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ENERGY FUTURE

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Innovative Approaches for Smart Cities of India

The Present and Future Perspectives

Tracking the Sun for a Gainful Purpose

A Cost-Competitive Energy Option for Extra Power Generation

Energy Consciousness in Smart City Movements

A Unified Approach for Effective Implementation

VIEWPOINT

Gautami Palanki
Director, US Green Building Council

teri

Head Office
TERI
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel. +91 (11) 2468 2100 or 2468 2111
Fax +91 (11) 2468 2144 or 2468 2145
Regional Centres
Southern Regional Centre
TERI, CA Site No. 2
4th Main, 2nd Stage Domlur
Bengaluru – 560 071
Email: terisrc@teri.res.in
North-Eastern Regional Centre
TERI, Chachal Hengrabari
Express Highway, VIP Road
Guwahati – 781 036
Western Regional Centre
TERI, F-9, La Marvel Colony
Dona Paula, Panaji – 403 004 (Goa)
Email: teriwrc@goatelecom.com
Affiliate Institutes
TERI North America
1152 15th Street NW Suite 300
Washington, DC 20005
Email: terina@teri.res.in
TERI Europe
27 Albert Grove, London SW20 8PZ, UK
Email: ritukumar@aol.com
Overseas Representation
TERI Japan
C/o IGES
Nippon Press Centre Building (8th Floor)
2-2-1, Uchisaiwai-cho, Chiyodi-ku
Tokyo, Japan - 100-0011
Email: teris@iges.or.jp
TERI South-East Asia
Unit 503, 5th Floor
Menara Mutiara Majestic
15 Jalan Othman,
Seksyen 3, 4600 Petaling Jaya,
Selagor Darul Ehsan, Malaysia
Email: nimtech@tm.net.my
TERI Gulf Centre
Flat No. 105, Dalal Building, Al Qusais,
Dubai, UAE

From the editor's desk...

Nowadays, there is a clamour to transform into a 'smart city'. It has intensified in India after the Government of India launched its 'Smart Cities Mission'. Recently, 20 cities were selected in the first round. But what does one mean by a smart city? At the very first instance a smart city is perceived to be an urban habitation that banks on information and communication technologies (ICT) to make it smart. Perhaps this thinking originated from IBM's 'Smarter Planet' initiative in 2008 conceptualized around digital technology, big data, cloud, and mobile connectivity. However, ICT will always remain a 'mean' to reach somewhere, to achieve something; ICT in the context of a smart city is not a 'goal' in itself. Against the backdrop of rapid urbanization—with ever increasing pressures on urban infrastructure—the needs for making cities smart could include: (i) Providing better services to the residents thereby facilitating better lifestyle; (ii) Fostering more inclusive and equitable growth; and (iii) Making the city more adaptive and resilient to climate change. These needs, in turn, translate into goals, such as optimal utilization of resources particularly energy and water; pursuing a trajectory that is significantly less carbon-intense; becoming self-reliant through locally available resources; and provision of overall good governance.

Thus, a smart city would essentially have many initiatives converging to affect the desired outcomes. These would comprise, for instance, increased reliance on renewables-based decentralized, distributed energy generation; use of efficient appliances with two-way communication with the utilities; rational use of energy in commercial and industrial sectors; a clear shift towards public and non-motorized transport along with greater use of electric personal vehicles; and, waste minimization on one hand and reuse of waste on the other. The point to be noted is that a smart city transformation is actually a process or continued evolution especially since technologies are changing so fast. Indeed today's 'smart' could turn 'unintelligent' tomorrow if technological advances of the day are not exploited for the betterment of the city. The energy future is intrinsically linked to such evolutionary processes, in terms of how the energy is generated and also, how that energy is utilized, even at a city level.

Amit Kumar

Amit Kumar
Dean (Distance and Short-term Education),
Department of Energy and Environment,
TERI University

Editor: Amit Kumar Radheyshayam Nigam
Printed and published by Dr R K Pachauri for The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi- 110 003. Tel. +91(11) 24682100, 4150 4900, Fax +91(11) 2468 2144 or Email teripress@teri.res.in, and printed by Batra Art Press, A-41 Naraina Indl. Area PH- II, New Delhi-28.

teripress@teri.res.in

Letter to the Editor

I read the January-March 2016 issue of *Energy Future*. The Cover Story titled, "Momentous Paris Agreement and the INDCs" appropriately summarizes the significant takeaways from the Paris agreement. It is heartening to note that a goal of keeping warming well below 2°C has been set at the world climate conference. After reading about India's INDCs and the International Solar Alliance, jointly launched by India and France, I am sure that the future is bright for renewable energy utilization not only in India but all across the globe. Such initiatives and efforts by the Government of India deserve appreciation!

Deepshikha Joshi
Dehradun, Uttarakhand

"I very much liked reading the Case Study published in the January 2016 issue of Energy Future, "Green ICT Reduces Literacy Barriers in India". It is reassuring to know that information technology is playing a pivotal role in energy and education requirements of our rural folk, particularly the children. SELCO Foundation's success story is also a heart-warming one as their intervention has enabled rural schools to be grid-independent. The solar-powered computer overcomes the issues of inconsistent grid power. The use of I-slates should be encouraged in rural areas all over India."

Hrishikesh Gupta
New Delhi

Thank you very much for your encouragement. The editorial team of Energy Future will ensure that the magazine caters to your information and knowledge needs. We welcome your suggestions and comments to further improve our content and presentation.

Email: teripress@teri.res.in

Editor
Energy Future

"The January-March 2016 issue of *Energy Future* makes for a good reading. The articles on COP21 and India's INDCs are very balanced in their approach and provide a very nice overview of the climate change conundrum. I hope that India's preparations to tackle climate change also keep moving in the right track as the author has very rightly pointed out that there is a challenging road ahead for India as the country also has to tackle issues, such as plaguing poverty, food security, healthcare for all the citizens, and disaster management."

Arunima Bandyopadhyay
Bengaluru, Karnataka

"I am a Class XIIth student and I aspire to become a solar energy engineer one day. I regularly read the Solar Quarterly section of *Energy Future*. I must say that reading the articles of this section has made my resolve even more strong. I had read about the dye-sensitized solar cells (DSSCs) earlier also but I must admit that the exhaustive information given by the author in this article is really remarkable. I expect publication of more such articles on the current solar energy technology in your magazine."

Vasant Prabhakar
Pune, Maharashtra

CONTENTS




METHANE LIGHTS UP BENGALURU CITY PARKS

The twin benefits of getting rid of garbage and generating gas to light up parks and high-mast lights in the city is saving crores of rupees in Bengaluru. Eleven methane generating turbines are successfully functioning in Bengaluru and the gas produced is being used in lighting up public places. The latest of such turbine was commissioned in Domlur recently and is supplying the lighting requirement of the park. Similar gas plants are functioning at South End Circle in Jayanagar, a park in Koramangala near the Forum Mall, KCDC Centre near HSR Layout, Begur, KR Market, Nagapura, Matthikere, Kuvempu Nagar, and Gandhinagar.

This way, the Bengaluru civic body is not only biodegrading the difficult-to-dispose of garbage of the city, it is also saving for itself a whopping ₹20 crore in electricity bills annually, according to its officials. Each of these gas plants requires around five tonnes of cow dung a day, along with other biodegradable waste to generate 10–12 cylinders of biogas and around eight tonnes of high-quality liquid organic manure. A total of ₹79 lakh is spent towards the construction of each plant. An engineer revealed that Bruhat Bengaluru Mahanagara Palike (BBMP) spends ₹120 crore annually on electricity bills and around ₹20 crore per year shall be saved because of these biogas plants. A five-tonne capacity plant requires 1,825 metric tonnes (per annum) waste material to be processed at full capacity to function while it can generate 192,000 units of electricity per year. EF

Source: www.bangaloremirror.com

CANADA'S CDPQ COMMITS $150 M TO INDIAN RENEWABLE ENERGY SECTOR

Canadian institutional fund manager Caisse de dépôt et placement du Québec (CDPQ) has set up its Indian operations and announced a commitment of $150 million to the renewable energy sector, its first in growth markets. "Over the next three to four years, CDPQ will use its commitment to target hydro, solar, wind, and geothermal power assets, with investments likely to take the form of select partnerships with leading Indian renewable energy companies," it said in a statement. The move comes at a time when the Government of India has set up a goal of 100 GW of solar capacity and 60 GW of wind power by 2022.

CDPQ has named former World Bank executive Anita Marangoly George as Managing Director, South Asia, effective from April 1, 2016. Based in Delhi, Ms George will head CDPQ India, with the objective of finding the best investment opportunities across all asset classes in South Asian markets. CDPQ invests globally in major financial markets, private equity, infrastructure, and real estate. "We believe India stands out as an exceptional country to invest in, given the scope and quality of investment opportunities, the potential for strategic partnerships with leading Indian entrepreneurs, and the current government's intention to pursue essential economic reforms," said Michael Sabia, President and Chief Executive Officer of CDPQ. EF

Source: www.thehindu.com

BHEL COMMISSIONS 270 MW UNIT OF PUNJAB POWER PLANT

State-run equipment maker Bharat Heavy Electricals Ltd (BHEL) has commissioned a 270 MW generation unit at the Goindwal Sahib Thermal Power Project of private producer GVK Power & Infra in Punjab. "The unit has been commissioned at the upcoming 540 MW (2×270 MW) Goindwal Sahib coal-fired Thermal Power Project of GVK Power & Infra Ltd, located in the historic city of Goindwal Sahib in Tarn Taran district, near Amritsar in Punjab," BHEL said in a statement.

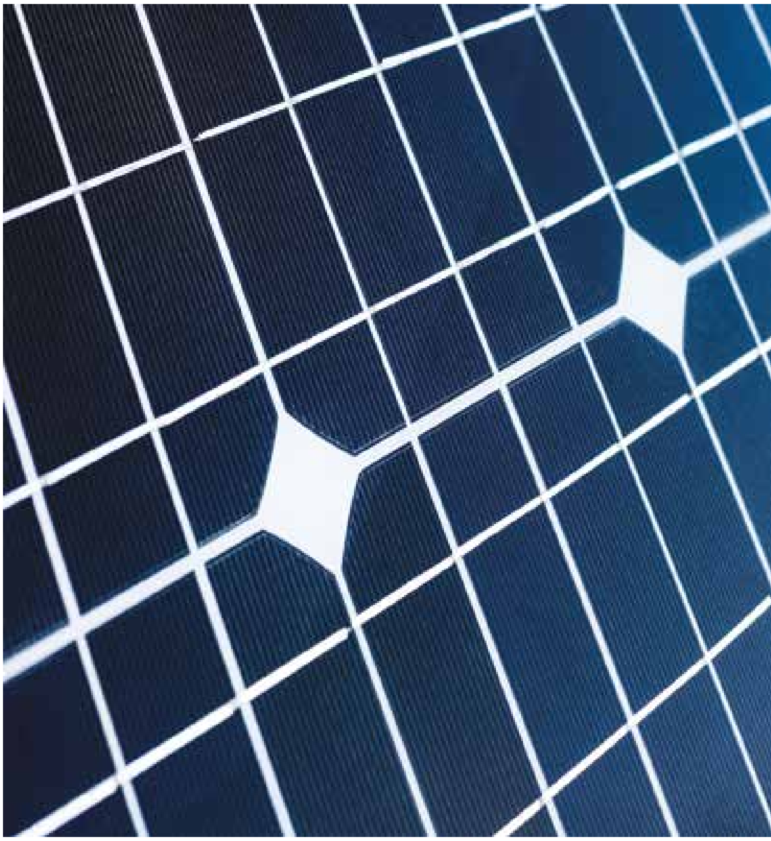
Thermal sets of 270 MW rating are in-house improvisations of the 210/250 MW sets supplied by the company earlier, which currently form the backbone of the Indian power sector and have been performing much above the national average as well as international benchmarks. All the operational sets of 210–270 MW class in Punjab have been supplied, erected, and commissioned by BHEL, i.e., six units of 210 MW at Ropar, two units of 210 MW, and two units of 250 MW at Bhatinda, besides 270 MW Unit at Goindwal Sahib. In addition to coal-based thermal projects, BHEL also has a significant presence in the state's hydro sector, with around 95 per cent share in the hydroelectric generating capacity of the Punjab State Power Corp.

Source: timesofindia.indiatimes.com

COAL INDIA'S 1,000-MW SOLAR PROJECT MAY HELP IT SAVE 30 PER CENT POWER COSTS

State-owned miner Coal India has embarked on a project to generate 1,000 MW of solar energy to save 30 per cent of its power and fuel expenses. Coal India paid a ₹2,347 crore power bill in 2014–15 and another ₹1,860 crore during April–December 2015. Coal India's power costs have risen seven per cent during the first three quarters of the financial year 2015–16 in comparison to the year-ago period. Under the present cost structure, once completed, the solar power project is likely to help save Coal India at least ₹750 crore a year. Further, through a recent viability-gap funding scheme, a one-time grant of ₹1 crore per MW of solar power will be provided for this project by the centre. A memorandum of understanding (MoU) with the Solar Energy Corporation of India (SECI) has been signed, which is guiding Coal India through the process. However, the company is yet to take a call on issues, such as power banking, distribution of the solar output, policies on power sourcing from distribution companies, and other processes. Presently, Coal India's potential solar-power areas are in Maharashtra, Chhattisgarh, Odisha, Jharkhand, Madhya Pradesh, West Bengal, and Assam. The projects are likely to come up in these areas.

Source: wap.business-standard.com



SINGAPORE'S SEMBCORP TO DEVELOP 1 GW WIND ENERGY PROJECT IN INDIA

The Government of Madhya Pradesh recently signed a memorandum of understanding (MoU) with Singapore-based Sembcorp Green Infra for the development of 1 GW wind energy capacity. The Ministry of New and Renewable Energy (MNRE), Government of India has signed the agreement with the company on behalf of the state government. The size of the capacity addition is expected to be huge. Madhya Pradesh is among the leading states in terms of installed wind energy capacity in India and is expected to see significant growth in its installed capacity over the next few years. According to the MNRE, Government of India, Madhya Pradesh may add 6.2 GW of wind energy capacity as its contribution to the 60 GW installed wind energy capacity target for 2022.

The improved policy and economic environment in India has attracted several international investors to the renewable energy market. The likes of Goldman Sachs, GE Energy Financial Services, Global Environment Fund, and Abu Dhabi Investment Authority have invested in Indian renewable energy companies over the last few months.

