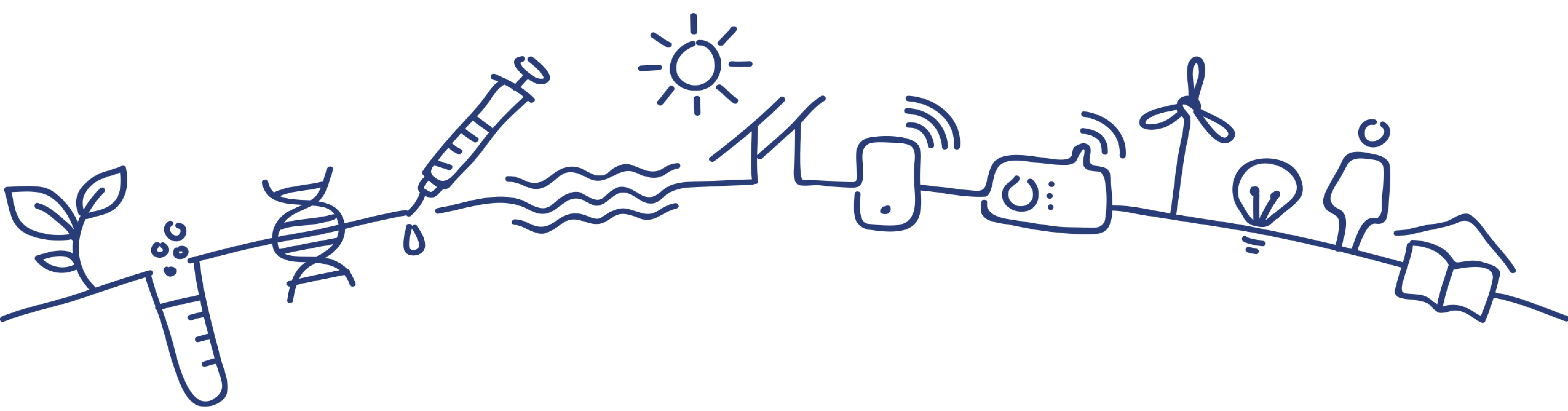
50 BREAKTHROUGHS

Critical scientific and technological advances needed for sustainable global development



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2014

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ACKNOWLEDGMENTS

This study, over two years in the making, would not have been possible without input, guidance and support from many, many individuals and organizations.

Our **Advisory Panel**, which gave us overall guidance on structuring, approach and ongoing dissemination of our findings, includes Steven Buchsbaum from the Bill & Melinda Gates Foundation, Carol Dahl from The Lemelson Foundation, Alex Dehgan formerly from USAID, Ashok Gadgil from the Lawrence Berkeley National Lab and University of California – Berkeley, Calestous Juma from Harvard University, Jaime Sepulveda from the University of California – San Francisco, and Laura Tyson from the University of California – Berkeley.

Our **research team**, which collected data, conducted interviews, and did much of the analytical work for the study, includes Kumar Bekbolotov, Rachel Boots, Aurelien Chu, Rachel Dzomback, Samantha Fernandez, Tammy Guo, Iris Shim, Bernice Wong, and Lina Vashee.

We received technical input from more than 500 experts, across the various areas of this study, from around the world. We are grateful for the support we have received from each and every one of these experts. Some of the technical experts whose engagement and guidance this study particularly benefited from are listed below. It is important to reiterate that these experts do not necessarily agree with our analysis and conclusions.

Global health

Peter Small, Bill & Melinda Gates Foundation
Thomas Evans, Aeras
Mel Spigelman, Global Alliance for TB Drug Development
Shelly Batra, Operation ASHA
Orin Levine, Bill & Melinda Gates Foundation
Rasa Izadnegahdar, Bill & Melinda Gates Foundation
Mike English, Oxford University and KEMRI-Wellcome Trust Research
Kirk Smith, University of California, Berkeley
Ellen Piwoz, Bill & Melinda Gates Foundation
Marc van Ameringen, Global Alliance for Improved Nutrition
Prabhu Pingali, Cornell University
Patricia Coffey, PATH
Anne Hansen, Boston Children's Hospital
Sam Thenya, Nairobi Women's Hospital
Mariam Claeson, Bill & Melinda Gates Foundation
France Donnay, Bill & Melinda Gates Foundation
Cyril Engmann, Bill & Melinda Gates Foundation
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Sudesh Menon, Waterlife India
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John Pasch, USAID
Jerome Chin, University of California - Berkeley
Anand Mehta, practicing physician and endocrinologist

