# EMERGING MARKETS:

# Top ICT Hardware Challenges

inveneo

# ACKNOWLEDGMENTS

This research paper was directed by Bruce Baikie, Executive Director of Inveneo, written by Dr. Laura Hosman, Assistant Professor of Political Science at the Illinois Institute of Technology, edited by Jana Melpolder, Media Manager, contributed by Matt Crum, former Project Engineer of Inveneo, and supported by USAID and ARM Limited.

## About Inveneo

Inveneo is a 501c3 nonprofit social enterprise. It is Inveneo's mission to deliver the tools of Information and Communications Technologies (ICTs) – sustainable computing and better access to the Internet — to those who need it most, people and organizations in rural and highly underserved communities of the developing world.

## Background to the Project

This research was conceived and supported by ARM, the world's leading semiconductor intellectual property supplier. In 2012, ARM met with Inveneo to ask how ICT hardware could be designed more appropriately for developing countries. ARM recognized the many problems faced by ICT hardware in emerging economies and knew Inveneo had the expertise that could establish what the key issues might be and how they could be overcome. ARM then took the concept to USAID and together they developed this research concept. ARM is at the center of the largest commercial ecosystem in the technology sector, so their intention is to take the outcome of the research and encourage the sector to respond to the challenge of designing more appropriate products.

USAID awarded Inveneo the Hardware Challenges project because of its significant ICT4D (Information and Communications Technology for Development) experience. Working in 32 countries, Inveneo has a growing record of bringing hardware solutions to more than 3,200,000 people worldwide. In addition, its team works with 128 ICT partners in South Asia, Sub-Saharan Africa, and other locations around the world. It approaches ICT4D challenges with a clear vision and coherent plan of action that includes undertaking research on how ICT hardware could be designed more appropriately for developing countries and regions. The Inveneo team is grateful for this opportunity to partner with ARM and USAID in the Hardware Challenges project, and it hopes that the information provided within will prove to be useful for ICT4D manufacturers and practitioners around the world.

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# Executive Summary

There is widespread agreement that information and communications technologies (ICTs) improve developing world quality of life and should be incorporated into development efforts at all levels. Scholars and researchers writing about ICT for Development (ICT4D) and its use by Development Organizations, Government and Industry Organizations mainly focus on the use of such technology to address complex social issues that underlie development challenges.

However, little of this work has focused on the technology itself. This is regrettable; technologies not designed for the harsh environmental and/or electrical conditions found in many developing world locations often fail. Devices and hardware can—and should—be better designed and built to function in these difficult conditions. This is where challenge meets opportunity.

The purpose of this paper is to educate engineers, designers, and manufacturers: to make them aware of developing world technology hardware requirements and realities. To this end, insights gleaned from in-depth interviews and a macro-level survey of experts, practitioners, academics, and end-users of ICT4D are herein presented as the Top 5 Technology Hardware Challenges in the Developing World.

The design and development of technology that meets the needs of the developing world represents an opportunity to both expand potential markets and increase the quality of life for many people. The potential for generating effective, disruptive innovations increases with outside the box thinking, such as that necessary when designing for truly constrained conditions. Below are the top ICT4D hardware challenges and recommendations, according to Inveneo's survey respondents and interviewees.

# Top 5 ICT4D Hardware Challenges

What are the main challenges related to the deployment of technology hardware across the developing world?

### Electricity/Power/Energy

Extremely low power and long battery life; robust handling of electrical spikes, swings, dips, blackouts, and brownouts; and—ideally—at 12-volts DC to be solar-power ready

### Cost

Balance must be found between lowest cost and solid, reliable, functional technology

### Environment-related Issues

Reliability/ruggedness/durability all of paramount importance (resistance to water, humidity, dust, dirt, and extreme heat); no moving parts recommended; screens are difficult to repair and difficult to read in direct sunlight

### Connectivity

Essential to the usefulness of just about any device in any location; is what creates value for entire ICT4D ecosystem: the more connected, the more valuable the network. Main method advocated was WiFi

### Maintenance & Support

The best technology needs no support. Transportation for repair, maintenance, and support is expensive. Sourcing spare parts is a challenge. Technology that cannot be locally maintained, supported, and repaired is not sustainable

# Introduction

Information and Communication Technologies (ICTs) are becoming pervasive, contributing to increased efficiencies, economic growth, and the transformation of societies. Their effects are, however, not uniform around the globe; the level of new ICT access inequality is extremely high—as is the disparity in their potential benefits. Thus, despite undeniable evidence that these technologies have transformed the way many in “developed” countries live, ICTs' transformative effects have not been realized in many poorer, “developing,” or resource-challenged locations.

This situation is particularly unfortunate, since those living in developing nations have the potential for much gain from ICTs—realized development goals; enhanced empowerment, opportunity, and security; a general improvement of quality of life. This promise helps explain why many governments, development organizations, for-profit and non-profit organizations, and even individuals are attempting to harness the power of these enabling tools for human development (Gerster & Zimmerman, 2005).

Even so, the challenges facing the realization of ICTs’ promise are myriad. Illiteracy, poverty, poor infrastructure (power, roads, and telephony), harsh environmental conditions, marginalization and exclusion of certain groups, and short-sighted regulatory, fiscal, and economic policies are all contributing factors that will require both public and private sector commitment to address. It is important to remember that ICTs are simply tools and do not solve social or political problems that are often at the very root of poverty: they are not a shortcut to, or panacea for, improving human well-being.

Still, there is broad agreement that ICTs should be incorporated into development efforts, at all levels. Not only should the global poor not be left behind in terms of increased communications capabilities and access to information, but nearly every aspect of development efforts—including the meeting of basic needs—can be improved by the application of technology. In other words, ICTs hold tremendous potential to address development challenges effectively (Waugamon, 2014).

