Equitable Energy Access & Climate Change: Opportunities for Innovation

Implementing Climate Pragmatism Framing Document One, November 2012

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Modern energy drives the global economy, and ensuring adequate, affordable, and reliable energy services is a fundamental concern of affluent and emerging nations alike. Access to modern forms of energy allows people to become educated, to travel and communicate, to diversify and increase incomes, and to improve health and longevity. A global agenda that prioritizes energy access is at the core of our pragmatic approach to climate change. This agenda requires recognizing the immense scale of the energy equity challenge; anticipating the demographic and climatic changes that will occur over the coming decades; and developing low-carbon innovations to meet the energy needs of current and future populations.

Currently, 1.3 billion people have no access to electricity, an equal number have unreliable access, and 2.7 billion still burn biomass as a cooking fuel.[1] This energy inequity compounds other features of structural poverty by limiting access to clean water, health care, emergency services, and mechanical power for agriculture and industry. The public health impact alone of burning biomass for cooking is an estimated 1.6 million deaths annually from indoor air pollution.[2] Insufficient energy access is connected to a variety of additional challenges, ranging from gender inequality to deforestation. At the current worldwide level of investment in energy access, one billion people will remain without access to electricity and 2.7 billion without clean cooking facilities in 2030.[3]

Providing universal access to modern energy services has therefore become a central component in energy, climate change, and development policies. But the diverse communities that have organized to advance these policies, despite setting many

[1] Fatih Birol, *Energy for All: Financing Access for the Poor* (Paris, France: International Energy Agency, 2011).
[2] *Fuel for Life: Household Energy and Health* (Geneva, Switzerland: World Health Organization, 2006).
[3] Fatih Birol, *Energy for All: Financing Access for the Poor* (Paris, France: International Energy Agency, 2011), p. 3.

global targets and agendas for "human development," have massively underestimated the scale of the challenge. Much of the discussion of alleviating energy poverty is predicated on providing subsistence-level energy at the household level, partly in reaction to perceived resource constraints and concerns about climate change. An incremental approach that starts with the most basic provision of energy services may be appropriate in some contexts, but energy access cannot stop there if development challenges are to be effectively addressed. Vastly more power is required to provide true energy equity, drive economic prosperity and social wellbeing for all, and enfranchise the world's poorest communities.

Energy systems are embedded in particular cultural, economic, technological, and institutional contexts. However, two global trends will have enormous impacts on the future of energy access: urbanization and climate change. As the majority of the global population moves into sprawling megacities, these new urbanites will need clean, reliable energy to take advantage of the economic opportunities that cities offer. Rapid urbanization has specific implications for how countries design and implement energy policies, and the kinds of technologies their energy sectors will utilize. Aligning these policies with anticipated demographic shifts and the consequent changes in energy consumption patterns is therefore critical.

At the same time, because the disparity in energy consumption of the poor and rich is several orders of magnitude, achieving true energy equity through conventional means (i.e., with fossil fuels) is not possible without huge increases in greenhouse gas emissions. Thus clean energy innovation must play a central role in sustainably meeting future energy demand. New markets for clean energy, collaborations between affluent and emerging countries, and a focus on the productive needs of the energy poor provide political, economic, and institutional opportunities to accelerate the development and deployment of clean energy technologies, services, and infrastructure. These opportunities have the potential to erase the implicit tension between energy access and climate change mitigation. Technological innovations also help vulnerable societies build more robust capabilities for adapting to changes in the climate.

This paper frames the challenge: How can we provide the energy necessary for all human populations to thrive, while also addressing the challenge of climate change? We start by outlining the scale of the challenge. We then discuss how climate change has obscured the challenge and relegated the issue of energy access to a "survival issue," with the potential effect of slowing the global pursuit of energy equity. We present the opportunities for innovation and sustainable development that the energy access challenge provides. We then explore the tensions between various pathways to global energy equity. By delving into the issue of how much energy is required for "thrival," or development beyond survival, we can envision the kinds of technological solutions that will be required. Indeed, thrival as a framework may finally allow the integration of approaches to both energy equity and climate change in a broader development context.

The Energy Access Challenge

Access to modern energy of sufficient quantity and quality for human needs and income-generating activities is a necessary component in eradicating poverty and improving the livelihood opportunities of people in developing countries. In fact, the International Energy Agency (IEA) states that the United Nations' "Millennium Development Goal of eradicating extreme poverty by 2015 will not be achieved unless substantial progress is made on improving energy access."[4] Socioeconomic development thus depends on relieving the burden of energy poverty—a collaborative task that presents tremendous opportunities for industrialized and emerging economies alike. These include expanded markets and investments in energy services, larger economies of scale for clean energy and associated infrastructure, and coop-

[4] *Energy Poverty: how to make modern energy access universal?* (Paris, France: International Energy Agency, 2010), p. 7.

erative innovation to meet the energy needs of the billions currently without safe, reliable, and sustainable access.[5]

To understand the scale of both the challenge and opportunities in universal energy access—and how this has been misjudged in the climate and development communities—looking at the resources needed to achieve universal access is useful. The IEA has broken down energy access into three "incremental levels of access to energy services." These include energy for basic human needs (such as lighting and cooking), energy for productive uses (like agriculture, commerce, and transportation), and energy for "modern society needs" (including domestic appliances, cooling, heating, and private transport). This last category is on the order of 2000 kWh per person per year—twenty times the consumption level of basic human needs,[6] but still far below the average per capita energy usage in the United States.