Source: www.cleantechnica.com

NEW DELHI STATION TURNS TO 'WASTE POWER'

Now, the waste generated at New Delhi Railway Station will not only be recycled but also be used to produce electricity to light up the station. The Delhi Division of Northern Railway is going to set up a waste-to-energy plant, that will turn the garbage and other waste collected at the station into electricity and manure. Waste generated at the New Delhi Railway Station will be segregated into bio-degradable and recyclable waste. Biodegradable waste will be converted into electrical energy and manure. Electrical energy will be utilized by the Railways, most likely at the New Delhi Railway Station itself. "It is yet another green initiative by the Northern Railway's Delhi Division and the bio-methanation plant at the New Delhi Railway station will be ready by June 2016," said Delhi Divisional Railway Manager Mr Arun Arora. "The municipal solid waste (MSW) handling capacity of the plant at New Delhi will be 15 tonnes per day," he added. The Railway Board has nominated RITES as the nodal agency for tendering for the waste-to-energy plant.

Approximately, 2,000 units of electricity produced (three phase, 415V) in the waste-to-energy plant per day will be purchased by the Railways from the contractor at the rate at which electricity is supplied to local municipal domestic users. Additionally, the Railway may also procure manure from the contractor. Nearly 15,000 m^2 of land will be required for this project, as well as 50 kW of electric power supply and 12 kl water per day at chargeable basis for operation of the plant.

Source: www.thehindu.com

CPWD TO GENERATE 42.50 MW SOLAR POWER BY SEPTEMBER 2016

By September 2016, several Government buildings across the country will be solar energy efficient with the Central Public Works Department (CPWD) setting up rooftop solar panels on them besides replacing conventional electrical fittings. The environment-friendly move will help the CPWD to generate 42.50 MW of solar energy across the country by September 2016 and in a total savings of ₹115 crore per year. The CPWD earlier signed a pact with the Solar Energy Corporation of India (SECI) for installation of grid connected rooftop solar photovoltaic panels in all government buildings maintained by CPWD across the country for generation of solar power. Consequently, SECI awarded works to 14 bidders for undertaking works in 16 States.

Ten MW of solar power will be generated in Phase-I covering Delhi (3 MW), Uttar Pradesh (2 MW), North-East, and Union Territories (UTs) (2 MW) and 1 MW each in Andhra Pradesh, Karnataka, and Maharashtra. In Delhi, solar panels have already been installed for a total capacity of 1.50 MW in six government buildings—Nirman Bhawan, Shastri Bhawan, East Block and Sewa Bhawan (RK Puram), Pushpa Bhawan near Sheikh Sarai, and CGO Complex, Lodhi Road. EF

Source: www.dailypioneer.com

MAHINDRA INAUGURATES ITS BIO-CNG PLANT IN MAHINDRA WORLD CITY (MWC), CHENNAI

The Mahindra Group has announced the inauguration of its all new Bio-CNG plant in Mahindra World City (MWC), Chennai. A joint CSR initiative between Mahindra Research Valley (MRV) and Mahindra World City Developers Limited (MWCDL), the Bio-CNG plant was inaugurated by Shri Piyush Goyal, Honourable Minister of State (Independent Charge)—Power, Coal, and New and Renewable Energy, Government of India, in the presence of Dr Pawan Goenka, Executive Director, Mahindra & Mahindra Ltd and other dignitaries.

Spread over an area of 1,000 m^2, the Bio-CNG plant aims to create a carbon neutral ecosystem at Mahindra World City (MWC), Chennai. The Bio-CNG plant will convert eight tonnes of food and kitchen waste generated daily at MWC, into 1,000 m^3 of raw biogas. Further, the raw biogas can be enriched to yield 400 kg/day of purified compressed natural gas (CNG) grade fuel which is equivalent to a 200 kW power plant. As a byproduct, four tonnes of organic fertilizer will be produced per day. The green energy (bio-CNG) can be effectively used to replace CNG as automotive fuel and liquefied petroleum gas (LPG) for cooking purposes as well as to power street lights at MWC. The organic fertilizer will be used by farmers to enhance soil fertility. Overall, it will create an end to carbon neutral ecosystem, wherein even the waste will be utilized for the benefit of the farmers. Hence, MWC has rightfully claimed the title of being India's first food-waste free city. EF

Source: www.mahindra.com

HELIATEK SETS NEW ORGANIC PHOTOVOLTAIC WORLD RECORD EFFICIENCY OF 13.2 PER CENT

Heliatek R&D teams reached a record conversion efficiency of 13.2 per cent for an OPV multi-junction cell, setting a new world record for the direct conversion of sunlight into electricity using organic photovoltaic cells. Thanks to the low light and high temperature behaviour of the organic semiconductor, the electricity generation of the newly developed cells corresponds to the output of conventional solar cells with 16–17 per cent efficiency when both are under real world conditions.

The world-record cell is a multi-junction cell combining three different absorbers. Each of them is dedicated to efficiently convert green-, red- or near-infrared light of the wavelength range between 450 and 950 nm into electricity. These absorber molecules have been developed and are patented by Heliatek. The new record efficiency was measured at simulated AM 1.5 illumination and was confirmed by the Fraunhofer - Center for Silizium-Photovoltaik - CSP." EF

Source: www.renewableenergyfocus.com

ANTIGUA AND BARBUDA SOLAR POWER PLANT INAUGURATED

The Government of Caribbean islands Antigua and Barbuda together with the UK-based clean energy provider PV Energy Limited officially inaugurated the 3 MWp solar power plant at the V C Bird International Airport of Antigua. The sun2live solar plant installation at the V C Bird International Airport, Antigua, developed and constructed by PV Energy Limited, plays a pivotal role in the clean energy strategy for Antigua and Barbuda. More than 12,000 top-tier polycrystalline photovoltaic panels generate up to 4.645 MWh per year and therefore save a substantial amount of CO_2 emissions during the same period and thus contribute to the goal of reducing the carbon footprint of the twin island state.

"The use of renewable energy sources shows the commitment of Antigua and Barbuda to defend and promote the values of sustainable development, to protect and respect the environment, and to preserve it for future generations. We are proud to support the Prime Minister's supreme vision of creating a greener environment. With this pioneering project, Antigua and Barbuda will set an example for the whole of the region", said Mr Peter Virdee, Chairman of PV Energy Limited. The 3 MWp solar power plant at the V C Bird International Airport is the first step on the path towards environmental sustainability on the Caribbean islands of Antigua and Barbuda, and further steps have already been initiated. Another PV solar power plant with a total capacity of 4 MWp will be installed in the Bethesda area on Antigua, as well as a 1 MWp solar power plant in the neighbouring island Barbuda, which will be soon installed by PV Energy Limited. EF

Source: www.renewableenergyfocus.com

CHINA OUTSTRIPS GERMANY IN SOLAR CAPACITY AFTER RECORD ADDITIONS

China, the world's largest consumer of energy, surpassed Germany as the country with the most installed solar capacity after record additions in 2015–16. The nation added 15.1 GW of new solar in 2015, bringing the total to 43.2 GW. China's solar capacity has surged almost 13-fold since 2011, according to data from Bloomberg New Energy Finance (BNEF). Germany had 38.4 GW of power supply from the sun at the end of 2015, while the US had 27.8 GW, according to BNEF. The world's biggest emitter of global-warming pollution wants to develop solar energy as a means to help meet its pledges to cut emissions. Additionally, a more robust domestic market is helping China, the world's biggest supplier of solar panels, downplay its reliance on the export market. The north-western region of Xinjiang led the effort last year to install new solar capacity, followed by Inner Mongolia and Jiangsu. EF

Source: www.renewableenergyworld.com

MIT RESEARCHERS TURN WASTE GAS INTO LIQUID FUEL

Turning the emissions of power stations, steel mills, and garbage dumps into liquid fuels has been demonstrated by MIT researchers using engineered microbes. The process has been successfully trialled at a pilot plant in China and a much bigger facility is now planned. Energy-dense liquids are vital to transport but are currently derived from oil, a fossil fuel, and transport produces about a quarter of the global carbon emissions driving climate change. Biofuels have been seen as possible replacement, but current biofuels compete with food production and have been blamed for driving up food prices. Using waste gases to create low-carbon liquid fuels would be a major advancement in the battle against global warming if they could be made at low cost and large scale. Another company expects to be using different microbes to produce fuel from steel plants in Belgium and China in 2017.

The Massachusetts Institute of Technology (MIT) process uses bacteria to convert the waste gases into acetic acid—vinegar—then an engineered yeast to produce an oil. The patents for the process are owned by MIT and have been licensed to GTL Biofuel Inc. EF

Source: www.theguardian.com

US ARMY BUYS 65 MW OF WIND, SOLAR FOR FORT HOOD

The US Army has signed a contract for its biggest renewable-energy project yet, picking Apex Clean Energy Inc. to provide 65 MW of solar and wind energy at Fort Hood in Texas.

The Defense Logistics Agency signed a 30-year contract with Charlottesville, Va. based Apex for 15 MW of solar and 50 MW of wind, the company said in a statement. The Army will pay closely held Apex as much as $497.4 million over the life of the deal, about $168 million less than what it would pay for power from the traditional electricity grid. The solar plant will be built at Fort Hood, located about 60 miles north of Austin. The wind farm will be built off-site in Floyd County, Texas. The agency expects 28 years of energy production from the farms, starting next year. The Army has as much as 600 MW of contracted renewable-energy projects in its portfolio. It also has 22 MW of rooftop solar and another 40 under development.

Source: www.renewableenergyworld.com

SWEDEN INVESTS €20 MILLION FOR CLEAN ENERGY IN ZAMBIA

Sweden's development agency will finance a €20 million ($22 million) fund to develop clean energy in Zambia through 2018. The Vienna-based Renewable Energy and Energy Efficiency Partnership (REEEP) said it will also work with Power Africa and other partners to roll out the project. The programme will probably focus on off-grid solar systems in the first year. It plans to install small hydro power plants and mini-grids later on.

REEEP will implement the projects and be responsible for the contracting. Power Africa, an initiative set up by the US President Mr Barack Obama in 2013 to boost electricity access, will provide an advisory role. The Swedish embassy in the Zambian capital of Lusaka will help with collaboration and local government relations. The group aims to bring renewable electricity supplies to 167,000 households, reaching 1 million people. About 95 per cent of rural Zambians do not have access to energy.

Source: www.renewableenergyworld.com

PAKISTAN PARLIAMENT BECOMES FIRST IN WORLD TO RUN ENTIRELY ON SOLAR POWER

Pakistan's Parliament has become the first in the world to completely run on solar power. The Prime Minister of Pakistan Mr Nawaz Sharif switched on solar-powered building of the Parliament in capital Islamabad. First announced in 2014, the venture has been funded by the Chinese government, with the solar power plant costing around $55 million. "This is the first time since independence (1947) that the Parliament has become self-sufficient in electricity through solar power. Other institutions in private and public sector need to follow it", Mr Sharif said.

According to the speaker of National Assembly Mr Ayaz Sadiq, the parliament solar panels will generate 80 MW power. He said 62 MW will be sufficient for the Parliament while 18 MW will be given to the national grid. Officials said that currently there are some parliaments like the Israeli Knesset which partly run on solar power. EF

Source: www.deccanherald.com

WELINK SIGNS $1.6 BILLION UK SOLAR DEAL WITH CHINESE COMPANY

China National Building Materials Ltd signed a 1.1 billion-pound ($1.6 billion) agreement with a UK unit of Hong Kong-based Welink Global Ltd to develop solar power projects and energy-efficient housing in the UK. China Triumph International Engineering Corp., a technology unit of China National Building Materials, will also work with British Solar Renewables in the deal to deploy more than 130 MW of solar panels in 2016, according to a statement from Welink Energy.

The companies plan to build 4,000 houses by 2018 using the energy-efficient Barcelona Housing Systems approach, designed by architects Cesar Martinell & Associates. They will feature rooftop solar panels, waste-to-energy and power storage technologies, according to the statement by Welink. A further 4,000 houses could be built after 2018 depending on demand.

"Given the scalability of our BHS solution and the near zero energy buildings that are constructed in combination with the engineering, financial and strategic support of our Chinese partners, we believe we can expand rapidly to fulfill the appetite for the development of affordable housing in the UK", said Barry O'Neill, chief executive of Welink Energy. EF

Source: www.renewableenergyworld.com

Energy Consciousness in Smart City Movements

A Unified Approach for Effective Implementation

A smart city is a sustainable and efficient urban centre that provides a high quality of life to its inhabitants through optimal management of its resources. Energy management is one of the most demanding issues within such urban centres owing to the complexity of the energy systems and their vital role. In this article, ***Atanu Dasgupta*** *focusses on energy aspects, in general, related to the theme of the Smart City deployment while dwelling mainly on the triumvirate of energy, mobility, and information and communication technology (ICT). The central idea is research and innovations on sustainability and self-sufficiency of energy in cities that are expected to pave the way to low energy blocks and areas and eventually spread their wings to whole of the city.*

A smart city is an urban development vision to integrate multiple information and communication technology (ICT) solutions in a secure fashion to manage a city's assets—the city's assets include, but are not limited to, local departments' information systems, schools, libraries, transportation systems, hospitals, power plants, law enforcement, and other community services. The goal of building a smart city is to improve quality of life by using technology to improve the efficiency of services and meet residents' needs. Smart cities have a high potential to significantly contribute to the achievement of the national energy and climate targets and achieve for the country likewise in a specific time-frame. For improved energy efficiency, it is essential to find low-carbon solutions for new buildings, blocks, neighbourhoods, and districts and new ways for the cost-efficient refurbishment of existing ones. The integration and management of energy supply with predominant exploitation of local resources and active citizen participation shall be the hall mark of smart city movements. Smart grids for electricity, gas, heating/cooling, etc., and an all pervading ICT infrastructure will be the prime enablers for this.

E-governance is identified as a prerequisite in smart city implementation which will be based on the above endeavours. In order to achieve such a goal, there are many challenges that include the management of open data, use of most appropriate applications, in addition to all related infrastructure and privacy issues. Standardization and interoperability are further key issues to be dealt with. Standards for future services and installations need to ensure compatibility with existing ones in a seamless manner. Considerations of the citizens' behaviour need to be assessed continuously and improved accordingly. Main gaps with regard to successful implementation of smart solutions may come from the associated non-technical fields, understanding of the project in a holistic manner, and quality of implementation.

