DISTRICT ENERGY IN CITIES INITIATIVE

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RAPID ASSESSMENTS OF FIVE INDIAN CITIES

NATIONAL ANALYSIS

COPENHAGEN CENTRE ON ENERGY EFFICIENCY SEforALL EE HUB

I·C·L·E·I Local Governments for Sustainability

EESL

Contributing to:

SUSTAINABLE ENERGY FOR ALL

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Report authors:

Copenhagen Centre on Energy Efficiency (C2E2): Dr. Zhuolun Chen
ICLEI: Nikhil Kolsepatil, Tejas Shinde, Ashish Verma, Soumya Chaturvedula, Emani Kumar
UN Environment: Benjamin Hickman, Parimita Mohanty, Lily Riahi

Reviewers and contributors:

The Carbon Trust. Danfoss. Dr. Alaa Olama. Empower. Energy Efficiency Services Limited. International Finance Corporation. Thermax.

Consultations between the project team and the Ministry of New and Renewable Energy, Ministry of Power, Ministry of Urban Development, Ministry of Environment, Forest and Climate Change and the Bureau for Energy Efficiency proved invaluable in designing the District Energy in Cities Initiative's activities in India and the approach and methodology for undertaking district energy assessments in Indian cities.

The project team appreciates the vision shown by all 5 Municipal Corporations that took part in this study and for agreeing to be a part of the District Energy in Cities Initiative. We are grateful for all the support extended by the Municipal Corporations and their departments to this exercise. We extend our sincere thanks to administrators, government departments and stakeholders across all five cities whose inputs and contribution to data collection have been invaluable to the successful completion of the district cooling rapid assessment in Thane and the compilation of this document.

The Initiative

The District Energy in Cities Initiative is a multi-stakeholder partnership coordinated by UN Environment, with financial support from the Global Environment Facility and the Governments of Denmark and Italy. As one of six accelerators of the Sustainable Energy of All (SEforAll) Energy Efficiency Accelerator Platform, the Initiative is supporting market transformation efforts to shift the heating and cooling sector to energy efficient and renewable energy solutions. Over 46 organizations, including industry associations, manufacturers, utilities, financiers, non-government groups, as well as 45 champion cities across the world have partnered with the District Energy in Cities Initiative to support local and national governments implement district energy policies, programs and project pipelines that will accelerate investment in modern district energy systems. India is one of the pilot cities in India and Thane, the Initiative's first pilot city in India, was selected as a result of these rapid assessments. The Initiative is working in partnership with Energy Efficiency Services Limited (EESL), the National Coordinating Agency of the Initiative in India.

For more information and contact details please visit districtenergyinitiative.org

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1 Introduction

This report contains the high-level national analysis undertaken alongside five district energy rapid assessments of the Indian cities Bhopal, Coimbatore, Pune, Rajkot and Thane. This report sets out at a high-level the national and state-level institutional and regulatory framework and provides initial policy, regulatory, research and institutional recommendations for the Government of India, state governments and cities. The recommendations are presented at the end of this report. UN Environment through the District Energy in Cities Initiative will provide support to further assess national and state-level barriers and further develop recommendations presented herein.

2 Background on District Cooling

Accelerating the uptake of energy efficiency and renewable energy in the global energy mix is the single biggest contribution to keep global temperature rise under 2°C. Cities account for over 70% of global energy use and 40 to 50% of greenhouse gas emissions worldwide. In several cities, heating and cooling can account for up to half of local energy consumption. Any solution for energy transition must explicitly address sustainable urban heating and cooling, as well as electricity consumption. One of the least-cost and most efficient solutions in reducing emissions and primary energy demand is the development of modern (climate-resilient and low-carbon) district energy systems in cities. To facilitate this energy transition, UN Environment and partners formed the District Energy in Cities Initiative as the implementing mechanism for the SEforALL District Energy Accelerator[1].

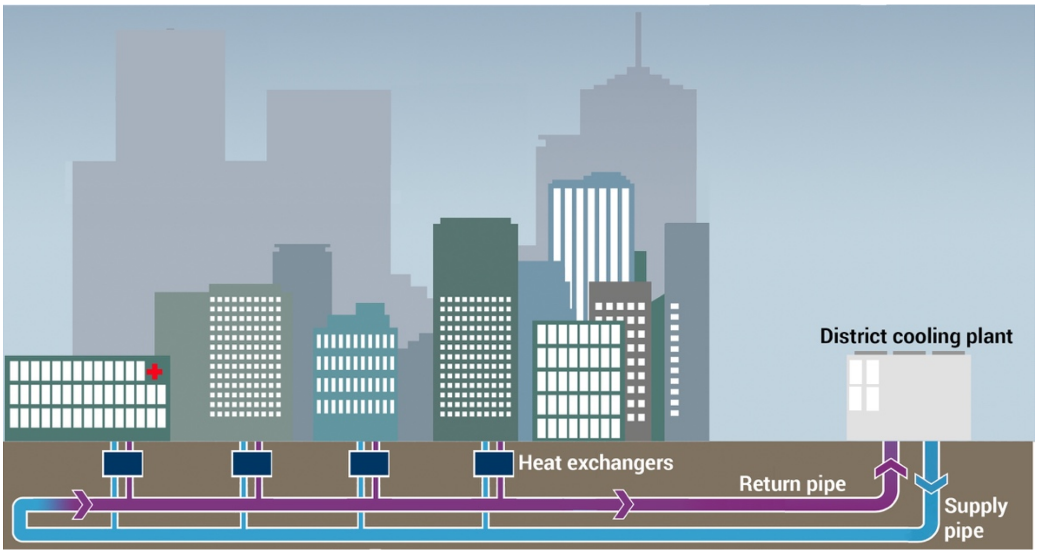
There is no fixed term used worldwide for ‘district energy systems’, and the authors note the following as being used worldwide: district cooling systems, district heating systems, community cooling/heating, heat networks, cool networks, decentralised energy systems, heat grids, CHP networks, trigeneration networks, community cooling, community heating, neighbourhood energy systems etc. Confusingly ‘district’ has different meanings worldwide and the authors note that in India it can mean a jurisdiction far larger than a city. ‘District’ when used in the context of the District Energy in Cities Initiative refers to a city district, i.e. a neighbourhood. UN Environment in its report ‘District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy’ explains the technology options in detail, as well as the benefits, policies (national and local) and business models[2].

District Energy Systems for Cooling and its Benefits

District cooling systems are a smart city solution that delivers the comfort of air conditioning with significantly reduced impacts, in particular, considerably reduced electricity consumption for space cooling. A district cooling system is a neighbourhood-scale air conditioning system that produces chilled water in a central plant and distributes it to multiple buildings via underground insulated pipes, replacing buildings’ stand-alone air

[1] For more information and contact details please visit www.districtenergyinitiative.org
[2] Available from www.districtenergyinitiative.org

conditioning systems. Centralizing production of chilled water and connecting diverse consumers means the central plant can be operated using lots of different efficient sources, and have large-scale thermal storage, leading to more efficient, reliable and environmentally friendly cooling in buildings. By cooling several buildings in a city neighbourhood, district cooling provides the economies of scale required to integrate large scale renewables or waste heat that cannot be connected at the individual building scale, lowering electricity consumption by up to 50%. In particular, district cooling systems dramatically reduce electricity demand for cooling, and shift electricity demand away from peak periods. Consequently, many countries across different climactic zones and at differing stages of economic development are rapidly developing district cooling to reduce energy bills, increase energy security and reduce cooling's impact on the environment. Countries all around the world are turning to district cooling, including but not limited to China, the USA, Malaysia, Japan, South Korea, Thailand, the UAE, Egypt, Colombia and the majority of EU countries.



District cooling systems offer a number of benefits to cities such as

- **Energy Efficiency Improvements and GHG emission reduction:** District cooling systems can help achieve rapid, deep and cost-effective reductions in primary energy consumption and related GHG emissions of at least 30-50% through operational efficiency gains, potential to integrate local energy sources, and thermal storage. District cooling also reduces the consumption of environmentally damaging refrigerants such as hydro chlorofluorocarbons (HCFCs) and hydro fluorocarbons (HFCs).
- **Use of Local and Renewable Resources:** District cooling can harness local energy sources, including free cooling sources such as rivers, lakes or seas; waste heat from metal smelting plants, waste incineration and other industrial processes and locally available renewable energy sources. Treated wastewater or effluent can also be used in the district cooling network instead of fresh water.
- **Air Quality Improvements:** District cooling systems can reduce indoor and outdoor air pollution and their associated health impacts, through reduced fossil fuel consumption (e.g. from coal power plants near cities or diesel generators within city limits)

- **Resilience and Energy Access:** Adopting district cooling can help reduce fuel import dependence and fossil fuel price volatility, while better managing electricity demand and reducing stress on the power grid.
- **Green Economy:** The reduction in energy demand leads to cost savings from avoided or deferred investment in generation infrastructure and peak power capacity, wealth creation through reduced fossil fuel bills, employment from local jobs created in district cooling system design, construction, equipment manufacturing, operation and maintenance.

More information on district cooling, its applications, case studies and benefits can be found on the website of the District Energy in Cities Initiative: www.districtenergyinitiative.org

2.1 Scope and approaches of the rapid assessment

Five Indian cities were selected by the District Energy in Cities Initiative, led by UN Environment, to be rapidly assessed for their district cooling potential. These assessments also examine space cooling's current impacts, ongoing and planned city programmes through which district cooling could be promoted and the policy options available to each city.

Each rapid assessment report includes high-level technical and financial assessments of multiple upcoming or existing real estate projects in the cities and identifies barriers to their implementation. In addition, an assessment of national programmes, barriers and the policy and regulatory framework relevant to district cooling has also been undertaken. Recommendations at the city, state and national level have been made and cities will continue to be supported through the District Energy in Cities Initiative. Apart from Pune, which hosts a small, privately-operated district cooling project, none of the cities have district cooling at the time of publishing.

In-depth stakeholder consultations were undertaken in each city and potential sites identified, high-level techno-economic assessments established, cooling demands estimated, policy and regulatory frameworks analysed and recommendations to city, state and national governments developed. The five cities were selected to have geographical diversity and different demographics climatic conditions, and rates of real estate development. All of the cities are part of the Government of India's Smart City Mission and Solar Cities Program.

