NEW POWERS: HOW INDIA'S SMART CITIES ARE GOVERNING AND TRANSITIONING TO LOW-CARBON ENERGY

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1. Introduction

Globally, cities are fostering a transition to low-carbon energy production and consumption at scale to mitigate climate change (Castán Broto, 2017a, 2017b; Rutherford and Coutard, 2014). This transition is of significance to India, where the trajectory of the urbanization over the next few decades, in particular the way urban energy systems are shaped, will be central to the country's future energy demand. It will also be significant in the country's response to climate change including meeting its Nationally Determined Contribution to the Paris Agreement (Khosla and Bhardwaj, 2018). At this early stage of the transition, decision-makers have the opportunity to lock-in low-carbon energy production and consumption infrastructures for the long-term.

Despite the increasing global focus on the potential of cities to foster a low-carbon energy transition, Indian cities have been lagging behind. They have almost no role to play since the governance of energy remains constitutionally within the purview of central and state governments. Electricity is managed by state-level distribution companies (DISCOMs) and regulated by state regulatory commissions. Some of the regulators main concerns are to increase reliability of supply and access to rural areas, to balance between rural-urban interests, and to manage costs and cross-subsidies across the industrial, commercial, domestic and agricultural sectors. DISCOMs conceptualise urban consumers as a reliable source of revenue and have created a host of schemes (from the Accelerated Power Development and Reform Programme (APDP) to the Integrated Power Development Scheme (IPDS)) aimed at the enhancement of urban distribution networks and consumer interfaces (Sudhakar, 2018; Swain, 2016). But beyond this conceptualisation of the urban as a place of reliable revenue and infrastructure upgrades, dynamics of urbanisation or interests of urban users are marginal in energy deliberations. No policies were created that enabled cities to lead changes in the energy systems, in both energy and urban policy sectors (Sivaramakrishnan, 2014; Sreekumar and Josey, 2012).

However, the launch of the 100 Smart Cities Mission (SCM) in 2015 explicitly included references to energy, indicating a surprising and significant departure from previous urban policies. Cities responded to these new responsibilities. The top sixty cities dedicated around 10% of their planned budgets for energy projects, i.e an amount of 13,161 INR crore (cr.) out of a total consolidated budget of 1,29,045 INR cr. (Taraporevala, 2018). The window of opportunity that the SCM provides for urban local bodies to engage with energy raises three questions: 1) what kind of energy projects are planned and what does it reveal about the cities' vision towards energy? 2) Does the Smart Cities Mission foster a low-carbon energy transition and if so, how is this transition envisaged? 3) and finally, what are the rationale and the drivers behind this apparent shift?

To answer these questions, we analyse energy-related investments, plans and projects proposed by the first sixty cities in India's Smart Cities Mission, based on a database built by Taraporevala (2018) and Anand, Sreevatsan and Taraporevala (2018) at the Centre for Policy Research. This database collates the plans that were submitted by the first 60 cities selected, and details the types of projects proposed, including their associated budgets. As the Mission is ongoing and there is limited publically available data on progress, this report does not comment on the implementation (HLRN, 2018; Vikram, 2018). Nevertheless, we intend for this analysis to generate interest and discussion on the role of city governments in governing energy and enabling a transition to low carbon energy, especially in light of growing recognition of climate change within urban policy deliberations in India (MoHUA, 2019). Keeping in mind future Indian urban policy, this report offers lessons on how Indian cities can play a significant role in fostering a transition to low-carbon energy.It also indicates to those concerned with climate and energy policy more widely, the potential of the urban sector in fostering the transition to low carbon energy.

Our analysis offers a two-faced reading of the Smart Cities Mission's introduction of energy in city decision-making. First, the Mission creates conditions by which city officials can enhance basic energy infrastructure and deploy low-carbon technologies in their jurisdiction, generally unencumbered by vested fossil fuel interests. While the deployment is limited in scale at this early stage, the Mission offers opportunities for city officials to gain further familiarity with the management and governance of low-carbon energy, building capacity for future larger scale deployments. However, and in the contrasting second face, the Mission currently limits city officials to a set of technologies and policy guidelines as devised by central ministries, and in line with the interests of private actors. There remains a risk that city officials will treat the deployment of low-carbon energy as an *ad hoc* directive from a central ministry, rather than a topic they can lead deliberations and decision-making. Clearer institutional arrangements for cities, including long-term incentives, within the wider urban, energy, and climate change policy regimes can enable local government to take a more active role in transitioning to low-carbon energy.

The report is structured as follows. The next section reviews the existing academic literature on energy transitions and smart cities, highlighing how cities are governing and emerging sites of low-carbon transitions. This section also reviews the energy component of the SCM. In section 3, we discuss our methodology. Section 4 details our main findings and make two arguments. First, the primary focus of cities is to invest in basic infrastructure, with a focus on enhancing the grid and energy supply, and some attention to efficiency and demand-side management measures. Second, the Smart City Mission is fostering the uptake of low-carbon technologies, in particular solar, electric vehicles, waste to energy and Light-emitting Diode (LED) lighting. The Section 5 is exploring the drivers and implications of these projects and finds that, even though there is space for cities to make choices, most technologies proposed are pushed by the central government and suited to growing private interests.

2. Urban Energy Transitions & Smart Cities

What has been the role of cities in governing energy? India's energy and urban governance are often considered separately, largely because urban governments have no mandate to govern energy. However, with the rising importance given to city governments in leading a transition to low carbon energy, urban scholars are beginning to grapple with the intricacies of energy infrastructure, and the role urban areas play in determining energy supply, distribution and demand, while energy and climate change scholars have only limitedly explored the role of urban settlements and urbanization. Our preliminary effort in linking the two is anchored in a study of the role of energy in 'Smart Cities', an emerging research area globally. This section briefly explores the main themes raised in the global literature on urban energy and smart cities, ranging from governance to transitions. The concepts of energy transitions and 'smartness' have both been influential in identifying the role that cities have in governing energy.

2.1 Urban Energy Transitions

Energy transitions are system-wide shifts to different sources and uses (Araújo, 2014), for example, the historical shift from low-density biomass sources to high-density fossil fuels in supply, and from mechanical to electrical energy use (Grübler, 2004). In face of the global climate change, there is now an imperative to foster a transition that combine a less carbon and energy intensive economy and ensure universal and secure access to energy services (Bridge et al., 2013).

In international policy circles, cities, drivers of greenhouse gas (GHG) emissions (Creutzig et al., 2016; Khosla and Bhardwaj, 2018; Romero-Lankao et al., 2014) have been recognised as playing a central role in steering the transition to low-carbon energy systems (e.g. in the 2015 Paris Agreement, in the UN-Habitat's 2016 New Urban Agenda, in the eleventh Sustainable Development Goal). As sites which concentrate energy demand, cities are key in shaping patterns of energy consumption and transitioning towards a low-energy demand society (Grübler et al., 2018; Zelem, 2012). Some cities can also influence systems of energy supply, and incentivize the uptake of low-carbon energy.

