
ISGF White Paper

LEVERAGING SMART GRID ASSETS FOR BUILDING SMARTER CITIES AT MARGINAL COST

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Abstract

The Smart Cities Mission has triggered the planning and designing of 100 Smart Cities in the country and it is expected that by 2030 more than 40% of India's population will live in urban areas. Using Smart Grids as anchor infrastructure to build Smart Cities in India makes sense given the need for modernizing the electricity distribution system to provide 24x7 supply of quality power to all. Compelling business cases are available for investment in smart grid technologies to improve operational efficiency and reduce system losses. Smart Grid is essential to integrate renewable energy resources on to the grid and green energy is a key element for Smart Cities and their sustainable future. This paper describes how Smart Grid assets can be leveraged to build Smarter Cities at marginal cost by extending the automation, IT and communication infrastructure of the Smart Grids to other infrastructure and services domains in a city.

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About India Smart Grid Forum

India Smart Grid Forum (ISGF) is a public private initiative of the Ministry of Power (MoP), Government of India for accelerated development of smart grid technologies in the Indian power sector. ISGF was set up in 2010 to provide a mechanism through which academia, industry, utilities and other stakeholders could participate in the development of Indian smart grid systems and provide relevant inputs to the government's decision making.

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INTRODUCTION

1. SMART GRID: A PARADIGM SHIFT

The 21st Century electric grid is witnessing several disruptive changes. After 100 years of centralized power generation and creation of massive electric grids, the shift is now towards decentralized generation. For the past five years we are witnessing an increasing share of new generation resources being added at the low voltage or distribution segment of the grid which is a major transformational change to the electric grid. The traditional model of electricity being generated at large power plants and transported to millions of consumers through long transmission and distribution lines is changing. The traditional boundaries between Generation, Transmission and Distribution are fast disappearing and the grid is evolving as an integrated grid. This change is primarily driven by distributed generation from renewables which have already achieved grid price parity to most customer classes in many geographies. Electric Vehicles are going to make the electric grid even more complex to manage as there will be less predictability of the loads!

Smart Grids have emerged as the critical enabling infrastructure for all flagship programs for Government of India (GoI) such as 24x7 Power for All, 100 Smart Cities, 175 GW of Renewable Energy by 2022, National Mission on Electric Mobility with a target of 6-7 million Electric Vehicles by 2020 etc. In order to bring efficiency and sustainability in the electricity distribution sector in India, introduction of Smart Grid technologies started with Restructured-Accelerated Power Development and Reforms Program (R-APDRP) and is continued with Integrated Power Development Scheme (IPDS). To take this on fast track a National Smart Grid Mission (NSGM) has been approved by GoI. NSGM envisages to launch projects in conjunction with other ongoing programs of GoI and State Governments to build smart grids in the country in a phased manner starting with urban areas and regions with huge transmission and distribution losses.

2. URBANIZATION AND INDIA

The rise of cities has grown over millennia, and have evolved over time as places where the entirety of human activities and services concentrate, spanning multiple modes of transportation, water supply, electricity, telecommunication and internet, schools and colleges, hospitals, markets and businesses, other resources and services across people with varied skills. As cities evolved with more and more facilities and services, they became more and more attractive to people from rural areas leading to even faster urbanization. Rapid growth of cities has led to the creation of metropolitan regions - clusters of cities in a region.

Urbanization accompanies economic development. Rapid urbanization followed as India transformed from an agrarian economy to industrial cum services economy during the past three decades. While the urban population is currently around 31% of the total population, it contributes to over 60% of India's GDP. It is projected that urban India will contribute nearly 75% of the national GDP in the next 15 years. It is for this reason that cities are referred to as the "engines of economic growth" and ensuring that they function as efficient engines is critical to our economic development. This trend of urbanization that is seen in India over the last few decades is expected to continue for few more decades. Hence we need to plan our growing urban areas as sustainable cities. The relatively low technology penetration in cities allows us to plan our urbanization strategy in the right direction by taking advantage of the latest developments in technology.

Comprehensive planning and development of physical, institutional, social and economic infrastructure is the right approach to develop smart cities. Government of India is accelerating the development of cities in India with the Smart Cities Mission. The 100 Smart Cities are to make their infrastructure ready to take on the population growth, supply 24x7 reliable electricity supply, secure every citizen's life with good health, education and employment facilities and make the city more liveable, workable and sustainable.

