WRI INDIA

REPORT

How cities can support India's clean energy transition

Studying India's clean energy transition through its cities

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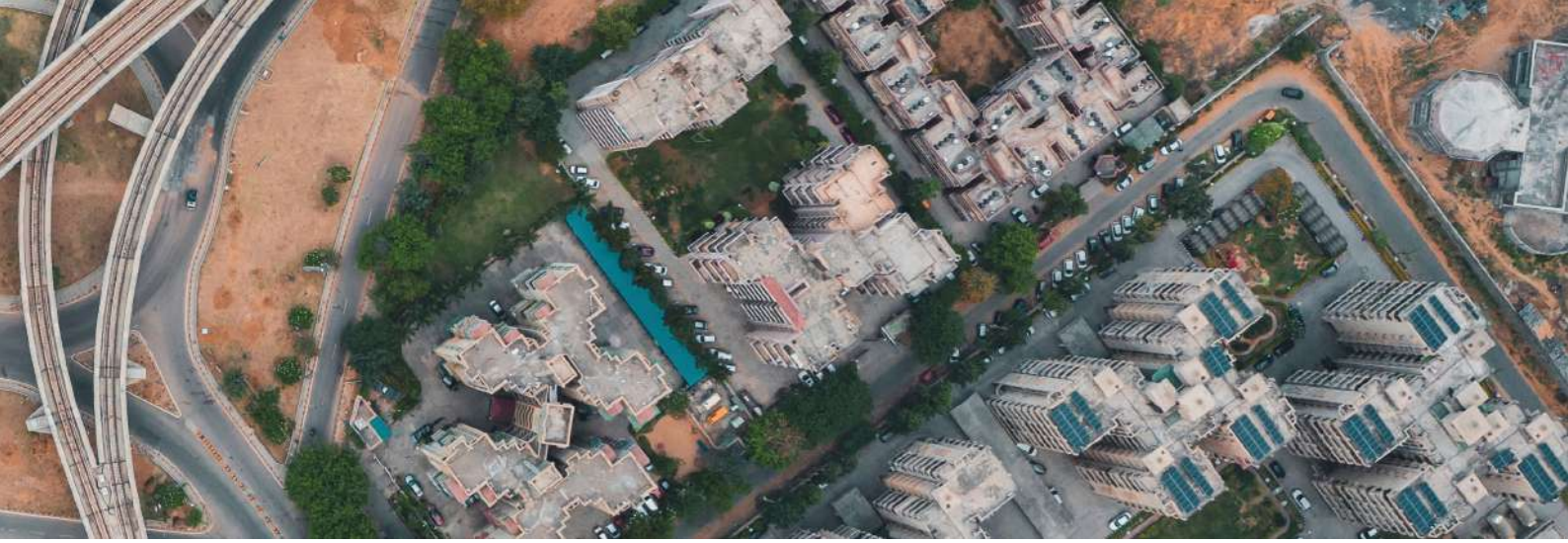

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Foreword

With Indian cities already contributing up to 60 percent of the national GDP, the country's ambitions of transitioning into a $30 trillion economy in the next two decades will be driven by urbanization and accompanied by a rise in energy consumption. However, as hubs for low-carbon innovation, cities have a unique opportunity ahead of them to transform India's growth trajectory.

India's energy transition is currently playing out primarily at the state level. Outside of large generation entities owned by the central government, the supply-side energy transition is taking place at state-level generation, transmission, and distribution entities. While this is expected to decarbonize cities connected to the grid, there is significant scope of upwards of 200GW of energy that can potentially be harnessed from urban solar PV. We also need to look closely at demand-side actions where cities will play a key role as significant consumers of energy.

Urban planning in cities remains primarily led by land use planning, with few cities looking more comprehensively at energy management. While recent efforts like city-level Climate Action Plans and the Climate Smart Cities Framework allow some focus on mitigation-linked climate action, the case studies in this report highlight the improvements that cities are able to deliver even through small, targeted actions. Chennai's rooftop solar installations, for example, delivered nearly 30 million units in annual energy cost savings across only 1378 buildings. Similarly, Pune now has over 70,000 buildings with solar water heaters, in part thanks to the Municipal Corporation offering property tax rebates for installing any one of solar water heating, vermicomposting, or rainwater harvesting systems.

Better energy use in cities is a journey from efficiencies at the individual level, to efficiencies at scale. With India at a crucial moment in its journey towards sustainable development, cities have the opportunity to showcase leadership. Further, at the point where innovation, demand, and finance all converge, cities can demonstrate the potential for transformation through integrated action. Approaches such as reimagining building bylaws in line with emerging technologies, including electric vehicles, public transport electrification, and district cooling interventions, can help cities achieve economies of scale and agglomeration.

This report showcases how urban areas are navigating the complex landscape of energy transition and highlights the successes, challenges, and lessons learned from these cities as they implement various clean energy initiatives. It serves as both a testament to the progress made and a call to action for further efforts. Drawing insights from these 10 case studies, Indian cities, in collaboration with states, can speed up their clean energy transition, securing a sustainable future for all their citizens.

Madhav Pai
CEO
WRI India

Executive summary

Indian cities are already playing a strong role in supporting India's clean energy transition. Many cities are implementing programs to promote clean energy and energy efficiency across buildings, transport, municipal services, and other sectors. There are untapped opportunities to scale good practices, instill peer-to-peer learning amongst cities, and inform the design of national and state-level policies and initiatives to further strengthen cities' contribution to energy transition.

HIGHLIGHTS

- As India urbanizes, cities are becoming key drivers of energy and resource demand and significant emitters of greenhouse gases. Through improved plans and actions, cities can significantly contribute to India's clean energy transition goals.
- We studied 10 cities across India to understand the roles of various actors in applying national and subnational energy transition policies or devising their own approaches to effect the energy transition. We identified areas where these cities have made the most progress and assessed the enabling conditions for and barriers to undertaking energy transition actions.
- City governments have primarily participated in energy transition through central government programs.
- In most cities, urban local bodies have taken the lead. In a few cases, entities termed Smart City Special-Purpose Vehicles (SPVs) have implemented projects. New actors such as metro rail corporations and city transportation corporations are framing clean energy goals within their daily operations.
- Cities face challenges in technical capacity and financing and rely on external aid for design and implementation.
- A collaborative approach to engaging cities that strengthens their capacity in different areas and considers the actors involved in achieving energy transition goals is needed. This can help enhance the role cities play in achieving India's clean energy transition goals.

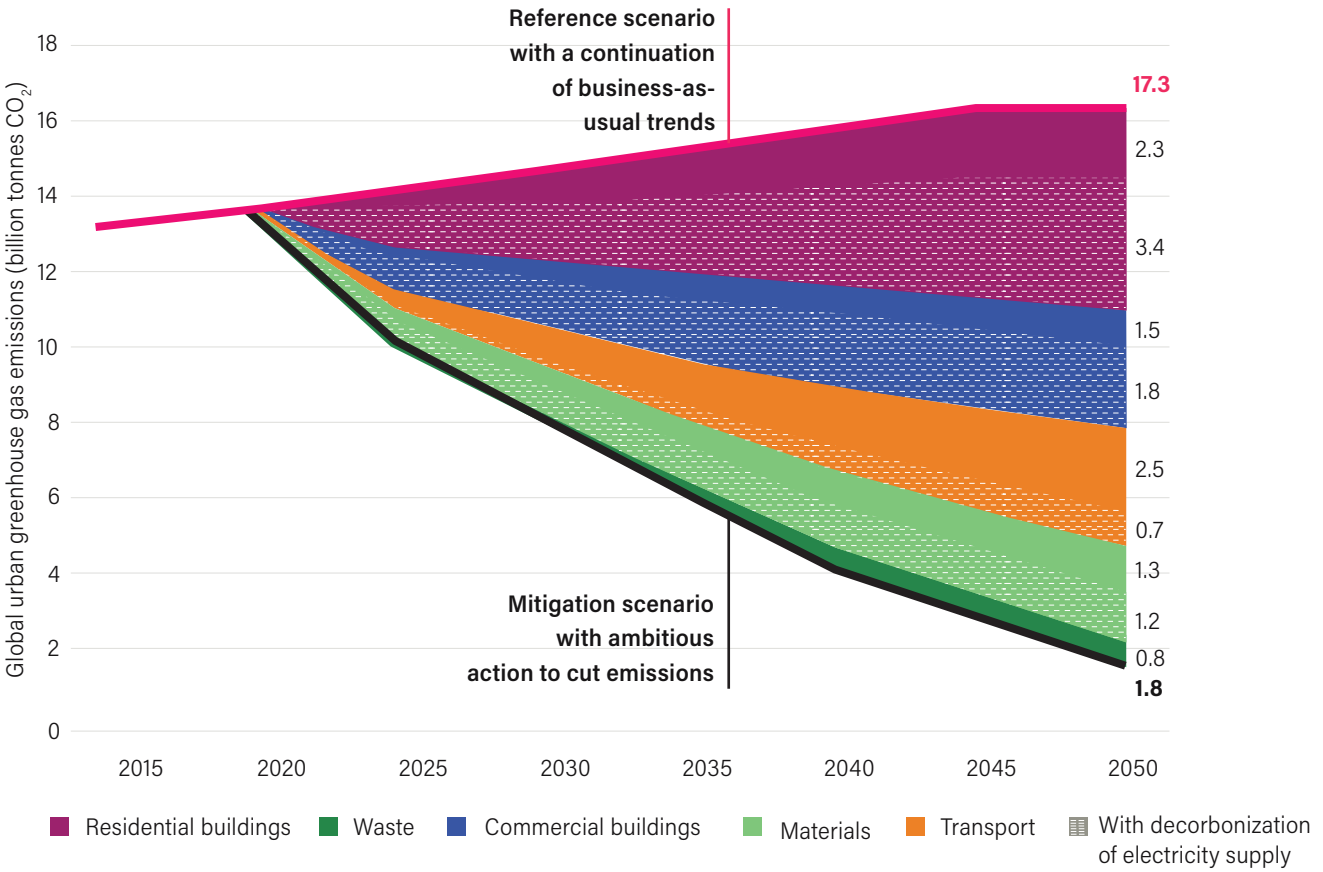
CONTEXT

To limit global warming to 1.5°C, cities are becoming active participants in climate mitigation strategies. In the last decade, there has been a global proliferation of city actions on energy transition, with cities taking on voluntary commitments to decarbonize energy supply, achieve high levels of energy efficiency across sectors, and—eventually—become carbon neutral. Cities are natural aggregators of demand and can help manage flexibility on both the supply and demand sides. They can also deploy sector coupling interventions through integrated action on transport, buildings, waste management, water supply, and more (see Figure ES-1).

Cities provide the scale to test and pilot innovative solutions, demonstrating what is possible before institutional investments are made at the national level. Cities can also strengthen their resilience to climate impacts through investments in clean energy and energy efficiency in buildings, transport, and municipal services that can further improve service reliability and affordability. The preparation of city climate action plans (CAPs) in response to the United Nations' Race to Zero campaign[1] has become an important tool for ideating mitigation strategies, especially those promoting energy transition in cities.

In tandem with increasing urbanization, the residential sector's share of India's total electricity consumption increased from 4 percent in 1997 to 24 percent in 2019 (CLASP 2021). By 2040, the International Energy Agency (IEA) estimates that about 270 million people will be added to India's urban population. Considering the accompanying rise in household appliances, this will translate to the residential sector accounting for half of the country's total electricity consumption (IEA 2021a). Growing urbanization will also translate into growth of the transportation sector, creating increased demand for fuel and energy to power municipal services. These evolutions highlight the need for Indian cities to transition to cleaner forms of energy, adopt energy efficiency measures, and promote fuel efficiency and other measures, including the electrification of public transportation. Energy transition is crucial in cities, not just for sustainably meeting their energy requirements but also for improving the lives of residents by providing co-benefits such as improved air quality and health and climate resilience.

FIGURE ES-1 | Reference scenario and mitigation potential for global urban areas in the residential and commercial building, transport, waste, and material production sectors



Source: Coalition for Urban Transitions (2019).

In India, Surat in Gujarat and Pune in Maharashtra were early movers in designing and implementing energy transition initiatives. In 2001, the Surat Municipal Corporation established an energy efficiency cell to reduce energy consumption across the municipality's operations (Surat Municipal Corporation 2014). In 2008, the Pune Municipal Corporation launched the Eco-Housing program, a voluntary rating and certification scheme for green and eco-friendly residential buildings (Pune Municipal Corporation n.d.). At the national level, the Bureau of Energy Efficiency under the Ministry of Power also proactively targeted energy savings in municipal services through the launch of a municipal demand-side management program in 2007. The national government superimposed energy and climate objectives on urban infrastructure development through the Atal Mission for Rejuvenation and Urban Transformation (AMRUT)[2] and the affordable housing program Pradhan Mantri Awas Yojana (PMAY), launched in 2015. [3] A more deliberate alignment of city development goals with energy supply options and demand management through energy efficiency has been observed since the launch of two other programs by the national government: the Solar Cities program, [4] first introduced in 2008 and revised in 2015 and 2023, and the Smart Cities Mission (SCM) launched in 2015. In both programs, cities were encouraged to plan and implement projects to promote local renewable energy generation and energy efficiency in buildings, municipal operations, public transportation, and other areas. Simultaneously, as if to align with the SCM's focus on LED street lighting, the Street Lighting National Program (SLNP) was launched in 2015 by the public sector energy services company (ESCO), Energy Efficiency Services Limited (EESL).

Introduced in 2019, the ClimateSMART Cities Assessment Framework (CSCAF) brought reporting on city-level climate action into focus.[5] India's Smart Cities were required to share data with the Ministry of Housing and Urban Affairs (MoHUA) on 28 indicators covering five sectors, including energy and buildings. Other thematic sectors also included indicators that assess cities' performance in adopting clean energy and energy efficiency interventions.

Studying India's energy transition through its cities: The need for this research

Researchers have studied some of the trends in city-level energy transition actions and have identified several research gaps. For example, in a review of the multi-level climate governance experiences of Indian cities, Beermann et al. (2016) identify the need for research on factors or mechanisms that explain the emergence, success, and failure of urban climate initiatives, actions, and frameworks. Other researchers recognize the need for more analyses of cities as emerging sites of innovative energy governance (Bhardwaj et al. 2019). Research also points out the need to reconsider the default reliance on "conventional" and existing institutions to address the multi-scalar nature of energy transition, given the inequitable distribution of externalities from energy transition actions (e.g., high air-conditioning demand exacerbating urban heat island effects) (Basu 2021). This report seeks to address some of these gaps. We were also motivated by the following issues:

- While the CSCAF 2.0 Cities Readiness Report (C3 NIUA and Ministry of Housing and Urban Affairs 2021) captures a few examples of cities undertaking energy transition actions, there is value in conducting a deeper examination of these and other examples to understand cities' journeys, the challenges they face, and the factors contributing to their success. Such an examination can facilitate peer-to-peer learning among different cities. This need was explicitly expressed by cities during the interactions between the authors of this report and city agencies and other non-state actors.
- Understanding of the untapped role of Indian cities in energy transition and the resultant co-benefits for states is limited. The national government has given cities some opportunities to participate in energy transition actions, albeit only partially and through top-down guidance. However, states have yet to fully respond to and address the need for stronger leadership and greater participation from cities on climate and development objectives.

ABOUT THIS REPORT

WRI's Strategic Plan 2023–27: Building a Better World for People, Nature and Climate (WRI India n.d.) identifies the need to transform two key human-centered systems—cities and energy (in addition to food, land, and water)—"from being the primary drivers of greenhouse gas emissions and ecosystem degradation to being positive contributors to a more sustainable future that includes reduced inequality and poverty, and additional benefits to people, especially the underserved." This report contributes to the knowledge of the interlinkages between the transitions in these two systems and the country-specific (India) shifts needed for better integration.

The current report aims to answer the overarching research question, "How can cities support India's clean energy transition?". This was achieved through an analysis of examples of energy transition actions in ten cities across seven states. We used the Census of India's definition of cities as areas with a population of more than 100,000 people. We also applied two other considerations to define cities:

- Cities as locations that can be administratively urban or rural; therefore, agencies servicing cities have both rural and urban jurisdictions.
- Cities as collectives of multiple actors participating in energy transition actions.

In this research, we took a broad view in defining energy transition actions. We studied direct strategies such as promoting clean energy supply or shifting to non-fossil-fuel energy sources. In addition, we explored energy efficiency efforts across different sectors (municipal operations, transportation, buildings) and urban planning processes that promote the efficient utilization of land and better connectivity to infrastructure and other public services to improve resource and energy efficiency. Evidence of the latter set of actions is usually found in city master plans and land use planning regulations.

Research methodology

To identify the 10 cities, we first reviewed information on clean energy transition actions in published articles, peer-reviewed papers, news reports, city corporation websites, and other gray literature to inform an initial list of 35 cities across 10 states. We looked for examples of projects, programs, and initiatives driven by different actors in the cities, not just government actors. Additional filters were applied to narrow the list to cities that were Solar Cities, AMRUT cities, cities selected for the SCM, and cities participating in global coalitions or transnational city networks like the C40 Cities Climate Leadership Group (C40) and the Global Covenant of Mayors (GCoM). There are also variations in capacity, expertise, and interest in energy transition actions depending on the size of the city; therefore, we considered the classification of cities in the Urban Regional Development Plans Formulation and Implementation (URDPFI) Guidelines 2015 (Ministry of Urban Development, Government of India, 2015), which is based on the population assessed in the 2011 Census. Finally, we selected 10 cities as case studies for this report: Bengaluru, Chennai, Delhi, Indore, Kochi, Nagpur, Pune, Rajkot, Shimla, and Surat. Table ES-1 lists these cities' performance on energy-related indicators using self-reported CSCAF 2.0 data.

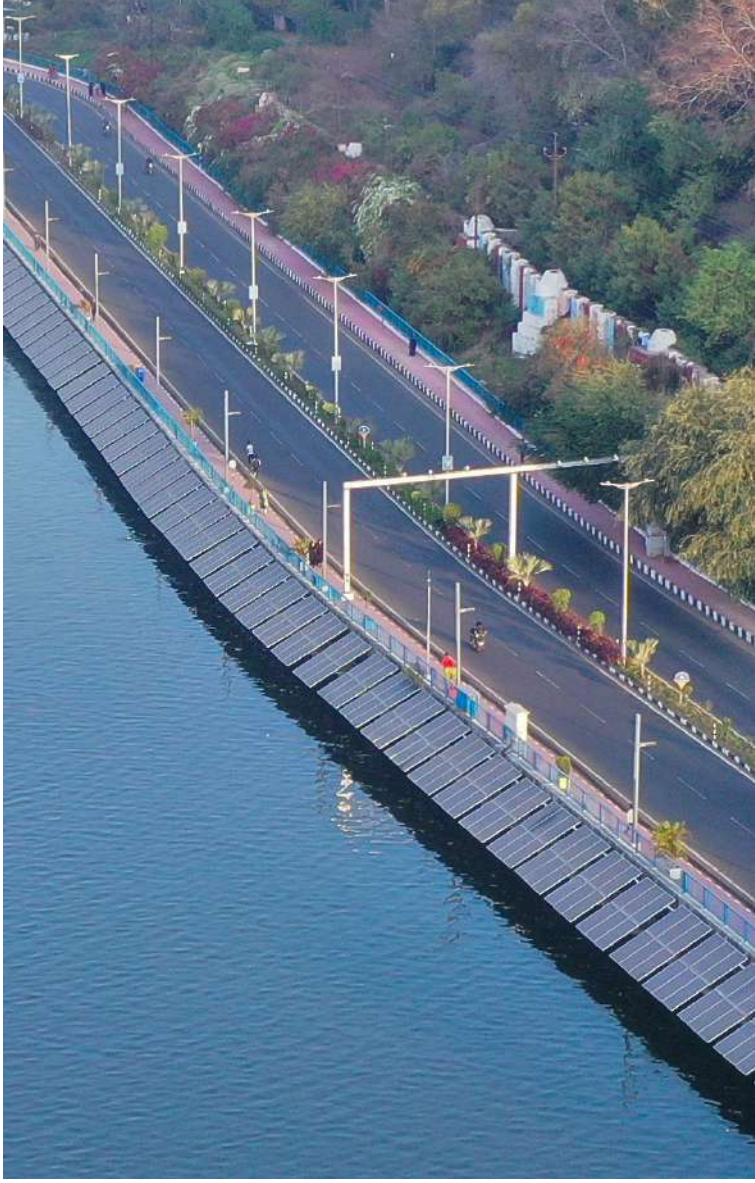


TABLE ES-1 | Case study cities' performance on selected CSCAF 2.0 energy-related indicators (self-reported data)

	CSCAF SCORE	URDPFI CLASSIFICATION (DERIVED FROM THE 2011 CENSUS)	PER CAPITA ELECTRICITY CONSUMPTION (NATIONAL AVERAGE 1546.32 kWh)	RENEWABLE ENERGY FACTOR (NATIONAL AVERAGE 9.20 KWH)	% OF ENERGY-EFFICIENT STREETLIGHTS (NATIONAL AVERAGE 81%)	BUA OF GREEN BUILDINGS IN THE CITY (M^2) (NATIONAL AVERAGE 422,469 M^2)	AGGREGATE SCORE ON 12 ENERGY-RELATED INDICATORS (OUT OF 1200)
Bengaluru	3 stars	Metropolitan city-II	1,160	3.31	88	11,253,103	433
Chennai	3 stars	Metropolitan city-II	2,224	1.65	100	6,428,308	329
Delhi	3 stars	Megalopolis	5,341	0.13	65	4,533,156	310
Indore	4 stars	Metropolitan city-I	1,326	0.84	98	200,387	762
Kochi	2 stars	Metropolitan city-I	1,123	0.5	25	320,578	283
Nagpur	3 stars	Metropolitan city-I	828	2.2	97	1,026,480	417
Pune	4 stars	Metropolitan city-I	1,668	19.13	100	6,324,394	682
Rajkot	4 stars	Metropolitan city-I	1,215	2.92	100	65,873	590
Shimla	3 stars	Metropolitan city-I	1,225	80	100	90,931	374
Surat	4 stars	Metropolitan city-I	846	19.32	83	87,635	774

Source: C3 NIUA (n.d.).

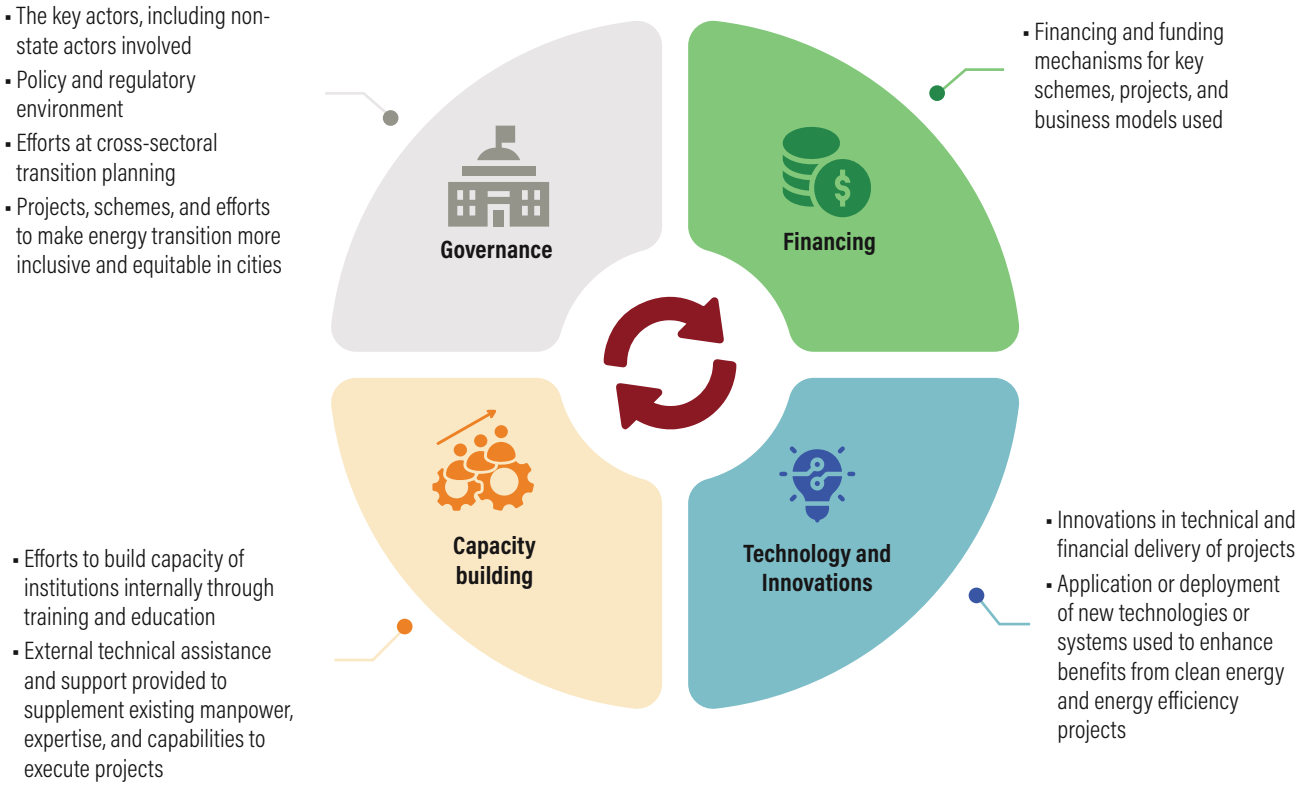
The second part of our literature review was aimed at selecting an analytical framework for gathering and interpreting data and information on city-level energy transition actions and initiatives. Our framework studied energy transition actions in cities across the four areas of (1) governance, (2) financing, (3) technology and innovations, and (4) capacity-building (Figure ES-2).

For each city, we compiled information and data on energy transition actions using the following three sources:

- Data on the progress reported by the 10 cities on energy transition themes, captured under the CSCAF 2.0 indicators for the assessment year 2020–21. Aggregate scores across 12 energy-related indicators were generated (score of 0–1200) to assess each city's performance.
- Information on energy transition projects and activities covered in news articles, city CAPs, white papers, and case studies.
- Information gathered through structured interviews with implementation partners working closely with city actors on climate action planning and other sectoral projects and city government initiatives.

We administered a survey to key stakeholders from utilities, municipal corporations, and transportation departments to gather detailed information on city-level energy initiatives, the governance and financing models adopted, the capacity-building exercises undertaken, any challenges faced in implementing renewable energy and energy efficiency initiatives, and notable technological innovations. However, we received a limited response. Consequently, we reached out to colleagues and partners to complete the questionnaire using their knowledge, networks, and interactions with the targeted stakeholders and publicly available literature or data collected during other WRI India initiatives in the selected cities. The analytical framework was applied to the information collected for each city. This approach helped us determine answers to the following research sub-questions:

FIGURE ES-2 | Components of the analytical framework applied to the 10 case study cities



Source: Based on the report from DNV-GL (2018), modified by WRI India authors.

- How are Indian cities participating in energy transition initiatives?
- What factors drive and limit participation in clean energy initiatives?
- What areas in energy transition management in cities need more research and thought leadership?

The energy transition actions reviewed and analyzed include both the transition from fossil-fuel-based energy sources to renewable energy and efforts to promote energy efficiency across different sectors. The complete typology of energy transition actions is summarized in Table ES-3.

TABLE ES-3 | Examples of actions studied in the 10 selected cities

SECTOR	TYPES OF ACTIONS
Buildings	Strategies to promote energy-efficient and thermally comfortable buildings include: ▪ Efforts to streamline the implementation of building energy codes—Energy Conservation Building Code (ECBC) and Eco Niwas Samhita (ENS) ▪ Green building certification ▪ Promoting on-site renewable energy generation, including rooftop solar ▪ Improving data collection ▪ Monitoring the energy performance of buildings
Municipal services	Strategies to promote energy efficiency in water supply and distribution, wastewater treatment, street lighting, waste-to-energy projects, and the procurement of renewable energy for powering municipal services
Low-carbon mobility	Strategies include a shift to cleaner fuels, the promotion of electric vehicles (EVs), and policies and investments in non-motorized transportation (NMT) infrastructure
Utilities/ DISCOM actions	Strategies implemented by electricity distribution companies (DISCOMs) on demand-side management (DSM), promoting energy-efficient appliances and equipment, solarizing building rooftops, promoting ground-mounted solar photovoltaics (PV), battery energy storage, and EVs
Cross-cutting	Examples of urban development plans or master plans that are attentive to energy planning. Development and implementation of climate/ energy action plans and/or clean air action plans that recommend energy-related actions to meet air-quality standards. Platforms and forums are established at the city level to facilitate dialogue and identify solutions

Source: WRI India authors.

This report has some limitations. Owing to a lack of data and limited time and resources, we were unable to uniformly apply the analytical framework to derive a complete description of the initiatives in each city and their implementation dynamics. We were unable to conduct a review and analysis of the activities of all actors in each city. We were also unable to independently verify all the information presented in news reports and the media. The paucity of publicly available and easily accessible information on projects tendered and the status of their completion may have inadvertently resulted in incomplete information being presented for some of the cities. The authors acknowledge this as a limitation of this research.

The intended audience for this report is a diverse group of government and non-government actors in cities who may find the narrative summaries from the 10 cities useful to inspire leadership and support the achievement of national and state-level energy transition goals. Reducing the greenhouse gas emissions of cities and urban buildings is the focus of the 2024 Mitigation Work Programme under the United Nations Framework Convention on Climate Change (UNFCCC).

KEY FINDINGS

How are cities participating in energy transition initiatives?

Cities in India have largely been implementing energy transition actions under national programs and schemes such as FAME, the Solar Cities program, and the SCM. Evidence suggests that these programs have helped cities orient their thinking toward energy transition, identify avenues to lead on some conversations (e.g., discussions on electric mobility), and participate as observers or recipients of technical assistance in others (e.g., discussions on energy efficiency). To assist with implementation, national ministries and allied agencies are building the capacity of city agencies. For example, through the Climate Centre for Cities (C3), housed within the National Institute of Urban Affairs (NIUA) and supported by MoHUA, cities are receiving training and capacity-building assistance related to understanding, implementing, and monitoring climate actions. Transnational networks and alliances like C40 and GCoM have engaged with cities signing on to Race to Zero and have articulated recommended measures for addressing emissions from the energy sector. Some of the studied cities (Rajkot, Pune, and Nagpur) have received technical assistance from bilateral cooperation agencies, which has helped them grow their portfolios of clean energy and energy efficiency actions.

Nevertheless, the response to such top-down efforts is not uniform across all cities, and we found evidence of differing results for the same types of actions in cities of similar sizes or even located in the same state. For example, at least 2 of the 10 cities have not shifted 100 percent of their municipal street lighting infrastructure to LEDs, according to CSCAF 2.0 data reported for 2020–21.

We also found that in some cities, the dynamic leadership of key bureaucrats in municipal governments and state urban agencies appears to have led to pioneering initiatives and utilization of available funds. These funds have been supplemented by timely and robust technical assistance from bilateral agencies, transnational networks, and think tanks. Financing for most clean energy projects in the cities has come from national programs and schemes (e.g., Solar Cities, biomass scheme) or partnerships with national public sector companies like EESL.

Where have cities made the most progress?

Energy transition actions in Indian cities have been technocentric, with a few solutions receiving the most attention. This can be attributed to the inclusion of these technological solutions in the guidelines and directives of national schemes and programs. The technologies that have gained the most traction are LED street lighting, solar PV, and low-carbon mobility:

- LED street lighting. All 10 cities have either completely or partially converted their conventional streetlights to energy-efficient LED streetlights. While no single program or scheme can be credited with completing this conversion, the acceleration provided by the SCM and the SLNP should be noted. Some Urban Local Bodies (ULBs) have used their own funds and implemented energy performance contracts with ESCOs. In other cities, ULBs have worked with EESL, using the ESCO business model of annuity-based deemed savings to achieve the conversion. Bilateral cooperation programs have come forward to promote the shift to LED street lighting by offering guidelines on procurement and sponsoring pilot projects. However, it is important to mention that, despite targeted technical assistance and clear financing and business models, cities like Bengaluru, Kochi, and Delhi have not achieved 100 percent LED street

lighting. In Kochi and Bengaluru, LED street lighting projects have been delayed because of technical reasons (*The Hindu* 2024) and tendering challenges (Menezes 2024), respectively.

