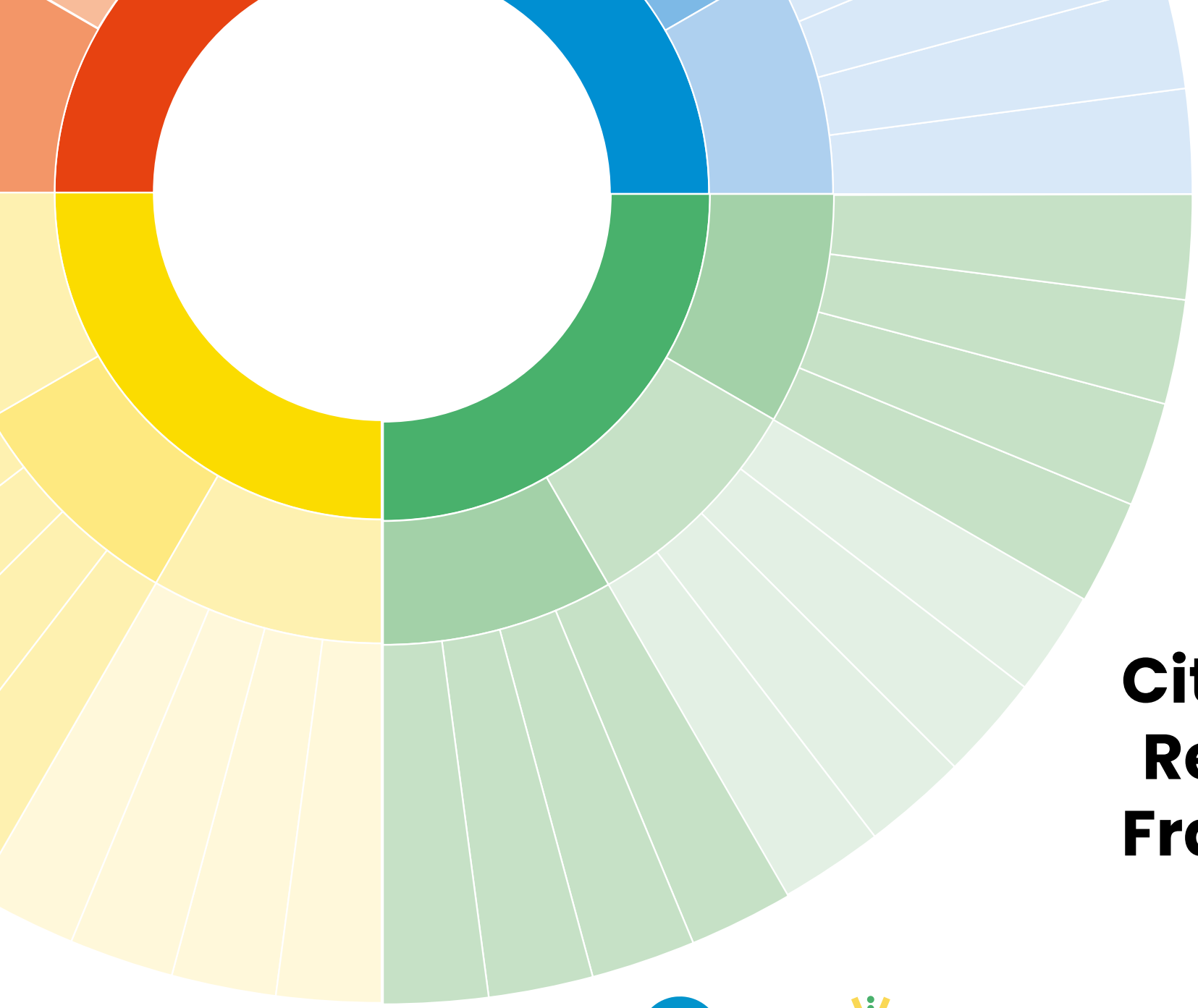

City Energy Resilience Framework

RESILIENT CITIES NETWORK

URBAN POWER

IMPRINT

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Resilient Cities Network (R-Cities)

Registered offices:
Mexico City
Durango 195- Piso 7 Sur, Roma Norte, 06700, Mexico City

New York City
28 Liberty Street, LISC Floor 34, NY, NY 10005

Rotterdam
Korte Hoogstraat 31, 3011 GK, Rotterdam, The Netherlands

Singapore
#06-01, 182 Cecil St, Frasers Tower, Singapore 069547

Program description:
Urban Power

Contact:
cerf.info@r-cities.org

Authors:
Eskedar Gessesse (R-Cities), Gladys Tan (R-Cities), Ada Rustow (R-Cities)

Design/layout:
Razvan Zamfira (R-Cities)

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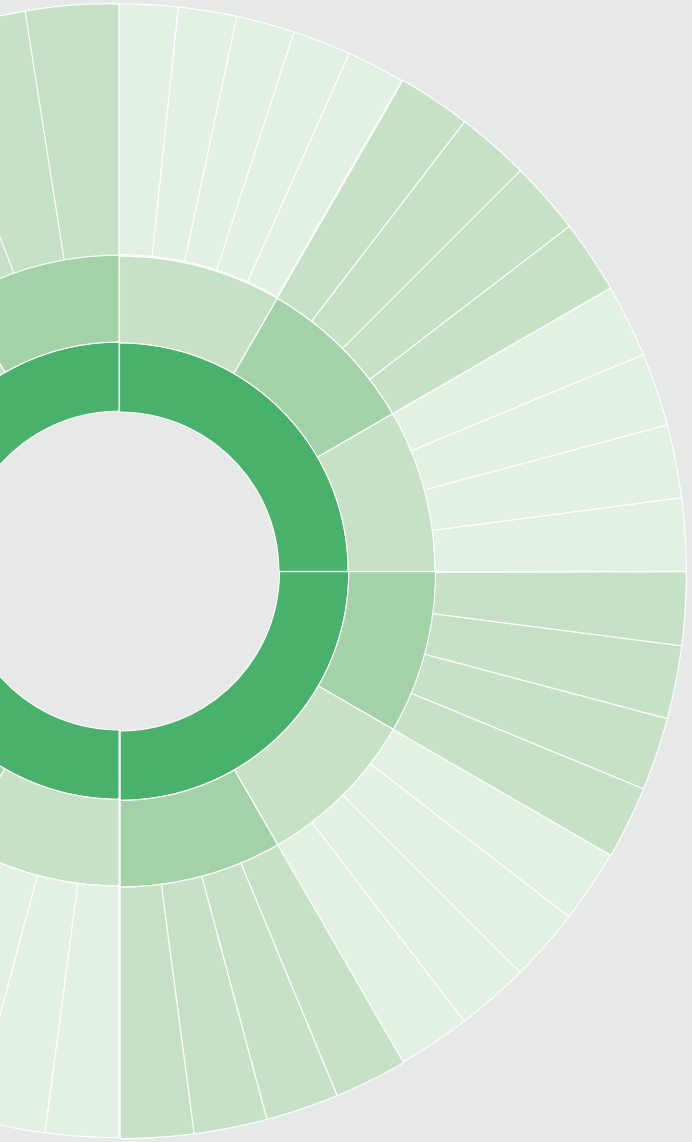