According to the IEA, achieving universal access by 2030 at the most basic level per household (enough to power a "floor fan, two compact florescent lights, and a radio for about five hours per day"[7]) will require 950 TWh per year, or almost 3% of the estimated global power use in 2030. This will cost approximately $700 billion, or $33 billion annually, between 2010 and 2030.[8] These are not unattainable figures; the IEA estimates that necessary generating capacity for meeting the additional demand is 250 GW—China alone installed double that amount between 2005 and 2011.[9] But a cost estimate that is closer to what we deem a thrival level of access is more than twice the IEA projection—above $100 billion per year, or $1.5 trillion to-

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[5] Morgan Bazilian, Ambuj Sagar, Reid Detchon, and Kandeh Yumkella, "More heat and light," *Energy Policy*, Vol. 38, 2010, pp. 5409-5412.
[6] Advisory Group on Energy and Climate Change (AGECC), *Energy for a Sustainable Future: Summary Report and Recommendations* (New York, NY: United Nations, April 2010), p. 13.
[7] *World Energy Outlook 2010* (Paris: International Energy Agency, 2010), p. 249.
[8] *World Energy Outlook 2010* (Paris: International Energy Agency, 2010).
[9] Energy Information Agency, "China Analysis," September 4, 2012, available at: http://www.eia.gov/countries/cab.cfm?fips=CH

tal in 2030.[10] This underscores both the scale of the challenge and the need for innovative policies and technologies to address it.

An impressive number of large developing countries are tackling the challenge of universal energy access through national electrification policies:[11]

	Programme name	Description	Financing arrangements
Bangladesh	Master Plan for Electrification – National Energy Policy of Bangladesh 1996-2004	Electricity for all by 2020.	Loans and grants from donors are passed on, under a subsidiary agreement, to the Rural Electrification Board. Domestic government funds cover all local costs of construction.
Brazil	Light for All	Launched in 2003, extended in 2011 to 2014. So far the programme has connected more than 2.4 million households and it aims for full electrification.	Funded largely by the extension of a Global Reversion Reserve tax incorporated into electricity rates. The scheme also benefits from an investment partnership of federal government, state agencies and energy distributors.
Ghana	National Electrification Scheme – Energy Plan 2006-2020	Electricity access for all by 2020.	Funded through grants and loans by donors and $9 million per year in domestic government budgetary support.
India	Rajiv Gandhi Grameen Vidyutikaran Yojana	Electrify 100 000 villages and provide free electricity connections to 17.5 million households below the poverty line by March 2012.	Total funds of $5.6 billion disbursed between 2005 and 2011. A government subsidy of up to 90% of capital expenditure is provided through the Rural Electrification Corporation. Those below the poverty line receive a 100% subsidy for connection.
Indonesia	Rural electrification programmes – National Energy Management	Electricity access for 95% of the population by 2025.	Investment costs are covered by cross subsidies by the state-owned power utility (PNL) and other costs are funded by donors.
Nepal	Rural Electrification Program – National 3-Year Interim Plan	Electricity access for 100% of the population by 2027.	A Rural Electrification Board administers specific funds for electrification of rural areas.
Philippines	Philippines Energy Plan, 2004-2013	Electrification of 90% of households by 2017.	Funded by grants and loans from a National Electrification Fund and PPPs.
South Africa	Integrated National Electrification Programme	Electricity access for 100% of the population by 2020.	Government funding disbursed by the Department of Energy to Eskom (state-owned utility) and municipalities.
Zambia	Rural Electrification Master Plan	Electricity access for 78% in urban areas and 15% in rural areas by 2015.	The government has created a Rural Electrification Fund that is administered by the Rural Electrification Authority.

The energy poor that these national policies are intended to help range from those with a complete lack of access to electricity and non-biomass fuel to those whose energy supply is restricted to unreliable, intermittent, unhealthy, or unaffordable sources. The energy poor live in remote rural villages or—increasingly—in dense urban areas.

A large proportion of the world's population still without access to electricity—some 400 to 600 million people—resides in India.[12] There, the 114 million house-

[10] Morgan Bazilian, Patrick Nussbaumer, Erik Haites, Michael Levi, Mark Howells, and Kandeh K. Yumkella, "Understanding the Scale of Investment for Universal Energy Access," *Geopolitics of Energy*, Vol. 32, Issues 10 & 11, 2010, pp. 21-42.
[11] Fatih Birol, *Energy for All: Financing Access for the Poor* (Paris, France: International Energy Agency, 2011), p. 18.
[12] *Power and Energy* (New Delhi, India: Government of India, Planning Commission), available at: http://planningcommission.nic.in/sectors/index.php?sectors=energy

holds who constitute the "base of the pyramid" (BOP) spend less than $75 a month on goods and services; these households constitute 76% of the rural population.[13] This is the target group for whom this challenge matters most.

The energy poor exist in large numbers in other developing countries as well. For instance, the greatest challenge is in sub-Saharan Africa, where 585 million people do not have access to electricity—about a third of the global total.[14] An indication of the incoherent policies, conflicting agendas, and lack of investment resources that hinder energy access—many of them unique to countries in Africa—can be found in the fact that "the amount of natural gas flared in the Niger Delta alone is enormous in comparison to the current energy demand in sub-Saharan Africa."[15] This situation is not expected to improve in the coming decades, and countries will not be able to meet the targets identified above, without major changes in how we address both energy poverty and climate change.

Climate Change

The lack of progress in addressing climate change at the international level reflects, in part, a stalemate over which countries are responsible for the buildup of greenhouse gases (GHG) in the atmosphere and which nations, therefore, must take action to mitigate the anticipated consequences of those emissions. This political impasse has existed since climate change first became recognized as a global challenge. In 1991, the Delhi-based Centre for Science and Environment (CSE) released a report aptly titled *Global Warming in an Unequal World*, which averred that "[t]he idea that

[13] Sreyamsa Bairiganjan, Ray Cheung, Ella Aglipay Delio, David Fuente, Saurabh Lall, Santosh Singh, *Power to the People: Investing in Clean Energy for the Base of the Pyramid in India* (Washington, DC: Center for Development Finance, World Resources Institute, 2010).
[14] *Energy Poverty: how to make modern energy access universal?* (Paris, France: International Energy Agency, 2010), p. 9.
[15] Morgan Bazilian, Ambuj Sagar, Reid Detchon, and Kandeh Yumkella, "More heat and light," *Energy Policy*, Vol. 38, 2010, p. 5410.

