

NOTE: Due to an editing oversight the version published by Issues in Science and Technology omitted the figures in this essay. This version includes the figures.

MORGAN BAZILIAN  
ROGER PIELKE, JR.

# Making Energy Access Meaningful

*The world's poor need more than a token supply of electricity. The goal should be to provide the power necessary to boost productivity and raise living standards.*

In a somewhat inconsequential meeting at the United Nations (UN) in 2009, Kandeh Yumkella, the then Director-General of the UN Industrial Development Organization, and UN Secretary-General Ban Ki-moon's informally assigned "energy guy", noted something obvious and profound, namely that, "the provision of one light to poor people does nothing more than shine a light on poverty". Yet much of an emerging discussion on the critical importance of global energy access as a pathway out of poverty continues to focus on what are, in effect, "one light" solutions. In this essay, we seek to help clarify the challenge of energy access, expose assumptions that are informing policy design in the development and diplomatic communities, and offer a framework for future discussions rooted in the aspirations of people around the world to achieve energy access compatible with a decent standard of living.

Our distinctly uncomfortable starting place is that the poorest three-quarters of the global population still only use about ten percent of global energy – a clear indicator of deep and persistent global inequity. Because modern energy supply is foundational for economic development, the international development and diplomatic community has rightly placed the provision of modern energy services at the center of international attention focused on a combined agenda of poverty eradication and sustainable development. This priority has been expressed primarily in the launching of the UN Sustainable Energy for All initiative (SE4All).<sup>1</sup> Still, areas of tension and conflict within such an agenda demand further attention, particularly in relation to climate change, as we discuss later in this essay.

Compounding the difficulty of decision-making in such a complex space is that the concept of "energy access" is often defined in terms that are unacceptably modest. Discussions about energy and poverty commonly assume that the roughly two to three billion people who presently lack modern energy services will only demand or consume them in small amounts over the next several decades. This assumption leads to projections of future energy consumption that are not only potentially far too low, but therefore imply, even if unintentionally, that those billions will remain deeply impoverished. Such limited ambition risks becoming self-fulfilling, because the way we view the scale of the challenge will strongly influence the types of policies, technologies, levels of investment and investment vehicles that analysts and policy makers consider

---

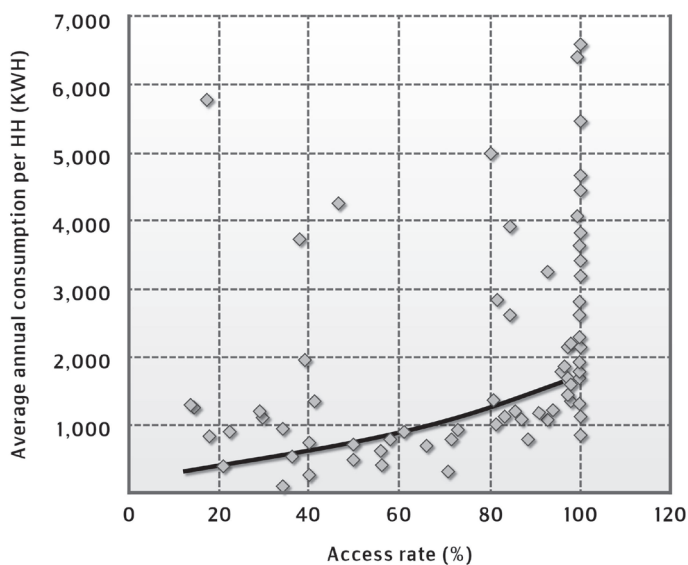
1. [www.sustainableenergyforall.org](http://www.sustainableenergyforall.org)

to be appropriate.

As Wolfram and colleagues observe in a recent study, “The current forecasts for energy demand in the developing world may be understated because they do not accurately capture the dramatic increase in demand associated with poverty reduction.” The point is that energy access is not an end per se; rather it is a necessity for moving to vibrant and sustainable social and economic growth. The lower the assumed scale of the challenge, the more likely the focus will turn to incremental change that amounts to “poverty management,” rather than the transformational changes that will be necessary if we are to help billions climb out of poverty.

