



URBAN POWER PROFILES:

Early lessons from Cali, Cape Town, Lagos and Rio de Janeiro on the pivotal role of energy systems in building urban resilience

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INTRODUCTION

Rapid urbanization and climate change threaten electric power systems by placing stress on infrastructure, increasing demand beyond existing capacity and straining the resources linked to generation. Today, over 55% of city dwellers worldwide experience regular electricity outages or lack electricity altogether. Extreme shocks and climate events also pose downstream risks to other urban systems and societal cohesion on which secure electricity provision depends. As cities confront the twin challenges of climate change and rapid growth, they are testing approaches that will enable a greener, more equitable and more resilient energy transition and foster more productive, healthy, and sustainable communities.

70%

OF ENERGY-RELATED EMISSIONS COMES FROM CITIES

75%

OF GLOBAL ENERGY DEMAND COMES FROM CITIES

55%

OF CITY DWELLERS EXPERIENCE FREQUENT BLACK-OUTS OR LACK ACCESS TO ELECTRICITY

1.2B

URBAN AND PERI-URBAN DWELLERS DO NOT HAVE SUFFICIENT ENERGY TO MEET THEIR DAILY NEEDS

Resilience thinking can help cities achieve these goals. It allows cities to not only build urban resilience through greener energy systems, but also ensure that their electric power systems, which enable essential services to urban communities, are resilient in the face of natural hazards, extreme weather events, cyberattacks, and other threats. Resilience thinking can also help cities design and manage power systems that are more adaptive, robust, and sustainable even when faced with anticipated or unanticipated shocks and stresses. A key aspect of this approach is to consider the interdependencies among different urban systems and actors. This is especially relevant for power system resilience, as it involves not only the physical infrastructure and technology, but also the social, institutional, and governmental factors that influence its management and performance.

With holistic urban resilience thinking at its core, R-Cities launched the Urban Power program in late 2021 to support network cities become more resilient and foster a just energy transition that puts people – especially the urban poor and vulnerable – at its center. With the support of the Global Energy Alliance for People and Planet and the S&P Global Foundation, Urban Power helps cities identify and address the risks and vulnerabilities of their power systems and promotes solutions that have multiple benefits for urban resilience, such as reducing greenhouse gas emissions, creating green jobs, and promoting equity. Through Urban Power, R-Cities is engaging with four network cities – [Cali](#), [Cape Town](#), [Lagos](#), and [Rio de Janeiro](#).









During the program's first phase, R-Cities collaborated with local and international partners to examine the governance and institutional landscape in each program city, shocks and stresses that impact the power system and its interdependencies at the urban scale, as well as the social and technical challenges of extending electricity access. The program also identified critical challenges to renewable energy transition and building resilience, all of which are summarized in an Urban Power Profile for each of the cities.

Despite each city's unique circumstances, the Urban Power Profiles surfaced some commonalities between them that provide valuable insight into the role cities will play in the global energy transition. First cities have different levels of autonomy and control over energy policy, regulation, and long-term planning. This constrains their ability to meet ambitious clean targets and to implement improvements that directly respond to local challenges. Second, electricity remains unaffordable for many urban residents, despite subsidies from both local and national governments. Advancements in technologies and the clean energy transition present opportunities to close the access gap but must be supported by careful policy and governance to account for their true cost and value. Lastly, local energy markets present significant opportunities for cities to drive the energy transition, increase decent green jobs, and accelerate low-carbon development.



SHOCKS AND STRESSES IMPACTING URBAN POWER SYSTEMS

Urban power systems are impacted by a variety of shocks and chronic stresses. The high-level assessment conducted in each of the four program cities revealed their vulnerability to several environmental factors, from natural disasters to chronic climate changes such as extreme temperatures. The assessment also identified several socio-economic shocks and stresses that hinder the equitable and reliable provision of electricity.