India and China must share the blame for heating up the earth and destabilizing its climate . . . is an excellent example of environmental colonialism."[16]

With organizations such as CSE driving India's early discourse on climate change, it is not surprising that India spearheaded the per-capita emissions-based approach to negotiating at the United Nations Framework Convention on Climate Change (UNFCCC). The CSE report launched the Indian government's position of "common but differentiated responsibility" (CBDR). CBDR froze the climate debate in an era when the global South's emissions were miniscule compared to the global North. Since then, the positions of the two sides have hardened while the global emissions scenario has shifted—an increasing proportion of the world's GHG emissions are now being generated in the South (although per-capita emission levels remain much lower). Thus little progress has been made in climate negotiations.[17]

Unfortunately, the stalemate over climate change mitigation influences the energy equity agenda, because energy consumption is an integral part of the climate policy debate. Developed nations fear that if the global South continues its rapid increase in energy consumption, there will be no progress on reducing GHG emissions. Leaders from the South, on the other hand, have long believed that there should be a clear distinction between "survival emissions" of the poor and "luxury emissions" of the rich. They recognize that ameliorating energy poverty, preferably in a way that does not irreparably harm the environment, is necessary to achieve economic prosperity. But suggested paths for development, such as negotiated initiatives like the Clean Development Mechanism, provide few long-term benefits to developing countries and do little to transition industrialized or emerging economies away from fossil fuels.[18]

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[16] Anil Agarwal and Sunita Narain, *Global Warming in an Unequal World: A Case of Environmental Colonialism* (New Delhi, India: Centre for Science and Environment, 1991), p. 1.
[17] Mukund Govind Rajan, *Global Environmental Politics: India and the North-South Politics of Global Environmental Issues* (New Delhi, India: Oxford University Press, 1997), p. 120.
[18] Anthony Patt, "Beyond conventional thinking: Mitigation and the real opportunities for developing countries," *Climate and Development*, Vol. 1, 2009, pp. 107-110.

Climate politics have been so driven by global emissions and temperature targets that policymakers failed to envision what attempting to achieve these targets would mean for those in the developing world. Scientists and policymakers alike have sought to assert the optimal level of emissions to avoid calamitous climate effects—for instance, keeping global temperatures below a 2° Celsius increase.[19] This forces the discussion into contentious debates over carbon budgets, binding targets, and allocations of the "right to pollute" among nations.[20] It exacerbates the false competition between climate and development policies, often at the expense of the latter. Furthermore, improving vulnerable communities' capacity to adapt to climate change has often been neglected in favor of mitigation efforts. But adaptation strategies, which can be linked to energy access, innovation, and socioeconomic development, offer potential synergies between technological innovation and equity-based development.

An example of the limitations of current climate politics is offered by the Greenhouse Development Rights Framework, which operationalizes the UNFCCC's recommendations through its responsibility-capacity index. The framework outlines the "South's dilemma" under an "emergency pathway" of a 2°C rise in global temperatures.[21] This dilemma, visible in Figure 1 as the green line, is that even with an immediate, drastic, and highly unlikely emissions reduction from industrialized (Annex 1) nations, emissions from the global South (non-Annex 1) must peak by 2015-2020 and then decline by 6% annually through 2050. Under this framework, India would only be allowed to increase its emissions to 2.41 gigatonnes (Gt) of CO_2 annually by 2020, and then have to reduce emissions to 2.09 Gt CO_2 by 2030.[22] All twelve Indian energy policy scenarios (with varying fuel-type mixes) up to the year

[19] For example, see the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC): R. K. Pachauri and A. Reisinger (eds.), *Climate Change 2007: Synthesis Report* (Geneva, Switzerland: IPCC, 2007).
[20] *Solving the Climate Dilemma: The Budget Approach* (Berlin, Germany: German Advisory Council on Global Change, 2009).
[21] Paul Baer, Tom Athanasiou, Sivan Kartha, and Erik Kemp-Benedict, *The Right to Development in a Climate Constrained World: The Greenhouse Development Rights Framework*, 2nd ed. executive summary (Berlin: Heinrich-Böll-Stiftung, September 2008).
[22] K. Singh, "India's Emissions in a Climate Constrained World," *Energy Policy*, Vol. 39, 2011, pp. 3476–3482.

2030 suggest that India's emissions will be at least 2 to 4 Gt CO_2 higher by 2030.[23] Clearly, it would be impossible for India to conform to this pathway and still attain its development agenda. This illustrates an obvious disconnect between energy planning and the climate debate.

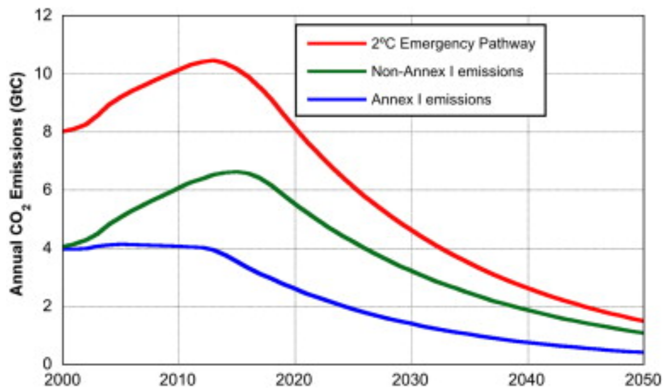

Figure 1. South's Dilemma, GDR Framework. The green line shows the emissions limits for the non-Annex countries in order to meet the global 2°C target (Baer et al., 2008).