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We are grateful to the S&P Global Foundation for supporting the development of the City Energy Resilience Framework, a tool designed to help cities apply a resilience lens to their energy system and engage stakeholders from across the energy system to deploy solutions that have knock-on effects across various urban sectors.

We appreciate the collaboration and feedback from four network member cities: Cali, Cape Town, Lagos and Rio de Janeiro, which applied an earlier iteration of the Framework that was designed to screen and identify major gaps in their city's energy resilience. In particular, we would like to thank the local government representatives and implementation partners who participated in this trial and provided targeted feedback to improve the Framework's structure and application.

We acknowledge the valuable contributions from Arup and the City of Rotterdam, which provided technical guidance during the development of the Framework. We also thank the following energy and resilience experts from various organizations who participated in technical review sessions: Tory Grieves and Rick Lord (S&P Global), Katie Van Dyke (City of Berkeley), Stephanie Hirmer (Oxford University), Kathryn Wright (Barr Foundation), Simbo Sojinrin (Solar Sister), Ricardo Luis Guerrero Lemus (Universidad De La Laguna), Matt Kennedy (Arup Ireland), Wilson Rickerson (Converge Strategies) and Mike Mulcahy (GreenCape).

BACKGROUND

ENERGY AND URBAN RESILIENCE

Urban resilience is the capacity of cities to survive, adapt and thrive in the face of various chronic stresses and acute shocks. Energy is a vital component of urban resilience, as it enables the provision of essential services and functions for urban communities. However, energy systems are also vulnerable to disruptions that affect their operation and performance. A holistic approach to energy and urban resilience requires cities to:

Understand not only the risks and vulnerabilities of their physical energy infrastructure but also the interconnections and interdependencies among the different urban systems and actors that influence the production, distribution and consumption of energy in cities.

Examine their institutional arrangements, alignment and collaborations in order to understand and respond effectively to critical energy challenges.

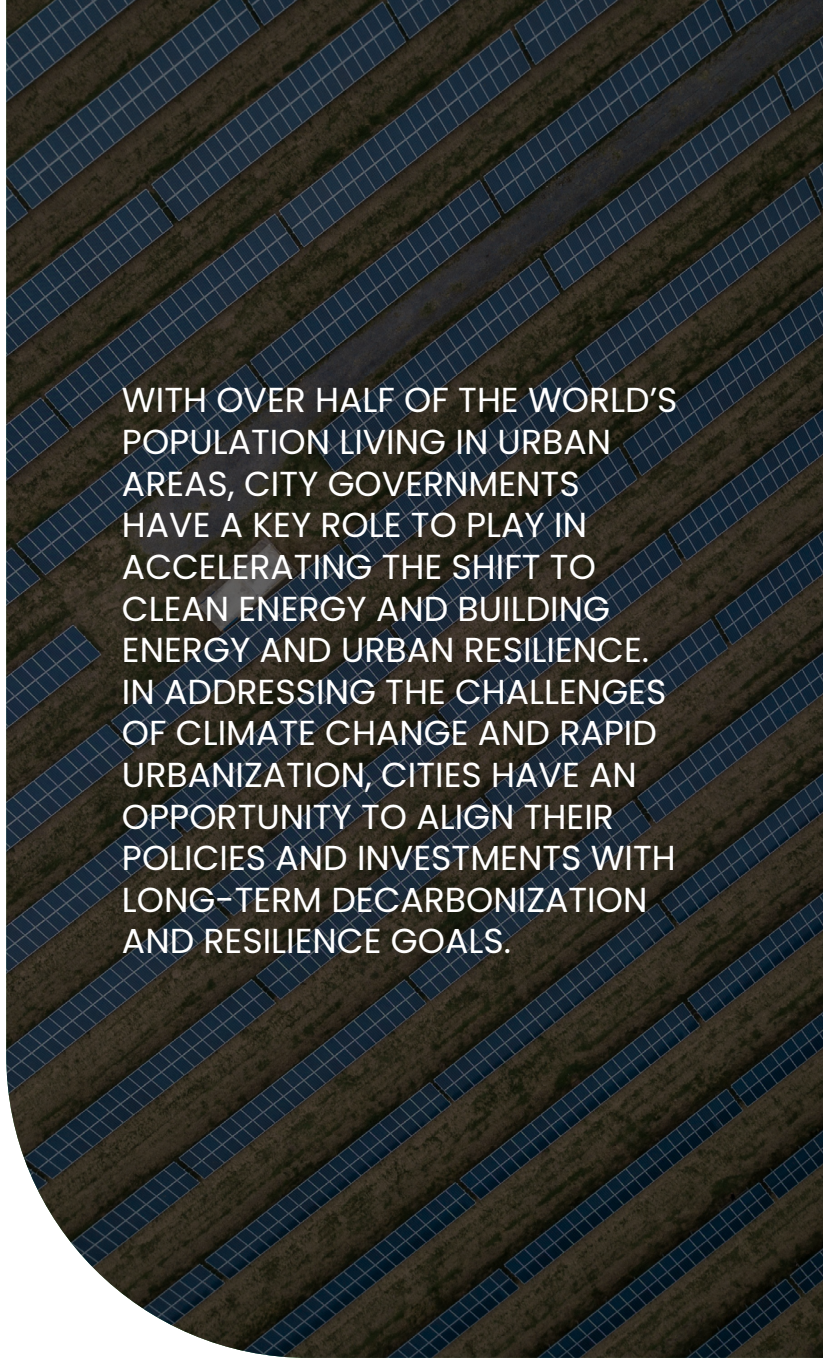
Assess the social, economic and environmental aspects of advancements and transitions within the energy system and the potential costs and benefits for urban development and quality of life.