### Old numbers

A first step to better understanding the scale of the energy access challenge is to ask: How much energy is actually needed to enable poverty alleviation—a level we will term “modern energy access”? To answer this question we focus, for simplicity, on electricity services, rather than energy for heat and cooling or transport. Still, answering the question is not simple. World Bank data shown in Figure 1 shows the wide range of what can be meant by “energy access,” and how it differs, on average, both between countries at “full electrification” as well as in those at much lower access rates. This considerable spread in average annual household consumption levels at different levels of access makes comparing some of the existing analyses tricky.



**Figure 1: The range of average annual household energy consumption (kWh) across countries with various degrees of “energy access” (World Bank, 2013).**

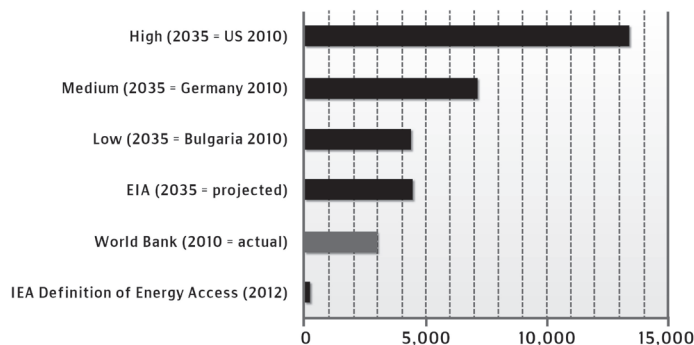
Let’s turn to places which have modern energy access by any definition of the term, with essentially 100% of residents and the broader economy under full electrification. The average resident of the United States consumes about 13,400 kWh per year, with a large variation by state – households in Maine consume about 40% of those in Louisiana. On average, Europeans generally consume considerably less energy than Americans. For instance, based on 2010 data the average resident of Germany consumes about 7,200 kWh per year, with Swedes consuming about 15,000 kWh and Greeks about 5,200 kWh, and on the low end the Bulgarians at about 4,500 kWh, or about 60% of German and a third of US levels. For comparison, the global average in 2010 was just under 3,000 kWh per capita per year, three quarters of Bulgarian consumption, but of course this number is strongly skewed by the enormous concentration of energy use in the industrialized world as well as the large number of people with no access at all.<sup>2</sup>

These numbers for the US, Germany and Bulgaria can be compared to the definitions of energy access that typically provide the basis for policy discussions and analyses. The International Energy Agency is one of the world’s most influential analytical bodies on energy policy and its flagship product, the World Energy Outlook, has played a leadership role for more than a decade in providing analysis and data of the energy access issues. It defines an “initial threshold” for energy access to be 250 kWh per year for rural households and 500 kWh per year for urban households, assuming 5 people per household. This equates to 50-100 kWh/year per person, or about 0.5% of that consumed by the average American or Swede, and 1.7% of the average Bulgarian.

These differences starkly illustrated on Figure 2, which shows various thresholds of per capita energy access. For a sense of scale - the use of a single 60 Watt light bulb four hours per day equates to about 90 kWh over the course of a year (i.e., 60W \* 4hr \* 365 days). The top three bars should global per capita energy access implied for 2035 at 2010 levels for the US, Germany and Bulgaria. Included also are the projections of the US Energy Information Agency for 2035 as well as the actual 2010 per capita levels of 2010 from The World Bank. The bar at the bottom of the graph shows the IEA definition of “energy access,” which is obviously small in comparison to the other five bars. The IEA does, however, assume in

2. Figures from the World Bank and EIA online databases (See recommended reading section)

**An Ambition Gap in Global Energy Access?**  
Global Per Capita Electricity Consumption (kWh/year)



**Figure 2: Assumptions of global per capita electricity consumption compared.**

its analyses a demand of 750 kWh/year per capita by 2030 for new electricity connections.

