EFFICIENCY FOR ACCESS

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EFFICIENCY FOR ACCESS RESEARCH AND DEVELOPMENT FUND: INNOVATOR SERIES

HOW SMART CONTROLLERS CAN HELP TO UNLOCK UNIVERSAL ACCESS TO DOMESTIC REFRIGERATION

HOW DOMESTIC REFRIGERATION CAN CHANGE LIVES

Access to refrigeration at the household level can provide a wide range of benefits, from extending the life of fresh produce to reducing the time spent on gathering and preparing food (especially for women and girls).

However, many households in poor, rural settings cannot afford off-grid refrigerators, which can be used in areas with no access to electricity. Including system costs, existing 100-litre off-grid direct current (DC) refrigerators cost at least US$1,000 in Kenya. As a result, only 17% of households in sub-Saharan Africa have a refrigerator, and appliance ownership among off-grid households is substantially lower.

DID YOU KNOW?

Only 4% of off-grid African households are equipped with a refrigerator

While the market for alternating current (AC) refrigerators used in developed countries is mature, the direct current (DC) refrigeration market remains nascent. There are few manufacturers active in the sector with limited levels of investment going into research and development projects.

However, DC refrigeration has many benefits, including using refrigerators directly with photovoltaic panels and a battery. This can be critical in making domestic fridges more affordable for low-income populations in rural settings, by reducing overall system costs and levels of maintenance required.

Traditional grid-powered refrigerators use AC compressors, whereas the preferred choice for off-grid DC refrigerators are brushless DC (BLDC) compressors. Existing DC refrigerators have little in the way of intelligent load control or are intended for use with large battery systems, resulting in a higher system cost.

DID YOU KNOW?

Off-grid, direct current refrigerators cost at least US$1,000 in Kenya

The Efficiency for Access Off-Grid Refrigeration Technology Roadmap identified priority areas that the Efficiency for Access Research and Development Fund aims to address. The roadmap identified compressor controllers as a critical investment to help address challenges in the off-grid refrigeration sector.

SURE CHILL'S SMART BOX: ADDRESSING THE NEED FOR SMART CONTROLLERS

The Sure Chill Company is a cooling technology company based in Cardiff, Wales, United Kingdom. Its patented technology harnesses a unique property of water to enable continuous cooling from inconsistent power. It removes the need for a battery by converting electricity into thermal energy and storing it in the form of ice in a water-filled chamber that surrounds the interior where food, drinks and medicine can be stored.

The Efficiency for Access Research and Development Fund supported Sure Chill in the development of an innovative refrigerator control platform and compressor combination for integration with a solar home system. The aim was to develop a prototype device that could be scaled for mass production.

After creating the first version of its prototype, the Sure Chill research and development team developed its latest controller version: the GEN2 Smart Box. The core features are —

- **Versatile interoperability:** The GEN2 Smart Box can be used in applications ranging from battery-less solar direct-drive and small solar home systems to mini- and weak-grid settings. It includes a communication module that enables integration with existing Pay As You Go (PAYGO) solar home systems. The GEN2 Smart Box also enables compatibility with a wide range of DC compressors.

- **System monitoring and management:** The GEN2 Smart Box monitors the state of the refrigerator, the Sure Chill thermal storage and the incoming power supply. This enables it to optimise the compressor operation, enabling the refrigerator to maintain an optimum temperature without compromising other loads on the system.

- **Compressor driver protection:** The GEN2 Smart Box acts as an interface between the power supply and the brushless DC compressor driver. It protects the driver from electrical faults and power surges and is compatible with a range of DC compressors.

