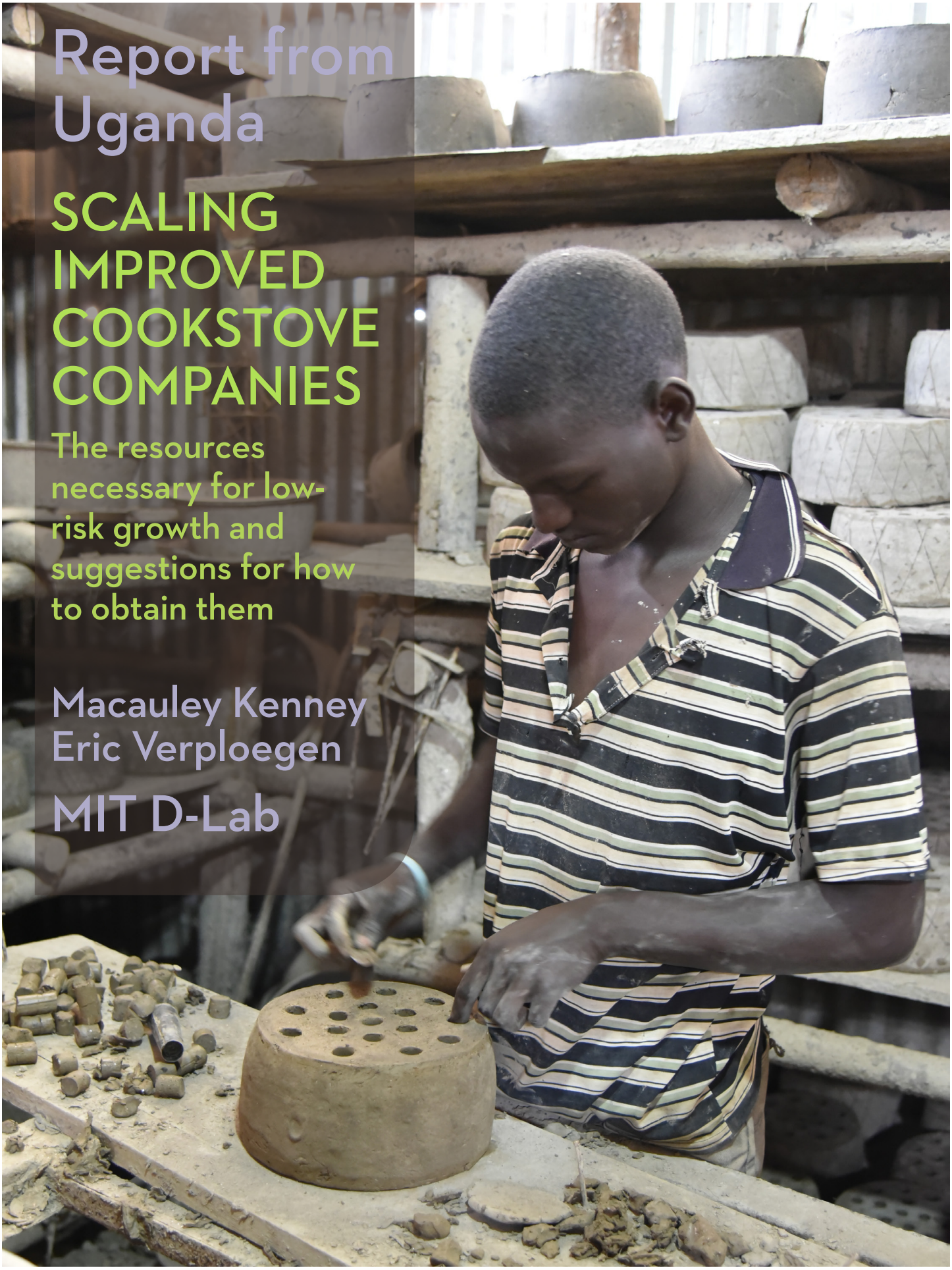

Report from Uganda

SCALING IMPROVED COOKSTOVE COMPANIES

The resources necessary for low-risk growth and suggestions for how to obtain them

Macauley Kenney
Eric Verploegen

MIT D-Lab

MIT D-Lab

Designing for a more equitable world

MIT D-Lab works with people around the world to develop and advance collaborative approaches and practical solutions to global poverty challenges. The program's mission is pursued through interdisciplinary courses, research in collaboration with global partners, technology development, and community initiatives – all of which emphasize experiential learning, real-world projects, community-led development, and scalability.

MIT D-Lab Off-Grid Energy Group

A global network of local innovators using design & technology to address poverty

D-Lab's Off-Grid Energy Group works to address energy access challenges by providing local organizations the tools to identify the most pressing needs and market opportunities in a specific community or region. We develop publicly available resources, convene stakeholders, and work directly with local organizations to design and implement programs that increase access to renewable energy solutions, such as efficient cookstoves, solar lighting, water pumps, and mechanical devices for increased productivity.

MIT D-Lab Work in Clean Cooking

D-Lab supports the adoption of clean cooking through:

- Evaluation of existing fuel and stove technology
- Design of advanced technologies
- Support for clean cooking ventures
- Participation in international policy on quality, availability, and adoption of clean cooking technology

The research team has been engaged in clean cooking technologies for 15 years, and continues to work on methodologies to measure the performance and outcomes of fuel and ICS.

Prior to this research initiative, MIT D-Lab had worked with two of the case study businesses, Appropriate Energy Saving Technology and GreenBio Energy, to provide technical support, and had provided grants to both of these companies and to Awamu Biomass Energy.

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EXECUTIVE SUMMARY

Purpose

This study assists the growth of improved cookstove (ICS) businesses by analyzing how the growth of five Ugandan ICS businesses depended, if at all, upon the expertise and resources of the founding team. We use this analysis to suggest a low-risk pathway for ICS business growth, and to identify the challenges such companies may face when scaling along this pathway. It is our hope that with this knowledge ICS business owners will be better prepared to bring their ventures to scale, and supporting NGOs, investors, and government agencies will be better equipped to facilitate the scaling process.

While the focus of this work, and target of the resulting recommendations, is the Ugandan ICS market, there is a high possibility of the results being applicable to ICS sectors in other emerging economies, as well as enterprises in other sectors. Local cultures, policies, and business environments should be examined before translating the lessons from this study to another region.

Intended Audience

The results of this study are intended for Ugandan ICS company leaders seeking strategies for scaling, and NGOs, investors, and government agencies interested in supporting this growth. Additionally, we look to support future entrepreneurs by highlighting five ICS businesses, from which they can draw inspiration for their own ventures.

Methodology

We conducted five in-depth case studies with ICS companies, each with a different level of expertise and resources in its founding team. Case studies were selected by generating a list of companies operating in the ICS sector, and filtering them based on geography, company age, and product type. This filtering process narrowed the field of candidates down to a specific segment within ICS sector, which enabled more direct comparisons to be made between companies. Purposive sampling (Yin, 2011) was used to select five case study participants from the filtered listed of candidates, with the dependent variables being the composition of the founding team (local, international, or a hybrid of local and international) and the location of the product manufacturing (local or international). Candidates for secondary stakeholder interviews were identified by their extensive work with ICSs and guidance from D-Lab's Biomass Fuels and Cookstoves group.

Once the case study participants (primary stakeholders) and secondary stakeholders had been identified, research was conducted through:

- Preliminary interviews via Skype with primary and secondary stakeholders (manufacturers, customers, affiliated NGOs, etc.)
- Site visits to primary stakeholder facilities for in-depth interviews and observation of business activities (sales and distribution process, manufacturing, etc.)
- Site visits to secondary stakeholder locations for interviews and, when applicable, facility tours
- Follow-up interviews via Skype with primary and secondary stakeholders

Analysis and Discussion

Scaling an improved cookstove (ICS) company without exposure to high levels of risk requires the company to successfully meet growing operational challenges in:

- business finances
- product technology
- product sourcing and/or manufacturing
- distribution and sales

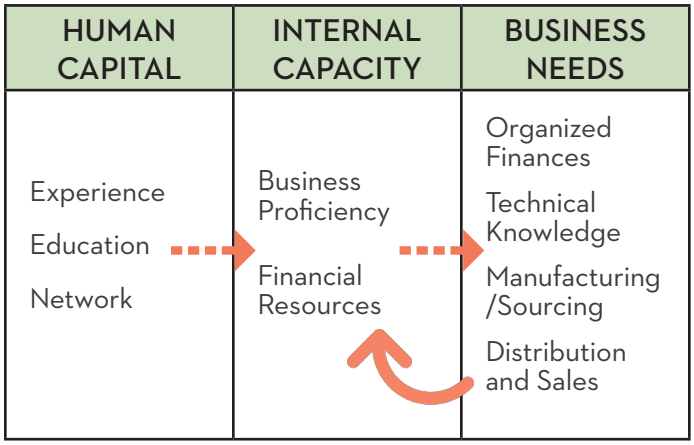
Together, these challenges can be referred to as business complexity (BC).

The ability to meet them is the company's internal capacity (IC). A high level of IC allows a company to safely build out its operations and scale, or to stabilize existing operations. IC is comprised of:

- business proficiency (knowledge finance, product sourcing and/or manufacturing, distribution, and sales)
- financial resources (revenue, grants, equity investment, debt financing, and carbon financing).

IC is gained through the human capital of the company, which brings personal and professional experience, education, and professional networks, all of which can be leveraged to increase business proficiency and financial resources. Financial resources can also be increased through revenue generation and personal finances.

In order to be operationally viable, an ICS company has to have both business proficiency in each of the numbered components of BC and the financial resources to act on that knowledge. The two are interconnected: financial resources allow companies to afford employees with high levels of business proficiency, and business proficiency can facilitate access to financial resources. However, business proficiency is particularly critical in the early stages of company development. While financial resources are a valuable and necessary component of internal capacity, knowledge in business strategy, financial models, distribution techniques, and manufacturing is arguably more necessary to ensure those limited resources are effectively allocated.



Human capital (experience, education, and network) comprises company IC (business proficiency and financial resources), which is necessary to meet the functional needs of the business (organized finances, technical knowledge, product sourcing, distribution and sales). Revenue from sales can also increase financial resources.

Recommendations

Leaders of Ugandan ICS companies looking to grow, and organizations looking to support these businesses, should assess the company's internal capacity and business complexity. From that assessment, the identification of where complexity exceeds capacity (i.e. in finances, product sourcing, distribution and sales), and whether expertise or financial resources would facilitate growth, can inform strategic decision making. Very often the companies will require both at the same time. In those scenarios it is important to exercise judgment on the ability of the company to efficiently utilize funding without business proficiency. It is very possible that external funds without business proficiency will not be impactful.

The companies in this study with full-time international founders possessed higher levels of business proficiency and access to financial resources and were able to scale more quickly than those with local founding teams. This was due in part to the western education of the founders and their international networks.

This observation does not mean that all international teams are similarly enabled, or that all local founding teams do not enter in with high levels of business proficiency or financial resources, but it does suggest that an increase in business proficiency might benefit a higher proportion of local founding teams.

Company leaders without strong business proficiency should seek ways to gain additional internal capacity before looking to increase business complexity and grow. Methods of building business proficiency include the following:

- Participating in external business training programs (ex: accelerators, incubators, etc.)
- Implementing internal business training programs (ex: on-boarding training for new employees)
- Utilizing online resources on business practices and education
- Hiring experienced employees
- Participating in local business chapters and online communities to attract attention and support from ecosystem enablers (ex: joining a clean cooking association, maintaining a company website, and creating an online presence).

Organizations supporting the ICS sector could have a great impact by increasing the number of capacity-building services available to ICS leaders such as:

- Training/mentoring programs
- Technical support
- Peer-to-peer knowledge sharing
- Incubators/Accelerators

Figure 1: Nolbert Muhumuza demonstrates an early version of a TLUD stove in Awamu's production facility.

