ABSTRACT

Background to guide for policy makers in India towards a pathway for standards based systemic mechanism design of sustainable energy in codified Smart Cities architecture

Shashanka Shekhar Panda

Founder Chairman and CEO
BLUE EARTH ENTERPRISE
shashanka.panda@bluearthenterprise.com
shashankshekharpanda@gmail.com
+919873305166
FOREWORD

The Smart Cities initiative by the Government of India presents an opportunity to transform the way in which we run our cities. While conversations on important topics such as sanitation, transportation, municipal finance, and water are ongoing, a crucial issue that is not sufficiently discussed from the perspective of cities and local governments is energy.

The UN estimates that cities are responsible for close to 75 per cent of global primary energy and 70 per cent of global carbon emissions. The situation in India is particularly severe - peak electricity demand in our cities is rising each year and yet over 400 million people in India are still waiting for access to reliable sources of energy. British Petroleum's Energy Outlook 2035 states that energy demand in India is expected to increase by 132 per cent by 2035 while the growth in production will be near 112 percent.

For India to achieve smarter and more livable cities it is vital for stakeholders to articulate strategies for achieving low-carbon, energy efficient and energy secure cities in India. With 70 per cent of India's building stock for 2050 yet to be built and potential annual savings from energy efficiency pegged at 42 billion USD the opportunities are immense. However, realizing these opportunities and unlocking cleaner options such as rooftop solar and bio-methane from sewage demand integrated action by municipalities, utilities, urban planners, citizens, State Governments and the Government of India.

In this backdrop, NIUA is pleased to invite a brainstorming and consultation on what should be a strategic overview and approach to energy in, and for, Indian cities. Convened in partnership with Blue Earth Enterprise this consultation is aimed at initiating a conversation between experts and actors that control or influence different levers of energy and electricity in our cities. The background paper sets out a broad canvas of technologies and ideas to stimulate a wholesome discussion. I am hopeful that our Energy Consultation will succeed in both, informing the policy framework for the Smart Cities mission, and identifying actionable strategies for our cities.

Professor Jagan Shah
Director
National Institute of Urban Affairs
Introduction

The Smart Cities Mission is an ambitious initiative that is pan-India and cuts across sectors. It seeks to redefine not just urban life but also the Indian economy and our social fabric as a whole. The potential is transformational, however, this mammoth undertaking necessitates a paradigm shift in the way we have been managing our cities. Smart Cities can be thought of as a singular overarching idea that brings under it multiple ideas that are whole economic sectors in themselves.

Sustainable Energy is one such idea in the quintessential multi-axial complex of Smart-Cities architecture and design. In the long list of public goods and services that a city provides its inhabitants with, Energy is preeminent. The direct impact and the indirect nexus that energy has with possibly every other sector, including critical ones such as water, transport, and industry makes Energy one of the topmost priorities when addressing the Smart Cities Mission. Before implementation begins, this mission will benefit from cogent mechanism design, a definitional framework with well-defined standards and standardized systems that are suitably modified only to meet regional and local objectives or constraints.

This first stakeholder consultation would act as the preliminary step towards achieving this objective. This background paper seeks to be a ‘conversation starter’ around the idea of Sustainable Energy integration in Smart Cities and would kick-start wide consultations with stakeholders that would ultimately inform government policy towards a cogent cohesive implementation framework for executing the Smart Cities Mission.

The Stakeholder Consultation is expected to be guided by the following key questions.

1. What are the international standards for sustainable energy in cities and what are the primary indicators that must be applied to cities in India?
2. At what level should we strategize for sustainable energy in Indian cities? What are the advantages of looking at the energy system as a whole? Should strategizing happen for smaller geographical entities?
3. How significant are renewable energy technologies for Indian cities and will they become a mainstay of energy supply in cities?
4. What policy interventions might be devised to integrate energy networks to optimize energy consumption in cities across buildings, transportation and industry? For example, should electricity regulators enter domains such as transportation?
5. What are the arguments and strategies for prioritizing sustainable energy initiatives in generation, and energy efficiency in transmission and distribution?
6. How would the present regulatory framework of the energy and electricity sector be impacted by policy design for Smart Cities? What fundamental shifts can we foresee?
7. How do we approach funding mechanisms for deployment of sustainable energy in Smart Cities? What would be the role of central, state and municipal financing and that of PPPs within these funding mechanisms?
8. What are the probable scenarios that we see emerging in the foreseeable and distant future? Is the reasonable case ‘hopeful’ or ‘challenging’?
9. What is the appropriate overarching structure of regulatory mechanisms for Smart Cities? What are the rewards and punitive measures for establishing development and operational integrity?

10. How can we address capacity building issues in monitoring and regulation of Sustainable Energy integration in Smart Cities? What are the appropriate Quality Management Systems required?

11. What role do we see local communities playing in development of Smart Cities? How can we integrate people in the discourse on Sustainable Energy integration in Smart Cities?