Cities offer a few political advantages in fostering transitions to new, and low-carbon energy systems. Because cities concentrate economic activities and concentrate affluent consumers, they are sites of innovation and experimentation (Bulkeley and Castán Broto, 2014) and, thus have a potential to foster a transition to a low-carbon economy at scale. Cities have increasingly caught on this trend, positioning themselves as innovators and leaders of the low-carbon energy transition, in order to attract investment (Long and Rice, 2019; Luque-Ayala et al., 2018; Rutherford and Coutard, 2014; While et (Long and Rice, 2019; Luque-Ayala et al., 2018; Rutherford and Coutard, 2014; While et al., 2004). They also tend to have organized civil societies which can form coalitions to put environmental issues and energy transitions on local political agendas (Blanchet, 2015). Social science scholarship on the urban energy transition has shown that potential actions are contingent to a specific socio-material and institutional contexts cities are embedded in (Castán Broto, 2017a; Rutherford and Coutard, 2014). To put it simply, urban energy transitions are influenced by how energy is governed. Research on urban energy transitions has emphasized the ways in which governance arrangements and political economy in cities influence the pathways of energy transitions. There is emphasis on the role of local state and non-state actors play in leading climate action , but also how national and regional priorities (national emission reduction targets and urban economic growth) condition low-carbon responses in the urban areas (Hodson and Marvin, 2012). Such scholarship emphasizes the conflicts and tensions between the various lobbies that exist in cities, for example, of affluent consumers, civil society and groups which organise to lower prices of energy (Criqui, 2015; Criqui and Zérah, 2015; Jaglin and Verdeil, 2017; Rutherford, 2014). Such lobbies, or urban regimes, can in certain cases present local resistance to objectives of climate mitigation to low-carbon energy (Monstadt and Wolff, 2015) and in others can even foster new growth coalitions aimed climate mitigation (Jonas et al., 2011).

In the global South, scholars have emphasised that cities have to consider their transition to low-carbon energy amidst multiple other challenges including addressing infrastructure gaps, and limited capacity (Khosla and Bhardwaj, 2018). These cities, where energy use and built form is most rapid (Grübler, 2004), face the challenge of decarbonizing energy systems while also extending services to more people. One area of attention has centred on the politics around access to electricity, such as the provision of pre-paid metering in low-income neighbourhoods (Baptista, 2015; Luque-Ayala et al., 2018; Pilo, 2017), while also ensuring a healthy environmental and equal distribution (Nagendra et al., 2018; Westphal et al., 2017). As sites of rapid economic and infrastructure growth, cities in the global South have a potential role to play in the management of energy consumption by providing affordable energy services, but locking in systems of lower consumption (Creutzig et al., 2018; Zelem, 2012).

The energy transitions literature raises relevant concerns for India's cities, which are projected to be centres of rising levels of consumption and carbon footprints in the coming decades (IEA, 2015). This unprecedented urban growth can represent a window of opportunity to lock-in low-carbon technologies and infrastructure and steer urban development choices towards a low-carbon future (Khosla and Bhardwaj, 2018). This reality opens questions on the ability for cities to manage transitions to low-carbon energy supply and trade-offs between improving basic, and affordable access of energy and locking-in to a lower energy demand pathway (Aggarwal, 2013; Khosla and Bhardwaj, 2018). However, scholarship on energy in Indian cities is limited in these dimensions. It has focused on the implications of privatising 'distribution licenses' in urban areas (Criqui and Zérah, 2015; Sant et al., 2003) and other 'neoliberal' reforms such as pricing through smart meters, how urban areas relate to wider state politics of electricity (Sudhakar, 2018), and the politics of improving access to 'slums' and unauthorised colonies (Burra and Riley, 1999; Criqui, 2015). This is mainly because, as stated earlier, urban local governments have limited say in policies on low-carbon energy and energy consumption (Khosla and Bhardwaj, 2018; Sami, 2018).

2.2 Smart Cities and Energy

The 'Smart Cities' concept, despite lacking specificity, has been met with enthusiasm from policymakers, private companies and international organisations, and broadly been utilised to justify the uptake of digital and Information and

Communication Technology (ICT) to solve pressing urban challenges, including making cities "inclusive, safe, resilient, and sustainable" (Bhattacharya et al., 2015; Datta, 2015a; Habitat III, 2015; Luque-Ayala et al., 2018, 2016). On energy, attention has been given to the potential of emerging energy technologies such as smart grids and meters which manage energy consumption and two-way supply, micro-scale grids to encourage the uptake of decentralized renewable technology, energy efficient technologies, and Electric Vehicles (EVs) (Calvillo et al., 2016). As Bulkeley, McGurik and Dowling (2016) in their work on the deployment of smart grids experiments in Australia argue, the smart city narratives are central in new governmental programmes that are situated "at the conjunction of the grid and the city" (p1710). Such programmes open discussions on the linkages between urban governance, and energy transitions, and the role cities and such ICT solutions can play in integrating renewables, bettering energy management, improving energy savings and reducing peak demand for cities (Mahapatra et al., 2017). Questions remain of the value of 'smart' solutions to address energy problems. For example, will ICT bring about energy savings or lead to rebound effects and increasing overall demand? (Viitanen and Kingston, 2014). Scholars such as Long and Rice (2019) also highlight how the concept of smart cities can be mobilised towards the objectives of carbon control, energy efficiency.

Critics of the "smart city" paradigm have interrogated its techno-centricism and assumed relationship between technology and objectives of progress that including efficiency, safety, inclusiveness, good governance and even urban democracy (Bunnell, 2015; Datta, 2015a; Hollands, 2008; 2015; Luque-Ayala et al., 2016). Other areas of caution concern the issue of privacy on the one hand and the increasing role (and power) given to corporate interests (Bhattacharya et al., 2015; Bunnell, 2015; Grossi & Pianezzi, 2017; Hollands, 2008; 2015).

2.3 Smart Cities and Energy in India

Similar concerns have been raised in relation to India's Smart Cities Mission and its aims utilise digital technologies to manage urban systems and to provide innovative solutions, amongst which include climate change and inefficient energy systems (Datta, 2015a, 2015b; Khan et al., 2018; Khosla and Bhardwaj, 2018; Mukhopadhyay, 2015). The ambitious Smart Cities Mission was launched in 2015 by the Government of India with the aim of creating 100 Smart Cities. A thorough description of the SCM is detailed in Taraporevala (2018) but it is important to recall briefly some of its main features. The central government development guidelines outlined a vision based on the expansion of multiple core infrastructures – "physical, institutional, social, and economic", to face the challenges posed by increasing urbanisation, while giving space for cities to interpret 'smartness' as per their own objectives ("Smart Cities Mission Guidelines," 2015, p. 5). The goal of this policy is to promote economic growth and create better living conditions for urban dwellers and ensure democratic deliberation in local areas (Anand et al., 2018; HLRN, 2018; Hoelscher, 2016; Khan et al., 2018). In order to access government funding, cities had to compete on the basis of proposals in which they outlined their vision and plan. The selection process was carried out in different rounds and the central government evaluated proposals on the content and the viability of their implementation plan. Once selected, the implementation requires the creation of a Special Purpose Vehicle (SPV). The SPVs, which are mainly headed by State-appointed bureaucrats, are tasked with the implementation of smart city projects, in collaboration with 'hand-holding' consulting firms and international/development agencies ("Smart Cities Mission Guidelines," 2015). This arrangement has been criticised by encouraging re-centralisation, and privatisation, especially as local elected political representatives are well under-represented in these bodies (Anand et al., 2018; HLRN, 2018; Khan et al., 2018). Cities were also encouraged to use various financial mechanisms in their proposals, such as public-private partnerships (PPPs), and leveraging equity and debt financing.