For its part, the IEA – and the other organizations active on this issue – have recognized that achieving energy access is a process, noting, “Once initial connection to electricity has been achieved, the level of consumption is assumed to rise gradually over time, attaining the average regional consumption level after five years. This definition of electricity access to include an initial period of growing consumption is a deliberate attempt to reflect the fact that eradication of energy poverty is a long-term endeavour.”

The World Bank presents a useful scheme for considering various levels of energy access, illustrating different “tiers” of access (Table 1). Still, even the highest level of access in the scheme, Tier 5, implies some 2,121 kWh/year per household of five people, or roughly 420 kWh/capita/year, which, at less than 10 percent of Bulgarian consumption, is still much lower than what typical energy services would imply in even the least energy-consumptive wealthy countries.

More than a billion people lack even the minimal levels of access to electricity, and policy analyses, national plans, and projects, must start somewhere. Still, achieving minimal levels of energy access is not to be confused with success in achieving goals of modern energy access. The sorts of policies that would make sense to get large numbers of people over a low and arbitrary threshold are very different from those that will underpin sustained growth in economies and consumption. Consider that we do not label people who live on more than \$1 per day as having “economic access” and address policies toward achieving a \$1.25 level, thus still leaving them desperately poor. Everyone understands that \$1.25 a day is still not nearly enough. In energy, we often lack such conceptual clarity.

Adding to the challenge of talking clearly about “modern energy access” and more realistic level of unmet energy demand in poor countries is the tendency in many analyses to discuss the issue in terms of household energy use. Energy access has links to all sectors of the economy. By focusing on household energy demand, other sectors of a growing economy can end up being ignored in critical power planning exercises and policies. Business and industry growth, for example, is severely constrained in many poor countries not only by a lack of access, but also a lack of access to high quality services, meaning those that are reliable enough to meet the needs of private sector enterprises from hospitals to factories. Access to modern energy services across an economy, not just in the home, is necessary to sustain and support continued economic growth - a reality that must be accommodated in projections of future energy needs.

If we aim too low, then there are risks not just in policy failure, but in the opportunity costs of policy success. If more ambitious goals are to be achieved, then some attention must also focus on real transformational change.

**TABLE 1**

**Tiers of electricity service demand (World Bank, 2013)**

**USE OF ELECTRICITY SERVICES**

TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
None	Task lighting <b>AND</b> phone charging (or radio)	General lighting <b>AND</b> television <b>AND</b> fan (if needed)	Tier 2 <b>AND</b> any low-power appliances	Tier 3 <b>AND</b> any medium- power appliances	Tier 4 <b>AND</b> any high-power appliances

This type of change is often difficult to conceptualize, and difficult to represent in most analytical models using traditional baseline or incremental growth approaches. But our analytical models should not limit our creativity and ambition, especially in light of the reality that many nations, such as Thailand, South Africa, Vietnam and China, have experienced remarkable economic growth and expansion of truly modern energy access for large populations over relatively short periods of time.

### New numbers

We now turn directly to the quantitative implications of moving towards much higher levels of assumed future energy demand for poor countries. As an example, consider the Obama Administration's recent announcement of a new "Power Africa" initiative, focused on increasing the electricity generation capacity of sub-Saharan Africa by adding 10 Gigawatts (GW) of capacity, in order to "double access to power." While such an initiative is to be applauded, placing it into context can help to calibrate the level of ambition.