- Solar PV. The solarization of public buildings (rooftop solar PV; RT-SPV) and stand-alone solar PV plants meet the energy needs of municipal utilities like wastewater treatment or water supply infrastructure. These initiatives have received funding under the SCM and are supported by states' solar or renewable energy policies and regulations like net metering.
- Electrification of public transportation. The drive to electrify public transportation fleets in India under national policies and programs (with support from similar state policies) has penetrated a few cities and achieved a certain scale (e.g., in Delhi and Bengaluru). In other cities, efforts to strengthen basic infrastructure to charge EVs, define procurement processes, and create a regulatory and policy environment for their promotion remain in the nascent stages.

Though solarization and electrification are moving forward, the same cannot be said of energy efficiency initiatives. The ULBs of Indore and Surat have been exceptions as they have paid attention to the efficiency of water pumping and other municipal services. The energy efficiency and energy conservation cell in Surat Municipal Corporation has adopted a holistic approach by first reducing energy demand and then shifting to renewable energy to transition to clean energy systems. Nevertheless, most cities score low on indicators related to energy efficiency in the CSCAF 2.0.

Which factors drive participation in clean energy initiatives and which limit continual progress?

To study the 10 cities, we applied a simple analytical framework, identifying four enablers—governance, financing, technological innovations, and capacity-building—that facilitate energy transition in cities. Though a uniform application of this framework was constrained by data availability, we distill some of the findings gathered within these limitations below.

- In most cities, government agencies like the ULBs, smart city SPVs, and state transport utilities are using their position as owners and service providers, and as large energy users, to design and implement initiatives aligned with their interest, contexts, and priorities. These include municipal corporations constituting energy efficiency cells to manage energy use in municipal operations (e.g., Surat) or using waste-to-energy plants to generate fuel for local public transport (e.g., Indore). Also being observed are models of cooperation and collaboration between public transport utilities and metro rail corporations that are approaching greening public transport collectively through integration of e-mobility, NMT, and procuring clean energy for mass rapid transit systems like metros. In some cities, city government agencies are playing a strong regulatory and enabling role through programs and policies to shift the local ecosystem toward higher efficiency and clean energy. In the Pune metro region, Pune Municipal Corporation (PMC) and Pimpri Chinchwad Municipal Corporation (PCMC) are the only two ULBs providing incentives to promote green building rating systems across all buildings. ULBs and state agencies can align better on the enforcement of regulations and policies governing energy use within the city boundaries. For example, on the implementation of renewable energy (RE) and energy efficiency (EE) policies in buildings and the municipal sector, cities need additional support from state agencies.
- Non-state actors support research, capacity, and resource needs for cities. In all the studied cities, we found evidence of the increasing role that bilateral development agencies, international and national NGOs, transnational network organizations, and think tanks are playing in supporting cities on the clean energy agenda. Cities have become spaces for convening and facilitating these conversations through the development of CAPs. Their partner institutions are also giving cities more perspective and a broader, global understanding of opportunities in the energy transition space and have supported them in a gradual ramping up of energy transition initiatives. More can be done to foster citizen participation in energy transition initiatives. This includes concerted efforts at engaging with low-income communities and other vulnerable groups for inclusive transition.

There are some areas for improvement for achieving better vertical and horizontal integration on energy transition at the local level:

- City-state relations. State governments have the closest connection with the cities and are attuned to their needs and priorities. In both Gujarat and Maharashtra, we note that institutional processes for coordination between state agencies and city bodies and authorities are robust. This is largely facilitated by an administrative model that requires state agencies and departments to communicate regularly with city officials. In other cities, there is limited evidence to suggest that state energy departments and allied agencies, such as state-designated agencies (SDAs) and state-nodal agencies (SNAs), are interacting with city agencies. Improved coordination can enhance cities' knowledge of the latest programs and schemes, particularly those promoting energy efficiency, and the assistance available to them. Survey respondents indicated that owing to limited interactions with SDAs and SNAs, cities do not tap into such agencies' expertise and mandates to implement clean energy and energy efficiency demonstration projects.
- City-DISCOM relations. In most cities, DISCOMs were found to play only a marginal role in anchoring or participating in city-level clean energy projects, especially those led by ULBs or other state agencies. Only in Delhi and Bengaluru did we find some evidence of intent and the implementation of activities under DSM and the promotion of renewable energy being led by DISCOMs. In Bengaluru, BBMP and BESCOM coordinated on enforcing mandatory compliance with solar water heater (SWH) systems on buildings of certain sizes.
- Project focus. City-level energy projects studied here have no large program-based financing options available for effectively addressing energy transition in different sectors (for example, providing a financial cushion to bidders during delays in public procurement). Cities are creatively merging and distributing the resources available under nationally sponsored schemes for energy transition projects. This has created a pool of projects that do not necessarily accelerate the decarbonization of local energy systems but do show some physical visibility of intent.
- Technologies and innovations are gaining ground, but scaling needs more support. We observed that cities are implementing technologies and innovations through pilot projects in diverse areas. In some cases, these innovations are led by non-state actors (e.g., Bengaluru) and in others through public-private partnerships (e.g., Indore, Rajkot, Nagpur). The scale and area of innovations vary. For example, in LED street lighting, standardizing technology requirements in procurement processes has helped scale and sustain impacts, but there is a stark variation between metropolitan cities and smaller cities in technology identification and eventual project completion. For example, in the case of e-buses, project delivery and operational challenges stemming from lack of capacity or experience with new technologies have plagued progress (e.g., Nagpur, Kochi). Further scaling of even more established technologies requires administrative reforms and more support from state governments.

What are some gaps in understanding or assessing energy transition pathways in these cities?

We highlight a few areas for future work to enhance the understanding of energy transition pathways in cities:

- Access to information on cities' energy profiles. The initial aim of this research was to study the energy supply and demand profile of the selected cities. However, this was not achieved due to the absence of publicly available information on the energy sector. Though some attempts have been made to collect this data (e.g., the CSCAF 2.0), not all this information is publicly available, and it is often restricted to electricity, which limits a deeper understanding of a city's energy system and opportunities in energy transition.
- Equitable and inclusive energy transitions. As cities have taken a largely ad-hoc approach to energy transition actions, concerns regarding equity and the inclusion of vulnerable groups in planning and implementation have been disregarded. More discussion is needed on the scale and level at which social equity objectives can be included in urban energy policy-making, program design, and implementation.
- User experience of technological innovations. It is important to understand how users interact with the technologies implemented. For example, some news reports note that smart LED streetlights in a few cities were not functioning well or providing the desired level of performance (Gadkari 2023; *Hindustan Times* 2023). Similarly, with RT-SPV, a greater understanding of consumers' previous experiences and

the challenges faced needs to be woven into policy design, and city actors need to be engaged to overcome those barriers. These and other experiences need to be captured to learn from them and design effective programs and initiatives to promote clean energy and energy efficiency.

- Role and contribution of climate finance in city energy transition pathways. Unsurprisingly, financing clean energy transition in cities is not very prevalent, given that, historically, climate finance conversations have not focused on cities. Considering the scale of action needed locally and the urgency required, more efforts are needed to improve cities' access to climate finance and energy transition finance to meet their climate and energy goals.

CONCLUSIONS AND RECOMMENDATIONS

When we think of key technologies driving energy transition globally, including RT-SPV, EVs, energy-efficient buildings, smart grids, and battery energy storage, cities are usually visualized as the locations of their implementation. This has also been the vision of national policies and programs geared toward piloting and scaling these technologies on the ground. Though this vision has brought cities firmly into the main focus of the energy transition process, corresponding efforts aimed at engaging cities and addressing systemic issues stemming from the decades of urban planning challenges and the lack of local capacity have been insufficient. We make the following conclusions based on our research:

- Limited alignment and coordination with state departments and agencies. Despite the presence of legacy clean energy and energy efficiency institutions like the SDAs and SNAs, the coordination and collaboration between these agencies and ULBs and other non-state actors is limited. We find that dedicated platforms for engagement and exchange of information are absent. Also missing are stronger partnerships of ULBs and DISCOMs, even though opportunities for them to interact are regular and required by policies and regulations.
- Ad-hoc approaches: Most of the studied cities have undertaken the increased pressures of clean energy program design and implementation under national schemes and programs with enthusiasm and a commitment to follow through. However, corresponding skilling and capacity-building efforts do not match the ambition and the size of the cities. Under these circumstances, cities have reacted with ad-hoc processes and frameworks that have limited reach and impact.
- Limited focus on equity and inclusion in city energy transition actions. The ad-hoc response from cities on energy transition actions also means that social equity concerns and the needs of vulnerable and marginalized communities have not found much resonance in planning and execution by state actors. With a focus on project delivery under prevailing procurement rules and regulations, the urban poor have not been prioritized in the discussions, though NGOs, think tanks, and citizen society organizations (CSOs), under more advanced ULB-transnational network partnerships, are trying to bring a sharper focus on the needs and aspirations of this segment of society.
- Rooftop solar is being promoted as the single most important technology for urban energy transition. Owing to its visibility, RT-SPV has been very attractive as the primary technology for promotion and green-branding of the cities. While the focus on RT-SPV is welcome, a public policy perspective requires us to retain space for other technologies and their associated adoption curves. Overreliance on one technology is not ideal. Cities must be included in discussions on these issues and given the right resources to make more informed decisions and choices for their local energy baskets.
- Relatively little attention to energy efficiency: Energy efficiency continues to be a lower priority for most cities, despite information available on its impact on ULB finances and the resultant co-benefits to the city at large (Surat Corporation has published details of energy and costs savings from its energy efficiency projects). This is despite the existence of super-ESCOs like EESL and decades of work behind municipal DSM toolkits and related knowledge resources. Some large cities are yet to achieve 100% conversion to LED streetlighting.
- Limited integration of urban planning with energy planning: Our research also took a deeper look at urban planning and its interface with energy planning. Only in Maharashtra does the state's Unified Development Control and Promotion Regulations discuss provision of incentives for green buildings. It is expected that the draft master plans for Kochi, Delhi, and Chennai

will be more aligned to provisioning the city's energy needs with renewables. Urban development plans working toward efficient services and infrastructure must work with energy supply and demand plans for cities to achieve their respective goals. As geographical and demographic entities, cities are in a unique position. They are aggregators of demand, sites for innovation, and places where technology and climate finance can converge to deliver climate action while meeting sustainable development goals. The opportunities that can be found in cities must be leveraged while recognizing the challenges of overlapping agency jurisdictions, the lack of direct mandates, and city governments' limited powers to act on energy transition. More work needs to be done at the institutional level, especially at the municipal scale, where actors have a mandate to govern and provide energy-dependent services to citizens.

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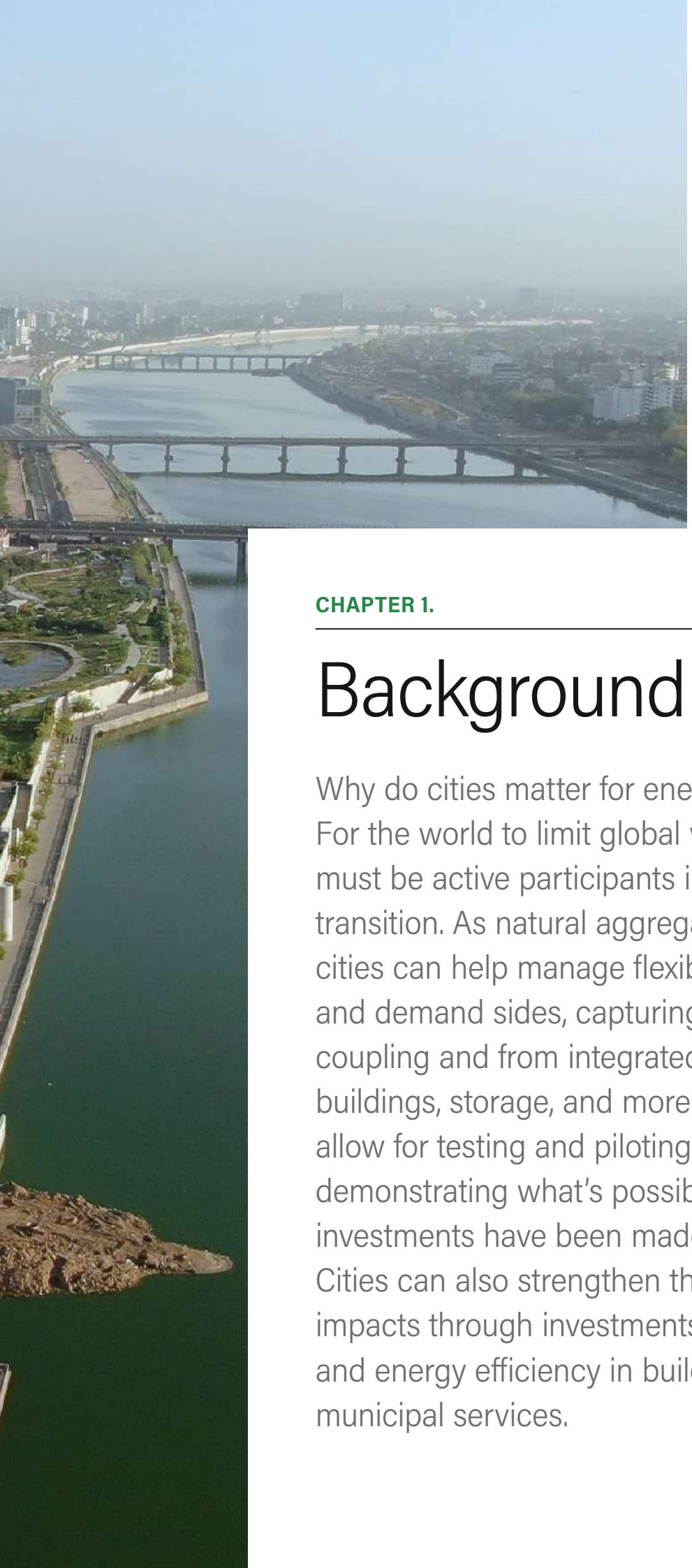
Additionally, cities need to gear up to respond to recurring climate impacts like heat stress that have implications for urban energy demand and supply infrastructure. Only one of the studied cities (Surat) had a heat resilience strategy that described energy efficiency measures to mitigate heat.

Going forward, what conditions will support the participation of Indian cities in clean energy transition? We provide a few recommendations below:

- Scale LED streetlighting and procurement of renewables for municipal infrastructure. Learn from integrated approaches to promote low-carbon mobility. As owners and operators of municipal infrastructure, ULBs in most cities have embraced energy-efficient LEDs for public streetlighting and solarizing their buildings. Some cities have taken the next step of adding solar PV systems to their public water supply and wastewater treatment facilities or procuring clean power from captive RE plants (e.g., Surat). A few cities (e.g., Kochi, Bengaluru) are trying integrated approaches to promoting low-carbon mobility, bringing together all transportation utilities and service providers to offer NMT and electric last-mile-connectivity vehicles. This must be further studied, and lessons learned to replicate best practices in delivery and improving access to greener public transport systems.
- Greater alignment with states to strengthen delivery of energy transition programs. Multistakeholder partnerships are necessary for instilling ownership and inclusion. The design and execution of energy transition programs and actions in cities requires close collaboration and alignment with state government. National and state government institutions may consider piloting collaborative and contextual approaches in select cities to demonstrate the institutional, financial, and technical mechanisms that work and those that do not, draw various lessons, and use the experiences to transform energy transition pathways in cities.
- Need for strong institutional support for energy transition initiatives within ULBs. A ULB is best positioned to anchor energy transition activities in a city in coordination with multiple stakeholders and actors. Surat Municipal Corporation institutionalized energy actions through the creation of an energy efficiency and energy conservation cell, thereby building in-house expertise to execute clean energy projects. The development of city-specific CAPs and the creation of climate change cells in a few cities are indicative of changing city ownership on climate actions. Since energy transition actions are part of these plans, the cells established for implementation will need adequate resources and empowerment, especially to take on the ambitious actions identified in CAPs. It will be critical for these teams to have the necessary financial autonomy and governance structures to support implementation. While this simple model appears easily implementable, our research found that such a team needs cross-sectoral, interdisciplinary expertise to expand the reach of the solutions to the wider community.
- Align urban and energy policies and integrate programs to encourage positive lock-ins. The perils of non-overlapping and asynchronous urban and energy planning need to be recognized to prevent further locking-in of inefficiencies in fast-growing cities. This would require a deeper level of both vertical and horizontal coordination between historically

non-coordinated ministries and line departments responsible for urban development and energy. To begin with, future iterations of national urban and energy policies can be more mindful of the need for coordinated action. Avenues for their integration can be created through state policies and regulations as urban infrastructure and energy planning are still largely state-controlled. With less than 50 years left to achieve India's carbon neutrality goals, all major cities must be mandated to develop long-term vision documents that put in place actions to implement national climate and energy targets and goals. This can help streamline and harmonize national programmatic efforts and send a clear signal to the market to invest in the energy transition in cities. The development of voluntary CAPs by many Indian cities signals a new era for subnational climate action. The CAPs offer cities a voice on the global stage. However, given the prevailing governance structure, political support from national and state governments will be critical to achieve positive outcomes for people and the clean energy system on the ground.

- Leveraging innovative financing options. ULBs have not fully tapped into several types of financing mechanisms, including municipal green bonds and carbon credits. Even among ULBs that are financially strong, leveraging innovative financial instruments has been limited. As observed in Indore, the use of these options has opened a window of opportunity to implement different clean technologies in the city. More cities must be made aware of these and other mechanisms. States can learn from other states that have given more financial autonomy to their cities and empowered them to achieve energy and climate policy targets.



CHAPTER 1.

Background

Why do cities matter for energy transition?
For the world to limit global warming at 1.5 °C, cities must be active participants in the clean energy transition. As natural aggregators of energy demand, cities can help manage flexibility on both supply and demand sides, capturing synergies from sector coupling and from integrated action on transport, buildings, storage, and more. The scale provided can allow for testing and piloting of innovative solutions demonstrating what's possible before institutional investments have been made at the national scale. Cities can also strengthen their resilience to climate impacts through investments in clean energy and energy efficiency in buildings, transport, and municipal services.

With their burgeoning populations, variety of economic activities, and ever-improving standards of living, cities around the world have become the demand centers for energy and materials. Cities were responsible for 72 percent of global CO_2 emissions related to energy production and consumption in 2018 (Lwasa and Seto 2023). In India, the megacities of Delhi and Chennai have a per capita electricity consumption that is twice and 1.5 times the national average of 1546 kWh/person, respectively. India's urban population stood at 483 million in 2020 and is estimated to rise to 675 million in 2035, which will comprise 43.2 percent of India's total population (United Nations Human Settlements Programme 2022). Meeting the increase in energy demand paralleling this population growth could result in a steep rise in the carbon emissions produced by cities and their peripheral areas. In addition, the demand for infrastructure such as roads and buildings has not only energy and emissions implications but also an irreversible impact on natural infrastructure, ecosystems, hydrological surfaces, and subsurface flows in urban areas (Goswami et al. 2022). This urban transition is juxtaposed with the energy transition and efforts to decarbonize buildings, industries, and transportation and build climate-resilient cities. In the buildings sector, urbanization will drive a steady increase in total residential floor space, which is estimated to increase from the present figure of "less than 20 billion square meters" to "more than 50 billion square meters" by 2040 (IEA 2021a). This process would involve the use of energy-intensive building materials, including steel and cement. The rapid development of buildings would also increase the demand for household electricity from about 25 percent today to nearly 50 percent of the total demand by 2040 (IEA 2021a). Furthermore, increasing urbanization would result in increased use of transportation, resulting in heightened demand for fossil fuels and a significantly higher level of emissions.

This situation presents both a massive challenge and a significant opportunity for cities. Given their large contributions to overall emissions, the local potential to accrue extensive co-benefits from energy transition policies is also high for cities. In addition to direct benefits such as reduced energy costs and energy-related greenhouse gas (GHG) emissions, the co-benefits of the energy transition for cities include improved air quality, human health, climate resilience, and employment generation. Better urban infrastructure and planning for the built environment in cities can also help further reduce GHG emissions. In 2018, the International Finance Corporation (IFC) estimated a US$29.4 trillion investment opportunity in cities in emerging markets that covers six sectors: waste, renewable energy, public transportation, water, electric vehicles, and green buildings. Of this opportunity, $24.7 trillion is in green buildings alone (IFC 2019).

In India, national and state-level actions to integrate an increasing share of renewable energy into the central and regional power grids are also expected to decarbonize Indian cities, which are connected to the electric grid. However, taking a city-centric view of energy transition is also important for the following reasons:

- The transition to a largely-renewables grid requires demand flexibility. Comprised of varied energy users, cities offer the flexibility needed and provide several opportunities for testing and scaling successful approaches to work with intermittent renewable energy.
- As cities are growing, they are becoming the largest consumers of the building materials and critical minerals that are required to power electric vehicles and local battery storage systems. The participation of Indian cities as large centers of ever-increasing demand for resources can help moderate the current and anticipated challenges in resource provisioning.
- The discourse on country-level energy security is heavily dominated by supply-side action. A supply-centric view can—and must—be balanced by a demand-side perspective. This would require shifts in the way we assess and understand energy demand and its role in moderating or mitigating the challenges and conflicts associated with resource and material constraints and optimizing the grid integration of renewable energy.

DRIVERS OF ENERGY TRANSITION IN INDIAN CITIES

In a global review, Ghosh and Bhaduri (2023) examined the literature on the types of drivers that can accelerate the energy transition in cities and their applicability for Indian cities. They identified five types of drivers:

- Policy and regulatory
- Technological
- Financial
- Social and informational
- Overarching or multisectoral

These drivers and the constituent initiatives are presented in Appendix A. They cover clean energy and energy efficiency actions that are multi-sectoral, focusing on buildings, municipal services, low-carbon mobility, and waste management.

In India, the 2009 National Action Plan on Climate Change laid the foundation for intentional and ambitious energy-focused climate action. The nine missions under this plan have seen varying levels of progress and impact at the local level, with the National Solar Mission and the National Sustainable Habitats Mission having direct implications for energy transition in Indian cities.

The Government of India has announced plans to go carbon neutral by 2070 (Ministry of Environment, Forest and Climate Change 2022b). These plans include a huge emphasis on deriving nearly 50 percent of the country's total energy from renewables and reducing its total carbon emissions by approximately 1 billion tonnes by 2030. The national government has also superimposed energy- and climate-related actions on urban infrastructure development and transformation schemes like the SCM, Solar Cities Program, AMRUT, and the Pradhan Mantri Awas Yojana (PMAY). India's 2022 Long-term Low-emissions Development Strategy identifies the promotion of energy and material efficiency in buildings and sustainable urbanization as part of the seven strategic transitions needed in a low-carbon development pathway. Cities' participation in the SCM is credited with providing them with the institutional space to "think about their energy systems," as well as the opportunity to simultaneously examine energy supply, distribution, and demand (Bhardwaj et al. 2019). These benefits can largely be attributed to the scheme guidelines (Ministry of Urban Development 2015), which, in addition to designing and sourcing financing for their projects, encourage Smart Cities to address the following issues:

Energy supply: Meet 10 percent of energy requirements from renewable energy.

Energy demand: Ensure 80 percent of buildings in greenfield and redevelopment models are energy efficient and green.

Energy distribution: Implementing grid improvement projects like smart metering and demand response.

These drivers act as leverage points for cities to undertake activities and initiatives that promote a shift toward clean energy, improve energy efficiency, and reduce energy consumption. Cities are being provided with technical and financial assistance to implement these actions by a mix of public-sector and non-state actors. For example, under its unique business model, the super-energy services company EESL is working with both government and private-sector bodies in several states to implement building retrofit projects (Building Energy Efficiency Project program), promote energy-efficient LED street lighting (SLNP), set up electric-vehicle (EV) charging infrastructure (Electric Vehicles—Energy Efficiency Services Limited), and implement smart metering solutions (Smart Meter National Program). EESL has also built an e-marketplace for government agencies to purchase energy-efficient appliances and equipment at subsidized rates.

Non-state actors, including bilateral funding agencies (e.g., GIZ, SDC) and local NGOs and think tanks (e.g., WRI India, ITDP), are providing technical support to city government agencies to address capacity gaps. In the recent report, Urban Climate Politics in Emerging Economies: A Multilevel Governance Perspective, Stehle et al. (2020)

assessed the role of transnational city networks (e.g., ICLEI SA and C40 cities) in supporting climate action in Indian cities. They concluded that while these networks provide significant support to cities, the full potential of their impact can only be achieved when domestic political-administrative and economic factors do not constrain their methods and tools.

WHY THIS REPORT? MOTIVATIONS FOR THIS RESEARCH

There are three types of literature on energy transition in Indian cities:

- Peer-reviewed literature studying the process of energy transition in cities. The available literature and scholarship are skewed toward studying the adoption and penetration of RT-SPV in Indian cities more extensively than other clean energy technologies (Devi et al. 2018; Gillard et al. 2018; Kuldeep et al. 2018; Zerah and Das 2023). Some researchers have reviewed clean energy progress in cities through the lens of climate governance (Bhardwaj and Khosla 2020). For example, recent scholarship on city energy transitions observes the lack of clear action plans and piecemeal approaches, with city-specific conditions determining urban energy transition trajectories (Broto 2017).
- Standalone case studies, articles, news reports, and other gray literature focusing on specific examples of city projects or initiatives. We found early examples of city leadership and initiatives for implementing clean energy and energy efficiency actions in Surat (Surat Municipal Corporation 2014) and Pune (Pune Municipal Corporation, n.d.). In both cities, dynamic officials at the helm of municipal corporations were piloting unique city-specific programs (e.g., Pune's 2008 Eco-Housing green-rating program) and institutionalizing the implementation of clean energy actions within the municipality's direct control (e.g., Surat Corporation's energy efficiency cell, which was first established in 2001). Pune received technical assistance from the United States Agency for International Development (USAID). News reports have covered other visible and similar programs. Most recently, the CSCAF 2.0 Cities Readiness Report compiled and presented clean energy and energy efficiency activities in a handful of cities, ranking their performance on key indicators of the framework.
- City climate action plans (CAPs). Several Indian cities have developed CAPs with chapters specifically dedicated to mitigation actions in energy and buildings. These documents typically describe an energy sector baseline for the city, contributions to GHG emissions, and the identification of actions to reduce energy consumption and decarbonize energy supply systems.

There is a need to synthesize these information sources to construct a narrative on cities' participation in India's energy transition by examining:

- Key actors involved.
- Factors shaping their choices and activities.
- Areas where further progress is needed to strengthen the city's leadership on energy transition.

Another motivation for our research was the need for independent and accessible documentation on experiences that would allow Indian cities to learn from their peers.

Finally, energy transition in cities also raises complex questions about equity and inclusion. Researchers have observed that urban climate actions are deepening social inequalities, with the benefits of clean energy and energy efficiency progress being felt more by elite and privileged urban residents (Castán Broto and Robin 2021). This publication attempts to highlight examples of efforts in the studied cities that include vulnerable communities and incorporate the principles of social equity in designing projects.

ENABLERS OF ENERGY TRANSITION

This research examined the role of enabling factors in facilitating and accelerating city-led energy transition. Through a literature review, we identified four enabling factors that facilitate energy transition more broadly (i.e., not just limited to energy transition in cities): governance, financing, technological innovations, and capacity-building. The sections below summarize global and national literature on these enablers.

Governance

In an assessment of the nexus between energy infrastructure and governance, Goldthau (2014) makes the following important observations regarding energy transition governance:

- Energy infrastructure comprises "sociotechnical systems" where the technology co-evolves with institutions, societal actors, and policies.
- There is a need to understand the context of energy infrastructure solutions, given the multiple scales of jurisdiction and decision-making.
- Energy infrastructure is recognized as a common-pool resource.
- Solutions exist at multiple scales.
- There is a need to adopt a polycentric approach to energy infrastructure governance that blends scales and engages multiple stakeholder groups.

Goldthau's conceptual and theoretical understanding of energy infrastructure governance can be applied to disentangle the complex nature of energy transition governance in cities.

Bhardwaj and Khosla (2020) use case studies of Rajkot and Coimbatore to examine the governance of urban climate action, which has parallels for energy transition. They argue that the bureaucratic machinery in city municipalities has used its powers to respond to climate change through the rollout of central and state "schemes," the prioritization of "development" as an objective, the need to implement "quick wins," and "visible" and "bankable" projects. They also conclude that a city's response to climate change is determined by the local context and its capacities and political arrangements, rather than global calls for action or efforts initiated by non-state actors.

In another review of the multi-level governance of climate actions in cities in four countries, including India, Stehle et al. (2020) conclude that committed local actors are needed for the support provided by transnational city networks to achieve their full potential.

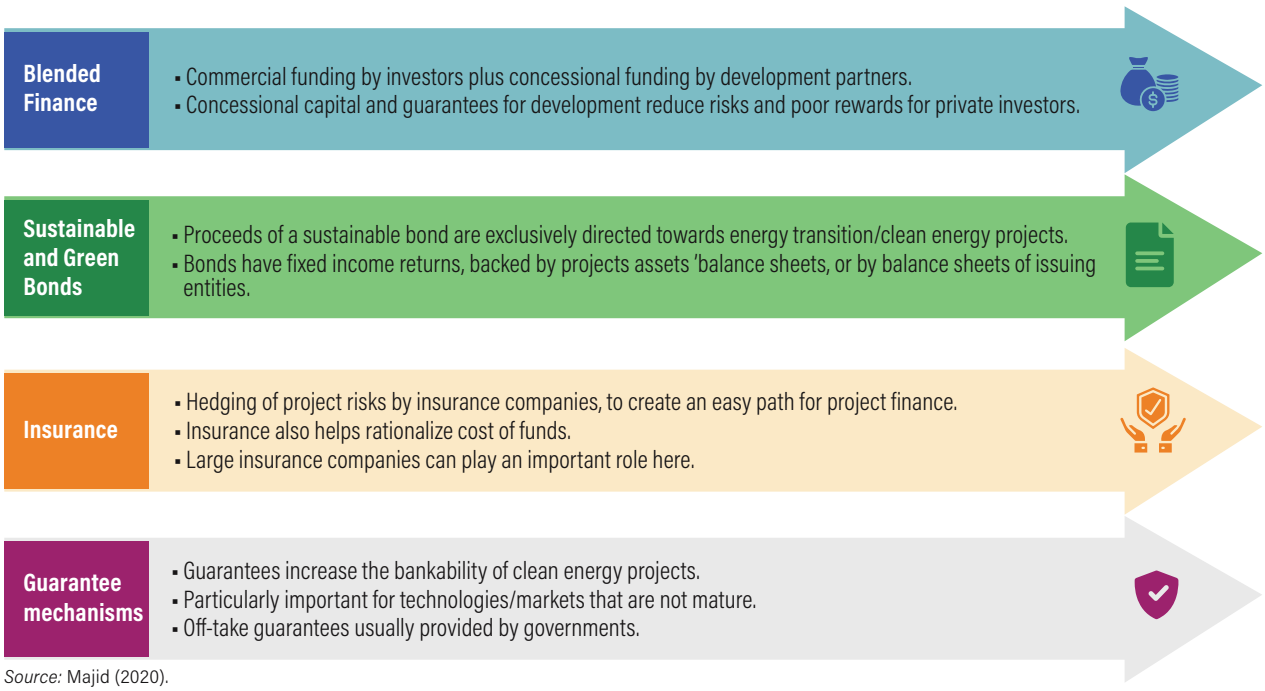
Financing

Sustainable finance is the key to effecting energy transition in cities. However, there are still gaps in its availability. Some of the key financial tools that support capital flows toward energy transition in cities are depicted in Figure 1 (Majid 2020).

