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ISSUE BRIEF

Deploying Distributed Renewable Energy to Reduce the Impacts of Extreme Heat on the Urban Poor

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The Atlantic Council's **Adrienne Arsht-Rockefeller Foundation Resilience Center (Arsht-Rock Resilience Center)** builds human capacity for resilience in the face of climate change, aiming to reach one billion people with resilience solutions by 2030. The Center focuses its efforts on people, communities, and institutions to help them better prepare for, navigate, and recover from shocks and stresses occurring across the globe.

The **Arsht-Rock Resilience Center**, with support from the **Rockefeller Foundation Global Energy Alliance Team**, is pleased to present this issue brief: **"Deploying Distributed Renewable Energy to Reduce the Impacts of Extreme Heat on the Urban Poor."**

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EXECUTIVE SUMMARY

Increased urbanization and related demographic shifts, combined with the growing threat of heat stress, extreme heat events, and other climate change–related impacts, are set to continue to strain urban centers in the coming decades. In the developing world, 215 million low-income people across five hundred cities are projected to experience dangerous heat extremes by 2050, marking an eightfold increase in exposure to extreme heat compared with today.

A direct consequence of these grim climate projections, especially for cities in the tropical developing world, is the growing recognition among a wide array of actors including policymakers, urban planners, and civil society organizations that they must reduce extreme heat risk, strengthen infrastructure, and increase social and economic resilience in their cities. Even if the challenge is well understood, however, extreme heat is a complicated concept to integrate into risk analysis, planning, and disaster risk reduction efforts as it is transversal in nature and generally not "owned" by a single city or municipal department.

This paper explores the potential for distributed renewable energy (DRE) to play an increased role in mitigating heat risk in large urban and peri-urban settlements via its integration into passive and active cooling solutions.

Currently, improving and increasing energy access and related service infrastructure in cities often follows a slow, formal, and traditional planning and execution approach, usually as a function of local priorities and other inter-

ests that municipal authorities manage day-to-day. Within that context, power deficits within city limits—often experienced by those living in slums and informal settlements—are not usually identified as issues of pressing concern, but rather are understood to be symptomatic of rapid and unplanned growth—in short, "growing pains." Therefore, the method of extending power to marginalized populations in informal settlements is often viewed as eventual grid extension, leaving the current barriers to acquiring and maintaining reliable energy access in those areas without sufficient attention and resources.

Lags in service delivery caused by this traditional approach necessitate consideration of the integration of DRE, traditionally applied in rural and "last-mile" electrification. DRE presents an alternate, versatile, and relatively speedy infrastructure extension strategy that should be further explored as part of a broader engagement to provide solutions, built in conjunction with community stakeholders. This approach seeks to benefit from trends in the renewable energy industry, including declining capital cost, rapid deployment, a reduced need for centralized coordination, and a cleaner environmental footprint.

There is limited experience globally in using DRE to provide reliable and cost-effective energy access to inhabitants of slums and new informal settlements in heavily populated urban centers, let alone as part of extreme heat risk reduction. But given the reality of more frequent and severe heat waves around the globe, and the opportunity presented by DRE to connect at-risk populations with a reliable energy supply for cooling, policymakers and urban planners should better understand the use case for DRE and the possibility for developing an integrated solution to prepare their cities' residents for future heat hazards. This paper highlights existing gaps in what is known about this intersection and advocates for further research on this topic as well as consideration of targeted pilots to fill knowledge gaps and increase energy access for cooling purposes.

Action Points:

- Further research is needed on the potential for DRE to be deployed as part of active and passive cooling measures as an innovative method of extreme heat risk reduction.
- Organizations with extensive expertise in extreme heat and cooling should lead in conducting two to three pilot projects that identify and address open questions, validate operating assumptions, and leverage alliances and partnerships.
- These pilots should result in proposed creative pathways to passive and active extreme heat risk reduction measures in informal settlements.

I. INTRODUCTION

This issue brief explores the potential for distributed renewable energy (DRE) to mitigate the impacts of extreme heat on those living in large urban slums and informal settlements. Currently, many of these communities lack access to reliable electric power—and rising trends in population growth, extreme heat risk, and energy demand threaten to exacerbate this issue. DRE—"power, cooking, heating and cooling systems that generate and distribute services independently of any [centralized] system"[1]—can help bridge the gap between demand for and access to energy for these vulnerable populations in part by being integrated into passive and active cooling solutions. The full extent to which DRE can meet the needs of these communities remains unclear, though case studies of current initiatives show its promise. This paper advocates for further research in this area, potentially including through additional targeted pilot projects on the ground, to fully investigate the potential for DRE to help address challenges surrounding energy access and extreme heat for the urban poor.