With these key questions in mind, the consultation aims to bring stakeholders from across the energy sector. Our goal is to initiate a discussion that allows policy makers to develop measurable standards and strategies for energy access and security in cities across India. This is essential to support regenerative efforts both in our existing cities and new ones that emerge.

Shashanka Shekhar Panda
Founder-Chairman and CEO
Blue Earth Enterprise
Contents

Reasons to act ‘smart’ .................................................................................................................. 5

The climate change equation ........................................................................................................ 5

Hurdle of urbanization and the need for speed: Turning challenge into an opportunity ............... 5

Demographic dividends, industry, information age and the urban cauldron ................................. 5

Mitigation Benefits, Co-Benefits .................................................................................................. 7

Sustainable energy integration in Smart Cities ............................................................................. 7

Fossil Energy with CO₂ Capture and Storage (CCS) .................................................................... 7

Shale (natural) gas: a transition fuel .............................................................................................. 7

Underground Coal Gasification (UCG) .......................................................................................... 8

Renewable energy generation ....................................................................................................... 8

Wind ............................................................................................................................................. 8

Solar ............................................................................................................................................. 8

Waste to energy ............................................................................................................................. 9

Smart grids and meters .................................................................................................................. 9

Energy Efficiency .......................................................................................................................... 9

Internet of Things (IoT) ................................................................................................................ 10

Industry and agriculture ................................................................................................................ 11

Jyotirgram Yojana: Transforming Agriculture and Electricity in Gujarat ..................................... 12

Transportation ............................................................................................................................... 13

Technology breakthroughs .......................................................................................................... 13

Thorium Nuclear Reactor ............................................................................................................. 13

Smart Cities Mechanism Design: pathway to regulatory policy implementation ......................... 14

SMAART CITIES© - Definitional Acronym ................................................................................. 14

Core and Supportive Indicators: ISO 37120:2014 and Global City Indicators .............................. 15

Data, Data, Data: In God we trust and everybody else brings data to the table ............................. 15

Open source ................................................................................................................................. 15

Mapping India through data visualization .................................................................................... 15

Technological and digital integration ........................................................................................... 15

Regulatory mechanisms ............................................................................................................... 16

Capacity building ......................................................................................................................... 16

Financing ..................................................................................................................................... 17
Sustainable Energy Integration in Smart Cities in India

Background to guide for policy makers in India towards a pathway to standards based systemic mechanism design of sustainable energy in codified Smart Cities architecture

Reasons to act ‘smart’

The climate change equation

India generated 2,505 MtCO₂eq of GHGs in 2010¹ (Source: World Development Indicators, World Bank) through anthropogenic activities. A significant 43% (electricity/heat – 37% and other fuel consumption – 6%) of this was contributed by the energy sector. Buildings in India accounted for 35% of the total energy consumption (Source: GBPN - Mitigation potential in India’s buildings). Further, due to the nexus of the transport sector (direct emissions: 6%, 2010, World Bank), especially passenger transport and the industry sector (direct emissions: 17%, 2010, World Bank), with urban lifestyles in India, it can be said that direct and indirect emissions attributed to urbanization in India pose a grave threat contributing to climate change.

The Fifth Assessment Report (AR) of the Intergovernmental Panel on Climate Change (IPCC) observes that, in the global context, the impact of doing nothing is very likely to have a significantly adverse impact on the environment – 3.7 degree to 4.8 degree centigrade rise in temperature by 2100.

Be that as it may, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) asserts that the baseline estimates of the “consumption loss” (not the same as GDP loss) of taking mitigation action in buildings, transport and the industrial sector combined would be negligible – 0.06% on an annualized basis till 2100 to meet the target of less than 2 degree centigrade temperature rise over pre-industrial levels or upto 450 ppm of CO₂eq of GHGs.

However, the IPCC adds a caveat that if such preventive measures are not deployed immediately it might be very difficult to reverse the tide, particularly after 2030.

The urbanization hurdle and the need for speed: Turning challenge into an opportunity

Demographic dividends, industry, information age and the urban cauldron

Approximately 62.6% of India’s population i.e. 784 million people are in the working age group of 15-59 years as against about a billion for China (68% of total population, Source: United Nations), a nation comparable in terms of population. However, by 2050, while India would boast of, by far, the largest pool of citizens in the working age group – over a billion (62.2% of population and only negligibly different than the global average of 57.5%), China would witness a decline to 727 million (52.5% of population, Source: United Nations).

The data above needs to be read in the context of the urbanization trends projected by the United Nations in its report “World Urbanization Prospects, 2014”. The report predicts that India would possibly add the largest chunk, 404 million people, to the global urban population of approximately 2.5 billion by

¹ India published GHG emission data last in 2010 for the year 2007 (Source: INCAA, MoEF)
2050. It puts China at a distant second at 292 million. Consequently India’s urban population would grow from 410 million (2014, 32% of population) to 806 million (2050, 50% of population).