Energy and urban resilience depend on effective communication, collaboration and coordination among various stakeholders at different levels. To build an energy system's resilience, it is necessary to look beyond technical solutions and address the social and institutional challenges that may affect the system's operation and management. Through investing in energy resilience, cities are able to:

1. **ENHANCE ACCESS TO RELIABLE, AFFORDABLE AND QUALITY PUBLIC SERVICES.**
2. **CREATE DECENT GREEN JOBS.**
3. **BOLSTER LOCAL ECONOMIES BY SUPPORTING INNOVATION AND ENTREPRENEURSHIP.**
4. **ADVANCE DIGITALIZATION EFFORTS FOR EFFICIENCY AND INTERCONNECTIVITY.**
5. **IMPROVE THE QUALITY OF LIFE FOR URBAN RESIDENTS, ESPECIALLY THE POOR AND VULNERABLE.**

The policy and planning choices that governments make in response to today's challenges will determine not only how they bounce back from acute shocks and chronic stresses that affect urban systems but also how successful they are in building a greener, fairer, more inclusive and more resilient future.

Urban resilience is a dynamic process that requires continuous engagement, innovation, adjustment and transformation. To this end, the City Energy Resilience Framework (CERF) and its Discussion Guide can help cities improve their approach to resilience and prioritize areas for improvement and action.



INTRODUCING THE CITY ENERGY RESILIENCE FRAMEWORK

PURPOSE OF THE FRAMEWORK

The City Energy Resilience Framework (CERF) guides cities in applying a resilience lens to their power system and working toward their overall energy transition and urban resilience goals. It incorporates key elements at the nexus of electricity infrastructure resilience, clean energy transition, equitable access to public services, effective emergency management and efficient recovery from shocks and stresses. CERF is an engagement tool to enable city governments to bring together stakeholders from various sectors to assess the gaps and challenges, as well as the goals and opportunities, for a more resilient energy system based on local policies, plans and initiatives. It aims to spark conversations, guided by examples from around the globe, about driving the uptake of energy solutions that have multiple benefits, which enhance the ability of urban communities to adapt, survive and thrive in the face of shocks and stresses.

TARGETED AUDIENCE

Although energy systems are often managed and regulated at the national level, cities have a key role to play in enhancing energy resilience at the local level. The CERF aims to help city governments adopt proactive approaches, by building a shared understanding of energy resilience and identifying and prioritizing the main gaps in the enabling environment (from national to municipal level), planning and infrastructure management, financing environment, disaster management and citizen engagement. It is designed to encourage city governments to lead efforts to enhance their energy resilience, while acknowledging that some local governments may have limited or no authority to change their electricity system significantly. City governments can use the CERF to identify gaps and implement solutions directly or, in cases where they have limited roles, to engage stakeholders from across the energy system in important conversations, which can lead to solutions that benefit multiple urban systems.

SCOPE AND LIMITATIONS

The CERF focuses on the electric power system, which is the main source of modern energy upon which various urban systems rely. Although end-use sectors, such as transportation and non-electric, fuel-based industrial and commercial activities, are important components of a city's energy system, the CERF is developed specifically to help cities identify challenges related to the efficient management, greening and resilience-building of the electric power system.

The CERF considers urban systems (e.g., healthcare, information, communication and water) that rely on the electric power system and the growing interdependencies across these systems, as many city governments are increasing the electrification and digitalization of various sectors for efficiency and connectivity.

As the electric power system's scope, interdependency and complexity grows, city governments need to continuously assess and mitigate risks to prevent the cascading effects of power system disruptions. Although the CERF does not explicitly outline resilience goals for non-electric systems, it does guide city governments towards actions that include and may benefit several urban systems.

PRINCIPLES: HOLISTIC APPROACH TO ENERGY RESILIENCE

Energy-system resilience, affordability, energy security and the clean energy transition are typically seen as competing priorities that require tradeoffs and compromises. For instance, improving the resilience of electricity infrastructure may require large investments, but these may then increase the cost of service and push up energy prices. Similarly, investing in distributed renewable energy sources may improve the energy system's resilience by reducing dependence on centralized grids and fossil fuels, but integrating more variable sources into local electricity generation may affect energy security. While these realities are undeniable, the CERF helps cities to adopt a holistic and integrated approach that balances and optimizes these priorities, rather than focusing on one at the expense of another.

Holistic resilience thinking not only builds urban resilience through greener energy systems, but also ensures that city electric power systems are resilient to natural hazards, extreme weather events and other threats. Resilience thinking contributes to designing and managing power systems that are adaptive, robust and sustainable, even when faced with anticipated or unanticipated shocks and stresses.

The CERF is based on four cross-cutting principles, to help cities prioritize pathways that achieve multiple benefits for residents by aligning and synergizing various objectives. These principles are reflected across the goals outlined in the CERF and intended to push cities toward equitable, risk-aware and eco-friendly solutions that leverage the interconnectedness of urban systems for overall resilience.

1. **Equity-Centered:** Providing equitable access to clean, safe, affordable and reliable energy by empowering multiple stakeholders and citizens, particularly the most vulnerable ones, to engage in decision-making processes.

2. **Risk-Aware:** Understanding the energy system's risks and vulnerabilities by leveraging data and technology for informed governance, planning, design and operation.

3. **Systems-Enabled:** Prioritizing solutions that leverage the intersectionality of different urban systems, reduce vulnerabilities and yield multiple benefits across the city.

4. **Ecology-Focused:** Accelerating the transformation of local economies through clean energy solutions that address the climate change crisis and foster low-carbon development, balancing human life and the built and natural environment.

DEVELOPING THE FRAMEWORK

LITERATURE REVIEW:

The framework-development process started with extensive research and a literature review to identify existing reports, frameworks and tools on energy system resilience. The foundational resources included the United Nation's Sustainable Development Goals,[1] good practice notes from World Bank's Global Facility for Disaster Reduction and Recovery,[2] and the City Resilience Framework.[3] These resources covered topics related to affordable and equitable access, renewable energy transition, sustainable cities, strong institutions, disaster management and overall urban resilience. The Framework drew inspiration from various urban and energy resilience and recovery frameworks, such as R-Cities' Resilient Recovery Framework, Arup's Energy Resilience Framework[4], City Water Resilience Approach[5] and the Rocky Mountain Institute's Reimagining Grid Resilience[6]. Frameworks were compared to craft a holistic definition of a resilient urban energy system. The Framework also benefited from the Resilient Cities Network's expertise and insight on how cities can build resilience across various urban systems.