II. RELEVANT GLOBAL TRENDS

Population Growth and Urbanization

Two-thirds of the world's population is projected to live in urban areas by 2050, representing an increase of 2.4 billion from 2015, particularly concentrated in Africa and Asia.[2] In line with or even at a higher pace than the growth of the overall urban population, the number of people living in slums or informal settlements and at the periphery of cities has grown, mostly in three geographic regions: Eastern and Southeast Asia (370 million), sub-Saharan Africa (238 million), and Central and Southern Asia (227 million). Globally, in 2019, approximately one billion people lived in slums or

1 Renewable Energy Policy Network for the 21st Century, *Distributed Renewable Energy for Energy Access*, Renewables Global Status Report, 2016, https://www.ren21.net/gsr-2016/chapter03.php.

2 United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables*, 2015, https://population.un.org/wpp/Publications/Files/Key_Findings_WPP_2015.pdf.

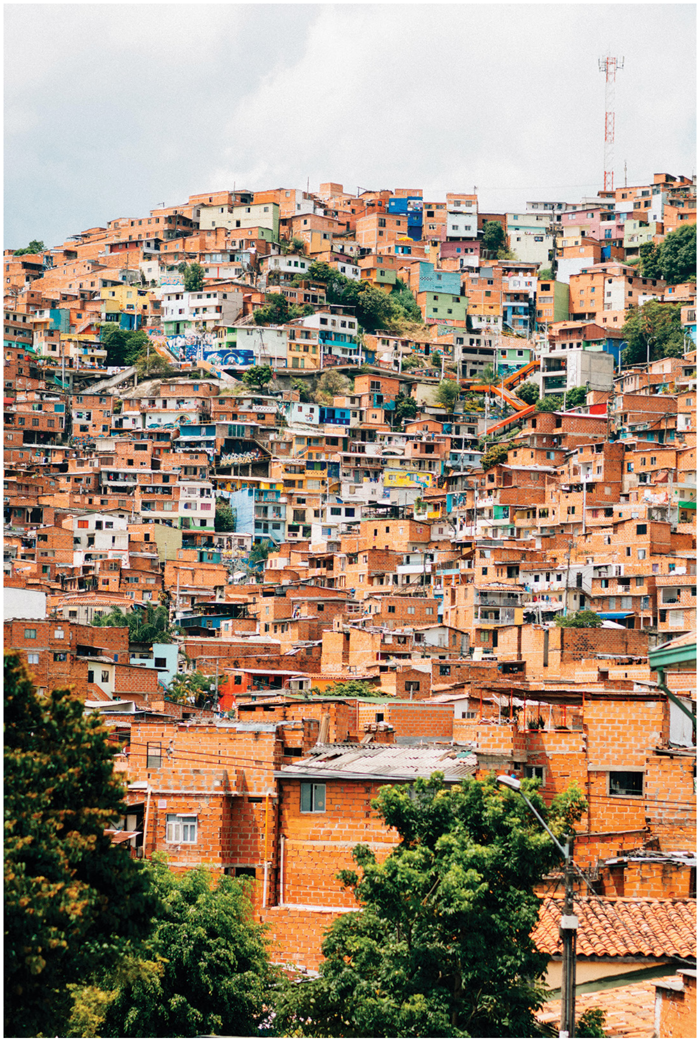


Photo by Kobby Mendez on Unsplash

informal settlements.[3] The growing number of slum dwellers is attributed to the trends in urbanization and population growth, with urban migration outpacing the construction of homes and expansion of infrastructure.

The Growth of Renewables and DRE

According to the US Energy Information Administration, world energy consumption is projected to grow by nearly 50 percent between 2018 and 2050, with much of that growth attributable to non-OECD (Organisation for Economic Co-operation and Development) countries.[4] By 2030, Latin America is expected to reach a 70 percent renewable energy threshold as a region[5] and by 2050, Asian and African renewable energy generation is projected to account for up to 50 percent of the global power supply. The expansion of renewable energy is a result of the falling costs of solar photovoltaic (PV) and other renewable energy generation technologies; improvements to transmission and distribution infrastructure and dispatch software; modularity of installations; increased technical capacities and knowledge; flexible integration of complementary technologies like storage and microgrids; and increased use of widely available off-grid DRE, all of which broaden the options for a shift from centralized power generation and delivery assets to an increased use of off-grid resources.