Development organizations, practitioners, and scholars bemoan the contrast between ICTs' promise and their relatively modest measurable impact. Many underlying reasons for this underperformance have been identified and studied; some of the explanatory factors originate from larger social and political issues (Gerster & Zimmerman, 2003).

However, a significant contributing cause—one that is under-discussed and poorly addressed—has to do with the technology itself. Nearly all of the world’s information and communications technology is designed for and produced in the developed world. The vast majority of devices and innovations are targeted to markets peopled by sophisticated, literate users who already understand how ICTs can improve work- and lifestyle-related efficiencies. These users take for granted advanced electrical and connectivity infrastructures and are able to afford expensive technologies and utilize them in safe environments. When technologies developed for this advanced market are employed in poor, resource-constrained locations—where environmental conditions are harsh, electricity and connectivity are not assured, and technological literacy and understanding are scant—they often fail.

Thus, many challenges exist in addition to those posed by socio-political "human" factors. The technology itself—the devices and hardware—can be better designed to function in the challenging conditions present across much of the developing world. This is where challenge meets opportunity.

Industry and private sector technology companies have two distinct, important factors to consider. First, the creation of technology that meets the real needs of the developing world represents an opportunity to both expand potential markets and increase the quality of life for a large number of people (London & Hart, 2004). Second, there is the Trickle-up, Disruptive Innovation effect to consider. It was, after all, the perceived potential competition inspired by the One Laptop Per Child (OLPC) concept that spurred the advent of the netbook revolution (Kraemer, Dedrick & Sharma, 2009), –and arguably, the rebirth of the tablet market– as technology companies raced to meet a market demand they had previously failed to perceive. The low-end netbook and tablet have proven successful with both developed and developing world consumers, and were, for many technology companies, rare bright spots for profitability during otherwise challenging economic times (Hosman & Baikie, 2013).

Disruptively innovative technology is more likely to be developed when designing for (or under) truly constrained conditions. Conversely, it may be difficult to do more than "tinker at the edges" of innovation if one never leaves the comfort of the technologically advanced world and designs solely for existing conditions. In addition, the OLPC example illustrates that technology designed for constrained conditions can be developed into successful products—not just in the developing world markets for which they were originally intended, but around the globe as well. Meanwhile, such devices will be less expensive and power-hungry; this benefits everyone.

It is not coincidental that Facebook has recognized the importance of preparing its developers to address the challenges and constrained conditions of low-income locales: since it is impractical to send each of its engineers to every market, the company created a lab on its Menlo Park campus (in Silicon Valley, CA) that replicates the conditions faced in Nairobi or Jakarta, for example, or even in rural villages with no electricity or 3G service (Honan, 2014). It can be exceedingly difficult to design technology useful to people facing circumstances vastly different from one's own, and nearly impossible to imagine all possible situations, occurrences, and relevant factors.

The goal of this paper is to educate the designers and manufacturers of technology hardware and devices to the needs, requirements, and realities present in the developing world. To that end—based on the insights gleaned from in-depth interviews and a macro-level survey of experts, practitioners, academics, and end-users of ICT4D—herein are presented the Top 5 Technology Hardware Challenges in the developing world, as well as the top related challenges interconnected to hardware.

Each of the following categories and the issues specific to them are elaborated upon in the Hardware Challenges section. The top challenges interconnected to the hardware are identified and explained in that section as well.

## Top 5 Hardware Challenges

**Electricity/Power/Energy**

**Cost/Affordability**

**Connectivity**

**Environment-Related Issues**

**Maintenance & Support**

## Top Challenges Interconnected to Hardware

**End-Users/Usability**

**Operating System/Software**

**Other Specific Hardware Features**

**Non-Hardware Issues**

# Data Collection Methodology

The findings presented in this paper are informed by data originating from three sources: Technology Salons, In-Depth Interviews, and a Macro-Level Online Survey. The multi-methods approach formed by combining qualitative and quantitative data provides a better understanding and greater validity of findings than a single method, as the two approaches complement and inform each other. While a survey can reach a large number of participants with narrow questions and measurable responses, in-depth interviews are useful when deeper probing is necessary. The mixed-methods approach also builds the research from one phase to another: each major research phase is informed by its predecessor.

- **Technology Salons**
  Inveneo convened international development experts for discussions of pre-selected topics relevant to ICT4D hardware challenges. These four roundtable discussions, with approximately 20-30 participants each, were designed to reveal important issues in ICT to inform subsequent stages of data gathering. These events took place in Nairobi, London, Washington DC, and San Francisco.

- **In-Depth Interviews**
  Structured one-on-one interviews with key stakeholders in the field of ICT4D were designed to allow in-depth discussion of technology hardware challenges in the developing world and to inform the online survey questions. Thirty-six academics, practitioners, and end-users were interviewed, most of whom self-identified with more than one of those titles or job descriptions. Gender, geographic location, and specific area of expertise were also major considerations while forming a sample cohort intended to be simultaneously representative and diverse. The interviews were recorded and transcribed. Content/thematic analysis was subsequently performed to identify common themes, allow categories to emerge, and permit the interviewees to develop and address the relevant research questions in their own words.

- **Online Survey**
  The survey was designed to collect descriptive and attitudinal information from a representative sample of actively online subjects self-identified as interested in ICT4D topics (as reflected by the survey distribution outlets listed below). As such, generalized statements may be made vis-à-vis the attitudes and beliefs of the larger ICT4D community. Survey invitations were distributed on Inveneo's email list, through its ICTWorks website, on the Engineering For Change (E4C) blog, at the Development Impact Lab 2014 conference, and on local web-based news sites (such as innovationafrica.org). Inveneo also promoted the survey through its social media channels that include Facebook and Twitter. The invitation reached an estimated 6,000 potential respondents; from this pool 460 surveys were completed.

