# Theory and Practice Together Builds Clean Energy Access

**Daniel M. Kammen**

Two interlinked challenges of sustainability define our energy future: the persistence of widespread energy poverty; and intensifying human-driven climate disruption[1]. These crises are inexorably linked through the energy technology systems that have so far provided the vast majority of our energy: biomass and fossil fuels. Both the energy service crisis and the climate crisis have become increasingly serious over the past decades, even though we have seen greater clarity over the individual and social costs that each has brought to humanity.

The correlation between access to electricity and a wide range of social goods is overwhelming. However, access to improved energy services alone does not provide a surefire pathway to economic opportunity and an improved quality of life. Figure 1 details the correlations that exist between electricity access across nations and a variety of measures of quality of life, such as the Human Development Index (HDI). Other indicators studied include gender equality in educational opportunity, and the percentage of students who reach educational milestones[2].

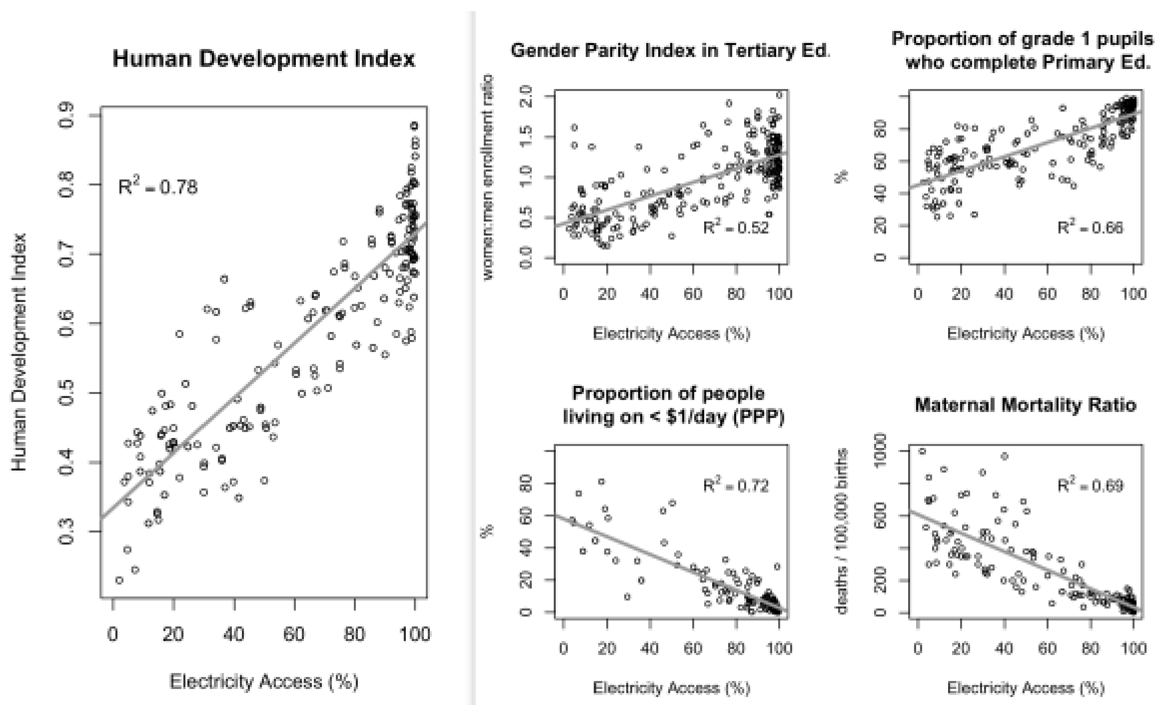


**Figure 1: The Human Development Index (HDI) and various additional metrics of quality of life plotted against the percentage of the population with electricity access. Each data point is country level data a specific point in time. For additional data, see (1).**

*http://energyaccess.org/news/recent-news/member-spotlight-daniel-kammen/*

**Figure 2: A village micro-grid energy and telecommunications system in the Crocker Highlands of Sabah, Malaysian Borneo. The system serves a community of two hundred, and provides household energy services, telecoms and satellite (dish shown), water pumping for fish ponds (seen at center) and for refrigeration. The supply includes micro-hydro and solar generation (one small panel shown here, others are distributed on building rooftops). Photo: DM Kammen.**