THE BACKGROUND

Cities around the world have been increasing in size and number and economic activities are concentrated in urban regions and urbanization has been on the rise. According to a recent World Bank Report, 250 million more people are expected to live in cities in South Asia over the next 15 years. While the ever-increasing urban concentration raises the environmental stress through growing demand for resources and services, such as mobility, cities often stage a unique environment to allow experimentation with innovations, such as smart solutions for sustainable energy and resource utilization. As a result, local authorities manage a unique role to play favouring innovation and bringing in technological and organizational excellence and leadership. The goal, therefore, is how best to design and develop cities into the so-called smart, intelligent, and sustainable communities.

Internationally, the concept of smart cities and solutions towards smart cities highlight a complex and multidisciplinary approach towards fulfilment of a better quality of life. The smart city initiatives include strong interconnections among infrastructure planning, technological development, and holistic integration and development of citizens' services and business, city governance involving all stakeholders. The challenges include, but are not limited to, the convergence of energy generation and use alone but development of mobility sector in general and widespread deployment of ICT in every activity in daily urban life. The methodologies with respect to energy aspects in smart cities must include the integration and management of the supply of energy with deployment of local resources as much as practicable. According to a relevant European study, a 'smart city' can be defined as one that shall offer maximal quality of living to its inhabitants with a minimal consumption of resources by intelligently interconnecting infrastructure (energy, mobility, communication, etc.) on different hierarchical levels (building, district, and city). Further, in appreciation of the central role of energy in smart cities and in view of an improved energy supply and demand-side management being targeted, the term 'Smart Energy City' was introduced by Nielsen in 2013 with the following definition—"The smart energy city is highly energy and resource efficient, and is increasingly powered by renewable energy sources; it relies on integrated and resilient resource systems, as well as insight-driven and innovative approaches to strategic planning." The application of ICT is commonly a means to meet these objectives. Thus, implementation of smart city is not just another project but it is a movement that aims for holistic well-being of the city dwellers.

Smart cities have a high potential to significantly contribute to the achievement of the national energy and climate targets and achieve for the country likewise in a specific time-frame. For improved energy efficiency, it is essential to find low-carbon solutions for new buildings, blocks, neighbourhoods, and districts and new ways for the cost-efficient refurbishment of existing ones.

ENERGY CONSCIOUSNESS

Keeping in view the definition of the 'smart energy city' discussed above, the following key expressions may be focussed on as parts of the strategic planning and implementation in connection with smart city movements:

- Sustainable energy scenario
- Energy conservation
- Energy on demand and new forms of energy storage
- Flexible energy management systems for buildings, factories, etc., for electricity, gas, and water infrastructure
- Local generation, co-generation, and renewable energy
- Light-emitting diode (LED) street and residential lighting
- Co-location, sharing, and convergence
- Mobility in the smart city
- Reduction of carbon footprint
- Pervasive ICT for all the above.

In the light of above, one of the key deliverables in a smart city is initiating a conversion from fossil fuels to renewable energy for everyday city life. This is aimed at: (i) Energy conservation and reducing greenhouse gas emissions (GHGs); (ii) Reducing use of fossil fuels progressively; (iii) Utilizing local resources and creating jobs for the local community; and (iv) Reducing the costs of energy towards 2050.

The aforesaid transition is expected to encounter challenges from multiple directions that may include, but not be limited to: (i) *Technology*: The development of new technologies and infrastructure—enablers for renewable energy resources; (ii) *Business*: Opening of windows for new markets, services, and industries for implementation of such new technologies and innovations; (iii) *Policy*: The creation of new policies and institutions that will promote the most beneficial technologies for society, that in turn will usher in the most profitable investments for these new businesses.

The fossil fuels-based energy system today makes the implementation and use quite flexible and predictable as good quantum of energy can be stored in liquid, gas, and solid forms through the use of fossil fuels. Thus, energy can be delivered 'on demand' any time conveniently and flexibly, as long as there is an access to a suitable fossil fuel storage in the vicinity like a coal storage for a power plant, cooking gas in a household cylinder, homes connected to electricity/thermal grid, etc. However, owing to diminishing resources and other challenges, such convenience and flexibility cannot be assured forever. Figure 1 presents a flow diagram of the current energy system.

The energy system of the smart city will predominantly rely on renewable energy resources, such as wind, solar power, biomass, and other non-conventional sources. Currently, such resources do not contain large amounts of stored energy, but instead the energy from the wind, sun, waves, and tides must be harnessed and used in the same form as it is produced. Smart city energy systems of the future are likely to be constrained by such deficiencies. The new task in the changing environment will be how the future energy system, which will be aimed to be based progressively on renewable energy, operate bereft of such flexibility presently being provided by fossil fuels-based stored energy at an affordable cost? Probably, the solution lies in the smart city energy system that will find new methods of creating flexibility of interlinked operation within the ecosystem of energy.

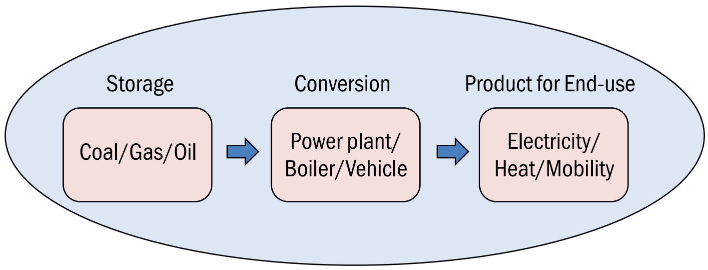


Figure 1: Energy system today

SOME SMART DEFINITIONS

- 'Smart electricity grids' are related infrastructures that can integrate the actions intelligently of all stakeholders connected to it—generating companies, DISCOMs, and consumers. The aim is to deliver efficient, sustainable, secure, and affordable electricity supplies all the time.
- 'Smart thermal grids' are a network of pipes emanating from centralized plants and from a number of distributed production units for heating or cooling and connecting the city including various residential and commercial blocks, so that the end-users can be suitably served.
- 'Smart gas grids' are gas infrastructures including storage units that can intelligently integrate the actions of all users and producers connected to it in order to efficiently distribute sustainable, affordable, and secure gas supplies and manage storage.

Based on these fundamental infrastructures, an optimal solution for each individual sector as well as for the overall energy system is going to be achieved in a smart city energy system in which a unified approach is central to collectively coordinate among smart electricity, thermal, and gas grids for the benefits of all stakeholders.

The future smart energy system shall embrace new techniques and infrastructures to present new forms of flexibility of operation in the 'conversion' stage of the energy system hitherto unknown. Today's simple linear approach in energy systems (i.e., fuel converted for end-use) is going to change to a predominantly interconnected approach in this ecosystem in order to achieve this futuristic scenario. This approach shall be aimed at interconnecting the electricity, thermal, storage, and mobility sectors in such a manner that the flexibility across these different sectors can meaningfully and affordably compensate for the lack of flexibility from renewable resources, such as wind and solar. The smart city energy system shall use technologies and wherewithal, such as: (i) Smart electricity distribution grids to meet flexible electricity demands, such as residential and street lighting and electric mobility system to the intermittent renewable resources, such as wind and solar power; (ii) Smart thermal grids (district heating and cooling) to interconnect the electricity and heating sectors to enable thermal storage to be utilized for creating additional flexibility and compensate for heat losses in the energy system; and (iii) Smart gas grids to interconnect the electricity, heating, and transport sectors to enable gas storage (including refined liquid fuel) to be utilized for creating additional flexibility.

Therefore, suitable infrastructure must be developed as parts of the deliverables. A comprehensive plan for solar and wind power generation shall have to be planned in advance for such cities that will also be supported by other renewable resources, such as biomass, geothermal, municipal waste, etc. Suitable electricity and gas grids with related infrastructure need to be developed concurrently with state-of-the-art thermal energy storage system. Individual homes/offices/market places, etc., shall be encouraged to generate required energy through rooftop installations, which may have grid connectivity. Home-based battery charging stations shall be used for electric vehicles (EVs), which can also deliver part of the energy required for the household.

The energy system of the smart city will rely heavily on energy conservation, which is another important component in the context of smart city. The age-old concept of 'energy saved is energy produced' is central to such an idea. Residential and street-lighting in cities consume significant electrical energy—about 24 per cent of total domestic consumption. Therefore, energy-efficient LED lighting in smart cities should be considered as one of the most important tools in the area of energy efficiency and conservation. Some progress in this connection has already been visible under Demand Side Management based Efficient Lighting Project (DELP) and LED street lighting projects being implemented by Energy Efficiency Services Limited (EESL) under government initiatives. However, such projects need to be synergized with smart city projects that are also being implemented by the government. The smart cities must consider other efficient devices and measures in the domestic and commercial arenas, such as energy-efficient fans, air-conditioning, and heating.

Energy conservation measures shall consider suitable retrofitting in existing buildings and factories necessary to reduce avoidable loading on energy consumption. For new buildings, the design shall be entirely different from the existing practices as emphasis must be laid on energy efficiency and conservation from day one of planning and implementation. Building an energy management system for large buildings, offices, factories, market places, etc., must synergize efforts of various associated energy facilities

including in-house generation/co-generation of electricity, gas, water, waste management, etc., and their consumption/coordination by the end-users. The smart energy city shall have its own smart grids carrying electricity, gas, water, and heating/cooling pipelines, etc., in such a manner that the entire operations shall be based on the highest possible efficiency at lowest cost so as to benefit the common citizens and all stakeholders to the maximum extent possible.

LOCAL GENERATION, CO-GENERATION, AND RENEWABLE ENERGY

One of the important parameters in smart energy city implementation is to be self-sufficient in energy generation based on renewable energy and local resources to the maximum extent possible. There will be a number of decentralized generating plants based on renewable sources that may even include rooftop grid-connected solar/wind generators—may be of very small capacities. Cogeneration plants for generating electricity, heat, and gas shall be made as viable options using latest technologies and experiences around the world. However, bulk energy through the national Extra High Tension (EHT) grid shall be made available for meeting energy requirements of such cities during implementation stages till they become self-sufficient. The dependence on such systems can be progressively decreased as the implementation advances.

CO-LOCATION, SHARING, AND CONVERGENCE

Co-location and sharing of facilities and infrastructure shall be very common in the smart energy city environment. For example, the number of telecom towers can be drastically reduced by co-locating the various service providers' equipment on fewer number of common (shared) towers. The poles for street lighting must be shared by service providers for placing their equipment for Wi-Fi and other radio systems for last mile connectivity. The gas/water pipelines must also carry piggy-back fibre-optic cables using the common right of way, which will also be shared by local electricity distribution grids. The EHT towers in the vicinity of the smart city shall also be used for co-location of telecom companies' radio antennas. Optical ground wire (OPGW) shall replace all overhead plain ground wire so that the former can also carry telecom traffic through optical cable impregnated in the ground wire. The conventional underground optical cable infrastructure shall be a thing of the past especially for the long distance routes. Thus, great convergence will happen in such environment which will ultimately benefit all stakeholders. The convergence initiatives thus taken shall help in reducing carbon footprint to a large extent furthering the concept of liveable cities.

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MOBILITY IN THE SMART CITY

A sustainable city transport system shall be developed by interconnecting energy and fuelling infrastructure, wherein fleets of transport vehicles shall be fuelled by predominantly alternative energy carriers for public and private transport systems. Electro-mobility will be totally integrated with the energy system through smart grid infrastructure.

THE SMART GRID CONCEPT

The smart city shall necessarily be under the purview of the smart grid system for managing the electrical energy scenario. Some action in connection with smart grid implementation has already been initiated in the country. The smart city will not be smart enough unless the proposed initiatives therein do not seamlessly connect with the smart grid initiatives already under implementation.

THE ICT INFRASTRUCTURE

The pervasive ICT infrastructure shall pave the way for the successful implementation and management of the smart city, wherein a multitude of highly complex and modern facilities are expected to work in synergy. For this purpose, high capacity optical backbone network shall be established along the smart distribution grid with adequate last-mile connectivity extended to individual users including homes and offices, market places, factories, and all relevant establishments. The smart metering system shall ensure optimization of electricity consumption and cost as applicable to all individual users and also offer the most efficient yet profitable control and coordination between the energy-producer(s) on one side and users on the other. The meaningful interaction of various sectors, such as energy (electricity, gas), mobility (EVs, railways, etc.), energy storage, water supply, sewage management, garbage disposal, and municipal waste management, etc., will all rely heavily on the robust ICT infrastructure that will be based mainly on optical cable network supported by technologies, such as Wi-Fi, Li-fi, Broadband over Power lines (BPL), etc. The e-governance facilities envisaged for the smart city shall totally depend on such infrastructure dedicated for this purpose. The ICT infrastructure shall also rely heavily on the Internet of Things (IoT) which is about deploying sensors (RFID, IR, GPS, laser scanners, etc.) for every object under consideration, and connecting them to the internet through dedicated protocols for trafficking of information, with a view to achieve intelligent recognition, location determination, tracking of mobility/movement, monitoring, control, and management.

With the technical support from IoT, smart cities need to have most essential features of being instrumented, interlinked, and intelligent. A smart city can be developed only by integrating all these intelligent features at various stages of development of IoT.

THE INDIAN SCENARIO

Appreciating the importance of the 'Smart City' movement, the Indian government launched the 'Smart Cities Mission' in June 2015. The 'Smart Cities Mission' is an urban renewal and retrofitting programme by the Government of India with a mission to develop 100 cities all over the country making them citizen-friendly and sustainable. Initially, 98 cities were selected as 'smart' candidates and these will be turned into smart cities in due course of time. However, by 2017, 100 cities shall be identified for this programme. The Smart City initiative of the Indian government is expected to initiate unprecedented activities of restructuring, development, and re-deployment of resources in selected cities. The smart city will strive to implement optimal and sustainable use of all the resources—precisely emphasizing on services rendered to the citizens while ensuring an optimal balance among social, environmental, and economic costs. Energy management, urban transportation, waste management, sanitation, water management, affordable housing, citizen services, and e-governance are the key sectors directly related to the smart cities initiative. Figure 2 presents the basic framework of a smart city.

SELECTION OF SMART CITY CANDIDATES

The mechanism being followed for selection of candidates for implementation of the smart city programme has been conceived of several stages. In Stage 1, State governments had proposed a number of potential cities as smart candidates and the Centre was to shortlist 100 cities based on certain evaluation criteria, such as existing service levels, institutional systems and capacities, self-financing assessment, and past track record. The Government of India released the list of 98 cities, including many state capitals for the ambitious 'Smart City Mission' on August 27, 2015. Subsequently, the proposal level evaluation considered impact of proposal, cost-effectiveness of smart city plan, innovation and scalability, and processes followed as the criteria at Stage 2.