Globally, financing energy transition in cities faces a few common challenges:

- A lack of initiating energy transition actions by subnational governments and the absence of framework conditions at the national-government level.
- Poor coordination between public and private sources of funding.
- Small projects or companies.
- Limited capacity to develop bankable project proposals.

FIGURE 1 | Financial tools for supporting energy transition



Source: Majid (2020).

Though these instruments are effective at the international/national level, at the sub-national level, or more specifically, at the city level, private capital has effectively been mobilized through "strategic investment funds and green banks" (Majid 2020). Sub-national governments face the challenge of bridging the gap between "small entrepreneurs and large transition projects," and the "deep pockets of the financial sector." To this end, local government acts as the "initiator and coordinator of projects," making available public funding that catalyzes private finance. Herein, local governments can use blended finance to "tap [the] resources (money, technology, knowledge) of the private sector." In 2014, a first-of-its-kind green bond for municipal governments was issued in the United States for "green properties for universities and sustainable water projects" (Majid 2020). By 2016, the $10.5 billion US green bond market was driven mainly by municipal green bonds. In 2021, the Ghaziabad Municipal Corporation became the first municipal corporation in India to raise and list a municipal green bond (The Hindu Business Line 2021). Expanding and diversifying the bond-issuer base to include local governments and municipalities can help create an effective tool to raise finance at the local level for effecting energy transition.

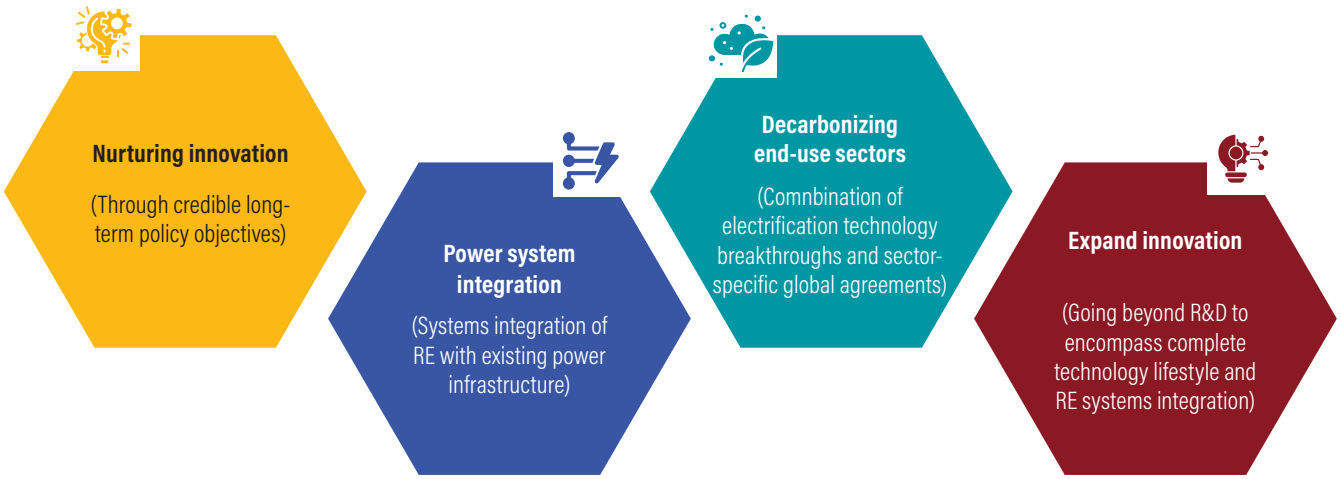
Technology and innovation

Technology and innovation play key roles in supporting energy transition at the national and sub-national levels. Technologies in the energy field are rapidly evolving, with newer forms of distributed energy technologies taking effect quickly. These include "microgrid applications and energy storage for community resilience" (DNV-GL 2018). The Internet of Things (IoT) offers a range of technologies that improve "resource efficiency and operations performance" in cities. These include smart grid and smart utility technologies for load balancing and demand response, EV charging stations, smart appliances, building-energy monitoring devices, and distributed energy resources. In its report *Accelerating the Energy Transition through Innovation,* the International Renewable Energy Agency (IRENA 2017) identifies the need for credible long-term policy objectives to nurture the economic and technical viability and commercial scalability of emerging innovations in technologies. The authors identify three other areas for urgent action:

- Expanding innovation beyond research and development, incorporating the technology lifecycle, and achieving higher levels of renewable energy systems integration.
- Decarbonizing end-use sectors.
- Integrating power systems, wherein renewable energy is integrated with existing power infrastructure (Figure 2).

India's start-up ecosystem has been offering innovative solutions to rapidly scale the deployment of clean energy and promote energy efficiency on the demand side. Several companies are offering digital trading in solar energy,

FIGURE 2 | Accelerating energy transition through innovation



Source: IRENA (2017).

energy management systems, and solutions to make meter reading and billing simple for distribution companies (DISCOMs) and consumers. From 2015 to 2019, WRI India organized a multi-stakeholder innovation accelerator platform, TheCityFixLabs. This platform aimed to address key gaps in the innovation ecosystem in Indian cities for three urban services: energy, waste, and water. Dhindaw et al. (2021) captured a few key lessons learned from this initiative:

- Indian ULBs are interested in low-risk pilots to test and learn about innovations in product or service delivery.
- The scaling of innovative solutions depends on the municipal request-for-proposals process.
- There is a need to reform procurement processes that prevent the participation of entrepreneurs.
- There is also a need to expand investments in innovations and create anchor institutions at the subnational level to coach and nurture innovations and their implementation.

Efforts to nurture energy transition innovations in Indian cities must consider these learnings.

Capacity-building

The technological advancements that accelerate the energy transition in cities require that city authorities and agencies be equipped with the skills and knowledge to adapt and apply these advancements. It is also imperative that capacity-building among governance and service delivery institutions accounts for differences (OECD 2020) in:

- the size of the city, given that large cities usually have greater abilities to facilitate and deploy innovations;
- the city authority leadership's attitudes and willingness to support energy transitions; and
- the skills and competencies of government officials and other actors, with smaller and mid-size cities requiring more capacity-building than larger cities.

Given the multi-sectoral and decentralized nature of some energy transition actions, capacity-building at the community level is equally important. For example, education, training, and local awareness campaigns to build knowledge of the benefits and co-benefits of community renewable energy projects create buy-in and ownership for these projects (IEA 2024).

Photo Credit: WRI India.


YOU
ARE INVITED

CHAPTER 2.

Research questions, scope, and methodology

This research explored the scope and depth of participation of Indian cities in India's energy transition, the areas where cities have made the most progress, the factors driving this and challenges faced by cities on their respective energy transition pathways. Researchers used surveys, expert consultations, and literature review to study the energy transition journeys of 10 cities.

RESEARCH QUESTIONS

This research aimed to address the main research question, "How can cities support India's clean energy transition?" To answer this question, we studied the experiences of 10 Indian cities. This main research question was further divided into the following three sub-questions:

- How are cities participating in energy transition initiatives?
- Which factors drive participation in clean energy initiatives, and which limit continual progress?
- What are the gaps in understanding or assessing energy transition pathways in these cities?

SCOPE

Defining energy transition in the context of cities

The Census of India defines cities as towns that have a population of more than 100,000. In this report, the term "city" refers to this demographic classification. Additional considerations for defining and studying cities that have implications for the scope of this report include:

- Cities as units of administration. Cities as locations of energy transition actions that are administratively urban.
- City agencies as distinct from their administration. Three out of the 10 cities selected for this report (Bengaluru, Chennai, and Delhi) are also a part of metropolitan regions. However, the clean energy actions studied in these cities correspond to those implemented by city agencies within both the urban and rural administration boundaries. For example, as the DISCOM in Bengaluru, BESCOM serves the city's urban and rural districts. Our recommendations, therefore, apply to actors that operate from the city, irrespective of their urban or rural jurisdictions. We also acknowledge that many "city" agencies have overlapping jurisdictions and service territories that span urban, peri-urban, and rural administrative boundaries.
- Cities as collectives of actors. We recognize the heterogeneity of actors (users, agents, and providers) within a city; therefore, the term "city" here refers to a collective of all these actors. It is easy to view energy transition actions through the lens of the activities that a city's urban local bodies, typically the municipality, can or cannot implement. However, for this report, we also studied the roles of other actors, including institutions (e.g., citizen groups), who are not always empowered to make decisions on the city's energy system.

We define energy transition as the shift of energy systems from fossil-fuel-based energy sources to renewable energy across different sectors. We also recognize the importance of energy efficiency in enabling system-wide transition and, consequently, include endeavors that address a reduction in energy use from energy efficiency strategies in city-wide energy transition efforts.

City-related energy initiatives, activities, and actors

Given the cross-sectoral character of the energy transition, we identified a few key actions across buildings, municipal services, and transportation sectors and efforts by local electric utilities/DISCOMs to put each city on a low-carbon, low-energy pathway (Table 1). In our view, the launch of the SCM in 2015 put a stronger spotlight on Indian cities as change agents, with the onus on city agencies to implement facelift projects, including those focused on clean energy and energy efficiency.

As such, we captured actions implemented from 2015 to March 2024 for this report and relied on literature available on status of project completion published until July 2024. Considering the multi-scalar and polycentric governance of energy transition, we studied initiatives implemented by local municipalities, SPVs, DISCOMs, citizen groups, private-sector actors (builders, technology providers), and other non-state actors such as academic and research institutions, think tanks, and NGOs.

We used a case study methodology, taking a mixed-methods approach that analyzed qualitative and quantitative data.

METHODOLOGY

Methods and data sources

Selection of case studies

We selected 10 Indian cities across seven states and one union territory for a deep-dive assessment. We first reviewed the quantitative and qualitative data for 126 cities covered in the CSCAF 2.0 Cities Readiness Report to prepare a master list of 30 cities that had an overall rating of 2 to 4 stars. In these 30 cities, we marked those that were Solar Cities and/or part of the AMRUT scheme. We also collected information on noteworthy energy transition actions in these cities from published news articles, case studies, and reports. Finally, we arrived at a final list of 10 cities: Bengaluru, Chennai, Delhi, Indore, Kochi, Nagpur, Pune, Rajkot, Surat, and Shimla.

Analysis of secondary data from established indicators

We collected and analyzed secondary data on established indicators. We studied the progress made on energy transition by the 10 cities by referring to their scores on the CSCAF 2.0 for 2020–21 (C3 NIUA and Ministry of Housing and Urban Affairs 2021). We identified 12 indicators, shown in Table 2, that were directly or indirectly related to progress on energy transition in cities and examined the cities' aggregated scores on these indicators (score of 0–1200).

TABLE 1 | Types of energy transition actions across the 10 studied cities

CATEGORY	EXAMPLES OF ACTIONS
Buildings	Strategies to promote energy-efficient and thermally comfortable buildings, including efforts to streamline the implementation of building energy codes (ECBC and Eco Niwas Samhita [ENS]), promote on-site renewable energy generation (including rooftop solar), improve data collection, and monitor buildings' energy performance and green building certifications
Municipal services	Strategies to promote energy efficiency in water supply and distribution, wastewater treatment, street lighting, and waste-to-energy projects, as well as the procurement of renewable energy for powering municipal services
Low-carbon mobility	Strategies to shift to cleaner fuels and promote EVs, and policies and investments in non-motorized transportation (NMT) infrastructure
Utilities/DISCOM actions	Strategies implemented by power DISCOMS in demand-side management (DSM); for example, promoting energy-efficient appliances and equipment, solarizing building rooftops, and promoting ground-mounted solar PV, battery energy storage, and EVs
Cross-cutting	Examples of urban development plans or master plans that are attentive to energy planning. This includes the development and implementation of climate/energy action plans and/or clean air action plans that recommend energy-related actions to meet air quality standards. It also includes platforms and forums established at the city level to facilitate dialogue and identify solutions

Source: WRI India authors.

TABLE 2 | Twelve Climate Smart Cities Assessment Framework 2.0 indicators used to assess clean energy transition progress in the selected cities

THEMES	INDICATORS
Energy and green buildings	Electricity consumption in the city
	Total electrical energy in the city derived from renewable sources
	Fossil fuel consumption in the city
	Energy-efficient street lighting in the city
	Promotion of green buildings
	Green building adoption
Urban planning, green cover, and biodiversity	City CAP
Mobility and air quality	Shared vehicles that operate with clean fuels
	% coverage of NMT network
	Clean air action plan
Water management	Energy-efficient water supply system
	Energy-efficient wastewater management system

Source: Climate Data Observatory (n.d.).

Literature review

We collected publicly available online information on energy transition activities and initiatives across different sectors for the selected Indian cities. Given the paucity of public data on cities' energy profiles, we also used gray literature and news articles to build a narrative for each city. We relied on published city CAPs and in-depth case studies and papers on individual cities, as well as other unpublished data and reports compiled from implementing agencies and partners working with cities.

Surveys

To gain deeper insights into our case study cities, we developed a questionnaire for three key stakeholders: utilities, municipal corporations, and transportation departments. The questionnaire is provided in Appendix B. The survey was designed to understand the implementation of clean energy initiatives at the city level, the governance and financing models adopted by the stakeholders to implement such initiatives, the type of capacity-building exercises undertaken by the stakeholders, any challenges they faced on the journey to implement renewable energy and energy efficiency initiatives, and information on notable technological innovations. The survey was distributed in 10 cities; however, the response from the targeted stakeholders was limited. To overcome this critical methodological constraint, we accessed the expertise and knowledge of WRI India staff located in or around these cities. We requested that colleagues compile responses to the survey questionnaires using their knowledge, networks, and interactions with the targeted stakeholders, as well as publicly available literature or data collected during other WRI India projects in those cities.

Interviews

We also conducted interviews with implementation partners (e.g., ICLEI SA, WRI India, C40) that work closely with city actors on climate action planning and other sectoral projects and city government initiatives. The objective of these interviews was to verify the completeness of the information available online, fill any gaps in the knowledge, and gather perspectives on the city's low-carbon and low-energy future based on partners' experiences.

CASE STUDY ANALYSIS

We analyzed the 10 case study cities to answer the research questions and spotlight the key enablers of energy transition described in Chapter 1, under the subheadings governance, finance and technology and innovation. Given the similarities in initiatives to support cities in their energy transition activities, we also studied a fourth enabler—capacity-building—more broadly across all the cities. Short descriptions of these four enablers are provided in Table 3. The findings from the analysis are presented in Chapter 3.

Across all the case studies, we tried to highlight initiatives that target the inclusion of the urban poor and low-income communities in the energy transition. Specifically, we sought evidence on clean energy and energy efficiency programs and projects that explicitly target these vulnerable groups across the 10 cities.

We also studied capacity-building efforts across the 10 cities. This included not only internal efforts to build institutions' capacities internally through training and education, but also external technical assistance and support provided to supplement existing workforce, expertise, and capabilities to execute projects. As capacity-building efforts are similar across cities, we present a consolidated analysis of the 10 cities in Chapter 4.

STUDY LIMITATIONS

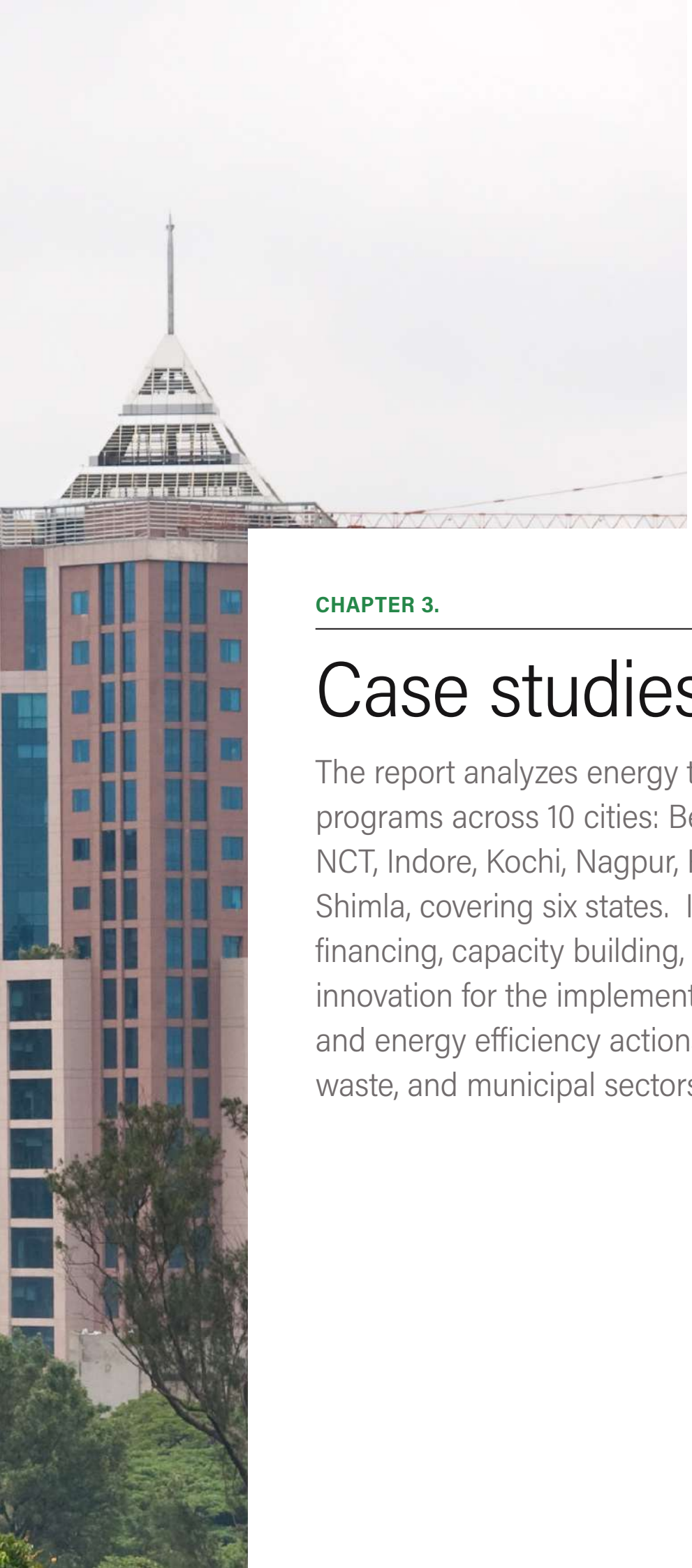
In addition to the limitations in our application of this study's analytical framework, we acknowledge that our research has the following additional limitations:

- The significant diversity in Indian cities means that the case studies in this report cannot be considered fully representative of all cities. As such, the findings cannot be extrapolated to the whole country.
- We did not collect data on the cities' energy consumption or energy profiles. This prevented a complete assessment of their energy systems and the identification of priority actions.
- Further, we did not assess the implementation nuances within each scheme/project. For example, in smart city projects, we researched the quality of implementation or the impacts of the project but not the project goal or the associated externalities (which have been documented in the existing literature), if any.

TABLE 3 | Enablers of energy transition across the 10 case study cities

ENABLER	SCOPE	ASSUMPTIONS AND CHALLENGES
Governance	▪ The key actors, including non-state actors, involved and the initiatives implemented by them ▪ The policy and regulatory environment supporting the governance of energy transition ▪ Efforts at cross-sectoral transition planning, such as city-wide CAPs or GHG inventories, which inform the acceptance and adoption of clean energy and energy efficiency actions ▪ Projects, schemes, and efforts to make energy transition more inclusive and equitable in cities	Though this research attempted to comprehensively record the relevant actors and their activities, given the complexity of governance models (as described in previous sections), some aspects are likely to have been missed. For example, information on implementation processes and mechanisms was publicly available only for a few cities owing to greater coverage in news media. In other cases, we were limited by the sensitive and often political nature of the governance of activities led by different actors. A political economy analysis could have teased out some of these nuances; however, we did not conduct such an analysis for this research
Financing	Financing and funding mechanisms for the key schemes, projects, and business models used	It was difficult to determine the source of funds for some initiatives and projects as this information was not publicly available and had to be synthesized from tender documents wherever possible. Consequently, complete information on all aspects of financing for each project could not be collected. Nevertheless, we also do not believe this information is necessary to apply financing as an analytical criterion
Technology and innovation	▪ Innovation in the technical or financial delivery of projects ▪ Application or deployment of new technologies or systems used to enhance benefits from clean energy and energy efficiency projects	The term "technological innovation" is widely used. Some of the applications are not necessarily "innovative" but are a first for the city and are therefore deemed interesting and pioneering

Source: WRI India authors.



CHAPTER 3.

Case studies

The report analyzes energy transition initiatives and programs across 10 cities: Bengaluru, Chennai, Delhi NCT, Indore, Kochi, Nagpur, Pune, Rajkot, Surat, and Shimla, covering six states. It studies governance, financing, capacity building, and technology & innovation for the implementation of clean energy and energy efficiency actions in buildings, transport, waste, and municipal sectors in these 10 cities.

The CSCAF was introduced by MoHUA to understand the importance of sustainable urban planning and climate-informed development actions across Indian cities. The framework is a first-of-its-kind assessment that evaluates cities based on climate-related factors. The CSCAF 2.0 framework includes 28 indicators grouped into five themes:

- Urban planning, green cover, and biodiversity
- Energy and green buildings
- Mobility and air quality
- Water management
- Waste management

A total of 126 cities, including 100 Smart Cities, capital cities, and others, participated in the assessment in 2020. The cities provided information on 96 data points across the 28 indicators and five themes. Based on the overall scores and thematic scores, the cities were classified into five different performance levels, ranging from five stars to one star (C3 NIUA and Ministry of Housing and Urban Affairs 2021).

BENGALURU, KARNATAKA

CSCAF 2.0 overall rating: 3 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 433/1200

Bengaluru is the capital city of the state of Karnataka. It is the third most populous city in India and the fifth most populous urban agglomeration. The city is widely recognized as the "Silicon Valley of India" owing to its rapid growth and significance in the IT industry. In 2018, Bengaluru was chosen as a smart city in the third round of the SCM. This selection paved the way for various projects focusing on developing roads, re-developing bus terminals, transforming parks, establishing digital health infrastructure, and retrofitting historic market centers, among several other activities (BBMP n.d.). Bengaluru has also witnessed the rapid expansion and densification of the built environment in the city's periphery, creating an increased demand for services, including energy services and infrastructure (Deb et al. 2020). Table 4 describes key actors working on energy transition in the city.

TABLE 4 | Key actors in Bengaluru

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Bruhat Bengaluru Mahanagara Palike (BBMP)	Municipal corporation	Responsible for solid waste management and for maintaining public spaces, water bodies, parks, greenery, and other civic services at the city level. BBMP also houses the Bengaluru Climate Action Cell, which is implementing the Bengaluru Climate Action and Resilience Plan
Bangalore Electricity Supply Company Limited (BESCOM)	DISCOM	Responsible for implementing DSM programs and the grid-connected solar rooftop program in the state. The company also created a dedicated EV cell to manage all aspects related to EVs and the development of charging infrastructure within the city
Bangalore Metro Rail Corporation Limited (BMRCL)	Transportation utility	Launched the Comprehensive Mobility Plan in partnership with the Directorate of Urban and Land Transport (DULT) in 2020. The plan promotes efficiency in transportation choices, including transit-oriented development and NMT. BMRCL has also been solarizing its metro stations
Directorate of Urban and Land Transport (DULT)	Transportation department	Led procurement of e-buses and promotion of NMT through policies and programs
Bengaluru Metropolitan Transport Corporation (BMTC)	Transportation utility	Bengaluru's public road transportation corporation, which services urban, suburban, and rural areas

Source: Aggregated by WRI India authors.

Bengaluru's energy transition journey

Bengaluru had a slow start in the SCM, and several smart city projects are still awaiting completion. Bengaluru's Master Plan 2031, first prepared by the Bangalore Development Authority in 2017, was scrapped by successive governments, and a revised master plan is expected to be completed in July 2025 (*Deccan Herald 2024*). The BMRCL has been slow to embrace renewable energy for powering its operations, and less than 3 percent of its total energy requirement is being met through rooftop solar systems on various metro stations in the city (*Bangalore Mirror 2023*). Karnataka, where Bengaluru is located, was one of the first Indian states to notify ECBC 2007 and introduce the code's requirements into the state's Model Building Byelaws in 2021 (Government of Karnataka 2021). However, evidence suggests that the adoption of this code remains limited across the city. Until recently, the city's municipal corporation, BBMP, had been largely absent from discussions on clean energy and energy efficiency. However, this changed in 2023 when BBMP launched a CAP for the city; this set several goals, including the promotion of green buildings, clean energy, and energy efficiency (BBMP et al. 2023).

Highlighted actions: Private-sector initiative for expanding the city's green-building footprint and DSM programs by DISCOM

Private-sector-led green buildings transformation

Interestingly, Bengaluru's green building movement has mainly been driven by the private sector, including IT companies and large multinational technology corporations. As India's IT hub, the city is often compared to California's Silicon Valley. The city's IT companies, such as Infosys, Wipro, and Cisco, have been at the forefront of sustainability, leading initiatives in renewable energy generation, water harvesting, and waste-to-energy (WTE) conversion. This has made Bengaluru one of the top three Indian cities in terms of registered green buildings. As of March 2016, the city had around 333 green buildings certified by the Indian Green Building Council (IGBC). Even without mandatory regulations or state government incentives, Bengaluru has embraced the green building trend, showing its commitment to sustainability and environmental responsibility. Large private builders and developers claim to have a large portfolio of green-certified real estate. The private developer Brigade Group (2021) states that it offers only green-certified commercial office spaces in Bengaluru.

The most notable example of the IT sector demonstrating leadership in clean energy initiatives is Infosys India Private Limited, which achieved carbon neutrality in 2020 (Infosys n.d.). In Bengaluru, Infosys has developed and deployed several innovative technologies in the energy domain; examples include radiant cooling, establishing a central energy management system, implementing large retrofit projects to achieve a 33.5 MW reduction in connected load, and adopting a lifecycle-based approach for building decarbonization (Infosys 2023).

DSM and clean energy promotion by DISCOM

Bengaluru's climate requires the use of hot water throughout the year. Under the Energy Conservation Act of 2001, the Government of Karnataka issued a notification in 2007 for the mandatory use of solar water heating systems in residential buildings with a minimum floor area of 600 sq. ft. or plot area of 1200 sq. ft. and above (Government of Karnataka 2007). The DISCOM, BESCOM, strictly enforced this rule and took measures to ensure compliance, for example, by denying access to permanent electricity connections to households that did not have solar water heating (BESCOM 2007). The only remaining option—a temporary electricity connection—required consumers to pay nearly twice the price for the electricity. BESCOM also offered a rebate of ₹0.50 paise/unit to up to ₹50 on compliant customers' electricity bills. This scheme was discontinued in June 2023 (KERC 2023). However, BESCOM has installed grid-connected RT-SPV systems across 123 government buildings, including schools, bus depots, and courts (TNN 2022b).

Under the UJALA scheme (renamed "Hosa Belaku" in Karnataka), BESCOM distributed LED-based bulbs and tube lights to consumers (*The Hindu 2016*). Through the PAVAN scheme, it also distributed Bureau of Energy Efficiency (BEE) 5-star-rated ceiling fans to domestic consumers within its jurisdiction (BESCOM n.d.). In addition, BESCOM has actively developed EV charging infrastructure to facilitate the adoption of EVs. The EV cell established by BESCOM has successfully set up 136 charging stations at 74 locations across Bengaluru.

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

The CSCAF 2.0 data show that an 88 percent conversion of streetlights to LEDs had been achieved in Bengaluru by 2020–21. BBMP had plans to achieve this conversion through a public-private partnership with Bangalore Streetlighting Private Limited in 2018. This consortium involved Shapoorji Pallonji and Company Private Limited, SMC Infrastructure Private Limited, and Samudra Electronics Systems Private Limited; however, news reports claim that this project has failed (Ramesh and DHNS 2021). In the WTE field, BBMP has been operating a few decentralized biomethanation plants and a biogas plant (Maheswara Reddy 2023).

Promotion of low-carbon mobility

To promote NMT, DULT introduced guidelines for planning and implementing pedestrian infrastructure in 2014 (DULT, Government of Karnataka 2014). A comprehensive mobility plan (CMP) launched in 2020 by BMRCL and DULT identified NMT as one strategy to achieve efficient and sustainable transportation in the city and recommended the development of plans to improve it (BMRCL and DULT 2020). The demand for improved NMT infrastructure has prompted citizen activism on the topic. In 2022, DULT drafted the Active Mobility Bill, which is aimed at promoting walking and cycling in urban areas. The bill is awaiting government approval (DULT, Government of Karnataka 2021).

The Karnataka EV and Energy Storage Policy 2017 created a policy environment for transforming the city's EV landscape (Commerce and Industries Department 2017). Spurred by the state policy and the national FAME-II scheme, the state-owned public transportation utility BMTC has been using a multi-pronged approach to roll out electric buses. This approach includes the mass procurement of e-buses, facilitating the provision of charging infrastructure in bus depots and bus stands, and converting diesel buses to electric. In 2023, the city had around 500 electric buses, the second-highest number after Delhi (Athavale 2023).

Partnerships with civil society, international agencies, and transnational networks

Bengaluru has a long history of collaboration between the municipal corporation and civil society (Deb et al. 2020):

- Bengaluru Smart City Private Limited signed an MOU with IGBC to facilitate the implementation of IGBC's Green Cities rating system for smart city projects (Bharati 2020).
- In December 2017, Bengaluru joined the C40 Cities network and committed to co-lead the new C40 Air Quality Network to identify climate-friendly solutions to address public health crises.
- In 2020, the Center for Study of Science Technology and Policy (CSTEP) developed a tool in partnership with BESCOM to accurately assess the solar potential of rooftops in cities using light detection and ranging (LiDAR) technology. This was the first time that LiDAR technology had been used to determine the RT-SPV potential of a city in India. The tool, known as the CSTEP Rooftop Evaluation for Solar Tool (CREST), identified precise locations for installing RT-SPV systems on buildings (CSTEP n.d.).
- Between 2015 and 2021, local NGO Technology Informatics Design Endeavour (TIDE) implemented Vidyut Rakshaka, a consumer-driven energy efficiency and energy conservation program, in partnership with WRI India (TIDE India n.d.) The program sought voluntary participation from BESCOM consumers: consumers shared their electricity consumption information with TIDE and, in return, received home energy reports that described recommended behavioral changes and other actions to encourage them to save energy. A 2022 evaluation of Vidyut Rakshaka's impacts found that the home energy reports led to a 7 percent decrease in average monthly energy consumption per household over 12 months (Hernandez et al. 2022).
- On November 27, 2023, BBMP launched its first-ever Climate Action and Resilience Plan under the C40 Cities network (PTI 2023), supported by WRI India. The plan focuses on different sectors, such as energy and buildings, transportation, solid waste, water and wastewater, urban planning, biodiversity, and disaster resilience, covering both mitigation and adaptation aspects. The plan emphasizes taking an evidence-based approach to setting the targets for future mitigation, adaptation, and resilience in the city.

Financing

The various approaches that Bengaluru's actors have used to finance clean energy and energy efficiency projects include:

- Partnership with EESL. In partnership with EESL, BESCOM employed a bulk procurement strategy to distribute LED light bulbs, tube lights, and BEE 5-star-rated ceiling fans to consumers within its jurisdiction. This strategy provided manufacturers with economies of scale, resulting in a significant price reduction that enabled greater adoption.
- Central financial assistance. Central government funds under the 13th Finance Commission were utilized to fund RT-SPV installation in government buildings under BESCOM's jurisdiction.
- Public-private partnership for WTE. A public-private partnership model has been implemented for WTE plants that use biomethanation to produce biogas.
- Complementary state-government funding. State government funds have been utilized to develop EV charging infrastructure, supporting the adoption of electric vehicles. In the case of electric bus deployment, Bengaluru has received both state government funds and financial support under the FAME scheme. The city has been using gross cost contracts of carriage to purchase e-buses.

