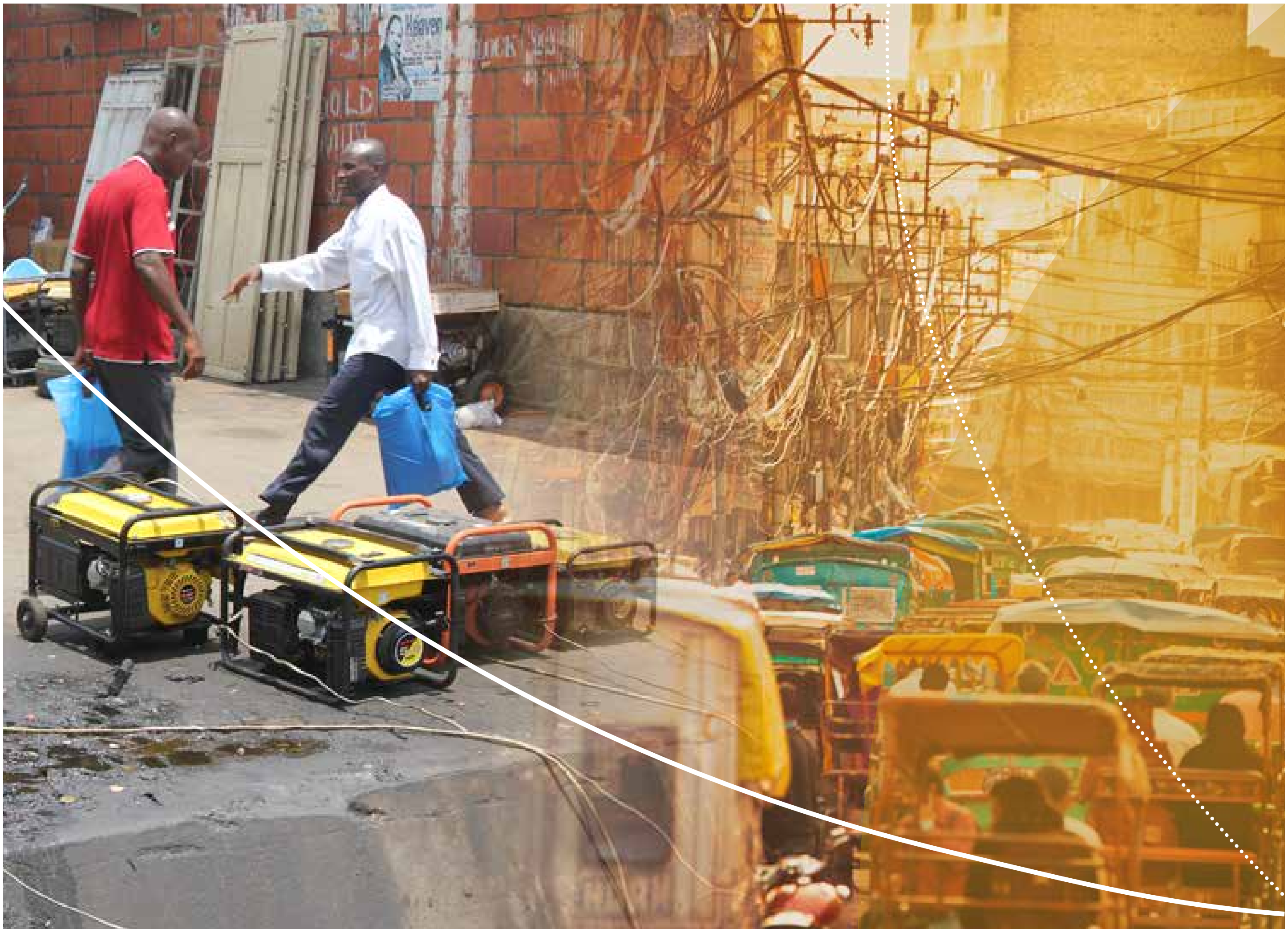

The Dirty Footprint of the Broken Grid

The Impacts of Fossil Fuel Back-up Generators in Developing Countries

IFC International Finance Corporation
WORLD BANK GROUP

Creating Markets, Creating Opportunities

FORWARD AND ACKNOWLEDGEMENTS

The following is a summary of preliminary research to model the global fleet of back-up fossil fuel generators. It is part of IFC's emerging work to support solar and energy storage solutions that can provide reliable, sustainable, affordable energy to people and businesses relying on fossil fuel generators.

The research findings include estimates of fleet size, composition, energy service, fuel consumption, and resulting financial costs and pollutant output (pollutant emissions) as an indicator for health and climate impacts. Our modeling focused on understanding global and regional trends to help clarify the overall footprint and related opportunity for alternative solutions. It applied a broad geographic scope including 167 developing countries (excluding China).