The methodology, lessons and model used to assess the five cities will be made available on the Initiative's website.

This report contains the high-level national analysis undertaken alongside these rapid assessments and initial recommendations for the Government of India and State governments. UN Environment through the District Energy in Cities Initiative will provide support to further assess national and state-level barriers and further develop recommendations presented herein.

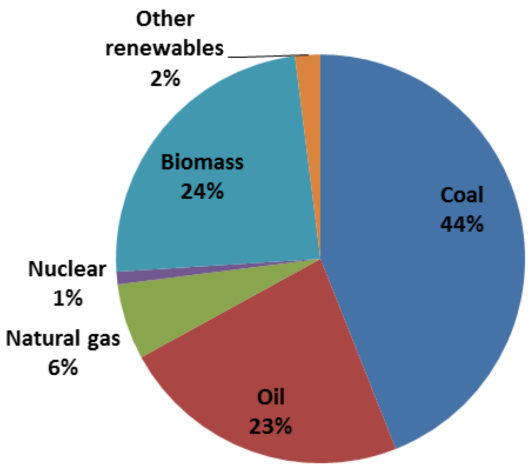
3 National Analysis

3.1 Overview of India's Energy Sector

Energy demand in India has grown substantially in recent years. Population rise, economic growth, increasing urbanization and higher electrification rates have led to primary energy demand doubling in India since 2000, up from 441 million tonnes of oil equivalent (Mtoe) to 775 Mtoe in 2013.

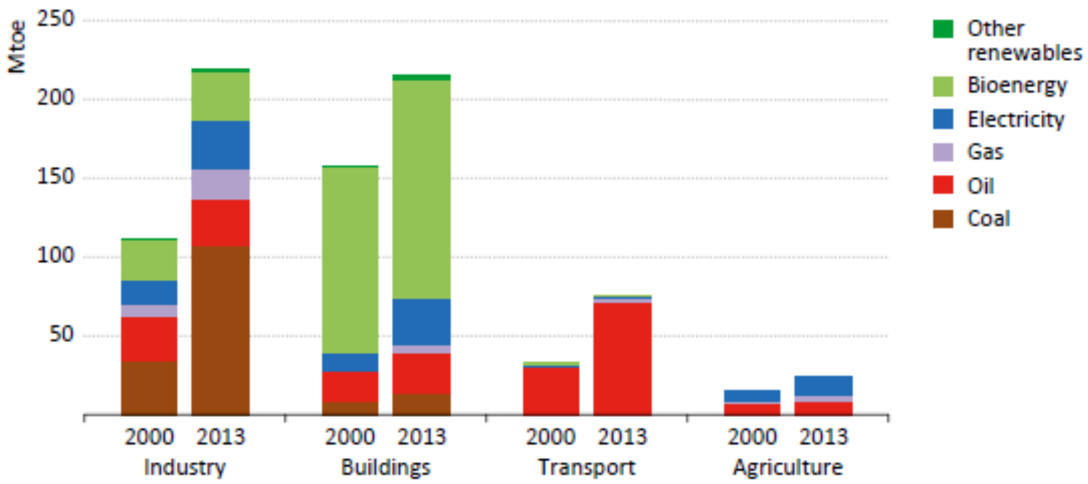
Fossil fuels account for nearly three-quarters of India's energy demand. Coal accounts for 44% of India's primary energy mix while share of traditional biomass fuels (fuel wood, straw and charcoal) has declined with households shifting towards use of liquefied petroleum gas (LPG) and natural gas in urban areas particularly (see Figure 39).

Figure 1: Primary energy demand by fuel in India (2013)



Industry and buildings sector are the prominent end users of energy in India (see Figure 40). Industrial demand, driven by consumption of coal and electricity, has nearly doubled over the 2000-2013 period owing to strong industrial expansion in energy intensive sectors such as steel. A key driver of consumption for the building sector, in both rural and urban areas, has been rising levels of appliance ownership, especially of fans and televisions, and an increase in refrigerators and air conditioners in urban areas in the recent years. Thus, electricity demand in the buildings sector has risen at an average rate of 8% per year over 2000-2013.

Figure 2: Energy demand by fuel in end-use sectors in India



India's power supply has been traditionally dependent on fossil fuels, which account for over two-thirds of the installed power capacity at present. While there has been an increasing emphasis on cleaner fuels in the last decade (such as natural gas and renewable energy sources), coal continues to be the dominant fuel to meet power requirements, accounting for 60% of the installed capacity (See Table 15). Driven by enabling policy and regulatory initiatives, financial support and incentives offered by the Central and State governments, and with renewable energy technologies becoming cost-competitive with fossil power, the installed capacity of renewable energy has grown over four fold from 9,389 MW in 2007 to 38,822 MW in 2016 (64% wind power, 13% solar power, 12% bio-power and 11% small hydro), contributing to 13.5% of the total capacity presently. Renewable energy targets have been pushed up recently up to a renewable capacity of 175 Gigawatt (GW) by the end of 2022, which includes 60 GW from wind power, 100 GW from solar power, 10 GW from biomass power and 5 GW from small hydro power.

Table 1: Total Installed Capacity (MW) by Energy Source in India (as of 31.01.2016)

Ownership	Thermal				Nuclear	Hydro	Renewables	Grand Total
	Coal	**Gas**	**Diesel**	**Total**				
Central	49,980	7,555	-	57,535	5,780	11,491	-	74,807
State	60,551	6,975	439	67,964	-	28,052	1,934	97,951
Private	64,707	9,978	555	75,240	-	3,120	36,887	115,248
All India	**175,238**	**24,509**	**994**	**200,740**	**5,780**	**42,663**	**38,822**	**288,005**

The total power requirement in 2014-15 was 1,068 Tera watt hour and peak demand was 148 GW. The overall power supply deficit stands at 3.6%, with a peak power deficit of 4.7%, dipping significantly from 10.1% and 12.7% in 2009-10 respectively. India's per capita electricity consumption was 957 kWh for 2013-14, much lower than the per capita consumption figures of 12,000- 15,000 kWh in developed countries and having a ranking of below 100 at the global level. Though 96% of urban population and 74% of the rural population have access to electricity, the availability of power varies significantly across the states and is particularly low for the rural households, with as much as 67 %age of the rural households that are electrified having per capita consumption of eight units or lower per month. While cities account for only 2.35% of India's land area, they account for about 80% of the country's electricity consumption. With Indian cities expected to contribute to nearly 70% of the country's GDP by 2030, India is set to undergo massive urbanization with massive growth in urban population, infrastructure and services, which in turn will propel energy demand. Power requirement and peak demand is expected to grow annually at 7% over the period 2016/17 to 2031/32.

3.2 Overview of Urban Growth and Energy Demand for Cooling in India

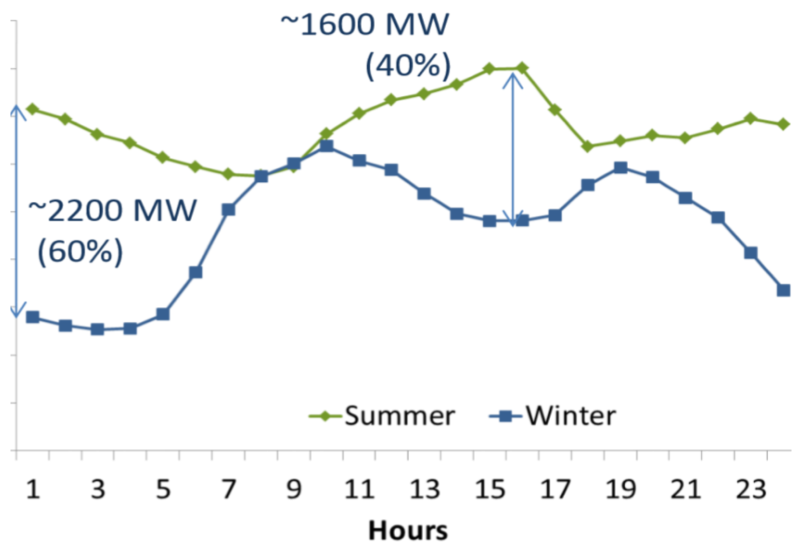
India has undergone noteworthy urbanization in recent years and has the second largest urban system in the world, housing 377 million people. About 91 million people shifted to cities over the last decade in India, resulting in the development of about 2,774 new cities (Government of India, 2011). The number of cities having a population of more than 1 million increased from 35 to 53 in the last decade. India's urban population is growing by over 30% per decade (2001-2011) and is expected rise to 590 million by 2030 (Pandey, 2012). With Indian cities expected to contribute to nearly 70% of the country's GDP by 2030 and driven by programmes such as the Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and Housing for All by 2022, Indian cities are poised to grow rapidly and witness significant development of physical and social infrastructure in the coming years.

To cater to the rapid economic and population growth in cities, building construction is accelerating at an unprecedented pace across the country. Between 2001 and 2005, Indian cities doubled their built-up area (Nexant, Inc., 2014). To house the rising urban population, with growing aspirations and incomes, nearly 51 million new houses were built in urban areas in the past decade (KPMG, 2014). Building floor space is expected to rise by five times till 2030 as compared to 2005 – driven by growing commercial office space, residential housing, retail spaces and the hospitality sector (Nexant, Inc., 2014). About 70 % of India's commercial building stock for 2030 is yet to be built (as of August 2014), with the demand for office space driven primarily by Information technology (IT) and Information Technology enabled Services (ITeS), banking and financial services, insurance and the manufacturing sectors**Error! Bookmark not defined.**. The retail sector is expanding rapidly, with about 3,500 supermarkets, 260 hypermarkets and 20,000 specialty stores coming up across India between 2006 to 2011 (KPMG, 2014) and is expected to grow over six-fold between 2005 to 2030 (Nexant, Inc., 2014). An increasing number of integrated townships are coming up in Indian cities, typically having luxurious residential apartments and social infrastructure including shopping centres, convention centre, commercial offices, hospitals and educational facilities. Coupled with a rapidly growing high-income population, luxury housing is the fastest growing segment among residential housing in India and it is expected that India would require about 1.5 million luxury houses by 2028 (KPMG, 2014).