Finally, cities were mandated to conceive smart projects for a portion of their urban area (Area-based development) as well as for a larger part covering almost the entire city (Pan-city initiative). The latter had to have a digital or ICT component.

Of interest to us is that the India's Smart City Mission provides an early indication of the priorities and the types of energy projects pursued by Indian cities. The Ministry also prescribes some Smart "essential features" which were expected to be integrated into each of the city proposals ("Smart Cities Mission Guidelines," 2015, p. 9). For energy, cities were mandated to provide:

- assured electricity supply with at least 10% of the Smart City's energy requirement coming from solar;
- energy efficient street lighting;
- the adoption of green and energy-efficient building design in case of redevelopment projects.

Further, precise examples of other Smart energy solutions listed in the guidelines are smart energy meters and management or Waste-to-Energy and fuel. ("Smart Cities Mission Guidelines," 2015, p. 6)

Such centrally mandated features can be interpreted as a mechanism to centralize decision-making, alongside its financial structure as a 'Centrally Sponsored Scheme', which mandates states to match central grants. It is coherent with the objective of 'convergence' as cities are encouraged to pool other sources of funding from other central schemes, such as the Swachh Bharat Mission and the Solar City Programme.

In conclusion, globally cities are transitioning to low-carbon energy, but the historically centralised arrangement of energy governance in India has given little agency to cities limiting their ability to contribute to this global trend. The Smart Cities Mission, by mandating cities to include energy features in their plans, offers a potential departure from this historical arrangement, and indicates how cities are conceiving their roles in governing energy, and how their priorities are formed. The next section, briefly outlines the methodology we undertake to explore these visions.

3. Methodology

Our analysis of Indian Smart Cities' strategy for energy is based on the visions they have submitted. We use the database created by Anand et al. (2018), which collates all the projects proposed by the top-sixty Smart Cities, that were selected in the first three phases (Round I + Fast Track + Round II) (Anand et al., 2018; Taraporevala, 2018). This original database[1] compiled all the projects proposed across sectors using different documents: (i) the Smart City Proposals which cities submitted to the expert panel, where they listed their planned projects; (ii) the annexures to the proposals, which provided more detailed information on single projects;[2] and (iii) the set of the project inventories, or lists of projects.[3]

To create an energy data base, we followed a series of steps[4]. First, we singled out all projects with an expected impact on urban energy systems from the original data base. Second, we added entries that had not been included in the database from the same set of public documents in Anand et al. (2018). Third, we created our own classification of the projects, for which we made a few assumptions to take care of a few discrepancies between our sources: (i) when the financial information was not detailed enough, we had to exercise judgement to match it with projects; (ii) whenever possible, we have broken down projects into their various 'components'. For instance, a project that contains 'solar

[1] Anand et al. (2018)'s research created multiple databases on the SCM in the form of various Excel spreadsheets. The same databases were used in Taraporevala (2018). The specific spreadsheet used for this report is described in Taraporevala (2018) under the section 'Projects and Finance of top 60 cities' (p. 8). However, that was only a starting point, and our research significantly modified the original spreadsheet.
[2] Proposals and Annexures are available at http://smartcities.gov.in/content/city_challenge.php
[3] Lists of projects are available at http://smartcities.gov.in/content/innerpage/city-wise-projects-under-smart-cities-mission.php
[4] All versions of the database(s) can be made available for research purposes under request at the Centre for Policy Research (New Delhi).

panels and LED lighting' will have two components, one on solar panels and another on LED lighting.[5] However, the definition of projects is not consistent across cities. In some cases, the components of projects is given (e.g. 'smart bins' and 'Waste-to-Energy' projects) while in others a project is only described in a general term, such as a 'solid waste management' project). Therefore, the database consists of two types of entries: projects and components.

Projects in the database are gathered in either the 'List of Projects' or 'Financial Details' of the proposals. They usually have a defined budget while components do not have an associated budget. As a result, we have conducted a two-level analysis. The first one, based on projects, provides a financial analysis of the energy content of the SCM. The second one, based on components, allows a much finer reading of the sectors concerned.

Since our aim is to grasp the energy dimension of the SCM, as well as the transition to decarbonize, we have created two categorizations. Box 1 presents all the energy projects that have been classified into six categories, further split into different sub-categories. Box 2 identifies four main clusters of low-carbon technologies that cut across categories and include solar, lighting, e-mobility and waste to energy.

Box 1: Categories of Energy Projects

1. E-mobility 1a. E-vehicles, primarily e-rickshaws 1b. E-buses 1c. E-boats 1d. Charging Stations 1e. Waste Transport 1f. E-bikes 1g. Miscellaneous	**2. Green Buildings** 2a. Residential Buildings 2b. Public Buildings 2c. Commercial Buildings 2d. LED Lighting (in buildings) 2e. Miscellaneous	**3. Energy Power Network** 3a. 24x7 Supply 3b. Distribution Network 3c. Underground Wiring 3d. Smart Metering 3e. Smart Grid 3f. Smart Pole 3g. Control System 3h. Gas Distribution Network 3i. Gas Metering 3j. Miscellaneous
4. Energy Production 4a. Rooftop Solar 4b. Other Solar (primarily ground mounted) 4c. Waste to Energy 4d. Wind 4e. Misc.	**5. Lighting & Equipment** 5a. LED Street Lighting 5b. Unspecified Street Lighting 5c. Solar Powered Municipal Equipment (for example, solar e-toilets, solar pumps, solar compaction bins) 5d. Solar Street Lighting (inclusive of Solar LED lighting) 5e. Energy Efficient Municipal Equipment (for example, efficient pumps) 5f. Electric Crematoriums 5g. Miscellaneous	**6. Cross-Category**

Note: The Miscellaneous sub-categories consist of projects with components that pertain to different sub-categories within the same category. The Cross Category consists of projects whose components pertain to more than one category, for example area-based rehabilitations which include LED street lighting, rooftop solar, electric vehicles, …

[5] Components have been retrieved either from the 'Key Components' or the 'Essential Features Achievement Plan' in the 'Area-based proposal' section in proposals, the 'Components' in the 'Pan-city proposal' section in proposals, the 'Implementation Plan' section in proposals, the 'Itemised Costs' in the 'Financial Plan' section in proposals, or the Annexure 3.