We limited our view to this scope and did not account for non-fuel maintenance costs, nor estimate the value of lost productivity from generator downtime and management, or costs passed onto customers from enterprises reliant on generators for day to day operations. We only present the part of the picture that we felt we could reasonably estimate with available data from multiple sources. We rely on official import/export data, and therefore do not account for generators imported unofficially or produced locally. The available date for generator performance typically comes from laboratory testing, which would likely underestimate fuel use and emissions for generators in use on the ground. Overall, the estimates presented in this summary are conservative, we believe significantly so.

This is the foundation piece of an open source resource that we hope becomes a broader collaborative effort at producing and sharing data. Because of our global focus and standardized approach to modeling, the specific results should be treated as a starting point for further research, rather than a final result. Focused work in national and local markets will be crucial to follow through on this first effort.

This is the impressionistic painting. We hope it leads to a more detailed and fuller picture.

We would like to acknowledge and thank our research partner, the Schatz Energy Research Center at Humboldt State University with whom this work would not have been possible. This research and IFC's engagement in this area will be further developed in partnership with the IKEA Foundation, Netherlands Ministry of Foreign Affairs and the Italian Ministry of Environment, Land and Sea.

BACKGROUND: THE PROBLEM

Access to reliable electricity is fundamental to economic growth, improvements in health and livelihoods, and the development of societies. Around the world nearly one billion people are still living without any access to electricity, and of those with access, an estimated 840 million more live with unreliable and intermittent service from electric grids that are essentially broken.

In areas where the grid is broken, frequent blackouts can stretch for hours, sometimes days on end, leaving homes and businesses in the dark. For decades, energy sector issues have prevented electric utilities from delivering reliable and steady service to many cities, townships, and villages, resulting in a seemingly intractable grid reliability deficit across much of Asia and Africa. The structural challenges underlying these conditions are varied, including low population density, underinvestment in infrastructure to meet demand, mismatch between costs and customers' ability to pay, financial pressures on utilities, and general mismanagement.[1] Communities are left to cope with the outcomes.

1. Banerjee, S. G. & Pargal, S. More power to India: the challenge of electricity distribution. 1–255 (The World Bank, 2014)., Trimble, C. P. et al. Financial viability of electricity sectors in Sub-Saharan Africa. 1–105 (The World Bank, 2016).

A Failed Solution: Fossil Fuel Generators

Responding to decades of unrealized promises, tens of millions of people have turned to fossil fuel back-up generators as a stopgap measure for their unreliable grid connection at homes and businesses. Many of these generators were originally designed to deliver only emergency and temporary relief from grid failure but often serve as primary and often exclusive sources of power. While generators are a pathway to accessing electricity, they offer only a problematic, intermediate solution: The cost of operations is often double or more that of grid electricity; the rumble of engines fills neighborhoods and cities with noise pollution; the exhaust is foul smelling and hazardous to health and the environment; and the time and effort required to install, fuel, and maintain generators imposes significant additional costs to those that depend on them. Despite these drawbacks, generators are now commonplace and dispersed across the Americas, Africa and Asia, and used for thousands of hours per year in places with the worst grid reliability. Until now they have been the best bad option available. As solar and storage technologies have matured, they have emerged as viable and proven alternatives to fuel generators. They offer reliable, clean, and quiet electricity services that meet the needs of households and businesses. Hybrid solutions allow substantial reduction in generator run times, and fuel generators can be cost-effectively fully replaced in a growing number of applications.

The Impact on Health, Climate, and Economies

To better understand the impacts of generators on health, economies, and the climate, the International Finance Corporation (IFC) has partnered with the Schatz Energy Research Center at Humboldt State University to embark on the most comprehensive inquiry to date into the footprint and repercussions of using back-up generators in regions of the world with bad grids. (The full research report that supports this analysis is available here). This study explores fundamental questions about the scale and impacts of back-up generators that have been largely unanswered beyond anecdote and local or regionally focused studies, which hint at a significant global scale.[2]

2. World Bank. "Diesel Power Generation: Inventories of black carbon emissions in Kathmandu Valley, Nepal." (2014) World Bank. "Diesel Power Generation: Inventories of black carbon emissions in Nigeria." (2014) Farquharson, DeVynne, Paulina Jaramillo, and Constantine Samaras. "Sustainability implications of electricity outages in sub-Saharan Africa." Nature Sustainability 1.10 (2018): 589.

Using the best available data, our research models fleet size, operations, and the impacts of back-up generators in 167 developing countries. The countries modeled represent 94% of the people living in low and middle income countries, excluding China. We explore the extent to which running these engines imposes economic burdens, compromises health, and contributes to disruption of our global climate. In the process, we also address several basic but important knowledge gaps related to the scale of generator use in developing countries.

THE IMPACT OF GLOBAL GENERATOR USE IS STAGGERING.