The Indian government finally selected 20 cities from among the initially shortlisted 98 cities on January 28, 2016 based on evaluation discussed above.

CHALLENGES FOR THE SMART CITIES INITIATIVE

Each of the designated smart cities has its own implementation plan and strategy being directed by a group of consultants, bureaucrats, and politicians. True local sensitization has been far less than adequate as stakeholders are hardly aware of responsibilities towards and expectations from such projects. There is no unified approach which makes the challenges more onerous and implementation heterogeneous and haphazard. In many cases, such projects have been planned through retrofitting of infrastructure, facilities, and services which are even more difficult to implement rather than greenfield projects. It must be recognized that effective inter-linkages need to be assured among technological development efforts, infrastructure planning and overall integration, ushering in the era of new services and business, e-governance and seamless involvement of citizens and service providers. Convergence of total energy sector, mobility, ICT, and IoT in the smart city environment is recognized as a major challenge for seamless development in future. Another important area in the present context is complete preparedness for disasters triggered by natural calamities and failure/malfunctioning of operating/management systems in connection with all smart city facilities and establishments.

Unified approach for project implementation

It is understood that there will be a multiplicity of implementation strategies for selected cities being dictated by local authorities and politicians. It is therefore recommended that a centralized and unified approach be taken for

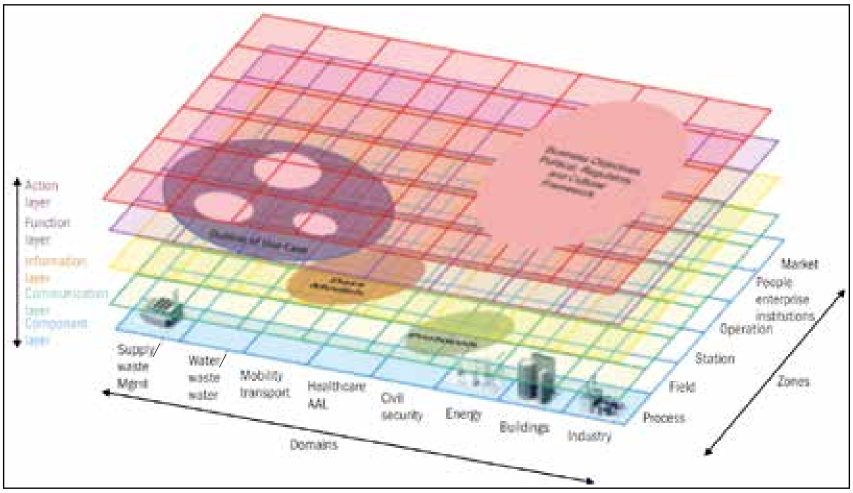


Figure 2: Framework of a smart city
Source: Energy Research Knowledge Centre, European Commission

the success of such projects being conceived for implementation in view of the complexities associated with such projects having multiplicity of coordination challenges and synergies envisaged. The unified approach shall ensure identical strategies and plans for execution starting from the conceptualization stage to delivery for all the cities. Considering the Indian scenario and background in general, it may be assumed that the selected cities have very similar problems and challenges while the expectations of the citizens are also identical. The unified approach shall also keep room for corrections mid-way, should something fail somewhere owing to miscalculations or errors.

Interoperability and standardization

Next to energy-consciousness, interoperability, and compatibility among various service sectors including various systems, subsystems, and installations will extend credibility to the smart city movement. A close examination of Figure 3 shall once again establish the fact that such interoperability among various service sectors is a must to ensure flexibility, reliability, and efficiency of services to the end-users and service-providers. Interoperability must be based on sound and robust principles of standardization in the absence of which the smart city systems cannot operate efficiently and reliably. In this connection, it appears that the

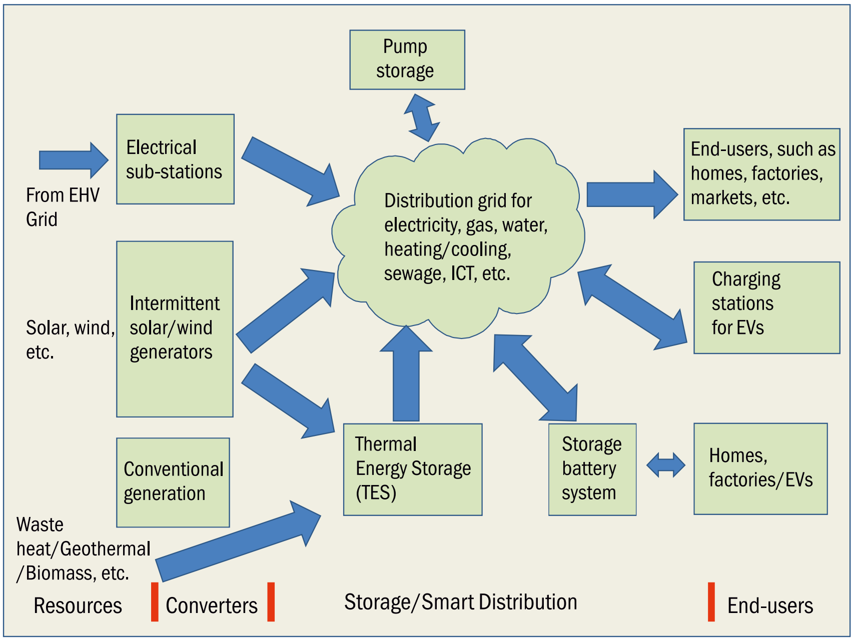


Figure 3: The future smart city energy system

Bureau of Indian Standards (BIS) has already presented and finalized some framework. Internationally, Europe, Japan, Korea, and the USA have already seen lot of activities in this regard. In order to ensure quality of implementation, interoperability of services and functions, etc., it is felt that experiences from such countries should be looked into and examined for inspiration and meaningful assistance for the Indian endeavour.

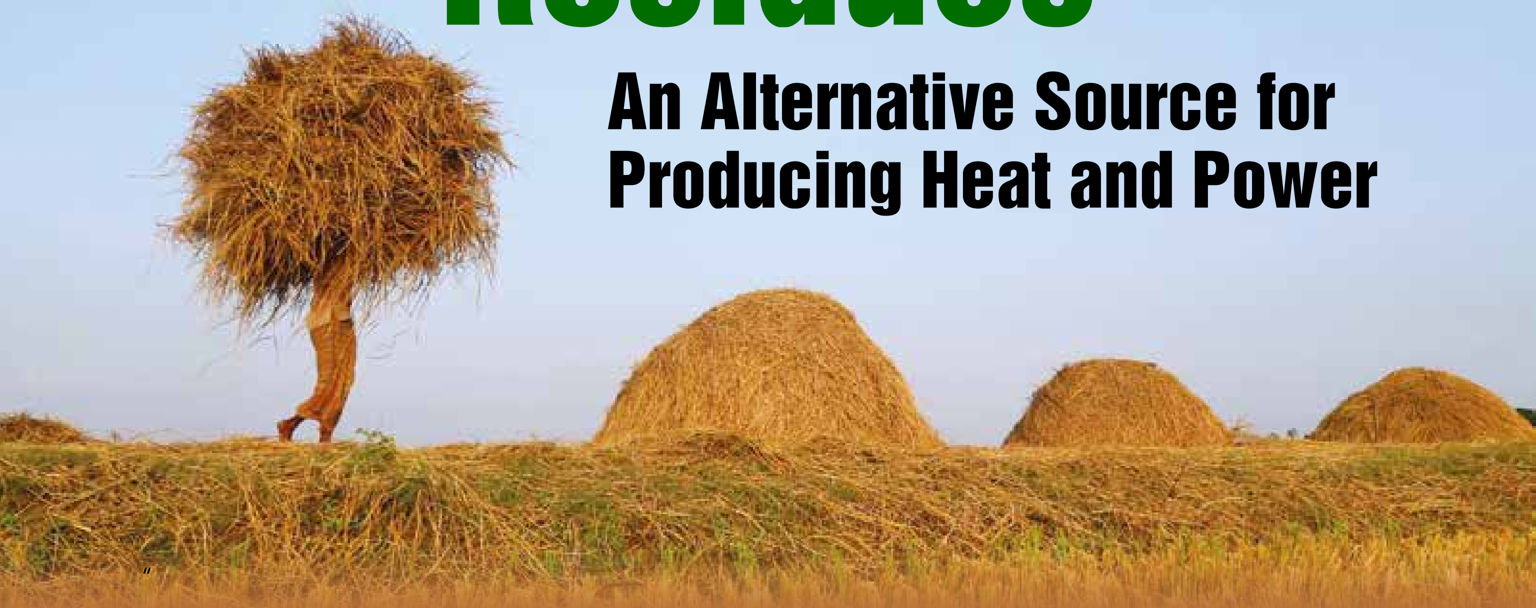
CONCLUSION

As brought out earlier, smart city movement with energy consciousness at its core is not just about implementation of another government-initiated project. It cannot just be another municipal body-led model of urban development with usual in-built attributes, such as inefficiency, cost overrun and uncertain implementation schedule. It is important that all the stakeholders in the project must be adequately sensitized beforehand at the time of conceptualization of the project itself. Apart from energy consciousness, the smart city initiative has many components that must be considered, debated, understood, and accepted by all concerned before adapting such a complex and multifaceted project for implementation. A unified execution approach is necessary for success of such projects for all the cities wherever the projects are going to be implemented. The unified approach shall determine the objectives of such projects with realistic expectations and goals taking due cognizance of the Indian context and arrive at methodologies for implementation for all the cities. Keeping this requirement in view, a centralized task force must be constituted to determine the sensitivities, components, and phasing of the smart city projects, methodologies for implementation from feasibility stage to delivery including packaging of contracts, technical specifications, implementation schedules, etc. The task force must be constituted of international consultants with adequate ideas, knowledge and exposure in the related fields; and technocrats, ICT experts and professionals experienced in various fields in connection with smart city implementation. The execution at each selected city shall be managed in a corporate style independent of bureaucratic and political interferences and for this purpose a special purpose vehicle route shall have to be developed. EF

Mr Atanu Dasgupta is an independent consultant in the field of Energy and Power System Telecommunications. Email: vu2atn@gmail.com.

Generation of Green Power and Manure from Surplus Crop Residues

An Alternative Source for Producing Heat and Power



Biomass is partially oxygenated hydrocarbon. It contains more ash but less sulphur than fossil hydrocarbons. Since the heat content of a good quality biomass is about 70 per cent of high grade coal and 40 per cent of diesel, it could serve as an alternative resource for generation of heat and power, and industrial raw materials. In this article, ***Dr Madhuri Narra****,* ***Dr Anil Kurchania****,* ***Dr Murari Shyam****, and* ***Dr Bhim Sen Pathak*** *discuss the process of generation of green power and manure from surplus crop residues taking example of a pilot plant installed at the Sardar Patel Renewable Energy Research Institute (SPRERI). They have highlighted SPRERI technology on conversion of crop residues into methane-rich biogas.*

As a result of fourfold increase in agricultural production since 1951, large quantity of crop residues are produced, some of which have become surplus to their traditional uses as animal feed, domestic fuel, construction material, etc. (Figure 1). The annual surplus of crop residues in India is estimated at 70 million tonnes or more, which at present is generally burnt on-farm, are available every year in the country, mostly in irrigated areas. The rice (and straw) yields in Punjab are one of the highest in India. A glaring example of the waste of surplus residues is the on-farm burning of about 14 million tonnes of rice straw in Punjab each year. This crop residue is burnt during the months of October–November each year to clear the land for wheat sowing. Collection and disposal of this straw, which is spread thinly over a large harvested area, pose a practical problem. Farmers spend time and money in burning the straw. There is a general desire to restrict and even stop the practice of uncontrolled burning of rice straw because it causes serious air pollution. Rice straw has high cellulose and hemicellulose content and low lignin content. Most of this surplus, which is now wasted, could serve as a source of energy generation in the form of methane-rich biogas along with good quality manure.

Studies carried out at the National Physical Laboratory, New Delhi concluded that the open burning of straw in the field resulted in perturbation to the regional atmospheric chemistry due to emission of gaseous compounds, such as CO_2, CO, CH_4, N_2O, NOx, NMHCs, and aerosols. The emissions of CH_4, CO, N_2O, and NOx were estimated to be about 110, 2306, 2, and 84 Gg, respectively, from the burning of rice straw in India during the year 2000. Residue burning also causes loss of plant nutrients, decrease in soil biota, and reduction in total nitrogen and carbon content in the top soil layer.

There is an urgent need to develop suitable technologies which benefit farmers at large by adding value to the surplus crop residues and simultaneously mitigate the problem of air pollution caused due to burning of crop residues on farm. Research and development (R&D) efforts are focussed throughout the world for developing cost-effective technologies for converting crop residues into methane rich biogas. Anaerobic digestion has great potential to become a major part of the crop waste management system as it has triple advantage of producing clean source of energy, returning the organic matter to the soil, and avoiding serious air pollution due to large scale burning of crop residues in concentrated crop production regions. Systems used to digest solid waste are classified according to the percentage of total solids (TS) in the waste stream.

- 10–20 per cent low-solids anaerobic digestion; wet fermentation
- 20 per cent high-solids anaerobic digestion; dry fermentation.

High-solids anaerobic digestion systems have been developed to digest solid wastes (particularly municipal solid waste) at solids contents of 30 per cent or above. High-solids systems enable the reactor size to be reduced, require less process water and have lower heating costs. In this direction, with particular reference to surplus crop residues, a technology for conversion of crop residues, such as rice straw, wheat straw, sugarcane trash, etc., into methane-rich biogas and good quality compost has been developed at the Sardar Patel Renewable Energy Research Institute (SPRERI).