The traditional climate agenda has neglected issues of energy access for the poor, even though disregarding energy access ignores ideas about human dignity and is not supported by existing energy access studies. For instance, IEA research indicates that "achieving universal electricity access would have a modest impact on energy-related CO_2 emissions," totaling approximately 2% of OECD emissions by 2030.[24] Similarly, increasing access to modern cooking fuels for 1.2 billion people would increase global oil consumption by 0.9 million barrels per day (mb/d) by 2030, which is less than one percent of the projected 96 mb/d of global oil demand by 2030. The "worst case scenario" of using fossil fuels to provide universal access to electricity and cooking fuels at the most basic level would result in a global total emissions increase of "as little as 2% of present world emissions."[25] Another study states that meeting basic energy needs for those without access to energy requires "around 1.2 percent of current world total energy consumption."[26]

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[23] *Integrated Energy Policy: Report of the Expert Committee* (New Delhi: Government of India, Planning Commission, 2006), pp. 1–125.
[24] *Energy Poverty: how to make modern energy access universal?* (Paris, France: International Energy Agency, 2010), pp. 19-22.
[25] Practical Action, *Energy poverty: the hidden energy crisis* (Warwickshire, UK: The Schumacher Centre for Technology and Development, February 2009), p. 4.
[26] Teodoro Sanchez, *The Hidden Energy Crisis: How Policies are Failing the World's Poor* (Rugby, UK: Practical Action, 2010).

To their credit, these studies are useful in disabusing various stakeholders of the notion that there is a conflict between meeting the energy needs of the poor and limiting GHG emissions. But unfortunately, many of these estimates assume that alleviating energy poverty entails supplying only a basic level of access—just enough to meet the survival needs of the poorest populations. The international development community—for whom energy and climate change are becoming central concerns—frequently fails to imagine what energy these populations will require in order to move up the development ladder and thrive. In part this has been because of climate change concerns, which lead to an emphasis on household access rather than providing (more) energy for other productive purposes.[27] But taking development aspirations seriously means that we need to think of scenarios for energy access beyond basic survival, to encompass the kinds of clean energy innovations required for all people to have enough energy to thrive.

The evidence that energy consumption and economic growth are inextricably linked[28] implies that we need to consider clean energy innovation as a component of energy-based development. When populations move beyond basic energy access, there has been a correlation between increased incomes, increased fossil fuel-derived electricity access, and accelerated climate change. Thus while poverty can be reduced through the economic opportunities that become available with better access to electricity, "there is no obvious reason to believe that increased wealth will be accompanied by a slowing down of consumption or by an increase in efficiency."[29] The likely impacts on climate of global energy consumption parity will be dramatic, even if a wealthier world is better able to adapt to these impacts.

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[27] One energy access practitioner notes sardonically that "household electricity for the poor does not address productivity increases needed for poverty alleviation; it merely illuminates their poverty at night." See Russell deLucia and Nikhil Desai, "Energy Service Companies (ESCOs) and S^{3}IDF's Social Merchant Bank Approach™ (SMBA)," S^{3}IDF white paper, 2012.
[28] Nicholas Apergis and James E. Payne, "A dynamic panel study of economic development and the electricity consumption-growth nexus," *Energy Economics*, Vol. 33, 2011, pp. 770-781.
[29] Brian Min, "The Politics of Energy and What it Means for the Climate," *II Journal*, University of Michigan, Spring 2012, p. 7.

Therefore the challenge presented is two-fold: we must provide appropriate energy access for thrival while simultaneously transitioning to energy sources that are both clean and inexpensive. Framed in this way, the opportunity for advancing technological innovation while addressing the energy access challenge becomes clear: the demand for "energy technologies that are advanced, efficient, and clean is robust and growing, and offers significant opportunity for profitable investment in technological innovation."[30] Indeed, if we begin to build political and economic support for energy access, and better understand the way people interact with energy resources (the models of participation, distribution, and sustainability of such systems), we may end up solving the climate crisis on the side.

Innovation

Discussions of how to achieve a universal level of energy access often engage the relative merits of centralized or decentralized (or distributed) generation. The international development community, including private, nongovernmental, and microfinance organizations, has focused mainly on micro- and off-grid energy in providing a basic level of energy access, for several reasons. First, environmental concerns—perceived resource constraints, concerns about GHG emissions, and local air pollution—are a factor in favoring clean, decentralized technologies. Second, end-use energy at the household level is easier to quantify and compartmentalize, and thus measurably increase through interventions in the energy supply chain.

Third, decentralized energy innovation is appealing to the development community because it tackles an immediate challenge that development organizations have the financial and technical resources to address. An NGO can more quickly and effectively deploy a micro-hydroelectric system to a poor community than develop an efficient coal gasification plant for base-load power generation. And in the impoverished, rural regions in which development groups often work, this strategy is entirely appropriate. Thus there has been an explosion of entrepreneurial activity

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[30] Sanya Carley, Sameeksha Desai, and Morgan Bazilian, "Energy-Based Economic Development: Mapping the Developing Country Context," FEEM Working Paper No. 25.2012, April 19, 2012, p. 15.

in decentralized renewable energy generation[31] and a global drive to provide clean energy to the poor.[32] Some of the resulting solutions include solar lanterns and more efficient cookstoves.

