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Eco-Innovations in Designing Ecocity, Ecotown and Aerotropolis

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Abstract

The development of aerotropolis around the megacities of the world is all together a recent conceptualization to build smart cities with sharp focus of eco-innovation and green economy. In a modern aerotropolis, the infrastructure is so built that it connects the megacity with massive road, transport systems and ICT (i.e. The Internet of Things) network in one hand; provides key linkages and services for the international businesses on the other hand. In recognition to these emerging modern trends sub-serving the growing interests of the fast changing lifestyle, this paper is dedicated to discuss and showcase the recent eco-innovations made in developing eco-cities, eco-townships and the aerotropolis world over on a selective case study basis.

Keywords: Eco-innovation; Eco-city; Eco-town; Aerotropolis; Megacity

Introduction

Benefits of developing eco-cities and eco-townships

There are several benefits of developing eco-cities and eco-townships; which among other things, are largely green and eco-friendly. These include: efficient land use, habitat preservation and restoration, effective transport management, efficient use of resource and enhanced quality of life for the occupants.

Efficient land use

In today's scenario, development has become synonymous with physical expansion or growth. There is a need for significant changes in the pattern of land use and construction that will provide communities with better quality of life and at the same time conserve natural resources. Green township rating system addresses the impacts of urban sprawl by encouraging compact, mixed-use developments and promotes higher urban densities without affecting the quality of life. Habitat

Preservation and restoration

Conventional development is generally insensitive to natural environment. Such developments may scar the landscape, take prime agricultural land out of production or destroy biodiversity and natural habitats. The green townships rating system is designed to facilitate restoration and preservation of the natural environment by encouraging strategies that aid interface between the built environment and natural environment. This approach will not only enhance the fabric of the planned development but also provide environments conducive for living and working.

Efficient transportation management

Traffic congestion, long distance commuting, rising levels of air and noise pollution are pressing issues in today's cities. Efforts to relieve congestion such as, constructing flyovers, road widening etc., are good initiatives but may not address issues such as fossil fuel consumption and associated emissions. 'green townships' rating system addresses these issues by encouraging effective and efficient transportation management strategies. Such strategies include increasing opportunities for bicycling, encouraging pedestrian friendly network; reduction in the number of automobile trips, promoting public transportation and use of alternative vehicles.

Efficient use of resources

Perhaps the most challenging problem facing our cities today is to meet the ever- rising demand for power, water supply and waste management. Meeting this demand requires enormous amount of investments infrastructure. Efficient and effective use of resources is thus vital in augmenting the existing infrastructure.

Water efficiency

Most of the Asian countries are water stressed, and in countries like India, the water table has reduced drastically over the last decade. Green townships encourage use of water in a self-sustainable manner through reducing, recycling and reusing strategies and can save potable water to an extent of 30 - 50%.

Energy efficiency

Green townships can reduce energy consumption of infrastructural equipment through energy efficient street lighting, motors, pumps etc. The energy savings that can be realised by adopting this rating programme in infrastructural equipment can be to the tune of 20 - 30%. Further, on-site power generation using various renewable energy technologies and other clean fuels can significantly reduce the load on grid power supply.

Enhanced quality of life

The place that we live in has profound effect on our lives. People have a natural predisposition to feel better and perform better in livable and safe environments. Green township developments are beneficial to the individual and community. Mixed land use and compact planning are the characteristic of a green development, which reduces dependency on automobiles and associated green house emissions. The outdoor air quality is enhanced by providing landscaped areas, encouraging the use of clean fuels for vehicles. Noise levels are reduced

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by provision of vegetative buffer. Green buildings and energy efficient infrastructure further aid in reducing the green house gas emissions. Public landscaped areas, walkable streets, bicycling lanes, community gardens and public spaces encourage physical activity and help in improving public health.

Benefits to developers

There is wide spread perception that environmentally responsive developments are time consuming and financially less rewarding. However, in reality well-executed green developments perform extremely well financially, as they require lower operating costs, increase health and productivity of the citizens and have higher marketability. The immediate benefits include reduction in water and energy demand right from the initial stages of operation.

Eco-city and eco-town: Innovations and economics

An eco-city is a city built off the principles of living within the means of the environment. The ultimate goal of many eco-cities is to eliminate all carbon waste, to produce energy entirely through renewable sources, and to incorporate the environment into the city; however, eco-cities also have the intentions of stimulating economic growth, reducing poverty, organizing cities to have higher population densities, and therefore higher efficiency, and improving health.