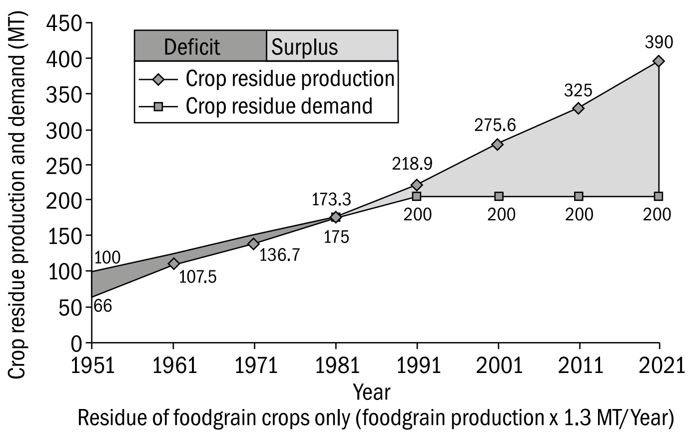


Figure 1: Estimated crop residue production in India during 1951–2021
Source: SPRERI, Vallabh Vidyanagar, Anand (Gujarat)

SPRERI TECHNOLOGY ON CONVERSION OF CROP RESIDUES INTO METHANE-RICH BIOGAS: SUBSTRATE AND INOCULUM

Paddy straw was collected from local farmers during the harvest, transported and stored near the plant. The straw size was reduced to approximately 1.25 cm long pieces. The physically pretreated straw along with the culture was anaerobically digested in batch type reactors at 50°C temperature for 21 days. The total solids content (TSC) of the reactor was 35 per cent.

Pilot plant

Based on the optimized parameters obtained at bench scale studies, 100 kg/day rice straw based biomethanation system was designed. The system consisted of six molten salted (MS) reactors each having the capacity to take load of 300 kg rice straw, an MS trough, an MS platform, gas storage unit, a heating system, and necessary pump and piping. Each batch reactor was connected to a common header by flexible pipe. Necessary valves were provided for isolating individual reactor from the header for monitoring work. Header was connected to gas conveying line for conveying gas to the gasholder.

The salient features of the system are as follows:

- Six independent reactors, which can be operated without disturbing the operation of other reactors
- A lid with hinges at the bottom for easy opening and closing of reactor from the bottom and easy removal of the digester material from the reactor
- Flange groove and gasket around the bottom of the reactor and for gas tight closure of the reactor at the bottom
- A water jacket around the top with lid for prevention of gas leak and providing anaerobic condition
- An insulated trough with six water inlets and outlets for hot water circulation and maintaining the temperature of the reactors
- Gas header with valves for conveying gas from each reactor to the gas storage unit
- A separate gas storage unit consisting of a water tank and a gasholder
- Biogas-based water heating system for maintaining the temperature of the reactors
- Platform over the trough for easy inspection and loading of the reactors.

Compositional analysis

Rice straw and inoculum were analysed for physico-chemical characteristics after collection using standard methods and its TS and volatile solids (VS) were analysed every time before feeding into the reactor. Biogas was measured every day at fixed time. Gas was analysed, periodically, for its methane content using gas chromatograph. Partially decomposed material was analysed for TS and VS every time it was removed from the batch reactor.

Feeding the batch

The average daily gas production from one kg of TS fed obtained during bench scale studies was computed and found that consistent gas production was obtained if the batch is charged every third day on multiple batch operation. Hence, reactors were fed twice a week, i.e., on Mondays and Thursdays regularly. Each reactor was fed with 300 kg of chopped rice straw. Water was added to the chopped rice straw to make TS concentration 35 per cent in the feed. The prepared rice straw and culture ratio was kept as 2:1. Both mixing and feeding were done manually. A thermocouple wire was placed at the centre of each reactor while feeding for measuring temperature of the reactor. After charging the reactor, the lid was placed over the reactor in water jacket provided and gas outlet was connected to the gas flow metre. Gas produced for two days was recorded using this separate metre as it contains more carbon dioxide. Gas outlet of the reactor was connected to the header subsequently. Each batch was terminated after the incubation period of 201 days.

PERFORMANCE MONITORING

The biogas yield per day and per unit reactor volume for the straw were found to be 3.2 and 8.0 times of the cattle dung, respectively. Besides, the water requirement is reduced by more than 85 per cent. The reduction in TS and VS was 23.6 and 38.2 per cent, respectively (Table 1). This shows good decomposition and anaerobic digestion activities in the reactors. The methane contents of the biogas varied between 55–57 per cent. Picture 1 provides an overview of the pilot plant installed at SPRERI.

Table 1: Average performance of the pilot plant for biomethanation of paddy straw

Parameter	Paddy
Mass of straw fed (kg/d)	78.85
Total solids concentration (%)	35
Reactor temperature (°C)	50
Retention period (d)	21
Biogas yield	
- l/kg TS fed	239
- Methane content (%)	55–57
- TS reduction (%)	23.6
- VS reduction (%)	38.2

Picture 1: Overview of the pilot plant installed at SPRERI

Investment on the power plant based on SPRERI technology including mechanized materials handling systems may be recovered in a reasonable time-period through sale of the power and the compost provided carbon credit and financial incentives for avoiding serious pollution caused by uncontrolled burning of crop residues in open fields.

COMPOSTING OF PARTIALLY DECOMPOSED MATERIAL

Partially decomposed material removed from the batch reactor on its termination was composted. It contained around 66–71 per cent moisture and 52–62 per cent VS. The initial moisture content of 50–70 per cent is considered to be the most satisfactory for aerobic composting. Since the material had enough moisture required to start composting, its moisture level was not altered and its composting was initiated immediately. The material was piled up in the form of a heap. The height of the heap of all the batches was kept 1.4–1.6 m. The heap was turned on every Monday and Thursday. Temperatures at various points throughout the composting mass were recorded with thermocouples using 1 m long probe. The maximum temperature was recorded at the centre of the mass. More than 75°C temperatures were achieved. It can be concluded that the mass was properly aerated and it did not turn anaerobic, as high temperatures do not persist under anaerobic conditions. In aerobic composting, adequate supply of air throughout the mass is of prime importance, otherwise the mass would turn anaerobic. Composting process went on smoothly. Lump formation that is common during composting was not observed in any of the batches. Some lumps were seen in partially decomposed material when it was removed from the reactor. These were soft and broken during turning and composting. The colour of partially decomposed material was light brown, which changed to darkish brown during composting. The final compost had a nice aroma and good humus content. It contained N, P_2O_5, K_2O as 1–1.2, 1.3–2.2, and 1.2–2.1, respectively. Quality of the compost prepared by SPRERI is quite comparable with the quality of compost usually being marketed at various places.

CONCLUSION

As per SPRERI's estimation, about 70 million tonnes (MT) of surplus crop residues is available. If collected and converted, this surplus of crop residues has an estimated potential of producing over 15,330 million m^3 of biogas annually by using SPRERI-developed technology at high solid biomethanation process (219 m^3/t biogas production per day). The anaerobic digestion of paddy straw resulted in biogas and good quality manure. Total reaction cycle, i.e., from rice straw to biogas and compost can be completed in 50 days instead of 80–90 days required for conventional composting. Hence, SPRERI process is faster and produces energy in addition to manure. The pilot plant developed is simple to operate and easy to maintain. However, fully mechanized system of MW size is required to be developed, evaluated and technical soundness and economic viability should be worked out. EF

Dr Madhuri Narra, Dr Anil Kurchania, and Dr Murari Shyam, Sardar Patel Renewable Energy Research Institute (SPRERI), Vallabh Vidyanagar, Gujarat, India. E-mail: bio@spreri.org, madhuri68@gmail.com; and Dr Bhim Sen Pathak, Energy Consultant, KC-5, Ghaziabad, Uttar Pradesh, India.

Innovative Approaches for Smart Cities of India

The Present and Future Perspectives

*A 'smart city' is an urban region that is highly advanced in terms of overall infrastructure, sustainable real estate, communications, and market viability. They tap a range of approaches—digital and information technologies, urban planning best practices, public-private partnerships, and policy change—to make a difference. In this article, **Aditi M Phansalkar** and **Dr Anjali Parasnis** review the current status of resources, such as water, food, and land in urban areas of India, with special reference to the Mumbai Metropolitan Region (MMR).While suggesting a few novel and innovative approaches for the Indian smart cities, they feel that its time India revisits its own potential in terms of its advanced vernacular architecture and traditions and goes that extra mile to articulate a robust plan for the smart cities of the future, which will reflect India in all possible ways.*

Before we anchor ourselves into the crucial discourse of smart cities and their emergence in the future, here is an excerpt from a book called *Anti-Fragile* by Nassim Nicholas Taleb, a New York Times bestseller author. He has coined an interesting concept, applicable to the current splurge of smart city buzz. He articulates that some things benefit from shocks; they thrive and grow when exposed to volatility, randomness, disorder, stressors and love adventure, risk and uncertainty, yet there is no word for the exact opposite of fragile, let's call it 'anti-fragile'. The resilient resists shocks and remains the same, the anti-fragile, becomes better. Anti-fragility is a singular property allowing us to deal with the unknown and manage it well. The concept merely highlights the state which India is already into. The state of randomness, with ever-increasing flow of stressors, the shocks (both perceived and experienced), and transitions. In all probability, we can assume, this is the state which can help us get better. With a multitude of opinions and theories revolving around the grandiose concept of smart cities, we must aspire to craft the vision well-suited for India.

While we talk about the transitions, Indian traditions have reflected ecological harmony for centuries and have made our civilization a better suited one in the context of the traditions which were followed. The traditional houses, meaningful integration of festivals into our lives, the food patterns, and the traditional outfits largely seemed to be 'well-thought responses' to the surroundings and the environment. These actions behold deeper scientific logic than they perceived and projected.

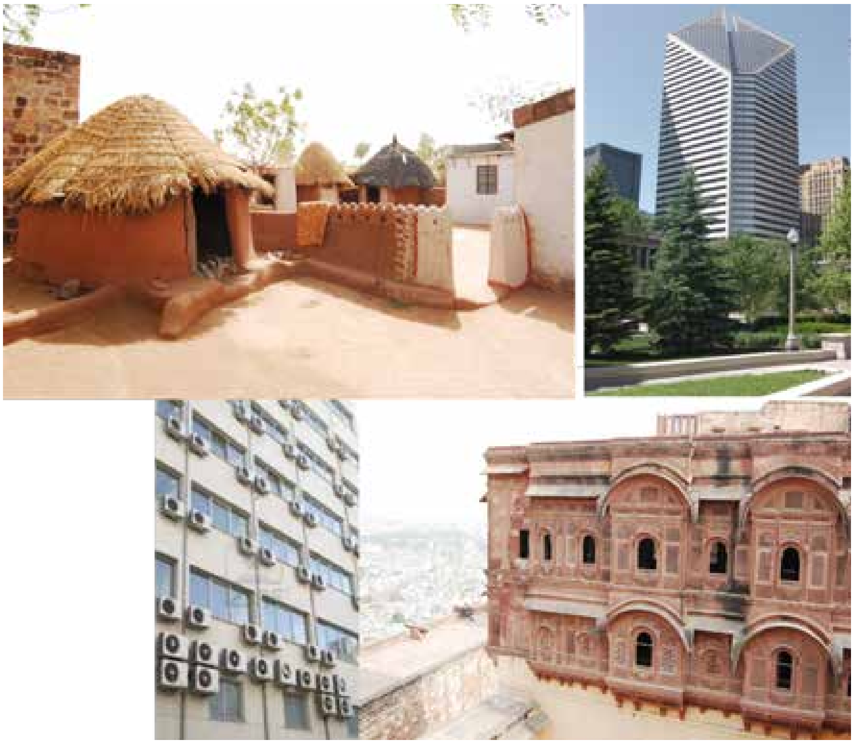
For instance, all over India, there are sacred groves, a 'smart' way of conserving natural resources. These are essentially dedicated to local deities. These predominantly were one of the many direct ways and means to protect the local biodiversity of the region. In Maharashtra, these 'sacred groves' are located in the Western Ghats and are locally known as 'Devrai'. The word 'Devrai' came from two local words; that is, 'Dev' which means God and 'rai' means forest. So it means 'God's forest' is *Devrai*. Similarly, a native tree found in Thar desert of western Rajasthan known as *Khejri* is valued for its moisture-retaining properties and it is not axed even if it comes in the way of construction. Tree conservation activities were integrated in the lifestyles of the communities.

However today, the lifestyles are rapidly changing, the products are becoming market driven, and synthetic materials are freely entering into the value chain. These elements are flooding the markets, the households, and also the garbage bins. The society, which was once completely relying on the wholesome concept of reuse, reduce, and recycle of material for generations, is clueless about the usage and disposal of these newer elements, ultimately leading to a chaotic situation. Globalization and consumerism is dragging us into its whirlpool, where we are unable to efficiently adapt. We are just responding. We need to keep into account the complex nature of such transitions while we plan our future 'Smart Cities'.

CITIES, ENERGY, AND ARCHITECTURE

In the context of urban explosion, especially, the gradual yet steep rise in commercial floor plates, India is the world's fourth-largest energy consumer. It is envisaged, that with this pace, India will take over China in the next decade and will become the primary energy consumer. This can bring along huge implications on the overall economic performance of the urban fabric. While expanding the urban centres is on the Government's agenda, the uncertainty associated with energy access to all households, commercial spaces, and industries still holds itself rooted. Moreover, unaccounted distribution losses significantly impact the overall accounting in India. In India, average T&D (Transmission & Distribution) losses have been officially indicated as 23 per cent of the electricity generated. However, as per sample studies carried out by The Energy and Resources Institute (TERI), these losses have been estimated to be as high as 50 per cent in some states. The number is huge and unwelcoming, especially in the context of the burgeoning energy security issues. Energy efficiency measures will not hold true, if these concerns are not addressed by the competent authorities on priority.

Additionally, the mushrooming of matchbox style compact designs of commercial spaces, especially malls and retail complexes, are infamous for their huge energy and water footprints. Climatic conditions have a direct impact on the usage of energy in buildings. A deeper understanding of the existence as well as sustenance of such resource-intensive spaces with respect to the climate and context should be required. The architecture in India too has always been climate responsive, responding to different climatic zones. Be it sloping roofs in high rainfall areas, such as coastal Maharashtra, Kerala or *Jaali* windows in hot and dry climates, or mud houses in arid regions, all have emerged as signature styles not out of mere aesthetics but as thoughtful design responses. 'Response' essentially formed the design philosophy in traditional architecture. Similarly, 'response' formed the driving force for defining the landscape of cities. The shadow casting techniques utilized in the hot and humid cities, to maintain cooler temperatures and



Picture 1: Comparative understanding of the Indian traditional architecture—Past and Present

direct heat gain on the streets, stand as an excellent epitome of climate responsiveness (Picture 1).