APPLICATION:

An initial version of the Framework was tested across four cities that participated in Resilient Cities Network's Urban Power program: Cali, Cape Town, Lagos, and Rio de Janeiro. The goals from an earlier version of the Framework were used to assess whether the cities have undertaken the necessary actions to meet each goal. The test focused on identifying elements of energy transition, access to public services and infrastructure resilience that should be included to further expand the Framework. Feedback on each goal's clarity and specificity was also captured and incorporated into the revised version of the Framework and the Discussion Guide (Annex I).

TECHNICAL CONSULTATIONS:

The Framework team held consultative workshops to gather technical feedback on the structure and content of the Framework from Arup and the City of Rotterdam, who served as technical partners in the early stages of the framework-development process. The workshops helped to identify gaps in the list of goals and features that could improve the Framework's applicability and practicality for city decision-makers.

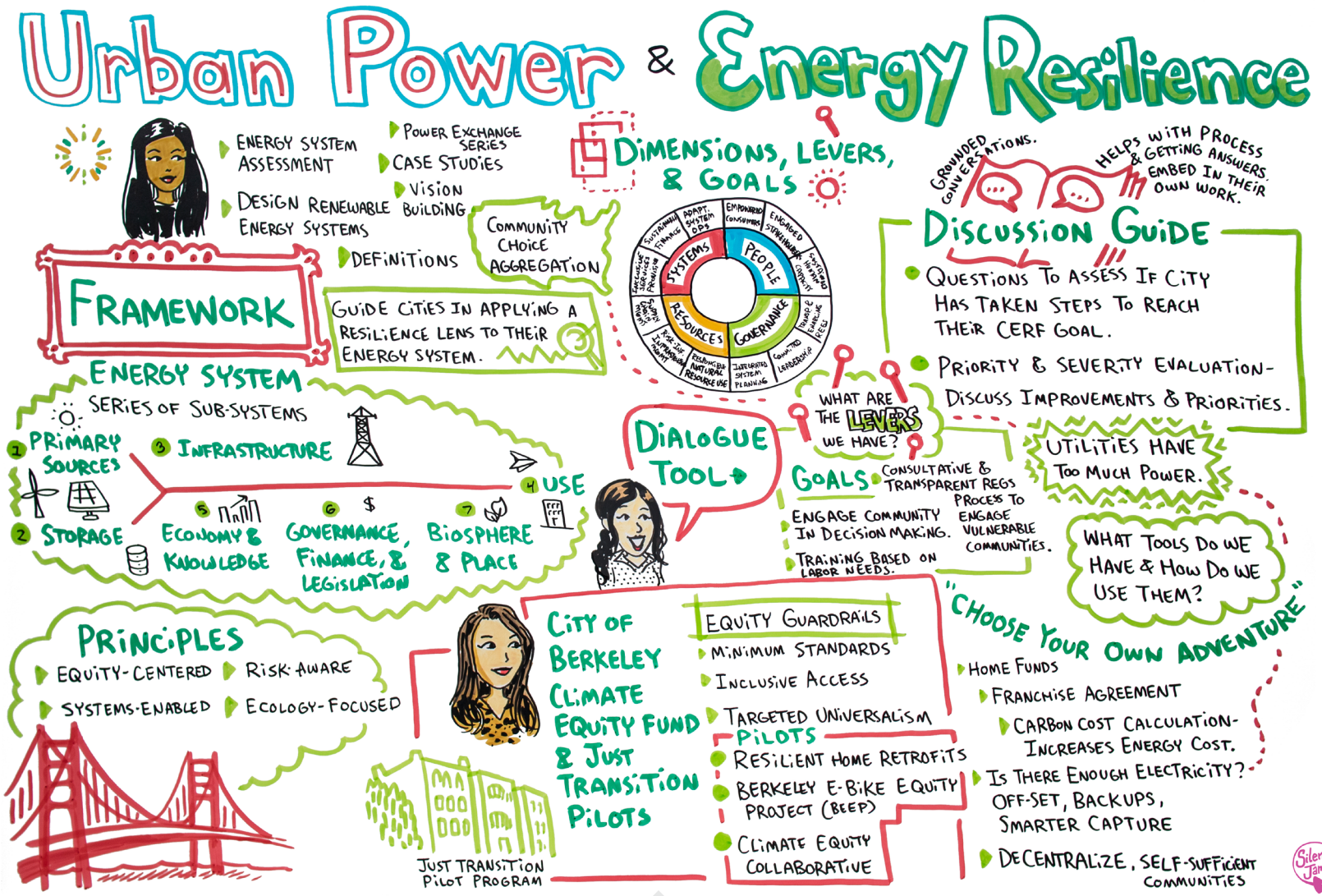
TECHNICAL EXPERT REVIEWS:

The Framework team conducted three technical expert review sessions with 12 external reviewers (listed below) from city governments, partner organizations and academia that specialize in urban resilience, infrastructure resilience, energy transition, inclusive electricity access, disaster management, data management and energy transition. Reviewers provided guidance on balancing the different elements of the Framework, clarity of language, and structuring of goals across levers and dimensions. Reviewers also shared existing resources and tools that could further inform the Framework.

IN-CITY IMPLEMENTATION:

An updated version of the CERF was implemented in three additional member cities of the Resilient Cities Network: Addis Ababa, The Hague, and Monterrey. Based on the processes of implementation and feedback from participating cities, the framework's language was slightly revised to increase accessibility for a wide range of city audiences. Additionally, the workshop design process helped standardize a best practices facilitation process to be used by cities going forward.