Origins: The concept of the "eco-city" was born out of one of the first organizations focused on eco-city development, "urban ecology." The group was founded by Richard Register in Berkeley, California in 1975, and was founded with the idea of reconstructing cities to be in balance with nature [1]. They worked to plant trees along the main streets, built solar greenhouses, and worked within the Berkeley legal system to pass environmentally friendly policies and encourage public transportation. Urban ecology then took the movement another step further with the creation of The Urban Ecologist, a journal they started publishing in 1987. Urban ecology further advanced the movement when they hosted the first International eco-city conference in Berkeley, California in 1990 [2]. The conference focused on urban sustainability problems and encouraged the over 700 participants to submit proposals on how to best reform cities to work within environmental means. In 1992 Richard Register founded the organization eco-city builders which has acted as convener of the conference series ever since. Eco-city conferences have been held in Adelaide, Australia; Yoff, Senegal; Curitiba, Brazil; Shenzhen, China; Bangalore, India; San Francisco, USA; Istanbul, Turkey; Montreal, Canada; Nantes, France and Abu Dhabi (2015) [3].

An eco-city is an ecologically healthy city. Into the deep future, the cities in which we live must enable people to thrive in harmony with nature and achieve sustainable development. People oriented, eco-city development requires the comprehensive understanding of complex interactions between environmental, economic, political and socio-cultural factors based on ecological principles. Cities, towns and villages should be designed to enhance the health and quality of life of their inhabitants and maintain the ecosystems on which they depend. Eco-city development integrates vision, citizen initiative, public administration, ecologically efficient industry, people's needs and aspirations, harmonious culture, and landscapes where nature, agriculture and the built environment are functionally integrated in a healthy way. Eco-city development requires Ecological security - clean air, and safe, reliable water supplies, food, healthy housing and workplaces, municipal services and protection against disasters for all people.

a. Ecological sanitation - efficient, cost-effective eco-engineering for treating and recycling human excreta, gray water and all wastes.

b. Ecological industrial metabolism - resource conservation and environmental protection through industrial transition, emphasizing materials re-use, life-cycle production, renewable energy, efficient transportation, and meeting human needs.

c. Eco-scape (ecological-landscape) integrity - arrange built structures, open spaces such as parks and plazas, connectors such as streets and bridges, and natural features such as waterways and ridgelines, to maximize biodiversity and maximize accessibility of the city for all citizens while conserving energy and resources and alleviating such problems as automobile accidents, air pollution, hydrological deterioration, heat island effects and global warming.

d. Ecological awareness - help people understand their place in nature, cultural identity, responsibility for the environment, and help them change their consumption behavior and enhance their ability to contribute to maintaining high quality urban ecosystems.

Eco-city development criteria: There are currently no set criteria for what is considered an "eco-city," although several sets of criteria have been suggested, encompassing the economic, social, and environmental qualities an eco-city should satisfy. The ideal "eco-city" has been described as a city that fulfils the following requirements [1,4,5]:

- Operates on a self-contained economy, resources needed are found locally

- Has completely carbon-neutral and renewable energy production

- Has a well-planned city layout and public transportation system that makes the priority methods of transportation as follows possible: walking first, then cycling, and then public transportation.

- Resource conservation-maximizing efficiency of water and energy resources, constructing a waste management system that can recycle waste and reuse it, creating a zero-waste system

- Restores environmentally damaged urban areas

- Ensures decent and affordable housing for all socio-economic and ethnic groups and improve jobs opportunities for disadvantaged groups, such as women, minorities, and the disabled

- Supports local agriculture and produce

- Promotes voluntary simplicity in lifestyle choices, decreasing material consumption, and increasing awareness of environmental and sustainability issues

In addition to these initial requirements, the city design must be able to grow and evolve as the population grows and the needs of the population change [6]. This is especially important when taking into consideration infrastructure designs, such as for water systems, power lines, etc. These must be built in such a way that they are easy to modernize (as opposed to the dominant current strategy of placing them underground, and therefore making them highly inaccessible). Each individual eco-city development has also set its own requirements

to ensure their city is environmentally sustainable; these criteria range from zero-waste and zero-carbon emissions, such as in the Sino-Singapore Tianjin Eco-city project and the Abu Dhabi Masdar city project, to simple urban revitalization and green roof garden projects in Augustenborg, Malmö, Sweden [7-10]. Using a different set of criteria, the international eco-cities initiative recently identified as many as 178 significant eco-city initiatives at different stages of planning and implementation around the world [11]. To be included in this census, initiatives needed to be at least district-wide in their scale, to cover a variety of sectors, and to have official policy status.

Practical achievements of eco-city

Economic impact: One of the major and most noticeable economic impacts of the movement towards becoming an eco-city is the notable increase in productivity across existing industries as well as the introduction of new industries, thus creating jobs. First, the movement away from carbon-producing energy sources to more renewable energy sources, such as wind, water and solar power, provides local economies with new, thriving industries. The creation of these industries, in turn, births an increase in the demand for labor; thus, not only does total employment increase, but an increase in wages also mimics increasing employment [12]. Moreover, one of the main priorities of a sustainable city is to reduce its ecological footprint by reducing total carbon emissions, which, economically speaking means increasing productivity. Merely increasing the rate of productivity in an industry reduces costs, both monetary and environmental; that is, as an industry becomes more productive, it can more efficiently allocate and use both its physical and human capital, reducing the time it takes to make the same amount of goods which also allows for a higher wage (because employees are doing more) and a lesser environmental impact [12]. In all, although the initial movement towards becoming a sustainable city may be quite costly for a smaller, poorer city, the benefits of such movement are plentiful in the long-run economic model. Moreover, as more and more countries move towards becoming more sustainable, the technologies required to initiate this movement will become more readily accessible and cheaper; therefore, many rich, developed nations should put themselves forth as an example of what other cities should model themselves like, thus sparking the innovation towards a future of sustainable technology.