Today, unfortunately, our cities are seen to be responding to global signature languages. However, this has come with the cost of diluting the scientifically correct local responses and being oblivious to our current status with respect to the access and availability of the dependent resources. Interestingly, the Energy Statistics 2013 of India's National Statistical Organization (NSO) shows that electricity accounted for more than 57 per cent of the total energy consumption during 2011–12 in India, and the building sector is already consuming close to 40 per cent of the electricity. This is expected to increase to 76 per cent by 2040. A large share of demand will come from the residential sector in India.

As per the Bureau of Energy Efficiency's (BEE's) assessment, lighting and air conditioning use 80 per cent of the energy in commercial buildings, whereas fans and refrigerators guzzle maximum energy in residential buildings. Furthermore, as per the USAID ECO-III Project's commercial growth forecast, commercial spaces are yet to increase by 66 per cent than the existing by 2030s. This means that a serious focus on building designs, as per Indian climatic conditions, complimenting the same with various other energy conservation measures, can ensure mitigation of the GHG emissions. Thus with this context, one can deduce that, sustainable development has very little to do with what the world is focussing on these days and has a lot more to do with what we already did till date.

While envisaging the growing urban centres becoming the replicas of the western urban fabrics appears lucrative, the long-term sustainability of such centres of growing concern. Dependence on renewables could be one solution, but demand optimization should also be equally prioritized. Net metering for energy could be of immense help. In order to manage a problem, it is important to measure it in the first place. Thus, in order to manage the energy to further optimize it, we need to know the consumption of the energy at every stage.

MAPPING OUR CURRENT STATUS

Peri-urban areas and infrastructure development

While we aspire to venture into the new age of smart cities it is imperative to know, what is the state of different resources, how and where are they sourced from? What is their state of being? What is their availability? And many more such mind alluring questions.

According to a study (Figure 1) conducted by the Indian Institute for Human Settlements (IIHS) in 2011, in 1951, there were only five Indian cities with population greater than 1 million and only 41 cities more than 0.1 million population. In 2011, there were three cities with population greater than 10 million and 53 cities with population greater than 1 million. Furthermore, by 2031 it is projected that there will be six cities with population more than 10 million. Now the concern here is not how many cities are lined up to get mushroomed. The concern is, will they mushroom sporadically or upon emergence, would they be cities or just haphazard settlements getting regularized out of no choice.

City development is largely observed and is also projected to occur in the green field areas. There is an equally rapid spillover of population and allied infrastructure in the peri-urban areas. Whereas, in the brown field areas, since land is in high demand, the city developers often opt for high rises. It is estimated that Asia's peri-urban populations will increase by approximately 200 million over the next 25 years, accounting for 40 per cent of urban population growth. These areas, once catering to the immediate responsive needs, a breather to

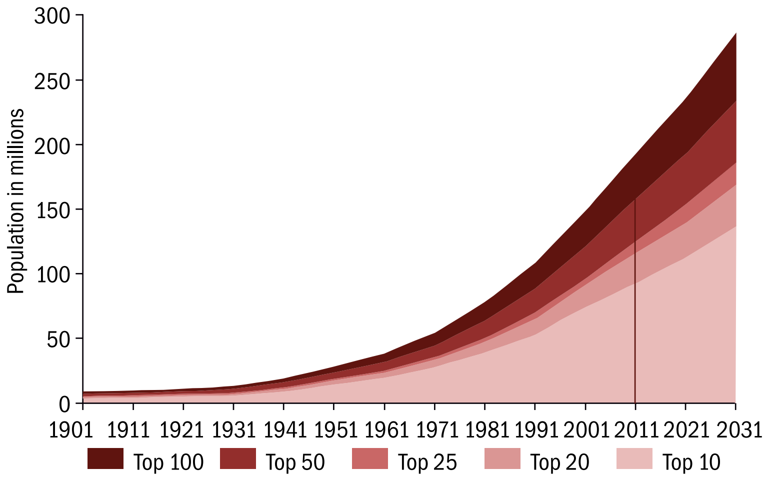


Figure 1: The increasing population trend
Source: Urban India 2011: Evidence, Indian Institute of Human Settlements and India Urban Conference

older settlements, are now getting themselves converted into dependent entities again adding pressure on surrounding areas or still worst the distant areas, thus, literally dragging all the systems into a unidirectional, compulsive non-stoppable whirlwind.

Most often, the structures in the core city or brownfield areas are dependent on distant sources to take care of its basic needs like food, water, and energy, and also of the disposal of waste and sewage. Already, cities such as Delhi, Bengaluru, and Chennai ferry water from as far away as 200 km. While we need to budget the resources well, it is imperative to also install a cap as per the carrying capacities of the resources. But our current status speaks otherwise.

STATUS OF THE RESOURCES

Water

Globally, if we investigate, a study conducted by the International Water Management Institute (IWMI) looks at the future water availability scenarios for India. It deduces that the total water demand in the Business as Usual (BAU) scenario is projected to increase 22 per cent by 2025 and 32 per cent by 2050. The per capita water consumption especially in urban areas may rise to 200 lpcd as against 135 lpcd. Studies by KPMG India effectively highlights the crossing over of water demand on water availability in the near future (Figure 2). This would mean the cities will have to look for their own fresh water source.

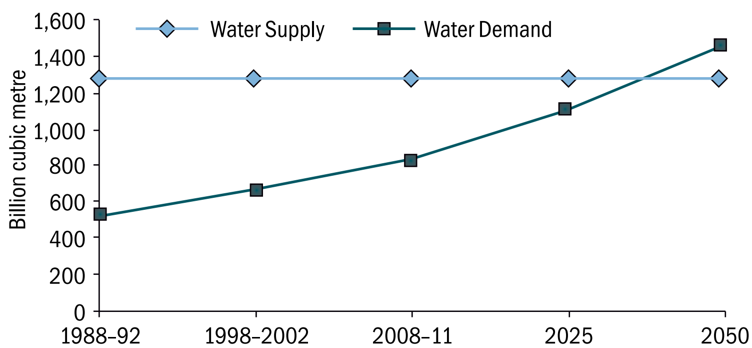


Figure 2: Future water scenario in India
Source: Water Sector in India: Overview and Focus Areas for the Future, Pan-IIT Conclave 2010, KPMG India

Water security of smart cities, would be a function of protection of the water bodies which supply water, making necessary policy arrangements and ensuring their continual revival and safeguard.

Food

The state is no different when it comes to procuring food. As per the *Down to Earth* data, there are just 100 districts in the country left with more rural than urban population. They must be in all probabilities the districts, where our food is grown. Treating them as the living fossil of the agrarian country, they need not require a mere protection, but a paradigm uplift in the approaches which make us look at these areas as non-lucrative and secondary.

To delve further deeper in this issue of sourcing the food, TERI had undertaken a quick research, which indicated the potential increase in the food prices owing to the absence of planning in the Mumbai Metropolitan Region (MMR). The assessment assumed that the agricultural lands will be displaced to peripheral or green field areas and the basic food items, such as milk, eggs, and so on will be sourced from a distance. Thus, the annual fuel requirement for bringing in food products in MMR, even for basic food supplements, such as vegetables, milk, and eggs to meet the minimum dietary requirements is presumed to be very high. The minimum distance considered was typically from areas which are located 200 km and 500 km away. Table 1 provides the present food statistics for MMR region.

Table 2 clearly explains that there is a dire need to strengthen the food security, sufficiency as well as sustainability in cities. A smart city is thus presumed to protect its own food systems and practices while making it efficient enough to make it available at affordable cost and consumable quality.

Table 1: Present food statistics for MMR area

Food items	Annual consumption per capita	Total food consumption per year
Eggs	55 eggs	13 crore eggs
Vegetables	77 kg	18 crore kg
Milk*	71 kg	17 crore kg

*Note: * Although milk is measured in litres, we have considered it in terms of kg for maintaining the uniformity using standard conversion factors*

Table 2: Total fuel requirement to bring in basic perishable food items to MMR

Capacity of truck per item	Fuel required (in litres) for a single journey of a truck in km		Total number of trips	Total fuel requirement for a one way journey (in lakh litres)	
	200 km	500 km		200 km	500 km
13,000 eggs (small truck)	13	32	97,872	13	31
15,525 kg of Milk	40	100	107,143	42	107
10,000 kg of vegetables	40	100	178,127	71	178

If the agricultural lands continue to blatantly get converted for alternative uses, these areas will tend to shift farther away from cities. Which would mean, more inflated food prices even for basic food items. This may interestingly also result in a rise in demand for cheap local options, which may or may not be nutritious. Thus, shifting or encroaching agriculture lands would mean, a direct threat to food and nutrition security. This, again, places our perceived model of development under ambiguity.

Land

The process of urbanization establishes some reversible and irreversible impacts. While the reversible impacts can still be tackled, the irreversible are the ones, which need to be reckoned well in advance. As seen in Figure 3, urbanization, with the absence of planning, may result in a permanent damage to the system.

Figure 3 clearly indicates the need to remain anti-fragile to the future changes. Many changes, which our current developmental model demands are permanent and place the entire system in a state of irreversibility. The agriculture lands once lost for construction cannot be revived further, resulting in a permanent loss of food-growing areas. This implies procurement of food from alternative lands, which can be way too far from the source of consumption.

Humans and housing

Centralization of livelihood options is driving the human resources in one direction and destination, that is, the cities. Migration is one component which requires urgent attention. It can act as a catalyst to shackle all the demand-based statistics pertaining to the city's population to a great extent. As mentioned in one of the reports published by KPMG on affordable housing in India, urbanization can be described as a product of demographic explosion and poverty-induced rural-urban migration. Studies suggest that the net migration share to the urban growth in the world grew from 21 per cent to 24 per cent in the past decade which by all means is significant. If there exists no policy to encapsulate the population spurt which is projected to happen in certain locations, the resource management could remain a major and incremental

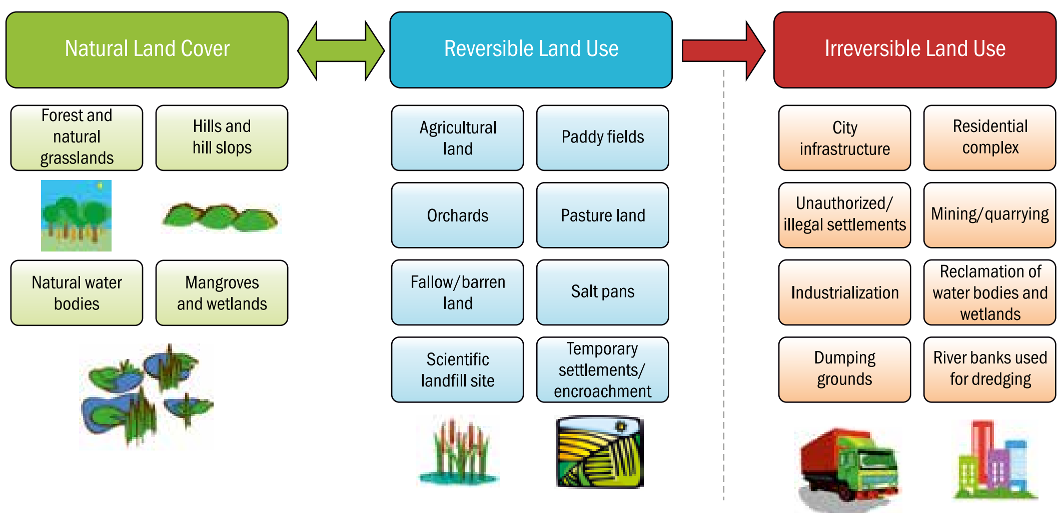


Figure 3: Unidirectional flow of change in natural land cover to land use

challenge for the civic authorities. Moreover, as per the Planning Commission and NSSO Report No. 508 (2004–05), it is estimated that the number of urban poor had increased by 34.4 per cent from 1973 to 2004. In such scenarios, the financial budgeting along with the resource budgeting, housing requirements and affordability of these basic amenities would go for a toss.

Surprisingly from all the cities, which have been selected under the smart city development programme, only one has committed to make its housing infrastructure green. The rest seem to be ambiguous on this aspect. Moreover, there seem to be no binding on inculcating these aspects which is presumably most resource-intensive.

The result of this is the incremental pressure on urban infrastructure and an increase in the number of homeless people living on the streets. Though the homeless people population has declined, as per the 2011 Census, it is still somewhere close to 1.77 million, which is again very significant. Inadequate availability of affordable housing could be one of the core reasons for this, whereas, absence of a clear policy framework is in turn making affordable housing a big challenge. Interestingly, housing infrastructure, irrespective of its affordability, simply cannot sustain without the resources.

This also becomes a challenge for the urban local bodies, as they have to face multiple management issues, such as storm water management and solid waste management. Incidences like the recent Deonar Dumping Ground fire, which blindfolded the city for days together adding toxic fumes, especially dioxins, which are carcinogenic, emerging out due to burning of plastic. A man-made act was capable of paralysing the entire system, owing to lack of management and the ever-increasing scale of solid waste. Other urban concerns, such as urban floods, fire outbreaks, and many more, remind us persistently that in all probabilities, we are missing out on charting a people centric developmental path. The concern here is, we are yet to build smart cities.

PROPOSED INNOVATIVE APPROACHES

Let us imagine a situation where the window of our living room, housed in a plush apartment of a 'new age smart city', overlooks nothing but another living room. 'What if' the solid waste 'we presume' we have disposed 'rightfully' lies right in front of our gates. 'What if', for most of the time in a year, we do not see the sun owing to pollution; however, we are still very much in an imposed 'Smart City'. The irony of the situation is, if we observe carefully, these 'dream home sellers' advertise their projects as 'Sea View Apartments', 'Hill View Apartments', where it is believed that a 'good' home essentially cannot be complete without the existence of these natural entities. But then the question remains, what are we doing to conserve them?

In the process, if we take a closer look at the definition of a smart city, as defined by the Government of India in their smart cities draft as published on their website, here is what it states:

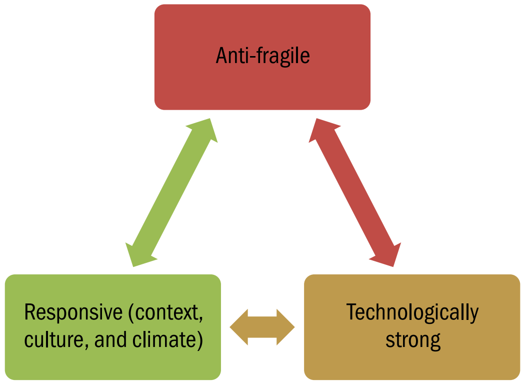


Figure 4: Proposed ideology for the development of future smart and sustainable cities in India

The first question is what is meant by a 'smart city'. The answer is, there is no universally accepted definition of a smart city. It means different things to different people. The conceptualization of Smart City, therefore, varies from city to city and country to country, depending on the level of development, willingness to change and reform, resources and aspirations of the city residents. A smart city would have a different connotation in India than, say, Europe. Even in India, there is no one way of defining a smart city.