Box 2: Categories of low-carbon clusters

SOLAR	LIGHTING	E-MOBILITY	WASTE-TO-ENERGY
(sub-categories: 4a Rooftop Solar.; 4b. Other Solar; 5c. Solar Powered Equipment; 5d. Solar Street Lighting)	(sub-categories: 2d. LED Lighting; 5a. LED Street Lighting; 5b. Unspecified Street Lighting; 5d. Solar Street Lighting)	(corresponds to category 1. E-mobility)	(corresponds to sub-category 4c. Waste to Energy)

The next section that details our findings is based on these two categorizations. While section 4.1 is focused on the types of the energy projects of the SCM, section 4.2 deals more specifically with the low-carbon strategies proposed by cities.

4. Findings

India's Smart Cities have proposed interventions which span a wide spectrum of energy sectors. We find that, consistent with findings from previous analysis (Khan et al., 2018), cities primarily focused investments in basic energy infrastructure such as grid improvement and underground cabling; standard poles and wires. However, cities have also proposed 'smart' technologies such as meters and grids, and low-carbon technologies such as solar panels, energy-efficient street lighting and electric vehicles. Finally, some cities included green buildings as part of their redevelopment and construction projects.

4.1. Energy and the SCM

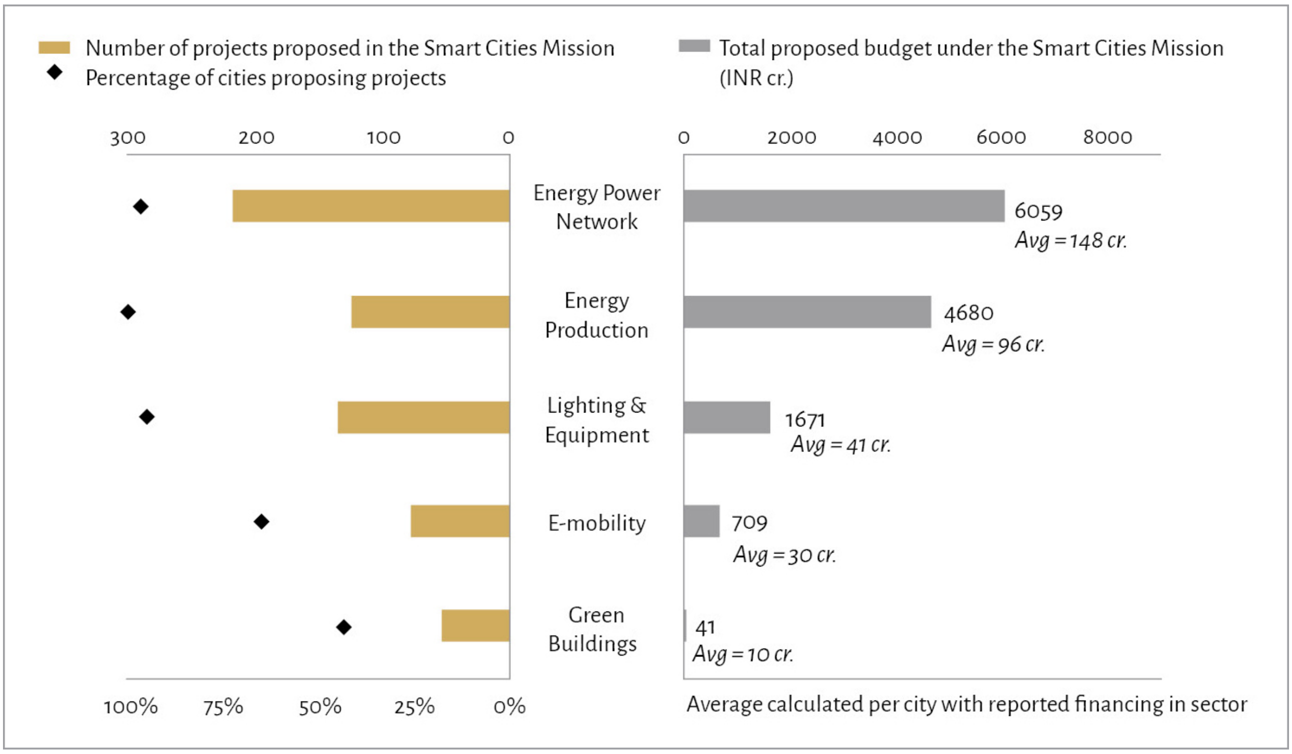
This first level of analysis is concerned with the energy sectors (Box 1) in which city have planned to invest in. Cities have emphasised investing in energy distribution and supply infrastructure, with 81% of all funds dedicated to these two sectors alone. The breakdown of projects and budgets according to the five categories from Box 1 is detailed in Figure 1 and offers a detailed understanding of the cities' priorities.

First, nearly 50% of the investments are budgeted for energy distribution networks (electricity and gas). This category has the highest total budget across the 60 cities (6059 INR cr.) and the highest number of proposed components (217). Most investment is proposed for upgrading the distribution network, such as underground wiring (62 components) and improvement of power sub-stations (31 components). Cities have also considered the deployment of 'smart' grid projects with 52 and 32 out of the 60 municipalities considered, proposing smart meters and smart grid systems respectively. While the focus is electricity networks, 14 cities have proposed improvements in their gas distribution network (17 components). This focus of municipalities on enhancing urban energy distribution, while warranted due to energy supply quality concerns in Indian cities, is striking as it is a sector traditionally under the responsibility of state electricity and gas distribution companies.

The sector with the second most investment is energy production, with projects of 4680 cr. of investments proposed, or 35.5% of all 'Smart City' investment in energy. It is the only category for which all 60 cities have proposed at least one component, reflecting the priority towards improving energy supply. Cities have prioritised the uptake of low-carbon and unconventional sources of energy. None of the proposed investments are for conventional fossil fuels: more than 50% of components proposed (63 out of 124) are rooftop solar solutions and another 21 components were for other types of solar installations. Waste-to-Energy conversion has also been proposed (see 4.2 for more details) while other renewable energy sources were almost totally absent. Only the two 2 cities of Belgaum and Surat, have proposed to develop wind production. Energy production, especially from fossil fuels, is normally undertaken by state and national-level public undertakings, or private developers. As cities are distanced from these arrangements and therefore encumbered by vested interests in fossil fuels, they could propose investments in non-fossil fuel technologies without local political resistance. Further, for most cities, renewable and unconventional energy production is understood as a 'smart' energy technology.

The remaining investments, 19% of the total proposed, have been dedicated to demand-side measures. Cities have proposed three types of demand-side interventions: Lighting & Equipment, E-mobility and Green Buildings. Amongst the three, almost all cities proposed investments in lighting and equipment, while fewer proposed projects in e-mobility and green buildings, even though they were also mandated as 'smart' features by the central government.

Fig. 1: Distribution of components and budget across categories. Percentage of cities that included projects per category



The forecasted spending for Lighting and Equipment is considerably smaller than the two previous categories (12.7% of the total investment for energy for an amount of 1671 INR cr.) but a very high percentage of cities (95%) included Lighting and Equipment in their strategies. The uptake across most cities is likely because Lighting and Equipment are directly under the control of municipalities require little upfront investments, and accrue energy and financial savings over time. Most projects proposed in this sector were for energy efficient LED Street Lighting. Use of solar to power street lighting (solar street lighting sub-category) has also been significantly integrated in proposals, followed by solar powered equipment, which includes a wide variety of projects such as bins with solar compaction or solar water heaters. Electric crematoriums and energy efficient water pumps have also been included in cities' visions, albeit very limitedly.