Improvement of environmental standards: Although local environmental standards may differ across eco-cities, each city nonetheless has its own appropriate and practical goals and expectations that have provided the foundation for their recognition as a sustainable city. Differences in these goals and expectations are to be expected, however, due to the limitations of technology and local financing. The primary goal for all sustainable cities is to significantly decrease total carbon emissions as quickly as possible in order to work towards becoming a carbon-free city; that is, sustainable cities work to move towards an economy based solely on renewable energy. Actions towards carbon-reductions can be seen on both the corporate and individual levels: many industries are working towards cleaner production, but individuals are also moving away from environmentally costly forms of transportation to more sustainable methods, such as public transportation or biking. On this note, another common environmental goal is to increase and make more efficient the public transportation systems. Many sustainable cities also work towards becoming more densely populated (urban density); having its citizens living closer to energy production means less environmental costs of transporting said energy to citizen households. Additionally, citizens living closer to the city-center also mean that transportation

to work is significantly reduced [13]. Often a city's primary goal is to increase environmental education in hopes of achieving better citizen involvement and cooperation. By making the private sector more aware of how its behavior affects the environment, a reduction in carbon emissions becomes more of a reality.

In terms of international standards, however, we can look to the international finance corporation (IFC). The IFC has a long history of implementing environmental and social standards in localized economies, and its primary mission is to promote sustainable development across the globe, primarily in developing countries. One of its plans to accomplish this goal is to encourage international cooperation in order to accelerate and promote sustainable growth across nations [14]. Overall, the most important aspect of setting an environmental goal is making it plausible. Many cities across the globe set goals that, although they may be super-sustainable are not entirely possible. These exaggerated goals include too much sustainable development for a small time period or an expectation that is simply too expensive. The globe needs to work together to make steps towards a sustainable future that are possible and execute them well, ultimately resulting in an overall spiral towards complete global sustainability.

Technology and urban layout for eco-city and eco-town

Transportation: By decreasing urban sprawl, eco-cities and eco-towns decrease the residential and commercial dependence on automobiles. Concurrently, improved public transportation further decreases the demand for cars. The development of metro station and light rail transit systems provide mass transit not only within sectors of a city but between cities. Furthermore, many eco-cities are employing expanded "clean" bus routes in order to decrease the emissions from single household vehicles. Critics note, however, that the high price of "clean" diesel, CNG/LNG, hybrid electric buses, and super capacitor-powered buses may not prove "economically and operationally viable" [15].

Coping with urbanization trend: Eco-cities as well as eco-towns may also seek to create sustainable urban environments with long-lasting structures, buildings and a great live ability for its inhabitants. The most clearly defined form of walkable urbanism is known as the charter of new urbanism. It is an approach for successfully reducing environmental impacts by altering the built environment to create and preserve smart cities which support sustainable transport. Residents in compact urban neighborhoods drive fewer miles, and have significantly lower environmental impacts across a range of measures, compared with those living in sprawling suburbs [16]. The concept of circular flow land use management has also been introduced in Europe to promote sustainable land use patterns that strive for compact cities and a reduction of Greenfield land take by urban spraw. In sustainable architecture the recent movement of New Classical Architecture promotes a sustainable approach towards construction, that appreciates and develops smart growth, walkability, architectural tradition and classical design [16]. This in contrast to modernist and globally uniform architecture, as well as opposing solitary housing estates and suburban sprawl.

Landscape development focus: Eco-cities primarily employ green roofs, vertical landscaping, and bridge links as methods of decreasing the environmental impact of land use. Constructing green roofs and investing in vertical landscaping create natural insulation for residential and commercial properties as well as allows for rainfall collection. Additionally, green roofs and vertical landscaping lower urban temperatures and help prevent the heat island effect. Bridge links

allow for development of a walkable city without disrupting the soil to run utility lines by connecting buildings with above ground walkways.