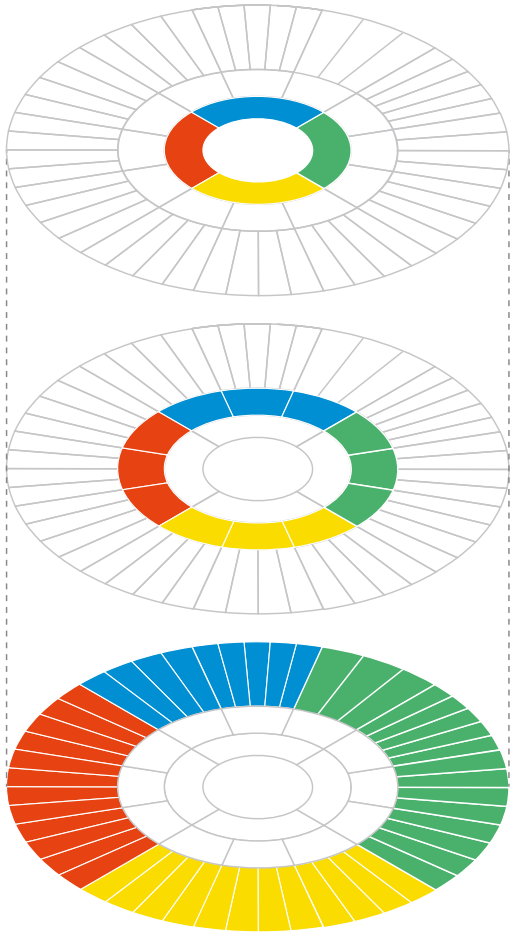
ARUP | BARR FOUNDATION | CITY OF BERKELEY | CITY OF ROTTERDAM | CONVERGE STRATEGIES | GREENCAPE | OXFORD UNIVERSITY RESILIENT CITIES NETWORK | ROCKY MOUNTAIN INSTITUTE | S&P GLOBAL SOLAR SISTER NIGERIA | UNIVERSITY DE LA LAGUNA



Graphic notes from a workshop session during the development of the City Energy Resilience Framework in partnership with the city of Berkeley, California.

FRAMEWORK DIMENSIONS, LEVERS, AND GOALS

To look at a city's energy resilience, the CERF uses four dimensions, 12 levers and 48 goals.



4
dimensions

FOUR DIMENSIONS
The dimensions outline the various stakeholders, systems and resources that must come together to build a resilient energy system.

PEOPLE: End users and stakeholders

GOVERNANCE: Leadership and strategy

RESOURCES: Infrastructure and natural resources

SYSTEMS: Operations and management

12
levers

The levers are mechanisms that decision-makers can use to drive efforts aimed at energy transitions and building resilience in urban energy systems.

48
goals

The goals are actions or pathways that cities can pursue to build resilient energy systems and move towards a low-carbon economy.

URBAN RESILIENCE IS THE CAPACITY OF INDIVIDUALS, COMMUNITIES, INSTITUTIONS, BUSINESSES AND SYSTEMS WITHIN A CITY TO SURVIVE, ADAPT AND GROW NO MATTER WHAT KINDS OF CHRONIC STRESSES AND ACUTE SHOCKS THEY EXPERIENCE.

THE SEVEN QUALITIES OF RESILIENCE: INTEGRATED, INCLUSIVE, FLEXIBLE, REDUNDANT, REFLECTIVE, RESOURCEFUL, AND ROBUST.

THE ROCKEFELLER FOUNDATION AND ARUP. 2015. CITY RESILIENCE FRAMEWORK


SYSTEMS
Operations and Management
PEOPLE
Endusers and Stakeholders
RESOURCES
Infrastructure and Natural Resources
GOVERNANCE
Leadership and Strategy
Adaptive System Operation
Sustainable Finance
Inclusive Service Provision
Empowered Consumers
Engaged Stakeholders
Sustained Human Capacity
Effective Supply Chain Management
Risk-Informed Infrastructure Management
Responsible Natural Resource Use
Integrated Infrastructure Planning
Coordinated & Committed Leadership
Transparent & Enabling Regulations
12.1 Enforcement of standards for effective system operations and service delivery, informed by prevalent shocks and stresses.
12.2 Disaster management plans informed by climate risks and post-disaster reflection.
12.3 Alignment of recovery processes with long-term power system development and resilience goals.
11.5 Dedicated funds for system maintenance, upgrades and grid modernization based on emerging risks.
11.4 Guidance on allocating emergency resources for coordinated response and recovery from shocks and stresses.
11.3 Guidance on assessing and disclosing climate risk for all power system investments.
11.2 Guidance and enforcement of infrastructure investment criteria based on social, environmental and economic assessment.
11.1 Guidance on sustainable business models and financial management for key institutions across the power system.
10.4 Accessible financial solutions and incentives for consumers to participate in clean energy transitions.
10.3 Established channels for community input to ensure iterative and inclusive service planning.
10.2 Disaster management plans co-created with vulnerable and hard-to-reach communities.
10.1 Inclusive electrification plan for universal access to clean, affordable, reliable and modern energy services.
9.4 Regular monitoring and replenishment of resources and emergency reserves across the power supply chain.
9.3 Established communication channels for diverse stakeholders in the power system that enable coordinated response and recovery from shocks and stresses.
9.2 Guidance on allocation of infrastructure risk and resilience responsibilities across stakeholders in the power system during project development.
9.1 Regular and open data-sharing across key decision-makers and operators throughout the power system.
8.4 Integration of secure and up-to-date digital systems for infrastructure management, monitoring, forecasting and early warning.
8.3 Identification of critical power system components and services for pre-disaster preparedness and effective response and recovery.
8.2 Incorporation of operational redundancies at infrastructure level to ensure reliable services during shocks and stresses.
8.1 Enforcement of infrastructure design and construction standards, informed by assessments of prevalent shocks and stresses.
7.4 Guidance and incentives for energy-sensitive design principles in new developments.
7.3 Natural resources development plan in line with environmental sustainability and biodiversity goals.
7.2 Guidance and incentives for sustainable resource use and demand management in energy-intensive facilities and urban systems.
7.1 Public land development plans for power infrastructure based on environmental and social impact assessments.
6.4 Short- and long-term strategies aligned across timescales and informed by scenario planning and prevalent shocks and stresses.
6.3 Data-driven power infrastructure planning informed by inclusive and multi-stakeholder data collection processes.
6.2 Power infrastructure planning for new and disruptive technologies and innovative service delivery models.
6.1 Collaborative power infrastructure planning that considers interconnected urban systems, informed by development plans of shocks and stresses.
5.4 Clearly defined institutional roles for managing the impact of power-related shocks and stresses.
5.3 Official and publicly available climate and resilience strategies and plans.
5.2 Alignment of clean energy transition goals with city's long-term development objectives.
5.1 Coordination and collaboration among different levels of government to achieve power-related goals.
4.4 Enabling regulations and labor policies for the development of the local clean energy market.
4.3 Transparent decision-making on public spending and disbursement procedures for power system development and clean energy transition.
4.2 Transparent and enforced electricity service quality standards.
4.1 Consultative and transparent regulatory processes and labor policies that engage vulnerable and historically disadvantaged communities.
3.4 Consistent knowledge exchange within city government and with peer cities to build the capacity of municipal staff.
3.3 Targeted education strategies and dedicated public resources to encourage the participation of historically disadvantaged groups in the labor force.
3.2 Capacity-building strategies for community preparedness and response to power-system-related shocks and stresses.
3.1 Education and training strategies developed based on labor needs throughout the power system.
2.3 Accessible incentives and public resources to drive innovation and investment in research and development of new technologies.
2.2 Coordination and collaboration among government, private sector, civil society and academia in short- and long-term strategy development and planning.
2.1 Resource mobilization informed by local, regional and national policies and long-term plans.
1.5 Promotion of accessible and affordable hazard insurance and emergency savings for consumers.
1.4 Education programs on climate risks and vulnerabilities of the power system.
1.3 Active engagement of communities in the decision-making process and throughout the power infrastructure and project lifecycles.
1.2 Communication of available resources, programs and opportunities to all stakeholders.
1.1 Education and awareness-building strategies and initiatives for clean energy transition.

