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RESEARCH ARTICLE

SUSTAINABILITY THROUGH DIMENSIONS OF SMART URBANIZATION

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ABSTRACT

Sustainable Development needs a new dimension in the present world of modernization. With Smart cities, smart development and smart growth which are a new concept in today's time; the relative dimension and definition of sustainability change. The need for smart cities and development have in-fact emerged due to the need for sustainable development in light of disadvantages of rapid urbanization, increasing disasters and climate change. The rapid urbanization and growing number of megacities, cause great ecological, economical and social problems and risks across the globe leading to serious issues like climate change, disasters, and environmental degradation. Cities place tremendous strains on natural resources and the environment. Despite being faced with urbanization such a large scale, as never experienced before, emerging cities do have advantages. Cities are engines of economic growth and advance technology; Cities represented two-thirds of global energy consumption in 2006 and this proportion is expected to grow to almost three-quarters by the year 2030. If properly planned and guided, urban development will lead to the evolution of smart cities with eight smart features, including Smart Economy, Smart Buildings, Smart Mobility, Smart Energy, Smart Information Communication and Technology, Smart Planning, Smart Citizen and Smart Governance. This paper discussed the some of the most prominent smart development techniques being used across the world, for sustainable development. The development of smart cities, smart transportation, low carbon electricity ecosystem and smart grid Technology are few of the revolutionalizing technologies which is trying to bring a boost of energy efficiently and is a major step towards sustainable development. This paper discussed these in brief.

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INTRODUCTION

It has been rightly said that "The 21st century is the century of the cities and of urbanization" (Kötter 2004). The process of urbanization is irreversible and unstoppable and hence it needs to be adaptive right at inceptive stage. The statistics by 'The State of World Population 2001' indicate that, the total population is increasing by 280.000 people per day (Kötter 2004). Nearly three-quarters of them will be inhabitants of the developing world (Doytsher *et al*., 2010). In development terms, urbanization has taken a back stand in the present time, and in most of the cases the process of sub-urbanization is being caused which is associated by a high rate of motorization combined with increasing traffic and communication infrastructure (Kötter *et al*., 2011). It has been observed that the developing countries are urbanizing at a faster rate than developed countries. In 2007, more than fifty percent population lived in cities (Doytsher *et al*., 2010). The fast rate of urban expansion is mainly because of the progress in agriculture, science of nutrition and medicine.

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Further, the rapid urbanization and growing number of megacities, cause great ecological, economical and social problems and risks across the globe leading to serious issues like climate change, disasters, and environmental degradation (Kötter, 2004). Cities place tremendous strains on natural resources and the environment. These impacts also cause challenges for urban policies and urban planning strategies to manage the development in a sustainable way, when the population in some cities doubles every 10 to 15 years (Kötter, 2004) with increasing urban vulnerability. Thus with these trends there is a strong need to go for sustainable development. New and more innovative solutions are needed to make cities more self-sufficient and sustainable, along with advances in technologies and significant environmental awareness in order to reformulate urban planning and development.

The UN World Economic and Social Survey 2013, focused on sustainable development and the challenges facing its economic, social and environmental dimensions. According to the Survey, sustainable development of urban areas requires integration and coordination, and investment to tackle land-use issues, food security, employment creation, transportation

infrastructure development, biodiversity conservation, water conservation, renewable energy sourcing, waste and recycling management, and the provision of education, health care and housing (World Economic Survey 2013). Despite being faced with urbanization at a scale which has been never experienced before, emerging cities do have advantages. "Re-engineering cities is urgently needed for global sustainability, …… emerging urban areas "have a latecomer's advantage in terms of knowledge, sustainability thinking, and technology to better manage such fundamentals as trash and transportation." Said Dr. Dhakal, Addressing the social, environmental and economic challenges associated with rapid and growing urbanization in London, for the "Planet Under Pressure 2012″ conference (Burger, 2012). In addition, he said, "smart buildings, cars, transportation, power, water and waste systems are examples of an emerging Internet,….. offering "a fast-growing number of high-tech, artificially intelligent, Internet-connected cars, appliances, cameras, roadways, pipelines and more – in total about one trillion in use worldwide today." Thus this paper tries to enlist some the emerging techniques of smart sustainable development. In the first two sections we try to understand the global urbanization trends, challenges and opportunities and thereafter we try to identify key solutions to it in the next section of the paper.

