Powering the Unplugged: Overcoming the Barriers to Electrification in the Developing World

Robert Bryce

Executive Summary

The thesis

From switching on our kettles in the morning to charging our phones at night, nearly everything we touch has, in one way or another, been electrified.

Yet, about 800 million people in the world remain in the dark, with no access to electricity whatsoever. Hundreds of millions more use only tiny amounts. Haiti, for instance, only generates enough electricity for an individual to boil a single kettle of water per day. Chad has even less electricity, with enough for a person to boil a single kettle of water *per week*. Indeed, the defining inequality in the world today is the enormous gap between the electricity rich and the electricity poor. The availability of electricity does not guarantee wealth, but its absence almost always means poverty.

So, how can we help lift people out of poverty and into prosperity? This paper argues that affordable, abundant electricity is vital to modern society, and it offers several pathways that can help electrify the developing world.

Mind the (power) gap

While nearly one in ten global citizens have no electricity at all, billions more are limited to miniscule quantities of power. This paper organises the global population into three segments to accurately present the scale of the challenge now facing policymakers. These include:

- Unplugged World: 3.7 billion people (nearly 47% of the global population) live in countries where per capita electricity use is less than 1,200 kilowatt-hours per year, enough energy to power a large kitchen refrigerator in the United States.
- Low-Watt World: 1.3 billion people (16% of the global population) have access to between 1,200 and 4,000 kilowatt-hours of electricity per year.
- High-Watt World: 2.9 billion people (37% of the global population) enjoy per capita electricity use of over 4,000 kilowatt hours per year.

What is the significance of these numbers?

The minimum electricity needed for a long, high-quality life is about 4,000 kilowatt-hours per year. When more than half of the world's population has access to considerably less than this amount, there is a clear and urgent need to plug in the rest of the world to alleviate energy and economic poverty.

The way forward

The best chance we have to fix this problem is by helping nations become self-sufficient with respect to their power needs.

Policymakers must find solutions that can help empower these nations so they can create and sustain electric grids with affordable, reliable, and resilient power that can fuel their homes, schools, hospitals, factories, and water treatment plants.

In short, the countries that have abundant and reliable electricity are prospering, whereas the ones that lack power are languishing. It is time to help more people come out of the dark and into the bright lights of modernity.

Powering the Unplugged:

Overcoming Barriers to Electrification in the Developing World

Robert Bryce

Abstract

Affordable electricity is foundational to modern society. The countries that have abundant electricity and resilient and reliable electric grids are prospering. The ones that lack electricity are languishing. Today, about 800 million people have no access to electricity.[1] Hundreds of millions more use only tiny amounts. For instance, per capita electricity use in Haiti is about 86 kilowatt-hours per year. That meagre amount of electricity is enough to allow an individual to boil a single kettle of water per day.[2]

Indeed, the defining disparity in the world today is the enormous gap between the electricity rich and the electricity poor. About 3.7 billion people—or roughly 47% of the global population—are now living in the Unplugged World, where, on average, per capita electricity use is less than 1,200 kilowatt-hours per year. To put that in perspective, 1,200 kilowatt-hours per year is roughly the amount of energy consumed by a large kitchen refrigerator in the United States.[3] This paper spotlights the vast disparity in global electricity consumption. It explains why electricity availability is fundamental to anti-poverty efforts and, in particular, why electricity is critical to elevating the status of women and girls. This paper examines the fuels used to generate power and the obstacles to electrification in the developing world and explains why corruption is hindering electrification efforts. It concludes with a discussion of policy measures that can help more people come out of the dark and into the bright lights of modernity.

Introduction

Electricity is the world's most important and fastest-growing form of energy.[4] It is also the most difficult form of energy to supply reliably.

Many of the world's most pressing challenges are tied directly to electricity, including carbon dioxide ("CO_2") emissions, women's rights, and poverty reduction. The electricity sector matters to climate change efforts because it is the single biggest source of global CO_2 emissions.[5] Electricity matters because it is one of the world's biggest industries. Global electricity sales exceed $4.5 trillion per year.[6] That means that the electricity sector generates more revenue per year than global automobile manufacturing, which generated about $3 trillion in 2022.[7] Furthermore, electricity-related investment is the biggest portion of global energy spending. This year, the International Energy Agency ("IEA") expects that global spending on the power sector, including investment in renewables, nuclear, hydrocarbons, grids, and batteries, will total $1.2 trillion. By comparison, spending on hydrocarbons—coal, oil, and natural gas—will total about $950 billion.[8]

Electricity matters because it is the ultimate poverty killer. No matter where you look, as electricity use has increased, so has economic growth. Having electricity does not guarantee wealth. But its absence almost always means poverty. Indeed, electricity and economic growth go hand in hand. Electricity spurs

economic activity, and economic growth spurs electricity use. Westerners take electricity for granted. But nearly everything we touch—almost everything we read, eat, or wear—has in one way or another been electrified.

Policymakers must have a laser-like focus on electricity because hundreds of millions of people in developing countries, including Pakistan, South Africa, and Bangladesh, are suffering from increasing numbers of blackouts and shortages. Even energy-rich countries like Iraq are experiencing regular blackouts. Amidst this backdrop, global power demand is booming. Urbanization, economic growth, population growth, electric vehicles, and soaring use of air conditioning in countries like India—where air conditioner sales are growing by nearly 8% per year—are all fuelling the need for more electricity.[9]

How much more power generation capacity will the world need? Over the past four decades, global electricity production doubled every 20 to 25 years. If that trend continues, global generation capacity will increase from roughly 7 terawatts today to about 14 terawatts by 2050.[10] To put that in perspective, the United States now has approximately 1.1 terawatts of generation capacity.[11] Thus, over the next 25 years, the world's countries will have to add generators, poles, wires, and electricity meters roughly *equal to six grids the size of the existing American grid.* That is an enormous challenge. Further, it will require using all of the fuels we have available.

Over the past two decades, climate activists and policymakers, particularly ones based in Europe and North America, have repeatedly claimed that the world economy can run solely on weather-dependent renewables. Investors have responded by pumping enormous amounts of capital into wind and solar projects. According to Bloomberg New Energy Finance, between 2004 and 2021, some $3.7 trillion was spent on wind and solar.[12] Despite that staggering investment, by the end of 2021, those two forms of electricity production were only producing about 10% of global electricity (see Figure 6).

Furthermore, numerous factors are constraining the growth of wind and solar, including land-use conflicts. As shown in the Renewable Rejection Database, local communities across the United States are fighting the encroachment of large wind and solar projects. Since 2015, there have been more than 400 rejections or restrictions of wind projects and more than 170 rejections or restrictions of solar projects.[13] Similar land-use conflicts can be seen across Europe, as well as in Israel and Australia.[14] In addition, the lack of high-voltage transmission capacity is hampering weather-dependent renewable projects. That capacity is necessary to move electricity from rural areas with the best wind and solar resources to urban areas where electricity demand is highest.

Although wind and solar are getting enormous subsidies and have staunch political support, the hard facts show that the global electricity sector continues to rely heavily on the incumbent sources—hydrocarbons, hydropower, and nuclear—which together provided about 87% of the world's electricity in 2021.

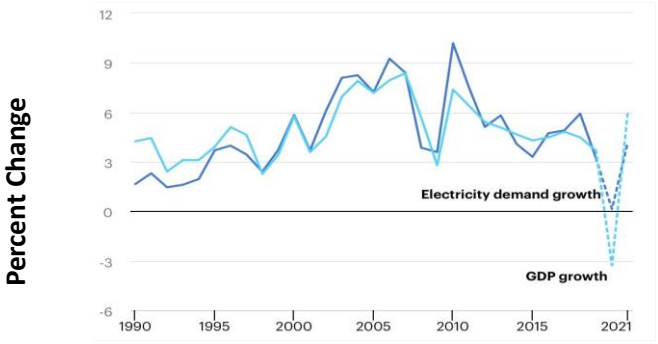
Given these facts, policymakers must regard the electric sector as a critical part of the economy and focus on measures that help ensure their electricity grids can supply affordable, reliable, and resilient power to their people, factories, and water treatment plants. Furthermore, they should focus on electrification first. Concerns about decarbonisation should come second. Before addressing how to bring more power to the unplugged, we must understand the importance of electricity and the enormous disparity between the electricity rich and the electricity poor.

Mind The (Power) Gap

Electricity is an essential driver of economic growth. That is true in developing countries and advanced economies alike. In 2020, the IEA published two charts that demonstrated the close correlation between electricity demand growth and gross domestic product ("GDP") growth.[15] As seen in the two graphics below, electricity use and GDP rise and fall in a close tango. (Note: the dark blue line is electricity demand growth. The light blue line is GDP growth, and the dashed lines are estimates.)

Figure 1

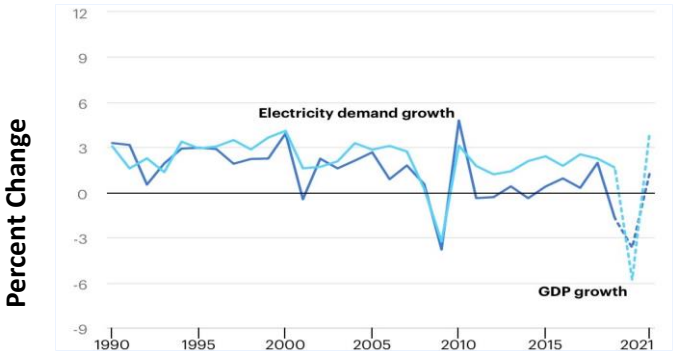
Electricity Demand and GDP in Emerging and Developing Economies, 1990 to 2021



Source: IEA https://www.iea.org/reports/electricity-market-report-december-2020/outlook-2021

Figure 2

Electricity Demand and GDP in Advanced Economies, 1990 to 2021



Source: IEA https://www.iea.org/reports/electricity-market-report-december-2020/outlook-2021

The transformative power of electricity has been the subject of numerous academic papers. In 2010, two academics at the University of Karachi published a paper that examined the "causal relationship between energy consumption and economic growth" in Bangladesh, India, and Pakistan. The analysis studied data between 1971 and 2008. While the analysis did not focus specifically on electricity, the conclusion of the authors, Kashif Imran and Masood Mashkoor Siddiqui, was clear: "Energy serves as an engine of economic growth and economic activity will be affected in the result of changes in energy consumption…GDP is basically determined by energy."[16] In 2014, two Turkish researchers, Yilmaz Bayar,

and Hasan Alp Ozel, analysed about two dozen published papers on electricity and economic growth. They found "unidirectional causality between electricity consumption and economic growth."[17]

While electricity drives economic growth, it is also clear that greater wealth increases electricity consumption. Energy writer Roger Andrews spotlighted this bi-directional effect of wealth and electrification in a 2015 study in which he concluded that in developing countries, "wealth creates electricity and not the other way round. There is no question, however, that once a country gains wealth it cannot sustain it without electricity. When the electricity disappears, the wealth goes with it."[18]