Technology and innovation

The use of LiDAR to map Bengaluru's rooftops for suitability for RT-SPV systems in 2018 was the first time this technology was used in India to map solar potential in urban areas. A few other examples of technological innovations tested in the city include:

- Digital trading in solar energy. Widely recognized as the start-up hub of the country, Bengaluru is home to many digital trading companies offering a suite of innovative solutions. In 2020, SundayGrids installed the city's first community solar project offering trading in solar energy credits (SundayGrids, n.d.). A 5kWp RT-SPV project was installed in Northern Bangalore, where SundayGrids entered into a power purchase agreement with the host of the RT-SPV project to buy the solar energy generated at an agreed-upon tariff. This solar energy is "digitally reserved" in the form of credits by other consumers (who cannot install RT-SPV systems) to gain discounts on their electricity bills.
- Infosys's automated monitoring system for high-performance buildings. Infosys developed in-house capabilities to advance the energy monitoring of its buildings (Infosys 2023). The IT company's command center uses equipment and a building-level automated monitoring system that sends real-time data and feedback to alert maintenance teams to save energy.
- Passive design innovations for thermal comfort in informal housing. Pune-based organization cBalance piloted the application of several innovative insulation-material interventions to improve thermal comfort in 23 slum dwellings in Bengaluru. These materials included ecoboard (a multi-layer board made of compressed recycled material such as Tetra Paks), alufoil (a type of foam with a coating of aluminum on one side), and water-filled polyethylene terephthalate bottles. The findings from the pilot indicated some impact on occupants' thermal comfort but also highlighted areas for improvement (cBALANCE and Ashden 2022).
- Sustainable EV-charging depot. Magenta Mobility, a private EV ecosystem solutions provider based in the city, established an EV-charging depot capable of charging 70 EVs at the same time (*Financial Express 2023*). Located in Bengaluru's Bilekahalli, the facility is equipped with other on-site measures that demonstrate attention to sustainability; for example, sensor-based LED street lighting, water gutters, and rainwater harvesting. The depot has 63 3.3-kW AC chargers and three 15-kW GB/T DC fast chargers and has a separate 315-kVA power substation.

CHENNAI, TAMIL NADU

CSCAF 2.0 overall rating: 3 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 329/1200

Chennai City, often called Greater Chennai, is the capital of Tamil Nadu. Previously known as "Madras" for more than a century, it took its new name in 1996. Chennai gained attention for sustainable development by emphasizing NMT in its second master plan, prepared in 2008. However, this master plan did not include a comprehensive vision for climate and disaster resilience. Chennai's new masterplan, being developed by the Chennai Metro Development Authority (CMDA), will focus on curbing the impact of climate change (*The New Indian Express 2020*). In 2014, Chennai was selected as one of the Rockefeller Foundation's 100 Resilient Cities (Chennai Resilience Centre n.d.) and in the same year the Greater Chennai Corporation became the first municipality to introduce a city NMT policy (Corporation of Chennai 2014). Thereafter, in 2015, it was one of the 20 cities selected in round one of the union government's SCM. It is the second city to receive an equal amount of funds from its state government (along with funds from the center) under the mission for smart city projects and stood second for completion of projects in 2021 (Aijaz 2021). In 2022, the city worked with C40 and the Urban Management Centre, Ahmedabad, to prepare the Chennai Climate Action Plan and aims to become carbon neutral by 2050 (C40 and Greater Chennai Corporation 2022). The CMDA is currently developing a third master plan for the period 2027–46. Table 5 describes key actors working on energy transition in the city.

Chennai's energy transition journey

Chennai's efforts toward achieving a clean-energy-powered, energy-efficient future have been scattered and have not been led by a specific group of actors. These efforts also lack the scale of partnership and coordination needed between city agencies and a deep, concerted policy push. Despite a state EV policy, the adoption of e-buses in the city has also been relatively slow.

However, Chennai saw a host of new initiatives between 2021 and 2023, mainly including partnerships with international NGOs and think tanks focused on the climate-resilient development of the city. The city's Master Plan 2046 is being prepared with technical assistance from the World Bank (*The New Indian Express 2020*). This assistance is conditional on the inclusion of environmental safeguards in the Master Plan. Highlighted actions include solarization of public buildings and state-MDB (Multilateral Development Bank) partnerships for greener affordable housing.

Highlighted actions: Solarization of public buildings and sustainability considerations in affordable housing projects

GCC worked with CSCL to install RT-SPV systems in 1,378 of its buildings (Chennai Corporation n.d.). CSCL supported GCC in putting in place a renewable energy service company (RESCO) model, covering 5.6 MWp solar capacity, at a capital cost of ₹33.83 crores. Both the

TABLE 5 | Key actors in Chennai

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Greater Chennai Corporation (GCC)	Municipal corporation	GCC manages administration in Chennai City and has been involved in various initiatives, such as LED street lighting, ground-mounted solar, solar rooftop systems, NMT infrastructure, and clean public transportation
Chennai Smart City Limited (CSCL)	Smart City SPV	CSCL has been engaged in implementing LED street lighting, developing NMT infrastructure, solar rooftop programs, and other initiatives
Chennai Metro Development Authority (CMDA)	Development authority	CMDA is responsible for developing the Chennai Master Plan 2046, which forms part of the Tamil Nadu Housing and Habitat Development Project, assisted by the World Bank. CMDA's office complex in Chennai received IGBC Gold certification in October 2023
Chennai Metro Rail Corporation (CMRL)	Transportation utility	CMRL has been solarizing metro stations in Chennai City. As of October 2023, 12–15% of its operational energy requirements were being met through RT-SPV plants

Source: Aggregated by WRI India authors.

scale of this endeavor and the partnership between the corporation and the municipality to facilitate the implementation of the state solar energy policy are noteworthy.

The project achieved a captive utilization of up to 8.4 million units of solar energy from solar rooftops with a 5.6 MWp rating (Chennai Smart City Limited n.d.) and resulted in annual energy cost savings of nearly ₹3 crores. Rooftop solar installation in buildings is a priority area of action identified by the City Municipal Corporation. In 2022, for instance, in its "carbon neutral by 2050" scenario, the Chennai Climate Action Plan highlighted energy-efficient buildings and decentralized energy generation as priority goals (C40 cities and Greater Chennai Corporation 2022). The Chennai Climate Action Plan considers integrating solar installations in buildings with shared rooftops and accelerating rooftop solar through a roof lease framework and an empaneled service provider as medium-term objectives to be achieved by 2040.

The success of the collaboration between GCC and CSCL to solarize public buildings prompted the Tamil Nadu State Energy Development Agency to announce the installation of grid-connected solar PV systems on more government buildings, including commercial tax offices, court complexes, and collectorates across the state. In early 2024, this agency floated a tender to install systems of 20 MW at a cost of ₹120 crore (*The Times of India 2024*).

State partnership with multilateral development banks to incorporate sustainability in affordable housing projects

Tamil Nadu has a history of receiving technical and financial assistance from multilateral development banks to institutionalize and implement urban reforms, including the provision of affordable housing. Chennai is home to the headquarters of the key state housing, financing, and urban planning institutions and has benefited from these partnerships.

- The second phase of the Tamil Nadu Housing Sector Strengthening program was launched in 2022. Like the first phase, this program has the same goals of "increasing the access to affordable housing by strengthening the policy, institutions, and regulations of the housing sector" (World Bank 2022). The International Bank for Reconstruction and Development is providing a development policy loan for this program and has mandated the creation of sustainability frameworks that must be adopted by the Tamil Nadu Slum Clearance Board (TNSCB) for the construction of affordable housing projects. The frameworks on resilient urban design and environmental management both encourage the adoption of clean energy and energy efficiency measures in new affordable housing.
- In 2020, the Tamil Nadu Urban and Habitat Development Board (TNUHDB), CMDA, and the Tamil Nadu Infrastructure Fund Management Corporation Limited agreed with the World Bank to execute the Tamil Nadu Housing and Habitat Development Project (World Bank 2024). The project aims to strengthen housing sector institutions in Tamil Nadu and improve access to affordable housing. Other partners include the Tamil Nadu Shelter Fund and TNSCB, agencies leading the execution of affordable housing projects in the state. The project's scope is vast. Under one sub-component, technical assistance is being provided to TNSCB and other relevant urban institutions to mainstream sustainable urban design and planning considerations, implement building energy codes like ECBC, use resilient construction materials, minimize urban heat island effects, and achieve green certification for housing units. In April 2022, TNUHDB introduced a government order mandating compliance with energy efficiency provisions in ENS for buildings, including affordable housing of a certain size constructed by the Tamil Nadu Housing Board and the TNUHDB (Shivakumar 2022).

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

In addition to the installation of solar rooftop plants in public buildings, other municipal-side initiatives include an almost 100 percent conversion of the streetlights maintained by GCC to LEDs (there are also some compact fluorescent lights). Some of this conversion was achieved in partnership with CSCL. However, EESL's National Street Lighting program has seen limited implementation in Chennai, with only 7,876 LED streetlights installed as a part of EESL's collaboration with other public institutions (EESL n.d.). Chennai was one of the first Indian cities to use sewage treatment plants to generate biogas and to use biogas to generate electricity. This process enabled the

sewage treatment plants to run entirely on biogas, reducing the operating costs of the Chennai Metropolitan Water Supply and Sewerage Board. GCC has also been using EVs for waste collection.

Promotion of low-carbon mobility

In 2019, a CMP for the Chennai Metropolitan Area was prepared by CMDA, CMRL, and the Urban Mass Transit Company (Chennai Metro Rail Corporation et al. 2019), oriented toward the promotion of public transportation and NMT measures like cycling and pedestrian-friendly streets. Chennai is one of the few Indian cities to have a Unified Metropolitan Transport Authority (UMTA), which was established in 2010. Chennai UMTA is in the process of preparing a new CMP for the entire Chennai metropolitan area, with citizen engagement and feedback at the core of its development. The authority launched this in April 2025.

Under the SCM, CSCL has worked on pedestrianization (i.e., designing streets for pedestrians and cyclists) and implemented the Cycle Sharing System through a prospective bidder in a design, build, finance, and operate model over a period of seven years (Chennai Smart City Limited,n.d.). This cycle rental scheme aims to increase the uptake of bicycles.

Partnerships with civil society, international agencies, and transnational networks

City agencies in Chennai have been collaborating with civil society organizations on various initiatives that directly or indirectly support clean energy transition:

- In 2014, Chennai joined the Rockefeller Foundation's 100 Resilient Cities initiative. In 2019, a Chennai resilience strategy was developed and launched by GCC. In 2021, the implementation of this strategy was institutionalized as the Chennai Resilience Center, which is housed within the NGO Care Earth Trust. The strategy's key pillar, "healthy and planned urbanization," involves several elements relevant to the energy transition, including a more integrated approach to urban planning and the promotion of transit-oriented development. A Chennai Resilience Center program, Urban Thottam, is supporting the creation of green rooftops that can cool the city, mitigate urban heat island effects, and serve as gardening spaces to cultivate food locally (Urban Thottam n.d.).
- In collaboration with the Institute for Transportation and Development Policy (ITDP), GCC received the Ashden: Climate Solutions in Action award for sustainable transportation in 2020 (Ashden 2020).
- In another initiative, a partnership between TANGEDCO, the Chennai-based consumer action group, and Bangalore-based TIDE ran Minsarathai Semippom, a consumer-focused energy efficiency and energy conservation pilot program for 500 residential consumers in Chennai. Participating consumers were provided with customized recommendations for saving energy, such as purchasing energy-efficient appliances, installing rooftop solar, and simple behavior changes.
- C40 is also working with CMDA to mainstream climate action in the Chennai Master Plan 2046.
- Under The Cool Coalition and the India-Denmark Green Strategic Partnership, the United Nations Environment Programme (UNEP) signed an agreement in 2023 to oversee the delivery of sustainable cooling in Chennai (*The Hindu Business Line 2023*).

Financing

Chennai has explored various financial avenues to support its energy transition initiatives. For instance, its street lighting project was funded through a combination of resources, including the capital grant fund from the state government, the municipal budget, and Smart City funds. The solar rooftop installations on public buildings and some of the street lighting projects were financed with Smart City funds using a RESCO model. Additionally, a public-private partnership model was used to fund the biogas initiatives in sewage treatment plants and the bicycle rental program. The RT-SPV projects on government buildings have also been implemented under a RESCO model.

Technology and innovation

Chennai has implemented energy-efficient LED street lighting projects equipped with a remote group monitoring system. This system allows real-time, remote control of streetlights and can issue alerts in case of malfunctions.

DELHI, GOVERNMENT OF NCT OF DELHI

CSCAF 2.0 overall rating: 3 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 310/1200

Delhi is both a city and a union territory governed by the elected Government of the National Capital Territory of Delhi. One of the nine districts of the union territory of Delhi, New Delhi is the capital city of India, with an officially estimated population of 20 million in 2020 (TNN 2020). Delhi has a total area of 1,483 km^2, of which 25 percent is rural and 75 percent is urban, and is the largest city in terms of area in the country. At 5,341 kWh/person, Delhi has the highest per capita power consumption in India: its peak demand routinely exceeds 6,000 MW during the summer, and reached 8,656 MW in 2024 (*The Indian Express* 2024).

In 2009, the government of Delhi initiated the preparation of a framework for implementing a climate mitigation and adaptation plan in compliance with the National Action Plan on Climate Change. The subsequent stakeholder engagement process resulted in a CAP for Delhi in 2013, the first of any city in India. A second climate change action plan for the period of 2011 to 2020 was approved in 2018. As of June 2023, a third plan was under development to cover the period from 2021 to 2030, and a heat action plan (2024–25) was approved by the Delhi government in 2024 (Delhi Disaster Management Authority 2024). From an urban planning perspective, Delhi's Draft Master Plan 2041 sets low-carbon mobility and the promotion of sustainability through energy efficiency as its fifth and sixth objectives, respectively (Delhi Development Authority 2020). The city's severe air pollution has prompted the accelerated promotion of low-carbon mobility solutions, particularly the expansion of public transportation systems and a shift to EVs. Table 6 describes key actors working on energy transition in the city.

TABLE 6 | Key actors in Delhi

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
North Delhi, South Delhi, East Delhi Municipal Corporation, South Delhi Municipal Corporation, New Delhi Municipal Corporation	Municipality	Implementation of RT-SPV projects across municipal buildings
BSES Rajdhani Power Limited (BRPL)	DISCOM	Implementation of programs and schemes to promote energy-efficient appliances and RT-SPV. Piloting demand response and battery energy storage projects.
BSES Yamuna Power Limited (BYPL)	DISCOM	
Tata Power Delhi Distribution Limited (TPDDL)	DISCOM	
Dialogue and Development Commission of Delhi	Think tank	Policy think tank of the Government of the National Capital Territory of Delhi, which was instrumental in the launch of the Solar Policy 2024 and the Delhi EV Policy 2020
Delhi Metro Rail Corporation (DMRC)	Transportation utility	This transportation utility has taken proactive measures to solarize its buildings and procure only renewable energy for its operations via open access
Department of Transport	Government department	Houses the EV cell (also called Switch Delhi) that is tasked with implementing Delhi's EV policy

Source: Aggregated by WRI India authors.

Delhi's energy transition journey so far

Delhi's actions to promote renewable energy and energy efficiency have been largely led by its private sector DISCOMs: BSES Rajdhani Power Limited (BRPL), BSES Yamuna Power Limited (BYPL), and Tata Power Delhi Distribution Limited (TPDDL). Delhi's struggles with poor air quality have spurred rapid advancements in the rollout of EVs, both through policy and technology. Different actors, including NGOs, CSOs, and think tanks have been providing technical assistance to the Delhi government in combating air pollution through clean energy interventions. In the last five years, Delhi has also seen progressive clean energy policies and thinking in the direction of integrated urban planning. For example, the Delhi Development Authority has prepared the Delhi Master Plan 2041 (Delhi Development Authority 2020) which considers a complete shift of Delhi's energy needs to renewables and the promotion of energy efficiency as key strategies to make the city sustainable. The plan highlights several measures, including:

- Promoting solar farms and floating solar PV.
- Mandatory installation of RT-SPV on government buildings, transportation depots, and other large-scale public facilities.
- Revising the unified building bylaws to promote on-site renewable energy generation in new constructions.
- Time-of-day tariffs to encourage the use of solar during peak hours.
- Promoting energy-efficient appliances and thermally comfortable buildings.

Delhi's Master Plan 2041 was placed in the public domain for comments in June 2020, but has so far not been approved. Similarly, Delhi has not notified ECBC and, consequently, the Delhi Development Authority did not include ECBC provisions in the unified building bylaws. A smart street-lighting project that was to install 90,000 LED streetlights has still not been commissioned (Mishra 2023).

On the positive side, the Delhi Solar Policy 2023 was approved in January 2024, with a new but reduced target of 4500 MW by 2027 (Government of National Capital Territory of Delhi 2024). Under this policy, consumers will be provided with generation-based incentives as well as an additional capital subsidy for rooftop solar installations. The policy also mandates RT-SPV installation for government buildings with a built-up area (BUA) of 500 m^2.

Highlighted actions: Promotion of EVs and DSM and clean energy promotion by DISCOM

Promoting the EV ecosystem

Delhi's government has identified the promotion of EVs as a high priority for combating air pollution. Delhi's EV Cell was established in March 2022 by the Delhi Transport Infrastructure Development Corporation to accelerate the implementation of the Delhi EV Policy 2020. In February 2022, Delhi became the first state in India to exceed 10 percent EV share in the market. This can be attributed to the Delhi government's approach to promoting EVs, which addresses the entire ecosystem from supply to demand and facilitates the deployment of technology and infrastructure to overcome key barriers.

- **Policy and regulatory enablers.** Delhi's 2020 EV Policy aimed to achieve a target of 25 percent of all new vehicles being electric by 2024. The incentives provided under this policy are funded by surcharges on polluting vehicles, pollution cess, road tax, congestion tax, and other charges. Non-financial incentives include road tax waivers, green registration plates for EVs, license fee waivers, and single-window clearances to install charging points in homes. The creation of the Delhi EV Cell, a separate institutional body responsible for EVs in Delhi and housed in the transportation department, was also a major contributor toward institutional readiness. Delhi also has a concessional electricity tariff for EV charging, as approved by the Delhi Electricity Regulatory Commission (DERC). In addition, Delhi's building bylaws have been amended to mandate the provision of EV charging in new buildings. Finally, to empower and educate consumers, the Delhi Development Commission (DDC) also published a guidebook for installing and managing EV charging facilities in Delhi's residential areas (WRI India and DDC, Government of Delhi NCT 2022).
- **Finance.** In 2022, the Government of the National Capital Territory of Delhi signed an agreement with CSCL to offer 5 percent interest subventions to buyers of electric cars and light commercial vehicles, which was in addition to a purchase incentive of ₹30,000 and a scrapping incentive of ₹7,500 (on submission

of proof), as per EV policy (*The New Indian Express* 2022). Financial incentives were also offered for private charging equipment. The government also provides reimbursement for state goods and services tax levied on the purchase of advanced batteries for swapping stations. Delhi ended its subsidy of ₹10,000 per kWh of battery capacity for electric 4W in 2021 when the target of 1,000 EVs was reached.

Demand-side management

Notably, Delhi's three DISCOMs have been among the leaders in the area of DSM efforts in the country. The DERC DSM Regulations 2014 created the policy environment for Delhi DISCOMs to act on DSM. A wide range of initiatives has been implemented by these DISCOMs, from appliance rebate and exchange programs to pilot projects on demand response. The DISCOMs have also adopted a strong consumer engagement model to create awareness of DSM; for example, providing energy-saving information on electricity bills and using social and digital media to seek consumers' participation in DSM activities and cooperation on pilot projects. In 2019, BRPL implemented an 18-month pilot project on behavioral energy efficiency with Opower, under which 200,000 residential consumers in South and Southwest Delhi were provided with personalized home energy reports complete with energy-saving recommendations to understand their energy consumption. Considerable savings were observed under this program. Following the pilot's success, BRPL submitted a petition to DERC in 2019 to scale the project up across BRPL's service territories. In 2020, BRPL and BYPL also piloted a virtual information campaign, Solarize Delhi, to create awareness of rooftop solar in residential colonies of Delhi (Gupta 2022). In 2023, TPDDL launched Urja Arpan, a unique demand response program that asked smart meter and automated meter reading consumers to voluntarily participate in demand response events between March and September 2023 (Tata Power DDL n.d.). Consumers were offered incentives calculated based on a 10-percent reduction in actual energy consumption compared to the baseline.

The DISCOMs TPDDL and BSES have both rolled out programs to accelerate the uptake of RT-SPV in residential buildings, with community participation at the core of program design (e.g., the Solarize Delhi campaign described in later sections). BSES has also piloted using RT-SPV energy for one of its charging stations. However, renewable energy accounted for only a third of Delhi DISCOMs' power purchase agreements as of March 2023. In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

The Municipal Corporation of Delhi (MCD), which comprises the North, East, and South Delhi Municipal Corporations, has undertaken RT-SPV projects for public buildings in partnership with the Solar Energy Corporation of India (SECI) and the National Thermal Power Corporation (NTPC) (Saur News Bureau 2023). On behalf of MCD, SECI has floated tenders for RT-SPV projects using a demand-aggregation approach. For example, in August 2023, SECI invited bids for 15 MW of RT-SPV projects for MCD. Delhi municipalities have shown less interest in reducing energy consumption in municipal services like street lighting, water pumping, and sewerage. For instance, only 65 percent of Delhi's street-lights were energy efficient according to CSCAF 2.0 data collected for the 2020–21 assessment. The Delhi Jal Board does not mention improvements in the efficiency of the pumping infrastructure as part of the Delhi Draft Master Plan 2041. Nevertheless, some evidence of Delhi Jal Board projects to reduce energy consumption in water pumping using automation was found (Sethi 2022).

Clean energy adoption by the metro transportation utility DMRC

The DMRC's service territory extends beyond the boundaries of the national capital territory. The mass rapid transit service provider meets 35 percent of its energy needs with renewable energy and plans to increase this level to 50 percent by 2031. A total of 30 percent of this renewable share comes from the Ultra Mega Solar Park in Reva, Madhya Pradesh. The DMRC has also changed the design of the roof structures of metro stations to allow for RT-SPV-based energy generation. As of April 2023, the DMRC had a total installed capacity of 50 MWp across its various locations, including metro depots (TNN 2023a).

Partnerships between civil society and city agencies

Think tanks and CSOs have also been participating in the governance of energy transition. Some examples include:

- The Center for Science and Environment, a Delhi-based NGO, has been actively bringing environmental issues in Delhi to the political forefront through decades of research.
- The Rocky Mountain Institute (RMI) worked with the DDC to host the Urban Mobility Lab, which aimed to implement Delhi's EV policy. RMI also ran the Deliver Electric Delhi pilot to assess the economic feasibility of electrifying last-mile delivery vehicles and led consultations for the DDC on the draft solar policy for Delhi in 2022.
- WRI India has been working with the DISCOMs BRPL and BYPL to understand the grid impacts of EV charging and promote renewable energy products like green tariffs.
- The DISCOM BSES collaborated with the environmental policy think tank Council on Energy, Environment, and Water on a study to examine the costs and benefits of grid-connected rooftop solar (BSES 2022).

Finance

- For RT-SPV projects, the RESCO model has been adopted to eliminate the need for upfront capital for the entire system. The model is attractive because the project developer handles all risks related to the project. Delhi municipalities and other public institutions (e.g., government-aided educational institutions and the DMRC) have largely used the RESCO model.
- The DISCOMs' DSM initiatives have received support from different sources but are largely funded by DSM budgets.
- The incentives provided under Delhi's EV policy are funded through several sources, including pollution cess (on polluting vehicles), road tax, congestion tax, and environmental compensation charges. This model of funding is called "feebate".

Technology and innovation

- Battery energy storage pilot. In April 2023, the other Delhi DISCOM, TPDDL, announced its plans to modernize the grid through smart meters and a pilot battery energy storage system (BESS) project, in addition to other grid enhancements. The 10-MWh BESS is expected to be the largest demonstration of grid-scale storage at the distribution level in South Asia. In May 2024, the Delhi regulator approved a BESS agreement between BRPL Rajdhani and Kilokari BESS for a 20-MW energy storage project with a capacity of 40 MWh, which became the only BESS project to receive regulatory approval (Mercom 2024).
- Automated demand response pilots. In 2020, a demand response pilot involving the load control of HVAC (heating, ventilation, and air-conditioning) systems in commercial buildings was implemented by BYPL (Mishra 2024). The DISCOM used a cloud-based intelligent interface to send signals to the HVAC systems to reduce the load on a real-time basis by controlling the systems' set point temperature and cooling modes.
- Community solar, hybrid RESCO, and peer-to-peer trading models. In 2018, BSES demonstrated a community solar model in a cooperative housing society where a single-point delivery system (a single meter) was used for solar panels installed on the rooftops of groups of apartment buildings. This enabled consumption costs and production benefits to be shared by all consumers in the cooperative.

The Delhi Solar Policy 2024 also proposes community solar, hybrid RESCO, and peer-to-peer trading platform models to address the space and financial constraints facing RT-SPV installation. Under the community solar model, groups of consumers can set up solar plants on a third-party site and jointly avail themselves of the benefits of energy production. The hybrid RESCO model will permit consumers to lease their roof space to a RESCO and buy the solar energy generated at a discounted tariff. A virtual platform to enable the peer-to-peer trading of excess solar power generated between consumers has also been proposed in the policy.


PATH
RECHARGE
Electric Vehicle
Charging Station

INDORE, MADHYA PRADESH

CSCAF 2.0 overall rating: 4 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 762/1200

Indore is the largest city and financial capital of the state of Madhya Pradesh. The historical city was first electrified in 1907. Indore's foray into climate action began in 2008 when it became a pilot city in the Rockefeller Asian Cities Climate Change Resilience Network initiative. The technical assistance helped Indore build an understanding of climate impacts and assess urban climate resilience through engagement with local communities. Pilot projects implemented under this initiative culminated in the launch of the Indore City Resilience Strategy in 2012. In 2015, Indore was one of the first 20 cities selected in the first round of the 100 SCM. Indore's Smart City plan focused on retrofitting, redevelopment, and the promotion of building efficiency, rooftop solar, and green buildings in selected areas. In 2016, Indore was declared a "non-attainment" city by the Central Pollution Control Board for not meeting the air quality standards prescribed by the India National Clean Air Program. However, Indore's pride is its comprehensive waste management model, which has contributed to the city's reputation as India's cleanest (judged the cleanest city in India in 2017 and 2018 by the Swachh Bharath Sarvekshan). In June 2023, Indore launched its own CAP under the guidance and supervision of the Environmental Planning and Coordination Organisation (EPCO)(EPCO, Department of Environment, Government of Madhya Pradesh 2023). Table 7 describes key actors working on energy transition in the city.

Indore's energy transition journey

Indore is a city of many firsts when it comes to the adoption of clean fuels and innovative financing mechanisms for its initiatives. It was the first Indian city to:

- Use hydrogen-blended natural gas to supply compressed natural gas (CNG) to vehicles and piped natural gas (PNG) to households (PTI 2022a).
- Execute waste-to-bioCNG plants where the bioCNG produced will be used in local buses (PTI 2022b).
- Initiate the installation of over 100,000 smart meters.
- Use carbon markets to generate revenue from its clean energy projects.

The driving factors behind these initiatives include improving air quality and protecting and upholding Indore's image as India's cleanest city.

While Indore has made rapid progress in large-scale WTE generation projects, other clean energy actions like e-mobility, NMT, the solarization of public buildings, and the promotion of energy efficiency in municipal services have not been priorities.

IMC is the lead actor anchoring and implementing most of the clean energy initiatives, either directly or indirectly as a part of the Smart City SPV. IMC oversees urban services like street lighting, water supply, waste management, and road maintenance. The Indore Development Authority

TABLE 7 | Key actors in Indore

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Indore Municipal Corporation (IMC)	Municipal corporation	The city's civic administrator, implementing WTE projects and a few clean energy and energy efficiency initiatives in municipal services like water pumping, wastewater treatment, and transport
Indore Smart City Development Limited (ISCDL)	Smart City SPV	Implemented LED street lighting projects and smart metering projects with IMC and the local DISCOM
Madhya Pradesh Paschim Kshetra Vidyut Vitaran Company Limited	DISCOM	Nodal agency for RT-SPV and smart metering projects in the city
Environmental Planning & Coordination Organisation (EPCO)	State body	The state knowledge management center for climate change at EPCO has been engaging cities in the development of CAPs; EPCO guided the launch of Indore's first CAP in June 2023

Source: Aggregated by WRI India authors.

is the planning and development agency that regulates land use and implements city master plans, which are prepared by the state town and country planning department.

Highlighted actions: Innovative financing mechanisms and business models

IMC has experimented with a few interesting models to finance its initiatives. Indore's use of a variety of financial instruments and business models to finance energy transition initiatives offers other ULBs lessons in both financing and project management.

- Green bonds. IMC issued a green municipal bond to finance a 60-MW ground-mounted solar PV project that would power a water-pumping station at a cost of ₹305 crores. This was only the second such municipal bond introduced by a ULB in India and was offered at a coupon rate of 8.25 percent per annum, payable half yearly with an effective yield of up to 8.42 percent per annum. On the first day of the offer, IMC collected ₹661.52 crores (Global Newsmakers 2023). The revenue streams such as taxes, fees, rental income, and other sources of income generated by IMC will be used to repay the green bonds.
- Public-private partnerships for WTE plants. For the 550-tonnes-per-day (TPD) bioCNG plant in Devguradia, IMC set up an SPV, Indore Clean Energy Private Limited (ICEPL), with a 100 percent capital investment of ₹150 crores from Indo Enviro Integrated Solutions Limited, the company operating the plant (Department of Economic Affairs, Ministry of Finance, Government of India, n.d). ICEPL also obtained a ₹50 crore loan from HDFC Bank as part of its environmental, social, and governance commitments. IMC buys 50 percent of the CNG produced in the plants, and the remaining 50 percent is sold in the market to make this operation profitable. The private company pays a premium of ₹2.5 crore to the civic body every year in return for wet waste being provided to run the plant. IMC is in a 20-year agreement with the private company.
- Carbon markets. Indore's ISDCL has tapped into the voluntary carbon market to generate revenue from the sale of carbon credits through the CO2 emissions avoided from the WTE plants (15- and 20-TPD biomethanation plants) and the solar PV for water-pumping stations (1.5 MWp)(Vasudha Foundation 2022b).
- ISCDL carbon market consultancy for government bodies. Given its experience with carbon markets, ISCDL is also providing consulting services to other government bodies, including ULBs, rural bodies, and other line departments, to help them benefit from carbon trading mechanisms and identify and support the implementation of projects to reduce emissions. This unique consultancy model is not being practiced in any other Smart City in India.

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

In terms of energy efficiency in Indore, only the LED street lighting initiative stands out. As of March 2020, IMC had nearly achieved the target of 100 percent conversion to LEDs and had applied technologies like smart sensors to control switching operations.