Energy management priority

Eco-cities look to employ renewable energy sources, such as wind turbines, solar panels, and biogas, to reduce emissions. Wind turbines present the opportunity of being able to provide both localized districts within eco-cities and the larger region as a whole with emission-free renewable energy that can additionally supplement existing power sources. Furthermore, by designing buildings with natural ventilation systems, eco-cities reduce the need for air conditioning, thus, drastically decreasing commercial and residential energy use. The energy generated can come from large scale energy production systems such as solar farms which supply many homes and businesses or from individual buildings energizing at least in part their own energy from solar photovoltaic or small scale wind turbines or biomass. Many eco-cities additionally look to deploy solar thermal energy. By installing solar collectors, developers will be able to provide hot water for space heating and individual and community needs while reducing dependence on gas fueled boilers. While solar thermal energy appears to be a more efficient source of renewable energy, many urban planners also view photo-voltaics as a viable source of energy. Photovoltaics directly convert solar energy into electricity; however, the extensive costs associated with developing this technology on the city-scale may limit its use when compared to its potential payback. Biogas technology is also deployed as a source of renewable energy as the organic material from wastewater is converted into fuel [17].

Water supply economy: Eco-cities aim to decrease water consumption by employing technologies that reduce the amount of water that is needed for irrigation and sewage flow while also preventing black-water and grey-water runoff from entering ground water sources. Developers suggest installing low flow fixtures, rainwater harvesting systems, and sustainable urban drainage systems to meet eco-city standards. Additionally, advanced irrigation systems (xeriscaping) aid in maintaining green infrastructure while decreasing green space consumption of water for irrigation.

Leading eco-cities and eco-towns in the world: Cases

Curitiba, Brazil: The city of Curitiba, Brazil proactively began to address the challenges of sustainable urban development in 1966 with a master plan that outlined future integration between urban development, transportation and public health. This plan has been realized in modern Curitiba, which is defined by linear stretches of urban development surrounded by green space and low-density residential areas. The city was designed for the mobility of people, not the mobility of cars. The city's bus system is highly developed, with high-capacity busses and dedicated lanes, it effectively reaches about 90% of the population. This bus system is utilized by 45% of the population, which has caused private automobile use to drop to 22% [18]. Despite this decline, to prevent congestion central areas of the city have been closed to cars. These road closures have led to dynamic economic growth for local shops and the development of community space for pedestrians [18].

The resulting public health and education gains from this initiative have also been substantial. Curitiba maintains the lowest air pollution rates in Brazil and over 300,000 trees in the city helps reduce natural flooding [18]. Curitiba has also dedicated resources to environmental education in primary school, which has translated into environmentally conscious citizens. Over 70% of city residents participate in recycling programs which fuels the city's progressive waste processing system. Curitiba has maintained a consistent vision of the future and worked to attain it by through careful urban planning that takes into account transportation, while also encouraging environmental initiatives and public health. In 2010, Curitiba recognized for their achievement with the Globe Sustainable City Award due to "their understanding of sustainable city development - both regarding policy and implementation [19,20].

Auroville, India: Auroville was founded in 1968 with the intention of realizing human unity, and is now home to approximately 2,000 individuals from over 45 nations around the world. Its focus is its vibrant community culture and its expertise in renewable energy systems, habitat restoration, ecology skills, mindfulness practices, and holistic education. Auroville is often referred to as a collective experiment dedicated to human unity, and can be viewed as a sustainable city-in-the-making. It was founded in February 1968 by Mirra Alfassa (1878 - 1973) - commonly known as 'The mother - on the Coromandel Coast in Tamil Nadu state, India. Auroville was envisaged to be a continuation of The Mother's efforts to materialise the teachings of her spiritual collaborator, the Indian poet and philosopher Sri Aurobindo. It is a working example of Sri Aurobindo's philosophy that views cities as reflecting mirrors of the collective aspiration of the societies living within them. The name Auroville stems from Aurobindo, but also means 'city of dawn'.

Organized around a common vision to promote human unity as opposed to sustainability per se, the material form of Auroville was not preconceived in specific detail. The Mother provided simple sketches, a Charter and guiding principles to direct actions towards human unity, but was clear that "the material conditions would be worked out as the realization proceeded." The charter 5 outlines that Auroville belongs to humanity as a whole; to live there requires serving the divine consciousness; it is a place of unending education, progress and youth, bridging the past and the future; and it is a site of material and spiritual searches towards actual human unity. With support from the Indian government, land near the town of Pondicherry was allocated to the project. UNESCO has supported the city since its inauguration and reiterated its support at four UNESCO general conferences. Financial support came from pioneers, private individuals, European and American foundations, and since 1968, from Auroville International Centres.

Roger Anger was the architect responsible for the city's original 'galaxy' design. Centered around the 'Matrimandir' building dedicated to silent meditation and completed in 2004, the city's four zones, residential, cultural, international and industrial, spiral outwards. A green belt promoting diversity, environmental restoration and organic farming surrounds the circular city. The green belt is also a fertile zone for applied research in forestry, soil conservation, water management, waste management, and food production. The entire city design has a radius of 2.5 km and spans 20 km². The Auroville Township Master Plan 2000 - 2025 contains the details of its design and has been endorsed by the Indian government. The end-goal is to build an environmentally friendly sustainable urban settlement with a population of 50,000, which simultaneously integrates and cares for an expanding rural neighbourhood.