PEOPLE

People refers to mechanisms and steps that need to be taken, so that the human capacity available within the city are effectively used to build a reflective and robust electricity system.This dimension's goals and levers include actions that city governments can take to maximize and benefit from the human capacity within the city and to empower vulnerable and historically underrepresented groups in decision-making.

Empowered Consumers

Effective communication channels, education and awareness-building for inclusive decision-making, program/project design and implementation.

Engaged Stakeholders

Coordination and collaboration among stakeholders across the energy system, including different levels of government, for decision-making, resource mobilization and innovation.

Sustained Human Capacity

Policies, plans and platforms for education and capacity-building that elevate historically underrepresented groups and ensure adequate human capacity for the effective management and operation of energy infrastructure.

GOVERNANCE

Governance refers to the key components of strategic planning, leadership and effective regulations needed to align various stakeholders around a shared vision. This dimension's levers and goals encourage city governments to consider all the key decision-makers within the energy system, from national to local government and including businesses and civil societies, for inclusive, resourceful and evidence-based decision-making.

Transparent and Enabling Regulations

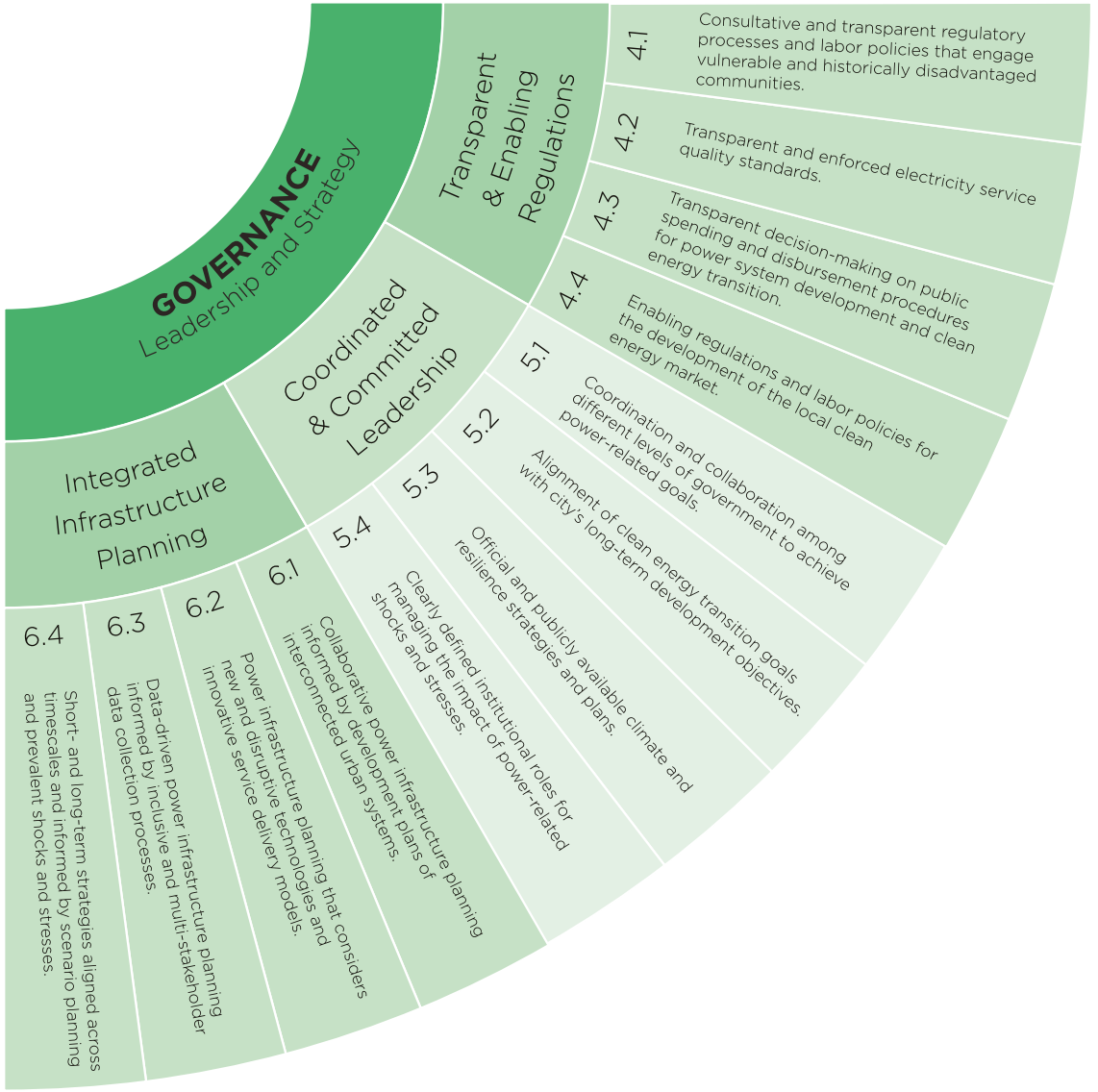
Transparent regulatory processes that safeguard the public interest and enforce guidelines aligned with the city's strategic vision.