The massive urbanization and growth in infrastructure, services and built floor space is bound to propel energy demand in India (McKinsey Global Institute, 2010). While cities account for only 2.35% of India's land area, they account for about 80% of the country's electricity consumption. India's per capita electricity consumption was 1010 kWh for 2014-15 (Central Electricity Authority, Government of India , 2016), much lower than the per capita consumption figures of 12,000- 15,000 kWh in developed countries, with a ranking of lower than 100 at the global level and is poised to rise rapidly in the coming years (FICCI, 2012). Power requirement and peak demand is expected to grow annually at 7% over the period 2016/17 to 2031/32 (NITI Aayog, Government of India, 2015).

The buildings sector is a prominent end user of energy in India, accounting for 35% of India's total final energy consumption (al, 2014). Electricity demand in buildings was seen to rise at an average rate of 8% per year over the period 2000-2013 (International Energy Agency, 2015). In recent years, a key driver of energy consumption in the building sector has been rising ownership of appliances such as ceiling fans and air conditioners to provide space cooling and comfortable indoor temperatures in urban areas. In cities such as Mumbai and Delhi, it is found that space cooling contributes to 25-40% of the peak load in summers, since air conditioning is primarily responsible for the seasonal variation in electricity demand in the residential and commercial sectors in these cities (Abhyankar et al, 2016) (see Figure 1). Heating, Ventilation and Air Conditioning (HVAC) systems contribute to 31% of the energy used by commercial buildings in India (Nexant, Inc., 2014).

Figure 3: Average Hourly Power Demand in Summer and Winter for Delhi



With rising incomes and a hot climate and lowering costs of air conditioners, sales of air conditioners have been growing at more than 15% per year since 2004, with more than 3 million units sold in 2012. Given that the penetration of air conditioners in India is a mere 3% at present, as compared to over 100% for the U.S.A. and China (Navigant Consulting, Inc. , 2016), the sale of air conditioners is expected to grow at a much faster rate of 30% per year over the coming years (Nexant, Inc., 2014). About 22% of the urban households will own a room air conditioner by 2020 and 47% urban households would own a room air conditioner by 2030, with the corresponding electricity consumption rising by over 30 times to stand at 239 TWh by 2030 as compared to that in 2010 (see Table 1). These are fairly conservative estimates given the projected incomes and urbanization in India, with the eventual future air conditioner penetration probably being much higher. A case in point is urban China, wherein air conditioning penetration grew from about 5% in 1995 to over 140% in 2015 (Abhyankar et al, 2016).

Table 2 : Projected Stock and Electricity Consumption for Room Air Conditioners in 2020 and 2030 for India

Year	2010	2020	2030
Total electricity consumption by room air conditioners in Business as Usual case (TWh/year)	8	77	239
Total stock of room air conditioners (millions)	4	37	116
Room air conditioner penetration in urban areas (total stock as percentage of urban households)	3%	22%	47%

Source: (Navigant Consulting, Inc. , 2016)

Considering India's large population, tropical climate and rising temperatures, increasing building stock and increasing penetration of ACs, India has 14 times more space cooling potential as compared to the USA (Navigant Consulting, Inc. , 2016). India's space cooling potential far exceeds that of other developing countries in humid tropical climates as well (see Table 2). In the absence of additional policy intervention, under a business as usual scenario, it is estimated that the rapid increase in air conditioning penetration will result in a peak demand addition of about 150 GW by 2030 and between 300-500 GW by 2050 (Abhyankar et al, 2016). While India's power supply deficit has reduced greatly in recent years and stands at less than 1% as of November 2016 due to the Government of India's efforts to increase power generation capacity supplemented by large scale energy efficiency programmes, meeting the additional power demand for rapidly accelerating space cooling would still require a massive increase in electricity generation supply, especially during the peak summer periods, and have implications for India's energy security as well.

Table 3: Comparison of Cooling Demand Potential across Countries

Country	Population (millions)	Annual Cooling Degree Days[3] (CDDs)	Annual GDP per Capita ($ 1,000s)	Total Cooling Demand Potential (Billion person CDDs)[4]	Relative Cooling Demand Potential (Normalized to the USA)
USA	316	882	53.0	279	100%
India	1,252	3,120	1.5	3,906	1,400%
China	1,357	1,046	6.8	1,419	510%
Indonesia	250	3,545	3.5	886	320%
Nigeria	174	3,111	3.0	541	190%
Pakistan	182	2,810	1.3	511	180%
Brazil	200	2,015	11.2	403	140%
Philippines	98	3,508	2.8	344	120%
Mexico	122	1,560	10.3	190	70%
Egypt	88	1,836	11.5	162	60%

Source: (Navigant Consulting, Inc. , 2016)

The rising demand for space cooling will also have implications in terms of increased GHG emissions. Space cooling contributes to GHG emissions in two ways-

- **Indirect emissions** resulting from generation of the electricity consumed to operate the space cooling systems through their useful life
- **Direct emissions** of the refrigerant used in the space cooling system occurring due to its leakages during initial charging, servicing, end-of-life disposal

While the proportion of direct emissions of refrigerants is relatively much lower than indirect emissions, the HCFC and HFC refrigerants used in most space cooling systems have a Global Warming Potential (GWP) several thousand times higher than that of carbon dioxide (CO_2) (GWP value of 1) and thus have disproportionately large impact on global warming relative to their mass (see Table 3). As one of the signatories to the Montreal Protocol agreeing to undertake accelerated phase-out of ozone depleting HCFCs at the 19th Meeting of Parties in 2007, India is currently phasing out HCFCs by 2030 (Ministry of Environment, Forests and Climate Change, GoI, n.d.). India will similarly reduce the use of HFCs by 85 per cent by 2045 over the 2024-26 baseline under the recent amendment to the Montreal Protocol[5]. However, since HCFCs have to be phased out earlier and given that HFC refrigerants are the most

[3] CDDs in the table use a reference temperature of 18°C and the annual CDDs for different regions of each country, weighted by the geographical distribution of the population.

[4] Denotes the product of population and CDD per year and may be used to approximate space cooling energy demand relative to that of the U.S. if developing countries were to adopt comparable air conditioning use patterns.

[5] An amendment has been made to the Montreal Protocol at the 28th Meeting of Parties to the Montreal Protocol held in October 2016 to regulate and phase out HFCs similarly, with an agreement to reduce global HFC use by 85% by 2045.

common substitutes for HCFCs, HFCs will continue to contribute to GHG emissions in the coming years.

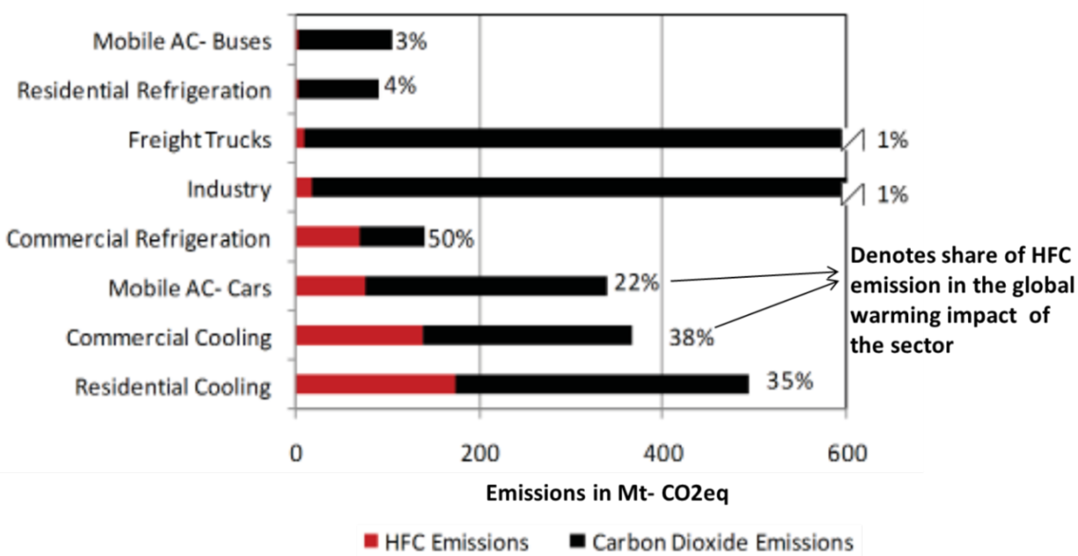
Table 4: Global Warming Potential and Ozone Depletion Potential of Commonly used HCFC and HFC refrigerants

Refrigerant	F-gas category	Ozone Depletion Potential	100 year Global Warming Potential
R-22	HCFC	0.034	1,760
R-123	HCFC	0.01	79
R-134a	HFC	0.0	1,300
R-410A	HFC	0.0	1,924
R-407C	HFC	0.0	1,624
R-32	HFC	0.0	677
R-290	Non-Fluorinated	0.0	3
R-744	Non-Fluorinated	0.0	1

Source: (Navigant Consulting, Inc. , 2016)

A recent study by the Council on Energy, Environment and Water (CEEW) and International Institute for Applied Systems Analysis (IIASA) estimates that residential and commercial space cooling applications will contribute significantly to India's GHG emissions (both in terms of CO_2 and HFC emissions) and contribution to global warming impact in 2050 (see Figure 2).

Figure 4: Sectoral GHG emissions and share of HFC Emissions in 2050 for India



Source: (Chaturvedi et al, 2015)

Given this context, it is important for India to focus on substantially reducing energy consumption and GHG emissions resulting from increased cooling demand in residential and commercial buildings in its cities. Considering that many parts of India routinely experience extremely hot temperatures, there lies an opportunity to improve health and economic well-being by using sustainable space cooling technologies such as district cooling systems to provide thermal comfort.

In recognition of the need to address building energy efficiency, the Government of India has undertaken a number of large scale initiatives such as the National Missions on Enhanced Energy Efficiency and on Sustainable Habitat, Energy Labelling of Appliances, Energy Conservation Building Code, Green Building Rating Systems, and Star Rating of Buildings. India's ambitious targets to increase its renewable capacity to 175 GW by 2022 offers opportunities to integrate energy sources such as solar, waste to energy and biomass into district cooling systems.

