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Can electricity reach the billion people who live without it?

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Abstract

Living in the U.S., it is hard to imagine a life without reliable and unlimited access to affordable electricity. Globally, however, 1.3 billion people – four times the population of the U.S. – lack this basic resource. Simply scaling up the energy supply with conventional coal, diesel and gas plants – the mainstay of the electricity system worldwide today – would be really expensive. In addition, building enough large fossil fuel power plants or hydroelectric megadams to distribute electricity to every single one of these people would be very unhealthy for people and the environment. However, this does not mean they are doomed to houses lit by candles and smoky paraffin lamps. (Just imagine writing your homework under the light of a kerosene lamp as a Kenyan student without electricity. See fig. 3)

Our research produced a vision of the future where every person on the planet has access to at least basic electricity. We are seeing a revolution today, where small family-scale energy systems powered by solar are changing how people access lighting, cellphone charging, televisions, and refrigeration. Electrical power can now be produced for people off the grid by rooftop or backyard solar, or by a small power station in their neighborhood, or by a large power station somewhere far away and delivered via the grid.

The change is not only in the source of energy, but in the business model, too. A rural family in Kenya can now pay their electrical bill using a mobile phone and an online payment system. With electric lights to study, students in rural Kenya (and elsewhere) have a better opportunity to graduate from school.

Never in history have we had so many choices about where to get our electricity and how to pay for it. Solar panel prices have been rapidly declining over the past 20 years. Modern, efficient electrical appliances only require a fraction of the energy old ones did. (Ever seen those 100 W incandescent light bulbs? Yeah, nobody uses them anymore. They switched to 10 W LED light bulbs long time ago. (Fig. 1.)

	STANDARD incandescent	CFL compact fluorecent lamp	LED
WATTS	100	20	10
LIFE (YEARS)	1	10	20
ESTIMATED ANNUAL ENERGY COST *	$7	$5	$1.50
INITIAL COST PER BULB	$2.00	$8.00	$12.00

Figure 1. *Cost of different types of light bulbs used by people on the grid. * given electricity costs 10 cents per kilowatt-hour.*

Background

Try to imagine your life without electricity. No lights at home. No TV. No laptop or internet. No music, other than your little brother's failing attempts to play the guitar. Though this may be hard to imagine for those of us living in the comfort of an electrified society, one sixth of the world's population does not have access to power at home. This needs to change.

Flip the switch and the light in your room comes on. Do you know where the electricity for it comes from? If you live in the U.S., more likely than not, it was produced in a power station burning natural gas. You may have some classmates who get their energy at home from rooftop solar but even though over 500,000 families in the US get their power directly from the sun, this is less than one home in 200. Imagine a future where every new home built has solar panels on the roof, and 3 – 4 days worth of energy is stored in a battery in the garage. In some places that is already the case today.

Now imagine somebody your age in a tiny school in rural Kenya. When they go home at night, most will need to burn a kerosene lamp and share it with their siblings. Some, however, can turn on bright lights to work on their homework. Many of those fortunate enough to have electricity are not connected to the grid. Instead, they have it produced by a solar panel on the roof of their home – a modest home completely "off the grid".

Research overview

Most people around the world currently get their electricity from fossil fuel technologies such as coal or natural gas power plants. One of the big problems with these options is that carbon emissions from the combustion of coal or gas lead to increased concentration of greenhouse gases in the atmosphere and climate disruption. There are big projects now to build solar, wind, and other renewable energy to replace fossil fuel, however big projects often replace or increase the supply of electricity to those who already have it. For the people that currently live "off-the-grid", other renewable solutions are needed. A lot of people say that if we want to reduce our impact on the climate, we cannot afford to provide electricity for all these poor people. But is that really true?

We did extensive fieldwork where we studied the services that new solar power energy systems could provide, the economics and the 'supply chain' to get lamps and other new technologies sold in rural communities.

Our research was driven by an interest in finding out:

1. What is the link between people's access to electricity and their quality of life (aka human development and equality between men and women, boys and girls)?
2. How did most people get access to electricity in the past 150 years?
3. How can modern technologies such as efficient solar panels and batteries make it easier to live off the grid?
4. How can new technologies such as mobile phones improve somebody's chance of having electricity at home?
5. Is providing electricity to the poor good for the world's climate?

Electricity and quality of life

Having electrical power at home is not just a convenience. It saves lives. It allows children to get an education and find a job, which can pull them out of poverty. Mothers can more safely give birth regardless the time of day. It reduces crime on the street. Scientists call these quality-of-life improvements "human development" and measure them in different ways (See fig. 2).

According to long-term data, countries where most people have electricity and an average person can use at least 200 kWh per month, have higher human development. (Have you ever looked at your family's energy bill? How much electricity do you use?)