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Alan Magill, Bill & Melinda Gates Foundation
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Elizabeth Ponder, Stanford University
Regina Rabinovich, Harvard University
Mary Galinski, Emory University
David Cook, Seres Health
Don Francis, Global Solutions for Infectious Disease
Mitchell Warren, AVAC
Stefano Bertozzi, University of California - Berkeley
Gene Walther, Bill & Melinda Gates Foundation
Jean-François de Lavison, Ahimsa Partners
William Rodriguez, Daktari Diagnostics
Francis Moussy, WHO
Bernhard Weigl, PATH
Rosanna Peeling, London School of Hygiene and Tropical Medicine
Mark Perkins, FIND
Amit Jain, eHealthPoint
Ajay Nair, MeraDoctor
Soura Bhattacharyya, Glocal Healthcare Systems
Madhukar Pai, McGill University
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Access to electricity

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Nikit Abhyankar, Lawrence Berkeley National Lab
Nihar Shah, Lawrence Berkeley National Lab
Anand Gopal, Lawrence Berkeley National Lab
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Arun Majumdar, Stanford University
Hasna Khan, Prokaushali Sangsad Limited (PSL)

Digital inclusion

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Arjuna Costa, Omidyar Network
Ermanno Pietrosemoli, Fundacion Escuela Latinoamericana de Redes (EsLaRed) and International Centre for Theoretical Physics
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Arlene Mitchell, Bill & Melinda Gates Foundation
Samuel Thevasagayam, Bill & Melinda Gates Foundation
Prem Bindraban, The Virtual Fertilizer Research Center
Steve Yucknut, Kraft Foods
Janet Cotter, Greenpeace International
Jordan Dey, GrainPro Inc.
Martin Fisher, Nick Moon and other staff members of Kickstart
Effatah Jele, Dairy Association of Zambia
Garron Hansen, Wood Family Trust
Various members of the International Water Management Institute
Richard Rogers, Bill & Melinda Gates Foundation
Enrico Pausilli, World Food Programme
Pascal Joannes, World Food Programme
Angela Hansen and various staff members of the Agriculture practice, Dalberg Global Development Advisors

Water

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Ashok Gadgil, Lawrence Berkeley National Lab and University of California - Berkeley
John Pasch, USAID
Peter Gleick and various other staff members of The Pacific Institute
Amitabha Sadangi, IDE India

Resilience against climate change and environmental damage

Jayant Sathaye, Lawrence Berkeley National Lab
Mathis Wackernagel, Global Footprint Network
Various members of the Intergovernmental Panel on Climate Change from the Lawrence Berkeley National Lab

We would also like to thank USAID and its Global Development Lab, who funded us through the Higher Education Solutions Network and the Development Impact Lab at the University of California – Berkeley, The Lemelson Foundation, The Schmidt Family Foundation, Dalberg Global Development Advisors (for technical and editorial support), The Good Company and OMG (for design), and The Lawrence Berkeley National Lab, for their generous support of this work.

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INTRODUCTION

This is the beginning of a conversation.

When the Millennium Development Goals were launched in 2000, the rallying cry was around the need for more development aid. As international institutions coalesce around the post-2015 Sustainable Development Goals, it is likely there will be a heavy emphasis on the role of science and technology in achieving them.

Through the post-WWII history of efforts to alleviate global poverty, a small number of breakthrough technologies have had transformative impact: the polio vaccine has all but eradicated a disease that was leading to life-long paralysis in millions of people around the world; new seed varieties developed by Norman Borlaug launched the Asian Green Revolution, which led to agricultural self-sufficiency through much of Asia; insecticide-treated bed-nets have led to remarkable successes in malaria control; and antiretroviral drugs appear to have rendered HIV/AIDS a chronic and manageable disease. More recently, the mobile phone revolution has led to innovations like the M-PESA mobile money platform, which has become the primary means of payment for low-income populations in Kenya.

Such major breakthroughs, however, are rare. One reason, we found, is that there is limited broad understanding of the underlying issues, and the role that technology can play. While deep knowledge rests among a small number of topic-specific experts, the nature of the international development sector is that a large number of the decision makers—donors, social impact investors, program officers, employees in government agencies, practitioners working in NGOs or international institutions—often make their decisions based on limited information and analysis. As a result, far too much of the effort in the technology-for-development space is focused on incremental technologies, which—despite compelling narratives, significant funding, and considerable media hype—fail to reach any reasonable scale or impact.