Another way to understand the correlation between electricity use and wealth is to look at nighttime luminosity—that is, the amount of light emitted by a region at night. In 2010, William Nordhaus, an economist at Yale University, published a paper that determined nighttime luminosity—measured by using images captured by satellites orbiting the Earth—has a close correlation with personal incomes. Nordhaus, who won the 2018 Nobel Prize in Economics, determined that luminosity is not particularly effective for analysing wealthy countries. But it is useful in analysing wealth in developing countries where traditional statistical information is not readily available.[19] In 2012, three researchers from the National Bureau of Economic Research used a similar technique in their paper titled, "Measuring Economic Growth From Outer Space." That paper concluded that nighttime luminosity provides "a very useful proxy for GDP growth over the long term and also tracks short-term fluctuations in growth."[20]

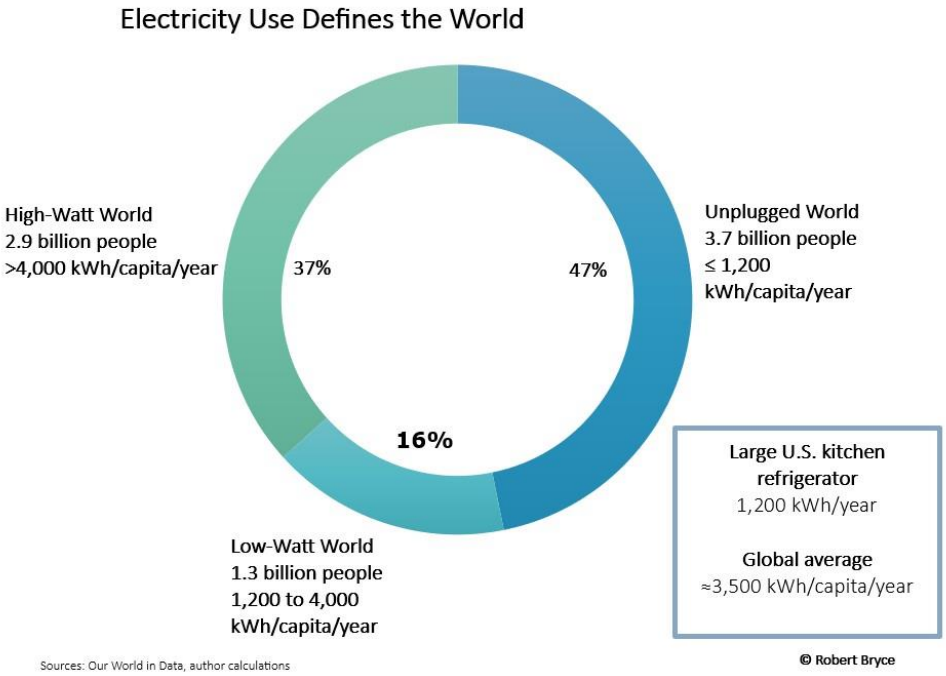
The punchline here is obvious: increased electricity use fosters economic growth, which, in turn, means better living conditions for humans. Electricity use also provides a reliable barometer for the health and wealth of individuals and societies. The IEA has called electricity "crucial to human development" and has said that electricity use is "one of the most clear and undistorted indications of a country's energy poverty status." Put another way, electricity bolsters economic growth and economic growth bolsters electricity demand. Together, those things help people escape poverty. As Paul Collier, the author of *The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done About It*, famously put it, "Growth is not a cure-all, but lack of growth is a kill-all."[21]

While people in the United States and other wealthy countries have come to expect cheap, abundant, reliable electricity as a birthright, the IEA recently estimated that about 800 million people still have no access to electricity.[22] But that figure does not account for the billions of people who only use small quantities of power. Nor does it provide context for the challenge facing policymakers.

To get a better focus on the vast disparity in global electricity use, I needed good figures for per capita electricity use. Finding no recent sources, I devised a method to get those numbers. My methodology was simple. I used country-level 2021 population numbers published by Our World in Data.[23] I combined the population data with 2021 electricity generation figures from the same source.[24] I then trifurcated the global population into three segments: the Unplugged World, the Low-Watt World, and the High-Watt World. I did so using these demarcations:

- The "Unplugged" countries, where per capita electricity use is less than 1,200 kilowatt-hours per year.
- The "Low-Watt" countries, where per capita electricity use is between 1,200 and 4,000 kilowatt-hours per year.
- The "High-Watt" countries, where per capita electricity use exceeds 4,000 kilowatt-hours per year.

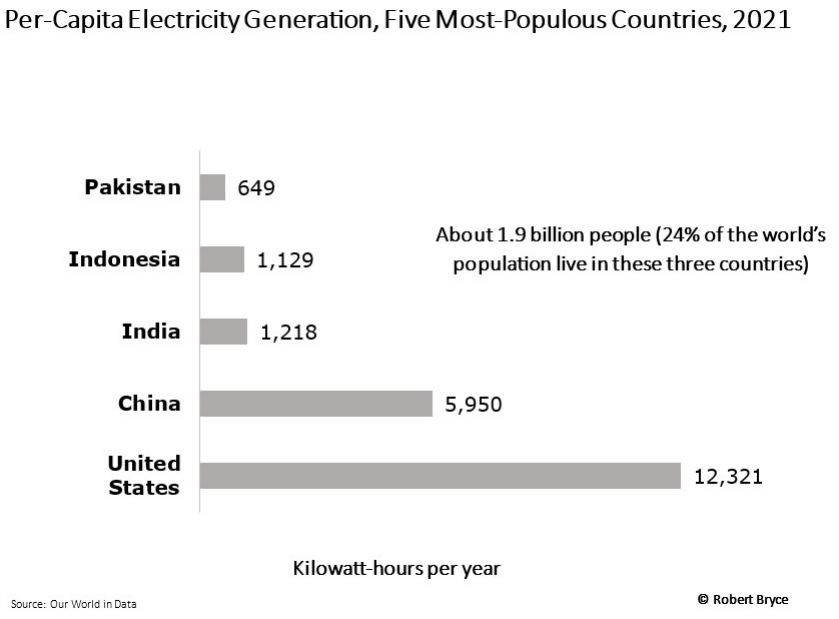
Figure 3



Those demarcations were chosen on purpose. The 1,200 kilowatt-hour-per-year was used as the cutoff for the Unplugged World because that is the average electricity consumption level in India, a country that has long been plagued by energy poverty. Although India has made great strides in recent years, the country still struggles to increase electricity availability and consumption.

To put that quantity in perspective, 1,200 kilowatt-hours of use per person is about one-third of the global average.[25] It is also about the same amount of energy as what is used annually by a large kitchen refrigerator in the United States. As seen in the graphic above, about 3.7 billion people—about 47% of all the people on the planet—are now living in the Unplugged World. The Unplugged countries include El Salvador, the Philippines, and Bolivia.

Figure 4



Further, as shown in Figure 4, three of the world's most populous countries are in the Unplugged World. Together, Pakistan, Indonesia, and India contain about 1.9 billion people. That means that about 24% of the world's population is, effectively, Unplugged. In those three countries, per capita electricity use is far less than one-third of the global average of 3,500 kilowatt-hours per year.

The Low-Watt designation applies to the locales where per capita annual electricity use is between 1,200 kilowatt-hours and 4,000 kilowatt-hours. About 1.3 billion people—approximately 16% of the world's population—are living in the Low-Watt World. The countries in this segment include places like Brazil, Argentina, and Turkey. These locales are not necessarily poor, but they are not among the wealthiest.

Finally, about 2.9 billion people, or 37% of the world's population, live in the High-Watt World, the segment where per capita electricity use is 4,000 kilowatt-hours or more, per year. The countries in this segment include the United States, Britain, Germany, and Israel.

Four thousand kilowatt-hours of electricity use per annum is a key demarcation line because that quantity of energy is considered the minimum for living a long, high-quality life. In 2000, Alan D. Pasternak, a chemical engineer who worked at Lawrence Livermore National Laboratory, published a paper that analysed per capita electricity consumption in 60 countries and then correlated that electricity use with indicators of human health and welfare.[26] Using data from the United Nations Human Development Index ("HDI"), which ranks countries based on measures like life expectancy, nutrition, health, mortality, poverty, education, and access to safe water and sanitation, Pasternak calculated a score for each country, with 1.0 being the maximum.[27] Pasternak found that less than 15% of the world's population enjoyed an HDI of 0.9 or greater. Further, Pasternak wrote that "there is a threshold at about 4,000 kilowatt-hours per capita, corresponding to an HDI of 0.9 or greater, in the relationship between HDI and electricity consumption."[28] In other words, Pasternak (who died in 2010) found that the 4,000 kilowatt-hours mark was the key dividing line.

"As electricity consumption increases above 4,000 kilowatt-hours, no significant increase in HDI is observed," he wrote. Conversely, he found that the lower the electricity consumption, the lower the HDI. In a summary of his findings, Pasternak was blunt, saying that neither the HDI nor the economic output "of developing countries will increase without an increase in electricity use." Pasternak continued, "What is of interest is the fact that large populations of the world are significantly below the electricity threshold level associated with a Human Development Index typical of developed countries." Those low rankings, he continued, "reflect short life expectancy and low educational attainment—measures that are far more compelling than the purely economic metrics usually associated with energy consumption." Therefore, he said, "there is a compelling need for increased energy and electricity supplies in developing countries."[29]

The essential point of Pasternak's paper is this: small amounts of electricity are not effective at alleviating poverty. Sure, small amounts of power are better than nothing. But Pasternak's paper shows that if the world's poverty-stricken people are going to come out of the dark and into modernity, we are going to need vastly more electricity than what is now being produced.

Why is there such a vast disparity in electricity use around the world? There are many ways to explain the reasons for the disparity. Before doing so, it is essential to understand who suffers the most due to the lack of electricity.

Women, Electrified

Electricity is essential for all human beings. But it is particularly beneficial for women and girls because it frees them from the drudgery of energy poverty. Put short, electricity emancipates women and girls from the pump, the stove, and the washtub.

Numerous academic studies have shown the positive effect electrification has on women and girls. A 2002 study in Bangladesh by Abul Barkat, an economist at the University of Dhaka, found that the literacy rate for females in villages with electricity was 31% higher than it was in villages that lacked electricity. The study concluded that the availability of electricity has a "significant influence on education, especially on the quality of education. This influence is much more pronounced among the poor and girls in the electrified households than the poor and girls in non-electrified households."[30]

A 2010 study on post-apartheid electrification in South Africa found that "employment grows in places that get new access to electricity." This was particularly true for women. The study found that electrification led to "large increases in the use of electric lighting and cooking, and reductions in wood-fuelled cooking over a five-year period, as well as a 9.5 percentage point increase in female employment."[31]

A 2012 study of rural electrification in India concluded that the availability of electricity had a significant impact on schooling for girls, finding:

> "…electrification access increases school enrolment by about 6% for boys and 7.4% for girls. It also increases weekly study time by more than an hour, and the increase is slightly more for girls than boys. As a result of more study hours, children from households with electricity can be expected to perform better than their peers living in households without electricity."