	CALI	CAPE TOWN	LAGOS	RIO DE JANEIRO
 FLOODING	✓		✓	✓
 INFRASTRUCTURE FAILURE		✓	✓	✓
 CYBER ATTACKS	✓			✓
 DROUGHT	✓	✓		
 POWER OUTAGE	✓	✓	✓	✓
 RAPID URBANIZATION	✓	✓	✓	✓
 INSECURE MUNICIPAL FINANCES	✓	✓	✓	✓
 POVERTY AND INEQUALITY	✓		✓	✓

SPOTLIGHT: FLOODING & URBAN ENERGY SYSTEMS

Flooding, or extreme rain events, pose a prevalent threat to urban power systems. Flood-induced erosion or mudslides significantly damage the distribution network causing substations to shut down and leading to extended blackouts and costly infrastructure repairs. Given that the power system is highly interconnected with other critical systems and services, including healthcare, communications and emergency response, cities remain vulnerable to acute natural disasters. Storm intensity and rainfall rates will likely increase over the 21st century in many areas across the globe, exacerbating coastal and river flooding in urban areas. For example, many parts of Rio de Janeiro are vulnerable to flooding and landslides, especially during the summer months, with the most affected communities being predominately poor and located in informal settlements. Similarly, Cali is vulnerable to flooding and landslides that impact the city's electricity distribution network, requiring the local utility to invest heavily in resilient infrastructure projects such as increasing the number of network lines between substations.

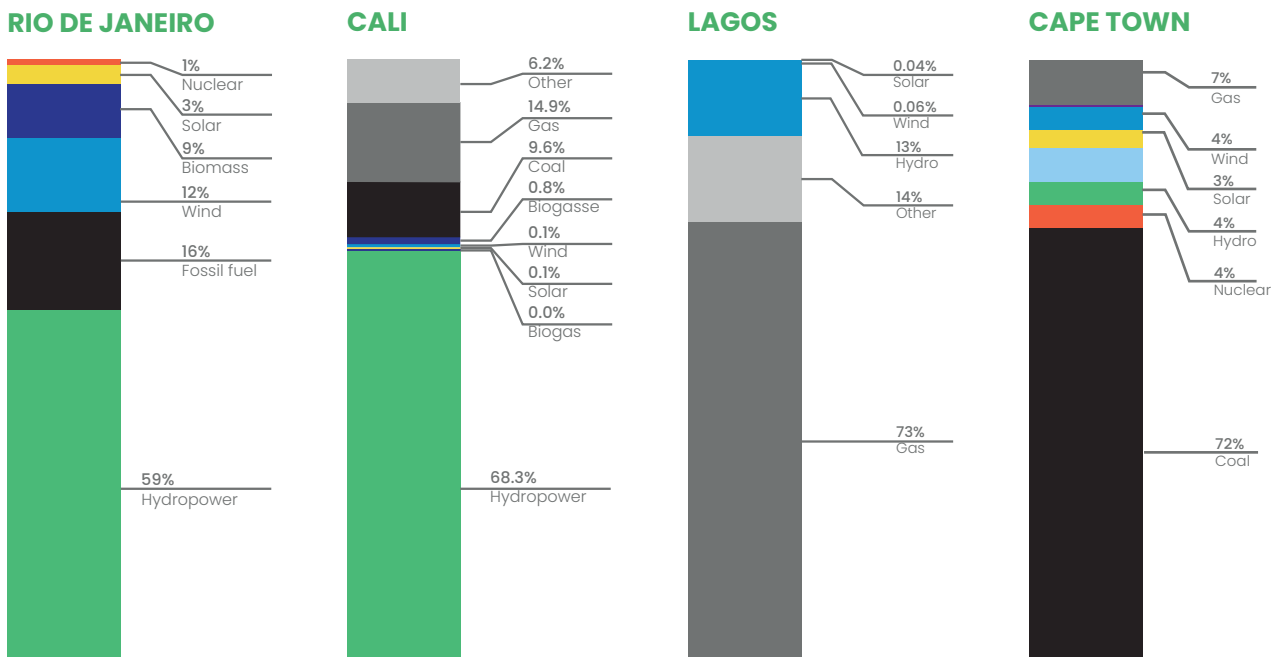
CREATING NEW PATHWAYS TO ACCESS AFFORDABLE, CLEAN ENERGY

In cities around the world, clean energy sources have emerged as drivers of a transition to low-carbon economies and increased urban resilience. However, with much of electricity generation and distribution controlled at the national level, local governments are constrained in their ability to meet their ambitious clean energy targets, implement, and invest in transformative energy projects and harness their untapped renewable energy potential.

