

Refrigeration: The Next Step in Off-Grid Energy Services

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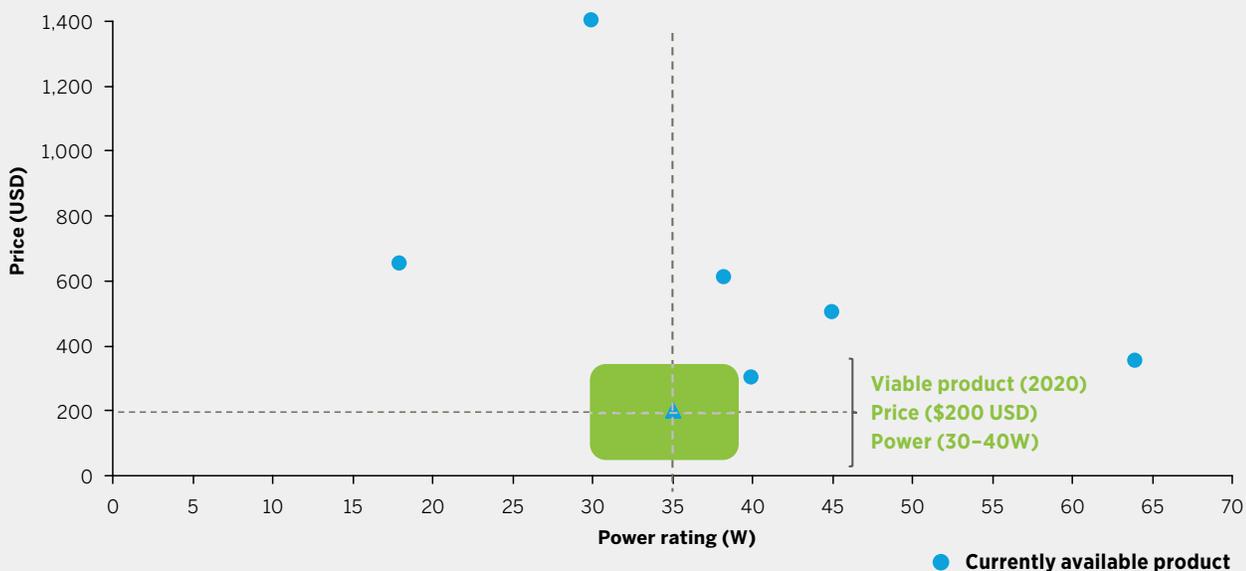
Refrigeration: The Next Step in Off-Grid Energy Services

The global market for off-grid clean energy technologies is gaining momentum, offering un- and under-electrified households and businesses throughout the developing world the possibility of life-changing modern energy services. To unlock the full potential of these technologies, a complementary market of appropriately designed, affordable and energy-efficient appliances and equipment is needed. Through the pioneering work of early-movers, a market for appropriate off-grid LEDs, televisions, and fans is in its early stages—the next big phase in the off-grid energy services market is refrigeration.

By improving nutrition, public health, trade, and income generation, refrigeration holds unique potential to unlock dramatic economic and social progress for off-grid households and businesses. Off-grid appropriate refrigeration can keep vaccines and other medicines viable in off- and bad-grid clinical settings, sustain the nutritional value of food and make wider varieties of food available, allow retailers to sell new types of products, enable the establishment of new businesses and income generating activities, reduce the amount of time each day that households spend shopping or gathering food, improve the lifespan of products sold by farmers and fishermen, and more. Off-grid appropriate refrigeration can have the same profound impacts that refrigeration had in the developed world. It will redefine lives and livelihoods.¹

But the global marketplace for off-grid refrigeration is extraordinarily nascent. A recent Global LEAP study found that, in order to be viable in off-grid settings and suitable for

PRICE & POWER CONSUMPTION OF CURRENTLY AVAILABLE OFF-GRID REFRIGERATORS, VS. IDEAL²



Source: Interview with manufacturers and distributors; Alibaba; Dalberg analysis

1. The Global LEAP Off-Grid Appliance Market Survey (2015) found that energy access professionals anticipate more demand for refrigerators over the next 3-5 years than for any other off-grid appliance category after basic lighting, mobile phone charging, and entertainment (e.g., televisions, radios). The survey placed refrigeration behind only LED lighting in terms of its potential to positively impact off-grid consumers' lives.