It is evident that these two sets of statistics simultaneously present a challenge and an opportunity; contextual to the response mechanism that India evolves over the next few years and the degree of success in implementation that can be achieved over the next few decades. Analyzing the Inclusive Wealth Index (IWI), 2012, UNEP & UNU-IHDP, would be relevant here. India ranks second only to China on the aggregate IWI but slips to a distant sixth on a per capita basis, primarily driven by lack of human capital development.

Consider just these two of many indicators on innovation in India:

- **Global Innovation Index, 2014, WIPO**: 76 out of 143 nations.
- **Global Entrepreneurship and Development Index, 2014**: India ranks at 76 out of 121 nations.

Even though it has improved significantly from 89 out of 118 nations in 2012, this is still concerning.

The trouble with the rankings above is not structural but symptomatic of lack of policy vision and execution over the past few decades. Given the huge potential demographic dividend and the substantial and heterogeneous natural resources (India ranks 16th on the value of energy resources including 5th on Coal reserves) that India has, intuitively one can say that the manufacturing sector is a fertile ground for establishing India as a global hub at the cutting edge of innovation and technology. A recent study (2014) by Boston Consulting Group and Confederation of India Industry (CII) states that India has the potential of becoming the third largest manufacturing hub in terms of value – USD 1.42 trillion – by 2030. These findings are consistent with the “Make In India” initiative launched by the Government of India.

**The ‘Chandrayan Relative’**

It would be worthwhile to mention the now famous ‘Chandrayan Relative’. India has sent a probe to Mars at a cost of USD 76 million, as against the NASA mission that cost USD 671 million. It has been relevantly pointed out that even the Hollywood movie Gravity (on a similar theme) at a budget of USD 100 million was costlier. Point being that India is able to achieve the same technological feats at a fraction of the costs, internationally. This ‘fraction’, relative to international costs, could manifest, scaled for various differences and idiosyncrasies across India’s economic sectors.

Further, according to a recent study by McKinsey Global Institute (India's technology opportunity, Dec 2014), India can add USD 500 billion to USD 1 trillion to its GDP, by 2025, by harnessing latent strengths in development of sustainable technologies that are the next frontier of scientific breakthroughs. The analysis presented in the report runs parallel to the aspirations expressed in the “Digital India” initiative of the Indian government. If India can achieve these aspirations, we would not just remain a low cost proposition but also become a high value destination.

In the light of the urbanization trends, economic objectives and extant potential in India mentioned above, it is self-evident that existing Indian metros, cities and towns need to be sustainably altered in
structure with sustainable behavioral changes to fructify achievements and progress. This idea is further buttressed by the mitigation strategy mentioned in the 5th AR of the IPCC: "Effective mitigation strategies involve packages of mutually reinforcing policies, including co-locating high residential with high employment densities". Clearly, “Make In India” and “Digital India” cannot succeed, it must be reasserted, in the absence of “Smart Cities”.

**Mitigation Benefits, Co-Benefits**

IPCC’s 5th AR points out that not only are the “consumption loss” towards effecting necessary mitigation efforts negligible but also clarifies that these “consumption losses” do not factor in the benefits and co-benefits of mitigation of adverse climate change impact. The co-benefits may be listed briefly as:

- **Energy sector**: energy access and security, resource sufficiency, employment generation, irrigation, flood control, lower air pollution, better water supply quality and quantity enhancement, and supply chain sustainability (not listed by IPCC)
- **Transport sector**: technological spillovers such as battery technology breakthroughs, lower noise and air pollution, efficient multimodal transport systems led decongestion resulting in productivity enhancement, road safety
- **Buildings sector**: energy security, productivity enhancement, asset values improvements, employment, pollution reduction, waste management, and water use optimization.

**Sustainable energy integration in Smart Cities**

Let’s take a look at the cards that nature has dealt India as far as energy reserves are concerned. India has the world’s fifth largest reserves of coal at 267 billion tons. However, just 20 billion tons is extractable (Source: TERI). India’s reserves of oil (894k barrels/day production vs. 3,727k barrels/day consumption, 2013) and natural gas (33.7 billion cubic meters production vs. 51.4 billion cubic meters consumption, 2013) are less than 1% of the world’s proven reserves (All data sources: BP Statistical Review of World Energy Report 2014). This is surely not a very good advertisement for energy security, a very critical measure of economic and national security, and thus deserves urgent attention.

Hence we must invest in installation, indigenization, research, development, and capacity building in renewable energy technologies, energy efficiency technologies, and energy storage technologies vigorously. However, fossil fuels are here to stay for a few decades if not longer. Therefore, it’s important that a few technologies be considered for research, development and deployment (RD&D) through the transition phase from fossil fuels to renewable forms of energy.

**Fossil Energy with CO₂ Capture and Storage (CCS)**

CCS prevents CO₂ emissions from entering the atmosphere by grabbing point-of-source emissions and interring them into a storage site such as geological formations or in the form mineral carbonates. However, capturing, compressing and sometimes transportation to the storage site increases fuel requirement by 10-40%, thereby reducing the efficacy in proportion to the extra fuel required. As a result, the financial feasibility of this technology is questionable.