Extreme Heat

Extreme heat is defined as summertime temperatures that are much hotter and/or more humid than the location-specific seasonal average. With temperatures rising, particularly in cities, scientists predict that the growing frequency, duration, and intensity of heatwaves will affect more than 3.5 billion people by 2070. Of these, 1.6 billion are expected to live in dense urban areas located in the tropical developing world. As temperatures rise, the urban poor are more vulnerable to this effect, adding to the challenges that current demographic trends and unplanned growth represent for large cities. Studies in Nairobi, Kenya, and Ahmedabad, India, show that slum dwellers are subject to higher temperatures than other city residents, increasing risks of mortality and morbidity.[6]

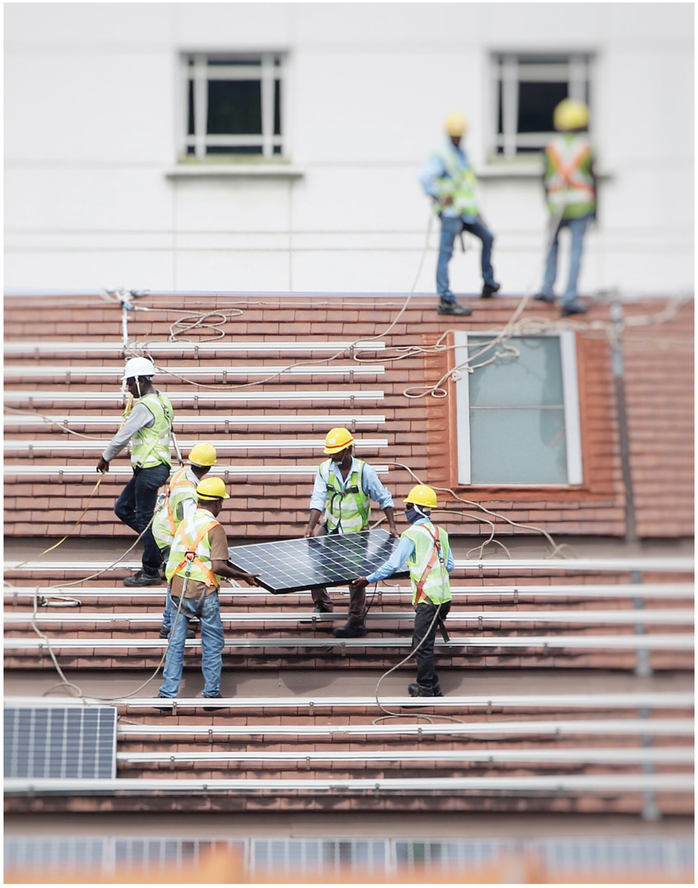
Heat, along with other factors such as air pollution, can exacerbate medical conditions (cardiovascular and respiratory

3 United Nations Statistics, "SDG Indicators," 2021, https://unstats.un.org/sdgs/report/2019/goal-11/.

4 Ari Kahan, "EIA Projects Nearly 50% Increase in World Energy Usage by 2050, Led by Growth in Asia," US Energy Information Administration, September 24, 2019, https://www.eia.gov/todayinenergy/detail.php?id=41433.

5 Valerie Volcovici, "Latin America Pledges 70% Renewable Energy, Surpassing EU: Colombia Minister," edited by Julia Symmes Cobb and Steve Orlofsky, Reuters, September 25, 2019, https://www.reuters.com/article/us-climate-change-un-colombia-idUSKBN1WA26Y.

6 Jiong Wang, Monika Kuffer, Richard Sliuzas, and Divyani Kohli, "The Exposure of Slums to High Temperature: Morphology-Based Local Scale Thermal Patterns," *Science of the Total Environment*, vol. 650 (2019): 1805-1817, doi:10.1016/j.scitotenv.2018.09.324; Anna A. Scott, Misiani Herbert, Jerrim Okoth, Asha Jordan, Julia Gohlke, Gilbert Ouma, Julie Arrighi, et al., "Temperature and Heat in Informal Settlements in Nairobi," *PLOS ONE*, vol. 12, no. 11 (2017): e0187300, doi:10.1371/journal.pone.0187300.



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diseases), and communities with insufficient means to mitigate this impact become more exposed. The growing threats to, and vulnerabilities of, these communities, as well as the follow-on demands on infrastructure (energy for cooling, refrigeration, and water) underscore the need for concerted efforts to address the anticipated impacts of rising temperatures.

In addition to these impacts, the cost of addressing extreme heat will also rise. Adaptive measures—such as increasing the use of electricity for cooling—are expensive, increase emissions, and will not be easily within reach of low-income populations. As a consequence, in addition to active cooling solutions—which use an external tool such as a fan to reduce temperatures—cities are integrating passive measures—which rely on heat sinks (e.g., water features and parks) or a heat spreader to cool an area. Examples of effective passive solutions include greening infrastructure initiatives (such as increasing shade and green space), increasing reflective surfaces (roofs, walls, pavements), and leveraging nature's ecosystem services.