2. Global LEAP. The State of the Off-Grid Appliance Market (2016)

off-grid customers, refrigerators must be considerably smaller, cheaper, and run on far less energy than most conventional products. Few refrigerators available today can satisfy the needs of the off-grid market.

Even where off-grid refrigeration is closer to viability – in some clinical, institutional, and agricultural contexts, for example – it is hampered by a fundamental lack of market infrastructure, scale, and competition, and resulting weaknesses in technical and design innovation and price. All in all, a good deal of work is needed to encourage the development of the competitive, sustainable commercial market that can make good on the promise of off-grid refrigeration.

This issue paper provides a brief summary of current off-grid refrigeration technology and market trends, and begins to identify some of the core challenges faced by specific stakeholder groups and market actors. It seeks to start a conversation among partners in the Efficiency for Access Coalition regarding joint and coordinated efforts to catalyze innovations in off-grid refrigeration design, marketing, finance and policy that will yield a vibrant global market for this transformational technology.³

Current Technology and Market Trends

The refrigerators used in off-grid contexts are too-often energy inefficient, expensive, and dangerous. Most often, these products are conventional AC refrigerators intended for mainstream use that consume significantly more electricity than off-grid energy systems can support. They require a large initial surge of power, often more than twice what running the appliance requires, necessitating significant off-grid and/or back-up energy supply. Because of financial and energy constraints, the few off-grid households and businesses that do own refrigerators frequently operate them only 2–4 hours per day, providing at best minimal protection against the spoilage of perishable food and goods. These refrigerators are also prohibitively expensive, with prices commonly starting at \$500. Other existing technologies, like propane refrigerators, have high operating costs and pose risks of fire and injury.

Few currently available products are designed specifically for off-grid application, and fewer still are as efficient and affordable as they need to be for broad uptake. Emerging technologies show promise but more investment is required before they can become commercially viable. Nevertheless, there is substantial untapped demand and the off-grid refrigerator market could quickly become a significant commercial opportunity. Un- and under-electrified households and businesses spent an estimated \$75 million on refrigerators in 2015. If more appropriate products were available, 2015 spending could have been as much as \$220 million. By 2020, the market could see 38% year-over-year growth and total annual spending approaching \$1.1 billion.⁴

To achieve this potential, off-grid customers' preferences must be better understood, and their needs must be met. To achieve this, the off-grid refrigeration market must see energy performance and design innovations, along with reduced prices brought on by

3. Please note: This brief makes little effort to differentiate between off-grid refrigeration deployed in clinical, household, small commercial, agricultural, or institutional contexts, though research and analysis to create greater clarity around these market segments is needed. This brief assumes that (1) progress in technological innovation and scale in any of these market segments implies benefits in others, and (2) the long-term goal of Efficiency for Access Coalition members is market conditions where refrigeration is viable in all of these market segments.

4. Ibid.

significantly increased market entry and competition. It will not be enough to have great technology—we will also need a marketplace that is ready for it.

Stakeholder Analysis

A dynamic, functional global market ecosystem will engage market actors and sustain forward movement. To date, however, the off-grid refrigeration market has been inhibited by many of the barriers and market failures that challenge other emerging off-grid energy service markets.

APPLIANCE MANUFACTURERS are often unaware of the commercial opportunity presented by the off-grid refrigeration market, and those that are have to date been unwilling or unable to design and market appropriate off-grid refrigerators at a price the market can bear. Much more intelligence on customer segmentation and paths to market is needed, as is investment in R&D around technical and design innovation. The best actors in the off-grid refrigeration manufacturing space have yet to be identified—when they are, they will need programmatic and policy encouragement, capitalization, and customers.

DEMAND-SIDE ACTORS such as wholesale distributors, off-grid energy companies, and institutional purchasers lack access to a reliable supply of appropriate, affordable products, as well as the working capital, consumer financing capabilities, and supply chain maturity needed to add off-grid refrigerators to their product suite. Further, this market has not seen the kind of policy and programmatic support that has made demand accessible in the solar lighting, solar home system, and mini-grid markets.

FINANCIAL INSTITUTIONS AND INVESTORS like development agencies, multilateral international financial institutions, banks, and private investors need a better understanding of market fundamentals to spur initial investment and guide longer-term engagement. The market and technical infrastructure needed to evaluate companies and differentiate between products is lacking, inhibiting market-supportive investment and procurement efforts.