Coordinated and Committed Leadership

Political will and governance that consider voices from across systems and communities.

Integrated System Planning

Integrated and adaptive system planning that considers new technologies, evolving best practices, and emerging shocks and stresses across interdependent urban systems.



RESOURCES

Resources refer to the technical and strategic approaches for the protection and well-being of the human, physical and environmental resources that exist within and beyond the city's electricity system. This dimension's goals and levers guide city governments in engaging with relevant stakeholders and decision-makers across the supply chain for reflective and ecology-focused management of resources.

Responsible Natural Resource Use

Concerted effort to drive energy transition and foster low-carbon economies that exist within the planetary boundaries.

Risk-Informed Infrastructure Management

Infrastructure design, plans and procedures, which are informed by prevalent shocks and stresses, for timely, collaborative and efficient infrastructure management, as well as response and recovery from shocks and stresses.

Effective Supply Chain Management

Coordination between institutions and stakeholders for information-sharing and cooperation, to reduce the impact of shocks and stresses on the urban energy system and its interdependencies.

SYSTEMS

Systems refers to the complex and interconnected institutions, infrastructure and information that must come together for integrated, robust and flexible electricity system management and service provision. This dimension's levers and goals include approaches that city governments can pursue to ensure their electricity system's financial and operational sustainability and to provide equitable access to all city residents.

Inclusive Service Provision

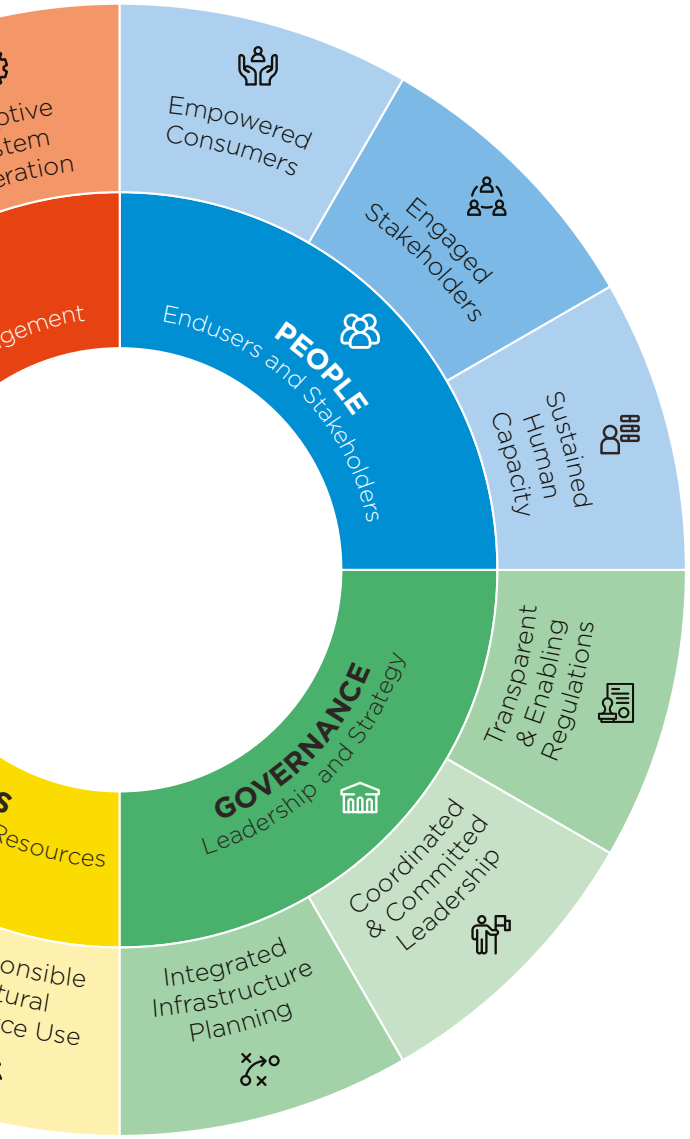
Infrastructure planning and service delivery for universal access and socially responsible response and recovery from shocks and stresses.

Sustainable Finance

Data-informed financial frameworks and investment approaches that consider changing economic conditions, technologies and risks.

Adaptive System Operation

Strategies and procedures for system operation that are informed by latest climate and disaster risk data and in line with long-term energy and urban resilience goals.



CONCLUSION AND LOOKING AHEAD

The collective effort of cities and their partners to create and shape resilient urban economies will determine the world's ability to meet sustainable development and climate change mitigation targets and to facilitate a paradigm shift towards low-carbon development.

The CERF represents a significant step forward in addressing the complex challenges of energy system resilience in cities. The tool has been digitalized, to provide cities with increased and simplified access to its analysis functionalities as well as the customizable features crucial for the CERF broad application in a wide range of urban contexts.

GLOSSARY OF TERMS

Accessible: The concept that people with disabilities and or disadvantages are able to access and use a product or a system, including with the help of assistive technologies.

Adaptation: The process of adjustment to actual or expected climate and its effects.

Capacity building: Providing necessary resources to enhance that ability of people, organizations, and society to manage their affairs successfully, including supporting individual capacity such as knowledge and skill; organization capacity, such as strategies, systems, and processes; and enabling environmental capacities, such as frameworks that support economic, political, environmental and social factors.

City resilience: Capacity of cities to function, so that the people living and working in cities – particularly the poor and vulnerable – survive and thrive no matter what stresses or shocks they encounter. .

Clean energy transition: The large-scale shift away from fossil fuels towards renewable energy sources for electricity generation and other energy needs to reduce greenhouse gas emissions and combat climate change.

Climate risk: Potential for consequences from climate variability and change where something of value is at stake and the outcome is uncertain. Often represented as the probability that a hazardous event or trend occurs multiplied by the expected impact.

Consumers or end-users (electricity): Any individually metered dwelling, building, establishment, or location that purchases power from service provider.

Emergency Savings: Funds specifically set aside to cover unexpected expenses.

Energy services: The useful functions or benefits consumers (end-users) derive from energy use, such as lighting, heating, cooling, and powering appliances.