Recently we have seen an emergence of off-grid and now mini-grid electricity systems that do not require the same supporting networks as the traditional forms of centralized power generation. These technological innovations are as much based on information systems as they are directly about energy technology. Mini-grids and increasingly diverse products (TVs, super-efficient refrigerators, etc. …) for individual user end-use such as solar home systems have benefitted from dramatic price reductions and performance advances in solid state electronics, cellular communications technologies, electronic banking, and in the dramatic decrease in solar energy costs[2]. This mix of technological and market innovation has contributed to a vibrant new energy services sector that in many nations has outpaced traditional grid expansion.

The classic utility model of a one-way flow of energy from power plant to consumers is now rapidly changing. The combination of low-cost solar, micro-hydro, and other generation technologies coupled with the electronics needed to manage small-scale power and to communicate to control devices and to remote billing systems has changed village energy. High-performance, low-cost photovoltaic generation, paired with advanced batteries and controllers, provide scalable systems across much larger power ranges than central generation, from megawatts down to fractions of a watt.

The rapid and continuing improvements in end-use efficiency for solid state lighting, direct current televisions, refrigeration, fans, and information and communication technology (ICT, as seen in Figure 2) have resulted in a 'super-efficiency trend'. This progress has enabled decentralized power and appliance systems to compete with conventional equipment for basic household needs. These rapid technological advances in supporting clean energy both on- and off-grid are furthermore predicted to continue. This process has been particularly important at the individual device and household (solar home system) level, and for the emerging world of village mini-grids[3].

Despite this rapid evolution, a tension exists between both traditional utility planners and the 'new skeptics' who see innovative challenges to the traditional grids as diversions from 'full energy services'[4]. The evolving technology and management base of distributed, modular and clean energy options has changed this landscape in ways that are not being reflected in the arguments against smart, clean, energy access. Off-grid (Pay-as-you-go) and mini-grid companies are now offering low-power color televisions, freezers, and other appliances as well as lighting, radios, outlets and other 'basic services'. This is not meant to say that small solar-based systems are the equivalent of full utility-grid based services today, but the skeptics need to catch up with the advance of technology and the systems-level innovations that are taking place.

We are now seeing these changes in perspective around off-grid and mini-grids more are more often. In fact, recently in Malaysian Borneo my colleague Dr. Rebekah Shirley and I have chronicled two key test-cases: coal-fired power plant and a mega-hydropower project rejected in favor of cleaner, more decentralized energy mix[5]. Noah Kittner and I are analyzing and observing a similar dynamic in the Balkans, where we find that the clean energy options are both faster to install and simply cheaper than the old fossil fuel dependent development path[6,7].

To enable and expand this process, a range of design principles emerge that can form a roadmap to clean energy economies. These include but are not limited to emphasizing the benefits of: a) *Establishing a clear energy access and development goals at the local level; b)*

*Empowering villages as both designers and as consumers of localized power*; and c) *Making gender and ethnic equity a central design consideration for energy access projects.*

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Biography:

**Daniel M. Kammen** is a Professor of Energy at the University of California, Berkeley, with parallel appointments in the Energy and Resources Group, the Goldman School of Public Policy, and the department of Nuclear Engineering. Dr. Kammen was educated in physics at Cornell (BA 1984) and Harvard (MA 1986; and PhD 1988), and held postdoctoral positions at the California Institute of Technology and at Harvard. He was an Assistant Professor at Princeton University before moving to Berkeley. His work is focused on energy access and on developing low-carbon energy systems across scales. He was appointed by Secretary of State Hilary Clinton in 2010 as the first energy fellow of the Environment and Climate Partnership for the Americas (ECPA) initiative, and in 2016 as a Science Envoy for State Department. Kammen served as the Chief Technical Specialist for Renewable Energy and Energy Efficiency at the World Bank from 2010 – 2011. Dr. Kammen has served as a Coordinating Lead Author on various reports of the Intergovernmental Panel on Climate Change since 1999. The IPCC shared the 2007 Nobel Peace Prize.

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