The section below presents the top hardware challenges identified from Inveneo's survey and interview respondents. The challenges are presented in bullet-point, summary format, and subsequently elaborated upon in descriptive, paragraph form.

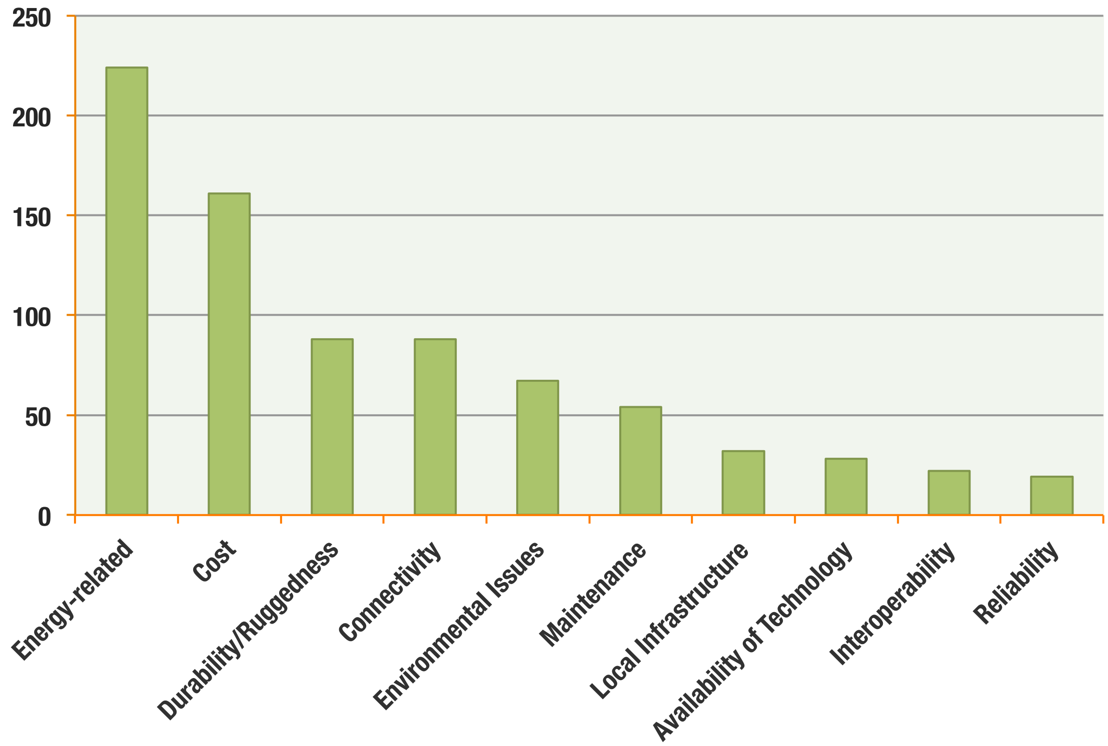
# Interview and Survey Findings

The online survey commenced with the following question: “In your own words, what are the top hardware challenges facing ICT4D?” This open-ended question was designed to capture the respondents’ spontaneous, unique, and uninfluenced insights and opinions before introducing them to a series of closed-ended questions. By definition, closed-ended questions are pre-populated with a fixed list of possible responses from which survey participants select the best response. The respondents were asked to rate (or rank on a Likert Scale) the importance of hardware features and related factors identified during the in-depth interviews and two rounds of pretest surveys.

This “open-ended to closed-ended” approach allowed the capture and comparison of respondents’ uninfluenced opinions with the fit and appropriateness of the pre-populated categories of hardware features. It also allowed for unique and heretofore unidentified issues to arise.

In the event, the issues identified as the top ICT4D hardware challenges by answers to the open-ended questions proved to be largely similar—although not identical—to those resulting from the closed-ended questions. Inveneo believes the similarities in outcome denote robustness of survey results, which are subsequently triangulated with the findings from the in-depth interviews in the sections below.

*Figure 1: The Top Ten survey responses to the open-ended question: In your own words, what are the top hardware challenges facing ICT4D?*




As Figure 1 illustrates, energy-related issues were deemed far and away the most important of the ICT4D hardware challenges. The second most commonly identified challenge was cost. Durability and ruggedness of hardware tied with connectivity issues for third most-important ICT4D issue. Rounding out the Top Ten list of challenges were: environment, maintenance, local infrastructure, availability of technology, interoperability, and reliability of technology.

These challenges are elaborated upon below in the order of importance indicated by survey respondents and interviewees. The first section is an overview of specifics identified within each major hardware-related category by the interviews and the survey. The second section explains the challenges, characteristics, and features in greater detail, with particular attention paid to the in-depth interviews.

## Specific ICT4D Hardware Challenges

- **Electricity/Power/Energy**
  - Low Power
  - Long battery life
  - Renewable (mainly solar) energy/chargeable on 12V/DC

- Avoid the need for inverters
- Where possible, devices should be power-smart, as well. Ex: a server could power down if not used overnight

- **Cost**
  - Everyone wants low cost
  - Balance must be found between lowest cost and solid, reliable, functional technology
  - Some pointed out that it can be extremely difficult to calculate the total, long run cost of a device in the developing world, since it is so difficult to estimate product life span. It is also difficult to estimate how much charging, connectivity, and potential repair costs will be

- **Environment**
  - Reliability/ruggedness/durability all paramount
  - Screens easily get scratched, smudged, or cracked (difficult or impossible to replace or repair)
  - Screens are difficult to read in direct sunlight
  - Devices should be waterproof or water resistant, humidity resistant, extreme-heat resistant
  - No moving parts and passive cooling important so that dust, dirt, and humidity won't ruin the technology
  - E-Waste: One (or more) device per user (will) add up very quickly when it comes to disposal and landfills. Recyclable and/or reusable devices needed