INTRODUCTION

Billions of people around the globe use solid biomass to fuel their daily cooking needs (Differ, 2012, International Energy Agency, 2016). Most traditional cooking practices that use biomass fuel, such as three-stone fires, produce hazardous emissions, damaging the health of the users (primarily women and girls) and contributing to global air pollution. Improved cookstoves (ICSs) are one mechanism of alleviating these effects. ICSs are a broad category of cooking devices that improve fuel efficiency and reduce hazardous emissions in comparison to traditional cooking methods.

ICSs have great potential to reduce the negative effects of cooking emissions for a wide spectrum of consumers. o They range in price, fuel, and model, and can appeal to both rural villagers and high-end consumers. However, despite the high potential for social impact, ICS manufacturers and distributors struggle with low margins, poor customer adoption, and lagging business growth (Global Alliance for Clean Cookstoves, 2015). This is particularly true in Uganda, where the estimated market for clean cookstoves is 6 million, but the sector is very nascent, with few large-scale manufactures and distributors (World Bank, 2015).

This study assists the growth of ICS companies by analyzing how the growth of five Ugandan ICS businesses depended, if at all, upon the expertise and resources of the founders. We use this analysis to suggest a low-risk pathway for business growth, and to identify the challenges ICS companies may face when scaling. It is our hope that with this knowledge, ICS business owners will be better prepared to bring their ventures to scale, and supporting NGOs, investors, and government agencies will be better equipped to facilitate the growth of ICS companies.

While the focus of this work, and target of the resulting recommendations, is the Ugandan ICS market, there is a high possibility of the results being applicable to ICS sectors in other emerging economies, as well as enterprises in other sectors. Local cultures, policies, and business environments should be examined before translating the lessons from this study to another region.

Global Need for Clean Cooking Solutions

Cooking over an open fire, traditional three stone fire, or cookstove, as over two billion people around the world do daily (International Energy Agency, 2016), is tremendously inefficient. These methods require a high expenditure of fuel for relatively little heat generation, which means preparing simple meals requires extended cooking times and either extensive fuel gathering or high volume purchase of fuels. Women and girls traditionally shoulder both cooking and fuel procurement, risking rape and assault as they travel to remote areas to gather fuel, and exposure to hazardous emissions and poor indoor air quality as they cook (Daniel, 2012). This pollution exposure has a severe impact on user health; globally over 3.5 million deaths each year are attributed to unhealthy indoor air quality (International Energy Agency, 2016). Given the population growth projections in the areas dependent upon un-improved cooking methods, the number of households experiencing these challenges is expected to increase.

There are alternatives to this current reality. The clean cooking movement has increased the production and adoption of ICSsas , which improve the efficiency of traditional cooking technologies leading to a reduction of cooking time, fuel consumption, and hazardous emissions. Gaseous, liquid fuel-burning, and electric ICS models have the highest potential to dramatically reduce hazardous emissions, but their current retail price makes them unattainable for many low-income households. Biomass burning ICSs that decrease emissions and offer improved efficiency over three stone fires and basic cookstoves are a more affordable, and thus a more viable product for user adoption, for many regions. These stoves, while not at the cutting edge of performance, have the potential to be a gateway product as users transition away from basic cooking technology and towards healthier and more efficient methods.

Diversity in Improved Cookstove Technology

Improved cookstoves (ICSs) is a general term for a broad range of technologies, which lacks specific classification. The ICS label is used almost ubiquitously for any product that decreases emissions in comparison with a traditional three stove fire (Figure 2) or an unimproved

Figure 2: Pot cooking over a traditional three-stone fire fueled with wood (Three Stone Fire, n.d.)

cookstove (Figure 3).

There is an incredible level of diversity in ICSs; products range from artisanal stoves created locally to mass produced brands shipped all over the world, and can be as simple as a pounded sheet of metal or have complex features such as cell phone chargers and solar-powered batteries. ICSs can also utilize a range of fuels including, but not limited to, charcoal, firewood, electricity, and biogas. Figure 4 demonstrates the different models that ICSs can take, and their respective potential impact on emissions reduction.

Large scale (institutional) improved cookstoves can be found in

Figure 3: Un-improved charcoal burning cookstove (Metal, n.d.)

churches and schools, but this work focuses on the portable models used in households.

Fuel Diversity in Improved Cookstove Models

Many cookstoves are designed to use a specific fuel, such as charcoal. ICS shape, material selection, and functionality will differ by fuel type. Fuel is an important consideration both when selling and researching ICSs, because it changes based upon the end user. For example, rural communities in Uganda primarily burn firewood, and charcoal burning stoves have limited adoption rates in those areas because the users cannot afford or access charcoal. In contrast, improved firewood and charcoal stoves often have limited traction with upper-end consumers who can afford more expensive fuels such Liquefied Petroleum Gas (LPG) and electricity. ICS companies may sell fuel alongside their stove products in an effort to increase access to the fuel specific for their product.

Table 1: Fuel options for ICS models

Solid Fuel	Liquid Fuel	Other
Charcoal	Liquefied Petroleum Gas (LPG)	Electricity
Firewood	Alcohol	Solar Power
Dung	Plant Oil	Biogas

Figure 4: One framework for categorizing improved and clean cooking solutions. Adapted from the World Bank Report: The State of the Global Clean and Improved Cooking Sector (Energy Sector Management Assistance Program, 2015). The pictured stove models are for illustrative purposes only, and this report is not advocating for the use of particular brands or models of cookstoves.

Agricultural Residue	Kerosene	
Coal		

Evaluating Stove Performance

There is no international standard for what constitutes an "improved" cookstove, and in Uganda any manufacturer can market their product as such. However, the International Organization for Standardization (ISO) has issued International Workshop Agreement (IWA) guidelines that consider stove 1) efficiency, 2) total emissions 3) indoor emissions, and 4) safety (Figure 5). These guidelines rate cookstoves in each of the four categories along 5 tiers (0: lowest performing- 4: highest performing). There is no tier threshold that must be met to sell an ICS, but products receiving carbon financing or grants from many large international organizations have to be evaluated under these guidelines and meet a specified tier ("IWA Tiers of Performance," n.d.).

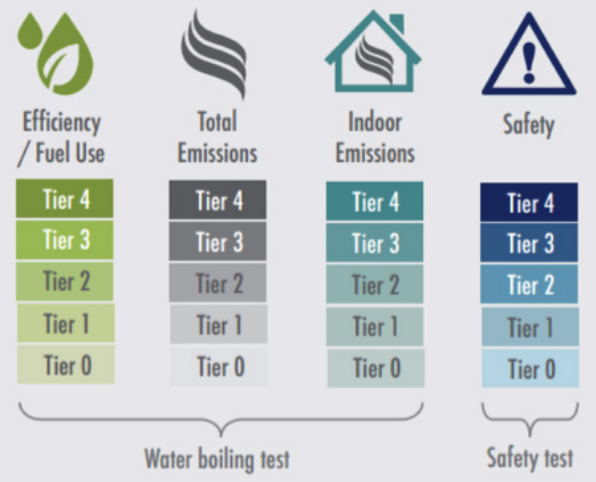


Figure 5: IWA Framework for evaluating improved cookstoves. Stoves are assessed in four categories, and are given a tier ranking between 0-4 (IWA Framework, n.d.)

Challenges to Clean Cookstove Businesses

New and existing ICS companies initiatives for clean cooking technology have been in place since the 1980s, but the sector gained new life and recognition with the 2010 launch of the Global Alliance for Clean Cookstoves (GACC), a public-private partnership hosted by the United Nations ("Our Mission," n.d.). Under GACC there has been an uptick in global awareness for clean cooking initiatives, but the ICS market remains nascent and fragmented in many regions.

New and existing companies selling ICS technology in Uganda face considerable challenges including, but not limited, to:

- ***Lack of consumer awareness***: Consumer awareness and demand for ICSs is minimal in many regions, requiring high levels of company marketing
- ***Fragmented supply chain and poor infrastructure:*** This encourages vertical integration, which requires higher levels of working capital and manufacturing expertise
- ***Limited access to capital:*** Loans are offered at extremely high interest rates; grants and investor capital, while available, can

Figure 6: Drying agricultural waste briquettes at AEST.

Lack of Market Awareness for Improved Cookstoves

At the time of this report (June 2017) Uganda lacks of standards on what constitutes an ICS,

This has led to inefficient cookstoves being falsely marketed as an ICS

Customers lack awareness of the health hazards of traditional cooking and the benefits of ICS

METHODOLOGY

We conducted five in-depth case studies on ICS companies, each with a different level of proficiency and resources in its founding team. Case studies were selected by generating a list of ICS companies and filtering them based on geography, company age, and product type. This narrowed the field of candidates down to a specialization within the ICS sector, which enabled more direct comparisons to be made between companies. Purposive sampling (Yin, 2011) was used to select five case study participants from the filtered list of candidates in order to ensure company diversity in the dependent variables: founding team composition (local, international, or a hybrid), and the location of the product manufacturing (local or international). Candidates for secondary stakeholder interviews were identified by their extensive work with ICSs and guidance from D-Lab's Biomass Fuels and Cookstoves group.

Once the case study participants (primary stakeholders) and secondary stakeholders had been identified, research was conducted through:

- Preliminary interviews via Skype with primary and secondary stakeholders (manufacturers, customers, affiliated NGOs, etc.)
- Site visits to primary stakeholder facilities for in-depth interviews and observation of business activities (sales and distribution process, manufacturing, etc.)
- Site visits to secondary stakeholder locations for interviews and, when applicable, facility tours
- Follow-up Skype interviews with primary and secondary stakeholders

Case Study Selection

Case study candidates were selected from a portfolio of East African cookstove companies generated through secondary research and D-lab institutional knowledge. The entire portfolio was filtered with a set of parameters to narrow the field of study:

- ***Cookstove focused:*** Candidates must have a large proportion of their business be dedicated to the sale of ICSs, as opposed to having ICSs an ancillary product suite to a different industry (ex: solar lantern company that also sells a few cookstoves).
- ***Located in Uganda:*** Selecting candidates from a single country removed the chance of regulatory differences between countries affecting the study outputs. Uganda was chosen because there was enough depth and diversity in the market to support a complete study, and D-Lab's strong connections in the region could facilitate company outreach.
- ***Sale of product:*** Case study candidates must be attempting to build a viable business model on the regional sale of cookstoves. Nonprofit or for-profit companies donating ICSs (as opposed to selling them) were not considered.
- ***Non-LPG fuel:*** Companies primarily selling LPG fueled ICS models were not considered. LPG is more regulated and less accessible than charcoal or firewood. Including LPG-fueled cookstoves would complicate the study by introducing variables such as regulatory business policies and supply chain issues.
- ***Similar market space:*** To limit our investigation to business operating in the same market, the field of interest only included companies producing ICSs for households and offices, eliminating candidates who only produced institutional or custom stoves.
- ***Age:*** Companies must have been operational prior to 2015

Case study participants were selected from the remaining subset of companies that met the above criteria. We intentionally varied the profile of the founding team (local, international, or a hybrid of the two), and the manufacturing location of the stoves (international or local). The five companies selected for a case study were: Appropriate Energy Saving Technology (AEST), Awamu Biomass Energy, GreenBio Energy, Humura Investments Ltd, and UpEnergy Group.

Primary Stakeholder Interviews

Field interviews of case study participants (primary stakeholders) were conducted in Uganda over a period of three weeks. Initial interviews were conducted with primary stakeholders prior to the in-person meeting via Skype. Each participant was told the purpose of the study and institutional review board (IRB) approvals prior to the interview and issued their consent to record and publish the information. Primary stakeholder interviews were semi-structured and were administered to the founders and managing directors of each company. Additional interviews with the company financial, production, and distribution manager were conducted when there were discrete personnel in each role. Specific questions varied between each interview, but the topics of interest for all consisted of:

- Origin story of the business
- Current business model and operations
- Founder personal history and business experience
- Challenges to the business
- Successes in the business
- What resources had been used to support the company (knowledge, finance, networks)
- Justification for target customer
- Business plan for the future

Case study interviews also included a tour of the office and either the production facilities (if existing) or distribution process. Post interview, each company submitted a document outlining their:

- Annual sales
- Product catalog and prices
- Sources and monetary amounts of investments, loans, or grants
- Number of employees (local and non-local)

A blank copy of this document and an outline of the interview structure and timeline are included in Appendix A: Business Case Study Information Document and Appendix B: Case Study Interview Structure.