This founding regenerative approach of the Auroville eco-town has evolved as developmental programmes and facilities in settlements around the city have researched and implemented the most context-appropriate sustainable systems in Auroville's rural and urban areas. Auroville has its own recycling site that processes all but 14% of the total generated waste, and non-recyclable waste is currently stored un-

til future solutions are found. The city has 20 community-level sewage treatment facilities experimenting with the most effective ways of treating wastewater so that it can be safely discharged back into groundwater. Renewable energy is generated by 1,200 photovoltaic panels, and water is circulated using 140 solar water-pumping units and 30 windmills. Some houses and small settlements rely completely on renewable energy sources. Auroville has supported expertise in earth building, and its Earth Institute develops and transfers cost- and energy effective earth-based building technology throughout India and to other countries through consultations, courses, seminars, workshops, its website, manuals and other documents.

Aurovillians live in settlements of varying sizes and degrees of self-sustainability, separated by Tamil villages and temple lands in the forest that covers the city. Each settlement contains one or more developmental programmes and facilities that test and implement appropriate approaches to reforestation, organic agriculture, education, health care, village development, appropriate building technology and construction, information technology, small and medium scale factories and businesses, town planning, water table management, cultural activities, and community services.

Green communes of Bangalore: Bangalore is a rapidly growing city. Its strong industrial heritage, mostly around textiles, and its position as a commercial node in South India has constituted the basis for rapidly growing Information Technology and outsourcing industries. This has fostered the growth of a cosmopolitan and educated middle class, which has generated new demands for housing. These new demands have driven the proliferation of gated communities in the peripheral areas of the city. Most of these developments follow energy and resource intensive designs that use imported materials, often transported over great distances. The great demands for energy and water in these new developments, whose residents are in the top brackets of resource use per capita in the city, compromise the capacity of an already strained government to provide public services. The governments in Bangalore, both the municipality and the government of the State of Karnataka, experiences difficulties in regulating the rapid urban growth in the periphery of the city while rationalizing its use of resources. Many in Bangalore believe that for the city to go through a radical transformation process towards lower carbon emissions and better use of resources, new models of sustainable housing are needed. Some argue that the private sector - which some describe as intrinsically innovative - has the capacity to deliver the innovation needed for such transition.

Biodiversity conservation India limited (BCIL) is one such company, whose members, according to their own website, were seduced by 'the idea' of providing sustainable ways of living to those who could afford them. In short, BCIL transformed the aspirations of a sector of the cultured middle class for sustainable (green) housing into a consumer product. They started by creating exclusive self-sufficient villas in the outskirts of Bangalore, and launched their first major initiative of a compound of 91 houses in 2003 called towards zero carbon development (T-Zed). Starting with the ambition of being as sustainable as was deemed possible, this new gated community was completed in 2007. After the successful commercial launch of T-Zed, BCIL has started new projects in other areas of the city that extend and learn from the experience of T-Zed.

Because water scarcity is one of the main resource-linked problems in Bangalore, BCIL focused on ensuring the self-sufficiency of the development by calculating the carrying capacity of the land in relation to the potential supply from a rainwater harvesting system. They also focused on utilizing recycled and locally sourced materials to reduce the embodied energy of the buildings. Design considerations, cooling systems and green roofs were introduced to reduce residents' energy consumption. Residents were implicated in community activities from cultivating organic vegetables, to separating wastes and managing the community's bio-combustion plant. The project was made possible by the marketing of a niche for green housing by BCIL, and by the commitment of numerous professionals who often committed more time and resources to this project than they would have committed to a conventional one. BCIL carried out an in-house evaluation to examine the performance of T-Zed in terms of carbon emissions reduction. Although their estimations rely on a series of assumptions, it is reasonable to assume that residents in T-Zed have lower emissions per capita than those in other new gated developments catering for the growing middle class in Bangalore.

Freiburg, Germany: The city of Freiburg, Germany, whose sustainable policies date all the way back to the 1970s, has constructed itself as a sustainable city by actively committing to its target areas of energy, transportation, and to its three pillars for sustainable development: energy saving, new technology, and renewable energy sources [21]. One of the largest motivators for success can be accredited to citizen's engagement; in the 1970s opposition to local nuclear power led to the creation of a campaign for sustainable solutions for the energy needs of the city. A network of environmentalists, research organizations, and businesses was established, helping the agenda of a sustainable city push forward [21]. Taking advantage of Freiburg's location, educated and active residents, and political priorities invested in the environment and economy has led Freiburg to be considered a solar capital [22]. Along with high solar electricity rates, Freiburg hosts such innovations as the world's first football stadium with its own solar power plant and the world's first self-sustaining solar energy building. In terms of both ecology and economy, Freiburg has been extremely successful in the fields of research and marketing of renewable energy. The Freiburg science network and solar industry embraces many research institutions, like the Fraunhofer Institute for Solar Energy Systems ISE, Europe's largest solar research institute. In addition to solar initiatives, over the last four decades Freiburg has made improvements to their transportation systems. Freiburg has over 500 km of bicycle paths and more than 5000 bicycle parking spaces as well as car-free centers, 30 kph zones, a region wide bus service, and tram lines [22].