Finally, E-mobility and Green Buildings account for a meagre 5.6% of the total investment planned and remain marginal, contrasting with the potential of each of the sector. E-mobility has a lower total budget than the previous categories (709 INR cr.), and the percentage of cities which proposed components in this category is smaller (65%). Cities that proposed e-vehicles dedicated about an average of 30 cr., an investment that is just enough for around 15-20 e-buses at current market rates. These average amounts include E-rickshaws, followed by E-buses, E-bikes, and E-boats. While E-rickshaws outnumber the other means of transport (37 components out of 78), E-buses has the highest total and average proposed budget reflecting the much bigger cost of an electric bus (a consolidated 472 INR cr. for e-buses vs. 105 INR cr. for e-rickshaws).

The Green Buildings category lags behind in terms of financing (41 INR cr.) and number of components (53) dedicated to it. It is likely that our methodological focus on project-level financing has underrepresented some investments in green buildings, which could be bundled as part of wider rejuvenation and rehabilitation projects. Not surprisingly, most proposed investments are envisaged public buildings (19), since it is perceived as an easier task and has become mandatory in most states. Residential and Commercial Buildings have been considered (with 10 and 6 components, respectively).

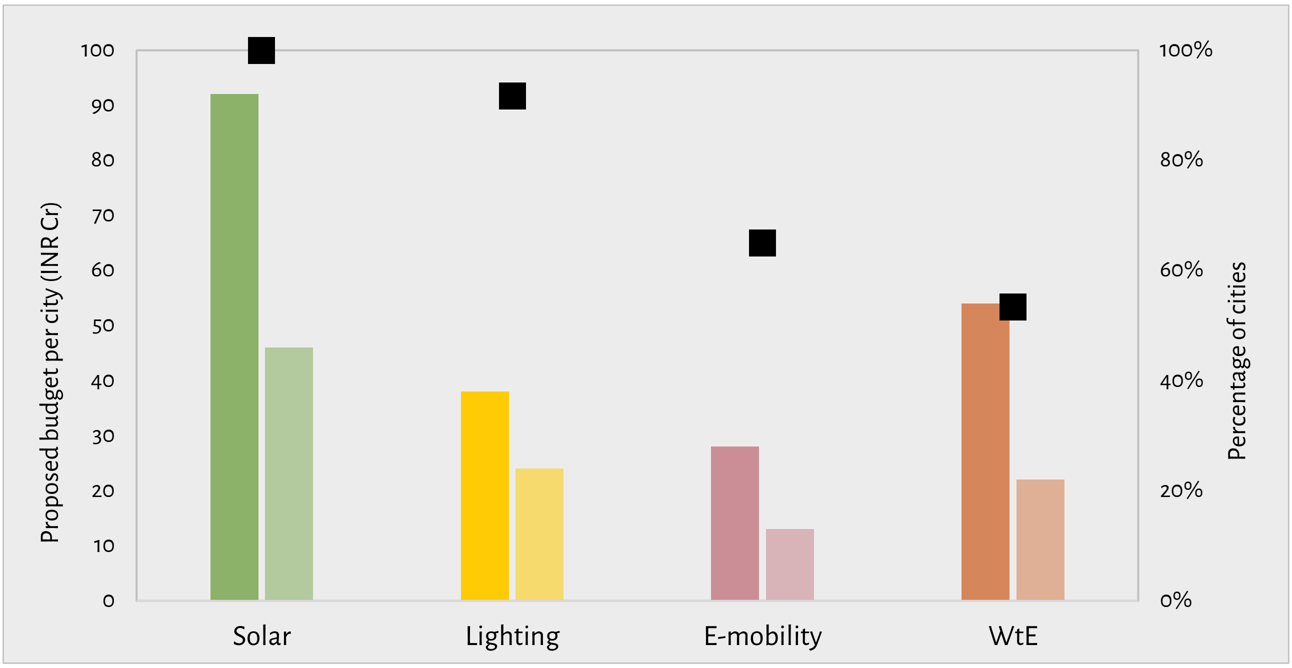
This first level of analysis of projects and budgets proposed allows for a set of preliminary conclusions. First, improving the infrastructural foundations of the urban energy systems is the primary concern of the Indian Smart Cities, before digital or ICT-based applications developments. Of the total budget, only 2349 INR cr. (~18%) of Smart City Mission funds were dedicated to smart grid or meter projects and only 31 out of 60 cities with a median proposed budget of 43 cr. proposed 'smart' digital energy projects. Most investments have targeted supply-side and distribution systems since Indian cities face structural problems with their power network, which hinders their capacity to meet proper distribution standards. Actual city decision making then reflects the recognition that improving the network has to be the first concern for cities rather than other innovative technological instruments. Cities therefore have exhibited some degree of agency in veering from the 'digital' as 'smart' narrative in the energy sector, in line with wider understanding that the SCM has focused on basic services (Khan *et al.* 2018). Second, even though this shift raises serious questions regarding the implementation of these projects, since energy has not been historically governed at the city scale, it also underscores the beginning of an engagement of cities with questions of energy governance. This is visible in the role that solar is given to increase energy productions as well as in the rising concern for demand-side interventions and, albeit comparatively less aggressively, the consideration for energy efficiency, e-vehicles, and green buildings projects. What we observe then is not a paradigm shift but an inflexion in policies and plans that reflects an increasing understanding of future challenges. In particular, this is evident in the degree of innovation in the adoption of new low-carbon technologies to which we now turn to.

4.2. Low-carbon transition

Our second level of analysis concerns the shift toward a low-carbon transition. The Figure 2 details the budgets planned for each city in our typology of clusters of low-carbon technologies: solar energy, energy efficient lighting, e-mobility and waste to energy as defined in Box 2.

The first and most important result is that cities are choosing to decarbonize by transitioning to a supply of solar-powered energy. Every of the Smart City Plans from the 60 municipalities has proposed solar-based technologies projects ranging from generation to solar-powered equipment. On average the cost of these projects were estimated at 92 INR cr. Three quarters of the investments is in rooftop solar projects (3080 INR cr.). Plans of conventional, ground-mounted solar plants (713 INR cr.) accounted for less than one third of the expenditure in solar rooftop. This is distinct from national trends where progress in rooftop solar has been slower in India as compared to other countries, with ground-mounted solar parks given priority (CSE, 2019). The emphasis on rooftop solar in these cities is primarily because real estate is at a premium in urban areas and availability of rooftops is higher. Provisions for rooftop solar have also been provided under the Jawaharlal Nehru National Solar Mission (JNNSM), in particular the Solar Cities Scheme, or the Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTII) scheme, which cities were tasked to implement. It is also important to note that the transition to solar technologies is not limited to power generation but includes also Solar Street Lighting (313 INR cr.) and Solar Powered Equipment (30 INR cr.).