Increasing energy demand makes all these targets challenging as energy consumption from fossil fuel will lead to more carbon emission and environmental issues. Energy is the key driver for cities and non-polluting energy essential in smart cities. To ensure 24x7 sustainable supply of electricity and energy security, the efficient management of the electricity distribution network in real time through use of intelligent devices and applications has become necessary.

3. SMART GRIDS FOR SMART CITIES

Smart grid is an electricity grid with communication, automation and IT systems that enable real time monitoring and control of power flows from points of generation to points of consumption at the appliances level. It is an evolving grid system that manages electricity demand in a sustainable, reliable and economic manner built on advanced digital infrastructure and tuned to facilitate the integration of both demand and supply. Smart Grid can implement basic building blocks for Smart Cities which can be utilised by other utilities like water, sewerage, piped gas, streetlights, etc., to integrate other solutions of Smart Cities and create a holistic eco-system with common command and control centre. Preliminary studies by India Smart Grid Forum (ISGF), indicate that in towns with AT&C losses above 25%, Smart Grid projects can bring it down to 10% with the payback period of 3-4 years. There are compelling business cases for Smart Grids which makes it an anchor infrastructure for Smart Cities and once Smart Grid infrastructure is in place, extending it to other domains and services to build Smart Cities can be achieved at marginal cost.

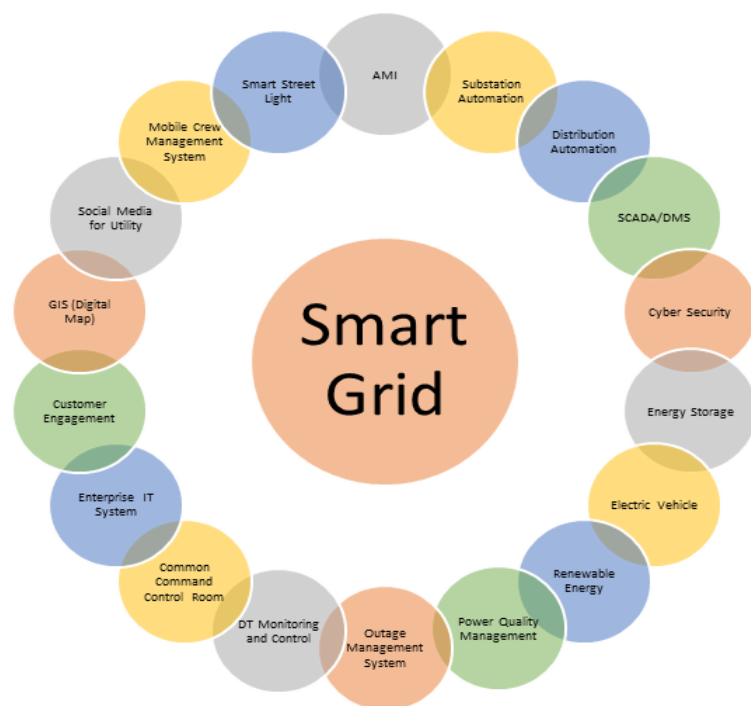


Figure 1: Smart Grid Components

In the Indian context where cities do not have a single owner for all their services, it would be a herculean task to integrate all infrastructure and services on a common platform. However, a beginning can be made by extending the available digital platform of one domain (say power) to offer services in other domains (say water, gas, internet, transport, security etc). The smart cities in India can be in two categories – existing cities that should be made smarter by integrating all services on digital platforms; and new cities that would be built as smart cities with integrated communication, IT and Automation architecture.

This would essentially cover the following:

1. Building GIS data of all infrastructure and services in an integrated fashion by one designated agency (with rules for sharing, security, etc.)
2. Smart electricity grids that ensure 24x7 stable electricity to all citizens
3. High levels of renewable energy mix that is integrated with the power grid
4. EV charging infrastructure and ability to operate large fleet of grid-connected EVs as virtual power plants (VPPs)
5. Efficient water distribution network with leakage detection systems and safe gas distribution networks
6. Integrated billing systems for a variety of services (electricity, water, gas, internet, house tax etc.); common consumer care centers and user friendly payment platforms
7. Intelligent transportation systems - coordinated operation of traffic lights, alerts on congested routes in advance, common cards for toll payments etc. which also extends to improved public transportation.
8. Digital security systems integrated with emergency services (police, fire, ambulance, municipality etc.)
9. Electrification of mobility, with fleet operations being the low hanging fruit, permit creation of virtual power plants (leveraging grid connected EVs)
10. Intelligent buildings with rooftop PV and EV Charging facilities integrated with automation systems of the electric utility participating in the demand response market
11. Demand Response would strengthen negawatt market and IT infrastructure permit its aggregation for meaningful dispatch.
12. Energy independence in long term and “intelligent energy harvesting” that would recycle incoming energy flows.
13. Sharing of data between various domains and building smart analytical tools
14. Seamless payment system for all services