The same study found that "The impact of electrification on labour supply is positive for both men and women; that is, household access to electricity increases employment hours by more than 17% for women and only 1.5% for men." Further, the study found that electrification reduces the overall poverty rate by 13.3%, and it concluded that "these findings indicate electrification's substantial positive effect on overall household welfare."[32]

Women washing clothes by hand, Nicholas County, Kentucky, USA, 1916.
Photo: Library of Congress.

Complex studies are not needed to show that extreme shortages of electricity are a common factor in nearly every country where women and girls are vulnerable to illiteracy and child marriage.[33] World

Bank data shows that the countries with the highest female illiteracy rates are all in the Unplugged world.[34] If you are a female in an impoverished country and do not have access to electricity, you are, effectively, a slave to the physical chores of the household: hauling water, making fires, grinding grain, and washing clothes. In 2014, the United Nations Children's Fund released its "State of the World's Children" report. It is a sobering document that details the plight of children around the world, and in particular, the plight of girls. Among the aspects that UNICEF examined was the issue of child marriage, that is, cases in which girls are married before age 18.

Figure 5

The Ten Countries with the Highest Rates of Child Marriage Are All Electricity Poor

Country	Child Marriage Rate, 2005-2012	Electricity use, per capita, kWh, 2021
Niger	76%	18
C. African Republic	68%	27
Chad	68%	18
Bangladesh	65%	476
Mali	55%	155
Guinea	52%	205
South Sudan	52%	53
Burkina Faso	52%	79
Malawi	50%	71
Mozambique	48%	621

As seen in the graphic above, the 10 countries with the highest rates of child marriage are all in the Unplugged World. Furthermore, among those 10 countries, the rates of child marriage tend to be highest in the places where per capita electricity use is lowest. For instance, in Niger, between 2005 and 2012, according to UNICEF, about 28% of girls were married by the age of 15. By the age of 18, some 76% were married.[35] As seen in the graphic and the Appendix, per capita electricity use in Niger is now about 18 kilowatt-hours per year. In the Central African Republic, electricity use is just 37 kilowatt-hours per capita per year. In Chad, it is 18 kilowatt-hours. In those three countries, the electricity usage rates are so small as to be insignificant. For example, a resident of Chad, who can use just 18 kilowatt-hours of electricity per annum, would, over the course of a year, only have enough power to boil a kettle of water every four days.

Electricity matters to women and girls because electric stoves can reduce the amount of cooking done with solid fuels. Indoor air pollution is a major cause of death for women and girls in developing countries.

Pivotal research on this problem was done by the late Kirk R. Smith, a professor of global environmental health at the University of California, Berkeley. Smith estimated that indoor cookstoves that use biomass released the smoke equivalent of 400 cigarettes per hour. In 2002, he wrote a piece for Science magazine titled "In Praise of Petroleum?" in which he challenged the notion that "for the poor as for everyone else, only renewable energy sources qualify as sustainable." He pointed out that clean-burning hydrocarbons like butane and propane can reduce indoor air pollution and provide "high-quality energy services" for poor households.[36]

During a 2009 interview, Smith told the author of this paper, "Poor women in rural areas of developing countries are about as low on the totem pole, globally, as you can get," Smith said. "They don't have

anybody speaking for them. They don't have their own Sierra Club or whatever."[37] Smith, who died in 2020, said, "Even if you were to substitute LPG [liquified petroleum gas, i.e., propane or butane] for all of the biomass used for cooking in the world, it would have very little impact on overall resources." He continued: "Why ask the poor to take on the need to use fancy, new novel untested, renewable energy devices when we have something that's good for them? They have many other needs. And this is a great thing for them."[38]

In 2007, the World Health Organization estimated that indoor air pollution was killing about 500,000 people in India every year, most of them women and children. The agency found that air pollution levels in some kitchens in rural India were 30 times higher than the recommended level and that the pollution was six times as bad as that found in New Delhi. Worldwide, as many as 1.6 million people per year die premature deaths due to indoor air pollution.[39]

A 2021 study found that the "morbidity and mortality caused by exposure to household air pollution from the use of solid fuels remain a significant public health burden in many developing countries of the world." According to the study, "[i]t is estimated that globally, about 3 billion people mostly in low-income countries use solid fuels for domestic cooking and heating with close to 646 million of these people living in sub-Saharan Africa, and this number is expected to continue to rise over the years." It continued, "The use of solid (biomass) fuels and kerosene exposes household members to health-damaging pollutants...Each year, close to 4 million people die prematurely from illness attributed to household air pollution from inefficient cooking practices."[40]

The plight of women was a primary motivator for the politicians who pushed for rural electrification in the United States during the 1930s. One of the biggest proponents of electrification was George Norris, a flinty Nebraskan, who helped push the Rural Electrification Act of 1935 through Congress. In his 1945 autobiography, *Fighting Liberal*, Norris wrote vividly about growing up on a farm. "From boyhood, I had seen first-hand the grim drudgery and grind which had been the common lot of eight generations of American farm women...I knew what it was to take care of the farm chores by the flickering, undependable light of the lantern in the mud and cold rains of the fall, and the snow and icy winds of winter. I had seen the cities gradually acquire a night as light as day." The full passage continues:

> "I knew the heat of those summer days in a farm kitchen…where humidity and blazing sun combined with the stove to create unbearable temperatures. I had seen the drudgery of washing and ironing and sewing without any of the labour-saving electrical devices. I could close my eyes and recall the…unending punishing tasks performed by hundreds of thousands of women…growing old prematurely; dying before their time; conscious of the great gap between their lives and the lives of those whom accident of birth or choice placed in the towns and cities. Why shouldn't I have been interested in the emancipation of hundreds of thousands of farm women?"[41]

Another New Dealer, Lyndon Johnson, who was born and raised in the hard-scrabble hills of the Texas Hill Country, also deserves credit for the effort to bring electricity to rural America. During his long political career, which included reaching the White House in 1963, Johnson was proud of his efforts to boost rural electrification. For him, the grinding poverty of farm living without electricity was not an abstract notion. He was, as one biographer wrote, "raised by the light of lanterns and cooked for on a wood-burning stove. He had seen his mother scrubbing clothes in a washtub. He knew the insides of outhouses."[42]

As electricity frees women from the pump, the stove, and the washtub, it allows them to get educated, find jobs, and become active in civil society. Given that fact, it is not surprising that crucial advances in electrification occurred at about the same time women were gaining more political power. A look at the

late 19th and early 20th centuries shows that women's suffrage gained critical momentum during the same decades that the world's major cities were being electrified. For example, 1893 was a turning point for the suffrage movement in America. That year, Colorado became the first state in the United States to adopt an amendment granting women the right to vote. That same year, at the Columbian Exhibition in Chicago, George Westinghouse proved that the alternating current would become the standard method of distributing electricity to customers. Also, in 1893—11 years after Edison began producing electricity in Lower Manhattan—women in New Zealand were granted the right to vote. In 1902, Australia gave women the right to vote. In 1906, Finland did the same.[43]

Of course, numerous factors contributed to the success of the suffrage movement. But it is also clear that electrification paralleled the rise of women in society. As electrification swept around the globe, women began leaving the isolation and energy poverty of rural farms and ranches for better opportunities in brightly lit cities. As women got more jobs and independence, so did their desire for more power in the workplace and political office.

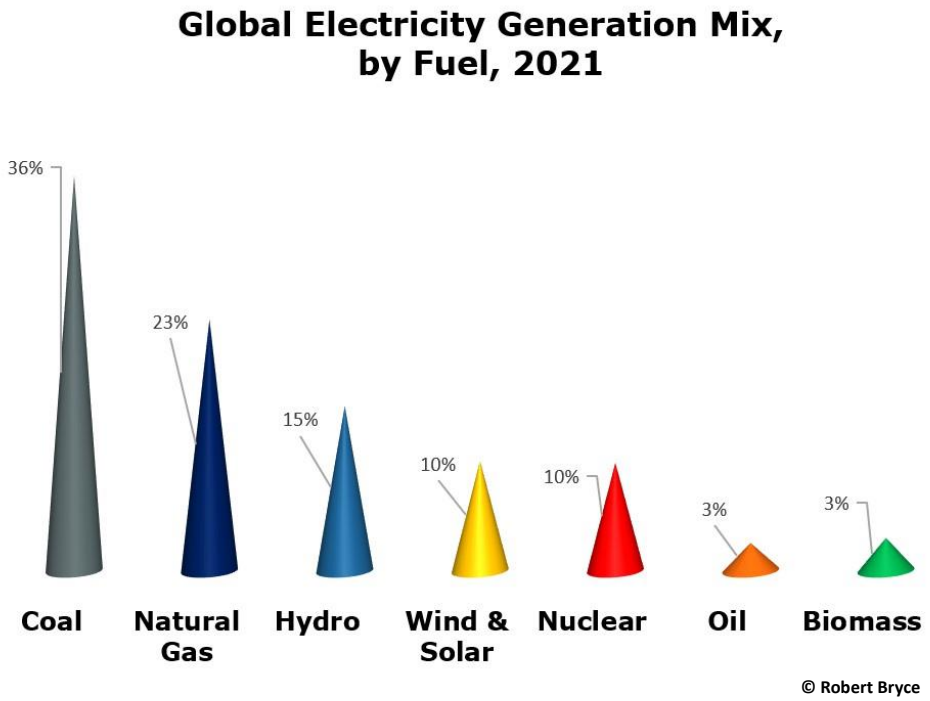
Today, policymakers should make reducing the death toll from indoor air pollution in developing countries a top priority. Electric cookstoves and better availability of LPG (liquefied petroleum gas) in those countries, could save hundreds of thousands of lives per year.

So, what are the keys to bringing more electricity to developing countries so that more women and girls have more opportunities? The next section will discuss some of the difficult realities that policymakers face as they consider the global electricity landscape.

Powering Up

Globalisation can be seen in nearly every commodity, from coffee to tennis rackets and beer to automobiles.[44] However, globalisation does not play much of a role in the electricity sector. Yes, there is plenty of trade in the fuels we use to produce electricity, including coal, natural gas, oil, and uranium. In addition, there is a booming global trade in solar panels, wind turbines, gas turbines, reciprocating engines, poles, and transformers. But very little electricity gets shipped across international borders. (Several countries in the European Union are the obvious exception to this fact.) The reason so little electricity gets traded across borders is that politicians are not willing to cede control of such a vital service to a foreign entity, no matter how friendly it might be. This lack of international trade means that countries must be largely self-sufficient in electricity generation. That, in turn, means that countries must choose the fuels and generation technologies that can assure affordable and reliable power for their citizens.