**Shale (natural) gas: a transition fuel**

Natural gas produces about half the CO₂ emissions than coal for the same quantum of energy generated. However, latest research points out that if natural gas leakage is even 3.2%, then natural gas is as bad as coal. In another research, it has been claimed that the leakage is more than 3.2% starting
from extraction to consumption (Source: Cornell University). However, this claim has been contested by Lawrence Cathles who says that more careful studies by the Environmental Protection Agency put the leakage at below 1.5%. Additionally, given the differentials in the decay of methane gas on burning natural gas as opposed to CO2 in burning oil or coal, the former is still a better bet.

The 5th AR of the IPCC also suggests, backed by robust evidence, that the replacement of “current world average coalfired power plants with modern, highly efficient natural gas combined-cycle power plants or combined heat and power plants, provided that natural gas is available and the fugitive emissions associated with extraction and supply are low or mitigated” is the way forward.

**Underground Coal Gasification (UCG)**
This seems to be a plausible case for India. UCG is applied in situations where coal reserves are not technically or commercially extractable. According to a survey of National Resources, 2007, World Energy Council, UCG can help exploit 600 billion tons of unreachable coal coal reserves. According to Lawrence Livermore National Lab, the exploitable USA coal reserves can be enhanced by 300% by UCG. Considering most of India’s coal reserves might be inextricable, UCG might just be the technology that is required at the moment.

UCG has a positive social and environmental impact. It doesn’t require mining and therefore it minimizes hazard to life and flora and fauna. Also, the environmental impact is minimal. There is no surface damage because there is no extraction process involved. As a result of minimal surface damage, noxious gases such as SO2 and NOx are not discharged into the atmosphere. There is a possibility that UCG can be used with CO2 Capture and Storage (CCS).

On the flip side there are a number of operational concerns with the technology and so judgment needs to be tempered in the light of recent incidents, one of which was in Australia where the government filed charges of environmental damages against Linc Energy UCG plant in 2014. Further, in 2010, Bulletin of Atomic Sciences asserted that UCG could lead to a quadrupling of CO2 emissions if used without CCS.

**Renewable energy generation**
Considering the relatively nascent situation of the various mitigation options for fossil fuel energy, we can see that the scope for localizing these technologies is still limited. Hence a switch to renewable sources of energy is highly desirable with more investment in R&DD for renewables.

**Wind**
India has an installed capacity of 22.5 GW as of December 2014. The potential of wind energy in India has been measured at 100 GW by the Center for Wind Energy Technology and MNRE. Further India’s offshore wind energy sector is said to have a potential ranging between 127 to 350 to 500 GW. Even as the best sites for wind in India are taken up, making incremental micro-sites more capital intensive, there is opportunity in the unexplored potential in offshore wind energy. Also, bigger wind turbines can replace smaller outdated wind turbines of lower capacity at older sites. Indigenizing technology and linking the development of renewables to the “Make in India” initiative would help reduce the capital cost and net operating cost to the country.

**Solar**
India has an installed capacity of 3.06 GW as of December 2014. India has a potential of 750 GW of solar energy, according to the National Institute of Solar Energy. As technology improves the capacity
utilization factors, the use of rooftop solar would become ubiquitous and the penetration levels of solar should increase. Financial incentives for adopting this green power should be given in a more systematic institutionalized and targeted manner.

Waste to energy
India generates about 62 million tons of waste. This number is expected to reach 436 million tons in 2050. At present, India’s municipalities lack an institutionalized functional mechanism to dispose waste appropriately. As a result 81% of the waste generated is dumped indiscriminately. It has been estimated that if mechanisms to handle this waste are not devised by 2050, a dump yard of the size of London with a height of 10 meters would be required to accommodate it. Today, India boasts of just 8 waste to energy (W2E) plants, 29 refuse derived fuel (RDF) plants, 172 biomethanation plants and 279 compost plants. Most of the W2E plants are defunct for various reasons such as lack of financial due diligence, non-supply of quality/ quantity waste contracted for, lack of know-how, inadequate market infrastructure and Not In My Back Yard (NIMBY) concerns.

India’s waste to energy potential as estimated by a government task force will be around 556 MW by 2050. This might be moderate but that should not be a reason to overlook the realizable potential. The W2E sector should not be looked merely as an energy generation sector but as complementary to sectors such as waste management, health, sanitation and water. The direct benefits and co-benefits of waste to energy far outweigh the efforts and cannot be merely captured in the shallow number of 556 MW of generation potential.

Smart grids and meters
India’s sustainable energy challenge does not stop at generation but continues into the transmission and distribution (T&D) sector as well. As of 2012, T&D losses for electricity were 24% as reported by the Central Electricity Authority (CEA). This compares poorly to the world average of 9.8% in 2010. India’s Southern Grid was only recently synchronized with the rest of India with the commissioning of the Raichur – Sholapur 765 KV line in December 2013.