Below you will find a summary of our key findings as well as a view of the potential to avoid the hazards of this stopgap technology with modern energy storage and distributed solar technologies. With rapid improvement in efficiency, performance and economies over recent years, distributed solar and storage technologies now offer a superior and effective alternative to the back-up generators that are proliferating across much of the developing world. What is emerging is an immediate opportunity for the private sector to catalyze a new market for improved modern energy access with the promise to vastly improve conditions in economies currently reliant on poorly performing electrical grids.

BACK-UP GENERATORS ARE ABUNDANT, EXPENSIVE, AND HAZARDOUS

The number of back-up generators in the developing world has grown over recent decades as the demand for electricity and the availability of seemingly inexpensive generators outpaces the capabilities of the grid. The energy service they provide is valuable, but it comes at great financial, health and environmental costs.

Key Findings of the Study:

1. **There are millions of actively used generators in developing countries—adding up to an installed capacity base that is massive.** We estimate the fleet of generators in modeled countries to have a total capacity of 350–500 GW (equivalent to 700–1000 large coal-fired power plants), spread across 20–30 million individual sites. These units generate an estimated 100–170 TWh of electricity annually, and account for a substantial portion of electricity service in some regions. In Western Africa, for example, the electricity provided by back-up generators is equal to 40% of the electricity generated by the grid.[3]

2. **Generators are an expensive and inefficient energy access pathway.** The annual spending on diesel and petrol for generators is \$30–50 billion, with an average service cost of \$0.30 per kWh for the fuel alone, approximately double the average cost of grid electricity. The full cost of this service is estimated to be between \$0.40 to several dollars per kWh in the most remote locations due to logistics and transport[4]. In markets with the highest generator use, including much of Sub-Saharan Africa, there is more spending on fuel for generators than on the entire power grid.

"The annual spending on diesel and petrol for generators is \$30–50 billion, with an average service cost of \$0.30 per kWh for the fuel alone, approximately double the average cost of grid electricity."

3. **Generators are substantial contributors to environmental and health burdens.** Generators are contributing significantly to the emissions of fine particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrous oxides (NO_x), carbon dioxide (CO_2) and other pollutants that compromise human health and contribute to climate change. They are often used in close proximity to the homes and businesses they serve, increasing the risk that their emissions are directly inhaled by people living and working nearby. In Sub-Saharan Africa, the NO_x from back-up generators accounts for 15% of all NO_x emitted in the region, and $PM_{2.5}$ emissions are equal to 35% of emissions from all motor vehicles. Given the significant uncertainty in the intensity of emission characteristics of back-up generators, conservatively low assumptions are used. The real scale of impacts could be greater than the initial estimates reported here especially in cities and neighborhoods.

"In Sub-Saharan Africa, the NO_x from back-up generators accounts for 15% of all NO_x emitted in the region, and PM2.5 emissions are equal to 35% of emissions from all motor vehicles."

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3. It is important to note that our fleet estimates do not include direct drive generators for agricultural and industrial applications, or a detailed analysis of telecom, mining, oil and gas, offshore barges, and the large industrial sector. We expect that the footprint of generator use in those sectors is similarly impressive.

4. Based on IFC field research and economic modeling from data gathered in India, Pakistan, Zambia, and Nigeria.

The Reach and Scale of Back-Up Generators

Back-up generators are a critical, transitional, stopgap electricity access technology for millions of homes and businesses. The fleet of back-up generators in the countries modeled serves 20–30 million sites with an installed capacity of 350–500 gigawatts (GW), equivalent to 700–1000 large coal power stations. Over 75% of these sites are already "grid-connected," meaning that their primary function is to operate when the grid fails, with the remaining 25% of sites operating off-grid.

The back-up generator fleet is distributed across a range of countries, not just in areas with the lowest grid reliability; significant fleets are also found in larger industrialized economies where wealthy households and businesses use them to improve service levels beyond the reliability of inadequate grid connections. Diesel generators account for most of the installed fleet capacity (and value), but small petrol gasoline generators account for over 75% of actual units on the ground. These smaller generators are often poorer performing and some provide just enough electricity to run lights and basic appliances in a home or a market stall.

The installed capacity of back-up generators is comparable to that of power plants on the grid in some regions. In 38 of the countries modeled, including half of Sub-Saharan Africa, the installed capacity of back-up generators is greater than the capacity of power plants connected to the grid.[5] In Nigeria, we conservatively estimate that the installed capacity of generators is between 15–20 GW, while grid capacity is only 5–15 GW[6].

5. Among 111 modeled countries for which grid capacity was available.

6 A range of estimates are available from Nigeria SE4ALL Investment Prospectus (2017) http://se4all.ecreee.org/sites/default/files/Nigeria_IP.pdf, a Power Africa estimate (2019) https://www.usaid.gov/powerafrica/nigeria, and others

In total, back-up generators supply 100–170 TWh of electricity annually. While back-up generators are widespread, there are a handful of countries with particularly large and frequently operated fleets. The top six countries generating energy by back-up generators are Nigeria, India, Iraq, Pakistan, Venezuela, and Bangladesh. These six countries account for over 50% of the electricity generated (and fuel burned) by back-up generators in the 167 countries modeled.