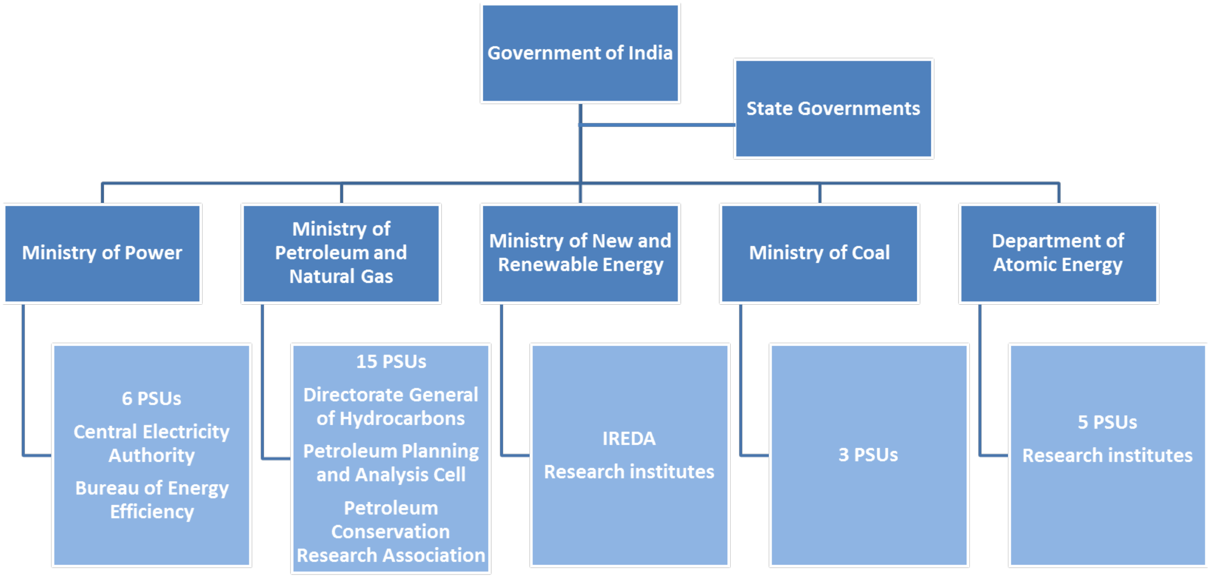
Under its flagship **Smart Cities Mission**, the Government of India plans to develop 100 Smart cities in a five year period up to 2020. Transformation strategies and implementation plans leveraging the smart city concept are being developed by selected Smart cities, which entails utilization of smart technology solutions and streamlining existing as well as planned infrastructure investments in order to provide a higher quality of living to residents. Smart City Plans constitute both pan-city and area based development plans, targeting the development of a defined area within the city through implementation of retrofitting and redevelopment or green field development initiatives. Area based development promotes compact mixed-use development and deployment of smart technology solutions to demonstrate impacts. Cities are assessing the feasibility of implementing demonstration projects in such areas. These areas are ideal for DC integration since the proposals envisage dense mixed use development with significant anchor loads and diversity to initiate the district cooling network. Thus, the current policy and investment climate in India offers opportunities to strategically integrate district cooling systems for optimizing the consumption of resources such as electricity, fuel and water in Indian cities. There is a huge opportunity to share knowledge, experience as well as the value proposition that district cooling can offer in fostering the transformation to smart and sustainable cities in India.

3.3 Institutional Framework of the Energy Sector

The responsibilities in the Energy Sector in India are shared between the Central Government and the States. Overall planning and decision-making powers in the Energy sector rest with various Central agencies - The Ministry of Power, The Ministry of Petroleum and Natural Gas, The Ministry of Coal, The Ministry of New and Renewable Energy, and the Department of Atomic Energy (see Figure 3).

All these nodal agencies are guided by their own legal framework, in terms of acts and policies on the issue. For instance, the Electricity sector is governed largely by the Indian Electricity Act of 2003. The nodal ministries are supported in various aspects of their functioning and responsibilities by public sector undertakings, government agencies/institutions, and research institutes.

Government Institutions in the Energy Administration in India

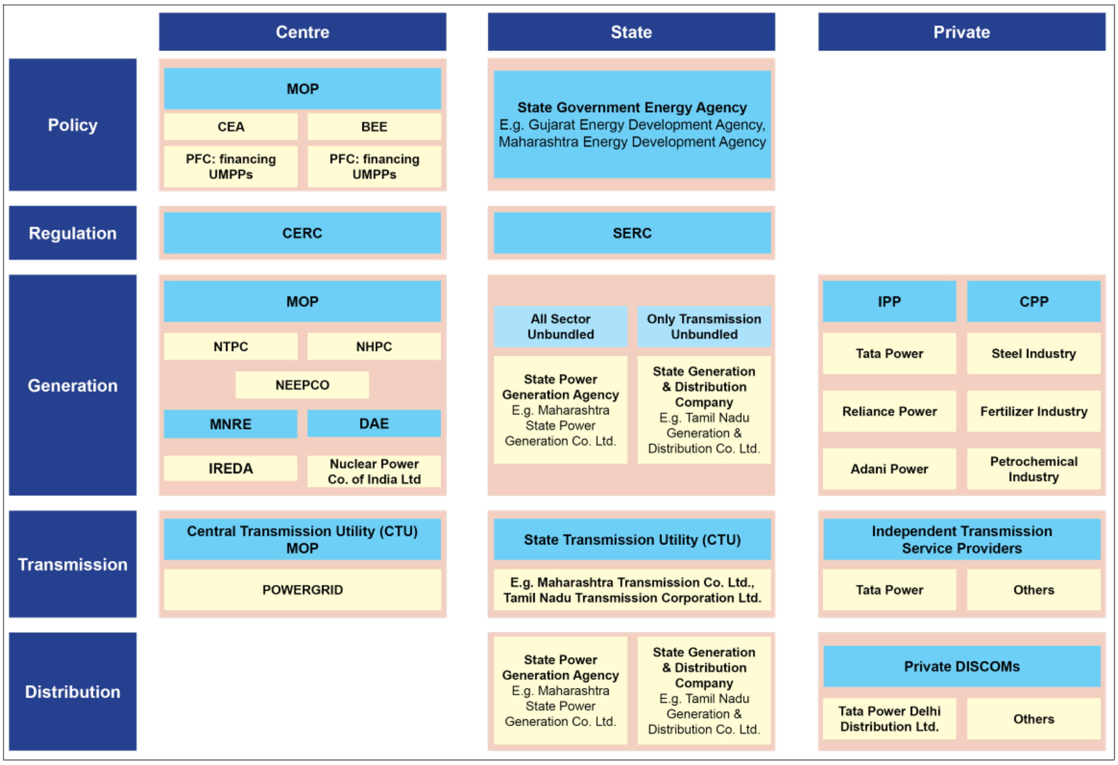


Source: (International Energy Agency, 2012)

With regard to the power sector, the **Ministry of Power (MoP)** is the apex ministry responsible for implementing national laws and developing appropriate policies and regulations for development of electrical energy in India. It oversees and co-ordinates two statutory bodies and six PSUs, which cover thermal and hydro power generation, transmission and distribution and financing (see Figure 4). The Ministry of New and Renewable Energy (MNRE) has the mandate to undertake policy and planning to promote and develop renewable energy sources.

The **Central Electricity Authority (CEA)** is a statutory body responsible for all the technical coordination and supervision of power-related programmes. It is responsible for preparing a National Electricity Plan in accordance with the National Electricity Policy once every five years. The MoP is assisted by the CEA in all technical and economic matters. The **Bureau of Energy Efficiency (BEE)**, established in 2002 under the Energy Conservation Act, 2001 is an important institution promoting energy saving measures in the Indian energy sector. BEE has played a major role in driving programmes related to demand side management, energy labelling and standards for appliances, training and capacity building, and development of energy auditing and performance evaluation mechanism. The**, Power Finance Corporation (PFC)** and the **Indian Renewable Energy Development Agency (IREDA)** are financing institutions to provide financial assistance for, power projects, renewable energy and energy efficiency/conservation projects respectively. The **State Designated Agencies (SDA's)/State Energy Departments** are the designated agencies identified in Energy Conservation Act, 2001 to assist the BEE in implementation of energy conservation and energy efficiency programs at the sub-national level in respective states.

Figure 5: Key Actors in the Indian Power Sector



Source: (International Energy Agency, 2012)

The **Central Electricity Regulatory Commission (CERC)** and the **State Electricity Regulatory Commissions (SERCs)**, are independent regulatory bodies at the National and state level to monitor and regulate the electricity sector in tariff-related matters and inter-state bulk sale of power, aid and advise the formulation of a tariff policy, frame the guidelines pertaining to tariff, promote efficiency in the electricity sector, and set power generation and transmission policies. The state distribution licensees (utilities authorised to distribute electricity over a given area of supply within the state) approach the SERCs, to fix the retail power tariff. While the different consumer categories vary from state to state, but the consumers can be broadly categorized into Agricultural, Domestic, Non-Domestic/Commercial and Industrial consumers. The tariffs for each of these consumer categories are differing across state and also vary for different distribution utilities within a state.

The electricity supply chain in India is split into three segments-power generation, transmission and distribution. A number of Government and private owned players exist across the three segments. Power generation, for instance, is handled by national government owned public sector undertakings such as **National Thermal Power Corporation (NTPC)**, **State-owned generation companies**, and Private **independent power producers (IPPs)** such as Tata Power and Adani Power. Power transmission and distribution is largely controlled by state government owned companies[6]. Presence of **private distribution**

[6] The power transmission and distribution segment in India is less attractive for the private sector due to high financial losses resulting from high aggregate transmission and commercial (AT&C) losses which stood over 22% in 2013-14, coupled with a rigid tariff system which does not fully account for fuel prices and availability.

companies (DISCOMs) such as Tata Power Delhi Distribution Limited in electricity distribution is limited, with few other cities such as Mumbai, Kolkata, Baroda and Surat having private DISCOMs. Private sector presence in the country's power sector has been growing in the recent years, as seen in sectors such as renewable energy, wherein enabling conditions for promoting domestic renewable energy industry such as minimal clearance procedures, fiscal incentives for duty and tax exemption has led to private sector constituting 95% of the installed RE capacity in 2016, whereas approximately two-thirds of conventional capacity is still owned by central and state governments (Central Electricity Authority, Government of India , 2016).