III. EXPANDING URBAN ACCESS TO POWER IN INFORMAL SETTLEMENTS/SLUMS: CHALLENGES AND OPPORTUNITIES

A. Urban Access to Power

Power access figures, as measured by the World Bank's *Energy Progress Report*, highlight a significant divide in access between urban and rural populations.[7] Rural populations made up about 84 percent of the global access deficit in 2019, while the penetration of urban electrification was nearly 97 percent as recently as 2016.

The 3 percent of the urban population without reliable access to power—concentrated in slums and informal settlements—have relied on autonomous solutions, including portable diesel- or gas-powered gensets and other means to independently manage the level, availability, and quality of power. This mirrors a similar type of entrepreneurial solution in rural settings. At the same time, electrification through decentralized resources, including renewables, has advanced much since 2010 and accelerated in recent years. The number of people connected to mini-grids (renewable and non-renewable), for example, more than doubled between 2010 and 2019, growing from five to eleven million people according to the International Renewable Energy Agency. As a result, in 2019, 105 million people had ready access to off-grid solar PV systems, an increase from 85 million in 2016.

B. Challenges to Providing Energy Access in Informal Settlements and Slums

Given the pace of growth and urbanization, municipal governments and service providers find themselves stretched and unable to meet demand for services. Maintaining existing infrastructure and/or upgrading it while planning for and expanding access to services incorporates a lag between planning and delivery that is not new. However, addressing it does take on added urgency given the accelerating shift toward cities and added challenges posed by climate change. To better understand the challenges in providing energy access in slums and informal settlements, it is helpful to carefully review and disaggregate them within the context of a static rate (97 percent) of energy access.

7 Tracking SDG 7, Progress towards Sustainable Energy, *The Energy Progress Report*, 2021, https://trackingsdg7.esmap.org/.

Service delivery/supply-side barriers[8]

Electrical distribution companies supply cities and neighborhoods with electric power and are responsible for service, quality, maintenance, and reliability. As their name implies, distributors deliver and commercialize whatever steady supply of power generation is transported by high voltage transmission lines to substations that provide for delivery to residential, institutional, and commercial customers. The following are identified barriers to providing service in slums and informal settlements:

- *Legal barriers*: Informal nature of the slum, illegal or nonexistent status of land tenure (subject of court disputes), difficulties establishing property claims and property rights
- *Physical location barriers*: Haphazard and/or dangerous physical conditions of dwellings and difficulties with access routes
- *Safety barriers*: High levels of insecurity/high crime areas in specific slum locations
- *Residence barrier*: Precarious nature/quality of habitats in informal settlements, often not up to city codes, presents difficulties for technical installations, upgrades, and maintenance
- *Informal nature of growth barrier*: Unplanned design leads to difficulties in installing basic service infrastructure including water pipes and sewers, meters, lines, and wiring
- *Lack of mandate/capacities*: Distributers may lack outreach or administrative structure/mandate needed to facilitate rapid attention to service needs
- *Regulatory, zoning, tariff restrictions*: Locations outside the regulatory service area of the power distributer and regulated tariff inflexibility may present obstacles
- *Distrust/hostility from the community:* This barrier is anecdotal and expressed in urban and rural settings in many countries; it reflects a general lack of trust of "outsiders" and the residents' marginalization by formal public and private sector actors and authorities
- *Financial barriers:* Despite the assumed demand for power services in slums and informal settlements, the precarious nature of purchasing power in these communities is also an obstacle considered by providers

Providing, maintaining, and ensuring quality and cost-effective service in these marginalized communities is a complex endeavor in the best of circumstances. Even when distribution companies respond to a regulatory mandate or well-intentioned and broad policy commitment to provide universal energy access in slums, the complexities highlighted result in a lag between intention and delivery.

Customer/demand-side barriers[9]

- *Formal address barrier:* Lack of a formal address or any type of formal existing basic services makes delivery and installation more difficult and costly
- *Financial integration barrier:* Lack of customer bank accounts, formal credit history, and often linkages to the city's administrative, legal, and financial systems
- *Cost versus purchasing power barrier:* Irregular incomes and lack of capacity to pay, lack of purchasing power, lack of formal income, and large household sizes
- *Outreach barrier:* A lack of communication/relational linkages, accountability, and trust among the energy service providers and municipal authorities and the urban poor
- *Business-as-usual solutions barrier:* In the absence of formal/official solutions, residents use a network of formal and informal middlemen and neighborhood "service providers" that provides immediate solutions/informal connections, service, and maintenance to the slum
- *Service quality/experience barrier:* If power service is provided it can be unreliable and difficult to maintain and repair, leading to a reduced willingness to pay given the very poor level and reliability of the service
- *Track record barrier:* Payments, even if service is successfully established, can be irregular, leading to additional difficulties in establishing formal linkages between provider and customer, resulting in late or nonpayment of bills and disconnections

Due to these barriers, reaching homes in slums requires making a substantial investment in expanding distribution

8 Global Network on Energy for Sustainable Development, *Urban Peri-Urban Theme*, 2015, http://www.gnesd.org/PUBLICATIONS/Urban-Peri-Urban-Theme.