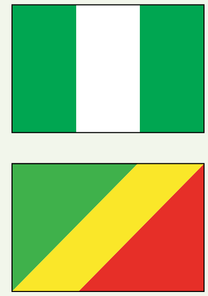
The generated electricity provided by back-up generators is equal to 40% of the electricity generated by the grid in Western Africa. Other regions also have significant percentages of power load served. In 18 of the countries modeled, backup generators account for over one quarter of generated electricity.[7]

"The top six countries generating energy by back-up generators are Nigeria, India, Iraq, Pakistan, Venezuela, and Bangladesh. These six countries account for over 50% of the electricity generated (and fuel burned) by back-up generators in the 167 countries modeled."

Powering back-up generators requires high volumes of fossil fuel: 40–70 billion liters of fossil fuel are consumed by back-up generators annually, 70% of it diesel. In Sub-Saharan Africa, one out of every five liters of diesel and petrol is burned in a back-up generator.

7. Among the 109 modeled countries for which estimates of grid generation were available.

The Real Cost of Back-Up Generators



We estimate that **Nigeria** spends **three times** as much on back up generator power as compared to the grid, and the **Republic of Congo** spends an astonishing **nine times** the amount.

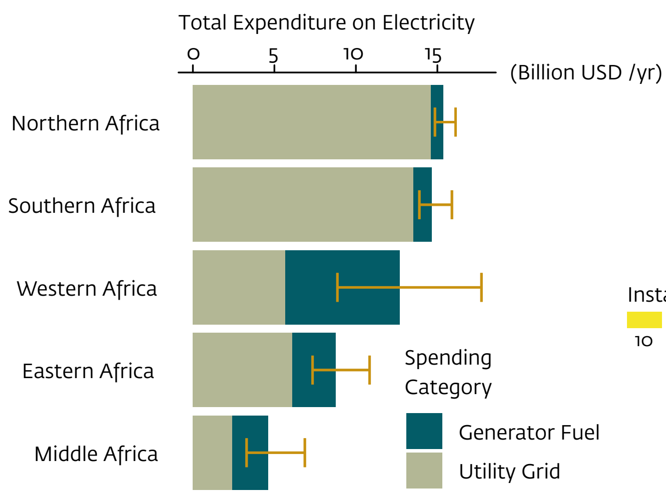
Relying on electricity from back-up generators is expensive. Users of back up generators in developing markets spent $30-50 billion USD on fuel each year, and the value of generators imported into developing countries exceeded $5 billion in 2016. By way of comparison, in Sub-Saharan Africa, the amount spent by users on generator fuel alone each year is equivalent to 20% of government spending on education and 15% of healthcare. In South Asia, these are lower but still substantial: 9% of educational spending and 8% of healthcare. In many countries, electric utilities are struggling to keep up with surging demand, suggesting that grid reliability will worsen and spending on back-up generation will increase, at least in the near term.

"In Sub-Saharan Africa, the amount spent by users on generator fuel alone each year is equivalent to 20% of education spending and 15% of healthcare."

This cost burden also extends to government budgets. Across the 167 countries modeled, we estimate that the cost of subsidizing the fossil fuel used in back-up generators was $1.1–2.1 billion in 2016. Much of this spending was concentrated in a few countries with large unit subsidies. Our estimate is a conservative, initial attempt to quantify the level of subsidies going specifically to consumer prices paid for fossil fuels used in generators in developing countries. It does not reflect upstream fuel production subsidies, nor does it factor in externalities. The total global fossil fuel subsidy cost burden ranges from $325 bn (IEA, 2015) to $5.3 tn (IMF, 2015),[8] based on methodology and approach.

8. Among the 109 modeled countries for which estimates of grid generation were available

GRID VS. BACK-UP GENERATOR FUEL EXPENDITURES



BACK-UP GENERATOR FLEET

Installed Capacity

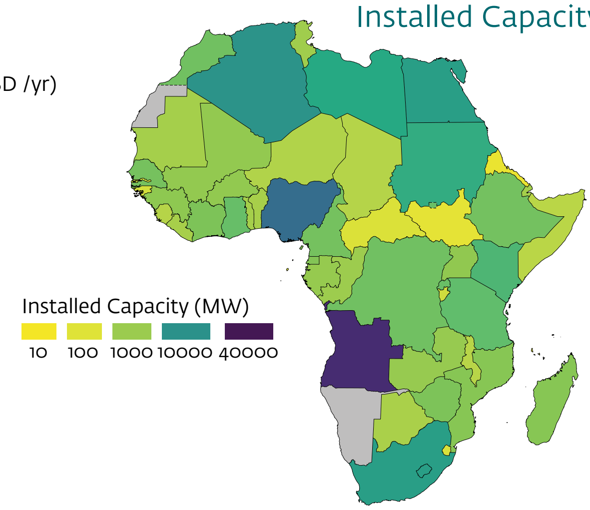


Figure. (Left) Annual expenditure on electricity (USD) from the utility grid and back-up generators. The spending on fuel for generators includes a 90% confidence interval error bar. (Right) Installed capacity of back-up generator fleets. Countries shaded in grey were not modeled.