SURE CHILL :

"The Efficiency for Access Research and Development Funding was pivotal in enabling Sure Chill to develop its Smart Box refrigeration control platform. This has led to significant reductions in the cost of off-grid domestic refrigeration, an important step towards unlocking universal and clean access to refrigeration"

- Sam Mann, CEO, SureChill Global

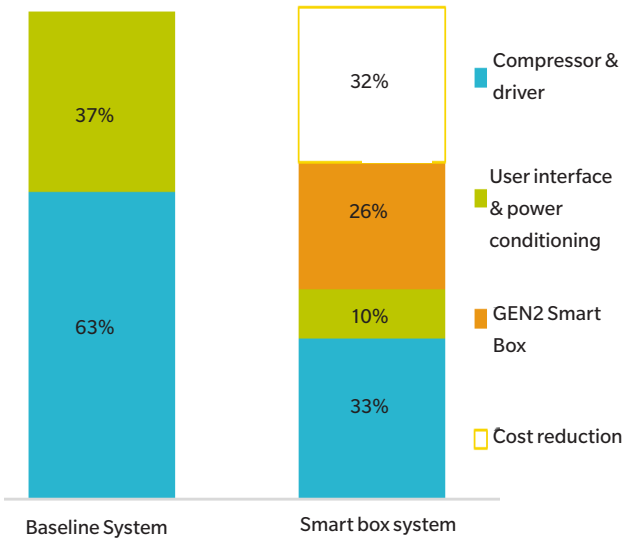
WHAT DID WE LEARN?

Smart controllers help to bring down the overall cost

The integration of the smart controller into Sure Chill's off-grid domestic refrigerator led to a 32% cost reduction for the compressor control system. It eliminates the need for large capacitors that had been required to meet the high in-rush current of the DC compressor.

The controller performs additional functions, such as powering the user interface, providing a robust supply protection and solar home system authentication, optimising fridge cycle control. These functions enhance the performance of the refrigerator for use in off-grid domestic settings. Sure Chill estimates that adding a smart controller results in an US$84 cost reduction for the end-user.

Graph: Costs for Smart Box system vs baseline DC system



Control platforms are essential for progress towards interoperability

Using brushless DC compressors in off-grid appliances is an emerging trend. An important feature of the Sure Chill GEN2 Smart Box is that it can be used with any brushless DC compressor driver and in a variety of system configurations. Developing such controllers can help facilitate the growth of an open and competitive appliance market.

Authentication protocol allows for seamless integration into existing sales models

Sure Chill worked closely with two solar home system distributors to integrate an authentication protocol into the GEN2 Smart Box. It enables customers to unlock the device remotely and the smooth transfer of data between the solar home system and the refrigerator. This is vital to in-country distributors as it enables them to control the asset. Integrating an authentication protocol was initially more challenging than expected, but Sure Chill worked with several key players in the sector including Solaris OffGrid to overcome this.

ON THE PATHWAY TO MASS PRODUCTION

The first version of the smart controller developed by Sure Chill has already been integrated into 90 domestic refrigerators delivered to Kenya for a sales trial with a solar home system provider working across sub-Saharan Africa. Larger production runs are planned for 2021 and will incorporate the GEN2 Smart Box controller, which is being finalised for full production. Development of the third-generation smart controller is already underway and will build on the lessons learnt from the first two iterations.

In 2018 Sure Chill received funding from Efficiency for Access Donor Coalition member, Shell Foundation, to assist the development of its domestic refrigerator from prototype to pre-production. Alongside this initiative, the Efficiency for Access Research and Development Fund has enabled Sure Chill to develop a novel control platform that will be integral to their off-grid domestic 65-litre refrigerator. Mass production is due to start in 2021, representing a significant step-change in Sure Chill's evolution. At scale, this will further reduce unit costs, ultimately benefitting the end-user.

Efficiency for Access' support has also enabled Sure Chill to explore partnerships with a range of organisations. These include UK electronics companies, solar home system distributors in sub-Saharan Africa, PAYGO software providers and compressor manufacturers in Asia. The latter has resulted in a collaborative partnership to optimise the performance of the compressor in the Sure Chill refrigerator. Further, Sure Chill has leveraged the partnership to influence the manufacturer to work with natural refrigerants that have low global warming potential such as R-600a.

PROGRESS TOWARDS UNLOCKING UNIVERSAL REFRIGERATION

The prototype of an optimised control platform for DC domestic refrigerators is a significant step towards unlocking universal and clean access to refrigeration. Technology-led innovation such as Sure Chill's project can help make solar-powered refrigerators more affordable and efficient for low-income populations. This will bring broader developmental benefits by helping to reduce food waste and generate additional income, both essential in combatting hunger.

GET IN TOUCH:

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