Secondary Stakeholder Interviews

Interviews were also conducted with other stakeholders involved with ICS adoption (secondary stakeholders), both in-country and over Skype, to supplement the information obtained from case study participants. These interviews were semi-structured, and centered around the organization's respective involvement and perception of the Ugandan ICS market. Primary areas of involvement for secondary stakeholders consisted of carbon financing and business support. A complete listing of all secondary stakeholder participants can be found in Appendix D: Secondary Interview Participants.

RESULTS

Results from the interviews with primary and secondary stakeholders in the Ugandan ICS industry are presented in the below three sections. The first section highlights common themes discovered across multiple interview participants, the second provides an overview of the case study companies, and the third displays the growth of participating case study companies over time.

Interview Trends

Three common narratives on the state of the Ugandan ICS market emerged after multiple interviews with company managers and affiliated secondary stakeholders. The first is that the market is dominated by locally manufactured, charcoal-burning, improved cookstoves with a clay liner and metal shell, as depicted in Figure 7. Made popular by the company Ugastove in the late 2000's, this model was repeatedly referenced during interviews and is sold by four out of the five case study companies. This type of stove is marketed towards peri-urban and urban customers who rely on charcoal for fuel, and not rural Ugandans.

The second narrative is that product margins for ICSs can be very thin. Ugandan manufacturers reported production costs for household stoves to be between 7,000-30,000 UGX ($2-$8 USD), and a retail prices for those products to be between 15,000-60,000 UGX ($4-$16 USD). Part of the widespread appeal for these locally manufactured stoves is their lower retail price when compared to other models (an imported stove with more advanced features can retail for 310,000 UGX ($86 USD), and companies expressed a lack of customer willingness to pay if they raised their prices to increase margin. There are exceptions to this, as demonstrated by Humura Investments who sells their locally manufactured clay lined charcoal stoves for 60,000-80,000 UGX ($16-$22 USD), but we were not able to discover any who have managed to do so at a high volume.

INTERVIEW TRENDS

Clay-lined, charcoal burning, improved cookstoves (ICS) with a metal shell dominate the market

Margins for this type of ICS are typically less than $3 before distribution and operational costs

Few companies have been able to become profitable off of ICS sales alone

Independent of the product sold, all of the companies in B2C sales expressed the importance of marketing, and all but one communicated the need for external funding to do so. The sole exception to this was Build Uganda, which had the working capital to purchase radio advertisements. No other company we interviewed was able to take similar steps. These managing teams expressed a desire to increase their marketing, and a recognition that marketing was essential to increasing their sales volume, but the company was not in a financial position to do so without additional funding.

This lack of financial resources was echoed when discussing scaling company operations, hiring additional skilled labor, and even paying salaries. Only two out of the nine companies interviewed (five case studies and four secondary interviews) were profitable, and only one of these was solely from cookstove sales; the second relied on revenue from a secondary loans business. The remaining companies relied on grants, loans, carbon financing, and debt to remain operational.

Case Studies

The following are brief profiles on each of the companies selected as case studies, focusing on their founding teams, product selection, and business model.

Figure 7: Charcoal burning cookstoves in the Center for Research in Energy and Energy Consumption (CREEC)

APPROPRIATE ENERGY SAVINGS TECHNOLGIES

AEST OVERVIEW

Operational Since: 2013

Number of Employees: 15

Primary Product(s): Improved charcoal stoves, briquettes

Manufacturing Process: Manufactures stoves entirely in-house

Distribution Process: Distributes through networks of female micro- entrepreneurs

Stoves Sold as of December 2016: 11,595

Founding Team Profile

Sisters Betty Ikalany and Helen Ekolu Acuku founded AEST together in 2013. At the time, Betty had recently returned from the Netherlands, where she received her master's degree, and the two had founded and were running Teso Women Development Initiatives (TEWDI Uganda), a non-profit with the goal of creating a women-centric enterprise that generated charcoal briquettes. Betty and Helen saw the opportunity for an affiliated for-profit enterprise with the same goal, and the two now split their time between TEWDI Uganda and AEST.

Figure 8: AEST/TWEDI Staff from left to right: Everlyne Argo, Accountant; Mary Josephine Aguti, Sales; Betty Ikalany, Founder/CEO. Not pictured: Helen Ekolu Acuku, Founder/R&D Officer.

AEST and MIT D-Lab have been connected since early 2012. The company (through TEWDI) was a participating member of the Harvest Fuel Initiative, an early stage support program providing mentorship and capital from The Charcoal Project with assistance from D-Lab, and was a recipient of a 2015 MIT D-Lab Scale-Ups fellowship. Additionally, Betty is a longtime friend of D-Lab, and has personal and professional relationships with many of its staff members.

Product

AEST sells both improved cookstoves (ICSs) and charcoal briquettes under the brand name Maaka. The Maaka Stove is a charcoal-burning ICS with a clay liner and metal shell, shown in Figure 9. Three different sizes of the Maaka are available, and they currently sell for 18,000-55,000 UGX[1] ($5-$15 USD) depending on the size in question. AEST produces the stove entirely in-house, including sourcing the clay and firing the liner. The production factory, which includes the stove-making facilities and briquette extruders and drying racks, is adjacent to the family homes of Betty and Helen. The Maaka briquettes use diesel and human-powered machines in their production, however the stove production process is still fully manual.

Figure 9: Completed Maaka stoves (left) and clay liners waiting for assembly (right).

Business Model

Production of the Maaka Stove and briquettes is done entirely in the facility, and the products are stored there until sale. AEST is marginally involved in direct door-to-door sales and tradeshows, but primarily rely on micro-entrepreneurs for product distribution. These micro-entrepreneurs usually have an existing platform or business from which to sell the stoves and, in line with the AEST business mission, are predominantly women. AEST has conducted trainings for their micro-entrepreneurs in the past to improve their professional and leadership skills, reaching 55 individuals, and plans to continue to do so in the future.

With this model the company has seen some profits from its stove sales, but requires larger and more regular purchases to see similar gains in their briquettes. External grants and fellowships were necessary to support operations for the past three years, and the company is currently seeking additional funding to establish a larger factory nearby and expand its marketing and sales operations. Carbon financing is not a viable option due to the high cost membership fees and time-intensive operational requirements, neither of which AEST can satisfy at the moment. The company recently expanded its staff to include a sales officer and an accountant, both of whom are female, and is seeking to bring on a production manager this year.

1. Stove prices for all companies may fluctuate based on the region of sale, volume purchased, and customer negotiation.

AWAMU BIOMASS ENERGY

AWAMU OVERVIEW

Operational Since: 2013

Number of Employees: 8

Product: Improved gasifier stoves

Manufacturing Process: Manufactures stoves entirely in-house

Distribution Process: Distributes through end user sales and micro-distributors

Stoves Sold as of December 2016: 3,850

Founding Team Profile

Awamu Biomass Energy is the result of a partnership between Ugandan-born Nolbert Muhumuza and American-born Paul Anderson. The two men met at a conference on improved energy at Makerere University in 2009 and exchanged ideas on ICS design prototypes before founding the company together in 2012. Both men had experience working with ICS technology, but neither had formed a business before. From the onset Nolbert took on the role of CEO and managing in-country operations while Paul, a retired professor and activist for improved cookstoves, provided support remotely.

Paul has been heavily involved in research and activism for top-lit updraft gasifier (TLUD) stoves, the model that Awamu produces, for the past 13 years. He primarily as an advisor to Awamu, and engages with other companies and non-profits around the globe to promote TLUD uptake. In addition to managing Awamu, Nolbert is the chairman of Biomass Energy Efficient Technologies Association (BEETA), a non-profit organization dedicated to the support and proliferation of renewable technologies, and runs his own local non-profit.

Figure 10: Awamu CEO and co-founder Nolbert Muhuzuma.

Figure 11: Awamu's top-lit updraft (TLUD) gasifier stove.

Product

Awamu's primary product is the TLUD stove displayed in Figure 11, which makes up 70% of the company's sales. Made almost entirely out of metal, this stove uses biomass (such as firewood) for fuel and can produce charcoal from that biomass when operated correctly. It sells at 60,000 UGX ($16 USD).

The remaining sales come from charcoal stoves (10%), wood chips, and custom institutional stoves (20% combined). Awamu marks each stove with a serial number and keeps a record of its customers to make post-sale calls on customer satisfaction and product durability. A warranty is not currently included in the sale, but low-cost repairs at <5,000 UGX ($1.50 USD) are available.

Business Model

Awamu is located in Kampala near Makerere University, where the company currently rents space from a local church for its production and office facilities. Its eight employees spend most of their time on ICS production, and Nolbert manages all other aspects of the business. This production of the gasifier stove is done entirely in-house and by hand. Completed stoves are sold through micro-distributors in central and eastern Uganda, at trade fairs and exhibitions, or directly on-site at the factory. Minimal marketing is being performed, but there is a strong desire to develop marketing activities once available funds are obtained. Currently Awamu is being supported by a combination of grants, debt, equity, and revenue, and Nolbert is actively looking to raise capital to expand the business.

GREEN BIO ENERGY

GREEN BIO ENERGY OVERVIEW

Operational Since: 2011

Number of Employees: 110

Products: Improved charcoal stoves, briquettes

Manufacturing Process: Manufacture stoves entirely in-house

Distribution Process: Sell wholesale to large distributors

Stoves Sold as of December 2016: 47,101

Founding Team Profile

Vincent Kienzler was performing research for his PhD in Uganda in 2011 when he met Alexandre Laure, a program manager at the French embassy. Neither one of them had experience with charcoal briquettes or ICSs at the time, but Alex had the idea to create and sell charcoal briquettes, and invited Vincent to join him in forming a company. They registered Green Bio Energy in 2011and began selling briquettes one year later under the brand name Briketi.

Alex left the company in 2013, and David Gerard, a French national who had joined as the company's business manager in 2012, assumed the role of Deputy Managing Director. Today Vincent serves as the company CEO and advisor, and David continues to serve as the Deputy Managing Director.

Figure 12: Green Bio Energy Deputy Managing Director David Gerard-Co-Founder (left) and CEO Vincent Kienzler (right).

Product

Green Bio Energy's two primary products are charcoal briquettes and charcoal/briquette burning ICSs with a clay liner and a metal shell. The company started out selling their own briquettes alongside another locally made ICS but, after doubting the stove's quality, began production of their own ICS line in spring 2013. Green Bio Energy sells some of these stoves under its Briketi brand name (Figure 13), but the vast majority of its products are sold at wholesale to large distributors. The ICSs retail for 27,000 UGX ($7.50 USD) (wholesale price differs), and a 50kg bag of briquettes is priced at 40,000 UGX ($11.00 USD).

Figure 13: Briketi ICS waiting for delivery to kiosks and small distributors.

Business Model

Unlike the other case studies, Green Bio Energy's business model has minimal direct sales to end users. The company maintains a few kiosks and displays in convenience stores (known as "cages"), its primary customers are large distributors such as Living Goods, BRAC, and UpEnergy. Early on in the venture Vincent and Alex felt that there was more space in the ICS market for manufacturers, and they transitioned the company away from distribution activities. All of the stove and briquette production is done in-house at either the original company factory in Mukono or the recently opened factory in Mbale. GreenBio Energy employs over 100 people, primarily Ugandan, across its two factories and its Kampala office space. David envisions a franchise model for Green Bio Energy in the future, with further expansion of production facilities around the country, and he plans to open a third production site in 2017. Each factory currently operates under its own label (Mukono factory ICS production is Clean Cooking Solutions, briquette production in Mukono is Fuel from the Earth, Mbale ICS production is Cash Savings Solution), but all are subsidiaries of Green Bio Energy.