A detailed description of the institutional framework and players in India's Energy and Power sector is provided in Annexure 1.

3.3.1 Mapping of relevant national and state level entities for district cooling development

The key entities at the national and state level with regards to district cooling in India are

Entity	Relevance
Ministry of Power (MoP)	MoP being the central nodal ministry for electrical energy in India will ultimately serve as the central authority and play a key role in formulating programmes and policy regulations to promote district cooling.
Ministry of Urban Development (MoUD)	MoUD is the apex ministry for formulation and administration of the rules, regulations and laws and large scale programmes relating to urban development and housing in India, and thereby is a key actor to promote and integrate district cooling in cities.
Bureau of Energy Efficiency (BEE)	The BEE is responsible for spearheading the market transformation in the economy towards energy efficiency through various regulatory and promotional instruments. BEE guides any policy and institutional changes with regards to energy efficiency (including cooling).
Ministry of New and Renewable Energy (MNRE)	MNRE is the nodal ministry to promote development and deployment of new and renewable energy. The MNRE also administers the Solar Cities Programme, with an intent to empower cities to undertake planning and integration of renewable energy and energy efficiency in the urban energy mix. The MNRE is exploring use of geo-thermal heat pumps/geo-exchange systems for space cooling and has formulated policy, guidelines and implementing

Entity	Relevance
	demonstration projects for the same. The MNRE has also adopted and supports the Green Rating for Integrated Habitat Assessment (GRIHA), the green building rating system. The MNRE is a crucial actor to promote district cooling development in cities and to integrate renewable energy sources therein.
Ministry of Environment, Forests and Climate Change (MoEFCC)	The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal agency for the planning, promotion, co-ordination and overseeing the implementation of India's environmental, forestry and climate change policies and programmes. MoEFCC can integrate district cooling into India's climate and environmental strategy and devise programme initiatives to support district cooling. MoEFCC is the Global Environment Facility (GEF) focal point in India and can liaise with other multilateral/bilateral institutions to access support for promoting district cooling.
Central Electricity Regulatory Commission (CERC) and the State Electricity Regulatory Commissions (SERCs)	CERC and SERCs being regulatory bodies at the National and state level, can promote district cooling by framing and implementing appropriate tariff based mechanisms and guidelines.
Bureau of Indian Standards (BIS)	BIS, the National Standards Body of India, is the agency in all matters concerning standardization, certification and quality, and will serve as a source for assisting in this regard for district cooling systems.
State Urban Development Department/Agency	The State Urban Development Department/Agency are the nodal agencies at the State level, in charge of ensuring proper and planned growth of cities and towns in the respective states with adequate infrastructure, amenities and services provided to the citizens through the Urban Local Bodies and parastatal agencies. These serve as the nodal department for co-ordination, monitoring and implementation of various National and State schemes for development, infrastructure creation, civic amenities, and thereby a key state level actor.

Entity	Relevance
State Designated Agencies (SDAs)/State Energy Departments	The SDA's/State Energy Departments are responsible for implementation of energy conservation and energy efficiency programs in respective states. The SDA's can play a major role in ensuring appropriate design and implementation of programmes and policy regulations to promote district cooling at the State level.
Power Utilities (State-owned and private)	State Electric utilities or private companies involved in generation, transmission and distribution of electricity are key resources to help in assessment of baseline and future power demand, identify and implement requisite mechanisms, incentives, undertake infrastructure augmentation to support district cooling deployment.
Indian Society of Heating, Ventilation and Air Conditioning (ISHRAE)	ISHRAE is an associate of ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers). ASHRAE and ISHRAE standards and guidelines are adopted for Heating, Ventilation, Air-Conditioning and Refrigeration (HVAC) design and integrated into energy efficient policy instruments such as the Energy Conservation Building Code (ECBC) as well. ISHRAE plays a key role in promoting the use of energy efficient cooling systems in India.
Refrigeration and Air-conditioning Manufacturers' Association (RAMA)	RAMA is a trade association working to promote the growth of the HVAC industry in India. RAMA also strives to facilitate adoption of standards related to energy efficiency, manufacturing, and environmental management of HVAC systems and equipment. RAMA can play a key role in awareness generation, market and supply chain creation, adoption of standards, and technical expertise with regards to district cooling.
Confederation of Indian Industries (CII) and Indian Green Building Council (IGBC)	CII is a non-government, industry-led business association with around 8000 members, from the private as well as public sectors, including SMEs and MNCs, and with linkages to national and regional sectoral industry bodies. CII catalyzes change by working closely with government on policy issues, enhancing efficiency, competitiveness etc. IGBC, part of the CII and formed in the year 2001, promotes Green Buildings concept in India and offers developing new green building rating programmes,

Entity	Relevance
	certification services and training programmes. CII and IGBC are key actors to promote uptake of district cooling systems in the industrial sector and buildings.
Financing Institutions and Banks	Financing institutions such as Indian Renewable Energy Development Agency (IREDA), Small Industries Development Bank of India (SIDBI), IFC, ADB, KfW and public and private sector banks can provide financial support and develop appropriate financing schemes for district cooling projects.
Energy service companies (ESCOs)	ESCOs will play a significant role in developing the market for improved cooling through district cooling in built environment. ESCOs can assist in conducting building energy audits and play an integral role in establishing a framework for measuring space cooling and HVAC performance.
Energy Efficiency Services Limited (EESL)	EESL will play a major role in the development of district cooling in India. A Public-Sector Company under Ministry of Power it has one of the largest energy efficiency project portfolios in the world (approx. $2 billion of projects ongoing). EESL's Board of Directors is represented by the Ministry of Power and Bureau of Energy Efficiency (BEE) and its innovative business models of Pay as You Save (PAYS) could be scaled-up to large district cooling projects. EESL has a large amount of capital, well-developed existing programmes related to cooling, a desire to export abroad and strong links to utilities and cities. EESL's expertise in district cooling could be boosted through partnership with international private sector to operate the system through a joint venture and/or with a local utility so as to internalize the benefits to the power system.

3.4 Legal framework for Land Use and Energy Planning in Indian Cities

3.4.1 Spatial Planning and Development

Local governments or urban local bodies (ULBs) in India have greater functional and financial autonomy; post the introduction of the 74th Constitutional Amendment Act (CAA), 1992, which recognized ULBs as the third tier of Government by assigning specific civic functions to them. The 74th CAA has brought various urban activities and services such as urban planning including town planning, regulation of land use, planning for economic and social development, and providing civic amenities within the purview of ULBs in India.

Master planning and land use planning in Indian cities is typically a responsibility of the development authorities. Development Authorities or Local Planning Authorities (which are parastatal bodies), City Corporations and District Administrations are the key agencies involved and responsible for formulating and implementing planning and development norms in urban areas. Urban land use is generally governed by statutory Master Plans prepared in line with the national Urban Development Plans Formulation & Implementation (UDPFI) guidelines. Development authorities and municipal corporations govern local planning and construction permissions. ULBs are responsible for formulating city specific building bye laws and development control regulations, which govern building typology, density and form in a city. The Development Control Regulations are locally revised in consultation with the state government from time to time. Buildings in a city are regulated by local governments. Annual property tax is also collected by municipal corporations and usually forms a major part of their revenue stream.

3.4.2 Energy

The Energy Conservation Act (2001), the Electricity Act (2003), New and Renewable Energy Policy (2005), National Mission on Enhanced Energy Efficiency (2009), amended National Tariff Policy (2016), draft National Energy Policy (2017), amended National Solar Mission (2017) are some of the key guiding frameworks and policy initiatives at the national level. At the state level, policies, regulations, guidelines are formulated specific to the state context. With energy being a Central and State subject in India, no specific regulation or policy mandates exist presently with regards to management of urban energy by local governments.

The Solar Cities Programme initiated by the MNRE in 2008, aims to empower local governments in India to address energy challenges in urban areas by providing support to ULBs for the preparation and implementation of a detailed Master Plan to promote and implement RE and EE applications. The Solar Cities Programme intends to develop 60 Solar Cities across India, targeting a minimum of 10% reduction in fossil energy demand in each city through renewable energy and energy efficiency measures. The programme provides financial and technical support to cities for the preparation of detailed Master Plans, including assessing the current energy situation, future demand and action plans for implementation, setting up a solar city cell to oversee implementation and for promotional activities, building capacity in ULBs and creating awareness in the community.

3.5 Relevant regulations related to building and appliance efficiency standards

The key initiatives undertaken to promote energy efficiency in buildings, appliances and space cooling are as follows:

- **Energy Labeling of Appliances:** This scheme, launched by the BEE in 2006, sets energy performance standards for refrigerators, air conditioners, motors and other appliances. The electrical appliances need to adhere to minimum energy performance standards (MEPS) and display energy consumption labels. Currently, the scheme covers 21 types of equipment/appliances[7]. Star rating for energy efficiency was made mandatory by the BEE for room air conditioners, tubular fluorescent tube lights, frost free refrigerators, distribution Transformers from January, 2010. The implementation of this mandate has resulted in increased adoption of energy efficiency amongst end users and the manufacturers.
- **Energy Conservation Building Code (ECBC)**: The ECBC was formulated in 2007, is India's first building energy code and targets building energy efficiency. ECBC addresses the design of new, large commercial buildings (having a connected load of 100kW or contract demand of 120 KVA and above) and also aims at optimizing the energy demand in buildings based on their location in different climatic zones of India. It sets minimum energy efficiency standards for design and construction. It covers minimum requirements for building envelope performance and also for mechanical systems and equipment, including HVAC systems, interior and exterior lighting systems, service hot water, electrical power and motors in order to achieve energy efficiency in different climate zones. Compliance with ECBC has been incorporated into the mandatory Environmental Impact Assessment (EIA) requirements for large buildings. Enforcement of the ECBC lies with the State governments and ULBs through notification within their states. States of Uttar Pradesh, Rajasthan, Odisha, Uttarakhand, Karnataka, Andhra Pradesh, Telangana and the union territory of Puducherry have notified the code while many other states are in the process of amending the ECBC to suit their local requirements. Over 300 new commercial buildings have achieved compliance with the ECBC. While ECBC norms are currently voluntary, all States would be mandating ECBC by the end of 12th five-year plan period i.e. the year 2017 (Government of India, n.d.).
- **National Missions on Enhanced Energy Efficiency (NMEEE) and Sustainable Habitat (NMSH) under the National Action Plan on Climate Change (NAPCC):** India's NAPCC was launched in 2008 and encompasses a broad and extensive range of measures and outlines eight national missions. The NMEEE promotes innovative policy and regulatory regimes, financing mechanisms, and business models and seeks to bring about market transformation for energy efficiency. Under the NMSH, the strategies proposed aim at promoting efficiency in the residential and commercial sector through various measures such as changes in building bye-laws, research and development in new technologies, awareness, etc., apart from management of municipal solid wastes and promotion of urban public transport.
- **Green Building Rating Systems:** GRIHA and LEED are two rating systems currently two rating systems in existence in India at present. The Indian Green Building Council

[7] These include Room Air Conditioners, Tubular Fluorescent Tube Lights, Frost Free Refrigerators, Distribution Transformers, Induction Motors, Direct Cool Refrigerator, electric storage type geyser, Ceiling fans, Colour TVs, Agricultural pump sets, LPG stoves, Washing machine, Laptops, ballast, floor standing ACs, office automation products, Diesel Generating sets & Diesel pump sets.