Figure 6



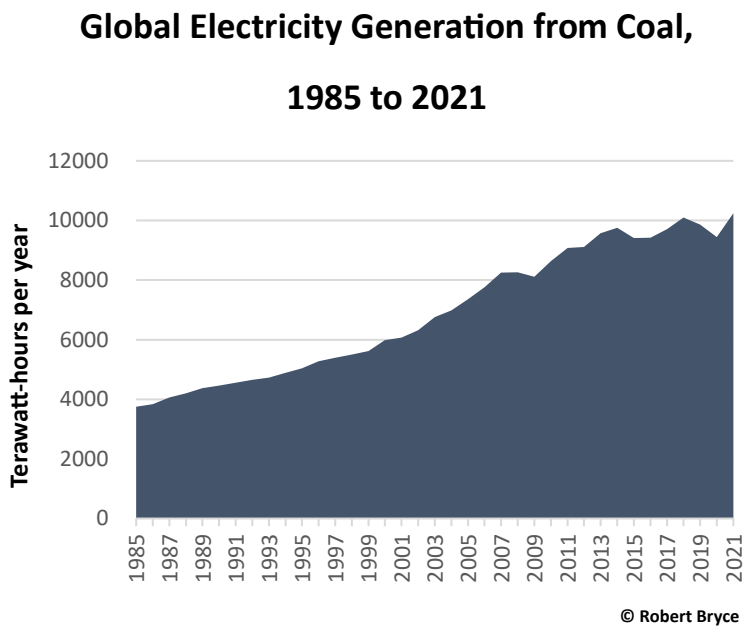
Over the past decade, renewable energy has grown rapidly in developing and advanced economies. That growth will likely continue. But as seen in the graphic above, hydrocarbons continue to dominate. Power plants that burn natural gas and coal provide about 59% of the world's electricity. By itself, coal accounts for 36%. In fact, coal's share of global generation has stayed between 36% and 40% since 1985, and that dominance will likely endure for decades to come.

In December 2022, the IEA reported that coal use was at an all-time high and that global coal demand would not peak until 2025 at the earliest. The Paris-based agency reported that "the current energy crisis has forced some countries to increase their reliance on coal in spite of climate and energy targets." The agency also predicted that global coal demand will likely plateau but is unlikely to peak until 2025, noting:

> "A convergence of factors is supporting an increase in coal demand. First, tight natural gas supplies and the resulting high gas prices are driving some countries and companies to turn to relatively cheaper coal. Second, heat waves and droughts in some regions of the world drove up electricity demand and reduced hydropower generation, creating a gap that had to be filled by mostly dispatchable thermal power plants. Last, nuclear power generation was exceptionally weak in 2022, especially in Europe, where France had to shut down a significant portion of its nuclear capacity for maintenance."

Also notable in that report was this line about the world's most populous country: "India's coal consumption has doubled since 2007 at an annual growth rate of 6%—and it is set to continue to be the growth engine of global coal demand."[45]

Figure 7



The continuing importance of coal for electricity production, which has grown almost every year since 1985, can be understood by reviewing several recent events in Unplugged countries.

On 23 January 2023, Pakistan was hit by a nationwide blackout that left about 220 million people in the dark. The blackout came just a few days after Prime Minister Shehbaz Sharif had ordered all federal departments in Pakistan to slash their electricity use by 30%. The government also ordered all markets to close by 8.30 p.m. and restaurants to be shuttered by 10 p.m. The blackout hit at about 7:30 a.m. on a Monday, and was blamed on a "major breakdown" in the national grid. A government official said there had been a "fluctuation in voltage" and that "power generating units were shut down one by one due to cascading impact."

The January blackout was only the latest in a long series of outages in Pakistan. In October 2022, southern parts of the country were hit by a blackout that lasted about 12 hours.[46] In January 2021, a blackout "plunged all of Pakistan's major cities into darkness, including the capital Islamabad, Karachi and the second-largest city, Lahore. There were no immediate reports of disruption at hospitals, which often rely on backup generators. A water and power ministry spokesman said electricity had been restored to some parts of the country but many areas in Lahore and Karachi were still waiting."[47] In 2018, a power outage hit most of eastern and northern Pakistan.[48]

Pakistan's shaky electric grid led to a predictable response from the Pakistani government. In February 2023, it announced it would quit importing liquified natural gas ("LNG") for its power sector and would instead quadruple the size of its domestic coal-fired generation capacity. The move came after a surge in global prices of LNG in the wake of Russia's invasion of Ukraine. Pakistan Energy Minister Khurram Dastgir Khan told Reuters, "LNG is no longer part of the long-term plan," and that the country would increase its domestic coal-fired power capacity to 10 gigawatts, a four-fold increase over the 2.3 gigawatts of capacity now in place. As Reuters explained, "Pakistan's plan to switch to coal to provide its citizens reliable electricity underscores challenges in drafting effective decarbonization strategies."[49]

In Bangladesh, fuel and foreign currency shortages have resulted in the country's worst electricity crisis in a decade. In mid-June, industrial and residential consumers were experiencing blackouts lasting 10

to 12 hours per day. During the first five months of 2023, the Bangladesh grid operator was forced to cut power for 114 days. For comparison, the grid operator cut power on 113 days in all of 2022.[50] Bangladesh, which is among the world's poorest countries, will be burning more coal in the coming years. In 2022, the country commissioned a new 1,010-megawatt coal-fired power plant.

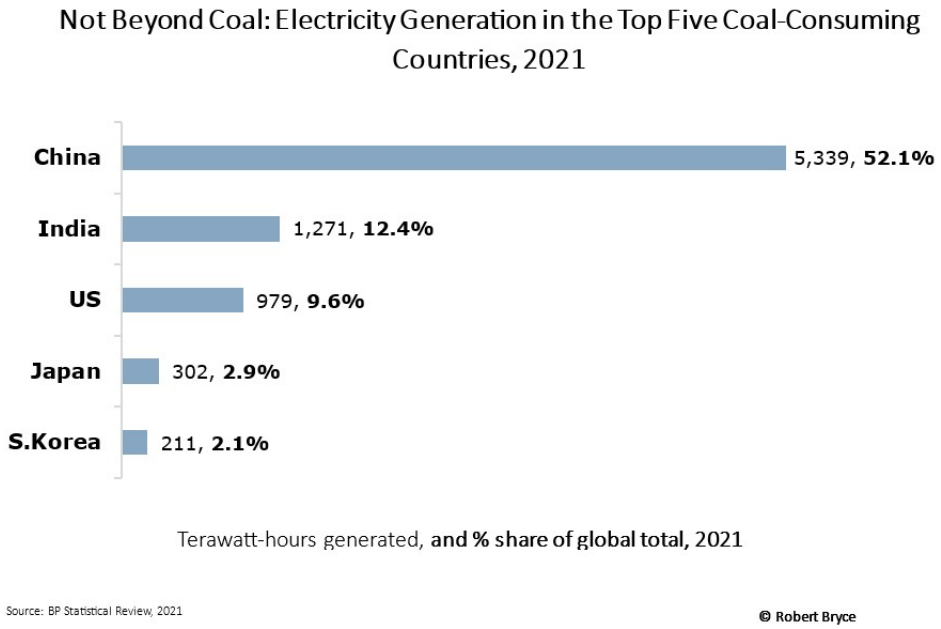
The most populous country in the Unplugged World, India, continues to embrace coal. In late 2022, the Indian government launched its biggest-ever auction for coal mining. According to an article in The Hindu Business Line, the government offered "133 blocks for auction, of which 71 are new mines and 62 are rolling over from earlier tranches of commercial auctions."[51] The auctions came just a few weeks after Power Minister Raj Kumar Singh said that India would add as much as 56 gigawatts of new coal-fired generation capacity by 2030. That would be an increase of about 25% over the country's current installed base of about 204 gigawatts of coal-fuelled generation. In explaining the move, Singh said "My bottom line is I will not compromise with my growth...Power needs to remain available."[52]

Of course, Pakistan, Bangladesh, and India are not the only countries that have turned to coal in recent years. So has Germany. In October 2022, German Chancellor Olaf Scholz announced that Germany was reopening five power plants that burn lignite, a low-rank coal. Furthermore, the country's need for lignite to keep its power plants operating was so critical that the German utility company, RWE, dismantled the Keyenberg wind project in the western part of the country to make room for the expansion of the Garzweiler coal mine. Lignite from Garzweiler fuels the Neurath C power plant, which is one of the power plants being brought back online. A spokesperson for RWE told the Guardian newspaper that "We realize this comes across as paradoxical."[53]

Paradoxical or not, the moves by these many countries provide clear evidence of the Iron Law of Electricity. The Iron Law of Electricity says people, businesses, and countries will do whatever they have to do to get the electricity they need. And that, of course, includes burning more coal.

Over the past six years, I have seen the Iron Law of Electricity at work with my own eyes. I have watched as people steal electricity in India, pay the generator mafia in Lebanon, and run small gasoline-fuelled generators in Louisiana to make sure they have the electricity they need to refrigerate their food, cook their dinner, and heat or cool their homes. The Iron Law of Electricity says that no one will willingly sit in the dark. Instead, people will find a way to get the electricity they need because energy—and electricity in particular—means life. The absence of energy means death. Those facts show why coal will not go away any time soon, particularly in Asia.

Figure 8

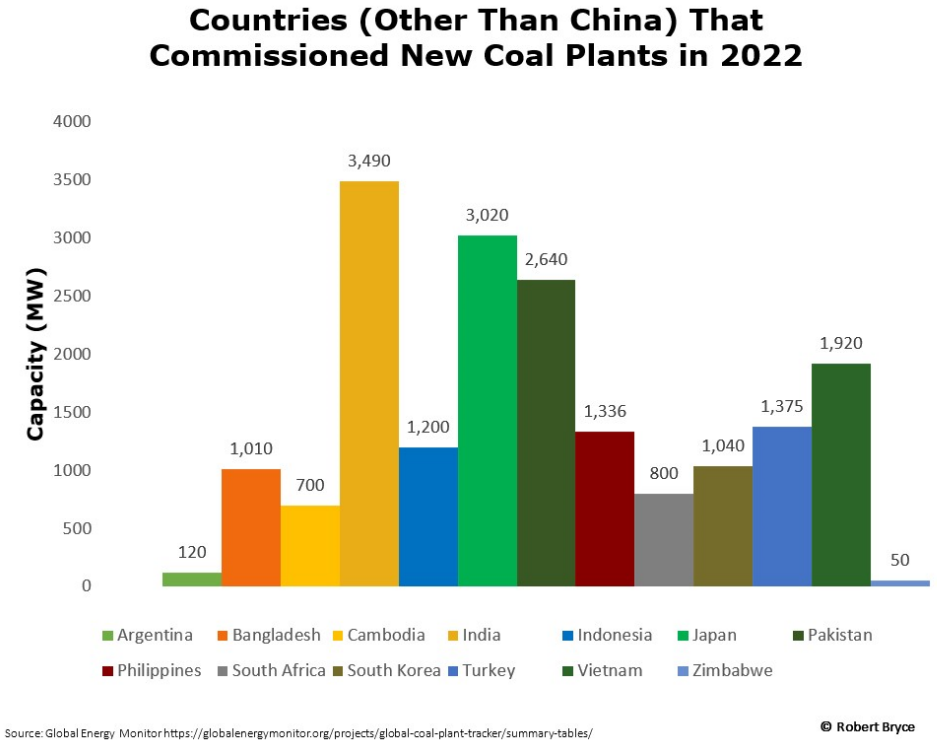


China consumes more coal (about 86 exajoules in 2021) than the rest of the world combined. China uses that coal to make steel and for industrial processes, but its biggest use is for power generation. As can be seen in the graphic above, China generated about 5,300 terawatt-hours of electricity from coal in 2021. That is about four times the amount generated by India and more than five times as much as the United States.[54]