- **Connectivity**
  - Essential to usefulness of just about any device, for any location
  - Connectivity itself what creates value for entire ICT4D ecosystem: the more people connected, the larger the network, the more people want to be—and will pay to be—on the network with their devices
  - Should be able to connect to the Internet/data. Primary means advocated was WiFi
  - Should also be able to cache information because being always connected is not a reality
  - Also essential because of frequent updates to software and OS only made available online
  - The only area it was pointed out that connectivity is not essential is in education

- **Maintenance & Support**
    - The best technology needs no support. Transportation is expensive if someone needs to travel for repairs or support
    - Spare parts sourcing is a true challenge for most developing world locations
    - If technology is not locally repairable, it is not sustainable
    - Lack of local technology experts (also relevant in terms of training)

- **Other Specific Hardware Features**
    - Most widely used plugs and slots, like USB, headphone jacks, etc., are important for finding these accessories locally and affordably. Interoperability is important.
    - Cameras, speakers, GPS, web browser interfaces, durable external keyboards, and/or user-friendly internal keyboards all seen as important
    - A few interviewees spoke in favor of open hardware, such as Arduino and Raspberry Pi, which is affordable, can be easily transformed to meet local (project) needs, and promotes curiosity, learning about, and familiarity with technology.

## Top Challenges Interconnected to Hardware

- **End-Users/Usability**
    - Smaller devices, such as tablets, are becoming more intuitive and user-friendly, but emphasis also given to the importance of training
    - End-user devices no longer come with manuals; devices need to be intuitive and user-friendly. Applications should be relevant for users or not come pre-loaded

- **Operating System/Software**
    - The overwhelming majority recommended to “use the operating system that works or makes the best sense in the context” even if an individual has a personal preference
    - Those who work with illiterate populations stressed the need for speech recognition software

- **Other Non-Hardware Issues**
    - If users don’t understand how a technology will meet a need in their lives or ease a pain, it won't: without seeing its relevance, they won’t make the effort to learn to use it, or invest their hard-earned money and buy it
    - Many non-technology users fear using a tool that is foreign to them: they are afraid they will break something

- Technology handouts will not incentivize local ownership, nor will they inspire belief that the technology will be useful
- Technology is generally imported, and prices are what consumers in the wealthy world can afford. In addition, many governments tax technology, making it doubly expensive and that much more difficult for the poor to afford
- The cost of connectivity often prohibits people from getting online or making functional use of SMS, voice, or data services. This is more of an issue regarding telecommunications companies, policy, and regulatory issues, but it relates closely to whether devices will be purchased and used
- The entire ecosystem of technology—supply chain and logistics—is essential and should not be overlooked
- Creative funding and financing options need to be developed to address the poor's inability to fund technology (or connectivity) in the ways in which it is done in wealthy countries. (One example is the use of Facebook purchased by the day, rather than by the byte: time is a denomination people can easily comprehend.)
- A few of the interviewees pointed out that theft was an important issue

*Figure 2: Top-Rated ICT4D Hardware Issues within Categories (Closed-Ended Questions)*