While building new cities and new neighbourhoods, it is possible to build all these in an integrated fashion, it is a tougher task to integrate the same in existing cities with different owners for different domains. The silver lining is that there are hardly any IT and Automation systems in most infrastructure domains in Indian cities which eliminates the risk of legacy systems with proprietary databases and protocols that cannot readily be integrated with one another.

LEVERAGING THE SMART GRID ASSETS FOR SMART CITIES

All state owned electricity distribution companies (Discoms) in India are implementing a set of basic IT and Automation solutions under the ongoing R-APDRP scheme of the Ministry of Power. Some of the digital assets created under this program that covers 1411 towns can be leveraged to build smarter cities at marginal cost. The IT and Automation Systems of the DISCOMS that can be leveraged by other infrastructure services providers is briefly explained below:

1. GIS Map of the Towns: All electrical assets (33kV, 11kV and Low Voltage lines and substations) and consumers are mapped on a digital map and the Discoms are updating this system on a regular basis to capture changes/addition to the electrical network as well as new consumers/buildings. This digital map can be effectively used by other infrastructure services providers for planning as well as operation and maintenance of their systems. This will be very useful for planning the laying of water supply and sewerage lines, telecom cables, gas pipe lines etc. It can also be used for planning of road network. As the simplest example of how a good GIS system can help beyond a single domain – if one knows the routing of underground power cables, then the same can be synergized to other utilities that would need to dig up roads (like water, sewage, telecom, etc. – thus one should, in the future, never interrupt other services for adding new connections/lines/pipes).
2. Billing and Customer Relationship Management (CRM) Systems: State of the art Billing and CRM systems have been implemented in all these towns and the consumers have multiple options to make their payments. There are also Consumer Care Centers at strategic locations and interactive consumer portals. Discoms have regular interactions with their customers on – meter reading, bill distribution, payment collection, attending to complaints, information on planned outages etc. Large number of consumers are already using the consumer portals. All water and gas consumers are electricity consumers also. The Billing and CRM systems of Discoms can be used for collection of water and gas bills, house taxes and other municipal dues, and can even be extended to private utilities such as cable TV, internet, telephone, etc. This not only reduces the overall collection cost, but also facilitates higher compliance in timely payment. If the consumer wishes, he/she could even opt for a consolidated bill across all such services.
3. SCADA/DMS System: For larger towns with population of 4 lakhs and above (about 78 towns), Discoms are implementing SCADA/DMS systems for monitoring and controlling the real-time power flows. The field infrastructure and dedicated communication bandwidth for SCADA/DMS can be leveraged to automate the water and gas supply networks as well.
4. Common Command and Control Center: A common command and control center that can handle the complaints from consumers for all their grievances related to electricity, water, gas, internet etc can be created. The incoming calls (on single

number) can be diverted to the respective teams responsible for each domain and their crew. The IT and communication infrastructure and cost can be optimized to a great extent. It will boost customer satisfaction to a great extent as they do not have to knock at different doors for each service.

5. Outage Management Systems (OMS) and Mobile Workforce Management (MWFM): OMS and MWFM can be shared by electricity, water, gas and internet/ other services providers.
6. Application Integration: All the applications of all interconnected domains can be integrated and the data can be shared and dashboards can be made available to operators, managers and policy makers to effectively plan and manage the city.

NATIONAL SMART GRID MISSION (NSGM)

Ministry of Power issued a Smart Grid Vision and Roadmap for India in August 2013 which envisages transformation of the entire Indian power system to a smarter grid by 2027. In order to achieve the goals envisaged in this roadmap a National Smart Grid Mission (NSGM) has been approved by Government of India in 2015. Under the NSGM it is proposed to build about 30 smart cities in the country leveraging the existing R-APDRP infrastructure and new systems that would essentially be implemented for first building smart grids and then extending the systems to other domains.