HUMURA INVESTMENTS, LTD

HUMURA INVESTMENTS OVERVIEW

Operational Since: 1991 (began selling household ICSs in 2001)

Number of Employees: 7

Products: Improved charcoal & solar stoves & ovens

Manufacturing Process: Performs most of the product manufacturing in-house

Distribution Process: No distribution process, customers pick up the product at the facility or exhibitions

Founding Team Profile

Humura Investments, Ltd. was founded in 1991 by Fred Rwashana under the name FK Rwashana Associates. Fred was inspired to start a briquette and cookstove business by the Ugandan government's initiative on deforestation and climate change in the 1990's, and received business training from Makerere University and a program sponsored by the Gatsby trust. The company rebranded in 2010 to Humura Investments and is now run by Adeline Muheebwa, Fred's daughter. Adeline has a Master's of Science in Development Management. In addition to her role as Humura's CEO she works as a private gender and development consultant and chairs the Association of Uganda Professional Women in Agriculture and Environment (AUPWAE).

Figure 14: From right to left: Fred Rwashana (CTO), Adeline Muheebwa (CEO), Josh (Adeline's son).

Product

Humura Investment products are expensive, high-tech, clean cooking technologies designed for upper income customers. Their products are the results of years of design refinement by Fred, and the company consults a local craftsman and a retired lecturer from a vocational school on technological specifications. Their product catalogue "Selina" includes domestic cookstoves (Figure 15) and larger ovens, both of which can be made to run on charcoal, or solar, or briquettes. The stoves range from 60,000-350,000 UGX ($16-$100 USD) depending on the size of the model and the number of accessories (solar lighting, phone charging, etc.) and the ovens from 900,000-1.5 million UGX ($250-$400 USD).

Figure 15: Solar powered Selina ICS

Business Model

Humura is designed to require very little working capital and to scale with customer demand. Its chief executive, finance, and technical officers are within Adeline's immediate family, and its four production workers are on contract. All of the stoves are made to order after advance payment from the customer. Production of the metal shell, stove assembly, and the inclusion of advanced features (ex: phone charging ports), are performed in the company factory, which is adjacent to the family home. Clay liners and bricks are sourced from a nearby company. Marketing is limited to trade shows, exhibitions, and customer word of mouth. There is interest in increased marketing activities and door-to-door distribution, but capital constraints currently prevent any action on that front. Unlike the other case study participants, Humura has not received substantial grants, loans or equity for operational support. The company was bootstrapped by Fred in its early years, and is now profitable. Both Fred and Adeline are reluctant to take out loans to increase operations because of high interest rates, and thus far grant applications have been unsuccessful.

UP ENERGY GROUP

UPENERGY OVERVIEW

Operational Since: 2011

Number of Employees: 7

Products: Locally-made improved charcoal stoves and imported improved firewood and charcoal stoves

Manufacturing Process: does not manufacture

Distribution Process: Door-to-door sales and networks of distributors

Stoves Sold as of December 2016: 76,335

Founding Team Profile

Five professionals from the United States founded UpEnergy Group with the idea to build a Ugandan company with a "well-established distribution channel" (Wurster, Erik, 2017). One of the co-founders, Evan Haigler, had previously founded Impact Carbon, a carbon financing partner that spun out of a research lab at UC Berkeley. Impact Carbon had been operational in Uganda and working with several ICS companies, the most notable of them being Ugastove, for five years before UpEnergy Group was registered. Impact Carbon and UpEnergy Group were closely affiliated during UpEnergy's first two years, and the former facilitated in UpEnergy's carbon financing project.

Erik Wurster, a co-founder, served as UpEnergy's CEO until late 2015, when he stepped into a director position. The company is currently run by the Operational Director, Moses Amone. Three of the remaining co-founders serve as either directors or advisors, and are occasionally called upon to take an operationally active role in the company.

Figure 16: UpEnergy Group General Manager Moses Amone.

Product

UpEnergy Group does not manufacture its ICSs, but acts as a distributor for both locally-made and imported models. At the start of the businesses the company primarily sold wood burning Envirofit stoves, but soon found that the product price point was too high to reach their desired sales volume. Their catalog has since diversified to include five stove models (EZYStove, Ecozoom, AES Stove, Biolite, and Smarthome Stove) ranging from 15,000-310,000 UGX ($4-$85 USD), and a smaller subset of water filters and solar lights. Despite having a suite of products, the lion's share of sales is made up by the locally-produced SmartHome Stove (Figure 17), which is manufactured by Green Bio Energy. This stove is part of a carbon financed project, and to meet project requirements it is branded with a serial number and comes with a free one-year warranty.

Figure 17: Smarthome stoves packed for a sales trip,

Business Model

Employees from the flagship UpEnergy office in Kampala operate six regional hubs across Uganda and hire contractors to sell stoves out of those hubs. The company currently has 24 employees spread across these six hubs and the Kampala office, and several hundred contractors. With this model it performs B2B sales to retailers, NGOs, and large organizations, and door-to-door B2C sales.

As mentioned above, the company has incorporated carbon credits into its financial model. Previously the money from carbon financing was used to subsidize the cost of stoves, but it is now put towards operating and marketing expenses.

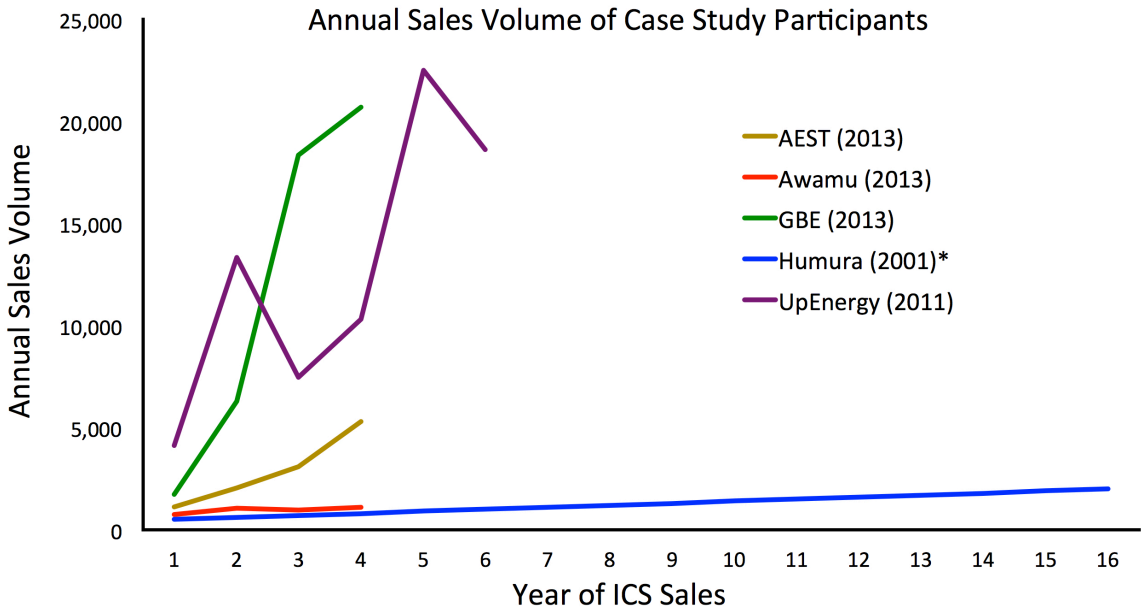


Figure 18: Annual sales growth of case study companies from first year of operation to present (2016). *Humura sales growth is estimated due to lack of sales records.

Early Stage Growth in Case-Study Sales Volume

Figure 18 tracks annual ICS sales volume for each of the case study participants from their first year of operation to 2016[2]. The graph has been normalized to start at the first year of the company's operation, instead of the calendar year. In this figure AEST and Green Bio Energy exhibit consistent annual sales growth while Humura and Awamu have relatively stagnant annual sales at a low volume. UpEnergy has a substantial dip in year three of operation, which was the result of delayed external funding.

ANALYSIS

Measuring a company's internal capacity (IC) and business complexity (BC) is our proposed method for determining its ability to manage its operations and sustain itself. BC is the level and number of operational challenges that must be met for the company to function as structured, and IC is the ability of company to meet these operational challenges. the greater the ratio of IC to BC, the more stable the company is. When a company increases its BC it takes on more risk and, without a corresponding increase in IC, it becomes less stable (Bonabeau, 2007; Sargut & McGrath, 2011). The less stable a business is, the less able it is to experience strategic, operational, or financial hurdles and remain active.

Company BC will always increase to some extent alongside company growth, as operating at a larger scale is inherently more complex (Churchill & Lewis, 1983). Increasing company IC as BC grows maintains the balance between the two and enables the company to safely manage more risk. Calculating the BC and IC of a business as it grows gives insight into its level of stability and exposure to risk. We calculated the BC (Table 1) and IC (Table 2) of the five case studies in this report in their first year operation and in 2016 to track their change in risk levels over time.

Business Complexity

Business complexity (BC) is the sum of the complexity of the following four components:

- business finances
- product technology
- sourcing/and or manufacturing product
- distribution and sales

All but one of these components, product technology, becomes more complex the larger the business is (Churchill & Lewis, 1983). Therefore, to measure the business complexity of the case study participants we assessed the four components, and the size of the business (based on the annual sales volume), on a low-medium-high scale:

- ***Complexity of Financial Model:*** considers the number of different funding sources and their respective complexities
- ***Product Complexity:*** takes into account the level of skill and machinery necessary to produce or source the product
- ***Manufacturing/Sourcing Model:*** assesses the complexity of the manufacturing (or product sourcing) process (ex. produce entirely in house, outsource clay liner production, source entire product from manufacturer)
- ***Complexity of Distribution and Sales Model:*** evaluates the size and the complexity of the distribution and sales network by considering the number of sales staff and their relation to the company (i.e. contractors, employees, micro-entrepreneurs)
- ***Annual Sales Volume:*** captures number of ICSs sold. As the sales (and production) increase, so does complexity

2. Figure 18 depicts annual sales from each company, and not the number of cookstove users who received an ICSs. As Green Bio Energy's primary customer is UpEnergy, the stoves Green Bio sells to UpEnergy are represented in their annual sales, and then again in UpEnergy's annual sales when the stoves are purchased by the end user.

Table 2: Summary of Case Study Business Complexity[3]

	Complexity of Financial Model		Product Complexity		Complexity of Manufacturing/Sourcing Model		Complexity of Distribution and Sales Model		Annual Sales Volume	
	Year 1	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*
AEST (2013)	**Medium**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Medium**	**Medium**	**Low**	**Medium**
Awamu (2013)	**Medium**	**Medium**	**Medium**	**Medium**	**High**	**High**	**Medium**	**Medium**	**Low**	**Low**
Green Bio Energy (2011)	**Medium**	**Medium**	**Low**	**Low**	**Low**	**High**	**Medium**	**Low**	**Low**	**High**
Humura (2001)	**Low**	**Low**	**High**	**High**	**Medium**	**Medium**	**Low**	**Low**	**Low**	**Low**
UpEnergy (2011)	**High**	**High**	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**Medium**	**High**

Internal Capacity

Internal capacity (IC) is a company's ability to meet operational challenges in finance, product technology, product sourcing and/or product manufacturing, and distribution and sales, when the business is at scale. To accomplish this a company needs both *business proficiency* and *financial resources* in each of the four categories. For example, to sell and distribute ISCs at scale a company has to have expertise on how to accomplish distribution and sales and enough money to act on that knowledge. IC is gained through the human capital of the company, which brings personal experiences, education, professional networks and personal financial resources, all of which can be leveraged to increase business proficiency and financial resources. Financial resources can also be increased through revenue generation and personal finances. Figure 19 outlines the relationship between human capital, IC, and the needs of the business. Note that the needs of the business may vary based on the business model (i.e. a manufacturer selling only in bulk does not need a door-to-door distribution team).