In Sub-Saharan Africa, excluding South Africa, the spending on fuel for back-up generators is 80% that of spending on the grid. There is a major regional reliance on generators in West Africa, where businesses and homes spend a total of 1.2 times the amount on generator fuel in comparison to spending on maintaining and expanding the grid. In some countries, the spending ratios are even more pronounced: We estimate that Nigeria spends three times as much on back up generator power as compared to the grid, and the Republic of Congo spends an astonishing nine times the amount.

Electricity from back-up generators is economically inefficient compared to the grid and emerging alternatives. Across Africa, fuel for generators alone accounts for 24% of the total spent by consumers on electricity, while providing only 7% of electricity service. In South Asia, generator fuel represents 4% of electricity costs but fuel generators provide only 2.5% of electricity service in the country. This discrepancy hints at the huge commercial inefficiencies and outsized costs of basic service imposed by reliance on back-up generators. In terms of the unit cost, the average service cost is \$0.30/kWh for generators (ranging from \$0.20/kWh to \$0.60/kWh depending on generator size and fuel type). This is much higher than the typical cost of grid-based energy (\$0.10–0.30 / kWh), and on par with the achievable cost of solar and storage that could replace them. It is important to note that these fuel service costs are comparable even before accounting for operation and maintenance (O&M), which can add 10–20% on top of fuel costs,[9] and external costs from health and climate impacts resulting from generator emissions. The results suggest an opportunity to transition quickly to clean energy on economic terms; economics that will improve as the cost of solar and batteries continue their fall.

"Across Africa, fuel for generators alone accounts for 24% of the total spent by consumers on electricity, while providing only 7% of electricity service. In South Asia, fuel accounts for 4% of expenditure on electricity but deliver only 2.5% of the service."

9 Range of O&M costs relative to fuel costs informed by an analysis of expenditures from businesses with generators in Zambia, Kenya, Nigeria, India, and Pakistan.

Hidden Costs: The Hazardous Footprint

The pollutants emitted from back-up generators impose risks to health and the environment. Back-up generators emit the same pollutants as cars, trucks and motorcycles, except they are used in closer proximity to people's homes and businesses, sometimes even indoors. As a result, a greater fraction of their emitted pollution is likely inhaled by people.

The "tailpipe" emissions from back-up generators are composed of thousands of chemicals, including many that are known to negatively impact human health and the environment. The exhaust from diesel engines is classified by the International Agency for Research on Cancer as "carcinogenic to humans", while numerous pollutants found in the exhaust of generators are associated with increased risk of non-cancer outcomes, including respiratory diseases. The global and local burdens of pollution from generators represent unaccounted costs of operation on public health and environment. Potentially eliminating them provides extended value beyond the simple monetary savings in fuel and capital expenses.

The national and regional emission estimates from our study rely mainly on performance characteristics of well-maintained generators (thus are conservatively low), and do not account for the impacts associated with the close proximity to living spaces where generators typically operate. Our estimates also do not account for the impurities often present in diesel and other fossil fuels, which generally increase emissions. Even with these caveats, back-up generators appear to be a significant source of some pollutants in several regions and countries where they are widely deployed. Local measurements of actual generator performance, air quality, and exposure in some of the heavily affected countries could reveal that generators are an even more important and potent source of exposure and neighborhood air pollution than indicated by estimates produced as part of this initial effort.

Generators contribute significantly to the emissions of health-damaging pollutants that have typically been attributed to other sources like transportation (where all or the majority of liquid fossil fuel consumption is often attributed). Using our results to update a widely used fuel and pollutant inventory, we were able to assess national and regional generator emissions in the context of other pollutant sources affecting the same areas. In Sub-Saharan Africa, for example, the nitrogen oxides (NO_x) emissions from back-up generators accounts for 15% of all NO_x emissions and is equivalent to 35% of transport emissions (cars, trucks and motorcycles)—the largest single emitting sector in the region. Generators also account for the majority of fine particulate matter ($PM^{2.5}$) and black carbon (BC) emissions from power generation. The annual $PM^{2.5}$ emissions from generators in Sub-Saharan Africa is equal to 35% of $PM^{2.5}$ from transportation—often the most important source in cities. Unlike automobile emissions, however, the emissions from generators occur in large part within, or in the proximity of the buildings where people live and work. This increases the risk that the pollutants emitted eventually get inhaled, implying outsized health impacts.