Long before it was taken seriously Freiburg was resolving to cut carbon dioxide emissions. In 1966, the city resolved to lower carbon dioxide by 25 percent by 2010. Although they did not reach their initial goal by 2010, they are continually extending their goals. By 2030, they resolved to cut carbon dioxide emissions by 40 percent and be climate neutral by 2050 [22]. Freiburg also focuses initiatives on waste management. Paper products are composed to 80 percent recycled materials. Financial incentive programs, like discounts for collective waste disposal and people who compost, are used to increase waste avoidance. Since 2005, Freiburg's non-recyclable waste has been incinerated and the heat energy released is converted to supply electricity to almost 25,000 households in the city. Freiburg is a green city. About 43 percent of borough area is woodland. In 2001, the Freiburg Woodland Convention was adopted and since 2009, the city officially supported the Freiburg Convention on the Protection of Ancient Woodland. For over 20 years Freiburg has worked to maintain their public parks with principles that work with nature: they no longer use pesticides, grass is mown less, and almost 50,000 trees line streets and parks [22].

Stockholm, Sweden: Stockholm in Sweden has been an environmentally focused city that is redeveloping itself to become an eco-city through efficient urban planning and resource use. Stockholm has established six environmental goals, called Vision 2030, that act as the foundation of this initiative. These goals include development of efficient transportation, sustainable energy, land, and water use, waste treatment improvements, and safe building and product materials. Beyond vision 2030, Stockholm is planning to be fossil fuel free by 2050. In terms of urban planning, Stockholm currently requires mandatory reuse of land before urban sprawl can continue [23]. This policy has led to complete revitalization of run-down and abandoned industrial areas that have been transformed into modern, efficient and integrated residential and business communities. The Hammarby Sjostad district of Stockholm is the primary example of this practice, as this resurrected industrial area has become twice as energy efficient as the rest of the city after an environmentally focused redevelopment. These gains are measured by the environmental load profile of the area, a life-cycle assessment tool developed by the city of Stockholm, the Royal Institute of Technology, and a consultancy firm. This unique measure allows for environmental performance analyses, on both the small and large scale, in terms of environmental costs and benefits. This comprehensive measure has allowed Stockholm to quantify their environmental progress and could be applied as a decision-making tool in other cities or districts to aid their environmental efforts. Stockholm has pursued green development and optimization of urban systems and achieved results. These efforts were recognized in 2010 by European Union, which deemed Stockholm the European Green Capital for "leading the way towards environmentally friendly urban living.

Adelaide, Australia: The eco-city of Adelaide is characterized by the following special eco-friendly features of eco-township blended with Sustainable development landscapes.

Urban forests: In Adelaide, South Australia (a city of 1.3 million people) Premier Mike Rann (2002 - 2011) launched an urban forest initiative in 2003 to plant 3 million native trees and shrubs by 2014 on 300 project sites across the metro area. The projects range from large habitat restoration projects to local biodiversity projects. Thousands of Adelaide citizens have participated in community planting days. Sites include parks, reserves, transport corridors, schools, water courses and coastline. Only trees native to the local area are planted to ensure genetic integrity. Premier Rann said the project aimed to beautify and cool the city and make it more livable; improve air and water quality and reduce Adelaide's greenhouse gas emissions by 600,000 tons of CO_2 a year. He said it was also about creating and conserving habitat for wildlife and preventing species loss.

Solar power: The Rann government also launched an initiative for Adelaide to lead Australia in the take-up of solar power. In addition to Australia's first 'feed-in' tariff to stimulate the purchase of solar panels for domestic roofs, the government committed millions of dollars to place arrays of solar panels on the roofs of public buildings such as the museum, art gallery, Parliament, Adelaide Airport, 200 schools and Australia's biggest rooftop array on the roof of Adelaide showgrounds' convention hall which was registered as a power station.

Wind power: South Australia went from zero wind power in 2002 to wind power making up 26% of its electricity generation by October 2011. In 5 years to 2011 there was a 15% drop in emissions, despite strong economic growth.

Waste recycling: For Adelaide the South Australian government also embraced a zero waste recycling strategy, achieving a recycling rate of nearly 80% by 2011 with 4.3 million tons of materials diverted from landfill to recycling. On a per capita basis this was the best result in Australia, the equivalent of preventing more than a million tons of CO_2 entering the atmosphere. In the 1970s container deposit legislation was introduced. Consumers are paid a 10 cent rebate on each bottle/can/container they return to recycling. In 2009 non-reusable plastic bags used in supermarket checkouts were banned by the Rann government preventing 400 million plastic bags per year entering the litter stream. In 2010 zero waste SA was commended by a UN habitat report entitled 'Solid Waste Management in the World Cities'.