There is a catch here. Let's repeat what it says- '*It means different things to different people*'. But then can this be assumed, that it gives the liberty to adopt tangent ways, given a common country of origin? So, we affirmatively presume that Central government is 'central' to the idea of developing a city in an Indian way.

With this reference our proposition of future smart cities essentially roots itself on the concept of 'cluster living'. Cluster living concept is nothing novel but a long established practice for us. However, it is indeed surprising to see the anti-fragility of the concept even in modern times. Figure 4 explains the core element of the concepts.

So, if we go by the current status of development, we assume that the food, water, land, energy, and human resources all would be sourced from places other than the core city. The existence of all these external entities, would define the sustainability of the core city. What if any of these systems collapse? Can we regard this establishment as sustainable, even if the basic minimum requirements of food, energy, and water supply are not met? And to add to the woes there are hundreds and thousands of such buildings, malls, and establishments, getting ready to add pressure to immediate and distant resources. The sharp peak in the energy consumption is inevitable, if appropriate measures are not undertaken right at the planning stages of these cities. It is also important to note that there is a dire need to compliment energy budgeting along with energy conservation measures.

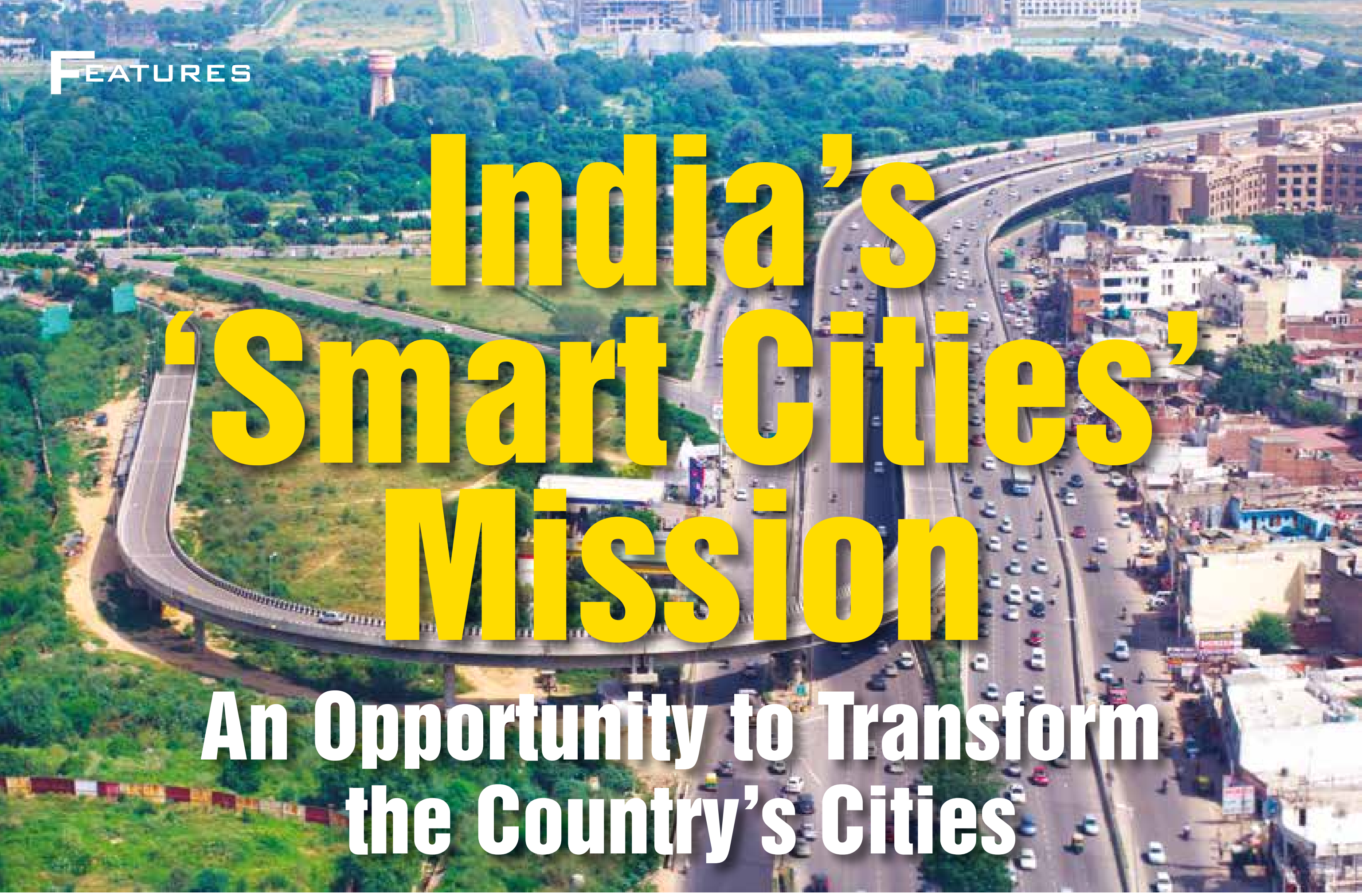
A smart city model should presume the need of conserving not just the immediate surroundings of the city, but also understand the deeper need to diligently protect the entities outside the city, which the core city is dependent on. Cluster living can ensure and encourage the protection of these dependent entities or resources. To put this simply, it won't be incorrect to claim that our economical as well as environmental stability is essentially at the mercy of these peripheral areas. A cluster living approach shall ensure that the cities are the amalgamation of self-sufficient units. Adoption of

this approach can invariably reduce the unidirectional pressure of the developmental demands on the scarce and singular sources available. Parallel efforts, such as mass awareness generation, improving the policy arrangements to drive the necessary actions, budgeting our resources for efficient planning, and diligently calculating the carrying capacities of our resources to be able to ensure their availability are some of the must-have approaches while we craft the vision for our 'smart cities'.

With increasing education levels and disposable incomes, the 'demand' for water, housing, transportation, and better medical facilities shall consequently increase. This may lay multifold pressures on the entire system. The result being that the cities will woefully fall short of all that is necessary to sustain the tag of 'smart'. It needs to be understood by all of us, that the making of a smart city cannot be the lone responsibility of the government. It is agreed, that the traditional practices have been tested for a smaller scale of operations, however, they could be tested for larger scales of operations, replicated with an inherent objective of harmonizing the development with the environment and basking on the ancestral wisdom which we possess.

As a famous saying goes, 'the only place you reach if you follow the crowd is exit' is apt of India. Indian traditions, festivals, rituals, practices, settlements, value systems, scientifically robust responses, and communities have evolved together. Old is gold but with a logic. Its time India revisits its own potential and goes that extra mile to articulate a robust plan which will reflect India in all possible ways. EF

Ms Aditi M Phansalkar, Research Associate, TERI Western Regional Centre, Mumbai, Maharashtra, India. Email: aditi.phansalkar@teri.res.in; and Dr Anjali Parasnis, Associate Director, Sustainable Habitat Division, TERI Western Regional Centre, Mumbai, Maharashtra, India. Email: anjalip@teri.res.in.



India's 'Smart Cities' Mission

An Opportunity to Transform the Country's Cities

The Government of India has announced the development and construction of 100 'Smart Cities' to meet the demands of its rapidly growing and urbanizing population. This new initiative includes construction of new municipalities and renovation of existing cities as the rural population shifts into urban areas. As countries move from being primarily agrarian economies to industrial and service sectors, they also urbanize. This is because urban areas provide the agglomerations that the industrial and service sectors need. ***Pallavi Shukla*** *believes that the concept of Smart Cities in India is an evolving one and much of its success will depend upon proper formulation and careful implementation by the authorities.*

It has been estimated that 90 per cent of the world's urban population growth will take place in developing countries, with India taking a significant share of it. Urban areas also contribute a higher share to the GDP. While the urban population is currently around 31 per cent of the total population, it contributes over 60 per cent of India's GDP. It is projected that urban India will contribute nearly 75 per cent 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. The global experience is that a country's urbanization, up to 30 per cent level, is relatively slow but the pace of urbanization speeds up thereafter, till it reaches about 60–65 per cent. With an urban population of 31 per cent, India is at a point of transition where the pace of urbanization will speed up.

These issues can be mitigated through the adoption of scalable solutions that take advantage of information and communications technology (ICT) to increase efficiencies, reduce costs, and enhance quality of life. It is in this context that the Government has decided on developing 100 'Smart Cities' in the country.

Cities that take this approach are commonly referred to as Smart+ Connected Communities (S+CC), i.e., Smart Cities. Interest in smart cities has triggered plenty of theoretical and technology-led discussions, but not enough progress has been made in implementation related initiatives. In addition, there are a number of factors hindering adoption of Smart City solutions—scaling of newer technologies is unproven; technology challenges the existing status quo in how cities are run; and the complexity of how cities are operated, financed, regulated, and planned. Smart Cities, however, present an opportunity to integrate physical city infrastructures—from utilities, transportation, and real estate to city services.

UNDERSTANDING SMART CITIES

Three pillars of Smart Cities are infrastructure, operations, and people. In a smart city, these pillars work in an interconnected and integrated fashion to utilize resources efficiently and strive to deliver services remotely over networks. Cities embracing the smart city philosophy aspire to move the vast majority of their processes for engaging with and delivering content or services to citizens online, such that the interaction between the citizen and the public authority is carried out on a connected device. The aim of the mission is to reach out service delivery beyond the confines of government premises and beyond the restrictions of the normal working day for public administration employees.

Smart city framework

An integrated smart city framework comprises the following key enablers—smart governance, smart living, smart people, smart mobility, smart environment, and smart economy (Figure 1).

WORLDWIDE SCENARIO

As world urbanization continues to grow and the total population is expected to double by 2050, there exists an increased demand for intelligent, sustainable environments that reduce environmental impact and offer citizens a high quality life. European Union (EU) classifies 240 of the 468 cities in the 28-nation block with 100,000+ inhabitants and at least one smart city characteristic as smart cities. The European Commission identifies Amsterdam (the Netherlands), Barcelona (Spain), Copenhagen (Denmark), Helsinki (Finland), Manchester (UK), and Vienna (Austria) as "the most successful" in the EU. Europe, The Middle Eastern and African regions represent the largest number of smart cities at present. It is expected that within a decade, Asia-Pacific will take the lead. By 2025, Asia-Pacific will account for 32 smart cities, Europe will have 31, and the Americas will contribute 25. In Japan, the national government has selected 13 locations for its Eco-Model Cities (EMC) scheme. This includes four major cities—Kitakyushu, Kyoto, Sakai, and Yokohama—plus nine further small and medium cities. China, too, is pursuing a smart cities strategy as part of its efforts to stimulate economic development and eradicate poverty. This strategy involves at least 54 smart city projects, and includes cities, such as Beijing, Shanghai, Chengdu, Hangzhou, and Wuhan, who are aiming to build smart cities during the Twelfth Five Year Plan (2011–15).

The Smart City is emerging as an important basis for future city expansion in the global scenario. High density city populations increase strains on energy, transportation, water, buildings and public spaces, so solutions need to be found which are 'smart', i.e., both highly efficient and sustainable on one hand, as well as generating economic prosperity and social well-being on the other. This is best achieved by mobilizing a city's resources and coordinating its actors using new technologies and forward looking joined-up policies. Smart City initiatives are spread across all six characteristics, but most frequently focus on smart environment and smart mobility.

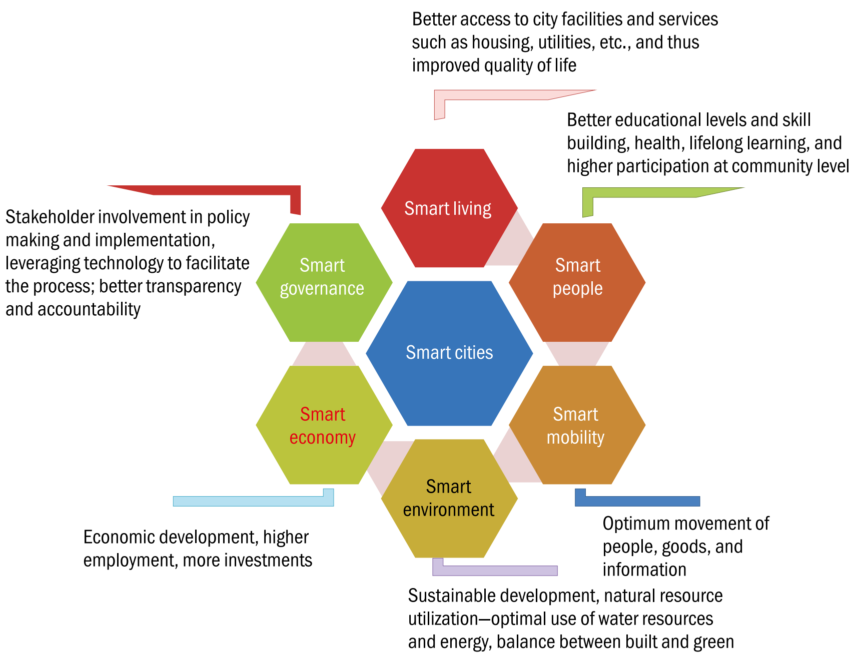


Figure 1: Smart city components

THE INDIAN GOVERNMENT'S 100 SMART CITIES MISSION

Indian government's biggest mission is to roll out 100 smart cities across the country (Table 1). These smart cities will leverage innovation and technology for e-governance, Digital India initiative, employment generation, involvement of the citizens in decision-making and policy execution, as well as in improving the quality of life. Moreover, with renewed efforts for a clean and green India, these upcoming smart cities will be modelled on the Swachh Bharat initiative and zero emission policies.