The NSGM initiatives will be coordinated with other programs such as Smart Cities Mission, Digital India, 24x7 Power for All, 175 GW Renewable Energy, Solar Cities Program, National Mission on Electric Mobility, National Mission on Enhanced Energy Efficiency, etc. for improved efficacy and asset/cost optimization.

NSGM has a three tier structure:

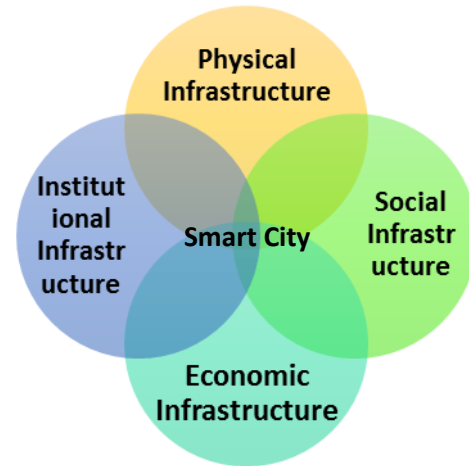
- At the apex level, NSGM has a Governing Council headed by the Minister of Power. Members of the Governing Council are Secretary level officers of concerned Ministries and Departments. Role of Governing Council is to approve all policies and programs for smart grid implementation.
- At the second level, the NSGM has an Empowered Committee headed by Secretary (Power). Members of the Empowered Committee are Joint Secretary level officers of concerned Ministries and Departments. Role of Empowered Committee is to provide policy input to Governing Council and approve, monitor, review specific smart grid projects, guidelines / procedures, etc.
- In a supportive role, NSGM has a Technical Committee headed by Chairperson (CEA). Members of the Technical Committee are Director level officers of concerned Ministries & Departments, representatives from industries and academia. Role of Technical Committee is to support the Empowered Committee on technical aspect, standards development, technology selection guidelines, etc.
- For day-to-day operations, NSGM has a NSGM Project Management Unit (NPMU) headed by the Director NPMU. Director NPMU is a Member of the Governing Council and Empowered Committee, and Member Secretary of Technical Committee. NPMU is the implementing agency for operationalizing the Smart Grid activities in the country under the guidance of Governing Council and Empowered Committee.

- Grant up-to 30% of the project cost is available from NSGM budget. For selected components such as training & capacity building, customer engagement, etc. 100% grant is available.

SMART CITIES STANDARD FRAMEWORK

ISGF has studied various domains and sub domains of Smart Cities and designed an exhaustive matrix depicting the interdependency of each of these domains on other domains. Each domain can achieve its described features with the help of technology enablers available as a solution to the problem. Four main Smart Cities Pillars are:

- Physical Infrastructure
- Institutional Infrastructure
- Social Infrastructure
- Economical Infrastructure



Each pillar is then divided into domains and sub-domains.

Figure 2: Smart City Infrastructure Pillar

Key technology enablers for the infrastructure are:

1. GIS (Digital Map)
2. Instrumentation and Control
3. ICT
4. Interoperability
5. Cyber-Physical Security
6. Data Management
7. Analytics
8. Planning and Modelling Tools
9. Environment Friendliness
10. Citizen Engagement and Participation
11. Governance

Sample of the Interdependency Matrix is as follow:

		PHYSICAL INFRASTRUCTURE															
		Energy					Water										
		Electricity (Grid)	Renewable Energy	Gas	Other Fuels	Energy Efficiency	Potable Water	Non-Potable Water	Industrial Water	Agricultural Water	Other Water Bodies (Ponds/Tanks/Lakes)	Rivers and Canals	Hazardous Waste (Toxic/Reactive/Corrosive/Explosive)	E-Waste			
PHYSICAL INFRASTRUCTURE	Interdependency Matrix	Electricity (Grid)	Efficient RE export to the grid for use in other applications.	24x7 reliable electricity supply for use in other applications.		HTH: Controlled release of Grid Power to meet demand.							HTH: Hazardous waste which does not have any specific regulatory, or which has high volume waste, may be hazardous. E-waste may require other treatment.	HTH: Hazardous waste which does not have any specific regulatory, or which has high volume waste, may be hazardous. E-waste may require other treatment.			
		Renewable Energy	Shows RE is electricity consumption from city.			HTH: Effective utilization of Solar PV.							HTH: Renewable energy is generated directly through solar power.	HTH: Renewable energy is generated directly through solar power.			
		Gas	1 MWe: 24x7 reliable electricity supply for use in other applications.	1 MWe: 24x7 reliable electricity supply for use in other applications.	1 MWe: 24x7 reliable electricity supply for use in other applications.	1 MWe: 24x7 reliable electricity supply for use in other applications.							1 MWe: Some portion of waste can be used for replacement.	1 MWe: Some portion of waste can be used for replacement.			
		Other Fuels															
		Energy Efficiency	HTH: 100% Load.	HTH: 100% Load.										HTH: Energy Efficiency is important in the case of industrial use of power.	HTH: Energy Efficiency is important in the case of industrial use of power.		
		1.Guidelines		2.Interdependency Matrix		3.Role of Enablers											