To be sure, technology is not essential to solving many of the problems surrounding global poverty. Tremendous progress can be made through institutional reform, infrastructure development, education, access to user finance, behavior change, and other policy and social interventions. Indeed, even when technology is necessary, it cannot achieve meaningful impact on its own. This study focuses on problems for which new technologies are critical. By definition, these breakthroughs do not currently exist, at least not in the right configuration of cost and usability. Typically, there is no need for them in industrialized countries, and the private sector likely does not see enough profits to invest in creating them for developing world markets. They represent breakthroughs because they have to be dramatically different from existing technologies in industrialized settings: available at a fraction of the cost, requiring only a fraction of the energy, significantly less reliant on technical skills to operate, not needing elaborate infrastructure, and being generally robust and maintenance-free.

These breakthroughs are decidedly not 'low-tech', in that they cannot be achieved by backyard hobbyists or part-time volunteers inspired by humanitarian objectives. They require serious science, robust engineering, and inventive business models for distribution, scale and sustainability. These breakthroughs have to be part of a new paradigm of technologies for a new set of users. Unlike in past decades, the proliferation of new off-grid energy and communication platforms offers unprecedented opportunities to create leapfrog technologies, some of which may even be valuable in industrialized countries.

Motivation and objectives

In this context, the main purpose of our study is to identify where such paradigm-shaping breakthroughs are most required. The intended reader of this study is the 'informed generalist' in international development rather than topic-specific experts. The study aims to:

- Launch a thought-provoking conversation among practitioners in the technology-for-development ecosystem in order to focus collective effort on the breakthroughs that really matter.
- Provide contextual background for technologists who may not yet have realized the relevance of their work to global poverty.
- Provide funders a guide to asking the right, and likely hard, questions as they evaluate their investment options.

As a part of this study, we consulted with a large number of topic-specific experts. It is important to note that not all of them agree with our conclusions. Undoubtedly, new evidence will disprove some of our conclusions and analyses. In many cases, the evidence that exists—and informs our analysis—does not rise to the level of academic precision. Notwithstanding these risks, we are sharing our findings with the belief that the problems we seek to address require urgent decisions with the best data available, and that our ecosystem needs a common starting point for debate.

Which brings us back to our first point. *This is the beginning of a conversation.*