To measure IC we assessed the company's business proficiency (in its finance, product technology, manufacturing/sourcing, and distribution and sales) and its financial resources. Business proficiency was assessed by evaluating the experience (in each of the four sub-components listed below), education, and network of the human capital within the company. The financial resources component was assessed by compiling the amount of grants, debt, loans, and investment funds the company had received.[4] We evaluated these components on a low-medium-high scale to generate a measurement for company IC:

» ***Experience:*** familiarity with the components of business (ex: keeping sales logs, business growth strategy, creation of standard operating procedures, etc.), including these subcomponents:
  - *Finance:* experience tracking and managing finances
  - *Product technology:* experience with technical aspects of the product
  - *Manufacturing/sourcing:* experience with manufacturing at high volume (or the ability to source product at high volume)
  - Distribution and sales: experience generating sales and delivering product through the company's distribution channel

» ***Financial Resources:*** the amount of capital (either from the personal finances of company members, revenue, or external sources) available to the company

» ***Founder Education:*** what level of education the founder received. Education contributes to expertise and financial resources by providing some (or all) of the skills necessary to operate a business and source capital (Chrisman, Bauerschmidt, & Hofer, 1998; Storey, 2016)

» ***Network:*** measures the number and quality of professional connections that can provide mentorship, technical support, or facilitate introductions to granters and funding sources. It is included because of its ability to supplement the roles of experience and education in business expertise (Dodd & Keles, 2014; Lechner, Dowling, & Welpe, 2006). Theoretically this professional network could be beneficial even if it only exists locally, but the maturity of universities, investor networks, and technological developments in the Western markets make those network connections extremely valuable.

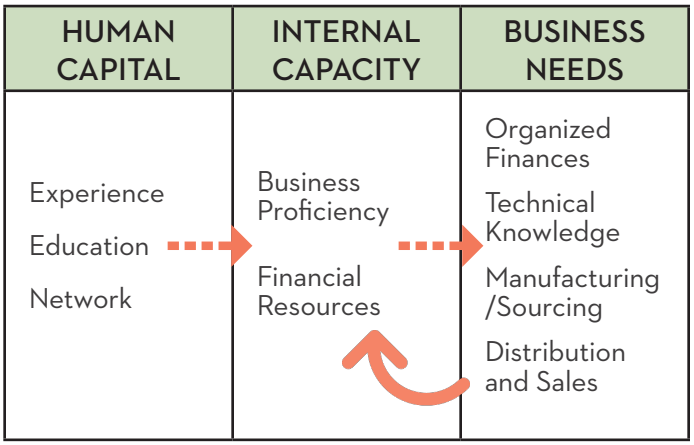


Figure 19. Human capital comprises company internal capacity, which is necessary to meet the functional needs of the business. Revenue from sales can also increase financial resources.also increase financial resources.

3. See Appendix E: Detailed IC and BC Matrices for assessment criteria and detailed company practices. Note that expertise and experience are not used interchangeably.

4. External funding was used to assess company financial resources due to the sensitivity of sharing company working capital and operational budget.

Because the companies have chosen different business models, they may have received similar rankings for vastly different founding team experiences. For example, in Table 3 GreenBio Energy and UpEnergy have a high IC for distribution and sales experience in 2016. GreenBio Energy received this ranking not because its employees experience in door-to door distribution, like UpEnergy does, but because they have experience in acquiring large distribution partners (the vast majority of their sales are wholesale). Similarly, UpEnergy is highly ranked in manufacturing/product sourcing experience because is its employees are experienced in sourcing ICSs, whereas the other businesses are ranked on their experience in product manufacturing.

Cumulative IC and BC values were generated using the components in Table 2 and Table 3. Figure 20 maps those cumulative IC and BC values for each case study during its first year of operation and in 2016, and illustrates the respective sales volume (circle diameter) at each point. Awamu and Humura increase in BC but remain relatively constant in BC and sales volume at both time points. In contrast AEST, Green Bio Energy, and UpEnergy, all increase in sales volume, BC, and IC from their first year of operation to 2016. In this study all components were treated equally, but additional research may be done to assign a coefficient to each component based on its relative importance.

Table 3: Summary of Case Study Internal Capacity

	Experience								**Financial Resources** *(ex: Grants, debt, carbon financing, revenue)*		**Education** *(education of company leaders)*		**Network** *(network of company leaders)*	
	Finance Experience		Experience with Product Technology		Manufacturing/Sourcing Experience		Distribution and Sale Experience							
	Year 1	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*
AEST (2013)	**Low**	**Medium**	**Low**	**Medium**	**Low**	**Medium**	**Low**	**Medium**	**Low**	**Medium**	**High**	**High**	**Medium**	**High**
Awamu (2013)	**Low**	**Medium**	**Medium**	**High**	**Low**	**Medium**	**Low**	**Low**	**Medium**	**Low**	**Medium**	**Medium**	**Low**	**Low**
Green Bio Energy (2011)	**High**	**High**	**Low**	**High**	**Medium**	**High**	**Medium**	**High**	**Medium**	**High**	**High**	**High**	**High**	**High**
Humura (2001)	**Low**	**Low**	**Medium**	**High**	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Medium**	**High**	**Low**	**Low**
UpEnergy (2011)	**High**	**High**	**Medium**	**High**	**High**	**High**	**Medium**	**High**	**High**	**High**	**High**	**High**	**High**	**High**

Initial & 2016 IC, BC, & Sales Volume of Case Study Participants

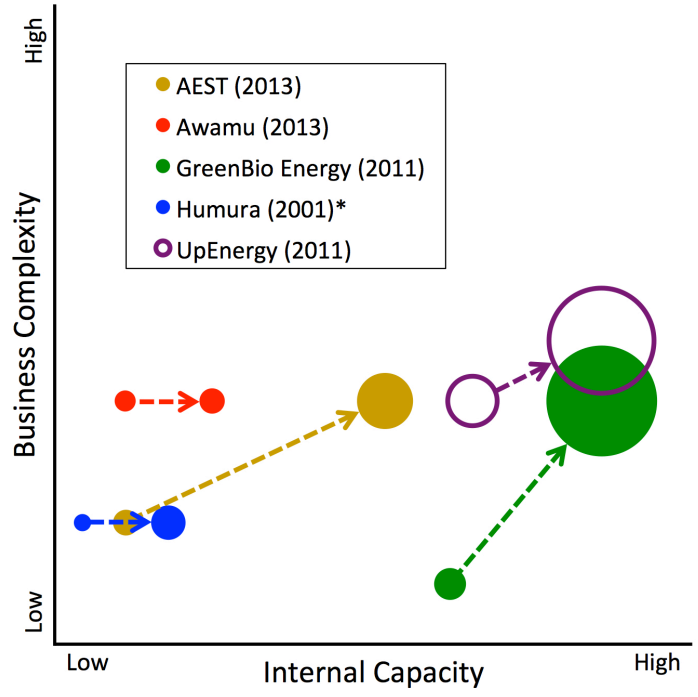


Figure 20: Internal Capacity, business complexity, and sales volume of the case studies at the start of operation (date in parentheses) and in 2016. Sales volume is expressed in the diameter of the circle. * Humura's sales volume is estimated due to incomplete records.

Figure 21 illustrates the levels of risk at each level of BC and IC, with risk increasing from the lower right corner of the fourth quartile to the upper left of the first quartile. Maximizing IC and minimizing BC produces the lowest level of risk, and as IC decreases and BC increases the risk levels become higher and higher. The higher risk level a company is at, the more vulnerable it is to upsets. All of the case study participants decrease in risk from their initial year of operation to 2016.

Founder Impact on Internal Capacity

Figure 20 illustrates that the companies that had the highest initial IC saw the largest gains in sales volume from their first year of operation to 2016. It is important to note then that the businesses with the highest initial IC, Green Bio Energy and UpEnergy, had non-Ugandan founders. These companies started with the advantage of a high IC because of the human capital on their founding teams,[5] and because of that they were able to operate at a higher level of business complexity (and larger sales volume) without exposing themselves to a high amount of risk. Specifically, these founders had high levels of experience, extensive education, and strong international networks, which generated high levels of business expertise. High levels of business expertise meant they needed less assistance improving their operational efficiency than the other participants, as they already had that capacity, and

5. While the IC of a company is not limited to the capacity of the founding team, in the early stages of development the founding team is effectively the entirety of the company.

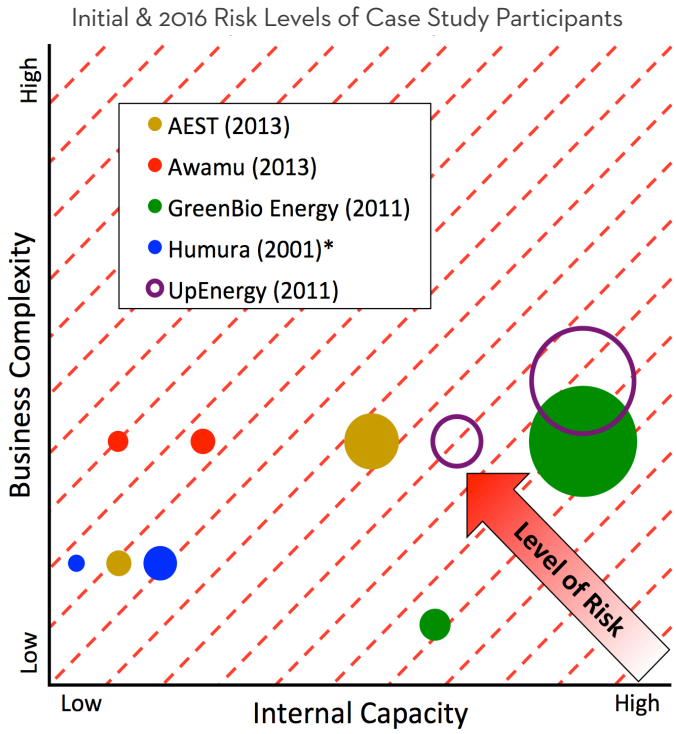


Figure 21: Company IC and BC and sales volume at the start of operation and in 2016. Risk levels increase from the bottom right of the plot (high IC low BC) to the top left of the plot (low IC high BC). * Humura's sales volume is estimated due to incomplete records.

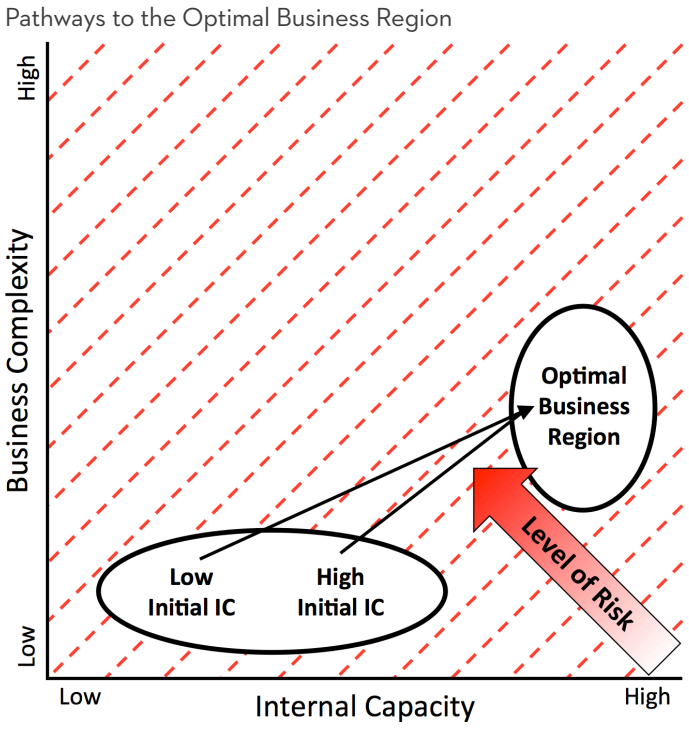


Figure 22: : Companies should reside in the optimal business range when at scale. A risk-averse pathway to the optimal business range requires IC to remain higher than BC. Companies with high initial IC start at a lower risk level and have a shorter pathway.

DISCUSSION

A business owner wants to limit risk to minimize the chance of failure. To accomplish this, he or she must minimize company BC and maximize IC. Unless the company leadership is overly minimizing BC, which can lead to business stagnation (discussed in Strategies to Minimize Risk while Scaling), BC will increase as sales and staff grow; IC must grow proportionally to maintain a balance between the two and prevent a rise in risk exposure. Thus, the optimal region for a business to reside on the IC/BC axes when at scale is where IC is high and BC moderate, as shown in Figure 22. Assuming that a business starts with a lower BC and IC than it has at a substantial sales volume the risk-averse pathway to growth and begins in the lower left of Figure 22 and moves upwards and to the right with a slope of less than one.