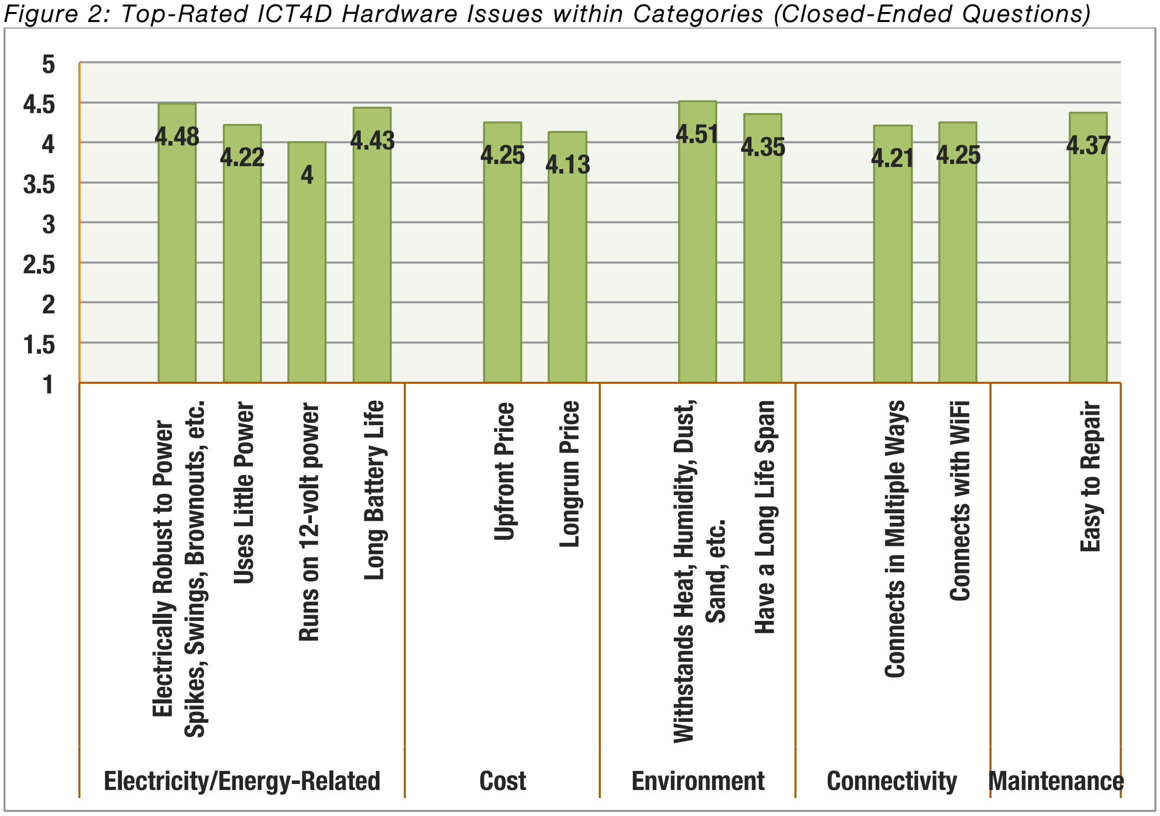



Figure 2, above, reports the top-rated individual ICT4D hardware challenges, categorized, from the macro-level online survey. Respondents were asked to rank each feature or characteristic on a scale from one to five, with one representing “not important” and five indicating “extremely important.” The findings from these closed-ended questions correspond closely to those from both the open-ended survey question and the in-depth interviews with experts, academics, practitioners, and end-users.

# Electricity/Power/Energy

The majority of survey respondents and interviewees agreed: Power-related issues are the top challenge facing hardware/technology in ICT4D; the lack of reliable, affordable electricity was seen as the biggest issue. Figure 1 visually demonstrates that Energy-Related Issues dwarfed the other categories in terms of the importance accorded it by the survey respondents.

Many interviewees and survey respondents alike pointed to power spikes, surges, brownouts, and blackouts as important challenges for ICT4D: hardware must be robust enough to handle power swings and surges, or it will fail right away. A significant number of the interviewees and respondents expressed the desire for hardware that can be powered at the 12-volt level, so that it is simple and straightforward to employ renewable energy—such as solar power—and with direct current, so that electricity is not lost in the DC-AC-DC conversion process.

# Cost

The challenge presented by the cost of technology proved to be the second most-important issue to the survey respondents. Cost was also second in importance among the interview subjects, who were able to place the issue of cost in perspective, given the ability to elaborate in an interview context. The vast majority of respondents and interviewees believe that incomes in developing world locales are not sufficient to afford the desired, useful technology.

A number of the interviewees articulated one of the main cost challenges: the finding of a price “sweet spot” that correctly balances expense with quality sufficient to provide durability and functionality. In their opinions extremely low-cost devices tend to fail quickly, making them more expensive—in the long run—than devices that maintain functionality longer. Nonetheless, the preference for extremely low cost devices prevails. This is not simply because of low-income levels, although this certainly plays a significant role, but because it can be extremely difficult to calculate devices’ long-run cost when it is so challenging to estimate charging, connectivity, and repair costs in a developing world context.

# Environmental Issues

**Reliability, Ruggedness, and Durability**

These interrelated concepts were identified as extremely important by both survey respondents and interview subjects. Many specific examples of typical device weaknesses or causes of failure under challenging developing world conditions were given. These included scratched, smudged or cracked screens, particularly when employed in a multi-user scenario. In addition, screens are often difficult to impossible to read in direct sunlight. Respondents would like to see devices that are resistant to humidity, salt-air, sand, dust, dirt, extreme heat, and water (or are even waterproof); these environmental hazards are common in the developing world, where it is often difficult to provide controlled environments for devices. Since this is the case, many advocated for devices with no moving parts, so that dust, dirt, sand, and humid air, etc. are not sucked in or blown around through use of a fan and/or vents that are otherwise intended to cool down a machine and prolong its life.

**E-Waste, Recycling, and Pollution**

Although e-waste was frequently mentioned by interviewees from developed or Western countries, it was far less important to those located in and originally from the developing world. This issue is not yet at the forefront of developing-world mindsets; the priority remains getting technology to as many users as possible in order to create the critical mass necessary to engender widespread technology uptake.

Many of the Western-based interviewees voiced the desire for recyclable technology, for hardware to employ easily swappable and interchangeable parts, and for e-waste recycling programs to be established where they are most needed—in places that have become dumping grounds for e-waste, particularly in the developing world. There was little to no discussion of the feasibility of taking such approaches. In addition, these issues were less prioritized by the survey respondents.

# Connectivity

Connectivity tied for third most important issue among survey respondents; it was also seen as vitally important by interview subjects. It is connectivity that gives meaning to the “I” and “C” in “ICT.” Without connectivity, there is no means of accessing the very information and communications capabilities that add value to this technology. Respondents pointed out that the more connected people each user knows, the more valuable their network—and indeed the entire network—becomes. Thus, the more widely available methods for getting connected and online, the better. WiFi, 3G, and 4G were all identified as important, although WiFi was seen as by far the most important among the three. In addition, since this is how most essential software updates are made available, connectivity becomes central to the continued operation of any given device.

Education was the only realm in which interview respondents identified connectivity as potentially non-essential, since it is possible to collect and store educational data offline (although doing so under constrained circumstances can present challenges of its own). In such situations—and where connectivity is not likely to become a reality in the near future—many interviewees pointed out the importance of having an offline data source of value to local technology users/learners to, among other things, familiarize them with the information available on the World Wide Web before it becomes available to them. This creates both interest and demand for when circumstances become favorable for connectivity to be established and used.