9 Ibid.

networks, with a small potential payoff, even if collecting payment is not a primary issue. As a result, in many countries, it is common to see homes in slums surrounded by electric lines overhead that they are not connected to either because the settlement was built without any formal permissions, or due to any of the other reasons already mentioned. Power distribution companies globally can experience as much as a 5-35+ percent loss of their power sales to what are known as "nontechnical losses," or stolen power, making the hurdles to economic feasibility for distribution companies much higher.[10]

So, while many experts on energy access consider DRE to be a quite viable, if not optimal, solution (contingent on the local conditions and context), this is not the case for policymakers in urban areas where traditional grid and municipal/distribution service extensions are considered to be part of the organic growth of city infrastructure, and as such more feasible. However, a fresh review is needed given the growing number of experiences with DRE in the field, the advent of more cost-effective and efficient technology, the growth of bottom-up entrepreneurial solutions and public policy mandates/objectives to better address the resilience of all urban communities, and the prospect of integrating DRE even under an existing grid.

IV. INTEGRATING DRE AS PART OF THE SOLUTION

The initial investment required to install a renewable energy distributed generation plant may be more cost effective than a traditional grid extension. This is because the latter assumes various layers of infrastructure upgrades will be made to ensure standardized quality of conditions, in which case DRE may simplify the technical and infrastructure requirements. In addition, and again depending on local circumstances, an extension may include the need for costly substation installations and underground wiring. As a result, DRE can be more cost effective in terms of capital expenditure, provide a modular and thus nimbler infrastructure footprint, and add versatility to address the immediacy of needs in slums. The need for a substation would be contingent on whether the microgrid is one that covers a block of houses or a larger area, and the DRE asset could be relocated when or if the need arises.

The prospect of nontechnical losses remains, but these losses can be addressed differently, by, for example, dealing with a community power initiative with roots in the settlement/slum itself (a bottom-up initiative) and/or through pay-as-you-go systems/smart meters integrated as part of the grid, specifically to ensure the inclusive and accountable nature of the system without prejudice. As in the case of rural electrification and last-mile projects, the peer administrative and localized management established can be effective, especially if there is an element of communal ownership and assumed stakes over the assets, the overall system, and the service provided.

Regarding customer-specific elements such as the precariousness of income and lack of credit, bank accounts, and property documentation, an approach that includes a community-based association or power cooperative can ease the "customer quality" aspect that a more traditional approach has a more difficult time absorbing. Oftentimes municipal authorities, local nongovernmental organizations (NGOs), or churches—and sometimes distribution companies themselves—have outreach programs in these settlements. Leveraging these existing initiatives and/or partnering with them would ease and speed up integration and outreach, and programs such as those addressing energy access and extreme heat could become useful vectors to achieve those objectives as well.

Finally, residents can have ownership over the day-to-day operations of the DRE system. Because DRE can be implemented on a small scale, much of its maintenance and regular monitoring, such as bill collection and metering, can be conducted at a local level by properly trained community residents. Long-term energy access outcomes may be improved when local actors are empowered to protect and service the infrastructure they directly benefit from.[11]

C. Case Studies

In contrast to rural electrification and last-mile work, there is not as much data and research on applying DRE in informal settlements in urban or peri-urban centers. In fact, many of the pilot experiences are either very specific or very general and broad. Experiences in locations as disparate as the slums of Brazil, through community power asso-

10 Quentin Louw and Pr Eng, *The Impact of Non-technical Losses: A South African Perspective Compared to Global Trends*, 2019, https://www.researchgate.net/publication/335337986_The_Impact_of_Non-Technical_losses_A_South_African_perspective_compared_to_global_trends.

11 David Schaengold, *Clean Distributed Generation for Slum Electrification: The Case of Mumbai*, Woodrow Wilson School Task Force on Energy for Sustainable Development, 2006, https://scholar.princeton.edu/sites/default/files/mauzerall/files/schaengold.pdf.

ciations and power cooperatives, and those in India,[12] with a variation on the traditional centralized power and invoicing system, show the creativity and resourcefulness of possible solutions.[13] The following are summaries of selected cases, each characterized by a distinguishing element in its approach to providing DRE solutions in slums.

- **India/Africa – Solar-Powered Products, Energy as a Service, and "Pay-as-You-Go" Systems**

  Case 1. Paying for power delivery[14]
  OMC Power rents out portable energy sources, such as battery-powered LED lanterns and power boxes, to users on a need basis. The equipment, which provides electricity at a lower cost than existing fuel sources, is charged locally by OMC's solar-, wind-, and biogas-fueled micro-power plants. Since its origins, OMC has expanded from Asia to Africa and has broadened its product and service offerings significantly.