Large-scale primary energy, on the other hand, is generally seen as the domain of extractive industries, utilities, and national governments; the development community tends to be mistrustful of these entities. Historically, postcolonial governments prioritized centralized energy systems that served urban and industrial customers, while often failing to extend electrification to their remote rural populations. Analogous to the false conflict between economic development and environmental protection, there is frequently an implicit—and mistaken—competition between grid (or centralized) and off-grid (decentralized) energy provision.[33] But effective electrification will plainly require a diversity of approaches, in which centralized and decentralized power sources and their advocates will play important roles.[34] Top-down and bottom-up strategies are needed to implement this multi-track approach.

While innovation in decentralized power generation is abundant and allows for the participation of a great number of small entrepreneurs, it is unclear how much effort is being put into innovation in centralized power generation. Large private utilities and government-funded projects make up the bulk of investments in innovation in this space. It is worth exploring how smaller players—private firms, community groups, NGOs, and others—may become involved in driving innovation for the future of centralized energy systems. Public-private partnerships like those that led to

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[31] Advisory Group on Energy and Climate Change (AGECC), *Energy for a Sustainable Future: Summary Report and Recommendations* (New York, NY: United Nations, April 2010).
[32] Sreyamsa Bairiganjan, Ray Cheung, Ella Aglipay Delio, David Fuente, Saurabh Lall, and Santosh Singh, *Power to the People: Investing in Clean Energy for the Base of the Pyramid in India* (Washington, DC: Center for Development Finance, World Resources Institute, 2010).
[33] Douglas Barnes and Gerald Foley, *Rural Electrification in the Developing World: A Summary of Lessons from Successful Programs* (Washington, DC: Joint UNDP / World Bank Energy Sector Management Assistance Program, December 2004).
[34] Shonali Pachauri, Abeeku Brew-Hammond, Douglas F. Barnes, Daniel H. Bouille, Stephen Gitonga, Vijay Modi, Gisela Prasad, Amitav Rath, and Hisham Zerriffi, "Energy Access for Development," Ch. 19 in *Global Energy Assessment: Toward a Sustainable Future* (Laxenburg, Austria: International Institute for Applied Systems Analysis, 2012), p. 1413.

the shale gas revolution[35] may hold answers to how affordable, cleaner energy sources can help expand access at a larger scale.

Decentralization

Renewable decentralized energy technologies come in many forms, usually differentiated by the type of end-use energy provided. Energy for cooking can be provided by biogas and efficient or "clean" cookstoves. Energy for lighting may be provided by solar photovoltaic (PV) technology in the form of solar lanterns or home lighting systems. In addition, lighting can be provided through mini-grids for entire villages by micro-wind turbines, micro-hydro plants, and biomass gasification-based electricity generation. Energy for small-scale industrial or agro-processing activity (pumping water for irrigation, drying crops, mills, localized transport, etc.) can be derived through the aforementioned technologies and also biofuels.

Because access to energy is a necessary condition for economic development and improved livelihoods, it is no surprise that decentralized energy solutions are able to have a tremendous impact on the households and communities where they are deployed. Field studies have revealed that solar home lighting systems in India have been able to provide alternate income streams for households, to reduce the dependence on and costs of kerosene, and to provide extended time for children to study.[36] Clean energy products may have "competitive advantages over conventional products because they can help rural BOP users improve their health,"[37] by reducing indoor air pollution and regional concentrations of black carbon in the atmosphere. (Although how and whether the health benefits influence consumer choice is unclear.)

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[35] Alex Trembath, Jesse Jenkins, Ted Nordhaus, and Michael Shellenberger, *Where the Shale Gas Revolution Came From: Government's Role in Development of Hydraulic Fracturing in Shale* (Oakland, CA: The Breakthrough Institute, May 2012).
[36] Kartikeya Singh, "In India's Sea of Darkness: An Unsustainable Island of Decentralized Energy Production," *Consilience*, November 2007.
[37] Sreyamsa Bairiganjan, Ray Cheung, Ella Aglipay Delio, David Fuente, Saurabh Lall, and Santosh Singh, *Power to the People: Investing in Clean Energy for the Base of the Pyramid in India* (Washington, DC: Center for Development Finance, World Resources Institute, 2010), p. 22.

No doubt the flurry of activity around the UN year of "Sustainable Energy for All"[38] (SE4ALL) will divert many millions of dollars toward decentralized energy technologies. The challenge will be to distinguish between those technologies that provide opportunities for sustained economic development and those that reinforce subsistence-level socioeconomic conditions. Decentralized technologies focused on household needs often cannot provide sufficient energy to power productive income-generating activities like irrigated agriculture, food processing, metal- and wood-working, etc. Thus a renewed focus on supplying energy to these activities is vital.

It is important to note that technological interventions to provide energy access need to be appropriate and adaptable to changing local circumstances. They must help advance economic opportunity as livelihoods improve and the need for energy grows. Simply providing cookstoves that lock people into biomass-based fuel for cooking does not provide a sustainable solution to energy poverty. Similarly, solar lanterns with short life cycles and limited lumens may not provide a useful quality or quantity of lighting for a community's needs. To meet the energy demands of large and growing populations, more focus should be placed on institutional, financial, and policy mechanisms that can facilitate scaling up technologies that provide energy access. Lastly, and perhaps most importantly, the kinds of solutions required will need to be integrated into an increasingly urbanized world.

Examining the case of clean cookstoves is illustrative. Several decades of developing and promoting more efficient cookstoves and fuels—the most significant energy service for poor rural populations—has achieved only modest success in the uptake of these technologies. Often cookstove initiatives (usually designed in the global North) failed to anticipate the needs of those in the South, and were not designed in accordance with how a community may actually use them.[39] Furthermore, what we know about technology diffusion explains why many cookstoves are not readily adopted, but suggests opportunities for better uptake. Researchers have found, for

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[38] See: http://www.sustainableenergyforall.org
[39] Vivek Dehejia, "The Cookstove Conundrum," *The New York Times*, April 23, 2012.

example, that a participatory approach to the deployment of these new technologies is necessary for communities to successfully adopt them.[40] Thus it is imperative for companies to undertake socio-technical surveys in rural communities to help inform the design of decentralized energy systems. In addition to a technology's attributes that can influence its "rate of adoption,"[41] there are other culturally dependent factors, including "the nature of communication channels diffusing the innovation" and the role and respect of early adopters in communities.[42] By recognizing and addressing these factors, enterprises that deliver decentralized energy systems can help ensure that their products are field-ready and willingly adopted by those most in need of access to energy.