Fig. 2: Average proposed (darker bar) and median proposed (lighter bar) city budget per cluster and percentage of cities that included projects pertaining to each cluster



Second, energy efficient street lighting has also been adopted by almost every city (92%), but the average amount budgeted per city (38 INR cr.) is considerably lower than solar. That is explained by the drop in prices of LED bulbs during the past years thanks to EE (energy efficiency) policies like the Street Lighting National Programme (SLNP) which managed to bring the cost down through bulk procurement.[6] LED street lighting represents an easy and cheap win-win strategy for cities to simultaneously pursue their development goals in terms of lighting and safety of citizens, and to reduce their carbon emissions[7]. In addition, 35% of the projects plan to use solar as the energy source to power street lights, indicating the potential for cities to integrate different low-carbon technologies.

E-mobility is the low-carbon cluster for which the lowest average finance has been allocated (28 INR cr. average per city), even though a substantial number of cities considered electric vehicles (e-vehicles, EVs) (65%). Few outlier cities are driving the amount dedicated to EVs. For example, Chandigarh and Pune plan to dedicate 163 INR cr. and 126 INR cr. respectively to e-mobility while at the other end of the spectrum, Agra has budgeted only 0.2 INR cr. Municipalities have focused on public transport exclusively, with no apparent attempt to incentivise private electric transport which cities have no mandate or ability to regulate. Components proposed include

[6] See http://pib.nic.in/newsite/PrintRelease.aspx?relid=170102

[7] In terms of lighting, only four projects mention LED lighting in buildings, not including green buildings.

mostly e-rickshaws (almost 50% of components),[8] but e-buses are considered as well (almost 20%). E-vehicles for waste transport are also included in proposals (4% of components in E-mobility). For example, Kakinada proposes to purchase 64 'e-Tricycles' for 0.77 cr. for waste transportation. Purchase of hybrid and electric vehicles was being promoted by policies like the National Electric Mobility Mission Plan 2020 (NEMMP) at time of proposal making.

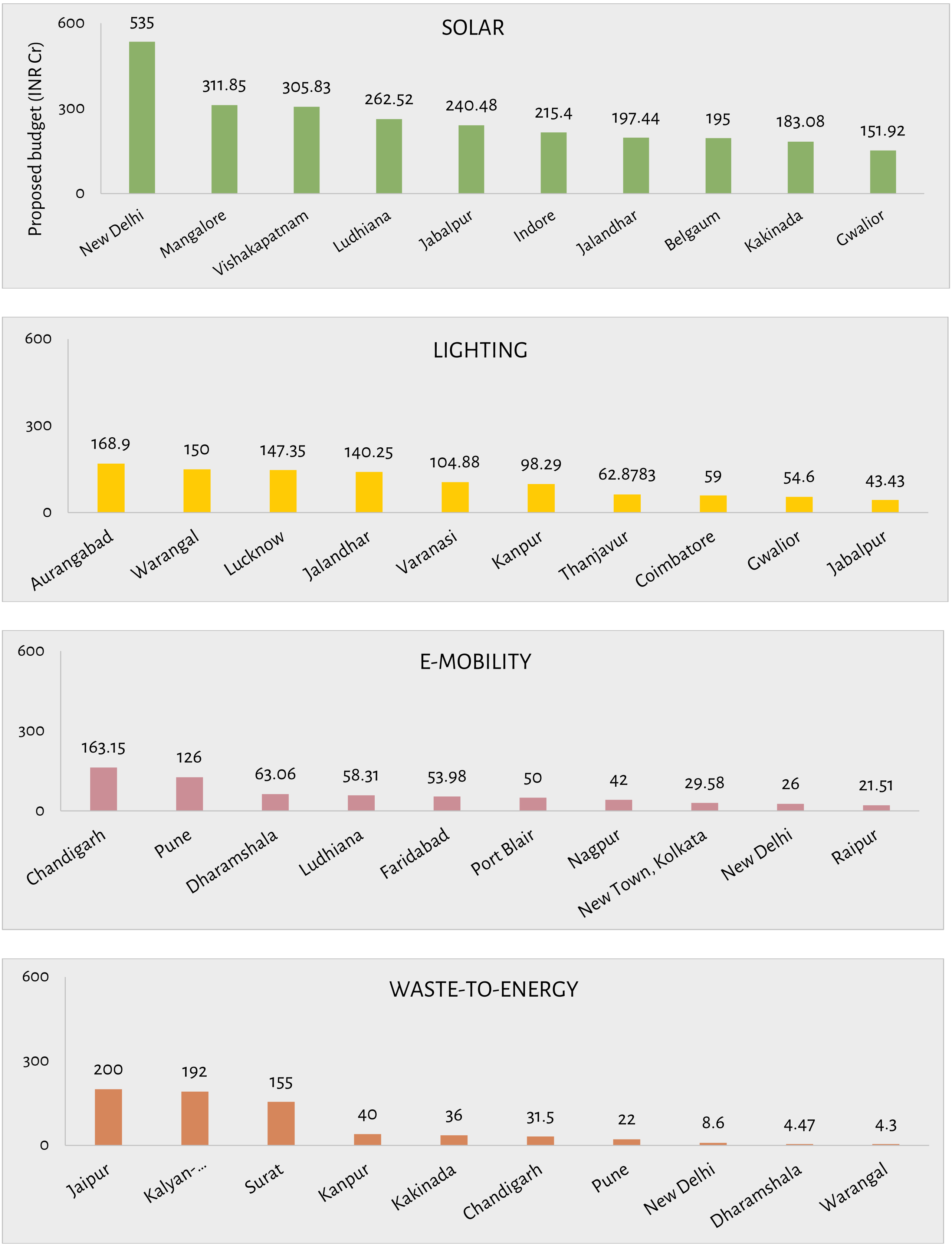
Energy recovery from waste is not a new concept for India's cities, as it has been one of the centrepieces of the national sanitation mission, the Swachh Bharat Mission (SBM). In the SCM, Waste-to-Energy technologies have surprisingly been less taken into consideration (53% of top-sixty Smart Cities). Critics of waste-to-energy have emphasised the unsuitability of energy recovery to India's relatively lower-calorific, and unsegregated Indian waste profile, and political economy around recycling (de Bercegol and Gowda, 2019; Demaria and Schindler, 2016; Doron and Jeffrey, 2018; Gidwani, 2015; Gill, 2012). This might explain a decline in the belief of the adequacy of existing solutions for the Indian context, alongside the large investments that this solution requires. Indeed, the average budget per city is higher (54 INR cr.) than for E-mobility and, despite a lower uptake, the total investment is almost the same as that for E-mobility (around 700 INR cr.). Most waste to energy projects have been proposed as part of wider solid-waste management plans, indicating that municipalities are aware of the system-wide changes required to get Waste to Energy plants off the ground, at least on paper. Almost all projects are bio-methanation plants, reflecting the organic-dominant waste profiles of Indian households (Yap and Nixon, 2015).

Collectively, the significant investments by cities into low-carbon technologies indicates the potential for the Smart Cities Mission to transition to low-carbon energy systems. Many of these proposals build on ongoing schemes and reflect an adoption by the city governments of solutions that are being promoted by the Central government. But were these plans part of a cohesive vision to re-orient city energy systems, or were they *ad hoc* and only based on available and promoted technologies? To answer this, we breakdown the proposals of individual cities across the four decarbonising clusters in figure 3.