Maintaining this IC/BC balance while scaling promotes stability, is attractive to external funders, and can facilitate rapid sales growth. The companies that do so are better positioned to remain a competitive force in the market when faced with financial, mechanical, or operational setbacks. Looking at Figure 18, you can see UpEnergy demonstrate this ability. The company cut its distribution activities in 2013 in response to dwindling funding, and experienced a 45% decrease in annual sales. UpEnergy had a high level of business proficiency at the time — gained from extensive business experience and strong networks — and was able to withstand this blow and stay active by modifying operations while the founders worked to secure additional capital. The company successfully rebounded in 2014 and continued scaling, with their IC to BC ratio in the optimal business region.

The pathway towards reaching the optimal business region is not the same for all companies, as they do not necessarily begin at the same starting point. Of our five case studies, only two (AEST and Awamu), began with the similar levels of IC; Green Bio Energy began with a higher initial IC than these two, Humura with lowest, and UpEnergy began with the highest of the five (Figure 21). Companies that have a high initial level of IC are closer to reaching the optimal region (Figure 22), and have the advantage of being able to build their BC faster than their IC without reaching high risk levels. Importantly, this makes them competitive for large contracts or grants with sponsors such as the UN or the World Bank. Such contracts or grantsusually require rigorous financial accounting, a well-crafted written proposal, and either an existing capacity for large-scale production and distribution or the ability to rapidly scale operations (Hyseni, 2017): qualities all present in companies with high IC and moderate-high sales volume (moderate-high BC). This becomes potentially problematic given the correlation between high IC and international founders (Discussed in Founder Impact on Internal Capacity), because it means a larger percentage of local founders may be perceived as less competitive, or deemed ineligible.

Strategies to Minimize Risk while Scaling

Regardless of their initial IC, companies who wish to mitigate their risk while scaling should seek to minimize their business complexity. By doing so, a company minimizes the number of potential hazards that could upset the business. Mechanisms to minimize BC include outsourcing part of the cookstove manufacturing and distribution

Role of Local Knowledge in Business Proficiency

"Local knowledge," or the understanding of local social and cultural norms, can play a pivotal role in shaping ICS company operations, particularly in marketing and sales. In this study however, acquiring local knowledge did not appear to be an operational hurdle. Companies acquired this awareness by hiring local staff and partners if local knowledge was lacking within the founding team. For all of the case study companies, the sales team was from Uganda and possessed this awareness, as did some members of middle and upper management. Through hiring, ICS companies with entirely international founding teams were able to gain local knowledge. In contrast, business proficiency in western business practices was much harder to obtain if the founding team did not have it at the outset. In the regions where the ICS companies are operating, there is much greater availability of knowledge about local culture and market conditions, as compared to local knowledge about western business practices.

process, relying on contract labor that can fluctuate with customer demand, and reducing product complexity. UpEnergy and Green Bio Energy minimized their business complexity by not vertically integrating; the former acts solely as a distributor and the latter almost entirely as a manufacturer. Table 4 describes the BC minimizations strategies for the case study participants, if any.

In contrast, AEST and Awamu have vertically integrated and own all portions of the manufacturing and distribution process, but have limited the complexity of their distribution and sales activities. Humura outsources some of its manufacturing, does not engage in distribution, and minimize sales marketing. By minimizing BC through a reduction in distribution and sales complexity the leaders of AEST, Awamu and Humura are preventing their respective companies from increasing to a higher risk level, but are also potentially hindering sales and revenue growth by not increasing customer awareness. This illustrates a tradeoff potentially inherent in BC minimization strategies: they can mitigate risk and reduce financial strain, but they also can restrict the speed of growth by limiting the increase in manufacturing capacity and activities such as sales and marketing. Humura is an extreme example of this. The company has the lowest BC and IC of any of the case studies in 2016 (Figure 20) and did not substantially increase its BC in the past decade, even as sales increased. To minimize BC, the founders kept manufacturing complexity lean by hiring contract labor and abstaining from distribution and sales outreach. As a result, they have an extremely low-risk business with the flexibility to accommodate market fluctuations, but have been unable to generate enough customer demand to substantially grow sales. Humura sells 2,000 stoves a year, and its CEO estimated they have seen minimal expansion since transitioning into household cookstoves in the early 2000s. If Humura continues in this manner the company may not be able to keep pace with its competition and secure a substantial place in the market.

Interestingly, Humura's IC is low not due to a lack of the business proficiency, but funding. The company leaders recognize how to scale the business and have the business proficiency to do so. They are limited in their network and access to external capital, and are unable to generate the financial resources to bolster that component of their IC.

Table 4: Case Study Business Complexity Minimization Strategies

	Financial Model	**Product Sourcing Model**		**Distribution & Sales Model**
	Financial Model	Product Complexity	Manufacturing Model	Distribution & Sales Model
Strategies for Minimal Business Complexity	Require upfront payment before manufacturing so limited financial resources are needed Humura	Sell a product that does not require technical design or manufacturing abilities AEST, Green Bio Energy, UpEnergy	Avoid manufacturing process by sourcing ready-made cookstove UpEnergy	Avoid end-user distribution by having customers (or wholesale partners) pick up the product at the factory Green Bio Energy, Humura
Strategies for Moderate Business Complexity	Do not participate in carbon financing AEST, Awamu, Green Bio Energy, Humura	Sell a complex product that requires technical skill to design but not to manufacture Awamu	Outsource some component of production (ex: clay liners) and/or hire production workers on a contract basis Humura	Perform minimal end-user marketing campaigns and/or work with micro-level distributors AEST, Awamu, Humura
Strategies for High Business Complexity	Participate in carbon financing UpEnergy	Sell a highly complex product that requires technical skill to design and manufacture Humura	Produce stoves entirely in-house AEST, Awamu, Green Bio Energy	Engage in door-to-door customer sales distribution and marketing campaigns UpEnergy

Business Proficiency & Financial Resources Are Necessary for Growth

Successfully scaling an improved cookstove (ICS) company hinges on increasing the company's internal capacity (IC) so that it remains higher than the increasing business complexity (BC). Greater IC allows a company to safely build out its operations or to stabilize existing, but vulnerable, practices. IC is comprised of:

- business proficiency (knowledge in finance, product technology, product sourcing/manufacturing, distribution and sales)
- financial resources

A company needs expertise and financial resources to function well. The two are interconnected: financial resources allow companies to afford employees with high levels of business proficiency, and business proficiency can facilitate access to grants, equity investment, debt financing, and carbon financing, and better use for these financial resources.

Substantial attention was given to building financial resources by our interview participants but, problematically, much less was devoted to increasing business proficiency. ICS companies seeking to scale, or external parties seeking to support the growth of ICS companies, should evaluate which aspect, access to financial resources or business proficiency, needs development. The following sections offer insight into the challenges of gaining either, and offer methods for ICS companies and supporters to overcome those challenges.

THE IMPORTANCE OF BUSINESS PROFICIENCY FOR GROWTH

Business proficiency is the knowledge of finance, product technology, product sourcing/manufacturing, distribution and sales- the necessary components for a successful business. It can be obtained through formal education, personal experience, family knowledge or mentorship (network), and it is critical to company performance and longevity. Business proficiency is what enables a company to be operationally competent and, in doing so, makes the company eligible for sources of funding. Without business proficiency a company is likely to be inefficient, underperforming, and unable to scale.

Unfortunately, business proficiency is overlooked and insufficiently supported in the Ugandan ICS industry. The company leaders we engaged with were less likely to identify weaknesses in their personal competencies than their funding strategies, and those that did found it difficult to remedy weaknesses in expertise. Work or school opportunities that provide this experience are limited in Uganda; most establishments/organizations/individuals that offer mentorship are located internationally in either the western markets or in major entrepreneurship hubs such as Lagos or Nairobi. This lack of resources disproportionally effects founders that do not have a formal education or international network to draw upon, a demographic that consists of more local founders than international. One solution, taken by Awamu CEO Nolbert, is to enroll in training courses and seek professional mentorship. This strategy was also taken by Betty of AEST, who also drew on her connection with MIT D-Lab to gain technical assistance and business mentorship. However, this requires a) a high level of founder awareness b) strong personal initiative and c) knowledge on where to seek such resources.

We cannot stress enough the important role of business proficiency in successful company growth. While financial resources are a valuable and necessary component of internal capacity, business strategy, financial models, distribution techniques, and manufacturing are arguably more necessary to ensure those resources are used effectively. Accelerators, incubators, and advisors can assist in gaining business proficiency, but there are not enough of these support systems in the Ugandan ICS market to meet the need. Additional capacity building programs, professional mentors, and university collaborations are all potential mechanisms to address this deficit. These mechanisms do not have to exclusively come from the international community, but a strong international presence could be of use as national capacity grows.

Increasing Risk in Exchange for Growth

Businesses can choose to not to minimize BC in the hope that they will reach the optimal business region by first increasing their BC and taking on risk, and then reducing risk by growing IC. Companies attempting this strategy will have more advanced operations than those with a similar IC, and a higher level of operational insecurity. Examples of this would be hiring full-time staff, engaging in marketing and sales, and vertically integrating across the production and distribution supply chain, without a similar increase in financial resources and staff expertise.

Companies who have increased their risk levels are vulnerable to operational failures, market slowdowns, overextensions of capital, and insufficient management, any of which could cause a business to fail. To mitigate this risk, founders look for ways to increase their IC and decrease risk levels. Thus companies following this strategy are likely to actively seek external funding, either in the form of grants, venture capital, or, less commonly, loans.

None of our case studies increased risk levels dramatically between their first year of operation and 2016, but AEST and Awamu both took on additional BC without substantial IC at times during that period, such as when Awamu expanded its production facilities without an increase in financial resources. This action was small enough not to register significantly in our measurement of BC and increase the company's risk level, but it did pose an additional risk to the founder at the time. We believe that many ICS companies expand their BC and take on additional risk, and fail. However, it is difficult to assess how common this phenomenon is, due to the limited visibility of failed ventures. Lack of formal registration and internet presence in many early stage ventures, regardless of founder nationality, makes it difficult to track inactive companies and assess their prevalence.

GAINING FINANCIAL RESOURCES FOR GROWTH

Funding is needed in early stage companies to expand operations and the number of salaried staff members. It is especially important in the ICS industry, where most companies are selling low-margin products. Revenue is minimal for low-margin products at a low volume, and so ICS companies need a longer runway of external funding before reaching the high sales volume necessary for profitability. In the companies we studied funding came in the forms of:

- Grants
- Investment (venture capital)
- Sale of carbon credits
- Loans

We discuss the challenges and mechanisms to obtaining each below.

Funding Mechanism: Grants

Grants were by far the most popular and common funding mechanism among interviewees. All of the case study participants, except Humura, have been the recipient of multiple grants, with allocations ranging from $2,000-$600,000 USD. Interestingly, international and local founders expressed that the other had the competitive advantage in grant applications and impact investment. One international founder expressed frustration that "funders[donors] are interested in the story you give", and believed that locally-run businesses provide a better narrative. Conversely, local founders repeatedly shared their belief that international founders had better network connections to investors. While we are unable to confirm or deny that locally-run businesses have a more appealing narrative to investors, our research suggests that there is no substantial advantage for local businesses when receiving grants. The two international companies in our case studies received over five times more in external funding, respectively, than each of the three local companies. Secondary interviews confirmed the trend of increased investor funding for internationally founded companies operating in East Africa (Hyseni, 2017; Locke, 2017).