To raise the entire region of sub-Saharan Africa to the average per capita electricity access available in South Africa (which in 2010 was about 4,800 kWh, similar to the level of Bulgaria) would require 1,000 Gigawatts (GW) of installed capacity – about the equivalent electricity of 1,000 medium-sized power plants. This means that sub-Saharan Africa would need to increase its installed capacity by 33 times to reach the level of energy use enjoyed by South Africans — and 100 times to reach that of Americans. A recent study by Bazilian and others (2012) showed that even a less ambitious tenfold increase, perhaps sufficient to provide full access but at relatively modest levels of electricity consumption, would require a 13% average annual growth rate in generating capacity in sub-Saharan Africa, compared to a historical one of 1.7% over the past two decades. When looked at from the perspective of energy access as the concept is understood in North America and Europe, the magnitude of the energy access challenge is starkly revealed.

Still another perspective is provided by the International Institute for Applied Systems Analysis in its 2012 Global Energy Assessment. Figure 3 shows for 10 countries the historical growth in energy access. In 1920, only 35% of Americans had energy access (here shown as "electricity access" defined as "household electrification" at an unspecified level of consumption). This total reached 100% by the mid-1950s or over a period of about 35

years. In contrast, Mexico was at about 35% access in 1930, and has yet to get all the way to the 100% mark. China went from 35% in 1970 to nearly 100% by about 2000, reflecting a very fast rate and in a very large nation. India is following a much shallower trajectory, going from about 25% in 1980 to 65% in 2010. How fast

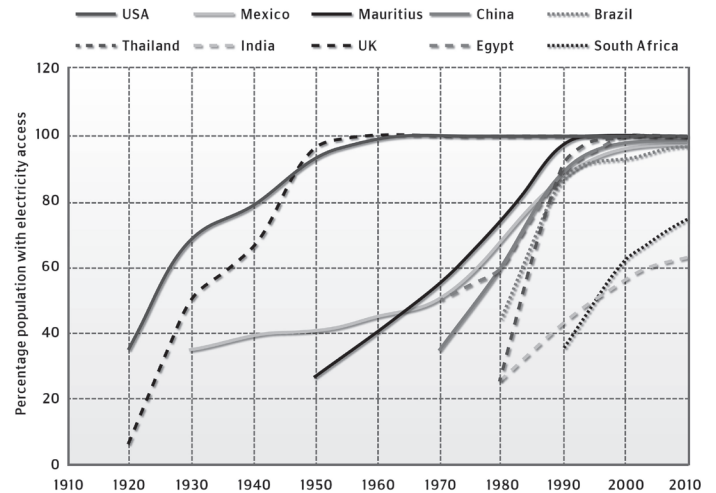


Figure 3: Historical rates of electrification in select countries (GEA, 2012).

and how far can truly modern energy access occur under an approach focused on rapidly expanding access to truly modern levels? This is the sort of question where researchers might productively place further attention.

Accelerating a transition to a radically different, and inclusive, energy system is clearly a generational challenge, and provides a just and consequential rationale for much greater attention to innovation in energy systems. A first step in that transition is to properly understand the scale of the challenge. With a sense of scale appropriate to energy access commensurate with the organization of modern economies, we are then in a position to discuss the possible costs of achieving such ambitious goals, recognizing that any such discussion is laden with assumptions about economics, technologies and politics - but also that history is replete with examples of nations moving rapidly to achieve greatly increased levels of access in the context of rapid economic growth.

What sorts of investments might be necessary for achieving modern energy access? Based on recent work done by Bazilian and colleagues (see "recommended readings" at the end of this article – 2010b and forthcoming), it would cost about one trillion dollars to achieve the IEA 2012 World Energy outlook definition of total global access – rising to 750 kWh per capita for new connections by 2030 - and 17 times more to achieve a level of world-

wide access equivalent to South Africa or Bulgaria. This massive difference in estimated costs, likely insensitive to the precise accuracy of either number, places a value on the “ambition gap” that results from the difference between a “poverty management” approach to energy access and one that takes seriously the development aspirations of people around the world. Of course, it is not just cost that changes in the face of such aspirations, but also the sorts of institutions, technologies, infrastructure, policies and other systems required to support broad-based energy services.