A first observation is that most cities are envisaging low-carbon projects across sectors. Our analysis shows that, of the sixty Smart Cities, around 80% have decided to invest in at least three clusters. Indeed, more than half (31) have proposed projects in three clusters and around 30% (18) in four clusters while less than 20% (10) have chosen to focus on only two clusters. However, the amount of money that each city wants to invest differs considerably from one cluster to another. For example, New Delhi, which is included in the National Solar City Mission, proposed an extremely generous budget for Solar (535 INR cr.), while in the other two clusters, E-mobility and Waste-to-Energy, the budget is considerably lower (26 and 9 INR cr., respectively). Jaipur, instead, leads the Waste-to-Energy cluster with an ambitious proposed budget (200 INR cr.), while its proposed investment in the other clusters is insignificant. Amongst the top 10 cities in each cluster, only New Delhi is present in 3 out of the 4, while 10 cities appear in 2 clusters.[9] This indicates that cities have distinct ideas on how to progress towards a decarbonised energy use, likely dependant on local priorities, expertise and interests. Variation amongst cities suggest that decision-making of urban bodies on the question of energy transition can result in distinct potential transitions across cities.

[8] However, this sub-category also includes general 'e-vehicles' projects in the database.
[9] The 10 cities are: Ludhiana, Jabalpur, Jalandhar, Kakinada, Gwalior, Warangal, Kanpur, Chandigarh, Pune, Dharamshala.

Fig. 3: Top-ten list of cities by budget in each cluster



Theoretically, another reason of differences between what cities prioritise could lie in how easy it is for cities to implement the projects. Each sectoral transition involve different degree of complexities, a specific set of actors to engage with, and various types of trade-offs, and consequently different rates of uptake. For example, solar rooftop projects involve a multiplicity of actors (property owners, solar rooftop manufacturers, operators and financiers) and tackling issues related to roof ownership and lack of data on the potential surface available. One the contrary, lighting systems are solely under the control of the municipal corporation, and companies, including the government undertaking Energy Efficiency Services Limited (EESL), have begun to provide turnkey solutions for switching to LED streetlights. For cities, implementing solar rooftop projects at scale requires capacity to structure deliberations between multiple actors and work towards a consensus, while deployment of LED bulbs for streetlight likely only requires cities to create a well-structured financial plan and technology tender. In spite of these differing implementation challenges, all sixty cities decided to include solar in their proposals, while fewer funds have been dedicated to lighting and equipment projects, which in theory is easier to implement. Differences between the two are likely due to different ways in which each sector is governed, the subject of the next section.

5. Shifting governance of energy: Discussion & Implications

The Smart Cities Mission provides a framework for Indian cities to make decisions on their energy distribution, production and consumption. This is unique, as the governance of energy rarely involves city governments, and very few agencies, bar Executive offices (Prime Minister, Chief Minister, or Cabinet offices) or government think tanks such as NITI Aayog, can strategize across energy sectors. Cities, by authoring their own proposals with the aid of private consultants and international development organizations, have exhibited some degree of agency in forming their visions for future energy systems. As stated earlier the focus of cities has been less on the digital, and more on the basic and low-carbon infrastructure, more reflective of their existing and urgent challenges.

Our findings show that the SCM signals a potential shift in how energy is governed in India. First, the Mission provides institutional space for urban local bodies to think about their energy systems when historically the local scale has been marginalized from energy decision-making. Second, the Mission also indicates the potential of cities as institutions which can think of energy supply, distribution, and demand simultaneously, in contrast with the fragmented, siloed, and centralised, institutional structure which governs energy in India. For example, in the existing set up, basic grid improvement and energy efficiency falls under the aegis of the Ministry of Power while the Ministry of New and Renewable Energy is responsible for solar technologies. Electric vehicles are caught in a tug-of-war between the ministries of Heavy Industries, Power and Transportation, and the push for Green Buildings is an effort shared by between the Ministry of Housing and Urban Affairs (MoHUA) and the Bureau of Energy Efficiency. The Smart Cities Mission, at least in theory, provides the opportunity for city governments to think of these various energy sectors in concert, and in a decentralized manner. For example, the city of Rajkot is developing low-carbon housing for low-income residents, funded by the 'Housing for All' Mission, and integrating elements such as passive ventilation and lighting to reduce energy demand (Bhardwaj and Khosla, 2017). A pilot project, in collaboration with international climate and bi-lateral development agencies, also funded the installation of rooftop solar photovoltaic in one block of flats. As part of the Smart City Mission, the city is also proposing non-motorised transport tracks sheltered with rooftop solar, bringing together low-carbon transportation and energy concerns as part of infrastructure upgrades in the city.

The role envisaged for urban local bodies in energy indicates an apparent break from existing practices of governing energy. Yet, from our analysis of the factors influencing city choices, especially in relation to the low-carbon clusters indicates a second face: decision-making in cities remains driven by existing practices of technological fixes, central directives, and contracting out services.

First, while it is encouraging that cities proposed the uptake of low-carbon projects, all actions collated in the database were technological fixes, in line with the smart cities paradigm (Chakrabarty, 2018). The Smart Cities proposal making process, including central guidelines, gave little opportunity for cities to develop strategies for comprehensive low-carbon energy planning. This fits existing bureaucratic practices, designed to implement 'thin', measurable tasks like the deployment of technology rather than 'thick' tasks involving complex deliberations across sectors and systems (Andrews et al., 2017). Investing in technological solutions then is an easier, and more familiar task, for Indian cities than directly addressing structural and long-lasting problems like uncontrolled urban sprawl which has implications for energy consumption, and therefore carbon footprints of cities. The housing developed in Rajkot serves as a good example of this. While the city engineers integrated low-carbon design features, the housing itself was located in the city's periphery, disconnected from existing transit links and with no health, education, or commercial services in the vicinity. A city like Rajkot then finds it easier (and more incentivized) to develop units of housing and install units of rooftop solar panels, than say integrating the city's urban growth and transit development.

Second, while cities have exhibited some degree of autonomy in prioritising technologies, many of their choices were guided by centrally formulated guidelines and the existing central schemes. Cities had incentive to follow the guidelines as closely as possible and to integrate mandated technologies. The four areas of low-carbon technological action we identified, were already supported by national schemes targeting solar energy production (e.g. Solar City Programme), energy efficient lighting (e.g. National Programme for LED-based Home and Street-lighting), electric mobility (e.g. NEMMP), and energy recovery from waste (e.g. SBM). The Smart Cities Mission also kicked off at a time when India aimed to achieve 100 GW solar (40 GW of which is rooftop) by 2022, indicating why solar power was a core technology proposed by cities. It was likely centrally incentivized.

In centrally-held meetings on the Smart Cities Mission, central line ministries held sessions to make city officials aware of ongoing schemes, and to prompt them to "converge" actions of different central scheme with Smart City actions (see Box 3 for a list of central schemes 'converged' with the Smart City Mission). Beyond bureaucratic directive, cities also had a financial incentive to converge their proposals with various central and state schemes, enabling them to raise additional grant-based funding for their projects when central outlays were not enough.