Although China accounts for the biggest share of global coal use, other countries are also increasing their use of coal. This is even true in Japan, the home of the Kyoto Protocol. Although the Japanese government has claimed that it will achieve net zero by 2050, Japanese utilities are currently building a new 1,300-megawatt coal-fired power plant near Kurihama called Yokosuka. The plant will have two ultra-supercritical generators and will be completed in 2024.[55] Shikoku Electric Power is also building a 500-megawatt coal plant in Saijo. Like the Yokosuka plant, it will use ultra-supercritical technology, which is the most efficient way to burn coal. In addition, Japanese utilities are building eight new gas-fired power plants that will have a total capacity of 5.5 gigawatts.[56]

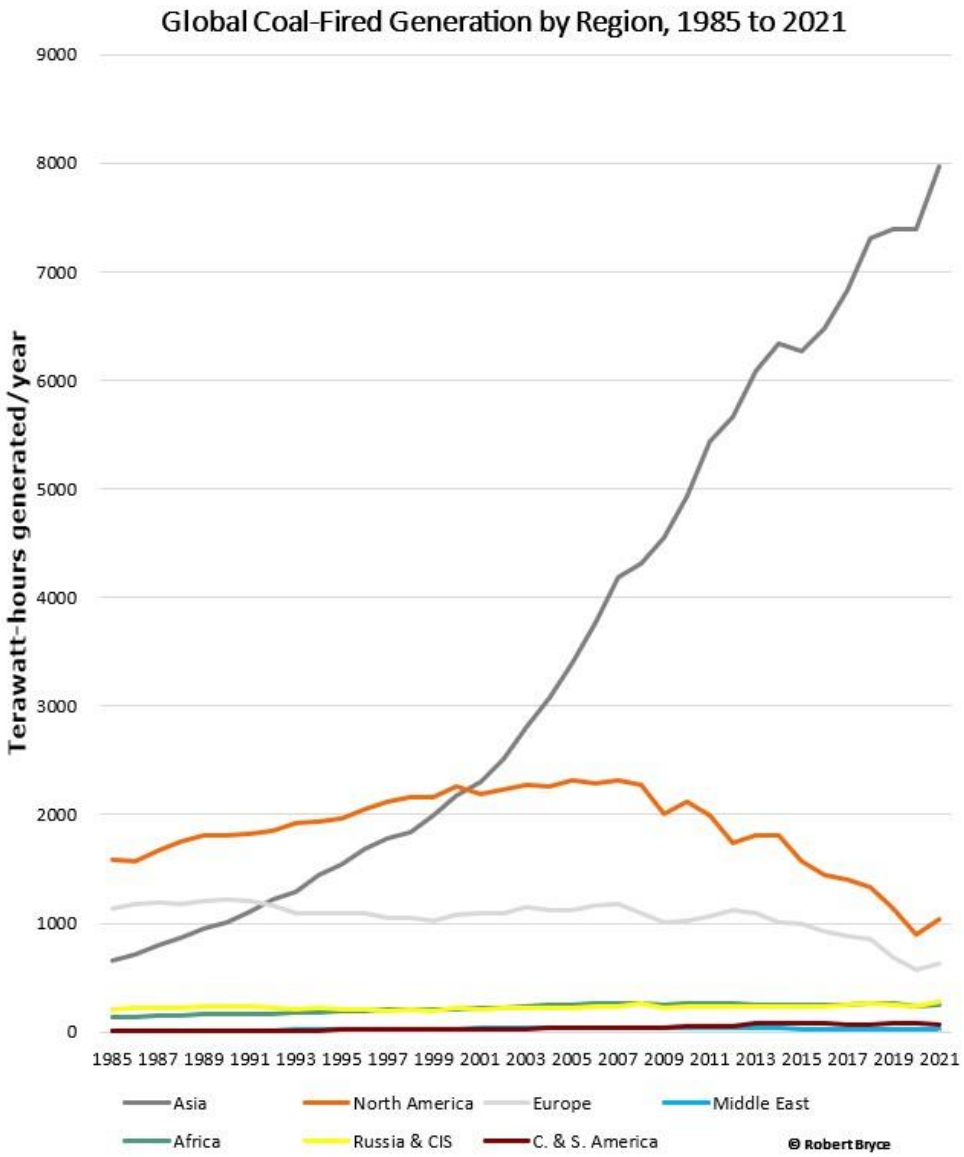
Indeed, while the growth in global coal use is slowing, it will remain a key fuel for electricity generation for decades to come. In February 2023, Global Energy Monitor reported that China permitted about two new coal-fired power plants per week in 2022. The permitted plants will have "a staggering 106 gigawatts of new coal capacity... equivalent to 100 large coal-fired power plants." The group also noted that permitted capacity quadrupled compared to 2021 and that "China has seen a rapid increase in electric peak loads...due to an increase in the prevalence of air conditioners and exceptionally intense heat waves. This is prompting an increase in coal power plant development."[57]

Figure 9



China accounted for 59% of the new coal-fired capacity that was brought online in 2022. But numerous other countries also commissioned new coal plants last year. According to Global Energy Monitor, Argentina, Bangladesh, Cambodia, India, Indonesia, Japan, Pakistan, Philippines, Turkey, Vietnam, and Zimbabwe, all brought new coal-fired capacity online in 2022. As can be seen in the graphic above, those countries brought on nearly 19 gigawatts of new coal-fired capacity. (China commissioned nearly 27 gigawatts.[58]) It should also be noted that of the 13 countries outside of China that brought on new coal-fired capacity in 2022, seven of them were in the Unplugged World.

Figure 10



As can be seen in the graphic above, coal use in North America and Europe is falling. That is not the case in Asia.[59]

It is essential to understand that industrial growth in Asia is driving much of that coal use as Western countries outsource manufacturing to China and other countries. Some of that fast growth in coal demand is occurring in Vietnam. On 14 June 2023, the Vietnam News Agency reported that the country's state-owned coal miner, Vinacomin, will boost production by 15% this year so that it can increase supplies to the country's power stations.[60] The announcement followed several weeks of rolling blackouts in Vietnam that were wreaking havoc on big manufacturers that have been flocking to the country in recent years. In a 12th June article, Reuters quoted Hong Sun, the chairman of the Korean Chamber of Commerce in Vietnam, who said, "Many factories have had to suspend production due to severe power cuts, and the cuts are regular...This is a very serious problem for South Korean companies operating in Vietnam."[61]

Despite significant investments in hydro, solar, and wind, Vietnam is now getting about 60% of its juice from coal-fired power plants. Since 2009, Vietnam's coal-fired electricity output has grown tenfold.

More growth is on the way. Last year, according to Global Energy Monitor, Vietnam commissioned about 1,900 megawatts of new coal-fired capacity. That capacity will be used to help meet soaring demand. Over the past decade, electricity generation in Vietnam has been growing by an astounding 9% per year.

On 27 May 2023, James Kennemer, a consultant who helps companies access manufacturing capacity in Asia, wrote that Vietnam will soon become the "premier location" for manufacturing "shoes, furniture, garments, and electronics...The world's largest brands are opening factories in Vietnam: Apple, Samsung, Nike, Adidas, LG, Foxconn, and others are examples of companies that have shut down Chinese factories in favour of Vietnamese factories." He continued, saying Vietnam is "open for investment with little red tape" and that more factories are moving to the country, "especially after the U.S.-China trade war escalation." He added that "big tech is moving into Vietnam...Apple recently started producing AirPods in Vietnam to cut down on import costs from China. Samsung has also moved into the country...The last few years have seen an increase of over 300% in electronics." And here was the key line: the "average cost of hiring a factory employee in Vietnam is 1/3 those in China."[62]

The trends at work are obvious: in their never-ending search for cheap labour, multinational corporations are moving manufacturing from China to Vietnam. China industrialised by burning massive amounts of coal. Now, it is Vietnam's turn.

Given the ongoing global dependence on coal-fired generation, how should policymakers be thinking of coal?

First, they should be working to assure that all coal plants are fitted with pollution-control devices to help reduce smog and air pollution. Second, they should be working to assure that all new coal plants are built with the highest possible efficiency so that grid operators are wringing the maximum amount of electricity possible from each ton of coal they burn. But recognising the ongoing need for coal only addresses part of the challenge. Bringing more poverty-stricken countries into modernity will also require overcoming the sticky problem of corruption.

Overcoming Corruption

In February 2023, while the entire country of South Africa was enduring rolling blackouts lasting eight or more hours per day, Andre de Ruyter, the outgoing CEO of Eskom, alleged that the state-owned utility was losing $50 million per month to corruption.

For years, Eskom, which supplies more than 80% of the country's electricity, has been dogged by allegations of mismanagement and corruption. But de Ruyter's claims were notable because they were made by such a high-ranking official. The timing of his claims was also significant because de Ruyter made them just a few days after South Africa's president, Cyril Ramaphosa, declared a state of disaster because of the electricity shortages, which he called an "existential threat" to the country's ailing economy. Furthermore, de Ruyter's allegations came at about the same time that South Africa's 60 million people were being warned that power cuts could be increased from 8 hours per day to 12 hours per day.

According to the Associated Press, inquiries into allegations about corruption at Eskom have implicated senior officials within the country's ruling African National Congress and former South African president, Jacob Zuma.[63]

Two months after making the allegations, de Ruyter appeared virtually from an undisclosed location for a parliamentary inquiry into corruption at Eskom. De Ruyter said he was taking extra precautions during his testimony because, according to the Associated Press, "sources who had provided him with information had expressed fears for their safety." De Ruyter himself told the investigators that the "criminal and unlawful activities that are currently under investigation are of a very sensitive and complex nature and they involve elements that are best characterized as organized crime."[64]

The problems in South Africa's electric sector are all too common in developing countries. Nigeria, an oil-rich country where per capita electricity use is just 147 kilowatt-hours per year, provides another unfortunate example of the corruption that is stifling electrification.