Table 1: Shortlisting of 100 Indian cities for the smart cities mission

Economic criteria Cities accounting for 54 per cent of incremental GDP till 2025	69
Geographic inclusivity — All state capitals (not included above) — Tourist or religious heritage cities (not included above) — Hilly and coastal areas — Mid-sized cities	12 8 4 7
Total	**100**

The government had unveiled a list of 98 cities (Figure 2), including 24 state capitals for its ambitious 'Smart Cities' project. Two other cities will be announced later. Maximum number of to-be-developed smart cities is in Uttar Pradesh, followed by Tamil Nadu and Maharashtra.

Out of these 98 cities, the government has announced the names of the first 20 cities which will be developed into smart cities in 2016.

The first 20 cities announced by the Government of India are: Bhubaneswar (Odisha), Surat (Gujarat), Kochi (Kerala), Ahmedabad (Gujarat), Jabalpur (Madhya Pradesh), Visakhapatnam (Andhra Pradesh), Pune (Maharashtra), Jaipur (Rajasthan), Sholapur (Maharashtra), Davangere (Karnataka), Indore (Madhya Pradesh), New Delhi Municipal Corporation (NDMC, Delhi), Coimbatore (Tamil Nadu), Kakinada (Andhra Pradesh), Chennai (Tamil Nadu), Ludhiana (Punjab), Bhopal (Madhya Pradesh), Belagavi (Karnataka), Udaipur (Rajasthan), and Guwahati (Assam).

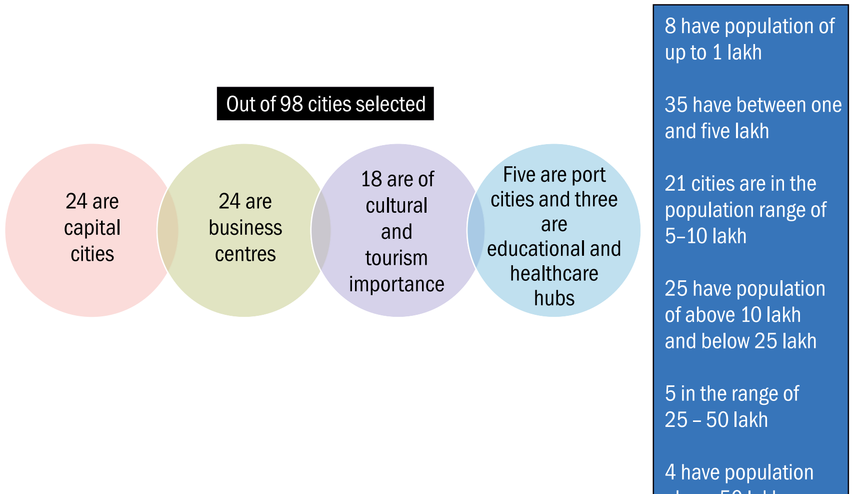


Figure 2: Description of the 98 cities to be developed as smart cities

Criteria for the selection

The cities in the first list have made it to the top of the competition based on implementation framework, including feasibility and cost-effectiveness, which had a weightage of 30 per cent, followed by result orientation (20 per cent), citizen participation (16 per cent), smartness of proposal (10 per cent), strategic plan (10 per cent), vision and goals (5 per cent), evidence-based city profiling and key performance indicators (5 per cent), and processes followed (4 per cent).

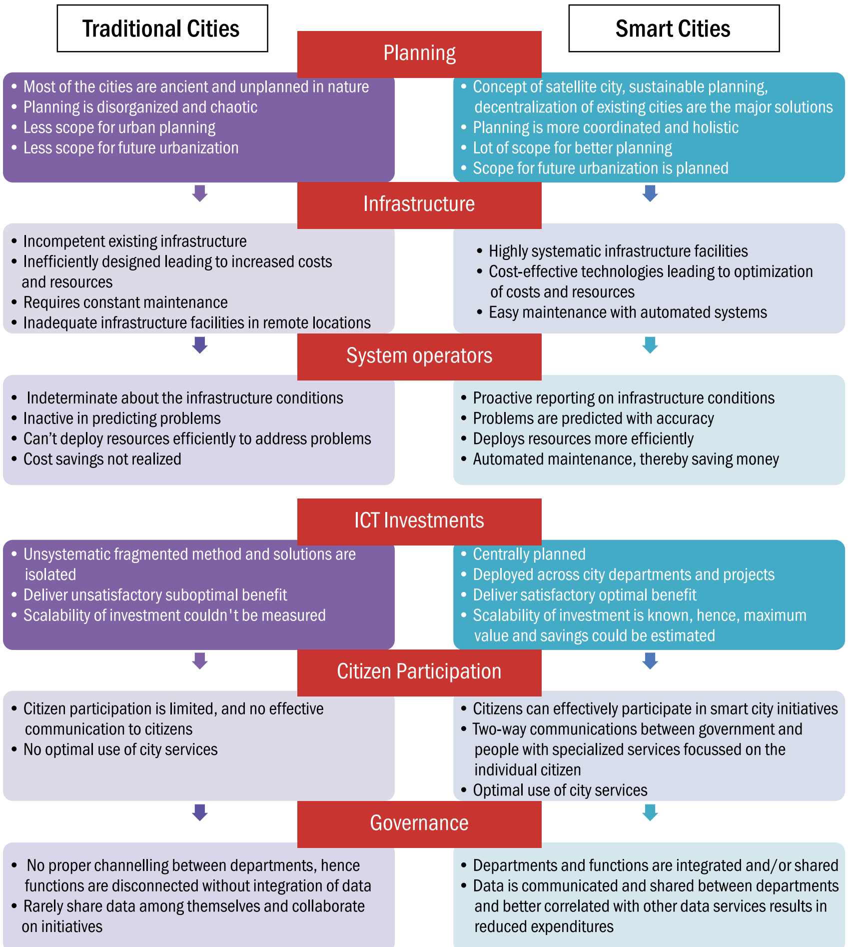


Figure 3: Traditional cities versus smart cities

In the subsequent years, the government will announce 40 cities each to be developed as smart cities as per the Prime Minister's plan to develop '100 Smart Cities' in the country. Figure 3 presents a comparison between traditional and smart cities.

STRATEGIES FOR SMART CITY DEVELOPMENT

City improvement, renewal, and extension are the basic strategic components in smart city mission. In Greenfield township development, smart solutions are applied covering larger parts of the city. Table 2 presents the descriptions of the three model components of smart city development.

Smarter solutions need use of technology, information, and data in different aspects of the smart city. Recently, Delhi government announced application of smarter solutions to make public transport robust. For example, e-tickets in buses, common mobility card, passenger information system, electric buses as well as 600 buses and 500 midi buses, etc. It will reduce average commute time or cost to citizens who will have positive effects on productivity and quality of life of citizens. Waste water recycling and smart metering are few examples which can make a substantial contribution to better water management in the city.

Funding

Centre approved ₹1 lakh crore for the ambitious five-year Smart Cities plan, whereas State governments and municipal bodies will account for merely one-fifth of the money needed for the mission. As per Central government estimates, a whopping funding amount of ₹4 lakh crore will be infused chiefly through private investments and loans from multilateral institutions among other sources.

In the initial phase, 20 smart cities recently announced by the government will get the funds first, to kick start their development process. With a per city allocation of ₹100 crore for each of the five years of the mission period, the central assistance to the mission is around ₹50,000 crore.

Bilateral and multilateral agencies

The Union government is set to approach the World Bank and the Asian Development Bank (ADB) for a loan of £500 million and £1 billion each for 2015–20. The Department of Economic Affairs, Ministry of Finance is presently scrutinizing a proposal sent

Table 2: The descriptions of the three model components of smart city development

Process	Retrofitting	Redevelopment	Green-Field Townships
Type of Development	Existing developed area	Existing urban sprawl (including railway, bus stations, etc.)	Vacant land
Land Extent Required	Minimum 500 acres in size	Minimum 50 acres in size	Minimum 250 acres for each township
Focus for Development	• Zero emission initiatives—solid and liquid discharge • High-speed, high-bandwidth connectivity and CCTV surveillance in all public areas	In addition to all retrofitting components, the following have to be deliberated: • Redevelopments with higher FAR and lower ground coverage to provide more green footprints within the city • Smart measures to make the buildings green and energy-efficient	In addition to all redevelopment components, the following have to be deliberated: • Trade facilitation, incubation, skill development centres
Infrastructure Development	• Quality electricity and water supply through smart metering • Installation of LED lighting, use of intelligent traffic and parking management systems in required areas	• Road widening, allocation of recreational and open spaces	• Development of base physical infrastructures, such as roads, power, water supply, sewerage, waste management, etc. • Quality infrastructure for education, health, and recreation • Provision and integration of multi modal transport systems
Implementation (No. of years)	Implementation in five years	Implementation in five years	Implementation in five years
Implementation (through)	SPV (ULB, State, Centre)	• SPV (Public/Private Developer) • Equity Participation by GoI, States, ULBs	• SPV (Public/Private developer) • Equity Participation by GoI, States, ULBs
Selection Process	Selection through 'City Challenge Competition'	Selection through 'City Challenge Competition'	Selection through 'City Challenge Competition'
Planning Principles	Planning in an existing built-up area of a municipal ward, preparing plan with citizen participation	Replacement of existing built-up area and preparing a new layout plan with enhanced infrastructure by way of mixed land use	Introduction of smart solutions in a vacant area using innovative planning
Case Examples	• Connaught Place in Delhi • Bhendi Bazar in Mumbai	Kidwai Nagar in Delhi	Land pooling/land reconstitution in outer Delhi, GIFT city in Gujarat

by the Ministry of Urban Development on procuring loans from these two institutions. Similarly, such proposals will also be sent for procuring funds from the BRICS New Development Bank, China-led Asian Investment Infrastructure Bank, Japan International Cooperation Agency (JICA), Agence Française de Développement (AFD), and Germany's GIZ, etc.

Technical assistance will be provided by The World Bank, ADB, AFD, KfW, JICA, in addition to a host of other agencies to the cities in preparation of their Smart City plans as well as on the procurement of consultants. These include UK government's Department for International Development, United Nations Industrial Development Organization, and US Trade and Development Agency.

FEATURES OF A SMART CITY

Some of the important features necessary for smart cities are assured water and power supply, sanitation, and solid waste management, efficient urban mobility and public transport, IT connectivity, e-governance, and citizen participation. A few of the important features of smart cities are as follows:

- Promoting mixed land use—planning for 'unplanned areas' containing a range of compatible activities and land uses close to one another in order to make land use more efficient.
- Expand housing opportunities for all.
- Reduce congestion, air pollution and resource depletion, boost local economy, promote interactions, and ensure security. Creating walkable localities—strengthening public transport, road networks for pedestrians and cyclists, and necessary administrative services

are offered within walking or cycling distance.

- Open spaces—parks, playgrounds, and recreational spaces—in order to enhance the quality of the life of citizens.
- Variety of transport options—Transit Oriented Development (TOD), public transport and last mile para-transport connectivity.
- Making governance citizen-friendly and cost-effective.
- Giving an identity to the city—based on its main economic activity, such as local cuisine, health, education, arts and craft, culture, sports goods, furniture, hosiery, textile, dairy, etc.
- Rely on online services to bring about accountability and transparency. By forming e-groups for listening to people's views and taking feedback, online monitoring of programmes and activities with the aid of cyber tour of worksites.

ENERGY MANAGEMENT

India is the world's fourth largest in installed capacity, according to the Ministry of Urban Development's 2014 Concept Note on Smart Cities. Yet it continues to be a country with scarce electricity distribution. Electric energy is one of the most important resources in any economy and the challenge posed by its supply must be handled well. The extent to which the economy can grow is fully dependent on the efficiency and sustainability of energy supply to industries and homes. Accenture's Digitally Enabled Grid of 2014 report found that India's rapidly-growing distribution systems need to address network and sustainability issues of outage response, to help in reducing cost per kilowatt-hour (kWh). This can be achieved through theft reduction of electricity and electrical installation systems. India's smart grid establishment received a big boost after blackouts that affected more than 600 million people in 2012. Smart grid technology allows systems (the grid) to be fed by alternate energy sources, such as solar, wind, and hydrocarbons, among others. The integration of this power generation into the smart grid enables further decentralization of distribution and boosts nationwide generation. Such innovation encourages low-cost systems that reduce transmission costs and have minimal impact on the environment.

The selected 20 cities have submitted their proposals for transforming their city into a smart city. They include all the components with action plan. Few essential features achievement plan for Bhubaneswar city are 24X7 energy supply project by establishing a ring fenced distribution network, underground electric wiring project to reduce transmission lines and susceptibility , solar rooftop projects on public buildings, railways, smart metering and SCADA project, etc. Pune included state-of-the-art energy efficiency practices in buildings, streetlights and transit systems, 24X7 energy supply, etc. Similarly, other cities have also included the energy component as a major category in their proposals.

CHALLENGES

Creating physical infrastructure is not the only solution for a smart city. India has not been able to provide good roads, clean water, power, transport, and so on for all its citizens, even after independence. It is hoped that public private partnerships (PPP) will deliver, but the mechanism seems to need a lot of tweaking in order for it to work. The big challenge will be to create self-sustaining cities, which create jobs, use resources wisely, and also train people. This also means more autonomy for the cities. However, the question of autonomy is still a moot question depending heavily on the maturity of the Indian political system.

The concept of Smart City envisioned by the incumbent Indian government is a much needed and timely one. The international comparison clearly shows that in Europe and elsewhere, a great deal of emphasis is being placed on preserving and developing smart cities. Multidimensionality of smart cities concept cross-cutting ICT applications on transport, energy management, water management, healthcare, etc., is an important aspect. In India, converting the existing congested cities into smart ones is a formidable task. While Greenfield cities, as planned along the Delhi–Mumbai corridor are a little easier to set up, but conceptualization and implementation of the same have to be done with a forward vision and continuous monitoring in existing cities. The concept of Smart Cities in India is an evolving one and therefore, a great deal, as stated above, will depend upon proper formulation and careful implementation. EF

Ms Pallavi Shukla, Information Analyst, Library and Information Center, Knowledge Management Division, TERI, New Delhi, India. Email: pallavis@teri.res.in.

Tracking the Sun for a Gainful Purpose

A Cost-Competitive Energy Option for Extra Power Generation

*While the sun moves from east to west direction during the course of a day, the assembly of solar modules do not budge even an inch from their position. This leads to loss of some amount of solar power. A simple tracking solution is now available to align the PV array in the path of moving sun. In this article, **Dr Suneel Deambi** takes a close look at the issues, challenges, and opportunities of single-axis tracking system from several key considerations.*