Masdar, Abu Dhabi: A zero-carbon city in the Arabian desert: Masdar (Arabic: مصدر, maṣdar, literally' source) is an ambitious eco-city project currently under construction 17 km south-east of Abu Dhabi in the United Arab Emirates. At its core is a planned city constructed from scratch by the Abu Dhabi Future Energy Company with the majority of the start-up capital provided by the government of Abu Dhabi. Designed by Foster and partners, it is intended that the city will be powered by solar energy and other renewable energy sources, with a sustainable, zero-carbon, zero-waste ecology. The initiative is being driven by the UAE's poor ecological performance record, new economic pressures on the current oil and gas-based energy system, and a strategic aspiration to develop a transition to alternative and renewable forms of energy. Taken together, these drivers have led to the construction of an emblematic urban solution for the Middle East that is a key part of a wider energy transition that may have relevance in other contexts with energy-related challenges. The plan is that Masdar will gain early-mover status and support Abu Dhabi's transition from technology 'consumer' to technology 'producer'.

The UAE has one of the largest ecological footprints and also the seventh highest oil reserves and sixth highest gas reserves in the world. Reducing dependence on fossil fuels is a key element of Abu Dhabi's energy and sustainability strategy. Despite vast reserves of fossil fuels leaders recognize that these are finite and, combined with a desire to reduce carbon emissions, a new strategy for developing renewable energy could provide an alternative environmental future. Yet there is also a strong economic rationale as the Abu Dhabi government wishes to maximize lucrative gas exports by reducing the amount of gas consumed internally for electricity through substitution by solar power. Abu Dhabi has lots of land, so has space for large-scale solar plants (both photovoltaics and concentrated solar power). This renewably generated electricity will go some way towards helping the Emirate achieve its target of 7% of primary energy production derived from renewables by 2020.

Songdo, Republic of Korea: A new international eco-city

Songdo international business district (IBD) is a free trade and international business hub currently under construction on 6.1 km² of land reclaimed from the Yellow Sea, near Incheon international airport in Republic of Korea. Developed by Gale international and Korea's POSCO E&C, this master planned aerotropolis is a model of city-scale sustainable development that is only 3½ hours flying time from a third of the world's population. With the completion of the new 15 km suspension bridge in 2009, Incheon international airport is just a 20 minute drive from the eco-city, making Songdo well-positioned to become an economic hub for Northeast Asia. Designed by Kohn Pedersen Fox, the 9.2 million m² master plan includes commercial office space, residences, retail shops, hotels as well as civic and cultural facilities (Figure 1). When fully developed in 2015, the city will house 80,000 apartments, 4,600,000 m² of office space and 930,000 m² of retail space. The delicate balance between maximizing energy efficiency

Figure 1: Songdo skyline viewed from the golf course.

and sustainable design versus project development costs is an area that has received much attention during design and construction of Songdo. Project funding consists of US$35 billion borrowed by Gale International from the domestic South Korean financial market, and US$100 million of Gale's own funds. More than US$10 billion has been invested thus far, and approximately 100 buildings have been completed or are currently under construction.

Songdo will set new standards in high-tech, green urban development.

A sustainable island community on San Francisco's 'treasure island', California: Treasure Island is a former naval air base built on 160 ha of reclaimed land in San Francisco, USA. By 2020, it is intended to become one of the most sustainable communities in the USA with 6,000 new apartments and businesses. Over 50 percent of the power will be from renewable resources, including solar electricity and solar water heaters; the street grid has been designed to maximize the exposure of rooftop photovoltaics to sunlight, and all the buildings would be within a 15 minute walk of a ferry terminal to San Francisco. The development will take place on Treasure Island and the neighbouring Yerba Buena Island. Both were created in the 1930s from fill dredged from the bay for the golden gate international exposition. Treasure Island housed a naval air base for many years, and this has left the groundwater and air contaminated with asbestos, plutonium, radium and other harmful substances. Following the closure of the air base in 1997, the island was opened to residential and other uses and was home to 2,500 people by 2010. The plans for Treasure Island entail population growth of more than 19,000 residents.

In 2000, plans were announced to redevelop Treasure Island into a model sustainable residential area. Skidmore, owning and merrill (SOM) lead the design team for the development, supported by two local San Francisco firms, SMWM and CMG Landscape Architects. In the development phase in 2005 - 2006, ARUP was brought in to advise on transportation planning, site infrastructure and sustainability strategies. In 2006, a sustainability plan was prepared that outlined the long term vision for the Treasure Island/Yerba Buena Island (TI/YBI) Project covering ten key focus areas across the triple bottom line of sustainable development: environmental stewardship, community development, and economic vitality. Strategic goals, objectives, strategies, and potential partners were outlined, providing guidance for subsequent planning and design efforts. The 2006 sustainability plan was ground breaking in its scope and approach to sustainable development for large scale mixed-use projects, and provided an exemplary yet practical pathway to sustainability that many international projects have since followed.