In 2022, IMC declared its commitment to transform Indore city into a solar city, with the target of achieving 300 MW of rooftop solar by 2026 (Outlook India 2023). Though it has been slow in adopting rooftop solar for its own buildings, IMC has implemented ground-mounted solar PV projects to reduce operational expenditure on municipal services. As part of the Smart Cities program, a total of 750 kWp of solar PV projects have been executed in different locations in the city (Smart City Indore n.d.). At one of its sewage treatment facilities, 180 kWp of rooftop solar was commissioned in September 2022 (Gupta 2022) to meet the plant's operational energy requirements. The CSCAF 2.0 report listed Indore as one of the two cities that have conducted an energy audit for wastewater pumping stations and treatment plants, reducing energy consumption by more than 15 percent from 2016–20. These two cities have also been able to use solar PV generation to reduce energy bills on wastewater treatment systems.

Implementation of large-scale waste-to-energy plants

Indore's successful waste management model has contributed to maintaining its clean-city image. It has also helped provide the high quality and quantity of segregated municipal waste needed to operate WTE plants, which is a prerequisite for the long-term sustainability of such projects. IMC has been able to make its WTE plants

financially viable by working on market linkages for the plants' by-products (e.g., compost/manure) and has integrated the informal waste collection sector by collaborating with two NGOs, Sarthak and Basix. IMC's three large biogas plants, which can process more than 50 tonnes of waste a day, are efficient and economically attractive as they produce compressed biogas (CBG) instead of converting biogas to electricity, which many of the smaller biogas plants do. The guaranteed offtake of the CBG generated in Indore's WTE plants has been identified as one of the city's key successes in the management and operation of these facilities. IMC and ISCDL also provided land in Devguradia for the installation of Asia's largest biomethanation plant, which has a 550-TPD capacity. In 2019, Indore's experience of executing waste-to-bioCNG plants was recommended as a model to be replicated in 79 countries (Yadav 2022).

ISCDL was established as an SPV through a partnership between IMC and the Madhya Pradesh Urban Development Company Limited to implement SCM projects. The ISCDL Board of Directors includes the District Collector of Indore and the Commissioner of IMC. The majority of ISCDL staff are on deputation from IMC; thus, coordination issues delaying the disbursement of Smart City funds are limited.

Partnerships with civil society, international agencies, and transnational networks

In 2022, a district-level CAP for the Indore district was developed by the Vasudha Foundation, an NGO, in collaboration with the State Knowledge Management Centre on Climate Change, EPCO, and the Department of Environment of the Government of Madhya Pradesh (Vasudha Foundation 2022b). EPCO's leadership was instrumental in facilitating data collection and inter-departmental coordination in the district, as well as IMC's participation. In June 2023, a city CAP was developed for the State Knowledge Management Centre on Climate Change within EPCO in collaboration with WRI India. In 2021, Indore also joined the USAID Clean Air Catalyst program and is implementing several initiatives to monitor and improve air quality.

In Indore, citizen engagement in discussions and deliberations for policy- and decision-making remains low. There is only a limited mechanism that allows for grievance redressal and public feedback.

Financing

The proceeds from the sale of Indore's first green bond are expected to finance its transformation into a solar city. All the city's three WTE plants have leveraged public-private partnerships (as described in detail in the following sections) and viability gap funding. The two biomethanation plants, which have capacities of 15 TPD and 20 TPD and cost ₹6.5 and ₹9 crores respectively, received viability gap funding of ₹10 crores from ISCDL. The guaranteed offtake of the CBG generated from the WTE plants for use in the city's buses has been instrumental in attracting private investment for these facilities.

The city's large-scale smart meter rollout was facilitated by a combination of grants from the Integrated Power Development Scheme and Smart City funds. The LED street lighting projects were financed through a combination of IMC's own funds, Smart City funds, and a partnership with EESL as part of an energy savings performance contract.

Technology and innovations

- Indore municipality has been a flag-bearer for the production of CBG from segregated wet waste. All the city's three WTE plants employ biomethanation technology that uses anaerobic digestion. The biogas is enriched to meet the Bureau of Indian Standards' requirements and allows for compression to generate CBG.
- In 2022, Indore became the first Indian city to pilot hydrogen-blended CNG as an alternative fuel for its transportation sector (PTI 2022a). The results from the pilot project are expected to inform the development of a regulatory framework for injecting hydrogen into natural gas in India.
- In 2023, the Bangalore-based think tank CSTEP worked with local DISCOMs in Madhya Pradesh, including the Indore DISCOM, on a rooftop solar assessment tool based on geospatial data. The tool can be used by consumers in the city to quantify the capacity of rooftop solar that can be installed on their rooftops.
- Indore is also the location of one of six lighthouse projects selected as part of MoHUA's Global Housing Technology Challenge to demonstrate sustainable affordable housing construction techniques and technologies (Global Housing Technology Challenge, Ministry of Housing and Urban Affairs).


अग्रवाल स्वीट्स
॥ आहार शुद्धौ... सत्व शुद्धिः ॥
(उपनिषद)
SINCE
1956
छप्पन दुकान, इन्दौर
Agrawal Sweets
Purity of mind follows...
Purity of diet (Upnishad)
PIZZA
AJ
BURGER
Sandwich
AGRAWAL
NAMKEEN
नमकीन सेंटर
कॉफी
बर्गर मैगी
AJ Sandwich
छप्पन दुकान की
असली रौनक है
आप!
इसकी
स्वच्छता
की वजह भी तो
आप ही हैं!

KOCHI, KERALA

CSCAF 2.0 overall rating: 2 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 283/1200

Kochi, formerly known as Cochin, is the most densely populated city in Kerala. It is often called the "Queen of the Arabian Sea." In 2008, Kochi was selected as one of 60 Indian cities in the Ministry of New and Renewable Energy's (MNRE) solar city development program. Kochi's solar master plan was approved in 2015, and the city was accepted into the union government's SCM in 2016. In 2015, Cochin International Airport became the first solar-powered airport in the world, receiving the UN's Champion of Earth prize in 2018. Table 8 describes key actors working on energy transition in the city.

Kochi's energy transition journey so far

The approved Master Plan 2040 for the Kochi Municipal Corporation area includes several provisions to promote a clean and energy-efficient future for the city. Unlike many other smart cities, Kochi did not see development in energy-efficient street lighting under the SCM until late 2021. CSML began implementing LED street lighting using its own funds; however, a CSML dashboard shows that the project, which started in 2019, has not been fully completed (37 percent physical progress and 32 percent financial progress). Kochi's progress on other common clean energy initiatives such as the solarization of public buildings has also been limited. As of September 2022, CSML had commissioned a cumulative capacity of 1 MWp for government buildings within KMC's limits (Cochin Smart City Limited n.d.). Kochi was identified as a solar city under the MNRE's Solar Cities program in 2015. A solar city plan was prepared for the city, and a solar city cell established within C-HED. Evidence suggests that the implementation of the plan has been limited.

Two agencies, CSML and KMRL, have been active in executing RT-SPV projects. KMRL, the city's metro service provider, has solarized many of its metro stations, meeting 50 percent of its energy needs from solar (Subhashini 2023).

The city has been taking the decarbonization of the transportation sector seriously, with support from think tanks and international agencies providing technical and financial assistance for its projects. KMRL has been implementing smart city projects on urban transportation.

TABLE 8 | Key actors in Kochi

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Kochi Municipal Corporation (KMC)	Municipal corporation	KMC has taken a keen interest in promoting EVs and NMT
Kochi Metro Rail Limited (KMRL)	Transportation utility	KMRL has been implementing several initiatives in the city: solarization of metro stations, ground-mounted solar PV, and last-mile connectivity through EVs and NMT
Cochin Smart Mission Limited (CSML)	Smart City SPV	CSML has implemented initiatives in the area of solarizing public buildings.
Center for Heritage, Environment, and Development (C-HED)	Think tank	C-HED coordinates the delivery of climate change, sustainability, and other environmental initiatives for KMC
Kerala State Electricity Board (KSEB)	DISCOM	KSEB works with city agencies on the deployment of EV charging infrastructure, solarization of buildings, and rollout of smart meters

Source: Aggregated by WRI India authors.

Several of the earlier smart city projects aimed at addressing last-mile connectivity, probably because the CEO of KMRL was also the CEO of CSML. More recently, with the creation of a project management unit, CSML's operations have become more consolidated. CSML has also been working with KSEB to install smart meters. In the last two years, KMC has strengthened its commitment to e-mobility and NMT in partnership with external agencies and institutions. The city also boasts some unique institutions, such as the municipality's think tank (C-HED), which supports the coordination and facilitation of externally funded projects.

Highlighted action: Institutionalizing the management of environmental initiatives

C-HED was established in 2002 as an institution dedicated to research and development in the areas of heritage, environmental conservation, and integrated development. C-HED is an institutional innovation in Indian cities, where ULBs typically do not have the technical capacity or resources to engage on sustainable development topics. It is an independent legal entity, largely funded by KMC's own budgets, and the C-HED team is compensated for professional and technical services provided under national and externally funded technical assistance programs (Sasidharan 2020). C-HED's position within KMC allows it the opportunity to engage with international development agencies, think tanks, and research institutions interested in working with KMC on energy transition and climate change projects. In addition, C-HED was the nodal agency for the Solar Cities program, under which it conducted research activities such as ward-level surveys on rooftop solar adoption and public awareness and outreach campaigns and implemented pilot rooftop solar projects. C-HED also facilitated the city's engagements with technical assistance providers on a Zero-Carbon Building roadmap, low-carbon mobility, and, more generally, green buildings. As a lesson for other cities, the German Development Corporation GIZ conducted an in-depth assessment of C-HED and the challenges it faces and made recommendations to strengthen the organization (GIZ Sustainable Urban Development–Smart Cities 2021). Five elements were identified for successfully replicating the C-HED model in other cities: institutionalization, resource mobilization, knowledge management, outreach and communication, and strategic leadership.

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

The Kochi Master Plan 2041 vision for sustainable energy

The Master Plan of the Kochi Municipal Corporation Area 2040, which was prepared by the state Town and Country Planning Department, was approved by the KMC council in December 2023 and notified in May 2024 (Kochin Corporation n.d.). The master plan identifies the goal of securing affordable, reliable, and clean energy for the corporation, as well as clean energy projects that could be prioritized for implementation.

Clean energy adoption by the metro transportation utility KMRL

All 22 of KMRL's stations have solar PV panels on their roofs. KMRL implemented these solar projects under the RESCO model. In February 2022, KMRL commissioned an 824.1-kWp ground-mounted solar plant at a metro depot, which was expected to meet 42 percent of the metro utility's energy needs (*The Hindu* 2022). KMRL also announced plans to become 100% clean-energy-driven by 2024 (TNN 2022c).

Promotion of low-carbon mobility

Kochi is a pioneer in the electrification of intermediate public transportation. Different actors have emerged to promote or facilitate this type of transport:

- KMRL has already initiated the deployment of e-rickshaws as feeders. KMRL had been working on procuring e-minivans and e-buses for seamless last-mile connectivity to efficiently increase feeder service (KMRL n.d.) but the status of progress on this initiative is unknown.
- Kochi is also known for envisioning the second-largest urban waterbus fleet in the world. The Kochi Water Metro project was initiated with the assistance of the Kreditanstalt für Wiederaufbau (KfW) under the Indo-German Development Corporation and UMTA, the local body that oversees coordination between various agencies involved in building Kochi's sustainable transportation system (ICLEI SA 2018). KMRL also presides over Kochi's Unified Metropolitan Authority, the institution that governs urban transportation in Kochi.

- KMC had initiated a process to develop an e-mobility plan for Kochi to mainstream EVs in the city. The corporation announced a subsidy to buy e-autorickshaws through the Ernakulam Autorickshaw Cooperative Society and launched a pilot e-autorickshaw project in 2022 with technical and financial assistance under the UN HABITAT-funded Urban Pathways project and supported by the GIZ Supporting Sustainable Forms of Transport in India (Smart SUT) project (Datey and Bali 2022).
- KSEB is the agency designated for setting up EV charging infrastructure across the state, with 18 EV charging units located in Kochi.

Partnerships with civil society, international agencies, and transnational networks

- In 2019, Kochi joined the Building Efficiency Accelerator (BEA), one of the six global energy efficiency accelerators launched at the UN Sustainable Energy for All Summit in 2015. The BEA aims to help cities reduce building emissions to meet climate goals. As part of these efforts, Kochi received support from WRI India on the development of a benchmarking program for offices. The BEA and WRI India successfully conducted a building energy performance benchmarking survey for 50 offices in Kochi and identified barriers to energy efficiency retrofits through a qualitative assessment. In addition, Kochi has also been working to refine and implement a Zero-Carbon buildings roadmap for its building sector.
- Additionally, with support from GIZ, KMC was working on incorporating possible design interventions to make its new office building a green building.
- Kochi has been a member of the EcoMobility Alliance since 2015, supported by ICLEI. Aiming to inspire local leaders to develop an eco-mobile transportation system that prioritizes walking, cycling, public transportation, shared mobility, and light EVs, this alliance seeks to promote city-to-city knowledge exchange and foster local innovation.

Finance

The majority of the e-mobility projects in Kochi have been financed by Smart City funds. The same funds have also supported the roll-out of smart meters by KSEB. The electric buses procured for the city used the gross cost contract model. The Kochi Water Metro Project is financed by KfW and the Kerala state government.

Under the Supporting Sustainable Forms of Transport in India (Smart SUT) project, GIZ provided financial aid to KMC to subsidize the procurement of 100 e-autorickshaws through the Autorickshaw Cooperative Society. A direct subsidy for the cost of the e-autorickshaws was provided for 20 autos by the UN HABITAT Urban Pathways project and by GIZ for 80 autos through the Smart SUT project, reducing the cost by 25%. The remaining cost was covered by the Autorickshaw Cooperative Society through a group loan from State Bank of India under a Kerala government guarantee (Datey and Bali 2022).

Technology and innovation

- Solar-powered airport. Cochin International Airport Limited runs completely on solar power.
- Water metro. In 2023, Kochi became the first city in India to inaugurate a water metro. The expansion plan for the fleet includes more than 75 electric hybrid boats that are being manufactured by Cochin Shipyard Limited. The boats' engines can be powered by both diesel and electricity and can ferry 100 passengers, connecting 10 islands around the city.
- Solar-powered IT park. In November 2019, the SmartCity Kochi IT park commissioned a 564-kWp rooftop solar plant under a RESCO model (475 kWp on the roof of the park and 89 kWp on the parking depot) (Smart City Kochi 2019). The IoT-based system allows for the smart operation and maintenance of the power plant, which is also equipped with module temperature sensors, ambient temperature, and a lightning arrester.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NAGPUR, MAHARASHTRA

CSCAF 2.0 overall rating: 3 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 417/1200

Nagpur is the third largest city in Maharashtra. It holds the winter session of the state assembly and is a crucial administrative hub. In 2008, Nagpur was selected as one of India's 60 Solar Cities as part of an MNRE program for solar city development and was selected for the union government's SCM in the second round in 2016. It was also one of the 43 cities in Maharashtra to join the Race to Zero campaign launched by the United Nations in 2020 to achieve net-zero carbon emissions by 2050. A Nagpur district CAP has been prepared by the Vasudha Foundation (Vasudha Foundation 2022c), and a city CAP was prepared by ICLEI SA in 2022 (ICLEI SA 2022a). Table 9 describes key actors working on energy transition in the city.

Nagpur's energy transition journey

Nagpur was selected as a solar city in the first phase of the MNRE's Solar Cities program in 2015. A solar master plan was created, and a few projects were implemented. The city's municipality, NMC, is one of the few municipal corporations in India to offer direct incentives to promote renewable energy generation in buildings. The city's public transportation is governed by the municipality; therefore, NMC has also been actively engaged in e-mobility projects and the provision of EV charging infrastructure. The smart city SPV, NSSCDCL, has been sharing its commitment to drive green initiatives in the city by focusing on green buildings, e-mobility, and NMT infrastructure provision.

Highlighted action: Coordinated leadership to design building efficiency programs

As a signatory to the BEA, Nagpur's NMC, along with NSSCDCL, received technical assistance from ICLEI SA and WRI on initiating policies and programs to promote

TABLE 9 | Key actors in Nagpur

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Nagpur Municipal Corporation (NMC)	Municipal corporation	NMC is involved in implementing LED street lighting, developing NMT infrastructure and electric buses for public transportation, managing construction and demolition waste, and various other initiatives
Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL)	Smart City SPV	This SPV is involved in implementing LED street lighting, low-carbon mobility, rooftop solar, energy efficiency projects in municipal buildings, and construction and demolition waste management, among other initiatives
Nagpur Improvement Trust (NIT)	Local planning authority	The NIT is responsible for developing and implementing development control regulations. The 2018 Development Control Regulations for the Nagpur metropolitan region mandates the installation of solar water heaters in buildings
Maharashtra State Electricity Distribution Co. Ltd. (MSEDCL)	DISCOM	MSEDCL has been involved in the installation of grid-connected solar rooftop connections in the area, as well as implementing smart metering and ground-mounted solar installations
Maharashtra Energy Development Agency (MEDA)	State-designated agency (SDA) for energy efficiency and renewable energy	MEDA is involved in energy efficiency projects and implementing rooftop solar PV in government buildings

Source: Aggregated by WRI India authors.

energy-efficient buildings (WRI n.d.). Under the BEA, the city developed guidelines to promote energy-efficient homes. Energy audits of municipal office buildings were also conducted from 2019–20 as part of the BEA. The work carried out as part of the BEA supported Nagpur's participation in the WRI-led Zero-Carbon Building Accelerator project, wherein ICLEI SA worked with the NMC and NSSCDCL to develop a Zero-Carbon Building Action Plan (Pinjarkar 2024).

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

In 2017, a large-scale, city-wide initiative called Project Green Light was undertaken in Nagpur by the SCM as the largest environmentally friendly LED lights project undertaken by any Indian city. The project's target was to replace 136,000 streetlights by 2020. NMC had previously contracted a private company using its own funds to undertake a smaller amount of LED conversion; however, this contract was terminated in 2018 due to long delivery delays. According to CSCAF 2.0 data for the assessment period 2020–21, NMC reports that all streetlights are now LEDs. The LED streetlight system is equipped with an automatic switch-on and switch-off, along with a dimming system integrated into the lighting infrastructure.

As a solar city, Nagpur has implemented RT-SPV projects on a few of its public buildings. The state SDA, MEDA, had been working with other government institutions like the Nagpur Medical College to install RT-SPV projects (Shetty 2023). NMC has been providing rebates on property taxes for solar generation in residential buildings for several years (Gupta 2020). Retrofit projects, including the replacement of existing lighting systems with LED lighting and the adoption of super-efficient fans in municipal buildings, have been executed.

Promotion of low-carbon mobility

NSSCDCL has been working on creating designated cycle tracks and non-motorized zones as part of MoHUA's Cycle for Change, Streets for People program.

In addition, NMC's transportation department had been working on converting the fleet of city buses from diesel-based fuel to CNG since 2019 but suffered setbacks on project completion during the COVID-19 pandemic (Chakraborty 2021). NMC had also established a public-private partnership with several bus operators to operate electric buses in the city. In 2023 and early 2024, NMC engaged directly with the central government to obtain additional financial assistance to procure e-buses under the Prime Minister's e-bus scheme even as it struggled to put the existing e-buses in its fleet into operation (Chakraborty 2024).

Partnerships with civil society, international agencies, and transnational networks

- The local government body, NMC, has actively engaged with various development organizations. From 2012 to 2015, with assistance from ICLEI SA and UN HABITAT, Nagpur formulated Low-Emission Development Strategies as part of the Urban-LEDS I project (Urban LEDS 2020). The city continued its participation in the project's second phase (Urban-LEDS II) in 2017, which led to the development of the Local Biodiversity Strategy and Action Plan and Climate Resilient City Action Plan (ICLEI SA 2022a).
- In 2018, Nagpur became part of WRI's BEA initiative (WRI n.d.). ICLEI SA assisted NMC and NSSCDCL in organizing and carrying out energy-efficient building initiatives. In 2022, ICLEI SA also prepared a roadmap for the decarbonization of the building sector as part of the Zero-Carbon Building Accelerator project and developed guidelines for the construction of green affordable housing (ICLEI SA 2023a).

Finance

The municipal corporation has used various financial avenues to support energy transition initiatives within Nagpur. These avenues include utilizing municipal budgets, adopting the public-private partnerships model, tapping into state government funds, and accessing financial support from central government schemes such as SCM, AMRUT, and Swachh Bharath.

- In the case of LED street lighting, a public-private partnership model was implemented, according to which the municipal corporation incurred no upfront payment. Instead, private contractors invested in the entire project, and the cost was recovered from the energy savings. In addition, the corporation used its own funds to augment the city's street lighting, for example, by replacing outdated cabling and developing new infrastructure.

- The ESCO model was employed to retrofit tube lights and energy-efficient ceiling fans in NMC-owned buildings. A RESCO model was adopted for the installation of grid-connected RT-SPV systems in municipal buildings, with funding sourced from the municipal budget.

The funding mechanism for the city's multimodal electric mobility initiative relied on private sector investment, with financial incentives provided by the state government.

Technology and innovation

In 2017, Nagpur initiated the first pilot project for multimodal electric mobility in India by partnering with the Ola Mobility Institute. The project aimed to explore various aspects involved in implementing EVs on a large scale in the country. This innovative pilot was aimed at deploying a fleet of 100 electric vehicles, including a mix of e-rickshaws and e-cabs, along with battery charging stations and battery swapping infrastructure. However, it was reported that the pilot failed due to several reasons, including poor EV charging infrastructure and unattractive electricity tariffs impacting the economic viability of the EVs (Reuters 2018). The learnings from this ambitious first-of-its-kind pilot were captured by Ola Mobility Institute in a white paper (Ola Mobility Institute 2019).


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PUNE, MAHARASHTRA

CSCAF 2.0 overall rating: 4 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 682/1200

Pune City is known as the "Queen of the Deccan" because of its historical, socio-cultural, and political significance. It is the second-largest city in Maharashtra. The city became an economic powerhouse due to its robust manufacturing industry and IT sector. Pune started to transition toward sustainable development between 2000 and 2010 during the pilot of the Bus Rapid Transit System (BRTS) and the development of NMT infrastructure (Kamath et al. 2018). In 2005, Pune Municipal Corporation (PMC) became the first urban local body to take up the implementation of the Eco-Housing program with technical assistance provided by USAID (Pune Municipal Corporation,n.d.). PMC was selected in the first round of the Government of India's Smart Cities Mission (SCM 2015), and neighboring Pimpri-Chinchwad was selected in the third round. In addition to being accepted into the union government's Smart Cities program, Pune was also selected for the Rockefeller Foundation's 100 Resilient Cities initiative in 2013. Pune recently constituted a Climate Action cell for preparing short- and long-term targets to achieve carbon neutrality and organize awareness programs for citizens (Express News Service 2023). Pune is among the 43 cities in Maharashtra to join the United Nations-led Race to Zero campaign, launched in 2020 to achieve net-zero carbon emissions by 2050. PMC's environment department also publishes an annual Environment Status Report that summarizes the city's efforts toward environmental sustainability. Table 10 describes key actors working on energy transition in the city.

Pune's energy transition journey so far

PMC and PCMC are two important municipalities governing the Pune metropolitan region that oversee basic urban services such as street lighting, water supply, and waste management for city residents. In 2023, Pune city received a Platinum rating under IGBC's green cities (existing) rating system (*Free Press Journal* 2023).

PMC is an influential urban local body. Its competence became visible in 2015–16 when 80–95 percent of its yearly budget (₹34.84 billion/$518 million) came from its own revenue, in contrast to an average of 36 percent for the 20 major cities in India (Kamath et al. 2018). PMC has a long history of pioneering sustainability initiatives. It was the first Indian municipality to undertake an initiative to promote energy-efficient and green buildings in 2008. The Pune Eco-Housing program is no longer operational, but these early efforts at capacity-building and raising awareness of implementing sustainability programs created the foundation for demonstrating similar intent by successive corporation leadership. According to the CSCAF 2.0, Pune has one of the highest scores on the indicators related to renewable energy generation within city limits. It also ranks high on indicators related to the promotion of green buildings.

Though the city's progress in promoting solar energy (RT-SPV in public buildings and solar water heaters) has been significant, it has lagged in areas like smart metering and DSM. As of July 2023, the local DISCOM MSEDCL had facilitated 259.93 MW of rooftop solar projects in Pune City (Gadkari 2023).

TABLE 10 | Key actors in Pune

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Pune Municipal Corporation (PMC) Pimpri Chinchwad Municipal Corporation (PCMC)	Municipal corporation	Both municipalities are actively involved in promoting a range of clean energy and energy efficiency initiatives, including green buildings, electric mobility, and solar energy generation
Pune Mahanagar Parivahan Mahamandal Limited (PMPML)	Transportation utility	PMPML utilizes bio-CNG produced from the city's waste and operates a fleet of e-buses
Pune Smart City Development Corporation Limited (PSCDCL)	Smart City SPV	PSCDCL implemented the LED street lighting project Smart Street Light

Source: Aggregated by WRI India authors.

Highlighted actions: Citizen engagement and promotion of green buildings

Citizen engagement

As a signatory to the BEA, Nagpur's NMC, along with NSSCDCL, received technical assistance from ICLEI SA and WRI on initiating policies and programs to promote energy-efficient buildings (WRI n.d.). Under the BEA, the city developed guidelines to promote energy-efficient homes. Energy audits of municipal office buildings were also conducted from 2019–20 as part of the BEA. The work carried out as part of the BEA supported Nagpur's participation in the WRI-led Zero-Carbon Building Accelerator project, wherein ICLEI SA worked with the NMC and NSSCDCL to develop a Zero-Carbon Building Action Plan (Pinjarkar 2024). Pune sets an example for other cities on how citizen awareness and engagement can accelerate energy transition initiatives. One of the main drivers of an active environmental cell that encouraged PMC's thinking about clean energy initiatives in the city is Pune's thriving citizen activism (Basu 2021). The climate change awareness campaign was launched by scientist Raghunath Mashelkar at a roundtable on climate literacy organized by the Pune International Centre in May 2018, when Climate Collective Pune was formed. The civic engagement program in Pune during the SCM is arguably the biggest in any Indian city in recent history. Pune city officials made an extraordinary effort to incorporate citizens as the key stakeholders and beneficiaries. Through diverse offline and online activities, the campaign reached 50 percent of Pune households during the first stage of the project (the "visioning" phase). After this initial phase of citizen education, Phase II began, allowing citizens to share their opinions on various subjects. The Pune Smart City team organized the entire citizen involvement effort into nine phases in accordance with the SCM criteria (Pune Municipal Corporation n.d.). The city adopted the "5 S" approach— Speed, Scale, Structure, Solutioning and Social audit—implemented through careful preparation and planning by a team of government officials, private sector, consultants, students, and media. The engagement model, divided into nine phases, was aimed at maximizing the involvement of citizens. A co-creation phase gave citizens the opportunity to co-create solutions and share their concerns and issues with PMC. In 2023, Pune constructed a climate action cell to prepare short- and long-term targets to achieve carbon neutrality, organize public awareness campaigns, and raise awareness and funds for the program's implementation.

Promotion of green buildings

In addition to the long-running Eco-Housing program, Pune's Development Control Regulations 2017 describe the provision of incentives for the construction of green buildings in the form of floor space index (FSI) bonuses (Pune Municipal Corporation 2017). Both IGBC and GRIHA (Green Rating for Integrated Habitat Assessment)-rated projects can avail of incentives ranging from a 3 to a 7 percent premium on basic FSI. These incentives are given for pre-certified projects. Both PMC and PCMC offer discounts on premium charges for developers using GRIHA. PMC offers a 5 percent rebate on property tax to property owners undertaking any of the three interventions—solar water heater, vermicompost, or rainwater harvesting. The rebate is increased to 10 percent for installing two of these three systems (Pune Municipal Corporation 2023). Pune had 72,821 buildings with solar water heaters as of 2022–23 (Pune Municipal Corporation 2023). Corporation officials are known to run inspections of apartment complexes availing themselves of the rebates to ensure they comply with the green features post-occupancy (Jedhe 2023).

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

In 2016, PSCDCL carried out the Pune Smart Street Light project in a public-private partnership, with a private contractor replacing 90,000 luminaires. Pune has achieved 100 percent conversion of conventional streetlights to LEDs. As per PMC's Environment Status Report 2023–24 (Pune Municipal Corporation 2023), PMC is targeting the reduction of electricity consumption by 15 percent through an ESCO model covering streetlights, wastewater treatment plants, and other municipal operations. This will be achieved in partnership with the Government of Maharashtra public sector undertaking agency Mahatma Phule Renewable Energy & Infrastructure Technology Limited, which is playing the role of an ESCO. PMC had adopted both RESCO and capital expenditure (CAPEX) models for achieving a combined RT-SPV capacity of 1.3 MW covering 39 municipal buildings. PMC also completed 1.25 MW of ground-mounted solar PV projects with the aim of using the energy generated for its own operations. PMC has completed solar projects with installed capacity of 1.25 MW. This is a grid-connected project with excess electricity to be fed into the grid, and net meters to be installed for the purpose.

PMC has a combination of waste-processing technologies deployed at various levels (decentralized and centralized). Pune has taken the lead in the deployment of biomethanation technology for the generation of bio-CNG from food waste, which is used as an alternative fuel in PMPML's fleet of buses. PMC is also working with The Green Billions Limited to produce usable green hydrogen from waste. The project is the first of its kind in India and was contracted to Variate Pune Waste-to-Energy Private Limited, a special-purpose subsidiary of The Green Billions. PMC entered into a 30-year agreement with this company to generate hydrogen from the refuse-derived fuel using plasma gasification technology in WTE plants (*The Economic Times* 2023). The plant was expected to be commissioned in November 2023 and completed by November 2024.

Promotion of low-carbon mobility

Pune has made great progress in the uptake of e-buses and as of December 2023, PMPML operated 458 e-buses in Pune City, with plans to replace all existing buses running on CNG and diesel to electric (Didmishe 2023). PMC houses an EV cell, created in 2021, which regularly convenes key stakeholders and actors, including citizens in the EV space, to coordinate policy implementation and understand barriers to EV adoption. The EV cell also produced an EV readiness plan in 2022 (Pune Municipal Corporation 2022).

Pune has demonstrated strong policy intent to promote NMT. A slew of initiatives, policies, and projects introduced since 2008 have created the foundations for a robust NMT infrastructure in the city (ITDP and PMC 2021). For example, in 2016, Pune launched a comprehensive bicycle plan, the Walk Smart pedestrian policy, and a parking policy to discourage the use of private vehicles. The city also introduced urban street design guidelines in 2016 and cycling design guidelines in 2017 (Itrans et al. 2017). In 2017, a public bicycle-sharing system funded by Smart City funds was introduced.

Partnerships with civil society, international agencies, and transnational networks

Pune has a strong network of regional CSOs and a history of collaboration with these organizations.

- To collaborate on transportation-related issues, Parisar, Pedestrian First, Nagrik Chetna Manch, and the Centre for Environment Education (CEE) founded the Pune Traffic and Transportation Forum in the 2000s However, the forum's efforts to accelerate NMT came to a halt owing to growth in the number of private vehicles (cabs and private taxis) in the last decade.
- In 2022, a Climate Change and Environment Action Plan (CCEAP) was developed for the Pune district by the Vasudha Foundation with support from the Shakti Sustainable Energy Foundation (Vasudha Foundation 2022d).
- Since 2019, PMC has been collaborating with the Natural Resources Defense Council, CEE, Indian Institute of Tropical Meteorology, and others on the development and implementation of a cool roof program and air quality control system.
- Pune is also a member of the 100 Resilient Cities network, and the Pune Resilience Strategy was launched in 2019 (Pune Municipal Corporation 2019). This strategy identified several resilience-building goals, actions, and projects for the city, covering the three pillars of growth, the environment, and the economy. One of the projects identified under the environment pillar involved establishing an energy efficiency and renewable energy program that would aim to increase the share of renewable energy in the city's energy mix.

Finance

PSCDCL tried the public-private partnership business model to procure and install LED streetlights. Under this project, the service provider was required to maintain a certain level of lux (unit for luminosity of lighting) and not conduct a fixture-to-fixture replacement. The solarization of public buildings has leveraged the RESCO model. The procurement of electric buses by PMC utilized the central government's FAME-II scheme.