POLICYMAKERS often lack the technical knowledge and institutional capacity to target and implement effective policy. Developing world governments often impose protectionist trade policy that can inflate costs or keep the best products out of the market entirely.

OFF-GRID CONSUMERS do not necessarily understand the benefits of refrigeration, nor do they know how to select between good and bad products. They also lack access to the levels of consumer financing required to support the purchase of refrigerators—the least expensive of which is still a very substantial investment for off-grid consumers. Even more important, the marketplace for refrigerators that off-grid consumers need is all but non-existent: there simply aren't enough appropriate products available in the right markets at the right price.

Despite these headwinds, interest in the off-grid refrigerator market is clear. With appropriate levels of support, the market is poised for significant development over the next few years.

Market Gaps

The stakeholder-specific challenges outlined above can be traced to a core set of gaps in the off-grid refrigerator market:

Market Intelligence

Information asymmetries exist across the off-grid energy services market, and are particularly challenging in the relatively immature off-grid refrigeration market. These gaps in market knowledge greatly inhibit market development, creating and compounding challenges for the entire supply chain. Much more market intelligence is needed to support investment, product R&D, business planning, and the development of supporting policies and programs.

Market Entry and Competition

Few manufacturers are engaged in the off-grid refrigeration market, and those that are have to date been supported primarily by pilot-scale development efforts. Commercial sale of products is limited, notwithstanding some initial successes by distributors who have targeted specific customer segments (e.g., roadside retailers) in narrowly-bounded geographies. Distributors exploring the off-grid refrigeration market often struggle to find suppliers. Greater participation in the market, particularly in the form of increased and more visible competition among manufacturers, will make it easier for distributors to find products and help achieve the scale required to reduce production costs.

Product Technology and Design

Improvement in energy efficiency and product design is needed to unlock the potential of the off-grid refrigerator market. Technological innovations specific to refrigeration, particularly improved compressor technology and insulation materials, and design innovations, such as product sizing, and placement of compressors and doors, can drive significant efficiency gains while resulting in a more appealing product.

Access to Finance

Financing for off-grid energy services companies has increased, with several large, high-profile deals closing in 2015. But financing for off-grid appliance manufacturers and distributors remains limited. Increased finance is critical for young companies doing the R&D needed to address technology and design challenges, and also to provide working capital to support operating costs during product development, provision of customer credit, and more.

Supply Chain Infrastructure

Off-grid refrigerator manufacturers will need to develop in-country distribution partnerships or build on-the-ground capacity in order to bring products to market. Most distributors will need enhanced physical infrastructure, such as warehousing capacity and vehicles that can safeguard and carry large, heavy products, in order to scale up off-grid refrigerator sales. Companies across the supply chain will also need to invest in human capacity.

Policy Infrastructure

Policy has a significant impact on off-grid appliance markets. Beneficial policies, such as tax and tariff rates that level the playing field for high-quality, energy efficient products can jumpstart young markets. Securing the buy-in of government representatives in target markets and leaders of multilateral organizations to advocate for beneficial policies, and then supporting the development of those policies, will reduce barriers to market growth.

Each of these gaps presents an opportunity for Efficiency for Access Coalition members to drive private sector engagement, innovation and policy change that will lead to market development. Some opportunities align well with existing efforts, while others might call for fundamentally new interventions.

Opportunities for Innovation

The table below provides a list of existing and prospective intervention opportunities, mapped to the market gaps they help address, for consideration and discussion by Efficiency for Access partners. **Currently existing opportunities are denoted by an orange box**, while **prospective opportunities are denoted by a green box**. Detailed descriptions of each intervention can be found beneath the table.

Interventions	Market Intelligence	Market Entry and Competition	Product Technology and Design	Access to Finance	Supply Chain Infrastructure	Policy and Market Infrastructure
Advance Market Commitments		●		●	●	
Business Plan Competitions		●			●	
Business-to-Business Networking and Matchmaking Events	●	●			●	
Business-to-Investor Networking Events	●	●		●		
Consumer Awareness Campaigns					●	●
Consumer Finance Mechanisms				●	●	
Consumer Needs Assessment	●	●	●			
Global LEAP Awards	●	●	●		●	
Global LEAP Off-Grid Appliance Data Platform	●		●	●	●	●
Investor Education Forums	●			●		
Market Opportunity Assessment	●	●				
Procurement Incentives		●				