India has currently invested in the development of smart grids with some seriousness. 14 smart grid pilots have been approved. They will be evaluated as proof of concepts for techno commercial feasibilities and then scaled up. The purpose of the smart grids would be to essentially take care of the aggregate technical and commercial losses, renewable energy integration, peak load management, power quality improvement, creation of micro grids and distributed generation.

Smart meters, though strictly speaking are essential for smart grid infrastructure, can also be viewed as a standalone area of intervention that needs to be addressed in parallel with reducing losses. Smart meters can allow power to be fed back into the grid from households that have a surplus (say through rooftop solar) while also helping households monitor their consumption and lower their energy bills.

Energy Efficiency
India’s energy intensity (quantum of energy required for a unit of GDP) has lagged behind that of most nations. According to the Ministry Of Statistics and Programme Implementation (MOSPI), in 1970-71, India’s energy intensity was 0.128 KWh. This has only risen marginally in 41 years to 0.148 KWh.
The 5th AR of the IPCC clearly points to energy efficiency and behavioral changes as a key mitigation strategy in scenarios for reaching atmospheric CO$_2$eq concentrations of about 450 ppm by 2100, without sacrificing growth.

Adoption and implementation of green building codes that specify various parameters for applicable ‘moving parts’ of the building energy infrastructure is the most intuitive step. Again, the 5th AR of the IPCC strongly advocates such adoption and retrofitting existing buildings and goes on to say -“Building codes and appliance standards, if well designed and implemented, have been among the most environmentally and cost-effective instruments for emission reductions.”

Reproduced below are the main findings of the IPCC report, organized by major efficiency mitigation strategies:

**Technology Efficiency**
- High performance building envelope (HPE)
- Efficient appliances (EA)
- Efficient lighting (EL)
- Efficient Heating, Ventilation, and Air-Conditioning systems (eHVAC)
- Building automation and control systems (BACS)
- Use of LEDs instead of CFLs
- Day lighting
- Heat pumps
- Indirect evaporative cooling to replace chillers in dry climates
- Advances in digital building automation and control systems
- Solar powered desiccant dehumidification

**System Efficiency**
- Passive house standard (PHS)
- Nearly/net zero and energy plus energy buildings (NZEB)
- Integrated Design Process (IDP)
- Urban planning (UP)
- District heating/cooling (DH/C)
- Commissioning (C)
- Advanced building control systems
- High efficiency distributed energy systems
- Co-generation
- Tri-generation
- Load leveling
- Diurnal thermal storage
- Advanced management
- Utilization of waste heat

**Behavioral and Lifestyle Efficiency**

*Internet of Things (IoT)*

Given the multi-billion dollar business that the idea of the IoT is expected to become, it feels strange to bracket it as a sub head under Energy Efficiency or a sub-head itself under Sustainable Energy. However,
Sustainable Energy Integration in Smart Cities | Background Paper

the bracketing is exact, considering the definitional mooring of IoT is most relevant to the characteristics of Energy Efficiency.

IoT has direct implications for the energy sector through technologies such as Smart Grids and Smart Meters, which are essentially examples of IoT. However, Smart Grids are just a subset of IoT that has wider applications, particularly in the transport sector, buildings, industry and healthcare. IoT, in a mature stage, 5-10 years hence could help drive autonomous cars or at least make cars more efficient in terms of traffic management and parking space location. In its current shape, pilot projects are currently being run to test parking sensors and autonomous pods. Autonomous car tests would begin in the UK by the Department of Transport in 2015 (Source: UK Government).

Yet another application would be in traffic management. Road Safety would also be enhanced through sensors that can prevent collisions. Transportation of goods can improve through streamlining of supply chains by providing better information on the location and condition of goods. Similarly, applications in other sectors such as industry, healthcare and agriculture are aplenty.

However, like most good things, IoT comes with strings attached. At present, IoT is an energy guzzler because of a flaw in the design of the devices – devices are designed to be either more or less completely switched on or off and not to be “slightly” awake or sleeping. The existing concept of standby mode doesn’t actually dramatically reduce the energy consumption - or at least not by enough to give energy planners, policy makers and policy strategists sufficient reassurance. There are 14 billion computing devices today, expected to reach 100 billion in 2030 and 500 billion in subsequent decades (OCED, 2012). Even at steady growth in the number of these devices the energy consumption implications are huge. It has been estimated that the energy lost because of more and more devices being “always on standby” mode, is 616 TWh or equivalent to the energy consumption of Canada (Bio Intelligence Service, 2013). This number is expected to jump to 1140 TWh by 2025 (equivalent of 6% of current electricity consumption of Russia). Clearly, this presents a huge challenge in terms of reducing energy redundancy.