Urbanization Trends

Rapid urbanization trends are seen all across the globe, leading to mostly uncontrolled and haphazard development, which is becoming the cause of increasing urban vulnerability, rise in disasters, climate change and environmental degradation. This is immensely affecting the urban population in terms of quality of life. According to UN reports, the urban population increased from 220 million in 1900 to 732 million in 1950 (29% of the world's population) (Un.org,. 2013). By 2030, around 4.9 billion people, that is 60% of the world's population, are expected to be urban dwellers (Un.org,. 2013; UNDESA, 2013).

This fast pace of urbanization, has diverging impacts and influences on future lives and mobility of people. Along with adverse impact, inversely it also brings, the opportunities for wealth generation and economic development, which has created the phenomenon of 'megacities'- that is the urban areas with a population of 10 million or more. There were 19 megacities (2010) in the world which are expected to increase upto 27 by 2020 (Doytsher *et al*., 2010). Over half of this growth is expected to be in Asia where the world's economic geography is now shifting (Doytsher *et al*., 2010). With respect to development, 55 percent of the growth is projected to be in developing economies of India, China, Russia and Latin America. As per the economic experts, the mega cities of developing economies, will witness a Compound Annual Growth Rate (CAGR) of 4.4 percent in GDP (PPP) from 2009 to 2025, as compared to a CAGR of 1.63 percent for the same period in the mega cities from developed economies (Anon 2009). Population experts also project that six cities of developing world, —São Paulo, Mexico City, Mumbai, Delhi, Dhaka, and Tokyo—will have topped the 20 million mark by 2015 (United Nations 2005).

The urbanization does not stop here; it leads to even greater phenomenon of mega regions. Convergence of two or more closely located mega cities will lead to the formation these huge mega regions. For example, by 2020, Johannesburg and Pretoria in South Africa will converge to form one big mega region called "Jo-Toria" (Anon 2009). These are areas of strong economy which can change anything. The Regional Plan Association, through the America2050 initiative, has defined mega-regions as "large networks of metropolitan regions that are linked by environmental systems and geography, infrastructure systems, economic linkages, settlement patterns, and shared culture and history" (Katie Bullard, 2014). Another trend of urbanization is the evolution of mega corridors.