Interventions	Market Intelligence	Market Entry and Competition	Product Technology and Design	Access to Finance	Supply Chain Infrastructure	Policy and Market Infrastructure
Program Related Investment				•		
Prototype Product Development and Demonstration			•			
Quality Assurance Framework	•	•	•	•	•	•
Supply Chain Best Practice Dissemination	•				•	
Supply Chain Stakeholder Coalition Development					•	
Support for Local Assembly		•			•	
Technical Assistance for National Policy Reform						•
Techno-Economic Analyses	•		•			
Technology Innovation Prize			•			

ADVANCE MARKET COMMITMENTS

Binding commitments by multilaterals, government institutions, philanthropies, and private sector organizations to procure products from high-performing companies will send a strong signal to both industry and investors. For a market as nascent as off-grid refrigeration, this could also reduce the time it takes to bring appropriate products to market at a scale that will also support sustainable long-term market growth. Advance market commitments could be aligned with other programmatic interventions, such as the Global LEAP Awards.

BUSINESS PLAN COMPETITIONS

The best off-grid refrigerators in the world won't sell, and won't deliver impacts, if there's no market for them. Companies interested in off-grid refrigeration must rigorously think about their to-market strategies. A substantial cash prize for companies that develop great off-grid refrigerators *and* demonstrate innovative business and marketing plans, could help launch the next great company.

BUSINESS-TO-BUSINESS NETWORKING AND MATCHMAKING EVENTS

Events coordinated by Global LEAP connect manufacturers of best-in-class off-grid appliances with off-grid appliance distributors, facilitating new business opportunities. Events have been held in Dhaka and Seoul, and another is expected in Delhi this year. Additional events with an explicit focus on refrigeration would help market actors create valuable new connections and learn from one another's experience and needs.

BUSINESS-TO-INVESTOR NETWORKING EVENTS

Face-to-face interaction between industry leaders and investors is critical. Investor-focused

events could co-locate with Global LEAP industry matchmaking events, affiliate specifically with the Global LEAP Awards and/or an innovation prize, or exist stand-alone.

CONSUMER AWARENESS CAMPAIGNS

Many off-grid consumers are unaware of the benefits of refrigeration. In addition, as more products become available, consumers will need information about how to find and purchase appropriate products. Targeted campaigns will help sensitize consumers to the ways that refrigeration can improve their quality of life and diversify their livelihoods. Consumer awareness campaigns can also include messaging about the importance of quality and energy efficiency, while providing information about financing and retail availability as well.

CONSUMER FINANCE MECHANISMS

Consumer financing has been a critical driver of growth in off-grid energy services markets. Off-grid refrigeration poses unique challenges related to price point and customer segmentation, and therefore will likely require the development of new consumer finance mechanisms. Support for applied research by market leaders could improve the design of these mechanisms, and broader financial support and investment from donors that absorb risk could ensure beneficial terms for consumers.

CONSUMER-NEEDS ASSESSMENT

Coordinated research in key national markets to provide insight on customer segmentation, the product characteristics preferred by different off-grid consumer groups (e.g., household/SME, SHS/mini-grid), and willingness to pay. Existing research efforts, such as the World Bank's MTF survey, could provide a starting point.

GLOBAL LEAP AWARDS

An international competition that identifies the world's best off-grid appliances, to date the Global LEAP Awards has focused on recognizing innovation in off-grid LED lighting, television, and fan products. Expansion of the Global LEAP Awards to include refrigeration would leverage a trusted programmatic brand to attract new market entrants and send signals about off-grid refrigerator quality and performance to manufacturers, distributors and investors.

GLOBAL LEAP OFF-GRID APPLIANCE DATA PLATFORM

This program samples off-grid appliances from the marketplace, tests them in accredited laboratories according to international best practice, and makes the data public. Expansion of the data platform to include refrigeration will help inform faster market action, enabling improved procurement, due diligence, product design, and policy, and would provide critical infrastructure to inform the development of a future quality assurance framework.

INVESTOR EDUCATION FORUMS

Facilitated sessions to help banks, private investors, and financial institutions understand broader off-grid refrigerator market trends, refrigeration-specific market dynamics, and equip them to perform necessary due diligence on potential investments. These sessions should be led by E4A partners or other market stakeholders with relevant market insights.