Technology and innovation

Pune's smart LED street lighting project was identified as being technologically innovative and received an award from MoHUA. The project implemented an Interact City system, under which the smart street lighting is centrally networked and can be viewed and managed from the integrated command and control center (Pune Municipal Corporation and Pune Smart City Corporation Limited, n.d.). Additionally, people can use a smartphone app or call a toll-free number to voice their complaints about poor road lighting or malfunctioning luminaires, which prompts the operations staff to respond immediately.

PMC's pilot of generating hydrogen from waste is another notable example of technological innovation.


SOHO
SOHO

RAJKOT, GUJARAT

CSCAF 2.0 overall rating: 4 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 590/1200

Located in the western part of India in the state of Gujarat, Rajkot is an industrial town famous for its foundry and machine tool industry. It is the fourth-largest city in Gujarat after Ahmedabad, Vadodara, and Surat and is located on the banks of the Aji and Nyari rivers in the central Saurashtra region. Rajkot embarked on its renewable energy journey in 2002 through the Asia Pro-Eco Programme, which led to a solar energy education program to raise awareness about the city's solar energy potential. Rajkot was selected as a Smart City in June 2017 in the third round of the SCM. The various projects covered under the smart city proposal consist of housing development, including affordable housing; building smart and robust infrastructure; and promoting solar projects, green buildings, and smart LED street lighting. In recognition of the city's consistent efforts to support national and global climate objectives, Rajkot received the National Winner award in the WWF One Planet City Challenge three consecutive times. In 2016, a mitigation action plan was prepared under the Urban-LEDS I project, followed by a Climate Resilient City action plan in 2018 under the SDC CapaCITIES I project (CapaCITIES 2018). A CCEAP was also prepared for Rajkot district in 2022 (Vasudha Foundation 2022a). Table 11 describes key actors working on energy transition in the city.

Rajkot's energy transition journey

RMC's lighting department has been spearheading initiatives on LED street lighting and RT-SPV. Rajkot was selected as one of the MNRE's Solar Cities in 2015, and a solar master plan was prepared. Rajkot was also the first Indian city to include district cooling as a part of its Smart City proposal in 2017 (Zhoulun et al. 2017). However, in our interviews, we found that only a few projects under the Solar Master Plan had been implemented and that the district cooling project did not take off, despite the extensive feasibility studies conducted. Through the General Development Control Regulations, RMC has mandated the installation of solar water heaters in new residential buildings and offers five-year rebates on property tax for both residential and commercial buildings (Rajkot Urban Development Authority 2016).

Highlighted action: Thermally comfortable, affordable housing

With funding support from the SDC under the CAPACITIES program, a pilot project of a 31.5-kWp grid-connected solar PV system was installed in 2020 at the Krantiveer Khudiram Bose social housing complex for common utilities like pumps, lighting, and elevators (ICLEI SA 2022b). The solar PV system was expected to generate approximately 3,780 units of electricity per month (45,360 kWh per year). The responsibility for the safety, security, and periodic cleaning of the panels was handed over to the Resident Welfare Association, which was trained in panel maintenance.

TABLE 11 | Key actors in Rajkot

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Rajkot Municipal Corporation (RMC)	Municipal corporation	RMC has been involved in the implementation of energy-efficient affordable housing projects, rooftop solar for municipal services, LED street lighting, and other initiatives
Rajkot Smart City Development Limited (RSCDL)	Smart City SPV	RSCDL conducted feasibility studies for district cooling systems since it was included in Rajkot's smart city master plan
Paschim Gujarat Vij Company Limited (PGVCL)	DISCOM	PGVCL is responsible for the implementation of the national solar rooftop program within its jurisdiction

Source: Aggregated by WRI India authors.

In 2017, under PMAY, RMC conceptualized energy-efficient and, thermally comfortable, affordable housing known as the Smart GHAR III (Green Homes at an Affordable Rate) project. The project consisted of 11 residential towers with 1,176 dwelling units and a total area of 57,408 m^2 (Malaviya et al. 2024). Technical assistance was provided to the builders and developers through the Indo-Swiss Building Energy Efficiency Project. A design charrette was conducted in the early design phase of the project to facilitate the implementation of cost-effective interventions. One of the key aspects of the project involved the use of AAC (autoclaved aerated concrete) blocks in the walls as they possess superior thermal properties compared to conventional materials. In addition, casement windows were installed instead of sliding windows to minimize heat gain, maximize daylight penetration, and improve natural ventilation. To ensure adequate ventilation, the existing service shaft between two flats was utilized: a fan installed at the top creates negative pressure, enhancing air circulation and increasing the number of air exchanges in the living spaces.

Smart GHAR III was allotted to intended users at the end of 2019. In April 2023, a post-occupancy survey was conducted to understand occupant experiences with comfort at different times of the year. The survey partially corroborated the thermal comfort impacts and identified building envelope, ventilation, and design changes that are needed to further improve thermal comfort and daylighting in such housing projects. The results from the Smart GHAR III project highlight the effectiveness of early-stage building design interventions and of using appropriate materials for achieving energy-efficient, comfortable, and low-cost housing with a reduced carbon footprint.

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

In 2012, under the Urban-LEDS I project funded by the European Commission, RMC partnered with ICLEI SA to survey Rajkot's street lighting system, aiming to reduce its energy consumption (NIUA n.d.). After evaluating the existing street lighting system and identifying areas for improvement, the city decided to undertake a pilot project of LED retrofitting to demonstrate the technology and impacts in the local context. Through the development assistance available under the Urban-LEDS project, 291 existing high-pressure sodium-vapor lights were replaced with LED lights on a selected stretch of road in the city. The pilot led to annual electricity savings of 70,000 kWh and helped achieve the desired illumination levels and quality. The successful implementation and positive results from the pilot demonstration encouraged the city government to scale up the program to a city-wide LED streetlight retrofit program. According to CSCAF 2.0 data, Rajkot reports a 100 percent conversion to LED streetlights.

In 2016, RMC installed a grid-connected 145-kWp solar PV system at the waste treatment plant facility and implemented energy efficiency interventions aiming to reduce energy costs (NIUA n.d.). This approach of integrating energy efficiency and renewable energy was replicated in other water treatment plants in the city, supported by allocated municipal budgets. Through our interviews, we found that RMC had announced plans to solarize its public buildings and put out tenders for the procurement of energy performance contracts for RT-SPV projects in 2021. It was also reported by implementation partners that as of March 2024, RMC had established 1.2 MW of solar PV projects on buildings and other municipal facilities.

Promotion of low-carbon mobility

Encouraged by the Gujarat EV Policy 2021, RMC announced plans in 2022 to set up 18 charging stations for EVs in its own buildings, instead of engaging in a public-private partnership model (TNN 2022a). Through a contract with a private company, RMC had plans to procure more than 100 e-buses as part of the FAME-II scheme. The private company also established an e-bus depot equipped with DC fast chargers and other services available on-site for e-bus maintenance and operations. In addition, RMC established an SPV for urban transport, Rajkot Rajpath Limited, which operates the city buses and implements bicycle-sharing projects. In addition to e-buses, RMC also procured CNG buses to meet the city's public transport needs and began phasing out diesel buses (Katheshiya 2024). As of July 2023, RMC was also drafting a city EV policy (ICLEI SA 2023b).

Partnerships between civil society and city agencies

- In 2016, Rajkot City was selected for the CapaCITIES project supported by the SDC. During the project, several quick-win initiatives were successfully

completed. These initiatives included the installation of a grid-connected solar PV system at the Aji water treatment plant and social housing complex, the establishment of an ambient air quality monitoring station, and the implementation of a groundwater recharge system (CapaCITIES 2018).

- Rajkot was one of six cities in the world selected for the BEA deep-dive project. Technical assistance was provided by ICLEI SA to develop voluntary green building guidelines. Energy audits were conducted in some of RMC's buildings, and the results were used to identify retrofit interventions (WRI n.d.).
- In April 2015, Rajkot was selected as one of five Indian cities (Rajkot, Thane, Pune, Coimbatore, and Bhopal) for the District Energy in Cities Initiative. The initiative was led by UNEP in partnership with ICLEI SA. A rapid assessment of district cooling was undertaken, followed by a deep-dive pre-feasibility assessment for select areas in Rajkot, including the greenfield Smart City area (Zhoulun et al. 2017). This work supported RMC in including the implementation of a district cooling system in its Smart City proposal.
- In 2021, Rajkot was selected as the first Indian city to develop and pilot an urban cooling action plan by the UNEP-led Cool Coalition. The city received technical assistance from ICLEI SA to develop an action plan. The plan was completed in 2022 and described the technological interventions (solutions at specific sites) and policy and urban planning recommendations for promoting sustainable cooling (ICLEI SA 2024).
- In January 2022, the Vasudha Foundation, Climate Change Department, and GEER Foundation collaborated to develop a CCEAP for the Rajkot district (Vasudha Foundation 2022a).

A new CAP for Rajkot is currently under development with technical assistance from the SDC-funded CapaCITIES II project, implemented by ICLEI SA.

Financing

- The financing scheme for the energy-efficient affordable housing project involved central assistance matched by the state government and complemented by low-cost loans for the beneficiaries.
- To address the challenge of upfront capital investment in the LED lighting model, the ESCO model was adopted in collaboration with EESL. In the solar rooftop installation at the water treatment facility, a co-financing model was employed, with partial funding from a bilaterally funded project and the remainder provided by the RMC.
- The solarization of common utilities in the housing complex was financed by the ESDC under the CapaCITIES project. The same program also partially funded the solar PV system at the waste treatment plant (145 kWp). The remaining funding was supplied by RMC under the Gujarat state's Swarnim Jayanti Mukhymantri Saheri Vikas Yojana urban development scheme (Global Covenant of Mayors GCoM 2023).

Technology and innovation

Rajkot was the only city to incorporate the implementation of a district cooling system in its smart city proposal. Though the project did not materialize, survey respondents shared that the Rajkot experience provided thrust to conversations on introducing district cooling infrastructure in Indian cities.

Rajkot's other innovative approach has been with thermally comfortable, affordable housing. In Smart GHAR III, energy simulation tools were effectively utilized to evaluate the impact of different passive measures on buildings' thermal comfort and energy performance. Design charettes were conducted to incorporate energy efficiency measures. Using simulation tools, various design interventions, such as walling, roofing materials, window design, and ventilation improvement, were modeled and analyzed. This technology-driven approach played a crucial role in enabling informed decision-making and cost-effective design implementation. The project's design interventions were eventually included in RMC's request for a proposal document for contracting vendors for the project's construction (Malaviya et al. 2024).

SHIMLA, HIMACHAL PRADESH

CSCAF 2.0 overall rating: 3 stars

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 374/1200

Shimla is the capital city of Himachal Pradesh and one of the most popular tourist destinations in the state. As a pilot Solar City, Shimla is actively striving for a minimum 10 percent reduction in projected demand for conventional energy through the implementation of energy efficiency measures and the use of renewable energy sources. In addition, Shimla was selected as a Smart City in the third round of the SCM, which has led to various infrastructure development projects and the installation of grid-connected rooftop solar systems. As part of the AMRUT mission, Shimla has undertaken projects focusing on energy efficiency in water treatment plants, sewage treatment plants, and the implementation of energy-efficient street lighting. The city is recognized for its commendable efforts in promoting renewable energy in public buildings, the adoption of LED street lighting, and being one of the first hill stations in the country to establish WTE plants to address solid waste management challenges. Table 12 describes key actors working on energy transition in the city.

Shimla's energy transition journey

The city of Shimla has implemented a handful of high-visibility projects in the clean energy space, most notably the near-complete conversion to LED street lighting.

Highlighted action: Waste-to-energy plant

As a popular tourist destination and a rapidly growing urban area, Shimla faced significant issues related to waste management that raised environmental concerns. The National Green Tribunal intervened and directed the local authorities to find sustainable solutions for waste management in the city (Sharma 2019). In response, Shimla Municipal Corporation established a WTE plant at Bhariyal, using gasification technology to generate 1.75 MW of electricity.

Shimla is the first Himalayan state to install a WTE plant to address the challenges of solid waste management. The region's mountainous geography poses difficulties for waste management as the remote and complex terrain results in improper waste disposal practices that cause environmental damage. The development of the WTE plant in Shimla serves as an example of increasing private sector participation in waste management solutions within the city.

The plant was developed by the Australian company Elephant Energy as part of a public-private partnership model with Shimla Municipal Corporation for a concession period of 20 years. The private sector entity set up the entire plant independently, with the municipal corporation only providing the land. A power purchase agreement has also been signed between this private sector entity and the Himachal Pradesh State Electricity Board Limited (Tribune News Service 2022). The electricity department will purchase power at ₹7.90 per unit, and in this manner, the company will recover its investment and recurring costs (IUC India 2021). Shimla Municipal Corporation collects approximately 100 tonnes of waste every day from Shimla and neighboring places, which is transported to the plant in Bhariyal. It is expected that the fully operational

TABLE 12 | Key actors in Shimla

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Shimla Municipal Corporation	Municipal corporation	This corporation has implemented a WTE plant and adopted energy efficiency measures in street lighting and the city's water supply system
Shimla Smart City Limited	Smart City SPV	The Shimla Smart City SPV has been involved in the implementation of rooftop solar, LEDs, and solar street lighting projects
Himachal Pradesh Energy Development Agency (HIMURJA)	State nodal agency (SNA) for renewable energy	HIMURJA has been involved in the installation of rooftop solar and other renewable energy projects in the state

Source: Aggregated by WRI India authors.

plant will generate 1.7 MWh of electricity from 70 metric tonnes/day (annualized) of municipal solid waste using gasification technology. This gasification technology is anticipated to result in waste residuals of less than 10 percent. The corporation plans on using the rejected materials to produce tiles and other products, reducing the strain on the landfill site (Shimla Municipal Corporation n.d.)

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

As part of the SCM, HIMURJA has installed grid-connected RT-SPV in 66 government buildings in Shimla (*Hindustan Times* 2022). In 2016 Shimla Municipal Corporation signed a memorandum of understanding with EESL to replace approximately 10,000 old streetlights with energy-efficient LED lights (Chauhan 2016), but reports suggest that this target was not achieved and the corporation was found to be tendering for a new EPC (Engineering, Procurement, and Construction) contractor for LED streetlights in March 2024 (Tribune News Service 2024). Under the AMRUT Mission, Shimla Municipal Corporation facilitated a detailed energy and water audit of the city's water supply network (Shimla Municipal Corporation 2021). The objective of this audit was to assess energy and water usage in the water supply system and recommend opportunities for improving energy efficiency and reducing non-revenue water. Eight pumps were replaced because of the recommendations provided in the audit.

Partnerships with civil society, international agencies, and transnational networks

The local government has collaborated with research, civil society, and international organizations to address climate impacts and support the city's efforts to reduce greenhouse gas emissions and promote sustainable practices.

- In 2016, Shimla joined the BEA and received technical guidance from ICLEI SA on the importance of building-efficiency policies and projects.
- In October 2015, Shimla Municipal Corporation collaborated with the Rockefeller Foundation, ARUP, and ICLEI SA to develop a resilience profile using the City Resilience Index. The project led to solid waste management being chosen as the priority sector (ARUP 2016). In 2021, a baseline study for the solid waste management project was conducted as part of the Shimla-Wolverhampton collaboration under the International Urban Cooperation India program. The study involved analyzing existing data, consulting stakeholders, and reviewing recommendations to provide insights for improving waste management practices (IUC India 2021).

Financing

A public-private partnership model was employed to establish the WTE plant in Shimla. The private sector agency provided the entire investment in the plant, with the municipal corporation providing the land. HIMURJA used Smart City funds to install rooftop solar on government buildings in Shimla. The EESL-ESCO model was adopted for the installation of LED street lighting. Under the AMRUT scheme, improvements in the energy efficiency of Shimla's water supply system were achieved by replacing existing inefficient pumps with energy-efficient ones.

Technology and innovations

In 2022, Shimla Jal Prabandhan Nigam Limited, Shimla's water utility, tested a micro-hydropower plant in partnership with Kirsloskar Brothers Limited (Kirloskar Brothers Limited 2022). Through pumps-as-turbines technology, the pilot project used energy from flowing water to generate up to 3 kW power from a micro-hydropower generator unit installed in the organization's water treatment plant.

SURAT, GUJARAT

CSCAF 2.0 overall rating: 4 star

CONSOLIDATED CSCAF 2.0 SCORE ON ENERGY TRANSITION INDICATORS: 774/1200

Located in the western part of India in the state of Gujarat, Surat is renowned for its textile and diamond industries. It is one of India's cleanest cities and is also known by several other names, such as "The Silk City," "The Diamond City," and "The Green City." From 1991 to 2001, Surat experienced remarkable population growth, industrial expansion, and an increase in business activities, leading to a significant rise in electricity consumption. This increase in demand was largely due to the formalizing of water supply in the city, which required a re-engineering of water supply routes. To address this, Surat Municipal Corporation (SMC) established an energy efficiency cell in 2001, dedicated to identifying energy conservation and renewable energy projects to reduce power expenditure and dependence on fossil fuels (SMC 2014).

In 2011, Surat was designated a Solar City by the MNRE, and a master plan was approved in 2013. The Solar City Master Plan encompassed numerous projects related to energy efficiency and the use of wind, solar, and biogas power plants. Surat was also selected as one of the first 20 Smart Cities in 2015 and has implemented several projects under the SCM. The city has received an award from MoHUA for its work in the areas of urban environment, mobility, transport, and sustainable integrated development. Table 13 describes key actors working on energy transition in the city.

Surat's energy transition journey

Though the energy efficiency cell at SMC was created in response to pressing energy needs and the challenges of meeting growing demand with existing infrastructure, its establishment signaled Surat's early commitment to energy transition. SMC's proactive attention to institutionalizing the sustainability of energy savings across municipal services and operations set an example for other Gujarat cities, and a similar cell was also established in Ahmedabad Municipal Corporation. The SMC's energy efficiency cell has continued to diversify its portfolio of projects and activities. Though it initially largely focused on energy savings, the cell has continued to leverage the growing popularity of renewables and has captive renewable energy power plants of varying sizes to fuel its operations.

Highlighted actions: Adopting energy efficiency measures, generating renewable energy on-site, and emissions trading

SMC has primarily implemented its energy efficiency and clean energy projects through capital subsidies provided by central government ministries. These projects have also received funding convergence from various programs, such as the Solar City, Smart City, and AMRUT initiatives. The Gujarat Pollution Control Board has piloted an emission trading market mechanism in Surat, as discussed below.

TABLE 13 | Key actors in Surat

ACTOR	TYPE	CONTRIBUTION TO CITY'S ENERGY TRANSITION
Surat Municipal Corporation (SMC)	Municipal corporation	SMC is the local self-government of Surat City and is responsible for providing essential amenities and services to city residents. The corporation is implementing energy efficiency and renewable energy projects to reduce municipal energy costs and enable the use of green power to deliver municipal services
Surat Smart City Development Limited (SSCDL)	Smart City SPV	SSCDL is involved in implementing various Smart City projects such as affordable housing, biogas plants, street lighting, and solar power plants across multiple locations
Torrent Power, Dakshin Gujarat Vij Company Ltd.	Surat DISCOMs	These DISCOMs are involved in facilitating RT-SPV installations for different consumer categories, in line with prevailing net metering regulations

Source: Aggregated by WRI India authors.

Adopting energy efficiency measures and generating renewable energy on-site

SMC has emerged as a leader in effectively managing energy costs through the implementation of energy efficiency and renewable energy measures in various municipal services. In 2001, SMC established a dedicated energy efficiency cell, with the ambitious target of reducing conventional energy consumption by 15 percent annually (Surat Municipal Corporation 2014). The corporation implemented comprehensive energy efficiency measures across water supply, sewage disposal, street lighting, and other areas. SMC also ventured into renewable energy sources such as wind power, solar energy, and WTE projects, further reducing energy costs and embracing green-energy solutions. Thereby, Surat became the first municipal corporation in India to invest in large-scale wind and solar power projects located outside the city limits, taking advantage of tax benefits and offsetting electricity expenses. In addition, SMC collaborated with the MNRE and successfully executed a pilot project focused on generating electricity from biogas derived from liquid sewage waste. This success led to the formulation of a policy mandating the installation of biogas power plants at all major sewage treatment facilities. SMC publishes data on its projects on its website. As of 2020–21, SMC had saved ₹157.15 crores and ₹ 343 crores from energy efficiency and renewable energy projects, respectively (Surat Municipal Corporation n.d.b.).

Emissions trading

The Surat emissions trading scheme was implemented as a pilot program in September 2019, making it the first scheme of its kind in India and the world's first cap-and-trade market for particulate matter pollution (Greenstone and Sudarshan 2019). The scheme sets a cap on the amount of pollution that industries in Surat can emit, with a specific focus on suspended particulate matter emissions. Industries can comply by reducing pollution through technology implementation or by purchasing emission permits to exceed their limit. This allows industries with surplus permits to sell them to those in need, encouraging the adoption of emissions-reducing technology. The Gujarat Pollution Control Board launched this innovative emissions trading scheme in Surat, partnering with the National Commodities and Derivatives Exchange to design the trading platform. Surat's textile-processing industry became the first in the world to practice trading in suspended particulate matter through this scheme. Initially, 155 industries in Surat participated in the pilot project. The project's efforts resulted in a 29 percent reduction in suspended particulate matter emissions. Following the successful outcomes achieved in Surat, a decision has been made to implement the same program in 202 industries in Ahmedabad.

In the sections below, we summarize the findings from the application of this study's analytical framework.

Governance

Clean energy and energy efficiency in municipal services

SMC has been at the forefront of implementing energy efficiency measures to reduce energy consumption in municipal services. The corporation has also demonstrated a proactive approach to adopting various clean energy technologies, including wind, solar, and WTE projects. Surat has emerged as a pioneer in embracing energy efficiency and clean energy initiatives to enhance the delivery of municipal services. The city operates its own wind power plants, generating approximately 32.4 MW of electric power. SMC has also established 6 MW of solar plants and is the first municipal corporation in India to operate a sewage treatment plant using biogas energy (Surat Municipal Corporation n.d.a.).

In 2016, Surat launched a campaign to promote rooftop solar and introduced a single-window online platform to encourage applications. SMC partnered with local DISCOMs and financial institutions to build its capacities to support the implementation of rooftop solar projects. The corporation received technical assistance from The Energy and Resources Institute for this initiative and introduced resources such as a single-window knowledge portal on rooftop solar, a rooftop solar calculator, and a guidebook and pamphlets on solar energy (TERI 2016). SMC's approach was adopted at the state level with the launch of the SURYA Ghar online portal by Gujarat Urja Vidyut Nigam Limited.

Promotion of low-carbon mobility

SMC has established 50 EV charging stations and ranked first in the sale of EVs in Gujarat in 2022 (DeshGujarat 2022). In February 2023, SMC announced the creation of a ₹450 crore corpus for funding green initiatives in the city and the issuance of municipal green bonds totaling ₹100 crore (Mehta 2023).

Partnerships with civil society, international agencies, and transnational networks

Many initiatives have been undertaken by the transnational network organizations in collaboration with urban local bodies to implement clean energy initiatives on the ground in Surat.

- In April 2017, Surat released its first resilience strategy with support from the Rockefeller Foundation's Asian Cities Climate Change Resilience Network (Taru Leading Edge and 100 RC 2017). The strategy was developed in collaboration with 100 Resilient Cities and TARU Leading Edge and received contributions from various stakeholders, including SMC, Surat Urban Development Authority, Surat Climate Change Trust, non-profit organizations, and several others.
- In December 2021, the Surat Clean Air Action Plan was developed as a collaboration between SMC and the Gujarat Pollution Control Board, with support from WRI India, Bloomberg Philanthropies, and the Shakti Sustainable Energy Foundation (Nagpure et al., 2021). This plan includes interventions such as promoting clean fuel in industries, managing construction dust, encouraging NMT, addressing open waste burning, and creating green spaces along corridors and traffic junctions.
- In 2022, ICLEI SA, TARU Leading Edge, and other partners, supported by the Climate and Development Knowledge Network, developed a City Heat Resilience Toolkit for Surat (ICLEI SA et al. 2021). The toolkit documents the experience of implementing solutions to prevent heat stress in Surat City.

Through workshops, training programs, and collaborative projects, Surat has prioritized empowering its residents, local authorities, and relevant organizations to effectively tackle challenges associated with heatwaves, air pollution, and other aspects of the energy transition.

Financing

Surat has utilized its own department funds to implement energy efficiency and conservation efforts across various sectors, including water supply, street lighting, and sewage disposal systems. The installation of wind power plants in the water supply system and rooftop solar power plants on buildings was carried out with support from the MNRE through a capital subsidy under CFA, as well as funding from SMC. The first biogas power plant was set up as a pilot project with a grant covering 50 percent of the total cost from the MNRE under the UNDP-Global Environment Facility scheme. The ESCO business model was employed for the installation of LED street lighting, and a centralized control and monitoring system for street lighting was also implemented.

Technology and innovations

Inaugurated in 2024, Surat Diamond Bourse, the city's diamond trade center, features several clean energy and energy efficiency innovations (Business Standard 2023; Grover 2024):

- It has a floating foundation RT-SPV project, which is touted as the most advanced project of this kind in the world. The plant uses third-generation inverter technology and solar panels that generate energy from both the front and back surfaces. It also uses a waterless robotic cleaning solution to save water and maximize energy generation.
- The facility was designed with passive design principles in mind and uses one of the world's largest centralized radiant cooling systems. It has been awarded the IGBC Platinum certification.


YASH
GUESTHOUSE
YASH
VRUDAM


Genus
SAKSHAM-100
kWh
Type SPEM 26
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kWh
Type SPEM 26
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kWh
Type SPEM 26

CHAPTER 4.

Findings

Cities have largely contributed to energy transition through their participation in national programs, schemes and missions. Cities are promoting energy efficient streetlighting and solar PV, while new actors like metro rail corporations are working towards greening their operations in many cities. While a wide variety of actors are involved, as owners and service providers, urban local bodies are driving most energy transition programs in partnership with other agencies.

HOW ARE CITIES PARTICIPATING IN ENERGY TRANSITION INITIATIVES?

Most of the cities studied in this report have gained the impetus to participate in India's energy transition journey through national programs and schemes. As recipients of funding, technical assistance, and support for capacity-building under these top-down efforts, cities have gradually ramped up their capabilities and knowledge of technologies, solutions, and project implementation models.

Initiatives across the cities vary significantly in scale and size. There is also a wide variation between metro cities and other non-metro tier-1 cities and between tier-2 cities located in different states. Even within the metro cities, despite the similarity in institutional structures, there are differences in the delivery and quality of initiatives.

Below, we identify a few consistent observations on the sectors and technologies receiving the most attention across the 10 case study cities.

- LED street lighting. While all 10 cities reported evidence of converting conventional streetlights to LEDs, the scale, pace of progress, and experience vary. According to CSCAF 2.0 data, Pune, Rajkot, and Shimla have achieved 100 percent conversion to LED street lighting, and Indore, Bengaluru, Surat, and Nagpur have achieved near 100 percent conversion rates. In all cases, streetlights that are "smart" and "intelligent," which implies an ability to communicate with remotely located operations and maintenance systems, have been rolled out. The EESL-implemented SLNP requires that the LED lamps have a central control monitoring system, which allows for the remote monitoring and operation of installed streetlights. Since street lighting falls under the purview of municipal corporations, most street lighting projects have been implemented by these agencies. Where streetlight conversion is 100 percent, the use of Smart City funds and, therefore, the involvement of the Smart City SPV, was observed. In a few cases, the financing for this type of work came from the ULB's own budgets, using energy performance contracts with ESCOs, including EESL. However, it is important to note that despite the national policy push and varied assistance available to ULBs, larger cities like Delhi, Bengaluru, and Kochi had not achieved full conversion to LEDs.
- RT-SPV and ground-mounted solar PV. In Pune, Shimla, Kochi, Surat, and Chennai, we found evidence of systematic efforts to deploy rooftop solar on public and residential buildings. Cities like Indore, Surat, and Rajkot have also deployed ground-mounted SPV or RT-SPV to meet energy needs in municipal services like water pumping and wastewater treatment.

- Greening metro rail operations. A relatively recent phenomenon, but one that has been directly linked to cities' sustainability image, is the emergence of voluntary initiatives by metro rail corporations. Metros run in 6 of the 10 cities, and in all cities, the transportation utilities have been implementing initiatives to green their operations by either solarizing the rooftops of metro stations or procuring renewable energy for their operations.
- Municipal waste-to-energy projects. Despite the historical controversies associated with WTE projects, most cities have either implemented (Bengaluru, Indore, Pune, Shimla) or were awaiting approval on (Chennai, Kochi) projects that aim to generate energy from solid waste collected in the city. A few WTE plants in India have faced legal scrutiny owing to the creation of local air pollution and related health problems for communities living adjacent to them, poor techno-economic feasibility, and the potential of incentivizing waste generation instead of reduction and recycling (Centre for Financial Accountability 2022). The technologies being considered vary across cities—incineration (Bengaluru), refuse-derived fuel-based gasification (Shimla), and biomethanation (Indore, Pune). In Indore, IMC has three large-scale facilities that use biomethanation technology to generate biogas that powers local transportation. Reports indicate that at least one WTE facility in Indore (Asia's largest) has managed to convert a waste dump site into a "clean fuel hub"; however, the lingering odor from the decades of waste dumping continues to plague neighboring villagers (Kaur 2022). The GOBARdhan (Galvanizing Organic Bio-Agro Resources Dhan) plant, which has a 550-TPD capacity, has been deemed successful because of factors such as the availability of high-quality segregated organic waste, the conducting of proper planning and feasibility studies to assess the plant's technoeconomic and environmental viability, and the systems in place to continuously monitor and evaluate the plant's impact.

There are notable gaps in action prioritization. Only four cities—Pune, Rajkot, Surat, and Nagpur—have initiatives to promote energy-efficient buildings. Interestingly, these cities are also located in the states of Maharashtra and Gujarat, which have not notified the primary code that promotes building efficiency—the ECBC.

WHICH FACTORS DRIVE PARTICIPATION IN CLEAN ENERGY INITIATIVES AND WHICH LIMIT CONTINUAL PROGRESS?

The findings from the application of our analytical framework are described below.

Governance

Globally, governance of energy transition includes state actors, and also non-state actors like the private sector and civil society. The latter makes important contributions to policy and exercises authority over energy supply and demand decisions. To some extent, we observed the same situation in Indian cities regarding the energy transition.

The evidence suggests that some cities are better organized and are more aligned with state institutions on energy transition initiatives than others. Some of this can also be attributed to early efforts to develop CAPs, resilience strategies, and similar frameworks that built official capacity, sensitivity, and awareness in relation to energy transition goals. In some cases (e.g., Surat and Rajkot), the reduction in energy bills from municipal operations was a driver of ULB-led progress.

We highlight three types of role that cities are playing in the energy transition:

1. **As owners and service providers.** Government bodies like ULBs, smart city SPVs, local agencies providing services, and state departments and agencies are collectively the largest consumers of energy. These institutions have made energy-related decisions for themselves and implemented energy transition initiatives for different reasons

- **ULBs have prioritized actions contextual to their needs.** In six cities—Indore, Pune, Surat, Rajkot, Shimla, and Nagpur—the ULB/municipal corporations have been designing and implementing projects aligned with national policy goals. The municipal corporations in Surat, Indore, Pune, and Rajkot have undertaken initiatives contextual to the city's needs and their own priorities. SMC's energy efficiency and energy-conservation cell, which was established in 2001, continued to expand its focus areas and services (e.g., to include renewable energy projects) as it saw results

from its efforts. Surat and Pune ULBs have invested in renewable energy generation to meet some of their energy needs. SMC has implemented wind energy, rooftop solar, and biogas projects with a cumulative capacity of 43 MW (as of March 2021). However, barring rooftop solar, other cities have seen limited progress in procuring green energy. Indore's success in waste management prompted the civic body to use the waste as a resource to switch to cleaner fuels, striving for a degree of energy independence while cutting emissions and fighting air pollution. PMC's history of implementing the EcoHousing program has resulted in a higher prioritization of interventions in the building sector.