ABOUT LIGTT, AND THE GENESIS OF THIS STUDY

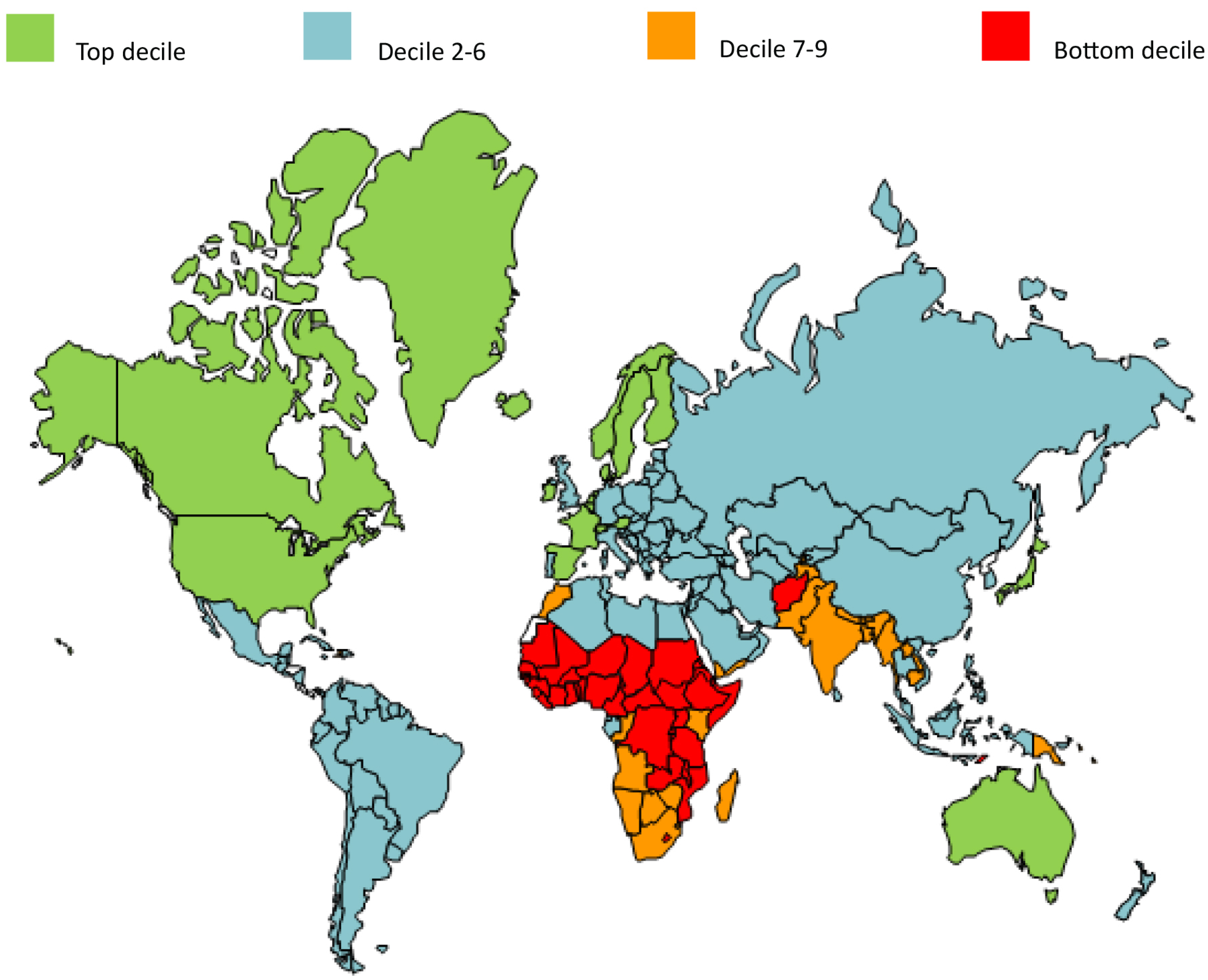
LIGTT (pronounced 'light'), is the Institute for Globally Transformative Technologies at the Lawrence Berkeley National Lab (LBNL). Founded in 1931 by the Nobel Prize winning physicist Ernest Orlando Lawrence, LBNL is one of the world's oldest and most storied institutions for scientific research.

Over the years, its scientists have discovered or synthesized many of the elements in the last row of the periodic table, invented a range of major technologies such as synthetic antimalarial drugs, electronic ballasts for more efficient lighting, Home Energy Saver (the web's first do-it-yourself home energy audit tool), a pocket-sized DNA sampler called the PhyloChip, windows with embedded electrodes that enable window glass to respond to changes in sunlight, and synthetic genes for anti-AIDS superdrugs. One of Berkeley Lab's most notable breakthroughs is the discovery of dark energy, a critical construct in astrophysics, which permeates all of space and accelerates the expansion of the universe. A number of LBNL's scientists have also served on the Intergovernmental Panel on Climate Change. Over the years, LBNL scientists have won 13 Nobel Prizes.

LIGTT was created in 2012, with the aim of leveraging LBNL's capabilities—3,500 scientists and engineers, $800 million in annual R&D, hundreds of patents, and dozens of facilities for experimentation, simulation, testing and fabrication—to develop and deploy breakthrough technologies for sustainable global development. LIGTT continues in LBNL's tradition of fostering transformative technologies, with the difference that we also focus on innovative business models for deployment. One of the first questions the LIGTT team set about trying to answer was, "what technologies should we focus on?" This led to an internal study to identify what eventually became the *50 Breakthroughs*. LIGTT aims to develop many of these breakthroughs, working with scientists from LBNL and other research institutions around the world.

GEOGRAPHIC FOCUS

The geographic focus of this study is sub-Saharan Africa and South Asia, primarily because poverty is concentrated in these regions. The map below shows the various parts of the world, ranked in terms of the United Nations' Human Development Index (or HDI, a composite metric which combines wealth, health and education), and grouped into population deciles. According to the HDI, the worst-off countries are in sub-Saharan Africa and South Asia (UNDP, 2013). While our focus throughout this study is on the two poorest regions, poverty persists in other parts of the world as well. In principle, the solutions identified in this study are just as applicable elsewhere as they are in both South Asia and sub-Saharan Africa.