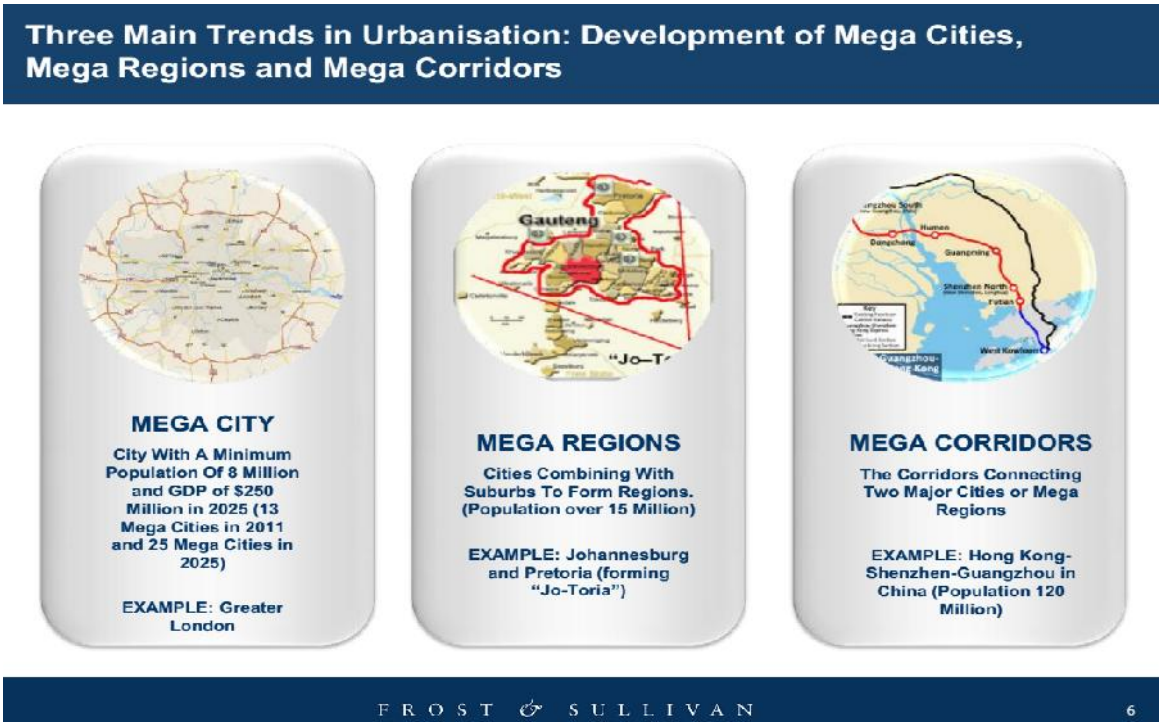

Figure 1. Shepherd B., 2011, *"Frost, Sullevan, throwing Light On the Future:Mega Trends That Will Shape the Future of the World"*

Infrastructure development, particularly transport corridors interconnecting two or more mega cities or regions, will lead to the expansion of these corridors. For example, the Hong Kong-Shenzhen-Guangzhou corridor in China is expected to house 120 million people by 2025. Therefore with such an immense potential of emerging economies, there is a strong need for smart urbanization and smart development, where urbanization becomes a boon and not a bane. This concept of Frost and Sullewan is shown in Figure 1.

Urbanization as a Challenge

If not properly guided, urbanization shall lead-*to serious environmental problems*, like expanding deserts, falling water tables, increasing water pollution, and declining air quality, and *Deletion of land and water*. Studies indicate that Asia's cities expanded at the greatest densities till date. For instance, Seoul, Hong Kong, Surabaya, Jakarta and Manila expanded at densities from 36,000 to 74,000 per square mile. It is estimated that next six urbanized areas, Los Angeles, San Jose, Edmonton, Ottawa, Miami and Paris will have expanded at over 5,000 per square mile, at 8,243 new residents per new square mile. Los Angeles rates the highest in North America, Edmonton, at 6,806 per square mile, has the highest density urban expansion in Canada (Demographia.com, 2000). These statistics are alarming. Urbanization also leads to *Increase in automobile and depletion of non renewable resources and increase of carbon emissions*. It has been observed that the developing countries are having even more serious issue of carbon emissions due to less developed technology and higher pace of increasing urbanization.

In general, cities are responsible for more than 70% of global CO_2 emissions, with urban area greenhouse gas emissions increasing in recent decades. Urban-area CO_2 emissions were estimated at about 15 billion metric tons in 1990, which increased to 25 billion metric tons in 2010, with forecasts of that growing to 36.5 billion by 2030 given a "business-as-usual" scenario."(Burger 2012); Vehicle traffic congestion not only wastes fuel and causes pollution, but also time. People wasted an estimated 4.2 billion hours sitting or moving slowly in traffic in the US alone in 2005. The estimated cost of traffic congestion in lost productivity in New York City has been estimated to total $4 billion a year, says statistics in Demographia. *Urbanization has also lead to more and more need of infrastructure; Ex:* In 2003 alone, China built 2,858 miles (4,600 kilometers) of expressways, bringing the total length to more than 18,645 miles (30,000 kilometers), second only to the United States. Thus urbanization is causing unprecedented development especially in medium sized cities of developing countries. They are moving toward a damaging, sprawling, auto-dependent settlement patterns, with greater distances to places of jobs, shops, and public services (Dickson *et al*., 2010). Unplanned or poorly managed expansion, together with the surging popularity of private vehicles, has led to a plague of "city diseases," such as traffic congestion, air pollution, and water pollution. Collectively, the unchecked development of hundreds of cities and towns has raised national and global concerns about food security, energy security, and greenhouse gas emissions (Appleyard *et al*., 2007). Thus over ultimate goal (with the help of integrated participation of people and administrators), must be to manage migration and urbanization in a way that will ensure sustainable development (Appleyard *et al.,* 2007). This is possible by smart development strategies using smart growth principles.