Energy intensive: Activity, process, facility or system that uses a large amount of energy to produce a unit of output.

Energy sensitive: Structures or facilities that prioritize minimizing energy consumption through a combination of features, such as passive heating and cooling strategies, smart controls for lighting and appliances, and building materials chosen for their thermal efficiency.

Flexible: Flexibility implies that systems can evolve and adapt in response to changing circumstances. This may favor decentralized and modular approaches to infrastructure or ecosystem management. Flexibility can be achieved through introducing new knowledge and technologies, as needed, including incorporating indigenous or traditional knowledge and practices in new ways.

Grid modernization: A process of upgrading the electricity grid with advanced technologies to make it smarter, with ability to communicate and manage electricity flow more efficiently; more resilient, with ability to monitor and withstand disruptions and restore power automatically; and more adaptable, with ability to integrate advanced technologies and energy resources to respond to changing demands.

Hazard insurance: Financial protection against potential damage that can be caused by sudden and unforeseen events.

Historically disadvantaged: Group of people or a community that has been systematically prevented from achieving equal opportunity due to past discriminatory laws or practices. These disadvantages can be social, economic, or educational.

Hard-to-reach: Individuals or communities who face significant challenges in accessing or benefiting from energy services. These challenges can be physical inaccessibility, such as geographical remoteness and lack of infrastructure or economic constraints, such as high upfront costs for connection. These groups are typically most vulnerable to energy poverty and lack access to reliable and affordable energy services.

Inclusive: Inclusion emphasizes the need to consult broadly and engage with communities, including the most vulnerable groups. An anathema to the notion of resilience is to address the shocks or stresses faced by one sector, location or community in isolation of others. An inclusive approach contributes to a sense of shared ownership or a joint vision to build city resilience.

Integrated Resource Plan: An integrated resource plan (IRP) is a roadmap that large utilities use to plan out generational acquisitions over multiple years. Many utilities use integrated resource plans for coal, natural gas, and smart grid energy.

Integrated: Integration and alignment between city systems promotes consistency in decision making and ensures that all investments are mutually supportive to a common outcome. Integration is evident within and between resilient systems, and across different scales of their operation. Exchange of information between systems enables them to function collectively and respond rapidly through shorter feedback loops throughout the city.

Planetary boundaries: Thresholds within which humanity can survive, develop and thrive for generations to come. Crossing these boundaries would lead to abrupt or irreversible planetary changes that would have a large-scale impact. The core boundaries include climate change and biosphere integrity.

Power infrastructure: The infrastructure system that includes all components related to the generation, transmission, and distribution of electricity, from point of production to point of consumption.

Power system: A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by control centers.

Redundant: Redundancy refers to spare capacity purposely created within systems so that they can accommodate disruption, extreme pressures or surges in demand. It includes diversity: the presence of multiple ways to

achieve a given need or fulfil a particular function. Examples include distributed infrastructure networks and resource reserves. Redundancies should be intentional, cost-effective and prioritized at a city-wide scale, and should not be an externality of inefficient design.

Reflective: Reflective systems accept the inherent and ever-increasing uncertainty and change in today's world. They have mechanisms to continuously evolve and will modify standards or norms based on emerging evidence, rather than seeking permanent solutions based on the status quo. As a result, people and institutions examine and systematically learn from their past experiences, leveraging this learning to inform future decision-making.

Resourceful: Resourcefulness implies that people and institutions are able to rapidly find different ways to achieve their goals or meet their needs during a shock or when under stress. This may include investing in capacity to anticipate future conditions, set priorities and respond, for example, by mobilizing and coordinating wider human, financial and physical resources. Resourcefulness is instrumental to a city's ability to restore functionality of critical systems, potentially under severely constrained conditions.

Robust: Robust systems include well-conceived, constructed and managed physical assets, so that they can withstand the impacts of hazard events without significant damage or loss of function. Robust design anticipates potential failures in systems, making provision to ensure failure is predictable, safe, and not disproportionate to the cause. Over-reliance on a single asset, cascading failure and design thresholds that might lead to catastrophic collapse if exceeded are actively avoided.

Scenario-Planning: A strategic, decision-making tool used to assess and account for various plausible future conditions (scenarios) that might impact an individual, organization, or community. The process involves identifying critical uncertainties that might impact the future, developing scenarios based on the uncertainties, exploring potential consequences of each scenario, and formulating appropriate adaptation strategies.

Shocks: Sudden, intense events, typically short-term but with significant impact on individuals, communities and systems within a city. Examples include natural disasters like earthquakes, floods, or heatwaves, as well as man-made events like terrorist attacks or infrastructure failures.

Stresses: Chronic challenges that weaken a city's ability to function effectively. They operate over a longer timeframe and erode a city's social and economic fabric. Examples include poverty, unemployment, limited access to healthcare, inadequate infrastructure, and social inequality.

Sustainable: Resource use or businesses model that endures over time and is resilient to the impacts of various types of shocks including climatic and economic.

Transparent: Sharing information, so all stakeholders know what is happening. Ideas are tested and issues are discussed in a variety of meetings, many of them with only some members present. Members approve of this process so long as information is shared.

Vulnerable: Varied capacity or inability of individuals or groups to deal with hazards and take effective measures to insure against losses. Vulnerability can be a result of physical and socioeconomic position, control over resources, as well as exposure to, awareness of, management of and ability to respond to risks.

ENDNOTES

1 United Nations. 2015. Sustainable Development Goals. https://sdgs.un.org/goals

2 World Bank Global Facility for Disaster Reduction and Recovery – Resilient Infrastructure https://www.gfdrr.org/en/resilient-infrastructure

3 Resilient Cities Network. City Resilience Framework https://resilientcitiesnetwork.org/city-resilience-framework/

4 Arup. 2019. Future-proofing energy systems: The Energy Resilience Framework https://www.arup.com/energy-resilience-framework

5 Arup and Rockefeller Foundation. 2019. City Water Resilience Approach https://www.arup.com/perspectives/publications/research/section/the-city-water-resilience-approach

6 Mark Dyson and Becky Xilu Li. 2020. Reimagining Grid Resilience: A Framework for Addressing Catastrophic Threats to the US Electricity Grid in an Era of Transformational Change. Rocky Mountain Institute. https://rmi.org/insight/reimagining-grid-resilience/


RESILIENT
CITIES
NETWORK

URBAN
POWER