The reasons given for this discrepancy in grant allocation were requirements for energy efficiency or emissions certification, lack of formal business operations in locally-founded businesses, and low production and sales volume. Grants promoting energy efficiency or low emissions require the ICS to undergo testing for certification, which costs upwards of $300 USD (Arineitwe, Kyayesimira, & Isabirye, 2017; Hyseni, 2017; Naluwagga, 2017). Low working capital prevents companies from submitting their products for testing, which then limits eligibility for grants. Many grants are structured for Western business practices and look for formal business operations that are norms in Western ventures (standard operating procedures, accounting, safety protocols, etc.). An inability to demonstrate such can effect grant eligibility and competitiveness. Securing contracts and grants can build out these capacities and increase sales volume, which then makes the company more successful in gaining future contracts and grants. In short, grant competitiveness is dependent upon the ability of the company to demonstrate operational success and to communicate that success to the (largely international) funders. This favors founders with the ability to financially support the company in the initial stages, and knowledge of the expectations of international funders, both of which are not limited to international founders but do often confer an advantage to them.

Support for businesses disadvantaged by this system that could increase grant eligibility include: seed capital for efficiency testing, establishing accounting systems (a commonly underdeveloped operation), or mentorship on financial management and other internal operations.

Funding Mechanism: Investment

Impact investment is the primary investment avenue for Ugandan ICS companies, because traditional commercial investors are less interested in funding small businesses (Granier, 2017; Locke, 2017). This means that when selecting companies to invest in, the majority of investors active in the ICS sector weigh the social "impact" (which can present itself in a variety of different manners) as well as the financial return, and that companies seeking investment have the additional demand of communicating their social good alongside their operational model.

To successfully convey social impact and financial viability, founders must connect and engage with investors (who are primarily based in the US and Europe) and demonstrate a high level of business acumen through pitch decks, executive summaries, financial records, and business plans. This requires a tremendous amount of business proficiency in, but not limited to, pitching, building financial projections, and communicating business strategy. When business proficiency is lacking, as it may be in founders with limited education or international experience, the company is not able to attract investors. As one member of an African financial advisory firm stated: "Lack of investment [in East African companies] is often not due to lack of funds, but lack of investment ready businesses or the ability to communicate investment readiness" (Locke, 2017).

To improve investment readiness founders may need assistance positioning the company narrative, developing the documents necessary for investor due diligence, and thinking about the business strategy. Business documents in particular are frequently underdeveloped. Capital from investors should come with business support pre- and post- investment, but there are not many services available on the able to provide that support. Incubators, accelerators, and companies (like Open Capital Advisors, a secondary interview participant) all serve in that capacity, but there are many unserved companies and founders who would benefit from similar assistance. Additionally, pre-investment business support also helps to connect companies with interested investors, and vice-versa. Impact investors primarily identify potential companies for investment from local incubators, accelerators, universities, and major cities, and companies operating outside of those spheres can go unnoticed. This is a particular disadvantage for many locally-founded companies, who less commonly have a strong internet presence or international connections to gain attention.

Funding Mechanism: Carbon Credits

Carbon credits are tradeable permits that allow the owner to emit one ton of carbon dioxide ("Carbon Credit," n.d.). They are purchased both by organizations legally mandated to reduce their carbon production and by those voluntarily looking to demonstrate corporate-social responsibility. Organizations involved with mitigating carbon dioxide release, such as cookstove companies, can generate these credits in direct proportion to the decrease in carbon dioxide emissions their activities support and sell them to other organizations. UpEnergy currently generates carbon credits and uses the money received from their sale to supplement operational expenses, and carbon crediting is a mechanism of generating additional revenue from the sale of an ICS without increasing the price of the product for the end user.

However, there is an incredibly high cost to entry for participating in carbon financing. Certification as an official Program of Activities is necessary, and companies have to meet the standard operating procedures, safety, and testing requirements of whichever carbon program they register for, all of which costs thousands of dollars. This entry process is also logistically complicated and can be overwhelming for individuals not familiar with the system and its standards. For companies and founders who do not have in-depth experience with these processes, external support is critical for entry into the carbon financing market. There are organizations, such as ICSEA and Impact Carbon, that facilitate entry into carbon financing, but their services can cost upwards of $15,000 USD. Furthermore, there is currently a glut of carbon credits available for sale (Farmer, 2017; Haglier, 2017). This means that generating revenue from carbon credits has become much more difficult, as companies are competing for contracts with the same small pool of buyers, almost all of whom are international.

Of our case studies, only UpEnergy currently participates in carbon financing. Several of UpEnergy's founders had founded or been employed at Impact Carbon, a non-profit that facilitates carbon financing projects, and their team entered into the ICSs industry with an in-depth knowledge of how to use carbon financing to supplement costs and with existing connections to potential buyers. In contrast, AEST's co-founder Betty expressed interest in carbon financing but is limited by her lack of knowledge of the industry, working capital to meet the cost of entry, and connections to potential purchasers of carbon credits. Assistance navigating the legal and logistical hurdles, as well as supporting the up-front costs of registration, would go a long way in opening up the carbon credit market to a broader range of companies.

Funding Mechanism: Loans

Loans have the potential to be a highly useful funding mechanism. Loans require less due diligence and business proficiency then equity, which makes loans more accessible to a larger number of companies. However, none of the primary and secondary stakeholders see loans as a viable large-scale funding mechanism for the ICS sector. This is due to the interest rate in East Africa, which is usually 18% or higher (Locke, 2017). We did find an exception to this in AEST's case study. AEST managed to secure a revenue-based loan from Open Capital Nairobi at a 1.5% interest rate, but there are few similar opportunities available for other ICS companies.

Figure 23: Cookstoves at Appropriate Energy Saving Technologies, Soroti, Uganda.

CONCLUSIONS

For this research study, we analyzed five Ugandan ICS companies to learn about their business practices and how company growth was dependent on the abilities and resources of the founding team. With the data collected from our case study participants and secondary stakeholders we concluded that increasing a company's business proficiency and financial resources (internal capacity) is necessary when increasing the complexity of business finances, product technology, manufacturing, or distribution and sales (business complexity) to avoid over exposing the company to risk.

While the two components of internal capacity are intertwined – business proficiency can be the determining factor for company eligibility for grants and investor funding, and external funding can be used to hire experienced employees– we see business proficiency as the initial requirement for growth. While financial resources are a valuable and necessary component of internal capacity, knowledge in business strategy, financial models, distribution techniques, and manufacturing is arguably more necessary to ensure those resources are spent effectively.

Companies should look to scale while minimizing their risk exposure, which involves maintaining a higher level of internal capacity (business proficiency and financial resources) than business complexity (complexity of financial model, product technology, manufacturing/product sourcing model, and distribution and sales model). In this some international founders have an early-stage advantage; those with levels of business proficiency due to exposure the western educational system and large mentorship/support networks, are able to have a high business complexity without taking on high levels of risk.

Recommendations for Improved Cookstove Companies

When looking to grow ICS companies in Uganda, founders, managers, and organizations looking to support these businesses, should assess the company's internal capacity and business complexity. From that assessment they can identify if complexity exceeds capacity and, if so, in what area of operation (i.e. in finances, product technology, manufacturing, distribution and sales). Very often the company will require both additional business proficiency and additional financial resources. In those scenarios it is important to exercise judgment on the ability of the company to efficiently utilize funding without business proficiency. It is possible that the external funds without business proficiency will not be impactful, and that once business proficiency is established financial resources will be more necessary. Company leaders without strong business proficiency should seek to gain additional capacity before looking to increase business complexity and grow.

Leaders should build business proficiency in their company by:

- Participating in external business training programs (ex: accelerators, incubators, etc.)
- Implementing internal business training programs (ex: on-boarding training for new employees)
- Utilizing Online resources on business practices and education
- Hiring experienced employees
- Participating in local business chapters and online communities to attract attention and support from ecosystem enablers (ex: joining a clean cooking association, maintaining a company website, and creating an online presence)

Recommendations for Improved Cookstove Supporting Organizations

Organizations looking to support ICS companies should focus on increasing business internal capacity, specifically in business proficiency. Financial support is important, but business proficiency is seminal to company support and is often overlooked by company leaders and support communities alike. Organizations supporting the ICS sector could have a great impact by increasing the number of capacity-building services available to these leaders.

Mechanisms to support business proficiency include, but are not limited to:

- Training/mentoring programs (ex: Enterprise Uganda, Energy-4Impact, ENventure)
- Technical support (ex: Harvest Fuel Initiate)
- Peer-to-peer knowledge sharing (ex: GACC Uganda chapter)
- Incubators/Accelerators (ex: UpAccelerate, FinAfrica)

Adding more capacity building programs, professional mentors, and university collaborations to the existing services in Uganda, particularly those that support more than "investment ready-ness", would supplement existing opportunities for financial resources and greatly assist ICS companies as they scale. These mechanisms do not have to exclusively come from the international community, but a strong international presence of supporting organizations could be of use as national support systems grow.

Recommendations for Research Expansion

We recommend that any research expanding upon this work increase the number of companies studied and company diversity. This initiative was narrow in its examination of Ugandan, portable, solid fuel, ICSs, and future examination of other ICS types or different regions may reveal different nuances. Furthermore, this work did not look into any effects that policy and regulation had upon the ICS industry, two areas that undoubtedly has a strong influence on company growth. Finally, we recommend that work be done outside of the Ugandan context to compare the results of this study with other ICS markets, and to identify any cross-country trends in the global market that can be used to inform support organizations.

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Appendix A: Business Case Study Information Document

The purpose of this document is to collect some quantitative information that will help us to better understand your business and create an in-depth case study. We've tried not to request any information that might be sensitive, but if you feel uncomfortable sharing this information, or are fine sharing it but do not want it published, please feel free reach out and let me know. You're welcome to fill out this template, or send along the information in another form if you already have something prepared.

Business Name:

Employee Statistics

Number of employees	
Number of female employees	
Number of international employees	
Number of people on the founding team	

Product Information (if not applicable please enter "n/a")

Product Name	Type (ex: charcoal cookstove, wood cookstove, gas cookstove, briquette, etc)	Price

Sales (if not applicable please enter "n/a")

	2012	2013	2014	2015	2016
Total Briquette Sales Volume (tons)					
Total Cookstoves Sold					
Cookstoves Sales Revenue (indicate UGX or USD)					
Briquette Sales Revenue (indicate UGX or USD)					
Other Revenue (indicate UGX or USD)					

Sources of financial support (list anyone or any organization that has contributed financially to your company). Note: if this information is sensitive generalize (i.e. source as "international NGO," "French government," "private investor," "VC")

Source	Type (grant, equity, debt, etc.)	Amount (range is acceptable) (please indicate UGX or USD)

Appendix B: Case Study Interview Structure

Pre-Meeting (Skype or phone call)

» Founder history interview
» Business plan interview
» Information sent (when comfortable sharing)
    - Operating budget
    - Sales per year (or number of customers reached)
    - Price of product
    - Investment or grant sources (if any)
    - Involvement in carbon financing (if any)
    - Number of employees (local and non-local)
    - Future goals
    - Founder-identified purpose of business

In-Country Meeting Day 1

» Interview founders on personal background, involvement, how they met, skill set, and education (brief re-cap only if collected pre-meeting) (<1hr)
» Talk with General Manager, Operations Manager to receive overview of business model, and financing (brief re-cap only if collected pre-meeting) (<1hr)
» Tour workshop/office (1-2 hrs)
» Observe manufacturing and/or distribution (if possible) (half day)
    - Speak with testing manager

In-Country Meeting Day 2

» Interview company heads (founder/CEO/general manager) on challenge and successes of the company, what resources they've used so far, what resources they wished they had access to (1-2 hrs)
» Confirm operational statistics (obtained pre-meeting) update if necessary (<1hr)
» Observe sales and/or distribution (if possible) (half day)
    - Speak with sales manager
» Close-out, discussion of any potential follow-up, and how you will disseminate the results to the participants