Opportunities of Urbanization

Cities are engines of economic growth and advance technology; as a result organizations/ companies/ firms prefer to locate in urban areas and cities with good access to labor markets, and customers. Increasing returns and specialization raise productivity where each unit of area generates far greater output and hosts greater economic assets. Cities represented two-thirds of global energy consumption in 2006 and this proportion and is expected to grow to almost three-quarters by the year 2030 (Pacific *et al*., 2010). The GDP of cities is very high as compared to rural areas and even higher in mega cities. This reflects the concentration and greater economic value of productive assets— as well as public infrastructure and private assets such as homes—in cities (Eric Dickson, Asmita Tiwari, Judy Baker 2010).

Urbanization, especially rural to urban transformation, provides an opportunity to rethink patterns of urban development (Appleyard *et al*., 2007). The explosive population growth and dynamic shift in urban sprawl strategies, pose a variety of opportunities for investors in different sectors. The mega cities form the emerging economies will be the largest markets for existing premium products and technologies, while their developed counterparts will witness a trend of sustainable measures. If properly planned and guided, urban development will lead to the evolution of smart cities with eight smart features, including Smart Economy, Smart Buildings, Smart Mobility, Smart Energy, Smart Information Communication and Technology, Smart Planning, Smart Citizen and Smart Governance. There will be about 40 smart cities globally by 2025, under this concept (Anon, 2009). Japan model of development, shows that it's possible to attain high standards of economic development without excessive automobile usage (Appleyard *et al*., 2007).

There are examples in China it has used its emerging urbanization smartly and boosted strong economy. This is possible because, the coming expansion of cities provides an unparalleled opportunity - to address a number of social and environmental problems, including the amount of greenhouse gas emissions (Authors *et al*., 2012a). With good planning and enlightened governance, cities can deliver education, health care and other services more efficiently and with fewer emissions, simply because of their advantages of scale and proximity. The global movement of people into urban centers is a positive development where cities generate jobs and income, and present opportunities for social mobilization and women's empowerment, helping to address the issues outlined earlier. In addition, the density of urban areas can help relieve population pressure on natural habitats and biodiversity. Building them sustainably from the beginning is an opportunity to build a future, more livable and efficient for future generations (UNESCAP and UNISDR 2010; Authors *et al.,* 2012a). The most constructive way to support low-carbon urbanization is through two pathways to innovation: Smart Transport and Smart Cities. These are discussed below;

Smart Growth

'Smart growth' aims to balance the needs of the economy, the environment, and the community. They promote more efficient use of land, services, and resources; put higher priority on building ecologically within existing communities; and encourage fewer and shorter automobile trips by promoting more attractive and effective transit alternatives (Appleyard *et al*., 2007). Thus 'Smart growth' is an urban planning and transportation theory that concentrates growth in compact walkable urban centers to avoid sprawl. It also advocates compact, transit-oriented, walkable, bicycle-friendly land use, including neighborhood schools, complete streets, and mixed-use development with a range of housing choices. The term 'smart growth' is particularly used in North America. In Europe and particularly the UK, the terms 'Compact City' or 'urban intensification' have often been used to describe similar concepts, which have influenced government planning policies in the UK, the Netherlands and several other European countries (Smartgrowth.bc.ca 2013).

By integrating transportation and land-use development, smart growth policies have been effective in curbing urban sprawl while delivering tangible environmental and financial benefits (Appleyard *et al*., 2007). A successful example can be seen of 'European smart city model': Since 2007, the TUWIEN (University of Vienna) team works on the issue of smart cities. In cooperation with different partners and in the run of distinct projects financed by private or public stakeholders and actors, the European Smart City Model was developed. Basically it provides an integrative approach to profile and benchmark European medium-sized cities and is regarded as an instrument for effective learning processes regarding urban innovations in specific fields of urban development. Currently, the 3rd release (2014) of the smart city model is already available. As per the model, A Smart City is a city well performing in 6 characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens (Smart-cities.eu 2013). The smart city network model of European Cities is shown in Figure 2.