MARKET OPPORTUNITY ASSESSMENT

Research that quantifies the scale of the commercial opportunity for off-grid refrigeration and identifies key market barriers. Market assessment is needed at both a global level, potentially building on the recent Global LEAP off-grid appliance market research report, as well as in key national markets, such as ITT's planned assessment of the off-grid refrigeration market in India, to catalyze investment and spur industry engagement.

PROCUREMENT INCENTIVES

For a market for appropriate products to develop, early actors and new market entrants need to see sales. Procurement incentives can help encourage a competitive process that brings appropriate products to market at scale.

A new program from Global LEAP and EnDev – Global LEAP+RBF – couples the Global LEAP Awards with results-based financing procurement incentives to provide a platform for early market movement. Broad engagement in a program like this by development institutions, philanthropies and other bulk purchasers could stimulate a competitive market by encouraging an important early customer base for high-performing companies in the off-grid refrigeration market.

PROGRAM RELATED INVESTMENT

Financial support for early movers in the off-grid refrigerator market – such as institution development grants, support for R&D, and first loss capital – often led by philanthropies and/or innovation funds. Such a facility could be aligned with the outcomes of other interventions.

PROTOTYPE PRODUCT DEVELOPMENT AND DEMONSTRATION

Academic laboratories and research institutions can play a valuable role in signaling technical potential to the market. Investments in technical research to develop prototype products – and broadly share the findings of that work – play important roles in the development of early stage markets.

QUALITY ASSURANCE FRAMEWORK

A robust, comprehensive quality assurance framework for off-grid refrigeration technology would enable the development of high-impact programs and policies while also encouraging manufacturer engagement, supporting investor decision making, and strengthening the supply chain. However, a significant amount of market infrastructure is needed before a quality assurance framework will be truly viable. The foundational work of Lighting Global and emerging Global LEAP efforts in the off-grid appliance market could be seen as initial contributions to the eventual development of a quality assurance framework for off-grid refrigeration.

SUPPLY CHAIN BEST PRACTICE DISSEMINATION

The refrigeration supply chain poses new challenges for off-grid companies. Documenting and sharing best practices on how to navigate key supply chain challenges – through case studies and comparative analysis – has the potential to save significant time and money for market stakeholders.

SUPPLY CHAIN STAKEHOLDER COALITION DEVELOPMENT

Cooperation between supply chain stakeholders can help overcome a variety of barriers to market growth. Creating a forum for stakeholder engagement will help pull together interested parties to discuss dynamics of national markets, identify key policy challenges related to importation and distribution of products, and learn more about the landscape of existing on-the-ground actors.

SUPPORT FOR LOCAL ASSEMBLY

Local assembly can create jobs, reduce costs, and simplify certain supply chain challenges. Financial backing for leading off-grid refrigeration companies interested in establishing local assembly facilities could jumpstart important national markets and generate important political support.

TECHNICAL ASSISTANCE FOR NATIONAL POLICY REFORM

Direct assistance for relevant national government institutions in key off-grid markets, which are often under-resourced, can be critical to push forward new or revised policies in a timely manner. This assistance will help identify policy priorities, advocate for the development of new beneficial policies, and provide relevant technical (e.g., laboratory testing) and analytical (e.g., cost benefit analyses) support.

TECHNO-ECONOMIC ANALYSES

Qualitative and quantitative research on the economic viability and developmental impact of different off-grid refrigeration products and technologies – as well as the techno-economic potential of evolutions in product price, design, and energy performance – can help target private and public sector action. Recent analyses conducted by Lawrence Berkeley National Laboratory on the implications of super-efficient appliances for off-grid energy services provide a starting point for this.

TECHNOLOGY INNOVATION PRIZE

A platform to incentivize development of breakthrough off-grid refrigeration technologies and accelerate the timeline for bringing those technologies to market. With a focus on next-generation R&D, this prize could complement the Global LEAP Awards' focus on identifying best-in-class commercially-available and prototype products. This might also be coupled with the business plan competition model highlighted above, as it is one thing to design a product and another thing entirely to bring it to market at scale.

Conclusion

By describing the current state of off-grid refrigeration technology and market trends, as well as summarizing challenges faced by key stakeholder groups and related market gaps, this issue paper situates the innovation opportunities described above in a nascent market that has the potential to drive transformative change. Efficiency for Access Coalition members are encouraged to explore ways in which resources can be deployed intelligently and in broad coordination to catalyze innovation that will kick-start growth in the off-grid refrigeration market. This, in turn, will ensure that off-grid communities gain access to life-changing technology as quickly as possible.

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