Industry and agriculture
Manufacturing and industrial processes along with agriculture are responsible for 17% and 22% of direct GHG emissions (Source: World Bank) and 45% and 17% (Source: MOSPI, 2012) of total energy consumption. Also, as stated earlier, the “Smart Cities” and “Make In India” constructs would need to both complement and supplement each other in order to achieve meaningful and sustainable success. Therefore, sustainable energy integration in industries and agriculture would be paramount.

It has been estimated in 2008 that the scope of energy efficiency in industries and agriculture is substantial – 27% and 33% respectively (Bhaskar Natarajan, ADB et al). Intuitively, the potential is most likely to expand in 2015 considering the rapid advancement in research and development of commercial and nearly commercial sustainable energy technologies. This applies particularly for the energy generation sector (significant augmentation in the size of wind turbines, higher CUFs in solar energy PVs), if not so much in energy transmission (smart grids is still a novel concept) and energy distribution (smart meters are only now being talked about). Further, it has also been demonstrated in sample case studies, all from the Indian perspective, that simple reorientations of operations according to existing energy efficiency best practices have yielded 12% saving in energy consumption with less or no investments (Source: Vijaykumar Kulkarni, Pradip Katti, IJRTE, 2013).
IEA has estimated that the industrial demand for energy is likely to expand by 3.5x to 4.2x between 2007 and 2050. Unless and until the primary industrial sub-sectors contribute to reducing their carbon footprint, sustainable energy integration in industrial and agricultural processes would achieve sub-optimal results. It has been widely recommended that the Indian industry shift to non-fossil fuel based generation technologies, CCS, improve material flow management and drive supply chain sustainability in systems and processes to realize the full potential of energy savings in these critical sectors.

It is an open question whether India can learn from USA and China in compelling an inevitable shift towards sustainable energy at least in the industrial sector through legislation and international partnerships.

"Gujarat, in the period 2003–06, implemented what is arguably the most far-sighted and successful experiment with its Jyotigram Yojana scheme. The cost was US$260 million—one-third of the Gujarat Electricity Board’s annual loss in 2001–02. The scheme goes “with the grain” of what farmers need but applies some simple yet effective ideas to slowly alleviate the fiscal burden of unsustainable subsidies: a ‘managed subsidy versus default subsidy’ (Shah, 2007a). The scheme basically involves separating feeders/power lines to tube-wells from those to domestic and non-farm users. As implemented in Gujarat, tube-wells get 8 hours of full-voltage electricity per day on a strict, pre-announced schedule and at a flat tariff, while non-farm connections receive 24/7 assured electricity. At the same time, new connections and pump sizes are being tightly controlled.

As a result of these changes, power supply to agriculture fell from 16 billion units in 2001 to 10 billion units in 2006, groundwater withdrawal was reduced by 20–30 percent, and Gujarat Government’s electricity subsidies have come down from US$786 million in 2001–02 to US$388 million in 2006–07 (Shah and Verma, 2008). The most satisfied group of stakeholders in this scheme are rural housewives, students, teachers, patients, doctors, and all non-farm trades, shops, and cottage industries that get 24 hour uninterrupted electricity supply. Tube-well owners are also pleased with the quality and reliability of electricity supply, though they would of course prefer longer hours. Water markets have shrunk, however, since power rationing is effective and water prices have increased. This has affected, above all, landless laborers and tenants - many have been forced out of farming as a result. The fact that it is the poorest who are most affected (and for whom an income support policy is therefore requested) offers an interesting insight into the benefits of the old policy which, it was usually claimed, benefited mostly the wealthy farmers (Shah and Verma, 2008).

Politically (and technically), this is an extremely successful scheme, as it creates a wide support base among farm and non-farm users, while at the same time controlling groundwater use and limiting subsidies. As agriculture becomes more diversified and incomes rise, the flat tariff (already 70–140 percent higher than before Jyotigram was introduced) will be gradually increased toward the average cost of supply. As described by Shah (2009), “there is nothing that … water laws, tradable ground water rights, ground water cess … can do that Jyotigram cannot do better and quicker” (p. 216)."

- Excerpt, Transforming Indian Agriculture – India 2040, Productivity, Markets and Institutions, 2010
Transportation
This sector plays an obvious and key role in any urban architecture. Given the integral nature of the sector to the design of Smart Cities Mission, it warrants equal attention.

The transportation sector accounts for 25% of total final energy consumption and 13% of GHG emissions (Source: Planning Commission, 2014) in India. Further, the ownership of vehicles per 1000 persons in India is amongst the lowest in the world. It can be easily fathomed that this number is likely to grow with expected economic growth spurred by demographic shifts. The Planning Commission projects a 7%, 8% CAGR in passenger, freight traffic between 2005 and 2030.

It is apparent, then, that Indian policy makers would have to choose wisely across transportation strategies and technologies to achieve lower carbon footprints in the transportation sector. Transportation strategies can range from building high-speed rail networks both in passenger and freight sections, constructing dedicated freight corridors and establishing transportation terminals including logistics parks. A specific intervention would be improving fuel efficiency of vehicles. Material substitution and non-fossil fuel choices would form the backbone of futuristic transportation networks.