Access to electricity is not the only factor determining a person's quality of life, but it is an important prerequisite. It allows you to have a mobile phone (your connection to the world), light at night, a fan (against the heat), a TV, a fridge and so on.

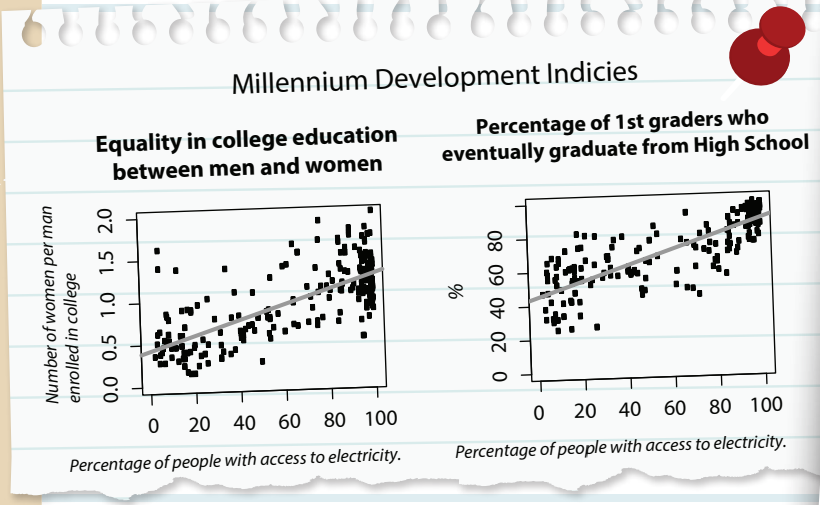

Figure 2. *Relationship between access to electricity and human development. What do you think explains the link between access to electricity and signs of human development such as number students who finish high school? (Alstone et al. 2015)*

Figure 3. *Writing homework with just a kerosene lamp is hard. (Copyright 2009 Wilkens / Lighting Africa).)*

The last 150 years

Ever since people started producing electricity in the late 1800s and distributing it through a grid, there have been around 1 billion people without access to it (Fig. 4a). Ultimately, large electrical grids have failed to provide enough connections to keep pace with the world's growing population. But if off-grid energy technologies spread as fast as mobile phones did (Fig. 4b), many off-grid people may end up with a solar panel on their roof before they are reached by the main electrical grid.

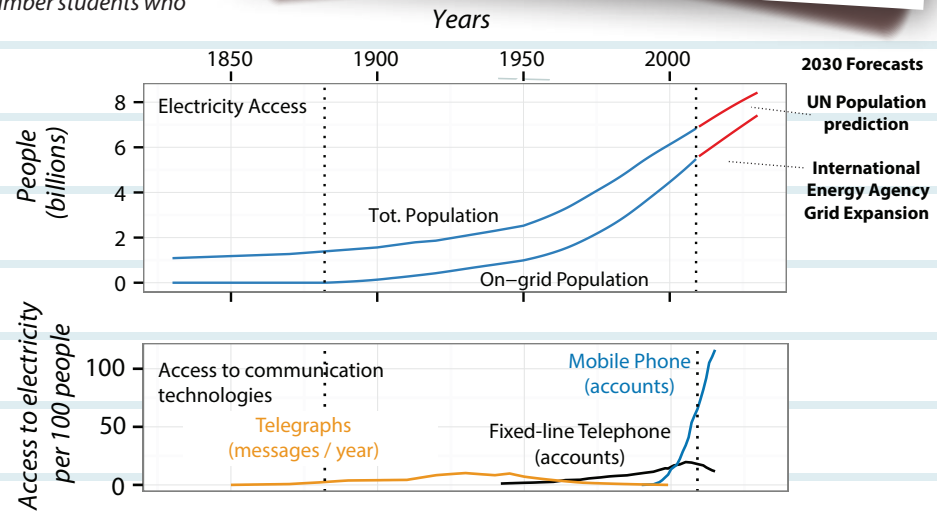

Figure 4. *Historical trends for adopting technologies. (a) Grid expansion roughly paced global population growth. (b) The more people have a mobile phone, the less they are interested in having a fixed-telephone line. Youth today see cell phones as a 'must have' and often see no need for a fixed line telephone at home; something their parents can still barely believe. (Alstone et al. 2015)*

Living off the grid

People find themselves off the central electrical grid for different reasons:

1. **Geographic isolation**: they live in a remote, difficult-to-access area, where it's hard to install transmission and distribution lines.

2. **Economic isolation:** they would use very little electricity and could barely afford the connection fee so utilities don't have an incentive to connect them.