In 2021, Nigeria's "The Guardian" newspaper carried an article headlined, "Corruption is Nigeria's power sector demon." The article, written by Zuhumnan Dapel, a researcher at the Scottish Institute for Research in Economics, said "Nigeria is home to over 200 million people, yet 85 million of its inhabitants live without access to grid electricity. To put this into perspective, the country has installed electricity capacity at the same level as Edinburgh, the capital of Scotland, and a city of roughly half a million people. Why does Nigeria, which has almost 400 times more people than Scotland's second-largest city, have such low levels of electricity access that claim its title as 'the world's most underpowered country.'" Dapel continued, noting that electricity shortages are so bad that:

> "…approximately 60% of businesses in the country own and use electric generators (self-generating 59% of their total energy need, which is three times more expensive than from the public grid). Moreover, Nigerians spent $13 billion per year buying gasoline and diesel to power their generators, thereby constituting a huge dent in the nation's foreign exchange and consequently balance of payments. To close its energy gap and to meet the growing demand of its bulging population size (over 400 million by 2045), Nigeria would need an installed capacity of 213 [gigawatts], that is, raising the current capacity by more than 1500%. According to estimates, this will require a yearly infusion of cash of up to $10 billion over a decade."[65]

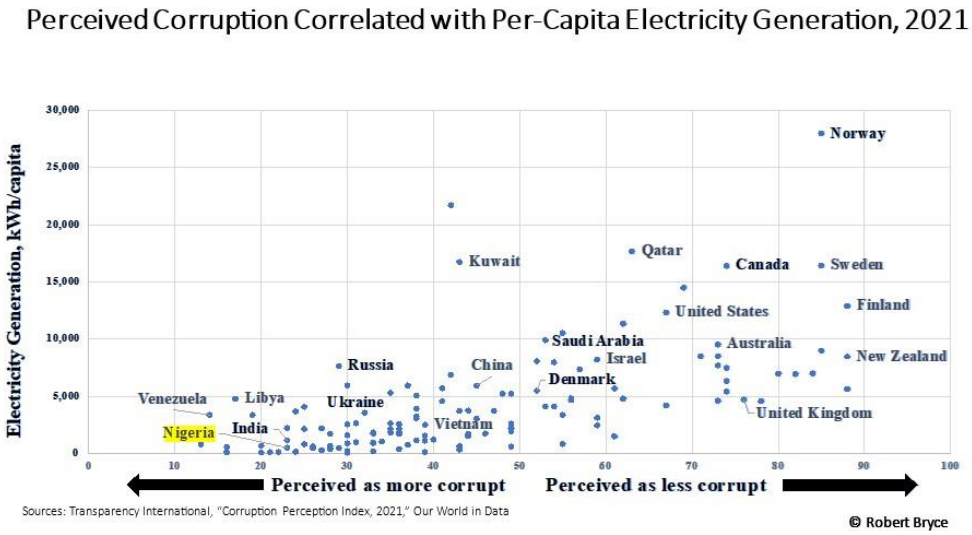
Nigeria's electric sector suffers from a lack of cash because many customers simply do not pay their bills. But ultimately, contends Dapel: "Corruption is the power sector demon. It heavily bleeds government investments in energy and stifles efforts that are designed to boost the availability of electricity in the country. Until this monster is vanquished—regardless of how much cash and expertise are infused into the sector—many Nigerians will remain in darkness."

Over the past decades, untold billions of dollars have been spent on Nigeria's electric grid. But the country, which ranks 150th out of 180 countries in Transparency International's 2022 Corruption Perception Index, has made little progress in increasing the amount of electricity it supplies via the national grid.[66]

How might Nigeria reduce the corruption that is crippling its electric grid? Dapel said that since "government intervention creates corruption avenues, rents for bureaucrats, and misallocation of resources, full privatization of the power sector might be one of the ways out of the problem." He continued, "In any case, Nigeria must find a way out of this situation if it must extricate itself from the iron grip of energy poverty."[67]

The electricity shortages in South Africa, Nigeria, and other countries that are wracked by corruption prove a simple truism: Theft is the enemy of light. And unfortunately, in many developing countries, endemic corruption is slowing, or even stopping, electrification efforts.

Figure 11



Transparency International's Corruption Perceptions Index provides a handy way to correlate corruption and electricity availability. In the graphic above, I matched per capita electricity generation numbers with the 180 countries on Transparency International's Corruption Perceptions Index. As can easily be seen, the countries that are perceived as more corrupt are producing far less electricity than those that are perceived as being less corrupt.

Understanding why corrupt societies cannot produce as much power for their people can be understood by remembering that electric grids run on fuels like coal, natural gas, uranium, solar, wind, or refined petroleum products, but the commodity that keeps grids running is money.

Successful electric grids require three things: capital, integrity, and fuel. Of those, integrity is the most important. In societies where corruption reigns, electric grids simply do not work well. The reason for that is simple: grids need constant infusions of cash and if the cash is not available, they eventually degrade and quit working. Constant infusions of money are needed to make sure that the electric system's generators are maintained, that the generators have enough fuel, and that the poles, wires, and transformers needed to deliver electricity to customers are in good condition.

Electric grids are like buckets. If they leak too much, they become useless. Successful electric grids keep leakage to a minimum. Leakage—whether it is political leaders taking kickbacks from suppliers, company insiders stealing cash from the grid operator, or marijuana growers who have illegally tapped a distribution line to reduce their electricity costs—theft must be kept to manageable levels. Put yet another way, for an electric grid to work and work well, there must be some *esprit de grid*. That is, the people who operate the grid, as well as the people who rely on it, need to have some sense of responsibility for it.

Understanding why integrity is so critical only requires a look at the overhead electric wires in your neighbourhood or city. Keeping electricity flowing to consumers requires putting enormous amounts of wire in the air, and in densely populated areas, safely underground. That wire—along with the necessary number of poles, towers, and insulators— must be kept in the air, no matter the weather.

Keeping those transmission and distribution wires high enough in the air to keep the wire safe from people—and people safe from the wire—is no small feat. It requires trucks, wire, rigging, slings, cranes, ladders, protective clothing, insulated tools, and lots of skilled workers who are ready and willing to go out in all kinds of weather at every hour of the day or night to keep the electricity flowing. But if a distribution line or transformer cannot be fixed because someone stole the bucket truck, or maybe just

the battery from the bucket truck, then electricity reliability in a given area will necessarily decline. Electricity use will cease until the wire or transformer can be repaired.

In short, electric grids have to pay for themselves. So how can policymakers and international lenders help reduce public corruption? One answer is greater transparency in the deals that are being negotiated. Another is the increased use of microgrids. Let's take those in order.

Promote Price Disclosure

In 2003, a group of energy industry officials met with non-governmental organisations ("NGOs") and investors and agreed to the Extractive Industry Transparency Initiative ("EITI") Principles. Those principles, which have since been widely adopted, were designed to assure that the wealth of countries that are rich in natural resources should have open and transparent disclosure to reduce the potential for graft. Countries that join the Extractive Industry Transparency Initiative:

> "Commit to disclose information along the extractive industry value chain—from how extraction rights are awarded, to how revenues make their way through government and how they benefit the public. Through participation in the EITI, more than 50 countries have agreed to a common set of rules governing what has to be disclosed and when—the EITI Standard.
>
> As the energy transition gains traction, it will have a transformative impact on the extractive industries and global economy. The EITI Standard can play a role in building awareness of how the transition will affect extractive sector activities and revenues and in supporting the responsible and transparent production of minerals that are critical for a sustainable future. The EITI provides data that can help identify and close channels for corruption—not only in mining, oil and gas but increasingly in the renewables sector."[68]

The Energy for Growth Hub, a Washington-based NGO, is using the EITI as a blueprint for a similar effort in the electric sector. Energy for Growth Hub has begun an initiative called PPA Watch, the goal of which is to make power purchase agreements ("PPAs") in developing countries more transparent. The group explains that "In emerging markets, PPAs are typically negotiated, signed, and implemented behind closed doors. Greater PPA disclosure will improve governance, attract sustainable investment, and ultimately expand clean power while providing citizens with reliable, lower-cost electricity." The move for more transparency, will, PPA Watch says, "harness open competition to support the efforts of policymakers and planners, investors, and development finance institutions to accelerate energy access and market development."[69]

PPA Watch has also begun publishing transparency scores for developing countries, ranking them as transparent, partly transparent, or not transparent. Todd Moss, the executive director of Energy for Growth Hub, said that negotiating and signing electricity supply contracts "invites all kinds of nonsense. Any time you have a secret price, by definition you aren't getting the best price. We want to see open competitive procurement and the market should be transparent." He continued, explaining that when electricity contracts are awarded in a competitive market, the "incentives are for everyone to behave themselves."[70]

Embrace Microgrids and the "Generator Mafia"

In Lebanon, nearly everyone pays two electric bills: One to Electricité du Liban ("EdL") the state-owned utility, and the other to the "generator mafia." The reason for this arrangement is simple: EdL cannot provide reliable electricity. A taxi driver in Beirut explained in stark terms during an interview with me in 2016. In his Beirut neighbourhood, Harit Herik, EdL was only providing electricity for "six hours. Seven hours, maximum. The rest of the hours, we pay for the generator."

The generator mafia thrives in Lebanon because of the ongoing economic and political disarray in the country. Indeed, the generator mafia provides a stark illustration of the fact that people will do whatever they have to do to get the electricity they need. If the government cannot provide reliable electricity, someone else will; and for the people who need electricity, concerns about cost, air pollution, and climate change take a back seat to their need for power.

Understanding how the generator mafia became integral to everyday life in Lebanon requires understanding its history. Lebanon is a war-torn cocktail of religious, political, and geographic alliances. It has 18 officially recognised religious groups, including four Muslim sects and 12 Christian ones. About 27% of the population is Sunni Muslim, 27% is Shia, and 21% are Maronite Christians. Greek Orthodox make up 8% of the population and Druze about 5%, with the remainder of the populace split among Mormons, Jews, Catholics, and other sects. Making things more complicated is the 1943 agreement known as the "National Pact." Under that arrangement, Lebanon's president must be a Maronite, the prime minister must be Sunni, and the speaker of parliament must be Shia.[71]

Lebanon's political-religious-military Rubik's Cube has been further complicated by the flood of refugees fleeing the war in Syria. Those refugees are putting additional strain on Lebanon's overtaxed power grid, which was already threadbare due to repeated conflicts with its neighbours. And while Lebanon's deadly civil war, which raged from 1975 to 1990, is officially over, the country continues to be paralysed by its hyper-factionalised and deeply corrupt politics. A friend of mine, I will call him Khaled, has lived in Beirut for many years. He has a doctorate in economics and has worked for the Lebanese government, as well as for private consulting firms and big international lenders. He described Lebanon as: "A failed state dominated by populism, sectarianism, nepotism, and fascism."

The lack of integrity in Lebanon's political system prevents improvements to the country's electric grid, which in turn, imposes an energy tax that is felt across the entire Lebanese economy. A 2016 analysis by Elie Bouri and Joseph El Assad, two academics at Holy Spirit University of Kaslik, found that blackouts are costing the Lebanese economy about $3.9 billion per year, or roughly 8.2% of the country's GDP.[72]

While that name—generator mafia—has a negative connotation, some analysts see microgrids, and the people that operate them, as necessary providers of a critical service. Riad Chedid, an engineering professor at the American University of Beirut, one of the most prestigious universities in the Middle East, told me that the generator mafia is getting a bad rap. "I don't like to call these 'mafias,'" he said. "I would say these are companies or businessmen that were created by necessity. If the government was giving or EdL, or if the national utility was supplying electricity reliably 24 hours, these wouldn't have existed." He went on, "My parents live in a village and I know without those generators, life would've been much, much more difficult. So to me, this is a party that's providing a service, a very costly service, but nobody is obliging you to buy it. You don't want it, don't get it."