Next, urban architecture would have to embed and integrate a multi-modal transport design. Further, digital technology interventions and IoT would be required for better traffic management. Construction and autonomous location of space-efficient parking spaces would have to be inbuilt in new cities and retrofitted in existing ones to yield a modern, low-carbon transportation superstructure.

Last but not the least, community efforts would need to be galvanized towards inducing behavioral changes such as the use of public transport. Walking and bicycling the last mile would also enhance the integrity of a low-carbon commuting design as well as throw up positive health consequences for a holistic city life and culture.

Technology breakthroughs
The imponderables in any policy design model are always the ones that offer the most risk to the predictability of the model. In our specific analysis, technological breakthroughs that appear to be promising can alter the discourse on sustainable energy. Therefore it is apt to take a quick look at these potential breakthroughs that might emerge.

Thorium Nuclear Reactor
This nuclear energy source deserves the foremost mention and it is not just because it is breathtakingly close to reality. Thorium based nuclear fission energy has been a long cherished dream of Dr. Homi J. Bhabha, and is regarded as the final frontier of India’s three stage nuclear program. India is the only country to have designed a prototype of a thorium-based reactor. This makes us pioneers in this technology, ahead of all developed nations who are usually at the forefront of nuclear science. Infact the AHWR (Advanced Heavy Water Reactor) design was completed in February 2014. The reactor is likely to go critical in 2025.

Thorium has many advantages over Uranium, especially from India’s standpoint. First, India has 25% of global reserves of Thorium as against 1% of global Uranium reserves. It has been estimated that India’s Thorium reserves are enough to generate 500 GW of electricity per year for 400 years. Moreover, Thorium based reactors would be so safe that they can be installed in the heart of a city such as Delhi.
Smart Cities

Mechanism Design: pathway to regulatory policy implementation

There are a few definitions of Smart Cities available globally, as discussed below. However, what we need is one that fits the Indian context and does justice to the ambition of the scale of the Smart Cities Mission of the Government of India as envisioned by the Prime Minister Shri Narendra Modi. It should also fit into the matrix of similar policy initiatives planned and designed by the central government such as “Make In India”, “Digital India”, “Swachh Bharat Abhiyan” and “Skill India Mission”.

SMAARTCITIES©2 - Definitional Acronym

SMAARTCITIES© is an eponym that stands as a definitional acronym which when expanded reads as Sustainable Multi-Axial Architecture of Regenerative Transformation for Cultural Integration, Technological Innovation and Economic and Skill Development.

The definition takes a holistic view of the meaning of the term in the context of the needs and aspirations of the people of India and integrates it with homogeneous policies of the core architectural parameters of Smart Cities as understood by widely acknowledged and emergent global standards. Even though the terms are self-explanatory, one term that requires particular mention is:

Multi-Axial Architecture: Sustainable Energy is one of the primary components of Smart Cities. The other primary components are:

- Urban Design
- Transport
- Water
- Waste
- Information Technology Infrastructure
- Security & Resilience

The Multi-Axial architecture would also have secondary components, a few of which are mentioned below

- Livelihood
- Health
- Education
- Food
- Art and Culture

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Core and Supportive Indicators: ISO 37120:2014 and Global City Indicators

The first complete global ISO standard of Smart Cities based on the Global City Indicators Facility, a program of the Global City Institute were published in 2014. The new standard gives cities a common performance yardstick. The standard has 17 clear defined core and supporting indicators with a standard approach for measuring each one. These indicators can be used to measure the performance of cities across a range of parameters. Several are not fundamentally different from the Multi-Axial Architecture mentioned above in the SMAART CITIES® definitional acronym.

It would be apt to mention that even as though it is efficient to adhere to a common global standard, some city indicators would be more relevant than others for different cities and respective national governments must evolve additional indicators wherever necessary. UK (BIS: PAS 180, PAS 181, PAS 182) and Europe have evolved their own definitions. It might be that these definitions and standards are rendered redundant, but it is necessary that national governments attend to the task of evolving standards and definitions diligently in the light of the ISO standards.

Data, Data, Data: In God we trust and everybody else brings data to the table

The study and analysis of the data thus generated by various stakeholders would be very essential for measuring the performance of the various aspects of Smart Cities and informing further development and course corrections. This cannot be stressed enough.

Open source

The general rule would be that data would be available on an open source basis. This would help private stand-alone entrepreneurs and researchers to contribute while keeping developments transparent and the costs low. This would also create a dynamic macrocosm of creativity and harness the latent human resource strengths of India and could impact economic growth and the social fabric in positive ways. However, protocols for security and standardizations need to be developed.

Mapping India through data visualization

The exercise in data gathering, classification, and analysis would essentially map India and its cities on various metrics. Data visualization would be an essential aspect of an intuitive understanding of a city’s performance across various parameters and aspects.