  Case 2. Innovative financing: "Pay as you go"[15]
  Simpa Networks, a solar startup, developed a "pay-as-you-go" payment system that functions similar to a home mortgage. Customers place a down payment, usually 20 percent of the price of a small solar array, in exchange for access. The rest is paid back gradually within two years. Simpa Networks, which began in rural areas and urban slums at the outskirts of Bangalore, has expanded to urban and rural markets in India.

- **Haiti – Earthspark's community power companies—"de-risking by doing"**[16]

  NGO Earthspark is a commercial enterprise that has developed several community-based microgrids in small towns in Haiti, and in the process has developed strong community power companies with generation, distribution, administrative, training, and maintenance functions. The systems use solar PV energy (some with diesel backup) and remain the only viable option for these small towns, which are unlikely to benefit from a national grid extension. This operating model, centered on community and smart meters, is seeking financing to expand, develop, and manage up to twenty-four microgrid systems in similar towns along Haiti's southern border.

- **Brazil – Revolusolar, a renewable energy cooperative in favelas**[17]

  Brazilian social enterprise and NGO Revolusolar provides DRE solutions inside some of Rio de Janeiro's most well-known and long-established *favelas* (slums). While these areas do have power available through the local distribution company, people seek out other options, such as informal solutions (nontechnical losses), due to unreliable and expensive service. Revolusolar organizes energy cooperatives within the favelas, and with them has begun to build small microgrid systems that are providing more reliable solar PV energy at lower cost. The operating model is evolving and is not self-sustaining yet, but the technical and social enterprise validation sought in the first pilots is being validated.

- **Nigeria – Rocky Mountain Institute's West Africa undergrid Mokoloki project**[18]

  The Rocky Mountain Institute's (RMI's) Mokoloki project is an ambitious solar hybrid project aiming to improve service, support the Mokoloki community, and reduce utility losses and electricity costs. Launched in February 2020, the project is groundbreaking as Nigeria's first commercial undergrid mini-grid in a rural setting. Through a partnership among a solar energy provider, the local distribution company, and RMI, this project seeks to demonstrate a path to collaboration by communities, distribution companies, and solar PV technology providers. "Early evidence indicates the project will improve electricity service, support community development, and reduce utility losses" at a lower power delivery cost.[19]

- **Smart Power India, supported by The Rockefeller Foundation**

  Smart Power India (SPI) helps energy service companies establish mini-grids in rural areas across India. Between

12 Coco Liu, "Renewable Energy, Once a Dream, Lights Up Some of India's Slums," *E&E News*, December 20, 2013, http://www.eenews.net/stories/1059992166.

13 "Revolusolar – Energia que vem da favela!" Revolusolar, accessed June 15, 2021, https://revolusolar.com.br/; "Por comunidades mais solares – Insolar," Insolar, accessed June 15, 2021, https://insolar.eco.br/en/.

14 "OMC - Power, Everywhere," OMC Power, accessed June 15, 2021, https://www.omcpower.com/.

15 "Simpanetworks | Home," Simpanetworks, accessed June 15, 2021, https://simpanetworks.wordpress.com/.

16 "Earthspark International Home," Earthspark International, accessed June 15, 2021, http://www.earthsparkinternational.org.

17 "Revolusolar – Energia Que Vem Da Favela!" Revolusolar, accessed June 15, 2021, https://revolusolar.org.br/.

18 "Nigeria's First Commercial Undergrid Minigrid Project," Rocky Mountain Institute, 2020, https://rmi.org/insight/mokoloki/.

19 Ibid.

2015 and 2020, SPI supported over 330 mini-grids serving over 280,000 customers. These mini-grids typically rely on solar panels or biogas plants to generate electricity that is delivered to customers within a one-to-two-kilometer radius. Utilities, entrepreneurs, or communities themselves own, manage, operate, or maintain these systems and raise revenues through local customers including households, shops, agricultural/industrial users, and/or institutions. In addition, SPI facilitates microenterprise loans to customers, which further help local communities maximize the social and economic benefits of access to reliable power.

While not all of these examples are located in slums or informal settings in large urban centers, they all reflect characteristics and lessons that are applicable in rural, urban, and peri-urban environments, highlighting the value of using innovative DRE solutions to address poverty and lack of energy access. Some of these experiences, such as those in Brazil and India, provide evidence that lower cost-per-kilowatt electricity in highly populated areas can be delivered successfully, albeit the project deployment review and approach may not be traditional and may require a broader scope than a more business-as-usual view.