Box 3. Central Schemes Converged with Smart City Proposals

Urban schemes	Integrated Power Development Scheme (IPDS)
Atal Mission for Rejuvenation and Urban Transformation (AMRUT); Swachh Bharat Mission (SBM); Heritage City Development and Augmentation Yojana (HRIDAY); Digital India; National Skill Development Mission; Housing for All, Pradhan Mantri Awas Yojana (PMAY).	Restructured Accelerated Power Development and Reforms Programme (R-APDRP); Solar City Programme; Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) Jawaharlal Nehru National Solar Mission (JNNSM); Generation Based Incentives (GBI) Scheme; National Electric Mobility Mission Plan 2020 (NEMMP); FAME India Scheme – Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicle India; Make in India; National Mission on Enhanced Energy Efficiency (NMEEE); National Programme for LED-based Home and Street-lighting.

So while there was a strong centralising imperative on the content of the Smart City projects, cities still had institutional space to prioritise between schemes to adopt from the long list, as indicated by the wide profiles of technologies prioritised by cities. The Mission can be considered as a framework for cities to co-ordinate across different fields of urban development (e.g. transport, buildings, etc.) as indicated by the energy projects pursued across sectors. Cities made novel linkages that had not necessarily been made by central agencies. For example, until recently in national deliberations, discussions around solar deployment have been distinct to domestic manufacturing. Back in 2015, the city of New Delhi affirmed that they will "try to procure solar PV panels Made in India", exhibiting convergence of two separate national policies that had yet to be done by any central agency. In another case of novel linkages, cities purchased e-vehicles for waste collection activity, effectively addressing objectives of both the National Electric Mobility Mission Plan and the Swacch Bharat Mission for sanitation. However, this brings additional onus on city government to draw from not only the Ministry of Housing and Urban Affairs but other Ministries and institutions that are addressing key priorities in cities. For example, if cities are proposing investment in electricity distribution, production and consumption systems, how will their visions stack up with those of other organisations such as state DISCOMs? If cities are mandated with the development of housing, how can they co-ordinate with other departments in charge of transport, healthcare, education, and local economy? Such relationships are yet to be negotiated and institutionalised. Central guidelines provide little support on this front.

A final, but significant impact of the Smart City Mission, is how it continues to open space for contracted service providers into the urban sector. The Special Purpose Vehicles, institutions mandated with the delivery of Smart City projects, are designed with the capacity to formulate 'business friendly' tenders; many capacity building trainings and support provided by consultants is around creating better procurement contracts for the deployment of urban services. For low-carbon energy, many of technologies are complex, such as solar photovoltaics, electric vehicles, and require sophisticated contracting, manufacturing and maintenance, prompting cities to outsource their deployment.

In sectors with an absence of public-sector led manufacturing or deployment of these technologies in India, this push for contracting out urban services has led to the increase of private interests in urban service delivery. Private consultants are commonplace when arranging contracts for procuring either rooftop solar, or electric buses. Especially stark is the role of private contracting in waste management, and waste to energy plants, where large contracts for managing and processing waste is contracted out to private actors (for e.g. Demaria and Schindler, 2016). This doorway towards privatisation of urban services is an explicit intention of the Smart City Mission, and a continuation of previous policies such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and wider trends towards 'entrepreneurial urbanisation', where city capacity building and operation is oriented towards the attraction and involvement of capital (Datta, 2015a). Outsourcing such urban services to private contractors can potentially introduce reduced accountability of levels of service provision and reduced ability of city governments to influence energy transitions in cities. It can also lead to failed projects. For example, Rajkot, in the previous decade, has attempted to develop its bus transit network in a public-private partnership, and outsourced the development of its waste-to-energy plants to private contractors, but in both instances the private companies folded, and the city was left without critical infrastructure.

While this drive towards privatisation is playing out most explicitly in the waste-to-energy and e-vehicles sector, private sector involvement in the Smart City Mission is far lower than expected (Anand et al., 2018). Who leads transitions in the solar or green buildings also remains to be seen. While private sector involvement has till date been limited, novel government-led undertaking such as EESL indicate the potential of public sector involvement in the energy transition. EESL is bulk procuring energy efficient appliances, driving down costs, and creating turnkey solutions which urban decision makers can take advantage of. This model can potentially be replicated for solar photovoltaics, e-vehicles and green buildings sectors, and offer a compelling alternative to private actors.

As of now capacity building in the Smart City Mission is termed less as developing the creative and capabilities of public sector officials to deliberate and respond to complex challenges with such innovative procurement and deployment models, and more as the capability to design procurement contracts to involve the private sector in the delivery of urban services. In this paradigm, our overarching concern is that Indian cities could become institutions which simply write and release tenders for technologies decided by central policies, rather than deliberate local opportunities and challenges. Leading the transition of each of these low-carbon technologies will require urban local bodies to development capacity beyond tendering such as regulation, incentivization, awareness building, negotiation, and enforcement. A future urban policy aimed at mainstreaming low-carbon energy in cities will do well to complement its ongoing efforts to improve tendering capacity in cities with other capabilities that can aid the implementation of complex multi-actor, multi-sectoral projects and plans.

6. Conclusion

By asking Indian cities to propose energy projects, the Smart Cities Mission opened space for urban governments to influence a transition to low-carbon energy. This report highlights this perceptible shift that the Smart Cities Mission brings to energy and urban governance in India. While limited to the proposals of cities, we present an analysis at crossroads of urban and energy research, two fields that have had limited dialogue in India, but globally has stressed the role cities can play in fostering a transition to low-carbon energy.

Our initial steps towards bringing together energy and urban scholarship in India, demonstrate that the SCM exhibited cities integrating energy, especially low-carbon energy, into their urban governance practices. This is recently embellished by the announcement of the 'Climate Smart Cities Framework' by the Ministry of Housing and Urban Affairs that aims to further incentivizing urban local bodies to uptake low carbon energy. Though it is too early to argue that the reconfiguring of urban energy systems in India could lead to cities leapfrogging to low-carbon energy systems, or indeed that municipal actors will be the agents of this transition, we assert that the Mission provides an opportunity to view cities as emerging sites of innovative energy governance that will need to be better understood in further research.

At this early stage, we can make two potential readings of the SCM: a pessimistic one that the energy projects proposed are only the result of the centrally-devised guidelines and in the interests for private actors, and a more optimistic one that the Mission opens a window of opportunities for city governments to lead a transition to low-carbon energy through deployment. Few cities have begun to exhibit such leadership. These two views are not mutually exclusive and we have observed instances of both, depending on the capacity of the city, opportunities provided by particular energy arrangements in cities, and the ability of local leadership to steer a dialogue on energy, climate change and their future development. Some cities have exhibited their potential to make linkages between carbon mitigation, waste management, local manufacturing, housing, amongst other objectives, indicating that with the right conditions, cities will continue to foster innovative energy projects. Such new powers opens new avenues of investigation, dedicated towards how such transitions will not only be proposed but also implemented.

DATA AVAILABILITY

Data used for the study is available on reasonable request to the authors.

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