- **Smart City SPVs delivering energy transition projects.** In Chennai and Kochi, the Smart City SPVs have taken the baton from the ULBs to deliver projects to promote solar energy generation, smart metering, and low-carbon mobility. In Kochi, CSML led the execution of 1 MW of rooftop solar projects on the city's government buildings. Similarly, in Chennai, CSCL supported GCC in solarizing public buildings and promoted NMT through the highly visible promotion of public bicycle-sharing facilities.
- **Metro rail corporations promoting clean energy and offering low-carbon mobility solutions.** Though metro rail corporations are not governed by city administrations, their location in cities and the advantage of having a single consumer with centralized energy requirements has led to a portfolio-wide approach toward greening metro operations. In 4 out of the 10 cities studied (Delhi, Bengaluru, Kochi, and Chennai), the metro rail corporations have taken up initiatives to solarize metro stations and procure renewable energy for their operations. These institutions are working with local and state transportation authorities to streamline and facilitate NMT-based last-mile connectivity, including the provision of infrastructure and growing citizen awareness to encourage the adoption of NMT modes .

2. **As regulators and enablers.** Through enforcement of state-developed codes and regulations governing energy use in buildings, cities are supporting the energy transition ecosystem

In the Pune metro region, PMC and PCMC have been providing incentives for the adoption of green building rating systems and RT-SPV. PCMC and RMC are also the only two city corporations that offer rebates and incentives to promote solar water heaters or solar energy generation. In Bengaluru, the DISCOMs BESCOM and BBMP coordinated to enforce mandatory SWH systems in buildings of certain sizes and categories. In Delhi, Bengaluru, and Kochi (but not elsewhere), local DISCOMs have been promoting rooftop solar and DSM measures such as incentivizing the purchase of energy-efficient equipment and appliances, improving the uptake of RTS-PV through different business models (Delhi, Kochi), and using new technologies (Bengaluru DISCOM using the CREST tool). DISCOMs in other states have not necessarily been as proactive on these issues. There is scope to further improve coordination between DISCOMs and ULBs on leveraging state RE policies and regulations to promote RT-SPV and DSM in public infrastructure.

There is scope for city governments and state agencies to collaborate better and align on the implementation of state energy policies:

- For example, in Indore, RT-SPV for public buildings has received little attention, despite being in the state with the most favorable net metering regulations. Indore is in Madhya Pradesh, where net-metering regulations permit the highest capacity of rooftop solar that can be installed as a percentage of contract demand or connected load in India. While another state DISCOM, Madhya Pradesh Urja Vikas Nigam Limited, has demonstrated demand aggregation for rooftop solar for institutional buildings, the Indore DISCOM—Madhya Pradesh Pashchim Kshetra Vidyut Vitaran Company. Ltd—has not adopted this approach.
- In a review of CAPs in the 10 cities, conducted by the report's authors, it was found that many of the recommendations for the energy sector require strong coordination between the ULB, the SDA, the SNA, and the state's energy department. There was little evidence that this was happening across the studied cities.
- Six out of the 10 studied cities are in states that have notified the ECBC, but none of these cities are enforcing the code. There is a gap in city implementation capacity and the requirements under state-led building rules and regulations.

3. **As convenors and facilitators, cities have created space for the involvement of non-state actors.** Non-state actors like think tanks, NGOs, and academic institutions have contributed time and resources to

support ULBs and other government departments in executing projects. Through multi-stakeholder consultative processes, these actors have engaged citizen groups and resident welfare bodies in climate action planning exercises that lead to local benefits.

In the area of energy transition, examples of local NGOs working to attract local attention to policy issues and highlight both problems and solutions were observed in Pune and Bengaluru. In Bengaluru, the grassroots NGO TIDE designed and implemented an initiative, VidyutRakshaka, to promote energy conservation and savings through behavioral nudges in partnership with the local DISCOM. In Pune, the NGO Prayas (Energy) Group, has undertaken research and analysis to engage with the city's energy transition issues.

Several city administrations have received support from international NGOs and transnational networks to prepare CAPs, which always include energy transition actions. The C40 Cities Climate Leadership Group and GCoM are facilitating access to technical and financial assistance for interested and committed cities (e.g., cities that are signatories to the UNFCCC's Race to Zero program). This assistance comprises:

- building baseline data on the city's energy system by developing sector-specific GHG inventories;
- developing CAPs that typically cover energy sector actions;
- advising city officials on governance mechanisms to ensure action plans are implemented;
- identifying and supporting the implementation of pilot projects; and
- sharing tools and resources for monitoring and tracking progress on actions and projects.

Some municipal corporations, such as those in Chennai, Kochi, Pune, and Delhi, have established systems to facilitate citizen participation in the process of policy- and decision-making from conceptualization to the finalization of proposals. In a few cities, such as Pune, CSOs and citizens have been proactive in demanding walking and cycling infrastructure. In most cities, however, it was found that citizen engagement in energy transition plans remains limited. Citizens have been largely identified as users or "beneficiaries" of projects but not as communities interacting with the technologies and solutions.

We also found limited evidence of programmatic and process-level attention to social equity and gender considerations and the participation of vulnerable communities in energy transition initiatives. Other than Rajkot, where the municipality was able to change procurement documents to improve thermal comfort in an affordable housing project (intended for low-income families), there were no other examples of similar attention to the needs of socioeconomically vulnerable groups.

Financing

We identified various major sources of financing and business models facilitating energy transition actions in the 10 studied cities, including the following:

- **Centrally sponsored schemes and programs.** Whether from the SCM, AMRUT, or PMAY-Urban, all 10 cities have received financial assistance under schemes from the national government. In the case of the SCM, states were expected to provide matching contributions, and the ULBs were encouraged to meet the remaining costs of projects through several other sources, including public-private partnerships, municipal bonds, and borrowing from financial institutions. Barring Indore and Nagpur, which have been able to leverage private-sector investment for their clean energy initiatives, other cities have seen little success with public-private partnerships. The Smart City SPVs were empowered to mobilize resources and raise funds through public-private partnerships, joint ventures, tax collection, and corporate social responsibility funding. However, evidence suggests that success with public-private partnerships on Smart City projects has been limited (Panwar 2024). The Government of India's FAME-II scheme supported the roll-out of e-buses in several cities, which have been more inclined to pursue the CAPEX or outright purchase model for procuring e-buses. Smart City funds have also been used for e-bus procurement.
- **Municipal bonds.** IMC and SMC announced the issuance of green bonds in 2022 and 2023, respectively, and are planning to use the proceeds to finance green initiatives. Indore aims to implement the ambitions of its Solar City Plan. In a review of municipal finances, the Reserve Bank of India (2022) found that the municipal bonds issued so far in India have largely been used to finance water supply, sewerage, drainage, and water treatment projects. Given the prevalent state guidelines governing the use of bond proceeds,

municipalities have mainly used bonds for capital expenditure and/or the expansion of essential municipal services. Higher-rated ULBs like Pune, Rajkot, Surat, and Indore have received a significant proportion of their revenue from levying user charges and, consequently, have demonstrated better performance on key CSCAF 2.0 indicators. Between 2017 and 2022, municipal bonds managed to raise only ₹3,840 crores, even though Indian cities contribute 55 percent of the country's GDP (Moneycontrol 2023).

- **External funding from international development organizations and multilateral development banks.** External funding from international development agencies has been used to implement pilot projects to identify areas for scaling and inform national policies; provide technical assistance to ULBs on project design, execution, and impact monitoring; and conduct research on energy transition topics. Multilateral development banks like the World Bank are financing RT-SPV projects for residential consumers in India. In 2022, the World Bank approved an additional $165 million to supplement its $648 million financing for RT-SPV in India. This amount will be used to provide concessional loans to residential consumers through the State Bank of India and mobilize an additional private capital of $71 million. In 2022, the State Bank of India availed itself of a low-interest loan of $150 million from KfW to finance RT-SPV projects.
- **Business models for promoting solar PV, LED street lighting, and e-mobility such as the following:**
  - ESCO and energy savings performance contracts. Under the SLNP program, ULBs have partnered with the super-ESCO EESL. In this model, EESL bears the entire capital and operational expenses of streetlights, and the reduction in electricity bills and maintenance charges are used by the ULB to repay EESL over a seven-year period.
  - RESCO. Almost all projects to solarize public buildings have used the RESCO model, wherein a Renewable Energy Service Company (RESCO) develops, installs, finances, operates, and owns the RT-SPV project. The RESCO supplies the power generated from the installation to the consumer who provides the rooftop space (through a power purchase agreement) or to the grid through net metering. In all cities, government institutions and agencies have floated tenders inviting proposals from developers to establish RESCO projects on rooftops of buildings.
  - Gross cost contract model for e-mobility. A type of public-private partnership model, a gross cost contract model has been used by at least three cities (Pune, Bengaluru, and Kochi) for electric bus projects. Under this model, the transportation corporations of these cities or equivalent enter into contracts with an operator or supplier of e-buses, who is paid on a fixed cost/km basis. The vendor is also in charge of procuring the e-buses and providing resources for their operation and maintenance.
  - ULBs' own funds and state funding. The cities in Gujarat have benefited from funding provided under state urban development schemes like Swarnim Jayanti Mukhya Mantri Shaheri Vikas Yojana. Some of these funds have been used to supplement financing gaps in clean energy projects. Financially stable ULBs like those of Indore, Surat, and Pune have also been using their own budgets for implementation.

In India, the multilevel governance framework poses challenges to researchers aiming to determine financing sources for urban programs and projects. In an analysis of the state of municipal finances in India, the Reserve Bank of India (2022) highlighted municipal corporations' dependence on state and central grants for meeting their expenditures and the mismatch between the functions and finances of ULBs. The effectiveness of the current system of financial governance is equally difficult to understand. There is little transparency on the funding sources and financial instruments of initiatives in cities given the dominance of state decisions on financing local projects. Even the websites of Smart City SPVs do not provide updated information on projects' financial flows. These challenges are not unique to attempts to understand the financing of urban energy transition. The national government is the primary facilitator and regulator of financial markets and institutions and, therefore, determines the supply of private financing to ULBs.

Gujarat and Maharashtra were identified as the only two states where elected councils and standing committees decide on capital expenditure from the municipality's own funds without seeking state government approval. In

Tamil Nadu, the state government plays a significant role in decision-making when it comes to sanctioning specific projects for ULB execution.

Technology and innovations

In all 10 cities, varying levels of technology deployment have been observed according to the actors driving it. The capacity and expertise to understand and implement new technologies by designing projects or procurement processes vary across cities. Here, the metropolitan cities appear to be significantly more advanced in deployment compared to smaller cities. This was found to be especially the case in e-mobility, where cities like Nagpur and Rajkot have seen limited progress despite their ambitions.

Some technological innovations have been attempted by willing DISCOMs or Smart City SPVs. Owing to their operational styles, which differ from those of public DISCOMs, Delhi's private DISCOMs have been favored by bilateral development agencies and technology accelerators to pilot innovations in battery storage, DSM, and demand response. The SCM can be given some credit for providing cities with a platform to interface with technology providers, including international firms. In LED street lighting, for example, cities have implemented fully automated systems, with intelligent controls and connections to centralized monitoring systems for effective maintenance of the street lighting infrastructure. However, the experiences of city agencies and users engaging with the innovations in these technologies require more research.

In a few cities (e.g., Indore, Surat), hybrid approaches such as combining ground-mounted or rooftop solar PV with WTE plants, wastewater treatment facilities, or water supply distribution facilities offer lessons in optimizing energy production and consumption. Smart-metering infrastructure projects are also gaining momentum in a few cities.

To overcome a lack of innovation opportunities, some cities like Indore have set up incubation centers in collaboration with academic and research institutions to support the development of a startup ecosystem. In the domain of energy transition, however, efforts remain limited.

Capacity-building

The establishment of Smart City SPVs was intended to provide additional, financially independent capacity in cities to address urban issues. However, in some cities we studied, the capacity in the SPVs has been outsourced to a third-party contractor (e.g., in Kochi) or borrowed on a deputation basis from the municipal corporation (e.g., in Indore). In Nagpur, frequent changes in the Smart City leadership have impacted the timely delivery of projects. Through our interviews, we found that the level of coordination and interaction between SDAs and SNAs and city administrations or municipalities could be significantly improved. In many cases, the ULBs were reported to be not communicating with these state institutions, which are mandated to provide technical expertise and resources for implementing projects with local governments. In our survey and interactions with experts, we found that cities are eager to accept support from SDAs and SNAs to overcome some of the capacity challenges they routinely encounter when seeking to implement the ideas listed in, for example, CAPs.

Cities have been able to access three types of capacity-building sources: national programs and schemes; transnational networks, think tanks, and CSOs; and partnerships with public-sector undertakings, as described following:

- National programs and schemes. MoHUA's National Institute of Urban Affairs (NIUA) is undertaking systematic capacity-building efforts to collect data on CSCAF indicators and develop training materials, toolkits, and resources to enable cities to improve their CSCAF scores. These efforts are not dependent on a city's participation and are available to cities irrespective of their willingness to engage. The MNRE's Solar Cities program offers funding to support the development of Solar City master plans. In addition, the BEE's training programs on DSM and mainstreaming ECBC implementation have targeted city officials for participation.
- External technical assistance. Facilitated by transnational networks, technical assistance has been offered by think tanks, NGOs, and bilateral development institutions, contingent on a city's leadership intent and political commitment. These actors follow common practices, such as conducting research to establish baseline data, engaging with and convening stakeholders through workshops and working groups, and enhancing profiles. The continued presence of these actors in some cities has resulted in the amplification of climate action efforts. In almost all the cities studied, these actors have significantly improved city visibility and access to additional resources to support city activities. Many implementation partners have used bilateral funds

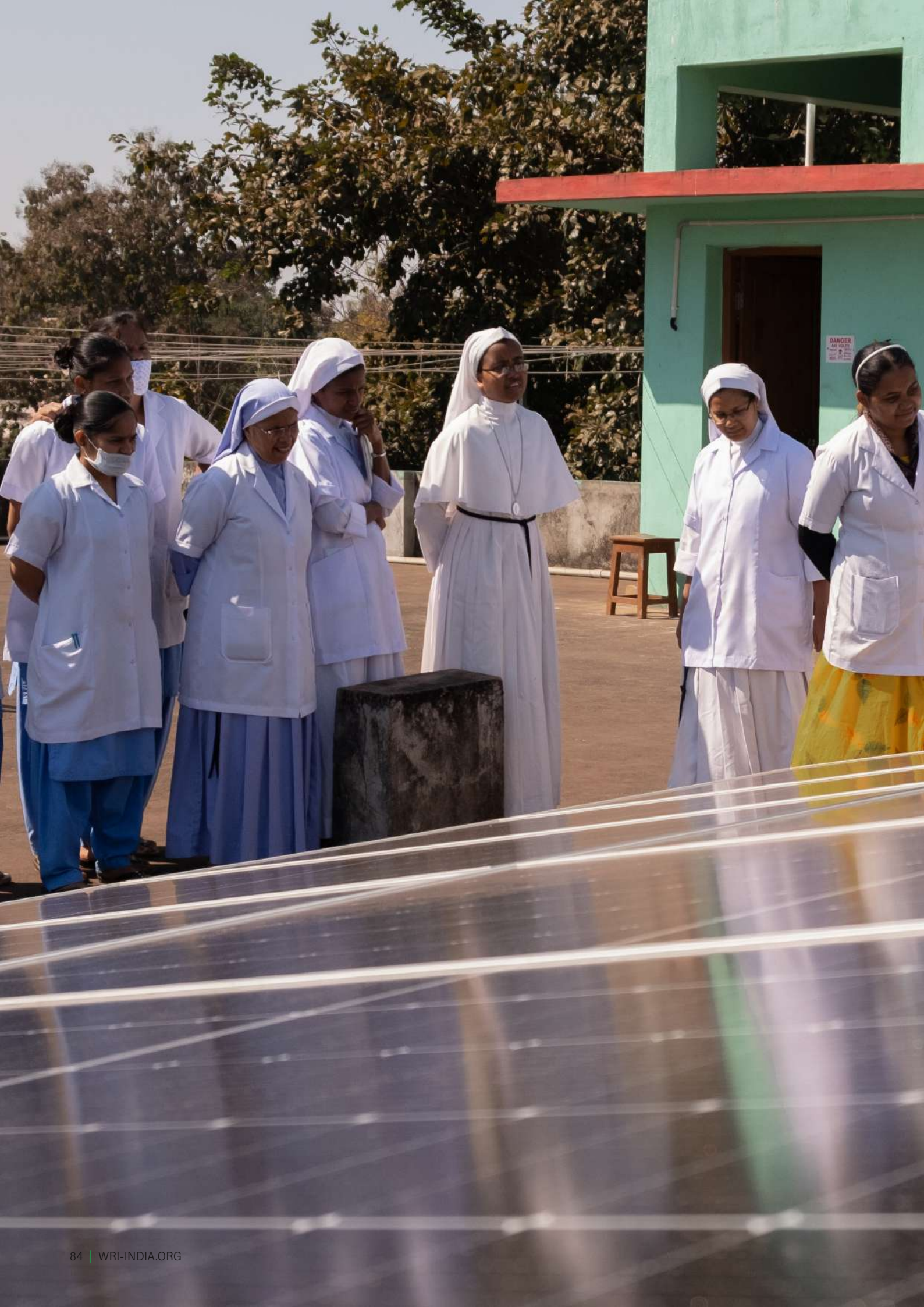
or the same funding agency to continue working in the same city for several years or to expand the scope of their support.

- Partnerships with Public Sector Undertakings. Public Sector Undertakings like EESL, SECI, NTPC, and the Indian Renewable Energy Development Agency (IREDA) have been working with municipalities to offer technical assistance on clean energy projects. These agencies select and hire service providers and vendors on behalf of municipalities by preparing procurement and contract documents. Most of these agencies have a national policy mandate to take on these roles.

WHAT ARE THE GAPS IN UNDERSTANDING OR ASSESSING ENERGY TRANSITION PATHWAYS IN THESE CITIES?

We identified the following gaps in understanding energy transition pathways in cities:

- Access to information on cities' energy profiles. Through the CSCAF 2.0 reporting, cities are being required to share data on their energy use, the energy performance of their operations, and renewable energy adoption. However, this information is not completely available publicly (only the total scores are reported) and is often restricted to electricity, which limits deeper understanding of a city's energy system and opportunities in energy transition.
- Equitable and inclusive energy transitions. The costs and benefits of energy transition in cities will not be equally distributed. Consequently, there is a need to take a deeper look at strengthening inclusivity and assessing and introducing social equity objectives in clean energy transition actions.
- User experience of technological innovations. It is important to understand how users interact with technological choices. According to news reports from November 2022, Pune's award-winning 2016 smart street lighting project, which is fully equipped with remote streetlight monitoring, drew complaints from both citizens and PMC about non-functional streetlights on several stretches (*Hindustan Times* 2023). PMC was considering replacing the same lights with fixtures that had dimming sensors, which it claimed would save more money and energy. These and other experiences need to be captured to learn from them and design better programs and initiatives to promote clean energy.
- Role and contribution of international climate finance. Financing has emerged as one of the weaker aspects in cities' journey toward a clean energy future. Given the scale and urgency of the actions required locally, more efforts are needed to improve cities' access to climate finance and energy transition finance that can help them meet their climate and energy goals.


DANGER

CHAPTER 5.

Conclusions

Rooftop solar PV has emerged as the single most important technology in the energy transition basket of cities. Evidence suggests limited collaboration and coordination of cities with state departments and institutions. Cities also need to do more on energy efficiency and incorporating social equity considerations in energy transition programming and planning.

Any effort to understand the trajectory of energy transition in Indian cities must be made in the context of the relationship between the city's energy system and the national and state energy systems. For example, cities have no control over the most ubiquitous energy infrastructure, the central grid, nor is there explicit acknowledgment of the impact of cities' energy needs on ecology or the environment. How can cities located in states that are poor in energy resources but that have hot-humid climates meet their cooling needs? These are the types of constraints that will have implications for levels of city participation and leadership in India's clean energy transition.

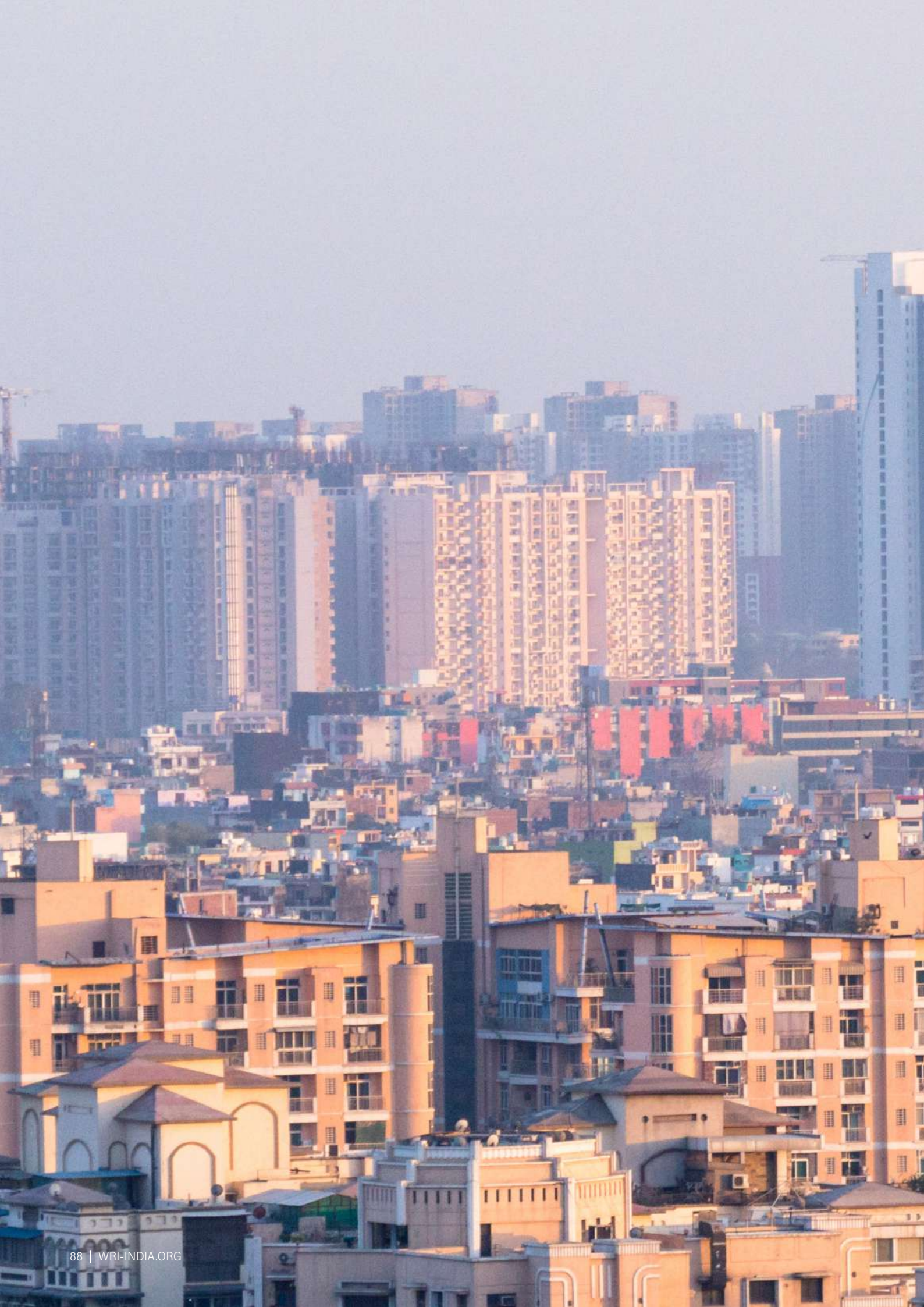
National and state policymaking on energy transitions has largely viewed cities as static recipients and implementers of actions, not as active participants. While energy transition is often defined as a process of socio-technological change, technologies have been introduced in cities to advance transition goals without acknowledging the complex nature of cities as social and ecological systems.

Based on the analysis of the 10 cities, we draw the following broad conclusions on the trajectory of energy transition in Indian urban spaces:

- Limited collaboration and coordination with state departments and agencies. Most cities have been administering national programs or scheme mandates but they have limited coordination with state departments and agencies like planning and energy departments, DISCOMs, SDAs, and SNAs. As the funding has been earmarked under "national" schemes and programs, options to streamline and scale results from clean energy projects by tapping into state schemes have been overlooked. The government departments of a few states (Karnataka and Maharashtra) have issued notifications and circulars mandating the efficient use of energy across all government departments, including ULBs, but evidence from cities in these states indicates no compliance with these rules. Similarly, some SDAs have programs to promote solarization of public buildings and incentivize regular energy audits. These agencies also have access to funds for demonstration projects in cities. In most cases, the awareness of these opportunities was found to be limited. This may be attributed to a lack of coordination capacity and efforts to align national and state agendas with city needs and contexts.
- Ad-hoc approaches. Indian cities' quest to achieve a low-carbon energy supply and efficient energy use can be described as ad hoc at best. The entry points for city-led or city-driven clean energy action have so far seen only one route: the top-down national missions and general urban rejuvenation schemes and programs. Implementing clean energy and energy efficiency projects was never the core objective of these initiatives; however, by mentioning them in their guidelines, such

programs opened cities to the idea of local participation in the clean energy transition. These programs expected cities to undergo a crash course on technology implementation, requiring them to rapidly get up to speed on the technical, institutional, and administrative requirements for the successful implementation of these actions. The programs were not designed with the needs and capacities of cities in mind. Most cities created action/master plans or incorporated the bare-minimum clean energy measures to tap into funding from schemes like the SCM or Solar Cities program. This has resulted in suboptimal outcomes, with cities perceiving their role as implementing allocated projects without much consideration and bounded by scheme guidelines.

- Limited focus on equity and inclusion in city energy transition actions. Missing from the energy transition landscape are the urban poor and low-income communities. The dominating supply-side narrative of energy transition that equates the process with the provision of hardware (i.e., the wires and poles) for reliable and affordable electricity access in cities has led to a lack of awareness of the demand side. How can clean energy and energy efficiency make energy affordable and reliable for economically and socially vulnerable communities? These questions remain unexplored. The only example of energy transition actions benefiting low-income groups was reported from Rajkot, where thermal comfort considerations were incorporated into the building design of an affordable housing project by RMC.
- Rooftop solar is being promoted as the single most important technology for urban energy transition. The national goal of achieving an increased share of renewable energy, particularly decentralized renewable energy, to meet energy needs has gradually been transmitted to cities. The technology of choice has been rooftop solar, which has emerged as the key marker for a city's commitment to energy transition. Locally harvested energy through solar panels dotting building rooftops presents a strong image of a city that has embraced green energy. However, studies indicate that decentralized renewable energy in this form can only meet 1 percent of megacities' energy needs owing to the mismatch between high urban energy-demand density and low local renewable-energy supply densities (Grubler et al. 2012). Geopolitical challenges facing solar supply chains and implications for local waste streams are also emerging issues that cities need to be prepared to address. Of course, this does not completely detract from the merit of national and state policies promoting rooftop solar as a local supply option. When integrated with urban infrastructure, decentralized renewable energy has also been known to be more climate-resilient, enhancing cities' capacity to adapt to climate change. Cities must review the long-term implications of technology choices and consider other untapped opportunities; for example, new rules and regulations such as the Green Energy Open Access Rules 2022 notified in a few states that allow for procurement of green energy through open access.
- Relatively little attention to energy efficiency. Though there is evidence available of energy efficiency interventions saving municipalities money (for example, Surat and Rajkot), most cities have not considered energy efficiency in municipal operations or buildings. The only energy efficiency intervention considered has been LED street lighting, which has not been adopted uniformly across all the studied cities. This lack of consideration is quite serious. According to the BEE, the adoption of energy efficiency measures under a Municipal Demand-Side Management program can result in a 23 percent energy savings (Bureau of Energy Efficiency 2021).
- Limited integration of urban planning with energy planning. Interventions related to urban planning were studied in all 10 cities; however, only those in Maharashtra stood out. In this state, the state government's Unified Development Control and Promotion Regulations promote green buildings through incentives like a higher FSI. This was the only example of such a consideration by an urban development policy. Most Indian cities are still growing, and researchers studying patterns of urbanization in India have concluded that Indian cities are sprawling, with growth concentrated outward toward the periphery and outside of municipal boundaries. This creates challenges for efficiently provisioning infrastructure and services. Consequently, urban planning must create conditions to achieve an energy-efficient, low-carbon built environment, which requires urban planners to coordinate and dialogue with energy system planners.



CHAPTER 6.

Recommendations

Indian cities can do more to scale LED streetlighting, procure renewable energy for powering municipal operations, and support low-carbon mobility through integrated approaches. States and cities need to be aligned along with stronger local capacity to deliver programs. Better integration of urban and energy policies and leveraging innovative financing mechanisms are also recommended areas for work to enhance cities' contribution to India's energy transition.

It is well known that ULBs have limited jurisdictional control over determining the trajectory of local energy-supply choices. There is a need to shift this supply-based narrative of energy transition policies to the demand side. Viewing cities as energy demand centers can facilitate the participation of a wider system of actors. Energy and climate policies for cities must acknowledge that the most impactful local decisions and policies influence the demand side—that is, they improve the efficiency of energy use—rather than the supply side (Grubler et al. 2012). The framing creates entry points for urban planning, land-use regulations, resource efficiency, behavior change, and other strategies.

How, then, can cities support India's clean energy transition? We propose several recommendations below.

Scale LED streetlighting and procurement of renewables for municipal infrastructure. Learn from integrated approaches to promote low-carbon mobility

As owners and service providers, ULBs in many of the studied cities have been quite successful in adopting LED streetlighting and solar PV, the latter being used for both public buildings and to power municipal operations like public water supply systems and wastewater treatment plants. ULBs in cities have reported significant energy savings and emissions from these projects. But as the study finds, some large cities continue with inefficient energy use in public streetlighting and have been slow in adopting RTS-PV for public buildings. It should be possible for cities to learn from each other in these areas, and there are several tools and resources available to inform and assist ULBs on the design and execution of such projects. Similarly, the approaches adopted by metro rail corporations in some cities of greening their portfolios can be easily adopted by other such institutions, including state transportation utilities running city public transport systems. There are some emerging best practices on collaboration between public transport utilities and metro rail (e.g., Kochi) to deliver an integrated resource-efficient system which can be replicated across multiple cities. There are significant untapped opportunities even within the existing policy framework. These include mandating and enforcing compliance with the ECBC and ENS for all types of municipal buildings and leveraging the Green Energy (Open Access) Rules 2022 to procure clean energy. This type of portfolio approach to decarbonizing energy supply and demand can significantly reduce both operating costs and emissions.

- Limited focus on equity and inclusion in city energy transition actions. Missing from the energy transition landscape are the urban poor and low-income communities. The dominating supply-side narrative of energy transition that equates the process with the provision of hardware (i.e., the wires and poles) for reliable and affordable electricity access in cities has led to a lack of awareness of the demand side. How can clean energy and energy efficiency make energy affordable and reliable for economically and socially vulnerable communities? These questions remain unexplored. The only example of energy transition actions benefiting low-income groups was reported from Rajkot, where thermal comfort considerations were incorporated into the building design of an affordable housing project by RMC.