### Climate interactions

Most readers will have already recognized that our discussion has significant implications for the question of climate change. Former NASA scientist James Hansen expressed his view of the issue with typical candor, when he said, “if you let these other countries come up to the level of the developed world then the planet is done for.”<sup>3</sup> For the most part, however, the ambition gap has kept this uncomfortable dilemma off the table. If one assumes that billions will remain with levels of energy consumption an order of magnitude less than even the most modest definition of modern access, then one can understand the oft-repeated claim that universal energy access can be achieved with essentially no increase in the global emissions of carbon dioxide.

For example, Figure 4 shows the projections of the IEA under its “Universal Access Scenario” for energy consumption and carbon dioxide emissions. The minimal

3. <http://www.euractiv.com/science-policy-making/james-hansen-verge-creating-clim-interview-519752>

consequences to emissions and consumption resulting from this scenario essentially reflect a “poverty maintenance” level of energy service provision. Emissions increase by such a small amount because new energy consumption increases by a very small amount.

Conflicts between climate and energy priorities deserve a deeper and more open airing in order to help better frame policy options, including the difficult question of trade-offs among competing valued outcomes. The issues are playing out right now, but remain largely unacknowledged. For instance, under US Senate Bill S.329 (2013) the Overseas Private Investment Corporation – a federal agency responsible for backstopping U.S. companies which invest in developing countries – is essentially prohibited from investing in energy projects that involve fossil fuels, a policy that may have profound consequences in places like sub-Saharan Africa that are seeking to develop oil and gas resources to help alleviate widespread energy poverty. At the same time, a different US federal agency - the U.S. Export-Import Bank - helped fund a 4.9 GW coal plant (Kusile) in the Republic of South Africa. The coal plant will help serve both industry and households that currently lack access. These simultaneous interventions appear incoherent. Making such issues more transparent, and opening them up to debates with multiple stakeholders with multiple values and success criteria offers the promise of enriching the array of policy options on the table.

The United Nations has attempted to square this circle of climate and energy through the phrase “Sustainable Energy for All”. Still, since value-judgments must be made

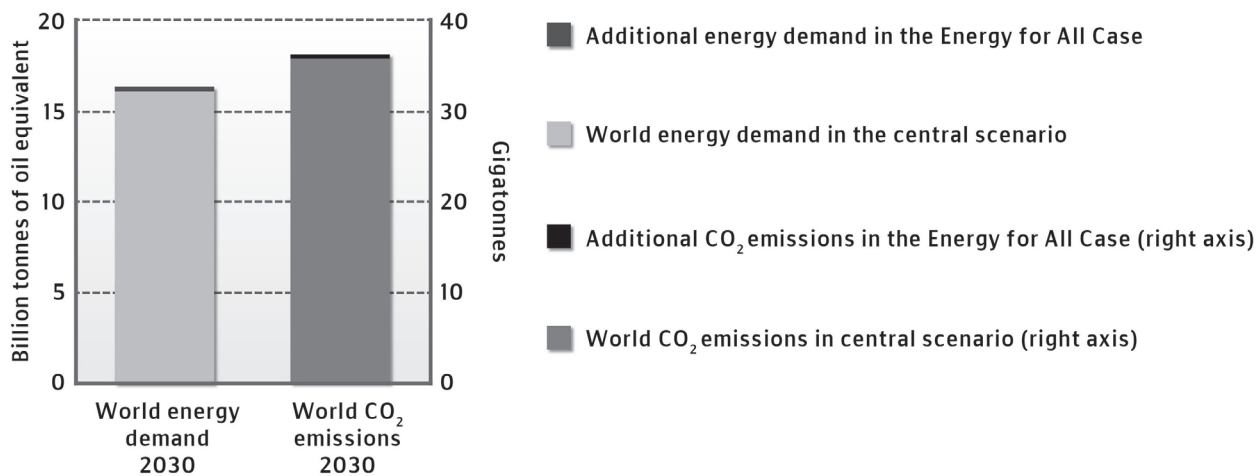


Figure 4: Impacts on energy demand and CO<sub>2</sub> emissions under the IEA’s universal energy access scenario (IEA, 2011).

and priorities established, the UN initiative has explicitly stated a “technology neutral” principle and given primacy to national decision-making, and implicitly has made the goal of universal energy access a “first among equals” of the three sustainable energy goals (the other two relating to renewable energy and energy efficiency). In practice however, as we have emphasized, the trade-offs involved in policies related to climate and energy have often received less than a full airing in policy debate.