For many cities, long-term planning and regulations of the power system are centralized at the national or federal level. Though local utilities may be able to independently develop business strategies and expansion plans, they must ultimately comply with national guidelines as well as sectoral plans and policies. Brazil's Nationally Interconnected System covers 98% of the country's electricity consumption, and as a result, almost all of the high-level planning and policymaking that shape Rio de Janeiro's power system are devised at the federal level. This lack of direct control over long-term planning can hinder cities' capacity to implement improvements that directly respond to local challenges, or to meet targets that are typically more ambitious than those set at the national level.

In some cases, power sector oversight has been shared by national and local governments, causing a duplication of responsibilities as well as a tension in local governments' efforts to provide electricity directly to their residents. In Lagos, this tension was addressed in 2022 when the national senate passed a bill to allow states to generate and distribute electricity. The Lagos State Government has established its own Ministry of Energy and Mineral Resources, as well as a state regulatory agency, electricity board and the Lagos State Power Council, which encourages private-sector participation in power generation.

COMPARATIVE ENERGY MIX



KEY

- Hydropower
- Wind
- Nuclear
- Pumped storage
- Coal
- Solar
- Biogas & Biomasse
- CSP
- Gas
- Others

Increased participation and direct engagement in power-sector-related planning allows cities to take advantage of local generation capacity, local economic resources and to effectively lead the charge in a clean and resilient future. Through distributed renewable energy generation as well as large-scale renewable projects, cities can supplant high-emitting energy production at the national level with cleaner, local alternatives. In addition to being low-carbon, these alternatives can help cities expand energy access in hard-to-reach or otherwise vulnerable communities.

Cities are also working to incentivize electricity generation at the household level, utilizing innovative financial and policy measures to encourage homeowners to invest in renewable energy technologies. In Rio de Janeiro, the capacity of on-site solar PV generation has increased dramatically over the last seven years, growing by almost 14,000%. This has been made possible by the development of new credit lines, which allow households to invest in renewables as well as local policies that allow homeowners to invest in shared generation. With a capacity of 137 MW, solar PV now represents 95% of the city's total distributed generation capacity, predominantly spread across residential, commercial, and public sector facilities.

SPOTLIGHT: POWERING CRITICAL SERVICES WITH DISTRIBUTED RENEWABLE ENERGY

Solar installations on hospitals, schools and other public institutions have not only allowed municipal governments to model clean energy transition and encourage residents to invest in these technologies but have also become the primary source of electricity during grid failures and extended blackouts in some cities. Lagos State's Solar Nigeria Program has enabled 172 schools and 11 primary health care centers to be powered through off-grid solar systems, delivering electricity to about 920,000 beneficiaries, which otherwise would have remained unconnected. The important role of these off-grid energy alternatives in powering critical infrastructure and thereby enhancing resilience in the city was especially pronounced during the peak of the COVID-19 pandemic.

CLOSING THE ACCESS AND AFFORDABILITY GAP

Reliable electricity supply remains out of reach for many urban residents despite great strides towards universal access in the last decades, with limited technical capacity, inaccessible site conditions and prohibitive costs remaining the largest barriers to energy access expansion. High connection costs and consumption tariffs have been linked to widespread energy thefts, with dangerous consequences for users and the grid stability alike. While distributed renewable energy solutions (DRE) have been looked to as a potential solution for increasing access to affordable electricity, without the proper regulation and market support, these may in fact limit cities' ability to provide electricity to low-income communities.

As energy costs have climbed, cities and states alike have attempted to mitigate the cost with significant subsidies. In Cape Town, local government is actively trying to close the access and affordability gap despite much of the power system being managed by the national utility, Eskom. With electricity tariffs increasing by 753% over the last ten years (as compared to a rise in inflation of 134%), energy theft has increased dramatically across Cape Town. To counter this trend, the city offers low-income households both subsidized grid connections and a subsidized tariff, partially funded by South Africa's Free Basic Energy allocation. These steps have worked to buffer the national utility's tariff increases and resulted in monthly electricity costs staying stable for households consuming between 50-200 kWh of electricity per month despite the tariff hikes.