D. Integrating Cooling Solutions

There is an immense need for widespread, sustainable cooling solutions that will be able to meet demand over the coming decades. Over one billion lower-income people worldwide face health and economic risks from rising temperatures and lack adequate cooling, and a "further 2.2 billion lower-middle-income people lack access to clean and efficient cooling."[20] As a result of rapid population and economic growth expected in several countries, including China and India, the world's two most populous nations, the number of global air conditioning (AC) units is expected to reach five billion by 2050, doubling 2020's numbers. The dramatic increase in cooling demand poses a major challenge for low-carbon development, as increased AC usage results in higher energy demand and greenhouse gas emissions.[21] However, in addition to the passive strategies discussed in Section II, active solutions (i.e., fans and air conditioning, refrigeration) can still play a role in heat resilience and abatement plans in urban centers, particularly if powered by renewable energy or made more energy efficient.

Off-Grid Cooling Solutions[22]

Fans are widely useful in off-grid settings due to their low electricity requirements and the ability to moderate their electricity use.

Air coolers are devices that use the endothermic reaction of evaporation to cool the air. Since they rely on water changing from a liquid to gas phase to work, air coolers are more effective in less humid climates, where the air is less saturated with water. Air coolers can be constructed in several ways, ranging from basic to complex, but all include a fan-like device, a water reservoir, and a means of dispersing water particles into the air.

Air conditioners use a vapor compression cycle of a refrigerant to provide space cooling to a specified temperature. While the basic concept remains the same, air conditioners can take several forms, ranging from inexpensive window-mounted units to multiroom coordinated systems, although the former is more common in an off-grid context. ACs rely on evaporators, compressors, heat exchangers, expansion valves, and refrigerants to cool the air.

ACs are high-load appliances that require a strong and reliable electricity supply, and so see negligible use by households or businesses with an inconsistent electricity source or insufficient funds to meet the power requirements of an AC unit. Despite these challenges, low-cost and lower-capacity units are available in developing countries.

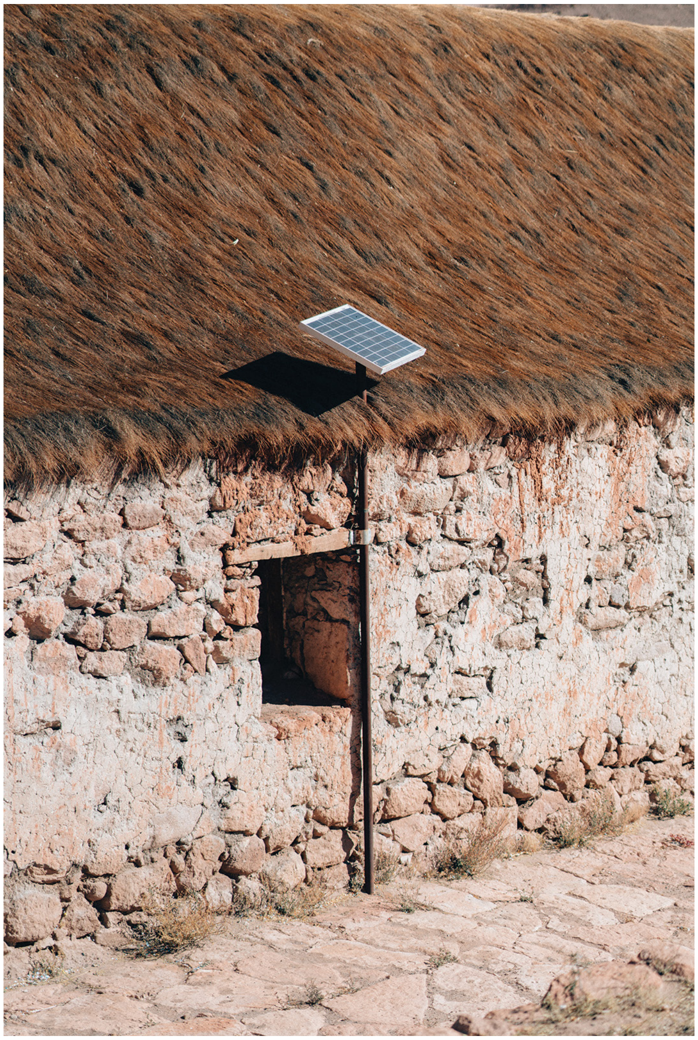
V. OPPORTUNITIES AT THE INTERSECTION OF URBAN ENERGY ACCESS AND EXTREME HEAT

Given trends in population growth; demographic shifts toward cities; climate change and increases in extreme heat prevalence; and related impacts on productivity, health, and quality of life, the challenge faced by urban centers cannot be overstated. Further research is needed on the potential for DRE to be deployed as part of active and passive cooling measures as an innovative method of extreme heat risk reduction.