Decentralized, household-level energy technologies bring many benefits to BOP populations, as noted above. But a closer analysis of decentralized energy options suggests that without collaboration with those for whom these technologies are intended, these technologies can be both inappropriate and inadequate in trying to achieve the end goal of equitable, affordable, and sustainable energy access. This may especially be the case as we move beyond the most basic needs. Some key issues include:

1. *Adequacy of energy provided*: Decentralized renewables may be enough for household survival needs, but generally do not supply adequate energy for meeting the thrival needs of communities, industry, and agriculture.
2. *Lack of standards within the industry*: The technologies offered to the world's poorest communities are often ill suited to local contexts and poorly designed.

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[40] Malini Ranganathan, Rakesh Prasad, and P.B. Singh, "Participatory approach for linking rural energy transitions and developmental needs in Uttar Pradesh, India," *Boiling Point*, No. 49, 2003, pp. 15-17.

[41] The five attributes include: relative advantage, compatibility, complexity, trialability, and observability. See Everett Rogers, *Diffusion of Innovations*, 5th Ed. (New York, NY: Free Press, 2003), p. 222.

[42] Everett Rogers, *Diffusion of Innovations,* 5th Ed. (New York, NY: Free Press, 2003), chapters 7-8.

3. *Lack of supply chains and local markets*: These technologies can be pushed into communities with complete disregard to the viability of sustaining the local energy economy, or meeting demands for certain kinds of energy.
4. *Diversion of local economies*: Where energy inputs are required for clean energy projects, they may at times come into conflict with how those resources have been part of the locally existing economy.[43]

A final issue is that presenting decentralized options as the solution to energy inequity is likely to be undermined by the fact that rapid urbanization is occurring in most societies where energy access is currently a challenge. One of the implications of this demographic shift is an increased need for centralized power sources.

Urbanization

In 2008, for the first time in history, more than half of the world's population (approximately three billion people) lived in urban areas. The UN Population Fund states that by 2030, "this number will swell to almost 5 billion, with the majority of urban growth concentrated in Africa and Asia."[44] This rapid urbanization has substantial consequences for the challenge of energy access. According to the World Bank, the 220 million energy-poor urbanites around the world face similar barriers to energy access as those in rural areas, including low incomes, lack of services, and unreliable supplies.[45] But the means to overcoming these barriers in urban rather than rural areas, on the other hand, are quite different. Given that economies of scale favor centralized energy distribution (the unit cost of energy is reduced in high density areas), urbanization facilitates the expansion of national grids and the centralization of energy production.[46] Furthermore, innovations in transmission and

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[43] An example is the use of coconut fibers in biomass gasification projects potentially diverting resources away from coconut fiber processing industries.
[44] See United Nations Population Fund: http://www.unfpa.org/pds/urbanization.htm
[45] *Addressing the Electricity Access Gap*, Background Paper for the World Bank Group Energy Sector Strategy (Washington, DC: World Bank, Energy Sector Management Assistance Program (ESMAP), June 2010), p. 10.
[46] *Addressing the Electricity Access Gap*, Background Paper for the World Bank Group Energy Sector Strategy (Washington, DC: World Bank, Energy Sector Management Assistance Program (ESMAP), June 2010), p. 9.

distribution networks through "smart grids" have the potential to more efficiently provide energy to large numbers of people through a centralized system.

Global urbanization trends show that energy access and equity issues will not be adequately addressed simply through policies focused on decentralized energy paths. The IEA has studied the implications of achieving modern energy for all. Their report envisages an increase in global electricity generation of approximately 840 TWh, or 2.5% more than is currently projected for 2030. Of this increased generation, "45% is expected to be generated and delivered through extension of national grids, 36% by mini-grid solutions and the remaining 20% by isolated off-grid solutions."[47] While over 63% of the on-grid generation will be through fossil fuels, this number drops to 7% for the mini-grid and off-grid generation. (Of course, this is just one scenario, and innovations in centralized or decentralized energy systems may dramatically shift these pathways over the long term.)

The IEA predicts that India, the country with the highest number of people without access to electricity, will achieve a 98% rate of electrification in urban areas and 84% rate of electrification in rural areas by 2030.[48] In addition, China is expected to achieve universal electrification by 2015, while the rest of developing Asia will have an average rate of electrification of 93% by 2030. These trends dictate reconsidering, in certain contexts, the importance of decentralized energy solutions within an agenda for thrival. The largest blackout in history, the recent grid failure in India that left 670 million people without electricity,[49] highlights how hundreds of millions of people are energy insecure, despite living in large cities and in proximity to large, centralized power plants. More power generation, modern infrastructure, and effective energy policies—rather than focusing on small, decentralized power

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[47] Fatih Birol, *Energy for All: Financing Access for the Poor* (Paris, France: International Energy Agency, 2011), p. 26.
[48] Fatih Birol, *Energy for All: Financing Access for the Poor* (Paris, France: International Energy Agency, 2011), p. 17.
[49] Mark Memmott, "Massive Failure: 670 Million in India Lose Power; Grid Collapses for Second Day," NPR News, July 31, 2012.

sources—may be the long-term solution to most of the developing world's energy poverty.