Subsidies have also been critical in preventing energy theft through illegal connections in many instances. In certain cities, illegal connections have become widespread due to the prevalence of criminal groups controlling municipal services, particularly in informal settlements, or the lack of meters to effectively regulate and measure supply. By subsidizing and formalizing grid connections, cities can reduce the risk that illegal connections pose to the end-user and to the grid itself and can ensure more consistent revenue.

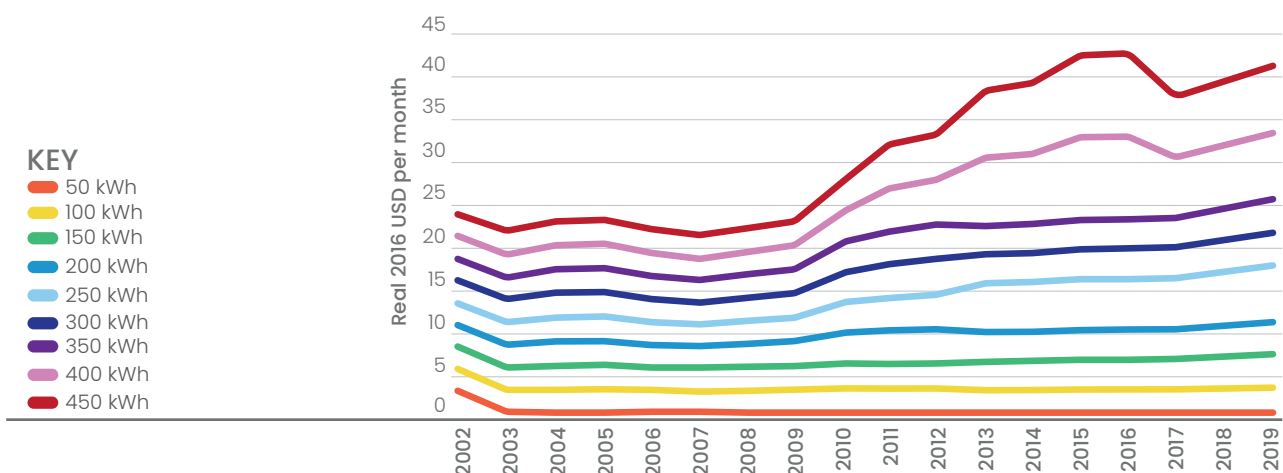
DRE solutions may also help expand access for the urban poor and vulnerable populations particularly by providing hard-to-reach areas with a grid alternative. In 2015, Cali’s multiservice utility – EMCALI – launched the Sustainable Households Program through which it financed and installed rooftop solar panels for low-income households to reduce the cost of electricity for particularly vulnerable families. The utility also provided smart meters for prepayment services to allow households to plan their energy consumption better and pay in small installments. EMCALI aims to expand the program to support more than 5,000 households by the end of 2023 and collaborate with the national institutions for large-scale implementation.

However, DRE solutions pose their own challenges relative to building more accessible and equitable grid systems. In Cape Town, where load shedding has become a part of daily life, high-income residents are increasingly turning to DRE to meet their energy needs. This means they are moving away from the grid and paying less into the system that subsidizes connections for low-income users. Cities must ensure that the roll out of these technologies are coupled with policies that account for the value and cost of such technologies on the existing grid infrastructure to ensure that the urban poor don’t get left behind.

SPOTLIGHT: ENERGY THEFT

Energy theft is a major challenge in cities like Rio de Janeiro, where access to public services is controlled by criminal groups across many low-income areas and informal settlements. Revulusolar, a local non-profit organization, is working to implement solar energy cooperatives in two informal settlements in southern Rio. Through the cooperative, Revulusolar is working to simultaneously install solar PV and energy efficiency retrofits, train residents in solar installation and electrical work, and provide environmental education for children and youth. These systems have generated more than 100,000 kWh and saved more than \$17,000 in electricity costs for residents.