Figure 3: Smart Cities Domain Interdependency Matrix

Each cell of the matrix describes “what is the interdependency of respective domain with other domains”. For example a smart city with 24x7 water supply would require reliable electricity supply; and what the electricity grid should do to achieve reliable supply to all water pumping stations will be described. Certain technology enablers can be common to multiple domains.

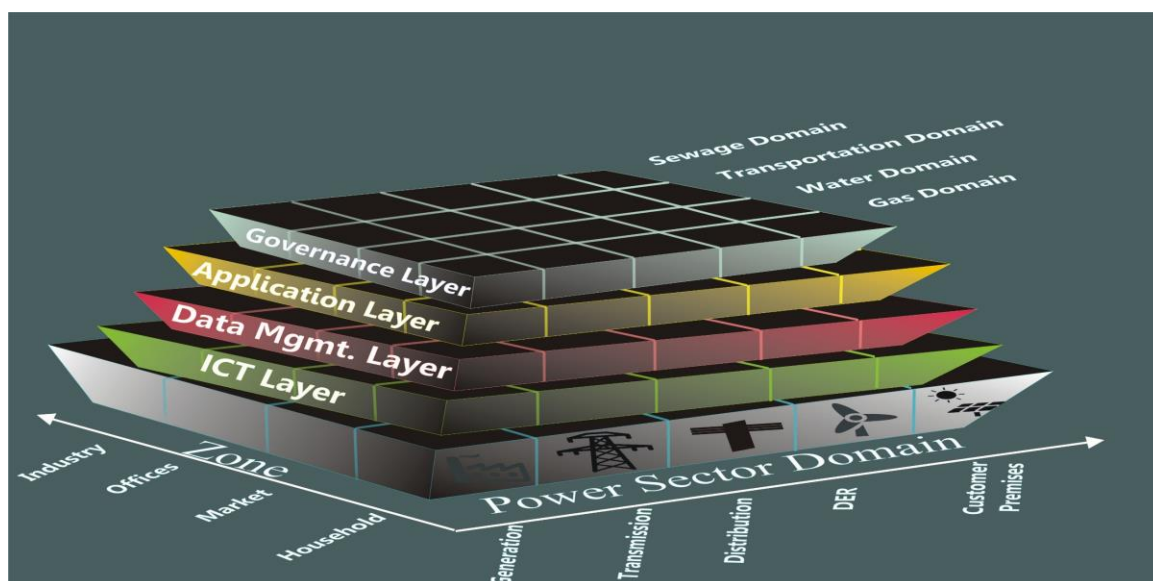


Figure 4: Interdependency of Domains

Detailed list of Infrastructure Pillars/Domains/Sub-domains are:

Sr. No.	Pillar	Domain Name	Sub-domain Name
A.	Physical Infrastructure	Energy	<ol style="list-style-type: none"> 1. Electricity 2. Renewable Energy 3. Gas 4. Other Fuels (cooking, heating, manufacturing) 5. Energy Efficiency
		Water	<ol style="list-style-type: none"> 6. Potable Water 7. Non-Potable Water 8. Industrial Water 9. Agricultural Water 10. Other Water Bodies (Ponds/Tanks/Lakes) 11. Rivers and Canals
		Waste	<ol style="list-style-type: none"> 12. Hazardous Waste (Toxic/Reactive/Corrosive/Explosive) 13. E-Waste 14. Medical/Bio-medical Waste 15. Sanitation & Sewage 16. Radioactive Waste 17. Rain Water/Storm Water/Drainage 18. Municipal Solid Waste (Incl. Religious Waste)
		Transportation	<ol style="list-style-type: none"> 19. Road/Rail/Metro/Tram/Multimodal 20. Water 21. Air 22. Electric Vehicles