### Conclusions

The course of development followed by virtually all nations demonstrates that people around the world desire a high-energy future. Our plea is that we begin to recognize that fact, and focus more attention and resources on positively planning for, and indeed bringing about, that future. Achieving universal modern energy access will require transformations - in aspirations, but also, for example, in technological systems, institutions, development theory and practice, and in new ways to conceptualize and finance energy system design. Being clear about what modern energy access means, and applying that clarity to the policy discussions galvanized by the 2014-2024 UN “Decade of Sustainable Energy,” can create a foundation for making huge strides in bridging the global equity gap not just in energy but in the new wealth, rising standard of living, and improved quality of life that modern energy access can help to bring.

Ultimately, a focus on energy access at a low threshold limits our thinking, and thus our options. Adopting a more ambitious conception of energy access brings conflicting priorities, as well as the scale of the challenge, more clearly into focus and makes hidden assumptions more difficult to avoid. Now more than ever the world needs to ensure that the benefits of modern energy are available to all and that energy is provided as cleanly and efficiently as possible. This is a matter of equity, first and foremost, but it is also an issue of urgent practical importance. Economic and technological challenges are hard enough; let us not add a failure of imagination to that mix.

### Recommended reading

M. Bazilian, A. Sagar, R. Detchon, and K. Yumkella, “More Heat and Light,” *Energy Policy* 38 (2010): 5409–5412.

M. Bazilian, P. Nussbaumer, H.-H. Rogner, A. Brew-Hammond, V. Foster, E. Williams, M. Howells, P. Niyongabo, L. Musaba, B. Ó Gallachóir, M. Radka, and D. Kammen, “Access Scenarios to 2030 for the Power Sector in Sub-Saharan Africa,” *Utilities Policy* (2012).

M. Bazilian, P. Nussbaumer, E. Haites, M. Levi, M. Howells, and K. Yumkella, “Understanding the Scale of Investment for Universal Energy Access,” *Geopolitics of Energy* 32 (2010): 19–40.

M. Bazilian, R. Economy, P. Nussbaumer, E. Haites, M. Levi, M. Howells, K. Yumkella, and D. Rothman, “The Scale of Investment for Universal Energy Access Revisited: Beyond Basic Access,” in Sovacool et al., Eds. (Oxford University Press, in press).

GEA, 2012: *Global Energy Assessment - Toward a Sustainable Future*, Cambridge University Press, Cambridge, UK and New York, NY, and the International Institute for Applied Systems Analysis, Laxenburg, Austria.

International Energy Agency, *World Energy Outlook* 2012. Paris, France, 2012. <http://www.worldenergyoutlook.org/resources/energydevelopment/definingandmodellingenergyaccess/>.

N. Nakicenovic and W. Nordhaus, “Editors’ Introduction: The Economics of Technologies to Combat Global Warming,” *Energy Economics* 33, issue 4 (July 2011).

C. Wolfram, O. Shelef, and P. Gertler, *How Will Energy Demand Develop in the Developing World?* (Haas School, University of California, Berkeley, CA, 2012).

World Bank, *Global Tracking Framework*. World Bank Sustainability for All Program, Washington, DC, 2013.

*Morgan Bazilian (Morgan.bazilian@nrel.gov) is a senior research scientist at the International Institute for Applied Systems Analysis, Laxenburg, Austria. Roger Pielke Jr. (Pielke@colorado.edu) is a professor in the Environmental Studies Program and a fellow of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado, Boulder.*