Another recent mass scale development of smart urbanization, "Chinese smart city model": in China, as many as 18 cities (according to a Lux Research report) have been announced with smart city plans. These include some of the biggest cities such as Beijing and Shanghai, and a number of small to medium-size cities, such as Ningbo, Wuxi, Chengdu, Wuhan, Kunming, Foshan, Shenzhen, and Guangzhou. Ningbo the first one in this series**,** is a seaport city in Zhejiang province, with a population of 7.6 million inhabitants, released its action plan(RMB) for developing as a Smart City (2011-2015). According to the smart city plan, RMB, 40.7 billion will be invested in projects in the next 5 years (12th Five-Year Plan period). The plan address Five "Speed Ups": Speed up construction of international strong port, building a modern metropolis, industrial restructuring, building a Smart City, construction of ecological civilization and improvement of life quality. There are 87 individual projects covering logistics, manufacturing, public services, energy, social administration, traffic, healthcare, residential site management, and entertainment services. For example IBM Smart Logistics Center, Ningbo Branch Corporation of Tata of India, BT Cloud Computing Center, Shuguang Cloud Computing Center have come to settle in (ICT4Green by Donato Toppeta 2011).

A low Carbon Electricity Ecosystem

The Waterloo Global Science Initiative (WGSI)—a non-profit partnership between Perimeter Institute for Theoretical Physics and the University of Waterloo—has released the *Equinox Blueprint: Energy 2030*. The Blueprint provides a view of high impact energy technologies along with a set of implementation strategies as a roadmap to a low-carbon and more sustainable energy future (Media, 2014). Part One of the Blueprint details the "exemplar pathways" developed by participants of the Equinox Summit, and incorporates specific proposals of technologies for generation, transport and storage of electricity. From this emerged the concept of a Low Carbon Electricity Ecosystem. The five exemplar pathways suggested there are: Energy storage technologies to enable renewable electricity generation; Enhanced geothermal, tapping into the Earth's heat using techniques; Advanced nuclear reactors for enhanced

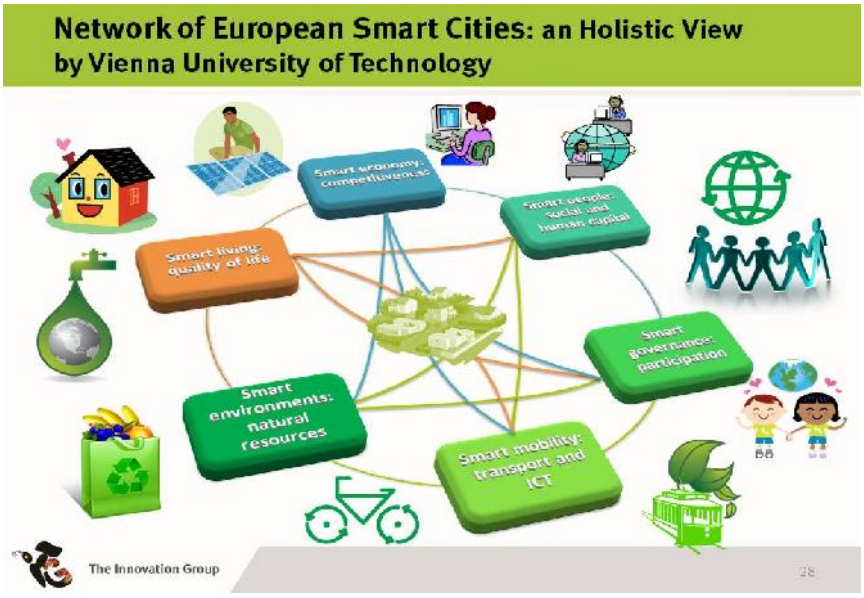

Figure 2. Network of European Smart cities, as given by Vienna University of Technology

safety, utilizing inexhaustible resources (recycled uranium, thorium, and high level wastes) to close the fuel cycle; Off-grid electrification using flexible solar cells and self-sustaining micro-grids; Smart cities and electric transport for a global future dominated by urban living . These 'exemplar pathways' together fit into a Low Carbon Electricity Ecosystem. Figure 3 gives the concept of "A Low Carbon Electricity Ecosystem".

