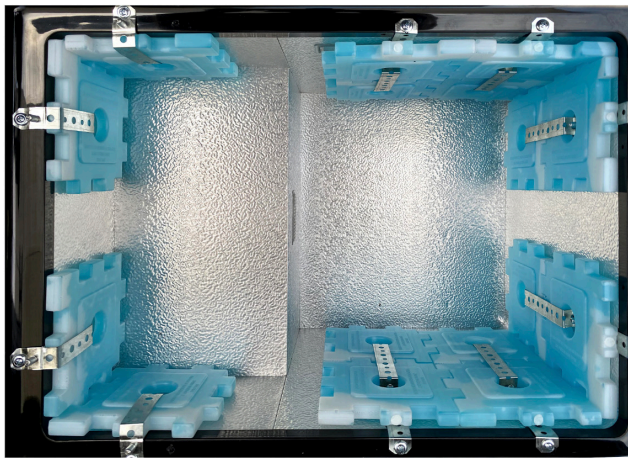
Only 4% of rural areas in Africa have access to refrigeration

A local shop uses an Amped 100 litre solar fridge to keep drinks cold and fresh for consumers.

A focus on performance

By focusing on specific design elements, such as building a custom fridge controller, Amped ensured strong thermal control. Amped's fridge was able to hold within 0.5 degrees Celsius, instead of the 10 degrees Celsius flux seen in other solar fridges. They were also able to maintain comprehensive control of the compressor and all powered components within the fridge. Furthermore, they improved the drive train efficiency by 18%, compared to the default controller supplied by the vendor.

A 'shelf storage' mode designed by the team allowed the fridge to remain in storage for over a year, without any impact on battery life. Finally, to ensure high performance in a hot, humid environment like Africa, Amped used a >100W compressor to maximise cooling power (2x larger than others on the market). This quickly became one of the most beloved features for small retail entrepreneurs who need to cool drinks quickly to command a premium price.



This image shows the inside of the 100-litre solar fridge with thermal energy storage.

An emphasis on cost reduction

With a focus on improving affordability, the Amped team used water in the PCM battery, instead of a specialised paraffin solution, accompanied by a thermal control scheme to prevent carbonated drinks from freezing. Integration of an ice battery results in a $160 saving for the end-user. By considering cost-effectiveness in every element of the design – from affordable sensors to circuits comprised of fewer components – the final system is retailing for under $735 (with PAYGO financing) and will eventually be under $600 at higher volumes later this year. The team also designed the fridge in a way that enables final assembly locally, which could reduce costs further through lower import duties and smaller shipping volume, with the added benefit of creating local, green jobs.

WHAT DID WE LEARN?

Quality pays for itself in reducing last mile warranties

With over 7 years' experience of selling solar products in Sub-Saharan Africa, Amped has learned that low warranty rates are essential to success. Each warranty claim costs twice as much to service in a remote or rural area than an urban one, so it was critical to build comprehensive data logging, diagnostics and Bluetooth data transfer into the solar fridge. Accordingly, additional support was unlocked from the Efficiency for Access Research and Development Fund which enabled Amped to add high impact, low energy Bluetooth functionality in the latter stages of the project. This allows the team to quickly analyse the performance of the initial hundreds of products sold, and deal with any issues and fine-tune components.

Resistance to challenging the status quo

The Amped team was surprised by the resistance to their proposed design changes from various fridge vendors. Vendors they engaged with were against deviating from the status quo and all recommended the use of a small compressor at low power. Persistence and familiarity with manufacturers enabled the Amped team to find the right partners and convince them to try something new. While the impact of COVID-19 created logistical challenges for Amped during their product pilots, support from distribution partners on the ground helped to overcome obstacles.

AMPED INNOVATION

The Efficiency for Access Research and Development Fund is providing crucial R&D support for customers who would otherwise be left behind. As a sector, we have a lot of catching up to do, since fridge access is still only at 4% in rural Africa. Thanks to the Efficiency for Access Research and Development Fund for supporting this pivotal work.

Kurk Kuhlmann, Co-CEO at Amped Innovation

Users want high-performing products

The overarching lesson from the project was that people want efficient performance from their appliances, not just affordability. The end goal should be to develop a product with the best performance/cost ratio, not to create the cheapest appliance.

From early prototype to production-ready fridge

The Efficiency for Access Research and Development Fund enabled Amped Innovation to progress through the product development lifecycle, from early prototypes to production-ready fridges. The first production run of fridges was completed in Q2 2023 and is being deployed across Sub-Saharan Africa.

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