The bottom line is this: billions of people will need cheap, clean, reliable energy from both centralized and decentralized sources. Meeting this demand is an immense opportunity to invest in innovations that can improve the reliability, efficiency, and decarbonization of energy systems. Differing national and regional de-demographics might favor various technological pathways and energy mixes. But because the need for energy is enormous and increasing, innovations in clean energy production and distribution at all scales must be made in order to meet demand within the context of a changing climate.

Some key issues to consider with regard to innovation in energy access as we move forward:

1. It is important for governments to remain technology-neutral when providing energy access for both off-grid and on-grid solutions. Fossil fuel subsidies and other market distortions often prevent the most sustainable energy from competing effectively.
2. Local communities should be involved in the planning process of rural and urban energy access programs. Scaling up effective programs should be a priority.
3. Reducing the cost of energy to the poor should be emphasized in order to speed up access and increase the pool of options.
4. Energy should be considered in terms of its productive end-use when planning for access.
5. Governments should continue grid extension efforts but also find ways to engage private players to help innovate for both centralized and decentralized energy systems.

Thrival

Newell et al. examine what it means to have a just transition to equitable energy access for all. Distinguishing the clean energy transition from energy access, they state that the former alone "will ultimately be ineffective in improving energy security and tackling energy poverty and climate change."[50] This suggests that a low- or zero-carbon energy transition can still be highly inequitable, particularly if the cost of clean energy remains relatively higher than traditional energy. Prioritizing this transition ahead of other needs in the developing world can compound this inequality. A 12-watt solar panel slapped on a thatch roof may meet some of a family's most basic lighting needs, but will not move a household far up the energy and opportunity ladder. While it is worthwhile to incrementally meet the basic needs of those without access, there are too many regulatory and financial challenges that affect even basic access in countries where electrification targets are set.

For example, India has failed to make adequate investments in its infrastructure, including energy infrastructure, in the 65 years since independence. Eighty percent of India's required infrastructure by 2030 is "yet to be built," according to a McKinsey report.[51] The costs of this are estimated to be $1.3 trillion between 2006 and 2030.[52] As India already struggles to meet its electricity demand nationally, the electricity service is poor even to those villages that have access to the grid.[53] The point is that there are many obstacles to universal energy access and thinking about how to overcome them through a thrival perspective presents a monumental opportunity for innovation. Moreover, given that energy systems in the developing world have yet to be fully built, such opportunities may face much lower political, cultural, and

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[50] Peter Newell, Jon Phillips, and Dustin Mulvaney, *Pursuing Clean Energy Equitably*, Human Development Research Paper 2011/03 (New York, NY: United Nations Development Program, November 2011).
[51] *Environmental and Energy Sustainability: An Approach for India* (Mumbai, India: McKinsey & Company, August 2009), pp. 1-70.
[52] *World Energy Outlook 2007: China and India Insights*, (Paris: International Energy Agency, 2007), pp. 423-585.
[53] One of the interesting caveats in the Indian government's electrification program is that only 10% of the households in a village need to be connected to the grid for the entire village to be considered electrified. Thus the entire country could theoretically be considered "electrified," but 200 to 300 million people will still be without access to grid power. This is illustrative of how arbitrarily governments can choose to define access and what that may mean for the quality of energy provided. Applying these standards for access across different countries is extremely challenging.

economic barriers than in the rich world, where the existing energy systems are protected from change by powerful incumbents.

There is not a clear consensus as to how much energy access is enough in order to drive economic prosperity. Even what constitutes "basic survival needs" is in dispute, and has been for decades. India's Advisory Board on Energy (ABE) calculated that 33 watts of useful energy per capita are required at the household level to meet the basic human needs of lighting, cooking and space heating.[54] Compared to the 500 watt *per person* calculated as necessary by Goldemberg et al., the ABE estimate is extraordinarily conservative.[55] These energy requirement assessments depend on "arbitrary assumptions regarding the type of energy consuming equipment, their sizes, efficiencies and intensity of use,"[56] and these assumptions can vary widely among regional and social contexts. However, we argue that setting a minimum survival standard for energy access misses the point: energy access must be planned on the basis of sustained livelihood improvement for a community, not based on the types of appliances a household may or may not use based on its income level.

The energy access agenda has yet to embrace a thrival perspective, falling far short of providing energy to support productive, income-generating activities, and thus compromising the development ambitions of many emerging economies. In an effort to galvanize the development community—donors, international development agencies, and governments—to address the issue of energy access, UN Secretary General Ban Ki-moon launched the ambitious "Sustainable Energy for All" at the recently concluded Rio+20 Earth Summit. The language of the vision states:

> The global community should aim to provide access for the 2-3 billion people excluded from modern energy services, to a *basic minimum* threshold of modern energy services for both consumption and produc-

[54] Advisory Board on Energy (ABE), "Towards a Perspective on Energy Demand and Supply in India in 2004-05" (New Delhi, India: Government of India, 1985).
[55] José Goldemberg, Thomas B. Johansson, Amulya K.N. Reddy, and Robert H. Williams, "Basic Needs and Much More with One Kilowatt per Capita," *Ambio*, Vol. 14, No 4/5, pp. 190-200.
[56] Shonali Pachauri and Daniel Spreng, "Energy Use and Energy Access in Relation to Poverty," *Economic and Political Weekly*, Vol. 39, No. 3, 2004, pp. 271-278.

> tive uses. Access to these modern energy services must be reliable and affordable, sustainable and, where feasible, from low-GHG-emitting sources.[57]

There are, as we have emphasized, various interpretations of what constitutes a "basic minimum threshold of energy services." But such a limited target might not facilitate achieving the overall goal, and could in fact generate greater structural inequity by locking in technological systems that deliver insufficient and inefficient energy services. Setting these kinds of objectives is based on prior methods of assigning targets for meeting basic human needs under the Millennium Development Goals. But energy must be tackled in a different way and should be based on the concept of thrival—development *beyond* survival.