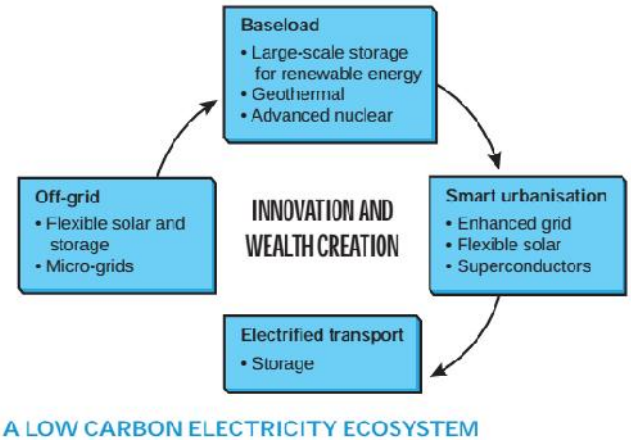

Figure 3. Bluprint *Equinox* 2030 summit, s discussions, a new model for the global electricity: the Low Carbon Electricity Ecosystem

Smart Transportation

Cities' transportations have been a leading driver behind globalization: shrinking distances, in the emergence of entire new economies and improving the quality of life for millions of people (Ibm.com 2013). But at the same time, the Transportation sector is responsible for majority of greenhouse gas emissions as CO_2 resulting from the combustion of petroleum-based products, like gasoline. Transport-sector CO_2 emissions represent 23% (globally) and 30% (OECD)(OECD-ITF Joint Transport Research Committee's Working Group 2010). In Mega Cities that favour public transport, total transport energy consumption is four to seven times less than cities with low densities (Kötter and Friesecke 2009; IISD, 2004).

But the personalized transportation in these cities produce 13% of total greenhouse gas emissions (Bongardt *et al*. 2010), (UNDP 2011). To deal this issue, Smart Transportation models have been developed by many companies such as IBM, transportation Department of US, etc. That can meet up challenge of CO_2 emissions. These are mainly achieved by electric mobility and enabled by creative ownership models for personal transport and mass transit. A model of smart transport is presented in 'BluePrint, Exuinox summit' where, Smart Energy Network (information-rich, intelligently operated through a Smart Grid design), utilizes superconductors for enhanced capacity of electricity transmission, and allows transportation needs to be met by multiple approaches not reliant on private ownership of vehicles which, coupled together, could be transformative step towards smart urbanization and for reducing CO2 emissions.

Experts note that as urbanization unfolds, it will be easier to manage through widespread adoption of such technologies, and can have significant positive impact on low energy usage and consumption. Some approaches might include: The *widespread electrification of transport* which can reduce substantially, the greenhouse gas emissions and fossil fuel use; A *shifting away from personal ownership of vehicles towards ubiquitous access to mobility through vehicle-sharing and mass transit* can additionally reduce pollution, traffic congestion and maintain healthy environment; *New information and communication technologies, integrated and enabled through the development of Smart Electricity Grids can help reduce demand for electricity*; The electricity needs of electric vehicles and other innovations can be efficiently met through *superconducting transmission and distribution infrastructure; Extension of bicycle lanes in densely populated urban regions will* allow greater access to this mode of transport, *Secure, weather-protected bicycle parking stations with recharging facilities for electric bicycles* close to city centers would also offer range conveniences to the people; facilitating a greater shift to electric cars, by *providing recharging stations at central locations and at all major shopping centres*; Mass transit needs to be clean and zero emitting (Falconer *et al*., 2006; IEA 2002). *Extension of electrified railway and tram lines will enhance access to these modes of public transport* to a greater number of commuters encouraging