Our results reveal that eliminating generators may be a necessary step for reducing the burden of disease from air pollution in some parts of the world. Exposure to ambient (outdoor) particulate matter air pollution from all sources in low and middle-income countries is responsible for 2.5 million premature deaths annually, with an additional 400 thousand premature deaths resulting from ozone exposure.[10] Addressing this burden requires identification and control of the major sources contributing to air pollution.

Our study reveals that each year, back-up generators emit more than one hundred megatons of CO_2 to the atmosphere. In Sub-Saharan Africa, the CO_2 emitted from generators is equal to about 20% of the total emissions from vehicles—the environmental equivalent to adding about 22 million passenger vehicles onto the road.

10 Global Burden of Disease Study 2017. Global Burden of Disease Study 2017 (GBD 2017) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2017.

TABLE 1: **SELECTED HEALTH AND ENVIRONMENTAL IMPACT DIMENSIONS RELEVANT TO THE OPERATION OF BACK-UP GENERATORS.**

Pollutant	Impact Areas	Data Quality	Notes on estimated scale of pollution and other supporting information
Particulate Matter, Black Carbon, Organic Carbon [$PM_{2.5}$, BC, OC]	Health, Environment	Low *Limited data on emission characteristics of generators used in focus regions. Currently assumes performance of units sold in industrialized countries.*	$PM_{2.5}$ is among the best pollutant indicators for health risk. In cities, where most generators are deployed, vehicle emissions are a dominant local source of $PM_{2.5}$, although residential biomass use often dominates at a national level. Black carbon (BC) and organic carbon (OC), portions of particulate matter, contribute to climate change. In Sub-Saharan Africa, the $PM_{2.5}$ emissions from generators is equivalent to 35% of vehicle emissions. It also contributes the majority of $PM_{2.5}$, BC, and OC emissions from power generation in Sub-Saharan Africa. Many generators are used near where people live and work, meaning that a larger fraction of what generators emit is likely inhaled by people.
Nitrogen Oxides [NO_x]	Health	Good	NO_x (NO_2 + NO) emissions are associated with combustion, usually from burning of fossil fuel in vehicles or for energy generation. Exposure to NO_x has been associated with increased risk of numerous respiratory illnesses. NO_x can also form other pollutants that impact health (i.e. ozone, particles) and the environment (i.e. particles, acid rain). Our results suggest that generators account for 5% of NOx emissions across all modeled countries and 15% in Sub-Saharan Africa.
Carbon Dioxide [CO_2]	Environment	Good	CO_2 is the single most important contributor to climate change. We estimate that 100 megatonnes of CO_2 are emitted each year from generators in modeled countries. In Sub-Saharan Africa, the CO_2 emitted by generators is equivalent to 20% of the CO_2 emissions from vehicles in the region.
Sulfur Dioxide [SO_2]	Health, Environment	Low *Limited data on fuel quality.*	SO_2 is a pollutant emitted from burning fuels that contain sulfur, such as coal, diesel, and kerosene. Among its impacts, inhaling SO_2 can exacerbate respiratory diseases and can also form small particles that contribute to PM exposure. In the atmosphere, SO_2 can contribute to acid rain and reduce visibility. In Sub-Saharan Africa, SO_2 emissions from generators is equal to about 50% of the total emissions from vehicles.
Carbon Monoxide [CO]	Health	Not Estimated *Limited data on emissions charac-teristics of genera-tors used in focus regions, especially two-stroke gener-ating units.*	CO is a leading cause of accidental poisonings globally and has modest climate effects. Carbon monoxide poisoning is a significant threat from generators inside or too close to occupied buildings. This is especially true for small two-stroke generators often used by homes and small businesses.,
Ozone [O_3]	Health	Not Estimated *Requires additional modeling.*	Ozone in the lower atmosphere is created from the reaction between NO_2 volatile organic compounds, and sunlight. Unlike the ozone in the upper atmosphere, which protects us from harmful UV radiation, ozone exposure in the air we breathe can lead to increased risk of respiratory diseases, such as asthma, and lead to abnormal lung development in children. A previous study identified generator emissions as an important source for ozone-formation in Africa.[1] Our results suggest that emissions of these ozone-forming pollutants from generators may be two to three times higher than estimated previously.
Noise	Health	Not Estimated *Limited data on noise levels of generators used in focus regions.*	There is evidence associating excess noise with various negative health outcomes, including high blood pressure and hearing loss. Assessment in Nigeria from 2013-2015 showed noise levels of most common generators are beyond WHO limits (greater than 90db)[2,3].