One official at a multilateral lender who has lived in Lebanon for many years, agreed with Chedid's assessment. He explained that while small electric grids are not optimal from a financial or operational point of view, (bigger grids are usually more efficient due to economies of scale) "if there's a lack of trust, then you have to shrink the system."

That concept—shrinking the system—makes sense from an operational standpoint. If countries like Nigeria and Lebanon cannot make their national grids work, then it stands to reason that operators have to make electric grids smaller until the integrity of their systems can be assured.

A 2020 paper by Pallavi Roy of the SOAS University of London's Anti-Corruption Evidence research consortium, concluded that due to corruption and inefficiencies in Nigeria's main power grid, "off-grid solutions are imperative." Roy continued, writing that microgrids operated by small to medium enterprises, or "SMEs",

> "…are potentially productive and are likely to play a critical role in sustaining growth and employment in Nigeria...we recommend an anti-corruption solution of disaggregated and embedded generation that is less expensive than the costs currently incurred to source electricity informally, while providing adequate electricity supply. The likelihood of insider support should also ensure that the policy is self-sustaining and therefore self-enforcing."[73]

In 2023, Roy, and three other researchers published an article in the journal *Energy Research and Social Science*, which again looked at Nigeria's electric sector. The article expanded on Roy's 2020 research. The authors pointed out that despite the privatisation of Nigeria's distribution and generation companies, the amount of available peak power did not expand, and instead, it "remained relatively stagnant below 5,000 megawatts from 2015 to 2022." They also found that Nigeria's electric grid:

> "…requires significant capital infusion to overhaul the efficiency parameters of the grid from gas supply to distribution as well as debt restructuring to improve the liquidity situation in the sector and attract investors. In the short term, a strategy is needed to identify solutions outside the national grid via investors who are willing to explore off-grid solutions. Our search for an anti-corruption strategy is a bottom-up approach to identify feasible and implementable solutions that work within the constraints of the sector's distribution of power. Our policy solution is to provide disaggregated, independent-but-embedded power-generating networks, often referred to as mini grids...Mini grids are electric power generation and distribution systems that can be isolated from the main grid and designed to provide high-quality, reliable electricity."[74]

These microgrids (or mini grids) would be operated by SMEs. And the hope is that they might eventually be fuelled by natural gas, a fuel that Nigeria has in abundance.[75] But due to lack of infrastructure, that is unlikely to happen in the near term. Instead, the generators will likely burn diesel or fuel oil, both of which emit far more CO_2 and particulates than natural gas.

While microgrids may offer an alternative to larger grids, they also come with significant downsides including environmental and economic concerns. The neighbourhood power plants in Beirut are causing serious air pollution problems.[76] And because many of these SMEs are unregulated, there is little chance that government officials will be able to impose rules that will address the pollution. In addition, the lack of regulation means that SMEs can charge exorbitant rates for the power they deliver. The SMEs will also be able to cut off customers at their whim, with no recourse. Finally, these smaller grids are usually less efficient, in both capital cost and energy efficiency, than their larger counterparts.

In short, microgrids are not a perfect alternative to centralised power grids. But for countries (and neighbourhoods) that are stuck in the dark, they may provide a viable alternative. They present a relatively low-cost and lower-risk opportunity for international investors and lenders to help in the electrification of developing countries. Microgrids can be deployed in stages and as the concept gets

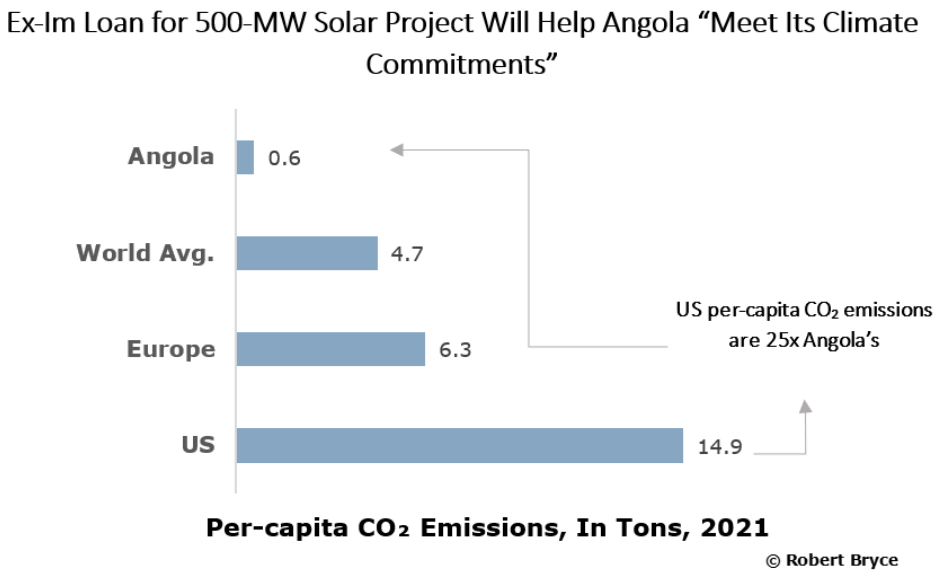
proven, it can gradually be expanded. Furthermore, microgrids allow flexibility in both fuel choice and generation technology.

In some cases, the microgrids might use solar and batteries. In others, they might use large reciprocating engines fuelled by diesel, fuel oil, or natural gas. Other grids may use turbines running on liquid fuel or natural gas.

Put electrification Goals First, Emissions Reductions Second

In June 2023, during a speech to the League of Conservation Voters, a Washington, DC-based NGO that focuses on climate change, US President Joe Biden proudly announced a $900 million loan to help build a 500-megawatt solar project in Angola. In a press release touting the deal, the Export-Import Bank of the United States said the project would "help Angola meet its climate commitments."[77]

Figure 12



Of course, financing any electrification project is a good thing. But Angola is one of the last countries in the world that needs to be concerned about climate commitments. In 2021, the average resident of Angola emitted about 0.6 tons of CO_2 per year. By comparison, the per capita global average was about 5 tons and in the United States it was nearly 15 tons. Indeed, it is more than a little ironic for an American president to be boasting about a solar project in Angola when the average American emits 25 times more CO_2 per year than the average Angolan.

Furthermore, in 2021, the average resident of Angola was consuming just 476 kilowatt-hours of electricity per year, or about the same amount as is used by the inhabitants of Bangladesh. Indeed, countries like Bangladesh and Angola need big power plants like the ones that produce electricity in Europe and the United States—plants that can produce large amounts of reliable, baseload power by burning coal, oil, or natural gas.

Unfortunately, the United States and many other Western countries will not provide financing for electricity generation projects that burn hydrocarbons. Why not? They are putting concerns about climate change ahead of people.

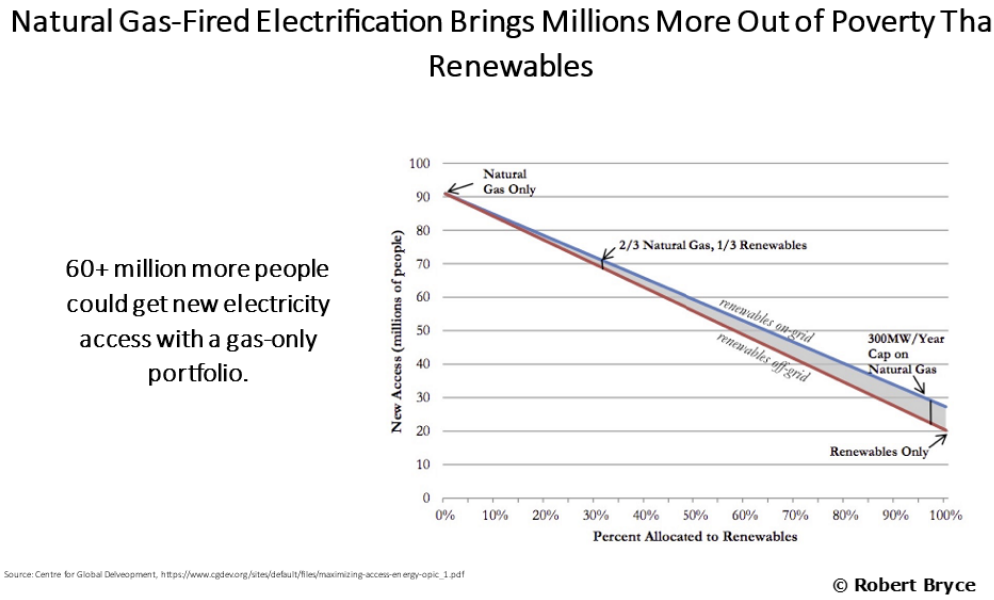
For years, bilateral and multilateral lenders have been under pressure to quit providing loans for such projects. In 2013, several groups, including Friends of the Earth, Greenpeace USA, and the Center for Biological Diversity, sent a letter to US President Barack Obama which said the proposed Thai Binh Two power plant, a 1,200-megawatt coal-fired facility in northern Vietnam, would "emit unacceptable air pollution that will worsen climate disruption." A few days after the letter was sent, the US Import-Export Bank announced it would halt its financing for the project.[78] That announcement came at about the same time the World Bank declared that it would limit financing of coal-fired generation projects to "rare circumstances."[79] In 2018, World Bank president Jim Yong Kim announced that the bank had abandoned the last coal project on its books, the Kosova e Re plant in Kosovo and would not support any more such projects.[80]

In 2021, during the United Nations Climate Change Conference (commonly known as COP 26) in Glasgow, the United States joined a group of about 20 countries that agreed to stop funding oil and gas projects in developing countries. As explained by one news outlet, the move

> "...could take billions of dollars away from future fossil fuel production and redistribute it to low-carbon energy projects such as wind and solar. The agreement covers 'unabated' projects, which generally refers to fossil fuel facilities that do not capture carbon dioxide emissions...The announcement goes beyond a separate agreement by the world's largest economies last weekend to end public financing for international coal power development."[81]

Also in 2021, the US Treasury Department issued guidance for multilateral development banks "aimed at squeezing off fossil fuel financing except in certain circumstances."[82]

Figure 13



But only lending for renewables reduces the amount of available funds to build other electricity infrastructure, and it, intentionally or not, reduces the amount of electricity that will be available to

developing countries. A 2014 study by the Center for Global Development found that "more than 60 million additional people in poor nations could gain access to electricity" if bilateral lenders like the Overseas Private Investment Corporation (now known as the International Development Finance Corporation) were allowed to invest in electrification projects that rely on natural gas instead of only being allowed to finance renewable projects. The authors of the study estimated the amount of generation capacity that would be built under an investment portfolio of $10 billion. They found that:

> "A natural gas–only portfolio could provide an additional 42,000 [megawatts] of electricity versus 4,200 MW in a renewables-only portfolio. Thus, we estimate that about 38,000 MW of generation is at stake. This is equivalent to about three times the entire installed capacity of all six countries that were included in President Obama's Power Africa initiative."[83]

Even if we assume that the authors of the study overestimated their findings by half, a gas-only portfolio would still provide 21,000 megawatts of electric generation capacity, or nearly five times the amount that would be available under a renewables-only scenario. For a continent like Africa that is desperate for electricity, that is a huge difference, and one that cannot be ignored. The lesson from the 2014 study is obvious: policymakers should be prioritising access to electricity, not emissions reductions. Preventing developing countries from using hydrocarbons is what Vijaya Ramachandran, an economist who works for the Breakthrough Institute calls "green colonialism."[84]

In 2022, the *Wall Street Journal* published an article by Uganda's President Yoweri K. Museveni titled, "Solar and Wind Force Poverty on Africa." In the article, Museveni wrote, "Africa can't sacrifice its future prosperity for Western climate goals. Africa will have to use fossil fuels as it makes the transition." He said that the "Western aid-industrial complex, composed of nongovernmental organizations and state development agencies, has poured money into wind and solar projects across the continent. This earns them praise in the US and Europe but leaves many Africans with unreliable and expensive electricity that depends on diesel generators or batteries on overcast or still days." Museveni concluded: "Africans have a right to use reliable, cheap energy, and doing so does not prevent the development of the continent's renewables. Forcing Africa down one route will hinder our fight against poverty."[85]

The way forward for policymakers is obvious: the first priority should be providing access to cheap, abundant, and reliable electricity. Concerns about emissions should come second.