# Maintenance and Support

Maintenance and support-related issues were identified as the fourth-greatest challenge by both interviewees and those surveyed. All interviewees agreed that in an ideal world, the best device would need no servicing or support—it would just work. Numerous respondents pointed out the difficulty of sourcing spare parts for developing world locations: having spare parts on hand is rarely in a plan-of-action for development projects or even market-oriented launches of new products in the developing world. The logistics and infrastructure challenges in these locations conspire to add significant costs to spare parts sourcing. On a similar note, transportation for the performance of servicing, maintenance, or repair is expensive as well, in particular due to the poor quality of infrastructure. The next challenge is the lack of local skilled talent to carry out repairs. A significant number of respondents gave the example of how globally popular basic mobile phones have their lifetimes extended by the relative ease with which they can be taken apart, diagnosed, fixed, and put back together, and how entire local ecosystems rise up to address this need. If technology is not locally repairable, it is neither locally affordable nor will it be locally sustainable.

# Other Issues

**Location and Distribution**
There is a disconnect between interviewees who stressed the need for designers and developers actually located in the developing world and intimately aware of the challenges facing that environment on a day-to-day basis, and the countervailing point made by others that technology and hardware designed for too specific a purpose will become “boutique” technology. This would negate the benefits of economy-of-scale—affordability and the ready availability of off-the-shelf replacement parts. A balance between these points of view seems unlikely. However, there is room for the creation of strong feedback loops to afford developing world designers and developers access to the capabilities and manufacturing and distribution channels of large technology companies.

**Non-Hardware Issues**
It is beyond the scope of this paper to analyze the myriad non-hardware issues identified by survey and interview respondents. Some of the most frequently mentioned are presented in the overview section above. Even so, it is worth noting how much importance respondents attached to non-hardware issues: If a “Non-Hardware Issues” category had been included with the open-ended survey question results in Figure 1 above, it would have ranked a close second to electricity/energy issues. A significant focus on non-hardware issues manifested throughout the interviews as well; even though both the survey and interview were clearly presented to respondents as focused specifically on hardware and technology ICT4D challenges, a significant number of participants gave non-hardware responses as their replies.

Perhaps this abiding focus on non-hardware issues reveals a widespread recognition of the importance of the entire ecosystem—from socio-political to infrastructural aspects, to name a few. It is certainly a reflection of respondents' firsthand experience with the challenge of bridging the gap between ICTs' promise and realized impact. The ecosystem—and whether it addresses local needs—critically impacts the adoption and meaningful use of technology. Although complex challenges remain, this paper asserts that if—and only if—ICT hardware is appropriately designed and manufactured to meet the needs and realities of the developing world can the technology make significant contributions to those challenges it purports to address.

## Conclusion

Just as the field of ICT4D is evolving and expanding rapidly and ICT4D projects are taking on broader scopes and scales—expanding into agriculture, governance, health care, and education—the critical analysis of best practices and lessons learned must continue. The quality of people's lives and their abilities to move out of poverty and live lives with increased levels of freedom and opportunity are on the line. The same holds true when it comes to analyzing the technology and hardware of ICT4D: understanding what works and what does not is of paramount importance to improvement.

This paper is intended to launch the critical discussion of how ICT4D hardware can better meet the needs and challenging conditions found in the developing world. The stakes are high and the opportunities are great. Inveneo looks forward to continuing this discussion.

# Appendix A

This section presents the results of survey respondents' ratings and closed-ended responses to specific hardware challenges within each category. The figures below illustrate the level of importance the survey respondents assigned to each aspect of the challenges facing ICT4D. The respondents were asked to rank each feature or characteristic on a scale from one to five, with one representing "not important" and five indicating "extremely important."

*Figure 3: How would you rate the following HARDWARE FEATURES, in terms of significance for ICT4D?*

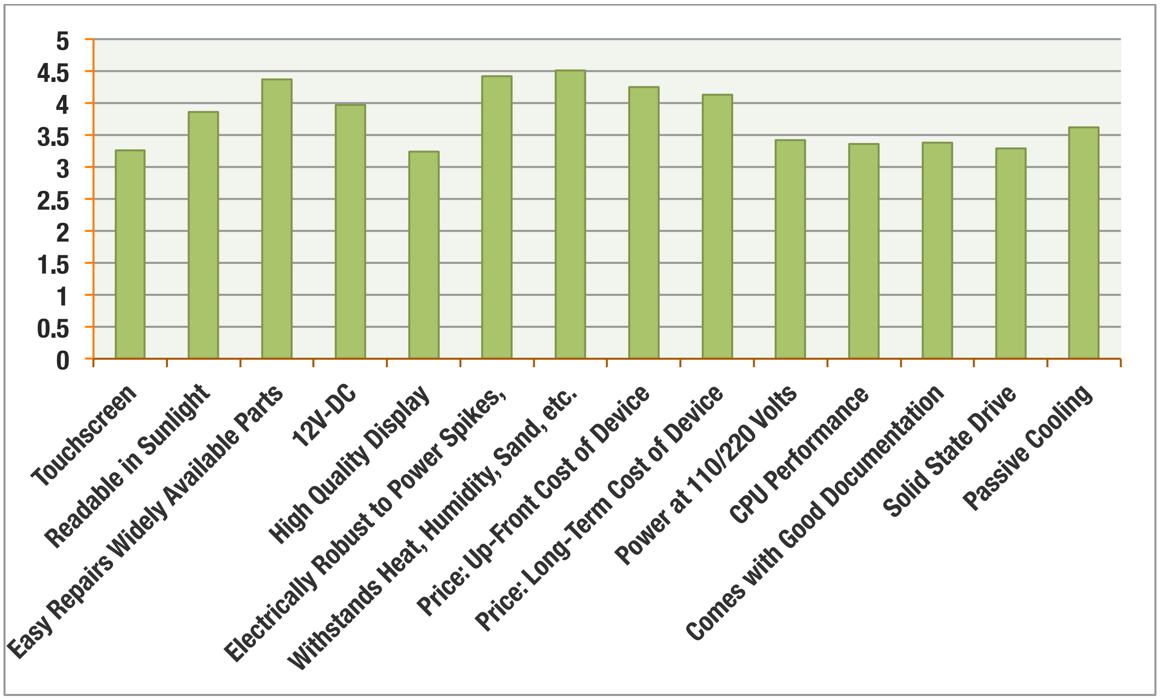


*Figure 4: From an ENVIRONMENTAL standpoint, how important are the following hardware features or related factors when it comes to ICT4D? Hardware should:*