Technological and digital integration

All the data would need to be made available in a digital environment via the Internet to all stakeholders.
Regulatory mechanisms
The Smart Cities Initiative would essentially need to be a rule-based system in its regulatory approach, with adherence to strict codes, methods, standards, and models. The swift and flawless execution of the initiative might require a specialized regulatory body to be created along the lines of the CERCs in the center and the SERCs in the states in the electricity sector. The Smart Cities Initiative could potentially exhibit features of a grid-like structure that spreads on a pan-India basis. Also, the involvement of the government and governmental agencies with Smart City developers (including but not limited to real estate developers) would be a central feature, overseen by an independent regulator. The Smart Cities Initiative would need to be based on a competitive mechanism of allocating awards, contracts, and orders in all aspects of Smart Cities development - especially those that involve government allocations of any kind and of any value. Further, transparency in policy design and regulatory mechanisms would be the key success factor.

These features might require legislation. The legislation would focus on devising laws, rules, systems, processes, procedures, standard and codes that would inform the execution of models, pilots and then scale them into full-fledged projects in an institutionalized manner.

The function of the regulators might range from enforcement of laws, arrived at after consultations that deal with financial and operational aspects of budgetary allocations to various parts of the Multi-Axial architecture. It stands to reason that the pending Real Estate Bill might become a base for working on a more comprehensive piece of legislation.

However, in the interest of exigency, the governance structure can bypass elaborate legislation and focus instead on federal cooperation through various budgetary financial incentives. Either way the Smart Cities Initiative, including the design and implementation of the Sustainable Energy aspect of the Multi-axial architecture will benefit from a dedicated authority / institution that is built to regulate the Smart Cities Initiative.

Capacity building
India’s Smart Cities Initiative is a massive undertaking that requires scores of experts from multiple economic sectors at the design stage itself. At the implementation stage, the success of the initiative would involve a pan-India workforce of hundreds of technically qualified, middle management professionals across economic sectors in various cities including metros, tier I, II and III cities.

Workforce
At the physical infrastructure execution stage, there would be a need for a large number of supervisors as well as skilled and semi-skilled workers. Therefore it is necessary that human resource training is of high standards to ensure that system design can be implemented as per agreed standards.

Skill development
There would be an immediate need for dedicated programs to be instituted and conducted to ensure standard operating procedures are followed.

Scientific research and development
This would be a long-term effort that would involve knowledge institutions acting in integrated mechanisms that would yield specific outcomes through investment in RD&D efforts. Success would require technological collaborations with international knowledge institutions and experts within India.
Financing

The crucial question overfunding the Smart Cities initiative may be understood in two parts:

1. What are the sources of funds available and what are the allocations that we can expect from the Centre, State, Urban local bodies and Private sector?
2. What kind of regulatory mechanism would apply to funding for projects, risk management and eventual ownership of projects and activities emerging from the Smart Cities Initiative?

A key prerequisite for funding sustainable energy integration in Smart Cities should be ‘doing things differently’. Primary objectives should be reducing the carbon footprint and energy intensity of the economy. This essentially implies rerouting, primarily, the current capital expenditures and secondarily the operating expenditures towards more efficient design.

It can be argued that the funding architecture of sustainable energy integration behaves essentially as a bond where the sustainable energy design is funded by the expected energy efficiencies on a year-to-year basis over the next 30-4-50 years.

Given the clear economic and social benefits that emanate from sustainable energy integration, one could say that a long-term bond market for Smart Cities appears to be the most apt mechanism for raising funds. Consequently, there would be both scope and necessity for ‘Public Private Partnerships’ (PPPs) on a project wise basis.

India lacks a deep and tradable long-term bond market. Here, the financial market regulator must play a leadership role in enabling a municipal bond market so that urban local bodies may independently approach financial markets to raise funds. In time, a market for a more sophisticated suite of financial instruments from debt to mezzanine to equity instruments might develop, supported by expected outcomes driven by the substantial benefits of energy efficiency and clean energy.

Public Private Partnerships: A silver bullet?

Given the national importance and footprint of the Smart Cities architecture that would permeate through the cities, life, culture and work of all Indians, ownership of assets created in the wake of the Smart Cities might need to be remain in public hands, especially if a significant share of investment comes from public sources.

Even though bond funding can cover significant investment needs, PPPs would play a catalyzing act in the Smart Cities initiative. A fresh and approach that can be envisioned is the use of PPPs to view them as more than a funding mechanism but a driver of sustainable technological breakthroughs especially by young entrepreneurs through incubation of startups.

Elucidated further, where the projects are technologically cutting edge - using state of the art proven technology developed through pioneering entrepreneurial efforts and of ‘medium’ financial intensity - PPPs might serve the purpose of not just acting as a funding mechanism but incubating the future entrepreneurs. This would also integrate and dovetail the “Skill India Mission” into the “Smart Cities Mission” and enhance efficacy of Government schemes.