20 Sustainable Energy for All, *Chilling Prospects: Tracking Sustainable Cooling for All 2020*, 2021, https://www.seforall.org/chilling-prospects-2020.

21 Sustainable Energy for All, *A Framework for Tracking Cooling Investment*, Energizing Finance Research Series, Climate Policy Initiative, 2021, https://www.seforall.org/system/files/2021-02/EF-Cooling-Investment-SEforALL.pdf.

22 Sustainable Energy for All, *Raising Ambitions for Off-Grid Cooling Appliances*, 2021, https://www.seforall.org/system/files/2021-04/Offgrid-Cooling-Appliances-SEforALL.pdf.



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Organizations with extensive expertise in extreme heat and cooling should lead in conducting two to three pilot projects to identify and address open questions, validate operating assumptions, and leverage alliances and partnerships to better frame, replicate, explore, and propose creative pathways to passive and active extreme heat risk reduction measures in informal settlements. The effort will benefit from the following:

- Ongoing advances in DRE
- The improving economics of deploying renewable microgrid and storage solutions
- Improvements in demand-side management hardware and software
- The consideration of global cooling as a service initiative
- The advent and mainstreaming of community empowerment in the local political landscape
- Collaborative social/circular enterprises
- Increased diversity in the investment/finance ecosystem

Potential Pilot Structure

To address the significant knowledge and experience gaps surrounding the integration of DRE access in cooling solutions, the objectives of a potential pilot should include the following:

- Exploring critical gaps in experience and knowledge
- Mapping and reviewing initiatives to close knowledge and experience gaps
- Identifying relevant champions and allies to further integrate EHRA into this space, within a framework of a pilot or a follow-on, more-focused study.

The high-level objectives of this framing could include collaboration with local actors expected to be engaged in measures focused on infrastructure resilience and adaptation. Local actors could include the following:

- Local governments such as municipal governments
- Energy distribution companies and/or entrepreneurs providing DRE solutions
- Community associations, local power cooperatives, and/or local NGOs

The following is a high-level view of the partners, objectives, and actions needed to address the knowledge and experience gaps:

Local governments such as municipal governments. These actors should be involved to provide targeted focus on *awareness and capacity building* on extreme heat, while ensuring support for demonstration measures on municipal buildings and properties (e.g., buildings, empty lots, parks, streets)—or *leading by example* while providing capacity-building resources.

Power distribution companies and/or entrepreneurs. These actors should be involved to provide high-level focus on *awareness and capacity building* on extreme heat, while *identifying* relevant target areas such as network coverage, outreach, and related social/low-income programs in place to reach out to marginalized communities. *Mapping the existing landscape* with a local power delivery actor provides an opportunity to *rapidly "land"* a high-level objective, strengthening the extension of existing infrastructure and including DRE initiatives into these areas.

Community associations, local power cooperatives, and/or local NGOs. These actors should be involved to reach a high-level focus on *awareness and capacity building* on extreme heat; a local NGO active in the DRE space and working on the ground with local communities could also research this work. This would also strengthen a follow-on pilot.

More comprehensive development of the indicative building blocks shared above should be determined as follow-on steps to an initial high-level proposal.

VI. CONCLUSION

Many of the challenges facing the cities mentioned here are transversal and interlinked. The demographic trends in urban and peri-urban informal settlements accentuate the rise in temperatures contributing to the heat island effect observed in mega-cities, thereby increasing local population vulnerabilities and demand for power. Proactively addressing this increase in temperatures will further strain the electric power delivery systems given more widespread air conditioning and refrigeration use, while highlighting access deficits, especially in slums and informal settlements in these large cities.

Recognizing the intersection between extreme heat, increased cooling needs, and incomplete access to power—as well as the precariousness of overextended municipal distribution systems—provides a scope of near-term action for added research and review, capacity building, the formation of transversal alliances, and eventual pilot projects relevant to the most vulnerable urban centers. Ensuring these population centers are better equipped to recognize, measure, and address this vulnerability also requires strengthening conditions that provide reliable access to power as well as practicable alternatives in the near term.

ABOUT THE AUTHORS

Jorge Barrigh has over twenty-five years of experience in field and leadership positions with energy companies, investment funds, national and international development finance institutions, energy and efficiency startups, and environmental services firms focusing on the intersection of energy, finance, innovation/entrepreneurship, and sustainability/climate. Mr. Barrigh has lived and worked in the USA, Venezuela, Panama, Canada, Argentina and Brazil. His career & track record has included work with the private and public sector as well as multilateral development banks, private equity and impact funds, blended finance and developers, mostly in the finance, environment and energy space in Latin America, the Caribbean and Africa.

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