COST OF ELECTRICITY TO HOUSEHOLDS ON THE LIFELINE TARIFF IN CAPE TOWN FOR VARYING MONTHLY CONSUMPTION SINCE TARIFF INTRODUCTION IN 2003



DEVELOPING URBAN ENERGY MARKETS TO CREATE GREEN JOBS AND REDUCE ENERGY POVERTY

Cape Town's Mayor Geordan Hill-Lewis has said on more than one occasion, "If cities are serious about making an impact on unemployment and poverty, you have to sort out electricity."¹ Across cities, clean energy rollouts hold the promise of green jobs and of reinventing local economies. By implementing training programs that target emerging jobs like solar PV installation, municipalities can also help lift low-income populations out of poverty and increase their competitiveness in national markets. Due to the possibility of small-scale local production, clean energy also opens the door to small and medium-sized businesses to participate in local electricity markets that can complement or provide an alternative to centralized national markets.

As a start-up and investment hub, Cape Town has become a center for various energy companies from around the world. The City established the Atlantis Greentech Special Economic Zone in 2011 to attract large manufacturers and investors in renewable energy technologies, green building materials, electric vehicles, and other green technologies. The manufacturing hub is expected to continue to attract more foreign direct investment in renewable energy and unlock the economic value of local resources and human capacity. As cities foster enabling environments for private sector engagement, they create more opportunities for innovation, collaboration, and green jobs.

In Lagos, the state government is currently considering establishing a local electricity market, which the state estimates would complement the centralized national market and have the potential to increase the installed capacity from 1,000 MW (in 2022) to 12,000 MW. The state government also estimates that renewable energy has the potential to create millions of jobs, given the potential for expanding the local manufacturing capacity and the need for a rapid generation expansion to meet the local energy demand.

Despite the clear potential of these markets and the urgent need to transition urban power systems, cities are still struggling to access the financing needed to facilitate their development and to initiate transformative energy resilience projects. As institutional investors primarily loan to national governments, the funding available to cities to independently initiate projects is insufficient. Moreover, many cities lack the capacity to research and identify appropriate grants and loans that could be used to support large-scale energy projects. Cities need more support and more targeted funding mechanisms that can enable resilience-building across the urban power system.

SPOTLIGHT: INTEGRATING LOCAL BUSINESS SECTORS

In Cali's broader metropolitan region, leading local economic sectors are revising business practices in order to contribute to renewable energy production. Colombia's sugarcane industry has become one of the region's main energy sources, with power generation capacity of 336.2 MW from bagasse produced from the sugarcane grown and processed in Cali's surrounding areas. It is estimated that by 2024, Colombia's Association of Sugarcane Growers (Asocaña) will have the capacity to generate 392.4MW, exporting over 210 MW of surplus power back to the grid.

¹ Joseph Cotterill, "Cape Town to source its own power as state-owned monopoly Eskom falters," Financial Times <https://www.ft.com/content/69f84a8c-ad42-4b78-b648-7d112139025e> (Accessed March 10, 2023)

CONCLUSION

The Urban Power profiles show that despite the multiple resilience challenges cities face, they are taking bold and creative actions to overcome legislative and regulatory barriers, make electricity more affordable and accessible and develop local markets to create jobs that support a green and equitable energy transition. However, cities cannot do all this alone.

To support them, we as a global community of governments, partners, funders, and city networks, must invest in the collection and analysis of data that enable city governments to take more coordinated and holistic action. For many cities, lack of access to consistent and reliable energy data remains a chief barrier in understanding the true challenges to and opportunities in building energy resilience. Increased communication between the bodies responsible for municipal, regional, and national planning is crucial to ensure consistent and coordinated energy sector development. Enhancing the resilience of urban power systems and facilitating the energy transition will require more investment in sub-national data and technologies that enable cities to meet energy demands alongside concentrated work to disrupt the silos that impact data-sharing and coordination.

We must also form multidisciplinary teams and coalitions that can help cities design projects that not only address urban energy resilience challenges but help secure resilience co-benefits in the process. We need to create avenues that enable urban poor and vulnerable communities to take part in the process and help design the solutions and interventions that will ultimately support their resilience. As documented in these profiles, urban power systems intersect with a wide range of city systems and their resilience, or lack thereof, directly links to residents' ability to live well-connected, secure, and integrated lives.

Visit the [Urban Power website](#) to read the full profiles and learn more about the Urban Power program..



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