(IGBC), which is a part of the Confederation of Indian Industry (CII), has taken steps to promote the green building concept in India. Currently, the IGBC is facilitating the LEED rating of the U.S. Green Building Council in India. LEED-India was launched in 2001, and rates buildings on environmental performance and energy efficiency during the design, construction and operation stages. Over 3,400 projects have been registered and over 700 green buildings have been certified by the IGBC (Website of IGBC , n.d.).

The MNRE has adopted the GRIHA rating system, which is an indigenously-developed rating system and accommodates climate variations, architectural practices, existing construction practices, and passive solar architecture. The GRIHA rating system takes into account the provisions of the National Building Code, 2005, the ECBC and other Indian Standard (IS) codes. This was taking fully air-conditioned buildings into consideration along with unconditioned and partially air-conditioned buildings. About 675 projects, covering an area of 25 million sq. m have been registered under GRIHA at present (Website of GRIHA, n.d.).

- **Star Rating Programme for Commercial Buildings:** The BEE launched a voluntary rating system based on the "Star Labeling Program" in 2009 for existing commercial buildings, which is based on actual energy performance of the buildings and expressed as the Energy Performance Index (measured as the annual electricity consumption per unit of built up area). This building star rating programme covers office buildings, hotels, hospitals, retail malls, IT parks and is applicable to buildings with a connected load greater than 100 kW. About 150 buildings have been rated under this programme (Website of BEE, n.d.).
- **City Level Building Regulations:** ULBs have authority to influence new building approvals and few cities have leveraged this authority by formulating notifications and offering fiscal incentives such as tax rebates for buildings to promote renewable energy technologies and energy efficiency design through the local building by-laws or development control regulations.
-

3.6 Status of Public-Private Partnership and Concession Laws

Significant emphasis has been placed to promote PPPs by the Government of India, given the enormous investment requirements outlined in the recent five-year plans and big ticket programmes such as the Smart Cities Mission which have been rolled out to bridge India's infrastructure deficit and the limited availability of public resources for investment in physical infrastructure. To provide a conducive environment for PPP development in India, a number of enabling measures have been undertaken in recent years such as establishment of institutional mechanisms for streamlining and speedy appraisal of PPP infrastructure projects by setting up the Public Private Partnership Appraisal Committee at the National level and creation of PPP cells within the Central Ministries and State Governments, extending financial support to make PPP infrastructure projects commercially viable such as the Infrastructure-Viability Gap Funding (VGF) scheme for PPPs , and supporting the development of a pipeline of bankable PPP projects through the India Infrastructure Project Development Fund (IIPDF). A draft National PPP Policy, 2011 has been formulated by the Department of Economic Affairs, Ministry of Finance.

Standardized bidding and contractual documents have been developed and standardized to help establish transparent and competitive bidding processes. Sector specific model concession agreements have been developed for different sectors including Highways, Ports, Urban Rail Transit, Power, Airports among others. To address the changing needs of the sectors, the model concession agreements have been subsequently updated to incorporate different PPP modes such as Built Operate Transfer (BOT) (Toll), BOT (Annuity), Design, Build, Operate and Transfer (DBOT) and Operate Maintain and Transfer (OMT).

3.7 National and State level Barrier Analysis

Policy and Institutional Barriers

- With regard to electricity end-user tariff, the CERC and SERCs are to set the tariff in reflection of the fuel price and cost of supply. However, in practice, due to political sensitivity, these regulatory bodies are overly cautious about increasing the tariff frequently or steeply irrespective of the rise in fuel costs. As a result, average power tariffs are largely below the average cost of supply, with this deficit standing at nearly 20% in the year 2013-14 (Planning Commission, Government of India , 2014). The tariff structure is distorted to subsidize residential consumers, thereby making district cooling a less viable alternative as compared to other options for space cooling.
- With average end-use electricity tariffs subsidized, financial condition of power distribution utilities is poor, with these utilities having to absorb the losses. As a result the utilities have reluctance in participating in interventions which reduce consumer energy demand and thereby reduce their revenues. This applies to large commercial and industrial consumers in particular, with the utilities largely dependent on revenues generated from electricity consumption in these consumer categories, which are being levied high power tariffs to cross-subsidise the agricultural and residential consumers.
- Policy focus on promoting energy efficiency with regard to cooling is highly insufficient in the country. Comprehensive policy, regulation and technical standards for centralized district cooling are absent.
- Institutional structures for district cooling deployment are lacking at the national, state and local level. Institutional framework and dedicated institutional capacity needs to be created to handle aspects of policy, regulation, technical know-how, and co-ordination with multiple actors at the state and local level with regards to district cooling.
- Limited role of ULBs in governance, planning and decision making of the energy sector.

  Urban energy (and efficient cooling) utilities are not addressed in the urban infrastructure and land use planning process in Indian cities.

Technical Barriers

- Existing energy consumption accounting structures do not capture cooling energy consumed or appliance-wise energy consumption in buildings. Energy baselines for different types of buildings across cities and across various climatic zones are not available. Limited availability of reliable consumer side cooling demand data poses challenges in terms of techno-feasibility assessments for district cooling systems, and estimations of resulting energy savings and environmental benefits. Data on potential local energy resources such as waste heat from industries and data centres, wastewater mains, free cooling is unavailable and not mapped.

- Technical standards, codes and regulation need to be framed to address operational challenges such as enforcement of operating guidelines for district cooling service providers and at the consumer-side for individual buildings, with regard to metering, billing and ensuring regular payments from consumers.
- The Indian air conditioning market is dominated largely by split, window and Variable refrigerant flow type air conditioners. Direct expansion (DX) systems are installed typically in large multifamily residential buildings, small offices and commercial establishments such as hospitals, educational institutions, hotels. A majority of the buildings in Indian cities do not have water based central cooling and thereby lack the ductwork for such systems. The absence of water based central cooling systems and ductwork in existing buildings, implies that retrofitting and integrating existing buildings within the district cooling network would be a costly proposition due to the additional costs of incorporating ductwork at the building level.
- Updated documented information on present status of land use is lacking in most Indian cities. In spite of central government programmes pushing for digitisation of development and infrastructure plans in cities on a Geographical Information Systems (GIS) platform, this has not been done in most cities. Availability of such information forms the basis for planning towards integration and scaling up of district cooling systems in cities.

Financial Barriers

- Viable business and implementation models for district cooling are yet to be established in the Indian context, although district cooling plants are being setup in locations such as DLF Cybercity, Gurgaon and Gujarat International Finance Tec-City (GIFT), Gujarat.
- The initial cost of district cooling systems is higher due to capital costs for construction of plant, pipeline network and connections. Since no pipeline network and/or right-of-way exists within Indian cities for district cooling, the infrastructure cost for laying the pipeline network is high, with large pipelines required due to the small temperature difference in the chilled water (about 10^{o}C).
- No enabling financial incentives and financing schemes exist for development, increased uptake and import of district cooling technologies, and to overcome the high initial cost barrier.
- With district cooling being a relatively new technology in India, the perceived market risks, lack of awareness and policy framework for district cooling are challenges to securing finance for projects.

Capacity and human resource

- Lack of public awareness and understanding of the technology, costs, energy savings, performance and benefits of district cooling is a major barrier towards acceptance and penetration of district cooling systems in the market.
- There is a lack of capacity to develop, integrate and implement district cooling projects at all levels amongst various stakeholders, from the policy makers, architects and building designers, building developers, decision makers and HVAC sector specialists.
- ULB and government agencies often lack requisite capacity to manage novel infrastructure projects through public private partnership model.

4 Summary of national barriers, impacts and recommendations based on rapid assessment exercise

Based on this initial analysis and government consultations, the District Energy in Cities Initiative has developed the below set of recommendations. These aim to initiate discussions on potential government intervention to promote district energy. The Initiative will continue to analyse these barriers and build-upon these recommendations.

4.1 Policy and institutional barriers

4.1.1 District energy not promoted in national or state-level initiatives

National and state-level barriers	▪ No government institutions realize the multiple benefits of district energy (which includes district cooling and trigeneration) including helping meet the country's CO_2, energy efficiency, renewables and refrigerant emission strategies. ▪ Limited evidence, and awareness of, the multiple benefits of district energy at national and state policy making ▪ State electricity utilities in financial difficulty are reluctant to promote interventions that could reduce consumer energy demand and consequently their revenues, such as district energy.
Impacts	▪ Few policy initiatives exist that incorporate district energy and trigeneration systems such as: supporting city assessments on district energy, capacity building programmes, government incentives or financial support, technical standards, codes, reference guidelines, regulation and operational guidelines for the optimal design and operation of the district energy. ▪ District energy is not integrated into current programs such as the Smart City Mission, Solar Cities Programme, National Mission on Sustainable Habitat etc.