1. Marais and Wiedinmyer. Air quality impact of diffuse and inefficient combustion emissions in Africa (DICE-Africa). Environmental Science and Technology. 2016. 50, 10739–10745.
2. Ibhadode, O. et al. Assessment of noise-levels of generator-sets in seven cities of South-Southern Nigeria. African Journal of Science, Technology, Innovation and Development 10, 125–135 (2018).
3. "A recent study by the World Health Organization estimated that at least one million life years are lost annually due to exposure to traffic noise pollution in Western Europe. Anecdotal accounts of the noise pollution generated by BUGS is widely documented in the gray literature, but no study that we are aware of has examined the potential health implications on local or national populations." https://www.who.int/quantifying_ehimpacts/publications/e94888.pdf?ua=1

Table 1 summarizes some environmental and health impact dimensions we have identified for back-up generators. There are significant risks across the categories, with some at a higher level of certainty than others due to the quality of data used to inform the estimates. We also highlight several impact areas that are likely important but were not modeled or examined in depth as part of this effort.

THE WAY FORWARD: CREATING MARKETS AND DEPLOYING CATALYTIC INVESTMENTS

Distributed solar and storage technology offers a commercially viable path away from back-up generator dependency. The technology has evolved to a point where reliable solar-based alternatives can cost-effectively displace much of the dangerous, expensive and dirty fleet of back-up generators that proliferate in the developing world. Yet the market dynamics facing new technologies require innovative programmatic interventions and catalytic finance in order to accelerate adoption of solar and storage solutions and expedite the transition away from generators.

Through the pioneering experience of IFC's early engagement with solar companies serving people in off-grid areas, IFC has created a blueprint for deploying multifaceted programs to create markets for transformative technology. Off-grid solar is now a $1 billion per year market and has enabled more than 200 million people globally to access modern energy. We believe a similar revolution is possible in the next few years by working with first mover companies to innovate the products and business models that will leverage available solar and storage technology to displace privately operated fuel-based generators at scale—commercially and sustainably. By deploying market-level interventions to lower first mover company risk, we can enable a faster acceleration of the market to scale and build the structure to mobilize investment in this nascent market.

IFC leverages its regional investment experience, expertise and networks in financial markets to mobilize funding for distributed energy and storage solution developers. Mobilizing commercial investment, on top of efforts by IFC and other development partners to address barriers to market development can accelerate the pace at which the nascent PV solar and storage market reaches it's potential. Collaborative efforts by development partners to lower transaction costs and first mover risk can enable the industry to more quickly develop and meet the needs of those currently reliant on a costly and polluting infrastructure of privately-operated generators.

KEY FACTS AND FIGURES

1.5 billion
Estimated number of people living with unreliable and intermittent service from electric grids

$30-50 billion
The annual spending on diesel and petrol for generators

100 Megatons of CO_2
Released into the atmosphere each year by back-up generators

$1.1-2.1 billion
Estimated cost of subsidizing fossil fuel used in back-up generators in 2016

40–70 billion liters
Amount of fossil fuel consumed by back-up generators annually, 70% of it, diesel.

Distributed solar and storage technologies are also poised to transform the power sector more broadly into a future where they will be commonplace in homes and businesses, providing an independent ability to generate, store and consume clean, safe and affordable electricity. The opportunity is at hand to accelerate the pace of that transition by targeting customers with the highest value proposition—those using back-up generators who bear significant costs to obtain reliable electricity. **There is both a moral imperative and a significant market opportunity for next generation technologies to quickly end the dominance of back-up generators on broken grids.** We look to join hands with the private sector, development community, donors, and industry actors to create the vibrant markets that enable a rapid transformation to that sustainable future.

PHOTO CREDITS:

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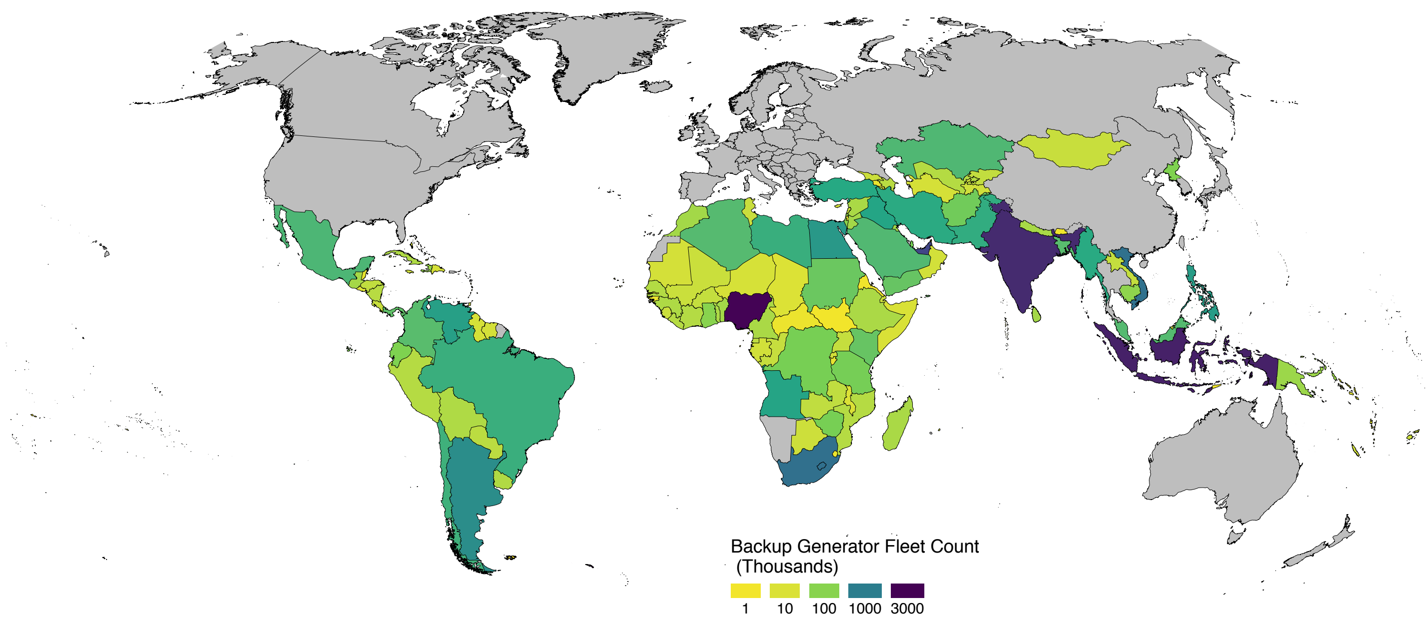
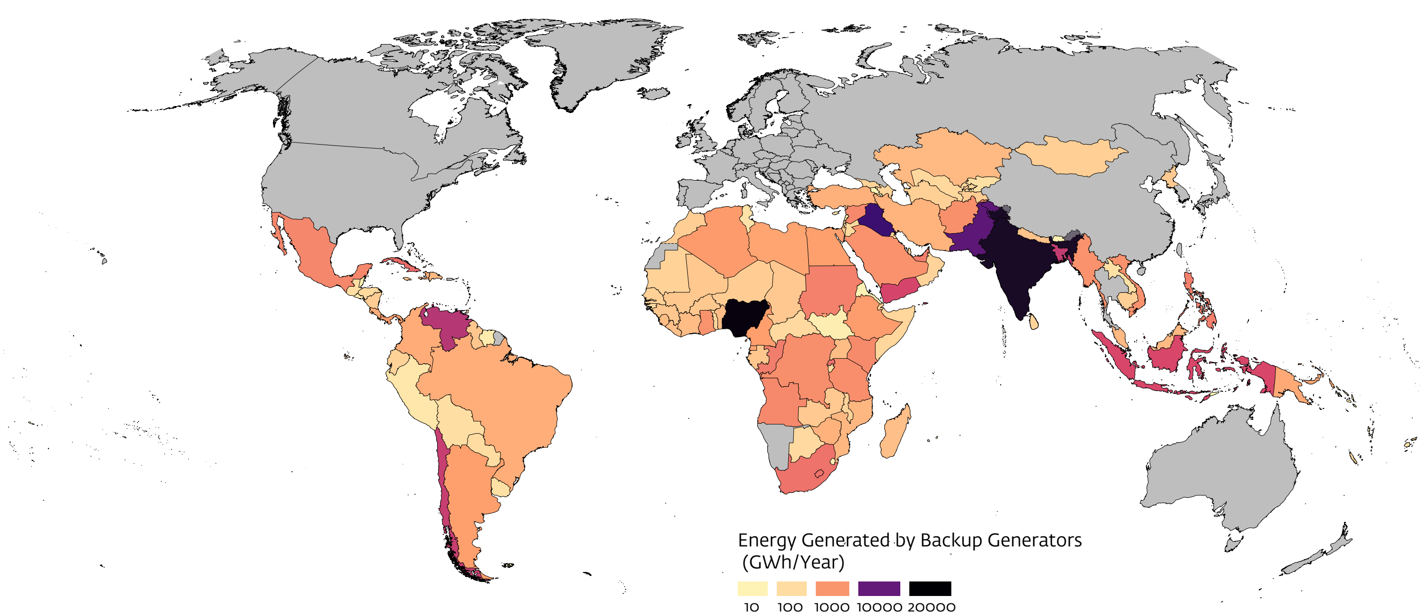
Picture on page 10, credit: Kim Eun Yeul / World Bank

Annex

ESTIMATED BACKUP GENERATOR FLEET SIZE



ESTIMATED TOTAL ELECTRICITY SERVICE FROM GENERATORS BY COUNTRY



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