Greater alignment with states to strengthen delivery of energy transition programs. Multistakeholder partnerships necessary for instilling ownership and inclusion

The energy transition pathways of Indian cities, like those of other cities, will be non-linear owing to differences in climate, resource availability, urbanization trajectories, and political economies. Consequently, a paradigm shift is required in transition management and planning.

As a first step, national and state policymakers must acknowledge the multi-actor and multi-scalar nature of energy transition governance in cities, and meet cities where they currently are when conceptualizing future clean energy programs and schemes. These actors can start by identifying cities as large demand centers. A demand-side focus requires bringing together several types of actors, including energy users, energy providers, and technology companies.

There is already some evidence that this is happening; examples include the collaboration between state transportation utilities, metro rail corporations, and ULBs to deliver NMT in cities, and the partnership between RE companies and metro rail corporations on procurement of RE for metro operations. State governments can

build on these organically emerging partnerships and mandate such partnerships in cities. State departments of municipal administration, energy, and finance and their affiliated agencies can meet critical technical and financial expertise gaps in supporting ULBs on these projects and other energy transition initiatives. Given the scale of the endeavor, national and state governments may consider selecting a few cities with different contexts to pilot and test multi-stakeholder partnership approaches across different levels. Such an approach may also address some of the criticisms levied against city energy transitions, which are largely seen to benefit only privileged, elite urban residents. Though the participation of community and grassroots groups in these approaches may push most city agencies outside their comfort zone, the city administration (i.e., the municipality) must initiate and promote such engagement. Creating platforms for peer-to-peer learning within the private sector also represents a significant opportunity. For example, the rethinking and redesigning approaches practiced by Infosys can be adopted by its peer companies and similar entities in other cities.

Need for strong institutional support for energy transition initiatives within ULBs

A city's municipal corporation is a significant consumer of fossil-fuel-based electricity. To reduce cities' reliance on fossil fuels and align with climate objectives, municipal corporations need to assume a more proactive role. Establishing a dedicated team within the municipal corporation to oversee energy transition projects is therefore recommended. Recent trends in the creation of climate change cells in ULBs are signaling a paradigm shift in city leadership on climate action. Such dedicated teams, however, need to be resourced and empowered to take charge on the implementation of ambitious actions identified in CAPs. Given the specialized and cross-sectoral nature of energy transition, cities may consider setting up dedicated teams responsible for planning and implementing initiatives related to renewable energy and energy efficiency in public buildings and municipal services, as well as promoting the integration of urban infrastructure like NMT to achieve a more resource-efficient city. The team can also set targets, identify opportunities, execute projects, and monitor progress in alignment with national and state-level goals. This step is pivotal in reducing energy costs, advancing clean energy adoption, and steering cities toward a sustainable energy future. The example from SMC illustrates this approach.

Align urban and energy policies and integrate programs to encourage positive lock-ins

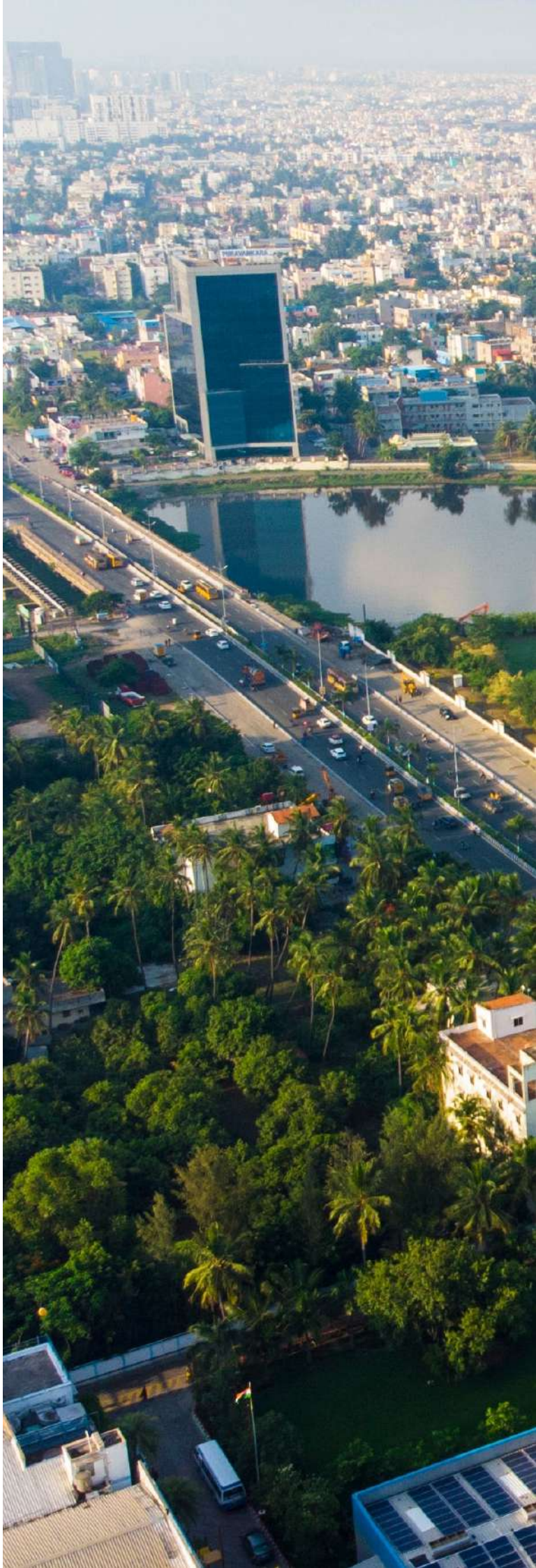
Currently, many cities are implementing energy efficiency and clean energy transition initiatives in an ad-hoc manner, lacking long-term planning. Some cities such as Mumbai have made net-zero commitments and aligned their strategies with national priorities. Contrastingly, Chennai has indicated an intention to integrate its CAP into a new master plan, which will require more structure and long-term thinking.

Energy-efficient, high-performing, low-carbon building stock can significantly reduce energy use. However, achieving this requires system-wide approaches; for example, incorporating infrastructure-integrated spatial planning and transit planning across a wide array of dispersed actors. Some of these barriers are hard to navigate owing to the legacy of siloed approaches to urban, transport, and energy planning in cities. To overcome these barriers, cities must be encouraged and incentivized to engage in collaborative planning approaches, thereby reaping long-term benefits from policy integration.

Of the 10 cities studied, 3 are either drafting new master plans or awaiting approvals on drafted plans. Furthermore, there are several city-level programs related to energy transition, such as Smart Cities, Solar Cities, and smart-metering projects, as well as CAPs, that are running independently. To streamline and harmonize these efforts, cities should integrate their various energy transition programs into a long-term vision document that ensures a unified approach and is legally binding.

Leveraging innovative financing options

ULBs face financial challenges in funding new infrastructure projects, primarily because of their limited resources, which are predominantly allocated to addressing basic civic concerns. According to a World Bank report (Athar et al. 2022) approximately 72 percent of city infrastructure is financed by central and state governments. ULBs contribute only 15 percent of their surplus revenues to financing, while the remainder comes as debts from public financing institutions. Therefore, to secure funding for energy transition projects, ULBs need to broaden their sources of revenue, including attracting private and commercial investments. Some of the ULBs studied (e.g., Indore) have shown an inclination to try novel approaches to finance their energy transition ambitions. Exploring innovative financing options like public-private partnerships, pooled financing, green bonds, and carbon credits can help ULBs secure the financial resources needed for the successful implementation of energy transition projects. This aligns with their responsibility for developing climate-resilient infrastructure and future development.



Appendices

APPENDIX A

TABLE A-1 | Select drivers of energy transition in Indian cities

TYPE OF DRIVER	EXAMPLES	SECTOR IMPACTED	LINK TO URBAN ENERGY TRANSITION
Multi-sectoral international drivers	Nationally determined contributions (NDCs) and net zero by 2070	Cross-cutting	Both NDC targets and net zero require the transformation of urban energy systems
	UN Race to Zero initiative	Cross-cutting	Several cities in India have signed up to the Race to Zero. Energy transition actions will be at the core of meeting this commitment
	C40 Cities and the Global Covenant of Mayors (GCoM)	Cross-cutting	Cities that are part of the C40 Cities and GCoM transnational networks are provided with technical and financial assistance to identify and implement climate and energy transition actions. These network cities have drafted city CAPs that explicitly identify mitigation strategies in the urban energy sector
Policy and regulatory drivers	Long-Term Low-Emissions Development Strategy (LT-LEDS) 2022		Submitted to UNFCCC in 2022, India's LT-LEDS recognizes the roles of smart city initiatives, the integrated planning of cities for mainstreaming adaptation and enhancing energy and resource efficiency, and green building codes in promoting sustainable and climate-resilient urban development (Ministry of Environment, Forest and Climate Change 2022a)
	National Mission on Sustainable Habitats (NMSH) 2.0	Cross-cutting	The NMSH was revised in 2021 and has two goals: ▪ Promote low-carbon urban growth to reduce the intensity of GHG emissions for achieving India's NDC ▪ Build cities' resilience to climate change impacts and strengthen their capacities to "bounce back better" from climate-related extreme events and disasters The revised NMSH identifies five thematic areas: ▪ Energy and green building ▪ Urban planning, green cover, and biodiversity ▪ Mobility and air quality ▪ Water management ▪ Waste management The mission's guidelines identify key adaptation and resilience strategies under each thematic area. The implementation of these strategies is targeted at an urban scale

TABLE A-1 | Select drivers of energy transition in Indian cities (cont'd.)

TYPE OF DRIVER	EXAMPLES	SECTOR IMPACTED	LINK TO URBAN ENERGY TRANSITION
Policy and regulatory drivers	Energy Conservation Building Code (ECBC) 2017	Buildings	Implementation of building energy codes by local bodies and authorities
	Eco Niwas Samhita 2018 and 2021	Buildings	Implementation of building energy codes by local bodies and authorities
	Ministry of New and Renewable Energy (MNRE) Grid-connected Rooftop Solar Program (1.0 and 2.0), PM Surya Ghar Muft Bijli Yojana 2024	Buildings	In MNRE's schemes, local distribution companies (DISCOMs) were given RT-SPV targets to achieve in their respective service territories within cities. Launched in February 2024, the PM's new scheme supersedes the MNRE's scheme and targets the installation of RT-SPV in 10 million households by covering most of the capital expenditure on RT-SPV with central funds
	Net-metering regulations, Electricity and Green Energy Open Access Rules 2022	Buildings and municipal services	Net-metering regulations in several states allow urban consumers to access rooftop solar energy to either export to the grid or for their own consumption The 2022 Green Energy Open Access rules allow any consumer to procure at least 100 kW of green power via open access. This opens the possibility for large public energy consumers, including Urban Local Bodies (ULBs), to procure green power by aggregating demand
	Model Building Byelaws 2016	Buildings	These building bylaws mandate provisions for renewable energy generation on-site and adherence to energy-efficiency principles in buildings
	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME), state electric vehicle (EV) policies	Low-carbon mobility	Introduced in response to the national FAME scheme in 2015, these policies engage with cities on the deployment of EV charging infrastructure and incentives for electrifying local transportation
	Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) scheme	Waste to energy	This initiative is aimed at the conversion of "waste to wealth." Its goal is to build a robust ecosystem for setting up CBG and CNG plants to drive sustainable economic growth and promote a circular economy. Other programs and schemes offered by different ministries, including the Waste-to-Energy Program and Sustainable Alternative Towards Affordable Transportation scheme, are also part of this initiative. Any plant or project that produces CBG/biogas (with a daily output exceeding 10 cubic meters) and bio-slurry as primary outputs is eligible to join GOBARdhan

TABLE A-1 | Select drivers of energy transition in Indian cities (cont'd.)

TYPE OF DRIVER	EXAMPLES	SECTOR IMPACTED	LINK TO URBAN ENERGY TRANSITION
Technological drivers	Smart Cities Mission (SCM)	Cross-cutting	The Government of India launched the SCM in 2015 to develop "core infrastructure" in cities and enable a "clean and sustainable environment"
	Solar Cities program	Buildings and municipal services	Launched by the MNRE in 2015, this program identified 60 cities for the development of Solar City master plans. These plans aim to help the cities achieve a minimum 10% reduction in projected total energy demand over a 5-year period through energy efficiency and renewable energy generation
	Smart metering programs such as the Integrated Power Development Scheme	Utilities	Smart metering projects are implemented by local or city-based DISCOMs
	Street Lighting National Program (SLNP)	Municipal services	This program was launched in 2015 and implemented by Energy Efficiency Services Limited (EESL) to replace conventional streetlights with LED streetlights in partnership with municipalities
	AMRUT	Buildings and municipal services	AMRUT emphasizes technological solutions for urban transformation, including those for promoting energy transition in cities. These include replacing streetlights with energy-efficient LED lights and developing Online Building Permission Systems to promote green and energy-efficient buildings
Financial/economic drivers	National Solar Mission, state solar policies	Cross-cutting	Many states have introduced renewable energy policies, set renewable energy generation targets, and prescribed incentives to promote renewable energy generation
Social and informational drivers	State Energy Efficiency Index	Cross-cutting	This index provides states with an assessment of their performance on energy efficiency indicators, including those related to the implementation of energy-efficient policies and programs in cities
	Mission LiFE (Lifestyle for Environment)	Cross-cutting	A global movement led by India to promote sustainable lifestyles and mindful consumption
	ClimateSMART Cities Assessment Framework 3.0	Cross-cutting (covers municipal services, buildings, low-carbon mobility, and utilities)	This framework establishes 28 indicators covering five sectors that help cities monitor and track their progress in addressing key environmental and energy challenges. There are five indicators under the energy and green buildings sector, which has the highest weighting in assessing cities' performance on the consolidated indicator set

APPENDIX B

Questionnaire for different stakeholders and sectors

Sector I: Public infrastructure

STAKEHOLDERS: MUNICIPAL CORPORATIONS OR URBAN LOCAL BODIES

Qualitative questions

1. Have the city councils/municipalities/ULBs prepared a strategic clean energy plan in the last five years? If so, what are the important milestones in this plan?
2. Do the ULBs have any commitments (overarching goals/targets under any national or international commitments) to address climate issues? Please elaborate on the commitments or milestones.
3. What types of services are provided by ULBs in the city? What type of renewable energy/energy efficiency initiatives have been adopted to deliver these services?
4. What has been the role of the municipal corporation/ULB/other local stakeholders in the implementation of energy efficiency or renewable energy projects under national initiatives like the Smart City Mission, Solar City initiatives, and AMRUT? Please elaborate on the outcomes achieved to date in each of these projects.
5. What level of involvement do the ULBs have at the planning/development stage of renewable energy/energy efficiency initiatives owned by the state government?
6. What other clean energy projects (excluding the above) have been implemented by the municipal corporation/ULB/other stakeholders in the last five years? What have been the major outcomes of each project? Who were the key supporting partners?
7. What renewable energy/energy efficiency technologies is the ULB currently focusing on? What are the examples of the adoption of new and emerging technologies taking place in the city?
8. Who are the different stakeholders involved in the decision-making for renewable energy/energy efficiency initiatives at the city level? Please elaborate by citing any specific renewable energy/energy efficiency projects.
9. What is the frequency of public-level/stakeholder consultations organized over the last five years for renewable energy/energy efficiency projects?
10. Are renewable energy/energy efficiency initiatives/projects put out for comments/feedback in the public domain? Please highlight a few examples.
11. Are there any partnerships between ULBs and academic institutions in the domain of renewable energy/energy efficiency projects? Please elaborate.
12. What role do industrial bodies/chambers play in the domain of renewable energy/energy efficiency initiatives? Please highlight a few examples.
13. Are there any linkages with global organizations/consortiums working on renewable energy/energy efficiency initiatives in the city? Please elaborate.
14. What different financing sources have been used by the ULBs/municipal corporations for renewable energy/energy efficiency projects in the city? Which financing models have been successful over the last five years in the renewable energy/energy efficiency domain? Please elaborate.
15. Are there any standout renewable energy/energy efficiency projects/initiatives that were funded through public/public-private entities and successfully commissioned? Please elaborate.
16. Have any pilot studies been rolled out for implementing renewable energy/energy efficiency projects in the city? Please elaborate.
17. Have any public awareness campaigns/information drives on the importance/benefits of transitioning toward energy efficiency/renewable energy been organized by ULBs for the public or other energy consumers?
18. Are there any energy efficiency initiatives/projects in new and existing buildings? Please give some examples.
19. Are there any incentives related to property tax/town planning approvals for green building implementation?
20. Please describe any specific actions undertaken by the municipal corporation/ULBs to encourage the use of EVs in the city.
21. Have any community-led renewable energy/energy efficiency initiatives been carried out at the city level? Please give some examples.
22. What are the broader challenges faced by the municipal corporation/ULBs/city-level stakeholders in implementing state-level and national-level renewable energy/energy efficiency programs? Please elaborate.
23. Please specify any specific challenges related to renewable energy/energy efficiency projects.
24. What are the main challenges faced by stakeholders in accessing finance for implementing renewable energy/energy efficiency projects?

25. What are the barriers to the adoption of new and emerging technologies (e.g., EVs, green hydrogen, battery storage)? Please elaborate.
26. What are the governance issues in the renewable energy/energy efficiency domain (e.g., coordination problems, frequent change of officials, differences between state/national-level decision-makers)? Please elaborate.

Quantitative questions

1. Please state the number and type (size, technology, financing, etc.) of clean energy projects initiated under the Solar Cities program.
2. Please state the number and type of clean energy projects initiated under the Smart Cities Mission.
3. Please state the number and type of clean energy projects initiated under AMRUT.
4. What is the municipal corporation's annual budget (average of last three years)?
5. What budget has the state government allocated for renewable energy/energy efficiency projects over the past few years (preferably the last three years)?
6. What percentage of the budget is used by the municipal corporation/ULBs to implement renewable energy/energy efficiency projects?
7. Please state the number of training programs on renewable energy/energy efficiency currently being held for staff working in ULBs.
8. Please state the number of skill-development/technical programs currently being held for staff working in ULBs.
9. Please state the number of international training programs currently being held.
10. Please state the number of renewable energy/energy-efficiency-awareness programs conducted by the municipal corporation for the public in the last five years.

Sector II: Electricity

STAKEHOLDERS: DISCOMS/REGULATORY COMMISSION

Qualitative questions

1. Please describe some of the recent technology initiatives (e.g., smart meters, solar pumps, rooftop solar, etc.) being implemented by the DISCOM in the city.
2. Please elaborate on regulations/policies (e.g., rooftop solar, smart metering, EV charging, etc.) initiated by the utilities to implement clean energy projects across the city.
3. Are utilities organizing public awareness campaigns/information drives for energy consumers on the benefits of energy conservation and transitioning toward energy efficiency and renewable energy? Please elaborate.
4. Please state the number and type of training/skill-development/technical programs currently being held for the utility's staff.
5. Please state the number and type of international training programs currently being held in your organization.
6. What types of renewable energy/energy efficiency projects (in buildings, public infrastructure, etc.) are being undertaken in the city?
7. Are there any renewable energy/energy efficiency initiatives in new and existing buildings?
8. Please describe some examples of public-private participation for DSM/demand response that have been successfully implemented at the city level.
9. What are the broader challenges being faced by the utility in implementing DSM programs in the city? Please elaborate.
10. Are there any specific challenges (e.g., technical, regulatory, or financial) related to renewable energy/energy efficiency projects? Please elaborate.
11. What are some of the barriers to the adoption of new and emerging technologies (EVs, battery storage, charging stations, rooftop solar, smart metering, etc.)? Please elaborate.
12. What are some of the governance challenges in the renewable energy/energy efficiency domain (e.g., coordination problems, frequent change of officials, differences between state-/national-level decision-makers, etc.)? Please elaborate.

Quantitative questions

1. Please state the total and per-capita electricity consumption.
2. Please state the peak electricity demand.
3. Please state the installed rooftop solar capacity.
4. Please state the total renewable energy consumption (share of renewable energy in total electricity consumption).
5. Please state power consumption in the city by consumer category (i.e., household, commercial, transportation, public amenities, industrial, miscellaneous).
6. Please state the total number of rooftop solar installations by consumer category (in the last three years).
7. Please state the total number of net-metering connections (in the last three years).
8. Please state the number of smart meter installations (in the last three years).
9. Please state the number of registered EV charging stations within the city.

Sector III: Transportation

STAKEHOLDERS: STATE TRANSPORTATION DEPARTMENT, STATE TRANSPORTATION UNDERTAKINGS, SMART CITY, CITY METRO

Qualitative questions

1. Has the transportation department developed a strategic plan for transitioning from fossil-fuel-operated buses to electric buses? If so, please elaborate on the important milestones and current status.
2. What kinds of clean public transportation initiatives have been adopted in the city (e.g., e-buses, metro, etc.)? Please elaborate.
3. Have any pilot studies been rolled out for implementing clean transportation (e.g., e-buses/e-bikes/e-rickshaws, etc.) in the city?
4. Are there any policies/regulations for promoting clean transport? If so, please mention some examples.
5. Are there any training/skill-development/technical programs for local capacity-building? Please elaborate.
6. Please state the number and type of international training programs currently being held, citing some program objectives.
7. Are stakeholders organizing any public awareness campaigns/information drives for the public on the benefits of transitioning toward greener and cleaner transport? Please elaborate.
8. Please describe the financing model adopted by the transportation department for procuring electric buses for public transportation.
9. Please describe specific actions undertaken by the transportation department to encourage the use of EVs in the city.
10. Can you give some examples of public-private participation that were successfully implemented at the city level? Please elaborate.
11. Please describe some broader challenges being faced by the transportation department in implementing state-level and national-level programs.
12. Are there any specific challenges related to clean transport? Please elaborate.
13. What challenges do stakeholders face in accessing finance for implementing clean transportation projects? Please elaborate.
14. Are there any barriers to the adoption of new and emerging technologies (EVs, e-buses, etc.)? Please mention some.
15. Are there any governance issues in the clean transportation domain (e.g., coordination problems, frequent change of officials, differences between state-/national-level decision-makers, etc.)? Please elaborate.

Quantitative questions

1. Please state the number of registered e-buses and e-vehicles/hybrid vehicles (public and private).
2. Please state the number of EV charging stations for buses.
3. Please state the current share of electric buses in the total public transportation fleet.

Sector : All sectors

STAKEHOLDERS: THINK TANKS/ACADEMIA/RESEARCH ORGANIZATIONS/INDUSTRY/CSOS/ETC.

1. What kinds of renewable energy/energy efficiency technologies are local government departments currently focusing on?
2. What are some examples of innovative technology adoption taking place in the city?
3. Please describe any pilot studies rolled out for implementing renewable energy/energy efficiency projects in the city.
4. Please describe any community-led renewable energy/energy efficiency initiatives carried out at the city level.
5. Please cite some examples of public-private participation that were successfully implemented at the city level.
6. Please describe the broader challenges being faced by local government departments in implementing state-level and national-level renewable energy/energy efficiency programs.
7. Have you faced any specific challenges related to renewable energy/energy efficiency projects?
8. Did you face any challenges in accessing finance for implementing renewable energy/energy efficiency projects? Please elaborate.
9. Are there any barriers to the adoption of new and emerging technologies (e.g., EVs, green hydrogen, battery storage, etc.)? If so, please elaborate.
10. What are some governance challenges in the renewable energy/energy efficiency domain (e.g., coordination problems, frequent change of officials, differences between state-/national-level decision-makers, etc.)? Please elaborate.

ABBREVIATIONS

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BBMP	Bruhat Bengaluru Mahanagara Palike
BEA	Building Efficiency Accelerator
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company
BESS	Battery energy storage system
BMRCL	Bangalore Metro Rail Corporation Limited
BMTC	Bengaluru Metropolitan Transport Corporation
BRPL	BSES Rajdhani Power Limited
BRTS	Bus Rapid Transit System
BYPL	BSES Yamuna Power Limited
BUA	Built-up area
C3 NIUA	Climate Centre for Cities, National Institute of Urban Affairs
C40	C40 Cities Climate Leadership Group
CAP	Climate Action Plan
CAPEX	Capital expenditure
C-HED	Center for Heritage, Environment, and Development
CBG	Compressed biogas
CCEAP	Climate Change and Enviroment Action Plan
CEE	Centre for Environment Education
CMDA	Chennai Metro Development Authority
CMP	Comprehensive Mobility Plan
CMRL	Chennai Metro Rail Corporation
CNG	Compressed natural gas
CREST	CSTEP Rooftop Evaluation for Solar Tool
CSCAF 2.0	ClimateSMART Cities Assessment Framework 2.0
CSCL	Chennai Smart City Limited
CSML	Cochin Smart Mission Limited
CSO	Citizen society organization
CSTEP	Center for Study of Science and Policy
DDC	Delhi Development Commission
DERC	Delhi Electricity Regulatory Commission
DISCOM	Distribution company
DMRC	Delhi Metro Rail Corporation
DSM	Demand-side management
DULT	Directorate of Urban and Land Transport
ECBC	Energy Conservation Building Code
EE	Energy efficiency
EESL	Energy Efficiency Services Limited
ENS	Eco Niwas Samhita
EPCO	Environmental Planning and Coordination Organisation
ESCO	Energy services company
EV	Electric vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India
FSI	Floor space index
GCC	Greater Chennai Corporation
GCoM	Global Covenant of Mayors
GHAR	Green Homes at an Affordable Rate
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Development Corporation)
GOBARdhan	Galvanizing Organic Bio Agro Resources Dhan
GRIHA	Green Rating for Integrated Habitat Assessment
HIMURJA	Himachal Pradesh Energy Development Agency
ICEPL	Indore Clean Energy Private Limited
ICLEI SA	International Council for Local Environmental Initiatives—South Asia (now renamed ICLEI—Local Governments for Sustainability)
IEA	International Energy Agency
IFC	International Finance Corporation
IGBC	Indian Green Building Council

IoT	Internet of Things
IMC	Indore Municipal Corporation
ISCDL	Indore Smart City Development Limited
ITDP	Institute for Transportation and Development Policy
KfW	Kreditanstalt für Wiederaufbau
KMC	Kochi Municipal Corporation
KMRL	Kochi Metro Rail Limited
KSEB	Kerala State Electricity Board
LiDAR	Light detection and ranging
LT-LEDS	Long-Term Low-Emissions Development Strategy
MCD	Municipal Corporation of Delhi
MEDA	Maharashtra Energy Development Agency
MNRE	Ministry of New and Renewable Energy
MoHUA	Ministry of Housing and Urban Affairs
MSEDCL	Maharashtra State Electricity Distribution Co. Limited
NDC	Nationally determined contribution
NIT	Nagpur Improvement Trust
NIUA	National Institute of Urban Affairs
NMC	Nagpur Municipal Corporation
NMSH	National Mission on Sustainable Habitats
NMT	Non-motorized transport
NSSCDCL	Nagpur Smart and Sustainable City Development Corporation Limited
NTPC	National Thermal Power Corporation
PCMC	Pimpri Chinchwad Municipal Corporation
PGVCL	Paschim Gujarat Vij Company Limited
PMAY	Pradhan Mantri Awas Yojana
PMC	Pune Municipal Corporation
PMPML	Pune Mahanagar Parivahan Mahamandal Limited
PNG	Piped natural gas
PSCDCL	Pune Smart City Development Corporation Limited
PV	Photovoltaic
RE	Renewable energy
RESCO	Renewable energy service company
RMC	Rajkot Municipal Corporation
RMI	Rocky Mountain Institute
RSCDL	Rajkot Smart City Development Limited
RT-SPV	Rooftop solar photovoltaics
SCM	Smart Cities Mission
SDA	State-designated agency
SDC	Swiss Agency for Development and Cooperation
SECI	Solar Energy Corporation of India
SLNP	Street Lighting National Program
SMC	Surat Municipal Corporation
SNA	State-nodal agency
SPV	Special-purpose vehicle
SSCDL	Surat Smart City Development Limited
SWH	Solar water heater
TIDE	Technology Informatics Design Endeavour
TNSCB	Tamil Nadu Slum Clearance Board
TNUHDB	Tamil Nadu Urban and Habitat Development Board
TPD	Tonnes per day
TPDDL	Tata Power Delhi Distribution Limited
ULB	Urban local body
UMTA	Unified Metropolitan Transport Authority
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URDPFI	Urban Regional Development Plans Formulation and Implementation
USAID	United States Agency for International Development
WTE	Waste to energy

ENDNOTES

1. Race to Zero is an UN-backed campaign to "rally leadership and support from a growing number of businesses, cities, regions and investors committed to a healthy, resilient and zero carbon world." As of March 2021, 708 cities had joined the campaign.
2. The Atal Mission for Rejuvenation and Urban Transformation, or AMRUT, was launched in 2015 with "the aim of providing basic civic amenities like water supply, sewerage, urban transport, parks as to improve the quality of life for all, especially the poor and the disadvantaged." AMRUT is currently in its 2nd phase, launched in 2021. More about AMRUT—Atal Mission for Rejuvenation and Urban Transformation—AMRUT: Ministry of Housing and Urban Affairs, Goverment of India (mohua.gov.in)
3. Pradhan Mantri Awas Yojana (PMAY) was launched in 2015 to facilitate access to affordable housing and targeting construction of 11.2 million houses under its different components. More about PMAY—PMAY-HFA(Urban) (pmaymis.gov.in).
4. Launched in 2008 by the Ministry of New and Renewable Energy, one of the objectives of the Solar Cities Program was to enable urban local governments to address energy challenges at the city level. The program required notified Solar Cities to develop a solar master plan with a goal of a minimum 10 percent reduction in projected total demand for conventional energy at the end of five years. This goal was to be achieved through energy efficiency measures and renewable energy installations. The program was revised in 2015 and 2023. In 2023, 34 more cities were added to the 60 initially identified in the program.
5. The Climate Smart Cities Assessment Framework is now in its third phase. CSCAF 3.0 has 28 indicators categorized into five themes. The technical document for the third phase published in 2022 is available here—CSCAF_3_0_Technical_document.pdf (niua.in).
6. URDPFI classification published in the 2015 *URDPFI Guidelines*, Volume 1, by the Ministry of Housing and Urban Affairs.
7. The Mitigation Work Programme is a process established by the UNFCCC to help countries scale up their mitigation ambitions and implementation to achieve the Paris Agreement's 1.5°C goal. The focus of the work program for 2024 is "Cities: Buildings and urban systems."
8. EESL's annuity-based deemed savings model. In this model, LED technologies are demonstrated in a designated area, and calculations are made based on the demonstration measurements to determine the overall energy savings per measure. EESL provides the capital investment and replaces the existing streetlights with LEDs (without any need for municipalities to invest). The consequent reduction in energy and maintenance costs for the municipality is used to recover EESL's costs over a period. The contracts between EESL and the municipality are typically for seven years. The contracts guarantee minimum energy savings (usually 50 percent) and the provision of free replacements and maintenance of lights at no additional cost to the municipality (Source: EESL - Proven LED Delivery Models8_Optimized_Final.pdf (esmap.org)).
9. SDAs are state-level nodal agencies that coordinate, regulate, and enforce the provisions of the Energy Conservation Act 2001 within the state/union territory. There are 28 SDAs, some of which are also SNAs that promote renewable energy at the state level through programs and policy coordination.
10. CAPEX model: Under the CAPEX model, the consumer owns the solar PV plant or makes an upfront investment in owning the solar plant.

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ABOUT WRI INDIA

WRI India, an independent charity legally registered as the India Resources Trust, provides objective information and practical proposals to foster environmentally sound and socially equitable development. Our work focuses on building sustainable and liveable cities and working towards a low carbon economy. Through research, analysis, and recommendations, WRI India puts ideas into action to build transformative solutions to protect the earth, promote livelihoods, and enhance human well-being. We are inspired by and associated with World Resources Institute (WRI), a global research organization. Know more: www.wri-india.org

Our challenge
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our vision
We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our approach
COUNT IT
We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT
We use our research to inform government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT
We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

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