	▪ State energy departments or State nodal agencies are not promoting district energy. State electricity utilities are not promoting district energy and do not recognize the technology as a key tool for demand side management, balancing and peak reduction. ▪ No programmes exist to promote city-action on promoting district energy
National and state-level recommendations	▪ National Delivery Unit established within a ministry or other powerful public body to support cities to assess and deliver district cooling projects including promoting methodologies, tools, best practices, contract templates, ToRs for consultants etc. (many of these are under development by the District Energy in Cities Initiative) as well as providing general expert advice from district cooling experts. for district cooling assessments developed by the District Energy in Cities Initiative ▪ Incorporation of space cooling into national initiatives as a separate sector and district cooling as a best practice technology for urban areas (Smart City Mission, Solar Cities Programme etc.) ▪ Smart Cities Mission could recognise district cooling as technology to integrate multiple aspects of smart cities (waste, green buildings, power, water etc.) and to meet targets of 80% energy efficient and green buildings in selected redevelopment or greenfield pilot areas (Area-based development) in Smart Cities ▪ Support district cooling demonstration projects in the Smart Cities Mission in order to create evidence for effectively integrating multiple aspects of smart cities ▪ Assess whether a demonstration project for district cooling using an innovative business model involving a DISCOM is feasible, such as a joint venture with an experienced district energy provider, which would allow upstream benefits to the DISCOM (e.g. balancing, reduced grid investment) to be incorporated in the business model and for the DISCOM to secure financial returns from energy efficiency.
City-level recommendations	▪ Assess how district cooling could fit into smart city plans and other national initiatives being applied at the city-level

4.1.2 National building regulations

National and state-level barriers	▪ Application of Energy Conservation Building Code (ECBC) in cities is an ongoing, long process. Many cities have still not adopted the regulations. The perceived cost to building industry of implementing ECBC efficiency standards is holding back implementation of the regulations in India ▪ ECBC does not currently promote or account for system-wide efficiency benefits of buildings connected to district energy. Only the Coefficient of Performance (COP)s and Integrated Part Load Value (IPLVs) of building chillers are considered

	▪ As very few district energy systems exist in India and no published findings of district energy connected to an ECBC compliant building.
Impacts	▪ ECBC implementation in many cities is a long process with significant capacity building, training, demonstration projects, stakeholder consultations and motivation to be undertaken and enforcement guidelines to be developed. ▪ It is not clear if a building connected to district energy would be compliant with ECBC ▪ ECBC includes voluntary energy efficiency performance levels beyond simple compliance; under these levels, district energy may be at a disadvantage to stand-alone cooling systems if specific incentives are given for 'ECBC plus' or 'Super ECBC' levels ▪ Building developers are not necessarily incentivised to invest in building or appliance efficiency measures as developers are not involved in building operation – similarly the industry may be reluctant to invest in district energy if it is seen to increase construction costs
National and state-level recommendations	▪ ECBC is designed to use building codes to integrate sectors, including: buildings, urban environment, power, economy, water and waste. District energy and ECBC thus naturally align. It is recommended that district energy's explicit incorporation into the ECBC is justified in the context of this alignment as well as efficiency gains and that the ECBC explicitly promotes district energy systems that integrate multiple sectors. ▪ Initially national and state-level government could promote city or state-led demonstrations of district energy and ECBC compliance ▪ Work with the Initiative and cities piloting both district energy and adopting ECBC to identify how the ECBC and the nationally issued templates on ECBC guidelines, trainings and compliance could be adapted for district energy – for example, system level examination of energy efficiency and renewable energy for district energy systems ▪ Develop interim recommendations for cities to handle applications from buildings connected to district energy ▪ In the medium/long-term government could incorporate recommendations into future iterations of ECBC ▪ Promotion of GIFT city adoption of ECBC and how the district energy system is compliant with ECBC or not.

City-level recommendations	
City-level recommendations	▪ ECBC is the main process through which cities will deliver green building programmes, as such it is vital it is integrated with district energy development. If district energy is regarded separately to ECBC implementation, it could be under-prioritised by cities ▪ Cities in the Smart Cities Mission are supposed to pioneer the implementation of ECBC and set examples to other cities – some could also pioneer its adaption and application to district energy ▪ Accounting for district energy systems when adopting of ECBC into local building by-laws and building codes by ensuring district energy connected buildings also comply with ECBC and are still able to access any benefits associated to ECBC compliance from the city ▪ Information sessions, stakeholder consultations awareness raising and training on ECBC could be aligned with similar activities on district energy. Plans for district energy implementation should follow the implementation plan for ECBC and related capacity building and roll-out ▪ Documenting of benefits regarding ECBC and district energy together in demonstration projects ▪ Cost-savings at the building-level and alternative revenue streams from district energy operation should be presented to building developers to encourage district energy development

4.1.3 National building certification

National and state-level barriers	▪ Building certificates can be adapted to account for the system benefits of district energy including energy efficiency, fossil fuel reduction, on-site renewable use, reduced water and refrigerant consumption and wastewater reuse. ▪ Some certificates already recognise system-level benefits. For example, within the IGBC SEZ rating scheme, wastewater reuse, on-site renewable energy, refrigerant reduction, waste management are regarded at the system level (although efficiency of cooling and electricity is only considered at the building level). Other IGBC rating schemes as well as GRIHA LD also examine system level benefits. ▪ Single building certification schemes, such as GRIHA or IGBC Green New Buildings do not recognise district energy connection and do not account for the full benefits of district energy systems ▪ BEE's Star Rating Programme may not apply to a building connected to district energy as it focuses only on electricity consumption at the building level

Impacts	▪ Certificates are linked to specific incentives (e.g. additional floor-area-ratio (FAR) to developers, capital subsidy, fast track environmental clearance, concessional interest rates) and planning mandates (e.g. government buildings required to meet specific certificate level) at the national, state and local level ▪ The recognition and use of building certification is increasing in India, as is their use to direct specific incentives. ▪ Incentives and mandates related to certifications that do not adequately recognise district energy both at the national level (e.g. through the Green Buildings Scheme) or city-level (e.g. providing additional FAR) may not be achievable by district energy connected buildings
National and state-level recommendations	▪ Early action can be taken by national government and institutions designing certificates to include a system-level approach to certification will deliver a fairer system, including recognising the system benefits of district energy. ▪ In the past it has been seen that rating systems have created a market push for energy efficient technological solutions in the building construction industry. Inclusion of district energy concepts in rating systems will help accelerate the district energy market. ▪ Lessons and best practice can be used from some existing certificates (e.g. aspects of the IGBC SEZ rating system and LEED). Particularly how energy efficiency can be evaluated at the system level and not only at the building level ▪ Identify and support demonstration projects for district energy that can determine shortfalls in existing certificates. ▪ Consider how national and state-level incentives and mandates linked to certificates could include provisions for district energy connected projects ▪ Support the inclusion of the Initiative and district energy into working groups and processes designed to adapt or update building certificates in India especially in IGBC and GRIHA.
City-level recommendations	▪ Ensure city mandates and FAR bonuses related to certificates do not disadvantage buildings connected to district energy and establish interim measures to overcome this disadvantage ▪ Cities could require LEED certification for building developments over a certain size – as is the case in GIFT City – this automatically ensures that district energy can be used for compliance

4.1.4 Role of cities in energy planning and promoting district energy through planning authority

National and state-level barriers	▪ Cities typically have a limited role in planning and decision making in the energy sector ▪ Many cities lack the capacity and resources to undertake significant interventions in the energy sector. ▪ Cities are best placed to promote energy efficient urban design including district energy but may not be aware of best practice policies and interventions in other cities ▪ The case for cities to take a significant and more active role in energy planning needs to be made further in India and disseminated. The Solar Cities Programme and Smart City Mission provide a platform for this, although cities are not necessarily sufficiently equipped and are hampered by resources and funding.
Impacts	▪ Urban energy (and efficient cooling) is not addressed in the urban infrastructure and land use planning process in many Indian cities.
National and state-level recommendations	▪ Define clearly the different tools already available to cities to incorporate energy into urban planning ▪ Policy best practices in urban energy planning could be further promoted including best practice case studies relating to zonal energy planning, FAR bonuses, minimum certificate requirements, city certification schemes etc. ▪ In the medium/long-term, identify how guidelines and trainings for cities on development of masterplans and urban planning policies could be adapted to incorporate urban planning practices that promote the most energy efficient urban design and district energy ▪ State governments could promote policies and regulations that foster district energy projects such as through their support to cities in revising Development Control Regulations
City-level recommendations	▪ The adoption of ECBC by cities provides an opportunity for them to intervene in the energy sector through planning policy – in parallel, cities could use this opportunity to undertake stakeholder consultations and training on other interventions in urban planning relating to the energy sector ▪ Cities have broad powers to intervene in the energy sector and promote district energy. City-to-city interaction and best practice sharing can help build capacity. Cities can sign up to the Initiative to have access to case studies from multiple cities and also to receive training. ▪ Cities can build upon existing planning authority they exert, such as granting planning permission and additional FAR, to incorporate energy and promote district energy.

4.2 Technical barriers

4.2.1 Insufficient research and studies on impacts of space cooling and potential of district energy

National and state-level barriers	▪ Current and future impacts of air conditioning on power infrastructure and GHG emissions are not sufficiently researched in India. ▪ Data and reliable estimates related to city or national-level cooling demand are very difficult to achieve as statistics for cooling are hidden within electricity consumption ▪ No state or national district energy potential studies exist in India
Impacts	▪ Energy efficient and sustainable space cooling are not prioritised in local and/or national policy framework ▪ Solutions to delivering sustainable cooling are overly focused on the power sector and appliance efficiency ▪ With cooling's impact not fully assessed, evidence-based policy making to deliver sustainable cooling at the city and national level s more difficult ▪ Space cooling not seen as a local problem meaning local solutions overlooked. ▪ Different cooling demand types not considered collectively, overlooking synergies that could improve efficiency: room AC (residential, small commercial, public), large building centralised cooling (manufacturing, commercial, public), refrigeration, cold storage, data centres and other industrial cooling uses
National and state-level recommendations	▪ National study on current and future impacts of cooling by Indian research institution(s) or university(ies) including: CO2 and refrigerant emissions, grid stress and investment, the offsetting of renewables progress with increasing space cooling demand, water stress, ▪ National institution identified to improve monitoring and reporting of cooling demand ▪ National study on the technical and economic potential of district energy and associated benefits
City-level recommendations	▪ Guidelines and tools developed for cities to assess cooling demand and its impacts ▪ Cities supported by the DES Initiative to monitor and report on cooling demand to help feed into national statistics

4.2.2 City-level data and information

Barriers	▪ The existing energy consumption accounting structures do not capture cooling energy consumption or equipment wise energy consumption in buildings.