** Map not to scale*

NOTES ON METHODOLOGY AND LAYOUT

Traditionally studies focused on future-facing topics have relied on surveys of experts, using approaches like the Delphi Method[1], a structured iterative process of interviews and reviews. Early in our study, we discovered two challenges with such a process. First, the absence of a broad, credible evidence base about what works has led to entrenched opinions. Second, such an approach would likely have led to a laundry list of 50 *technologies* or *devices*, rather than to a robust problem analysis which logically leads to the *breakthroughs* required—agnostic to specific technologies.

Hence, this study employs a six-part approach to reach its conclusions:

1. Describe and analyze the 5-10 most important contextual facts about the specific problem.
2. Identify the key challenges, which have kept effective solutions from becoming a reality.
3. Identify, based on input from recognized topic-specific experts, the most promising interventions to overcome those hurdles.
4. Determine the dependence of each of these interventions on: policy reforms, infrastructure development, education and human capital development, behavior change, access to user finance, an innovative business model, and finally, a new breakthrough technology.
5. We focus on interventions with a significant dependence on a breakthrough technology, and identify the important parameters the technology needs to fulfill. Based on the underlying technical challenges, we then estimate the time-to-market by when these breakthroughs may become deployable products.
6. Finally, we identify the most important hurdles to sustainable, large-scale deployment, based on many of the factors listed above (e.g., policy reforms, etc.), and score the difficulty of deployment on a 5-point scale: simple, feasible, complex, challenging, and extremely challenging. The purpose of this final analysis is to encourage technologists and funders to understand these challenges before making major investments in their work.

Each chapter is divided into three parts: Core Facts and Analysis, Key Challenges, and Scientific and Technological Breakthroughs. The 5-point scale and the complexity we ascribe to each of the factors and constraints relevant to the deployment of a particular technology are illustrated in **Table A**. The lowest score (feasible) is reserved for cases when the particular constraint is not relevant to deployment; the constraint is given the highest score (extremely challenging) if it can be a serious bottleneck to deployment. The aggregate score reflects the overall degree of difficulty, considering the collective weight of the individual constraints. The methodology is clearly subjective. **Exhibit A** is a sample of how we have illustrated the difficulty of deployment for each breakthrough across the study. This particular sample highlights a CHALLENGING breakthrough.

[1] A structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts who anonymously reply to questionnaires and subsequently receive feedback in the form of a statistical representation of the 'group response', after which the process repeats itself. The Delphi method is based on the assumption that group judgments are more valid than individual judgments. It was originally developed by the RAND Corporation in the 1950's to forecast the impact of technology on warfare.

Table A

	Simple	Feasible	Complex	Challenging	Extremely Challenging
Policies	Minimal role of policy/regulation	Low role of policy/regulation	Regulated market with supportive policies	Highly regulated market with policy changes required	Highly regulated and controversial changes required
Infrastructure	Minimal need for infrastructure	Dependent on existing infrastructure	Requires some improvements to existing infrastructure	Requires moderate improvements to infrastructure	Requires major improvements to infrastructure
Human capital	Minimal need for human capital development	Low-moderate need for human capital development	Moderate need to train a limited number of people	Requires high level of training for large numbers of people	Requires national scale training programs
Access to user finance	Financing not required	Limited financing required	Moderate financing needed, viable mechanisms available	Significant financing required, limited mechanisms available	Significant financing required, no identified mechanism
Behavior change	No behavior change required	Minimal behavior change required	Moderate behavior change required with evidence of behavior change being viable	Major behavior change required, potentially on daily basis	Significant behavior change needed on daily basis, changes contrary to cultural norms
Existing demand	Strong existing demand	Existing demand	Moderate demand	Low demand, needs to be built	Extremely low demand or not a perceived need
Market fragmentation/ Distribution channels	Highly concentrated market or well defined channels	Fairly concentrated market and/or well defined channels	Moderate fragmentation of customers, under-developed channels	Fragmented market, weak distribution channels	Highly fragmented, challenging to reach customers
Business model innovation	Clear deployment models existing at scale	Deployment model in process of scaling	Deployment model(s) being tested	Deployment model(s) being tested, major hurdles outstanding	No identified deployment model, major hurdles identified

Exhibit A

Breakthrough – Difficulty of deployment