3. **Political isolation:** often, they don't own the land they live on or may be outsiders in their local area, making it harder to ask for electricity connections and get a good response.

Solar minigrids (neighborhood electricity grids powered by solar panels) or household solar systems can help overcome these barriers. These decentralized power systems were just recently made possible by the advancement of technologies such new semiconductors, cheap photovoltaic solar panels, new batteries, DC power TVs etc (Fig. 4).

Propelled by those trends in technology, nowadays there are a lot of new organizations that work to provide decentralized electric power (See a list of them in the references section at the end of the article). With these new options, there are tens of millions of households now connected to off-grid small power systems. This way to deliver electricity to the world's poor is not in a test-phase anymore. It is a reality.

Figure 5. *Solar power produced by low-cost solar photovoltaics. The small-scale home solar energy systems in these Ethiopian homes are made possible from low prices for solar panels and other parts of the systems. In 2004, producing 1W of electricity with a solar panel cost $20. By 2010, the price had dropped to $2 or less.*

Mobile phone – electricity link

Mobile phones have a major role to play in electrifying these people's homes. For example, people can use Pay-as-you-go apps that allow them to pay electricity bills in small, almost daily, increments instead of as one large bill per month. Mobile connections also allow local minigrid managers to order replacement parts or ask for advice on how to fix a power failure instead of waiting for a technician to arrive. Finally, the opposite connection also exists: having reliable electricity at home is more valuable to people because it allows them to charge their mobile phones a lot cheaper and more easily than in a nearby town.

Electricity and climate

Isolating poor people without access to electricity is not only unfair but also bad for the global climate. The fall-back alternative to electricity is to burn kerosene lamps or use expensive and disposable dry-cell battery lights. Kerosene lamps release carbon dioxide and black carbon (aka soot) into the atmosphere, which trap solar radiation and heat up the world's climate. According to our calculations, a household using a kerosene lamp who switches to electricity can reduce their impact on the climate by 10x while getting 100x better service.

To make matters even more unfair, poor people who are not connected to any electrical grid pay twice as much as a fraction of their income for kerosene lighting than those who are connected to a grid. Ultimately, small renewable power systems can provide electricity to the world's one billion poorest people while minimizing effects on the global climate.

Glossary of Key Terms

Millennium Development Goals (MDG)

Humanity's aspirations for how to make the world a better place set by the United Nations at the start of the 21st century.
E.g. The second MDG is to achieve universal primary education, that is: every child in the world will finish at least elementary school.
See also: Sustainable Development Goals (2015) http://www.un.org/sustainabledevelopment/sustainable-development-goals/

On or off-grid

The way you get your electricity at home. If you live on the grid, you get electricity from a large central provider. By contrast, if you live off the grid, you are independent from the large provider and you probably produce it yourself or in cooperation with other off-grid homes.

Decentralized power

Producing electrical power at or near the homes of the people who use it instead of at a single central location, such as a coal or a nuclear power plant.
E.g. Many international organizations support the idea of decentralized power.

Climate change mitigation

Taking steps to reduce or slow down climate change.
E.g. One way to mitigate climate change is to produce electricity from solar panels instead of in coal power plants.

Megadam

Very large river dams which produce hydroelectric power.
E.g. The High Aswan dam provides electricity for many people in Egypt.

Solar minigrid

An electricity grid powered via solar panels which provides electricity to a single small community/neighborhood.
E.g. All 20 houses in the village are connected to the solar minigrid.

Photovoltaic (PV)

Electricity produced by solar panels.
E. g. Photovoltaic panels cost less and less every year.

Black carbon (aka soot)

Air pollutant released from burning biomass or fossil fuels.
E. g. Using kerosene lamps releases a large amount of black carbon which is very harmful to people's health.

References

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Some of the organizations that are active in supporting or building new ways to provide off-grid solar:

1. *UNITED NATIONS SUSTAINABLE ENERGY FOR ALL*
2. *POWER AFRICA & BEYOND THE GRID*
3. *GLOBAL OFF-GRID LIGHTING ASSOCIATION*
4. *LIGHTING GLOBAL*
5. *DFID*
6. *UN FOUNDATION*
7. *POWER FOR ALL*
8. *SOLARAID*
9. *GSMA MOBILE FOR DEVELOPMENT*
10. *ROCKEFELLER FOUNDATION*
11. *PACKARD FOUNDATION*
12. *SCHNEIDER ELECTRIC*
13. *SHELL FOUNDATION*
14. *SOLAR CITY*
15. *FIRST SOLAR*
16. *SIERRA CLUB*
17. *PRACTICAL ACTION*

KEY TERMS

Energy, electricity, grid, mobile phones, development, climate, Kenya, solar power, megadam, minigrid