	▪ Data on energy resources in cities is often not available ▪ GIS data of cities including building locations and types, road networks, utilities, energy sources etc. may not be available in many cities.
Impacts	▪ It is not possible to map the cooling energy demand at a city level. This poses a problem in carrying out the technical feasibility of district energy system and the estimation for energy savings and environmental benefits. ▪ Many cities are not using GIS tools to support the integration of energy into urban planning. Such mapping can examine and justify urban densification, mixed-use zoning, district energy development, can coordinate utilities and road works and can present and justify planned developments to the public.
National and state-level recommendations	▪ National initiatives that map resources and promote technologies such as geothermal, biogas or municipal waste could ensure city-level data is available and that cities are made aware of district energy opportunities for using these resources. ▪ Support and promote the Initiative's development of a city-level Monitoring, Reporting and Verification (MRV) framework for space cooling and district energy. ▪ Support and promote the Initiative's development of city-level Energy Mapping to identify opportunities for district energy and incorporation of renewables
City-level recommendations	▪ Cities that sign up to the Initiative will receive best practice guidelines and tools on: energy mapping; monitoring, evaluating and reporting cooling demand and district energy progress; and tools to assess high-level district energy potential.

4.2.3 Lack of district energy experience in India

Barriers	▪ Very few district energy systems exist in India ▪ The technical expertise required for the design of a district energy system lies with only few firms in India which is not sufficient.
Impacts	▪ Lack of published results of district energy's costs, benefits and operation ▪ Technical assessments of district energy in India may not follow international best practices or be sufficiently independent.
National and state-level recommendations	▪ Sharing and promotion of GIFT city case study including publishing results, trainings, study tours etc. ▪ Promote to cities the methodologies, tools, models and best practices that are adapted to the Indian context by the Initiative, particularly standards on rapid assessments, pre-feasibility studies, feasibility studies and commercialisation ▪ Promote business models that incorporate experience of international private sector in district energy while maintaining city control, for example management contracts, BOOT models, PPPs with cities, DISCOMs or national organisations such as EESL etc.

	▪ Support the Initiative to work with large companies such as EESL, Tata, Thermax etc. to become champions of district energy and build Indian capacity for this technology
City-level recommendations	▪ Explore strategic partnerships with international private sector in city-promoted projects. ▪ If mandating assessments of district energy, ensure a certain standard is maintained including following best practices methodologies and terms of reference. ▪ Cities can join the DES Initiative to gain access to cities and partners with global experience they are willing to share on district energy best practices.

4.3 Financial

Barriers	▪ District energy is a relatively new technology in India and may have difficulty attracting low cost finance. ▪ District energy projects have a high upfront cost that will require new business models for space cooling ▪ No funding is available for cities to undertake district energy potential studies, feasibility projects or to support in project commercialisations costs ▪ No targeted capital support programme for district energy projects providing grants, loans or guarantees ▪ Large portions of the district energy plant equipment are imported from overseas which are applicable for the import duty and other taxes resulting in additional financial burden on the developer. ▪ Sales of chilled water by district energy operators may be subject to VAT whereas stand-alone buildings' chilled water would not be ▪ Cities do not have enough human resource capacity and experience to manage large infrastructure projects in public private partnership models.
Impacts	▪ High potential district energy projects are not delivered as they are unable to attract sufficient low-cost finance ▪ Lack of published results around financial returns and commercial viability ▪ Import duty and VAT payments would result in an additional financial burden on the developer which could be alleviated ▪ District energy projects under PPP in cities could be difficult to establish, delayed and poorly handled.

National and state-level recommendations	▪ To encourage district energy, a relaxation on import duty on specific district energy components could be considered by policymakers in the short to medium-term. ▪ Guidance on VAT/GST rates applicable to the sale of chilled water. ▪ Assessment on the impacts of VAT/GST payments for chilled water on district energy potential and reducing of VAT to fair levels reflecting nascence of sector and that stand-alone systems do not pay VAT on chilled water. Government could consider providing VAT reductions linked to project innovation (e.g. integrating multiple sectors, high shares of renewables) or that are environmentally and socially more ambitious. ▪ Develop a fund providing dedicated financial support to partially cover project development costs alongside technical support ▪ Assess the role of a revolving fund to support late stage project commercialisation and CAPEX through soft loans, grants and guarantees. ▪ Support district energy projects to access national and international concessional finance, guarantees and grants. ▪ Assess role of state utility tariffs in improving the business case of thermal storage and trigeneration, for example lowering the off-peak tariff charged to a district energy utility
City-level recommendations	▪ Consider local incentives linked to Floor Area Ratio (FAR) payments, municipal taxes, provision of land, free use of services such as water, connection of public buildings and load guarantees, ▪ Directly invest in projects to support the business model and improve access to finance ▪ Consider directing selling municipally-owned, low-cost renewable electricity to district energy plants to improve business case

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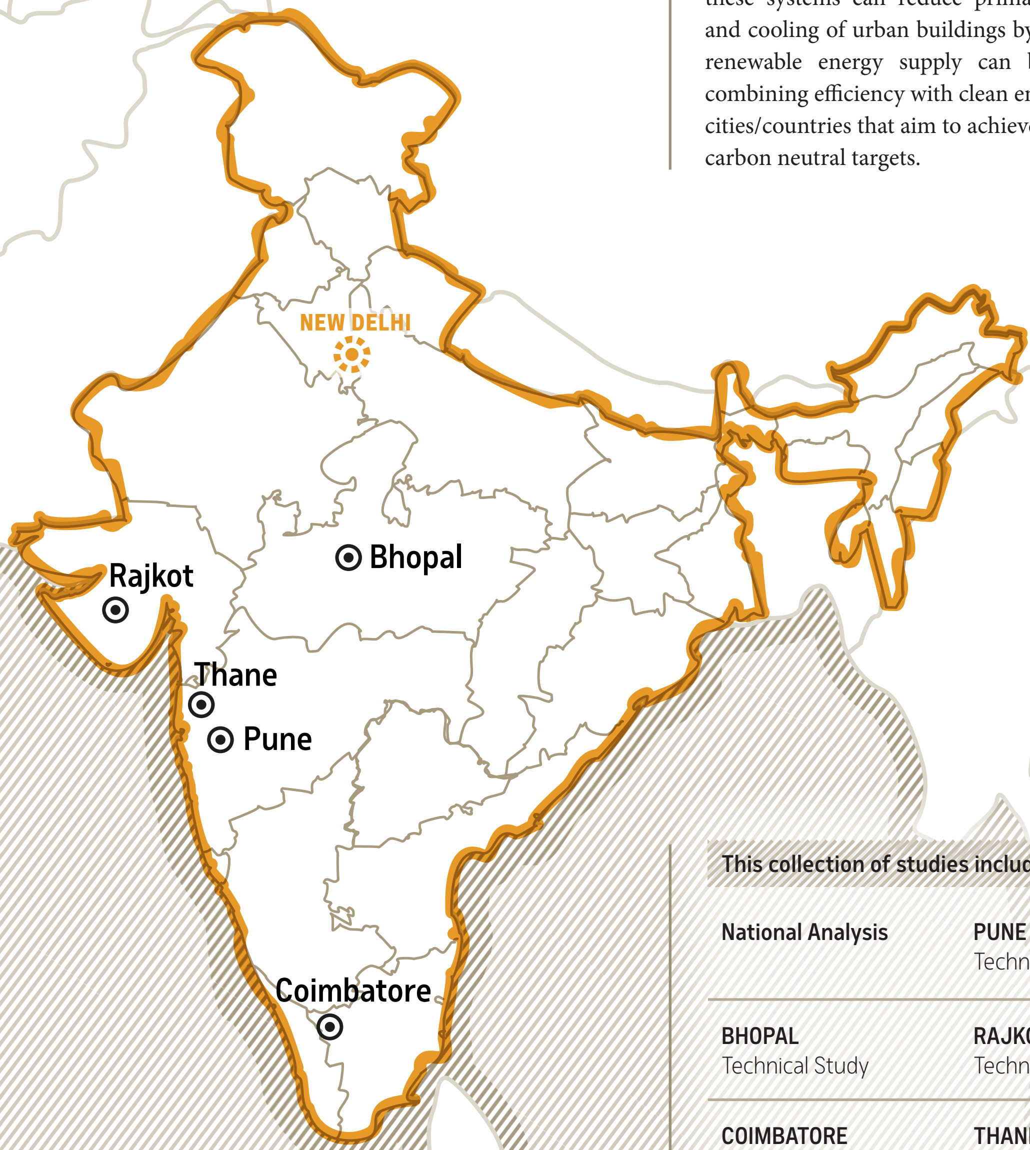
RAPID ASSESSMENTS OF FIVE INDIAN CITIES

The District Energy in Cities Initiative is a multi-stakeholder partnership that assists developing countries and cities to accelerate their transition to lower-carbon and climate resilient societies through promoting modern district energy systems. District energy systems are intelligent energy infrastructure, efficiently integrating clean sources of energy for cost-effective heating and cooling.

Through economies of scale, diversity of supply, balancing and storage, these systems can reduce primary energy consumption for heating and cooling of urban buildings by up to 50%. High levels of affordable renewable energy supply can be integrated with district energy, combining efficiency with clean energy, making them a key measure for cities/countries that aim to achieve 100% renewable energy, clean air, or carbon neutral targets.



This collection of studies includes

National Analysis	**PUNE** Technical Study
BHOPAL Technical Study	**RAJKOT** Technical Study
COIMBATORE Technical Study	**THANE** Technical Study

experts@districtenergyinitiative.org

@DES_Initiative

www.districtenergyinitiative.org

For more information, contact:

Ms Lily Riahi,
Programme Manager and Lead

District Energy in Cities Initiative
Energy and Climate Branch,
UN Environment – Economy Division

lily.riahi@un.org