Appendix C: Primary Interview Participants

Company Name	Company Overview	Founder Profile	Manufacturing Location	Year Founded	Interviewee
Green Bio Energy	Manufactures charcoal cookstoves and sells wholesale. Has connections to MIT's D-Lab through the Harvest Initiative/Scale up Fellowships.	International founder living in Uganda	Local	2011	David Gerard (Managing Director), Vincent Kienzler (Co-Founder)
UpEnergy Group	Uses carbon-financing, distributes cookstoves and water filters	International founder living outside of Uganda	International and local (primarily local)	2011	Erik Wurster (Co-founder), Moses Amone (General Manager), Joseph (Sales staff), Sam (Sales staff)
Awamu Biomass Energy	Manufactures and distributes top lit updraft (TLUD) cookstoves	International founder living out of Uganda and regional founder living in Uganda	Local	2012	Nolbert Muhuzuma (Co-Founder/CEO), Paul Anderson (Co-Founder)
Appropriate Energy Saving Techniques (AEST)	Manufactures and distributes charcoal cookstoves and briquettes. Has connections to the MIT D-Lab through the Harvest Initiative/Scale up Fellowships.	Regional founder living in Uganda	Local	2014	Betty Ikalany (Co-Founder/CEO), Everlyne Argo(Accountant), Helen Ekolu Acuku (Co-Founder/Research & Development Officer), Mary Josephine Aguti (Sales)
Humura Investments, Ltd	Family owned business that focuses on up-market stoves	Regional founder living in Uganda	Local	2010	Adeline Muheebwa (CEO), Fred Rwashana (Founder/CTO)

Appendix D: Secondary Interview Participants

Stakeholder	Relevance	Interviewee
Biolite	US improved cookstove company with Ugandan branch	Erik Wurster (Director of Carbon Finance)
Build Uganda, Ltd	Ugandan company selling improved cookstoves	Michael Simu (Co-founder) Robert Musoke (Co-founder)
Burn Manufacturing	Kenyan improved cookstove company	Boston Nyer (General Manager)
Center for Integrated Research and Community Development Uganda (CIRCODU)	Ugandan NGO testing emissions and efficiency of improved cookstoves	Joseph Arineitwe (Director General), Juliet Kyayesimira (Secretary General), Fred Isabirye (Field Manager)
Center for Research in Energy and Energy Consumption (CREEC)	Ugandan NGO testing emissions and efficiency of improved cookstoves	Agnes Naluwagga (Regional Testing and Knowledge Centre Coordinator)
The Charcoal Project	US non-profit supporting clean cooking activities	Sylvia Herzog (COO)
Energy for Impact	UK charity supporting Ugandan cookstove companies with business development	Julius Magala (Country Manager)
Envirofit	US improved cookstove company with branches in Latin America, India, and East Africa	Andrew Kumar (Product Manager)
Global Alliance for Clean Cooking (GACC)	Public-private partnership supporting clean cooking solutions	Amit Alex (Enterprise Development Manager)
Impact Carbon	US non-profit running carbon financing projects with Uganda branch	Evan Haglier (Executive Director)
International Lifeline Fund	US non-profit manufacturing improved cookstoves in Uganda	Vahid Jahangiri (Deputy Director)
Invested Development	US impact investment firm	Miguel Granier (Founder/Managing Director)
Ugandan Ministry of Energy and Mineral Development: Renewable Energy Department	Generating policies that impact clean cooking activities	Wilson Wafula (Acting Commissioner)
Nakabale Integrated Development Group(NIDG)	Ugandan improved cookstove company	Robert Ekiring (Founder)
Open Capital Advisors	Kenya-based financial advisory firm assisting growth and investment in sub-Saharan Africa	Andrew Locke (Project Leader)
Simoshi Limited	Ugandan improved cookstove company	Virginia Echavarria (Founder/CEO)
Uganda National Alliance on Clean Cooking (UNACC)	Ugandan non-profit working to advance clean cooking adoption	Gloria Birungi (Communications Officer)
Uganda Carbon Bureau	Ugandan carbon finance company	Bill Farmer (Chairman)
Ugastove	Ugandan improved cookstove company	Rehema Nakyazze (CEO)
United Nations Capital Development Fund, CleanStart Programme	UN initiative co-investing in and incubating early-stage clean energy businesses in Uganda	Hee Sung Kim (Programme and Knowledge Management Analyst)
World Bank	International financial institution funding an initiative for clean cookstove distribution in Uganda	Besnik Hyseni (Energy Specialist)
World Wildlife Fund, Uganda Country Office	International NGO acting as a regional distributor for improved cookstoves in Uganda	Ibrahim Mutebi (Renewable Energy Manager)

Appendix E: Detailed IC and BC Matrices

Table 1: Detailed Matrix of Case Study Business Complexity

Business Complexity	Complexity of Financial Model		Complexity of Product Sourcing Model				Distribution and Sales Model		Annual Sales Volume	
			Product Complexity		Complexity of Manufacturing Model					
	Year 1	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*
AEST (2013)	**Medium** Rely on revenue and grants	**Medium** Rely on grants to supplement revenue *Are currently profitable*	**Low** Charcoal stove with clay liner	**Low** Charcoal stove with clay liner	**Medium** Contract out some parts of the manufacturing process (e.x. liners)	**High** Produce stoves entirely in house	**Medium** Utilize networks of micro entrepreneurs	**Medium** Utilize networks of micro entrepreneurs	**Low** (1-4,000)	**Medium** (4,000-15,000)
Awamu (2013)	**Medium** Rely on revenue and grants	**Medium** Rely on grants to supplement revenue	**Medium** Top lit updraft (TLUD) stove	**Medium** Top lit updraft (TLUD) stove	**High** Produce stoves entirely in house	**High** Produce stoves entirely in house	**Medium** Utilize networks of micro entrepreneurs	**Medium** Utilize networks of micro entrepreneurs	**Low** (1-4,000)	**Low** (1-4,000)
Green Bio Energy (2011)	**Medium** Rely on revenue and grants	**Medium** Rely on grants to supplement revenue	**Low** Charcoal stove with clay liner	**Low** Charcoal stove with clay liner	**Low** Do not produce stoves, source locally produced models	**High** Produce stoves entirely in house	**Medium** Selling at kiosks and through small retail stores	**Low** Do some B2C distribution but primarily sell bulk orders to large distributors	**Low** (1-4,000)	**High** (15,000+)
Humura (2001)	**Low** Require upfront payment and have received no external funding	**Low** Require upfront payment and have received no external funding *Are currently profitable*	**High** Charcoal stove with clay liner, solar powered stoves, and ovens	**High** Charcoal stove with clay liner, solar powered stoves, and ovens	**Medium** Contract out some parts of the manufacturing process (ex. liners)	**Medium** Contract out some parts of the manufacturing process (ex. liners)	**Low** Do no distribution, customers pick up at manufacturing site	**Low** Do no distribution, customers pick up at manufacturing site	**Low** (1-4,000)	**Low** (1-4,000)
UpEnergy (2011)	**High** Rely on revenue, carbon financing and grants	**High** Rely on grants and carbon financing to supplement revenue	**Low** Primarily charcoal stoves made locally with a clay liner, and some imported models	**Low** Primarily charcoal stoves made locally with a clay liner, and some imported models	**Low** Do not produce stoves source imported and locally produced models	**Low** Do not produce stoves, re-sell imported and locally produced models	**High** Sell door to door to customers and to larger organizations (such as grocery stores)	**High** Sell door to door to customers and to larger organizations (such as grocery stores)	**Medium** (4,000-15,000)	**High** (15,000+)

Table 2: Detailed Matrix of Case Study Internal Capacity

Internal Capacity	Experience								Financial Resources *(Grants, debt, carbon financing, revenue)*		Education *(Education of company leaders)*		Network *(Network of company leaders)*	
	Finance Experience		Experience with Product Technology		Manufacturing/ Sourcing Experience		Distribution and Sales Experience							
	Year 1	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*	*Year 1*	*2016*
AEST (2013)	**Low** Have minimal experience with business finances and manual sales records	**Medium** Currently keep sales records, recently hired an accountant on staff	**Low** Founders have limited technical experience and moderate familiarity with product	**Medium** Product has gone through several revisions and company leadership has manufacturing experience	**Low** No large-scale production experience	**Medium** Small, full time, production staff with experience	**Low** Minimal to no sales or distribution experience,	**Medium** Moderate distribution experience, recently hired a sales and marketing manager	**Low** ($1-10,000)	**Medium** (100,000-500,000)	**High** Founders have advanced degrees	**High** Leadership team (founders) have advanced degrees	**Medium** Founder has relationship with local community and international universities	**High** Leadership team (founders) have strong relationship with local community and international universities
Awamu (2013)	**Low** Have minimal experience with business finances and manual sales records	**Medium** Currently keep sales records and have a part-time accountant	**Medium** Founders have technical and manufacturing experience with product	**High** Product has gone through several revisions and company leadership has strong technical and manufacturing experience	**Low** No large-scale production experience	**Medium** Small, full time, production staff with experience	**Low** Minimal to no sales or distribution experience	**Low** Moderate distribution experience marketing, no staff member assigned to marketing and sales	**Medium** ($10,000-50,000)	**Low** (1-100,000)	**Medium** One founder has advanced degree, second founder has bachelor's degree	**Medium** One founder has advanced degree, leadership team (second founder) has bachelor's degree	**Low** One founder is strongly connected to the local community, but limited involvement with international professional networks	**Low** Leadership team (co-founder) is strongly connected to the local community, but limited involvement with international networks
Green Bio Energy (2011)	**High** Have experience with business finances and have an accountant on staff	**High** Have experience with business finances and have an accountant on staff	**Low** Founders have limited technical experience and familiarity with product	**High** Product has gone through several revisions and company has hired individuals with strong technical experience	**Medium** No large-scale production experience so company is sourcing pre-made stoves	**High** Large, skilled, production team on staff	**Medium** Moderate sales experience	**High** Business model relies on wholesale orders, have experience selling and distributing to these large B2B customers	**Medium** ($10,000-50,000)	**High** (500,000+)	**High** Founders have advanced degrees	**High** Leadership team has bachelors or advanced degrees	**High** Founders are international and have strong international connections	**High** Leadership team is international and has strong international connections
Humura (2001)	**Low** Have minimal experience with business finances and manual sales records	**Low** Have minimal experience with business finances and manual sales records	**Medium** Founder has technical and manufacturing experience with product	**High** Product has gone through several revisions and company leadership has strong technical and manufacturing experience	**Low** No large-scale production experience	**Low** No large-scale production experience	**Low** Minimal to no sales or distribution experience	**Low** Minimal to no sales or distribution experience	**Low** ($1-10,000)	**Low** ($1-10,000)	**Medium** Founder has bachelor's degrees	**High** Leadership team has bachelor's or advanced degrees	**Low** Founder has limited involvement in local clean cooking network and no international connections	**Low** Leadership team involvement in local clean cooking network and limited international networks
UpEnergy (2011)	**High** Have extensive experience with business finances and have an accountant on staff	**High** Have extensive experience with business finances and have an accountant on staff	**Medium** Founders have technical experience with some models of product	**High** Company leadership has technical experience with a wide range of product models	**Medium** No large-scale production experience but some experience in ICS sourcing	**High** Extensive experience in ICS sourcing	**Medium** Moderate sales experience and knowledge of door to door distribution	**High** Extensive sales experience, performing in-village marketing, organize and execute door to door sales	**High** ($50,000+)	**High** (500,000+)	**High** Founders have advanced degrees	**High** Leadership team has bachelors or advanced degrees	**High** Founders are international and have strong international connections	**High** Leadership team has strong international connections

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ABOUT THE AUTHORS

Macauley Kenney holds a master's in Technology and Policy from MIT, and a bachelor's in Biomedical Engineering from Worcester Polytechnic Institute. She is a co-founder of the Rwandan brokerage Kumwe Logistics, and a board member for the Institute of Engineering and Technology. She served as a research fellow at MIT's D-Lab from 2016-2017 leading this research initiative on the impact of the founding team composition on the growth of improved cookstove companies.Macauley has a personal interest in data-driven international development projects, particularly those focused on entrepreneurship.

Eric Verploegen, who leads the MIT D-Lab Off-Grid Energy Group, joined MIT D-Lab in 2014 to expand its research efforts in the area of off-grid energy. He has a background in materials science and earned a doctorate in polymer science and technology from MIT in 2008. Prior to D-Lab, he worked on developing materials for solar cells and waste remediation systems for the oil and gas industry. He is passionate about helping organizations based in off-grid regions identify technologies, products and distribution strategies to increase energy access in their communities. He also enjoys playing pickup basketball and Frisbee.

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