		Buildings and Market	23. Residential 24. Commercial 25. Industrial 26. Shopping Malls 27. Market Places/Mandis 28. E-Commerce Infrastructure 29. EV charging stations 30. Parking Lots
		Communication	31. Voice 32. Data (Incl. M2M & IoT) 33. Video 34. Post & Courier
		City Control Centre	35. Common Command and Control Room 36. Weather & Events Forecasting
B.	Institutional Infrastructure	Governance Transparency & Accountability	37. E-Governance 38. Service Delivery
		Security	39. Physical Security 40. Cyber Security 41. Policing 42. Surveillance
		Emergency Services	43. Fire 44. Ambulance 45. Disaster Management
		Enforcement	46. Policing
		Planning	47. GIS 48. Modelling Tools 49. Data Collection and Analytics
		Legal	50. Court 51. Legal Cells 52. Prison/Juvenile Centres
		Environment	53. Environmental Sustainability
C.	Social Infrastructure	Education	54. Primary Education 55. Higher Education 56. UGs/PGs/PHDs 57. Research Institution 58. E-learning 59. Adult Literacy Centres 60. Vocational Training
		Health	61. Primary Healthcare Centers 62. Super Specialty hospitals 63. Mobile Health care services 64. Emergency Health care services 65. Preventive Vaccination 66. Child Mortality rate 67. E-Healthcare
		Religious And Culture	68. Public Parks 69. Recreation Clubs 70. Theatre and Auditoriums 71. Places of Worship
		Sports	72. Playgrounds/Gardens

		Recreation & Entertainment	73. Sports Academies/Training Centres 74. Training Centres
		Innovation	75. Culture inspiring Innovation, Development of Clusters
		Peoples participation in decision making	76. RWAs 77. Complaint/Suggestion Review 78. Feedback Collection
		Citizen Advisory Committees	79. Women/Children Welfare Bodies
D.	Economic Infrastructure	Economy	80. GDP 81. Job Creation 82. Incubation Centers 83. Government Institutions 84. Livelihood Activities 85. Market Growth
		Finance	86. Banking 87. Micro Finance 88. FDI & FII Investors

SMART CITY MATURITY MODEL (SCMM)

ISGF studied the ISO 37120 standard which specifies the benchmarking points for various themes/domains and designed a Standard benchmarking Framework for Smart Cities called the Smart City Maturity Model (SCMM). In the SCMM, the levels of maturity of a city in each of the above city domains/sub-domains will be defined in clearly measurable characteristics. This can be an effective tool for assessing the “AS-IS” state of a city in each of the domains. Once the “AS-IS” state is surveyed/evaluated, the stakeholders can decide where the city should focus on improving its infrastructure and services based on the long term vision for the city. Once the “TO-BE” state is defined for the city in each of the infrastructure domains and services, it will be possible to prepare a transformation roadmap for the city and plan projects in each domain in a phased manner and also undertake cost-benefit analysis for each of those projects. SCMM is being developed on the basis of Smart Grid Maturity Model (SGMM) being maintained by the Software Engineering Institute at Carnegie Melon University. This tool would help in order to prioritize and plan activities and develop a roadmap for building smarter cities and it would bring the competitiveness, sustainability and better quality of life in these Smart Cities.

CONCLUSION

The concept of a Smart City is gaining popularity, but the main challenge becomes how to start the process, and coordinate it. Instead of treating this as an IT project, it makes sense to anchor this around Energy and Power, for the below reasons:

- 1) IT is an enabler, a means to an end. The services and outcomes are really the end-goal
- 2) Power is a critical human need, and spans the entire multitude of operational, logistical, and philosophical needs for public utilities and services. It is neither as profitable as telecom, nor as loss-making as water/sewerage. It is neither entirely a public good (basic human right) like water, nor a purely commercial commodity

- 3) The scale and scope of both power and underlying efforts (from R-APDRP to Smart Grids) make this utility a logical anchor for all other functionalities

Smart Grid can become the anchor of Smart Cities to accelerate the development of liveable, workable and sustainable eco system in Indian Cities. Renewable energy is the key to build sustainable future which will enable green energy consumption in Smart Cities. Standard Framework for Smart Cities would help in understanding the interdependencies of various domains and better planning. Smart City Maturity Model would map and benchmark various domains in the City and offer a framework to develop the roadmap for transformation from AS-IS stage to TO-BE stage in a phased manner.

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