Energy for thrival will require that the poor have access to an improved quality and quantity of energy. Kerosene, sporadic electricity from badly managed grid systems, lighting from low-wattage solar panels, and poorly designed cookstoves will not provide a transition to energy access that unlocks the socioeconomic and long-term livelihood improvement these communities require. Aligning energy services with the needs of productive, income-generating activities (at and above the household level) will better ensure this transition. An understanding of these needs and outcomes through community participation is critical: if energy is meant to advance development, we must assess how providing energy access improves development indicators of income, health, education, environmental sustainability, and energy security in meaningful ways for the community.[58]

Institutions such as the Policy Innovation Systems for Clean Energy Security (PISCES) have begun to experiment with this type of evaluation by creating a "liveli-

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[57] Advisory Group on Energy and Climate Change (AGECC), *Energy for a Sustainable Future: Summary Report and Recommendations* (New York, NY: United Nations, April 2010), p. 9. (Emphasis added.)
[58] Sanya Carley, Sameeksha Desai, and Morgan Bazilian, "Energy-Based Economic Development: Mapping the Developing Country Context," FEEM Working Paper No. 25.2012, April 19, 2012, pp. 17-18.

hoods framework" to assess the impacts of various energy access programs.[59] Through comprehensive data analysis and stakeholder participation, this framework seeks to "increase the understanding of policy relevant trade-offs between energy, food, and water security for livelihoods in relation to bioenergy." Such methods will ensure that the energy being provided is not for mere survival but for creating thriving communities that are able to actively engage in the global marketplace.

As indicated in the SE4ALL initiative, the current agenda for development is based on the premise of survival. Turning this into an agenda for thrival requires novel methods for evaluating how all of humanity might reach certain development indicators together. As an example, the Stockholm Environment Institute recently released a policy framework that reaches beyond "basic energy access," called the "shared development agenda" (SDA) scenario.[60] The SDA scenario operates within traditional climate constraints, but focuses on economic growth in the poorest regions alongside energy intensity reductions. The Institute's analysis allows for global GDP per capita to increase through enhanced energy access while still meeting global climate targets.

In addition to better knowledge about energy needs, more rigorous evaluation methods, and new socioeconomic development priorities, implementing a thrival agenda will need creative mechanisms for financing the provision of energy services to the BOP. There are considerable opportunities for financing the supply side of the energy sector, by providing capital for energy technologies, expanding and upgrading grid infrastructure, and offering other energy services. It is also critical to invest in energy end-users. Merely extending the national grid to energy-poor communities is not enough to drive development; they also require access to capital to invest in the equipment and technologies that energy services power. Poor communities

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[59] Policy Innovation Systems for Clean Energy Security (PISCES): http://pisces.or.ke/
[60] Måns Nilsson, Charles Heaps, Åsa Persson, Marcus Carson, Shonali Pachauri, Marcel Kok, Marie Olsson, Ibrahim Rehman, Roberto Schaeffer, Davida Wood, Detlef van Vuuren, Keywan Riahi, Branca Americano, and Yacob Mulugetta, *Energy for a Shared Development Agenda: Global Scenarios and Governance Implications* (Stockholm, Sweden: Stockholm Environment Institute, June 2012).

offer viable markets for efficient, reliable energy products, particularly since they already spend a large amount of time and money on fuels like kerosene for lamps, biomass for cooking, and diesel for generators. But looking beyond the household, to finance small businesses and other productive enterprises, has the dual advantage of increasing productivity and stimulating demand for modern energy services.[61]

The United States pursued precisely this sort of approach during the Great Depression, through the Tennessee Valley Authority. India's early electrification strategy was designed to increase food security by providing energy for mechanized agricultural irrigation. So these ideas are neither novel nor untested, and there are many places in the developing world where expanding energy services can be extremely productive. For instance, only 4% of African farmland is currently irrigated. Providing reliable and inexpensive power for mechanized irrigation—likely through decentralized sources because of the continent's poor grid infrastructure and low population densities—has the potential to improve Africa's water security, agricultural output, and capacity to adapt to a changing climate.[62]

By reframing the debate on universal energy access around what we want energy to provide and how much energy is required to achieve those goals, we gain more options and better chances for success. It may bother some in the climate policy community that these options, to be feasible, may need to include nuclear, large hydropower, and coal or natural gas with carbon capture and sequestration (CCS). However, as Newell et al. state, it is only by fundamentally "changing *how* energy policy is made and *by* and *for whom* that we can expect some of the distributional inequities in access and exposure to the consequences of unsustainable energy pro-

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[61] Small-Scale Sustainable Infrastructure Development Fund (S^3IDF), "Emphasizing Financial Leverage and Integrated Support to Create Micro-Enterprises that Provide Basic Infrastructure for Poverty Alleviation," Backgrounder, July, 2012.

[62] Shonali Pachauri, Abeeku Brew-Hammond, Douglas F. Barnes, Daniel H. Bouille, Stephen Gitonga, Vijay Modi, Gisela Prasad, Amitav Rath, and Hisham Zerriffi, "Energy Access for Development," Ch. 19 in *Global Energy Assessment: Toward a Sustainable Future* (Laxenburg, Austria: International Institute for Applied Systems Analysis, 2012), pp. 1401-1458.

duction and use to be addressed."[63] In this way, a thrival agenda allows for a holistic view of what it means to accomplish development beyond survival, and this in turn demands a less doctrinaire view of pathways to addressing climate change.

[63] Peter Newell, Jon Phillips, and Dustin Mulvaney, *Pursuing Clean Energy Equitably*, Human Development Research Paper 2011/03 (New York, NY: United Nations Development Program, November 2011), p. 3.