Conclusion

Solving the global electricity challenge—bringing the 3.7 billion people now living in the Unplugged World—into modernity is among the biggest challenges of the modern era. There are no quick fixes. It will not be easy. And it will not be cheap.

The electrification of the developed countries has taken decades. Thus, it is reasonable to expect that the electrification of developing countries will take many years. Furthermore, each country will have to decide for itself the types of fuels and generators that will provide the most bang for the buck.

As outlined above, several policies can help accelerate electrification. They include:

- Understanding that if coal plants are built, they should be constructed with the best air pollution and efficiency technologies.
- Increasing transparency and disclosure on power purchase agreements.

- Supporting efforts to reduce corruption.
- Expanding microgrids as a way to accelerate electrification.
- Putting electrification ahead of concerns about emissions.

Bringing power to the unplugged is among the greatest challenges of our time. Darkness kills human potential. Electricity nourishes it. This point was made eloquently by Joyashree Roy, an Indian economist who was also a contributor to the IPCC reports on climate change. Roy has spoken about electricity in terms that verge on the evangelical. With electricity, she says that humans can engage in "co-creation with nature." But none of that creating—none of that God-likeness—happens without electricity. "If you are in the dark, if you are absorbed in the dark, darkness absorbs you, too," Joyashree said. "So you do not see the light and you cannot bring the light to others."[86]

It is time to bring more light to more people. Implementing measures that will help achieve that goal should be a top priority for policymakers all over the world.

Appendix

Countries Ranked By Per Capita Electricity Use, 2021

Country	Population	Per capita electricity use, kWh
UNPLUGGED		
Bermuda	64,213	n/a
French Guiana	297,462	n/a
Gibraltar	32,698	n/a
Guadeloupe	396,057	n/a
Martinique	368,799	n/a
Niue	1,957	n/a
Saint Helena	5,428	n/a
Western Sahara	565,590	n/a
Niger	25,252,722	18
Chad	17,179,744	18
Benin	12,996,901	18
Afghanistan	40,099,460	21
Somalia	17,065,588	24
Sierra Leone	8,420,642	25
Central African Republic	5,457,165	27
Burundi	12,551,215	29
Guinea-Bissau	2,060,730	39
South Sudan	10,748,278	53
Djibouti	1,105,562	54
Rwanda	13,461,891	63
Malawi	19,889,742	71
Madagascar	28,915,652	72
Togo	8,644,829	73
Burkina Faso	22,100,690	79
Haiti	11,447,575	86
Uganda	45,853,780	96
Yemen	32,981,644	107
Gambia	2,639,922	114
Democratic Republic of Congo	95,894,120	115
Ethiopia	120,283,020	122
Eritrea	3,620,324	124
Tanzania	63,588,332	128
Nigeria	213,401,330	147
Mali	21,904,990	155
Solomon Islands	707,855	155
Palestine	5,133,393	168

Comoros	821,632	170
Liberia	5,193,422	177
Nepal	30,034,988	204
Guinea	13,531,909	205
Lesotho	2,281,464	219
Vanuatu	319,146	219
Kenya	53,005,616	223
Kiribati	128,883	233
Cameroon	27,198,632	296
Senegal	16,876,726	332
Sudan	45,657,204	363
Cote d'Ivoire	27,478,250	400
Timor	1,320,944	401
Mauritania	4,614,981	407
Myanmar	53,798,090	416
Sao Tome and Principe	223,118	448
Bangladesh	169,356,240	476
Angola	34,503,776	476
Papua New Guinea	9,949,438	488
Zimbabwe	15,993,525	503
Cambodia	16,589,031	524
North Korea	25,971,910	556
Namibia	2,530,150	621
Eswatini	1,192,273	621
Mozambique	32,077,074	621
Ghana	32,833,036	638
Pakistan	231,402,110	649
Nicaragua	6,850,546	676
Congo	5,835,814	689
Sri Lanka	21,773,438	751
Tonga	106,034	754
Cape Verde	587,936	765
Samoa	218,781	777
Syria	21,324,366	786
Guatemala	17,608,484	820
Botswana	2,588,424	846
Macao	686,616	859
Equatorial Guinea	1,634,473	869
Bolivia	12,079,474	877
Zambia	19,473,132	909
Philippines	113,880,340	950
Gabon	2,341,185	978
El Salvador	6,314,165	1,039

Morocco	37,076,588	1,114
Indonesia	273,753,180	1,129
Honduras	10,278,346	1,165
India	1,407,563,900	1,218
Unplugged World (83 countries)	**3,681,998,090**	
Average consumption, kWh/capita		**374**

LOW WATT

Fiji	924,615	1,222
Maldives	521,469	1,266
Lithuania	2,786,652	1,496
Guyana	804,571	1,529
Saint Vincent and the Grenadines	104,340	1,533
Jamaica	2,827,701	1,538
Colombia	51,516,560	1,571
Dominican Republic	11,117,873	1,581
Belize	400,037	1,600
Grenada	124,624	1,685
Tunisia	12,262,949	1,707
Peru	33,715,464	1,724
Uzbekistan	34,081,452	1,737
Cuba	11,256,373	1,755
Algeria	44,177,964	1,755
Ecuador	17,797,736	1,817
Egypt	109,262,184	1,851
North Macedonia	2,103,329	1,883
Saint Lucia	179,663	1,948
Jordan	11,148,288	1,963
Tajikistan	9,750,078	2,024
Mongolia	3,347,782	2,127
Moldova	3,061,509	2,175
Kyrgyzstan	6,527,742	2,217
Mauritius	1,298,922	2,217
Iraq	43,533,590	2,234
Montserrat	4,438	2,253
French Polynesia	304,038	2,302
Dominica	72,435	2,347
Costa Rica	5,153,959	2,466
Vietnam	97,468,024	2,511
Azerbaijan	10,312,992	2,549
Panama	4,351,264	2,572
Thailand	71,601,100	2,610
Armenia	2,790,971	2,623

Mexico	126,705,140	2,659
Cook Islands	17,028	2,936
Romania	19,328,558	3,059
Brazil	214,326,220	3,091
Latvia	1,873,926	3,122
Nauru	12,533	3,192
Argentina	45,276,788	3,240
Suriname	612,989	3,295
Venezuela	28,199,862	3,360
Georgia	3,757,984	3,364
Turkmenistan	6,341,850	3,374
American Samoa	45,056	3,551
Ukraine	43,531,424	3,577
Lebanon	5,592,626	3,678
Hungary	9,709,784	3,703
Croatia	4,060,139	3,724
South Africa	59,392,256	3,758
Barbados	281,204	3,805
Turkey	84,775,410	3,908
Iran	87,923,430	4,070
Low-Watt World (55 countries)	**1,348,456,895**	
Average consumption, kWh/capita		**2,488**

HIGH WATT

Cyprus	1,244,193	4,115
Malta	526,751	4,120
Chile	19,493,184	4,181
British Virgin Islands	31,145	4,495
United Kingdom	67,281,040	4,565
Belarus	9,578,172	4,580
Uruguay	3,426,265	4,617
Saint Kitts and Nevis	47,631	4,619
Poland	38,307,724	4,667
Hong Kong	7,494,580	4,703
Libya	6,735,280	4,754
Portugal	10,290,109	4,805
Italy	59,240,336	4,834
Serbia	7,296,771	5,083
Bahamas	407,920	5,197
Greece	10,445,368	5,232
Malaysia	33,573,870	5,233
Falkland Islands	3,786	5,283
Bosnia and Herzegovina	3,270,948	5,313
Laos	7,425,055	5,383

Estonia	1,328,704	5,411
Slovakia	5,447,621	5,498
Puerto Rico	3,256,030	5,602
Denmark	5,854,246	5,647
Spain	47,486,932	5,703
Trinidad and Tobago	1,525,671	5,722
Kazakhstan	19,196,468	5,947
China	1,425,893,500	5,950
Paraguay	6,703,802	5,970
Turks and Caicos Islands	45,141	5,981
Montenegro	627,856	6,068
Seychelles	106,486	6,104
Ireland	4,986,525	6,337
Oceania	44,491,724	6,812
Bulgaria	6,885,864	6,869
Netherlands	17,501,696	6,948
Germany	83,408,560	6,981
Switzerland	8,691,409	6,986
United States Virgin Islands	100,100	6,993
Slovenia	2,119,408	7,356
Austria	8,922,086	7,504
Russia	145,102,750	7,652
Japan	124,612,530	7,692
Faeroe Islands	52,915	7,937
Czechia	10,510,748	7,966
Oman	4,520,474	8,088
Israel	8,900,057	8,211
New Zealand	5,129,730	8,464
Saint Pierre and Miquelon	5,905	8,467
Belgium	11,611,416	8,529
France	64,531,450	8,529
Aruba	106,543	8,729
Singapore	5,941,063	9,002
Australia	25,921,094	9,531
Saudi Arabia	35,950,396	9,920
Brunei	445,382	10,530
Greenland	56,266	10,664
Guam	170,546	10,672
Cayman Islands	68,157	10,711
South Korea	51,830,136	11,355
Bhutan	777,500	11,576
New Caledonia	287,809	11,674
Taiwan	23,859,904	12,060

United States	336,997,630	12,321
Finland	5,535,982	12,923
United Arab Emirates	9,365,149	14,482
Canada	38,155,012	16,405
Sweden	10,467,095	16,410
Kuwait	4,250,111	16,757
Qatar	2,688,239	17,670
Bahrain	1,463,266	21,705
Norway	5,403,021	27,977
Iceland	370,338	52,980
High-Watt World (73 countries)	**2,915,788,571**	
Average consumption, kWh/capita		**8,846**

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ISBN: 978-1-916948-16-7

www.arc-research.org

October 2023