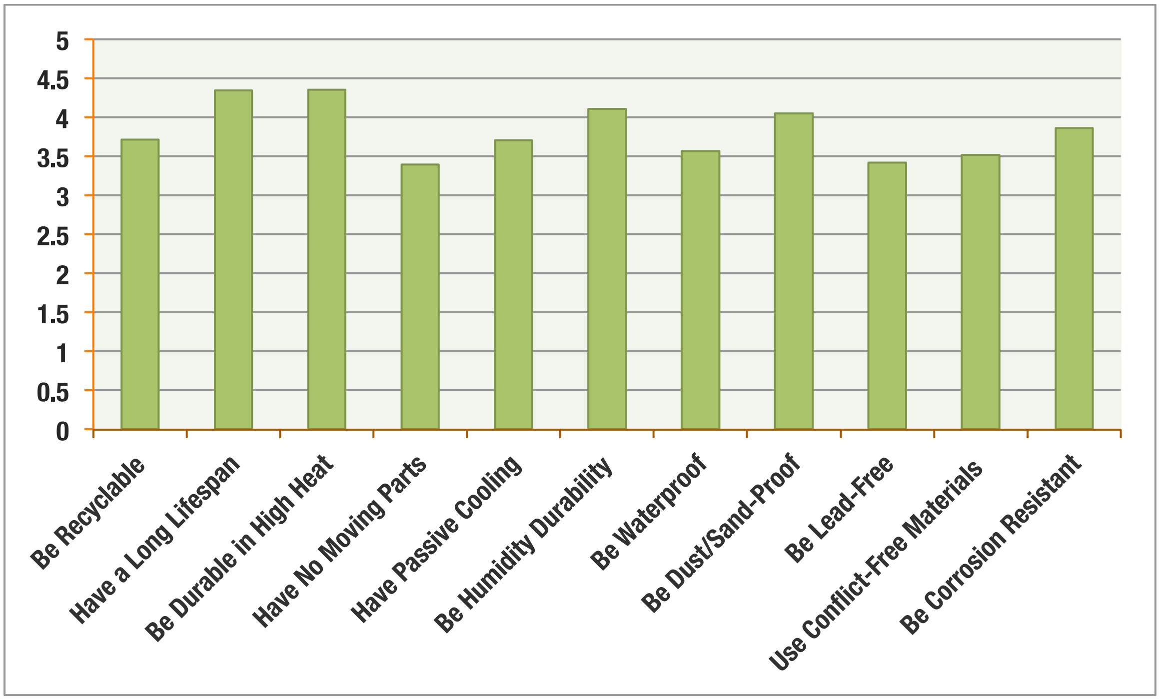



*Figure 5: In terms of POWER/ENERGY/ELECTRICITY, how important are the following features or characteristics relating to hardware for ICT4D? Hardware should:*

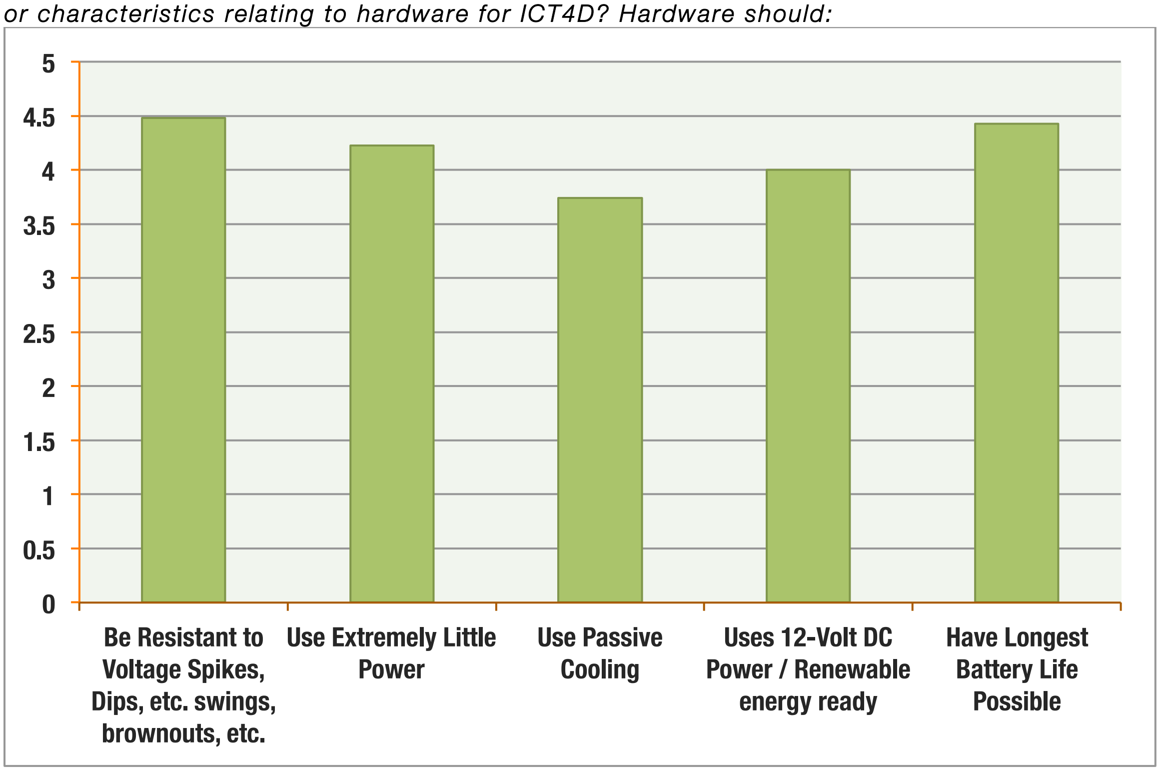


*Figure 6: When it comes to NETWORK CONNECTIVITY, what level of importance would you assign to the following hardware features? Hardware should:*