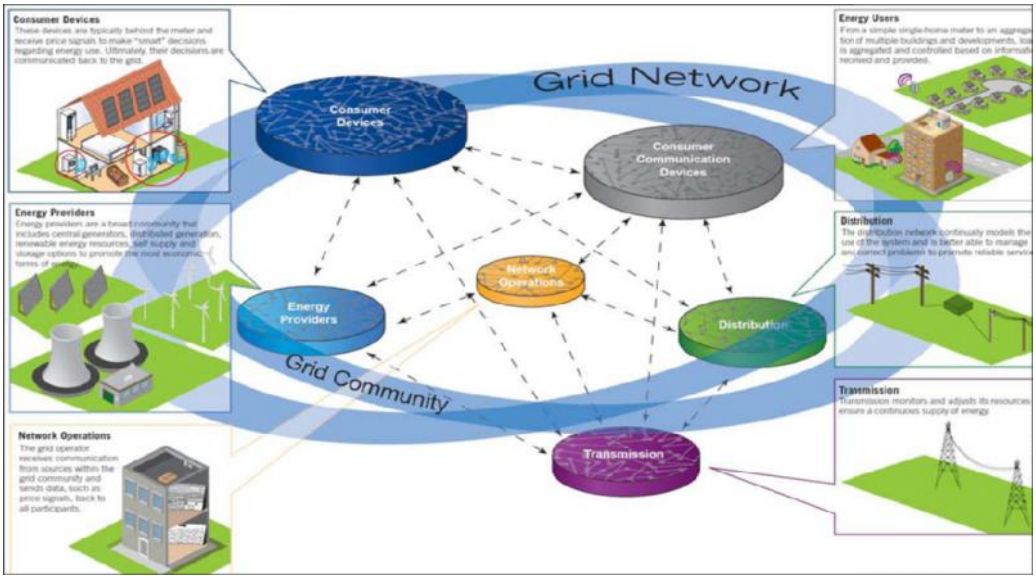

Figure 6. The Provincial Electricity Authority (PEA) Smart Grid

a shift away from private cars; *The use of electric buses in urban areas will further reduce urban emissions while allowing a shift away from conventional carbon-based transport fuels* (Ibm.com, 2014; IEA 2002; Its.dot.gov, 2013). An alternative approach battery charging stations would involve the use of a mechanically rechargeable battery or fuel cell that allows rapid refuelling and unlimited range extension as buses need to be on the road for up to 20 hours a day.

Smart Grids to improve Energy use

The smart grid is a relatively new concept. The literature says; **"**A smart grid is a digitally enabled electrical grid that gathers, distributes, and acts on information about the behavior of all participants (suppliers and consumers) in order to improve the efficiency, importance, reliability, economics, and sustainability of electricity services. Smart grid policy is organized in Europe as Smart Grid European Technology Platform" (DeepResource, 2012). The energy systems of the 21st century are likely to be characterized by cheap and abundant use of information and communication technology (ICT), enabling more efficient energy use and integration of renewable energy through an integrated energy network. (Authors *et al*., 2012b) Energy supply and consumption are influenced by the behavior of individuals, which determine the evolution of the overall energy system. The near future electricity grids will enable two-way flows of electricity and of information, as new technologies make possible new forms of electricity production, delivery and use.

The Smart Grid is the Utility name given to the new electricity system that has emerged as a paradigm shift in this direction. A Smart Grid is a modernized electric system that uses sensors, monitoring, communications, distribution system automation, advanced data analytics and algorithmic for anomaly detection to improve the flexibility, security, reliability, efficiency, and safety of the electricity system. It increases consumer choice by allowing them to better control their electricity use in response to prices or other parameters (Ieso, 2009). *Example***;** the Provincial Electricity Authority (PEA) is a government enterprise under the Ministry of Interior. The PEA Smart Grid is utility information and communication technology to manage, monitor and control the generation, transmission and distribution and electrical energy. The PEA Smart Grid enables distributed generation from alternative clean energy sources, and maximizes profit from asset utilization with a new management system. The PEA Smart Grid also enables the use of electric vehicles and provides connection services to the electrical network through smart metering. Finally, the PEA Smart Grid will provide efficiency, security, safety, reliability and international standards of power quality to meet customer needs in the 21st century (Powergenasia.com 2014). Figure 6 conceptualizes, The Provincial Electricity Authority (PEA) Smart Grid.

Conclusion

It has been seen that urbanization which is the phenomenon of every city and country is posing many challenges for urban areas and cities. Especially, the cities of developing countries are not able to cope with the rapid urbanization which is resulting in haphazard development, along with environmental degradation and great pollution. These are in turn increasing the green house gas emissions which is causing a major ecological change. This challenge has been addressed by the economists, and researchers through the development of New technology in a "smarter Way" where the technology is used to achieve energy efficient modes of development, resulting in smart urbanization. But there are few challenges which if not met, will not yield fruitful results of these technologies. The most important is public participation and the inclusive approach to any design. The people need own the problems in order to participate in meeting their solutions. Second most important issue is governance, which can solely initiate any strong solution of urbanization. The lesson we learn here is though there are many technologies being developed, it is very important to select the appropriate technology based on the available resources and adaptability level of people in any city. It is then only, that the results will be fruitful.

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