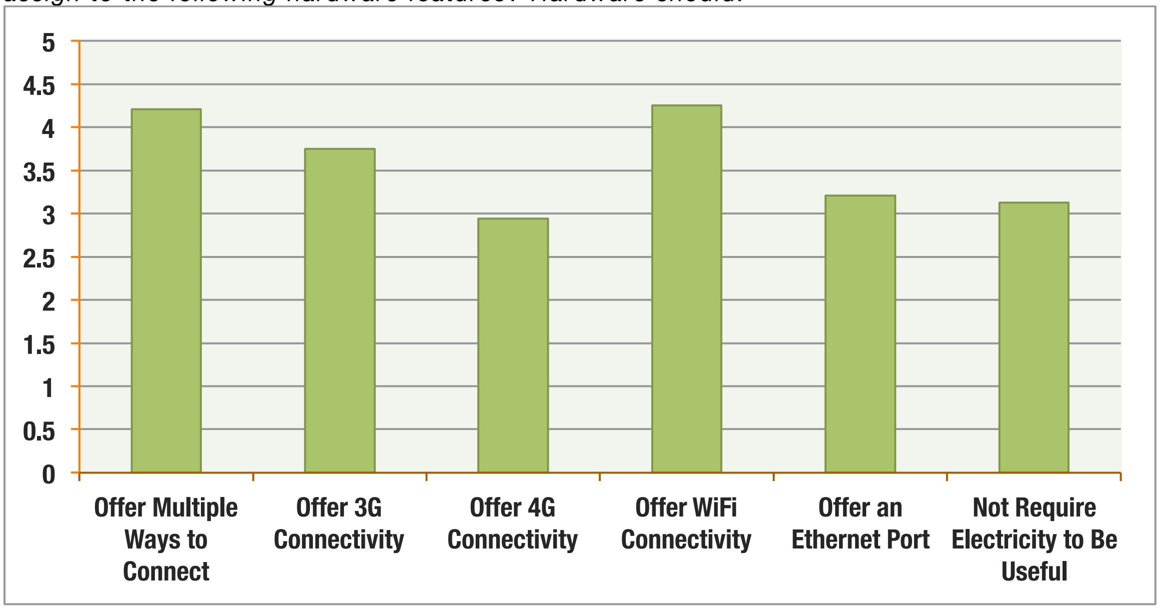
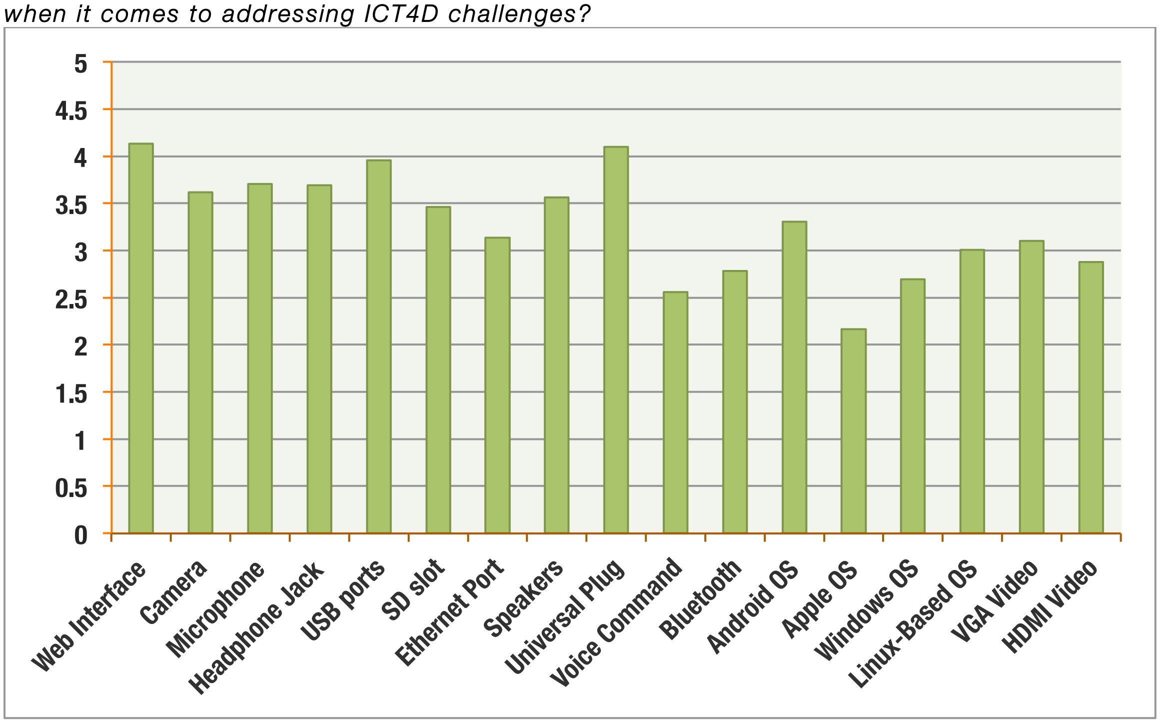



*Figure 7: How important would you say the following PERIPHERALS AND SOFTWARE are when it comes to addressing ICT4D challenges?*



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