Sustainable eco-city in Vauban, Germany: The planning of Quartier Vauban began in 1993 when the city of Freiburg (approximately 221,000 inhabitants) bought an area of land accommodating a former army barracks from the German Federal government to help address housing shortages. The original project included buildings with low energy standards, green spaces, dense urban design, public transport and a school. Additional goals like reducing car traffic and supporting co-building groups were included during the planning process, which involved the participation of citizens. Following unsatisfactory results of the participation process in another district, results which only highlighted issues of interest to future residents rather than fundamentally changing the master plan, the city of Freiburg went beyond legal requirements for participation in Vauban. Instead of just hearing from the future inhabitants through a consultation process, the city of Freiburg allowed them to play an integral role in the planning of Vauban by nominating Forum Vauban - a non-profit organization established by local citizens, to organize the participation process in a professional way. From 1995 onwards, Forum Vauban was recognized as the official organizing body for citizen participation in the project [22].

Vauban's development plan specified an energy consumption standard for heating of 65 kWh/m² per year for residential buildings. This was developed in accordance with the Low-Energy Housing Construction standard adopted by the city of Freiburg in 1992 for contracts in which the city council sold land. Some developers however, have chosen to exceed this standard, constructing passive houses with energy requirements for heating of 15 kWh/m² per year or less. One emblematic project was the Solar Settlement consisting of 50 houses. These houses are referred to as 'plus energy' houses due to their high energy efficiency and use of large photovoltaic cells that generate more electricity than the residents consume. Their surplus energy of approximately 9,000 kWh/m² per year is fed into the public grid. Also, solar collectors were installed in several houses for room and water heating. One of the key elements of Vauban's success was the participation of future residents in the district planning, as well as in other collectively organized initiatives such as the co-building groups. Under the umbrella concept of a sustainable model district it was possible to test sustainability concepts in several areas. The average number of motor vehicles in Vauban is half the national average for Germany at 250 cars per 1,000 residents and low energy housing adopting passive houses standards in 270 residences is estimated to reduce CO_2 emissions by 2,100 t per year.

Eco-city in the People's Republic of China: The PRC alone houses more than 20% of the world's population and is urbanizing faster than any country in history. Its cities will require huge amounts of nonrenewable materials, resources, energy, and water, thus providing the rationale for green cities approach. In 2009, the PRC had 120 cities over 1 million population and 36 cities with over 2 million. By 2030, the PRC will have an estimated urban population of 1 billion, and 221 cities of more than 1 million. Since its introduction at the 17th National Congress, the low-carbon eco-city model has been touted officially as the answer to the PRC's urban development, social, economic, and environmental problems. This position is reflected in a preliminary scan of PRC literature on eco-cities and sustainable urban development, where the model is frequently cited as the strategy for overcoming the PRC's myriad urbanization problems.

The first eco-city project to be announced in the PRC in 2003, the Dongtan eco-city, was also proclaimed as the world's first purpose-built carbon neutral eco-city. The first phase of the project was targeted

for completion in 2010, in time for the Shanghai World Expo. Aside from the Chongming island bridge, which links to Shanghai mainland, and a wind farm, however, Dongtan eco-city has since largely failed to materialize for a number of reasons. The Dongtan site is located on an estuary tidal flat at the east end of Chongming Island at the mouth of the Yangtze River, about an hour's ferry ride from Shanghai. Phase one of the eco-city, which was scheduled to be completed in 2010, was expected to accommodate up to 10,000 residents in an area of 1 km^2. The start-up area of 6.5 km^2, housing 80,000 people, was targeted for completion in 2020, while the completed eco-site was to have covered 30 km^2 with a population of 500,000 by 2050. The eco-city was envisaged to have small pedestrian friendly, self-contained towns and an ecological footprint of 2.6 global hectares per person, which is 60% smaller than that of conventional cities in the PRC, 66% lower energy demand with 40% energy supplied from bio-energy, 83% reduction of waste going to landfills, and almost zero carbon dioxide emissions[24].

Research in the PRC regarding defining, designing, developing, managing, and measuring the performance of eco-cities has experienced explosive growth in recent years. The term "eco-city" now appears as a catch-all phrase for a variety of new urban development models. Although there has been a proliferation of eco-city research in recent years, there has been comparatively little research on the practical aspects of urban planning as this relates to concrete eco-city development in the PRC. Green Building Concept in Practice-Juiting, People's Republic of China Source: Crone, Sydney.

Sino-Singapore Tianjin eco-city: Tianjin, the third largest city (population 11.8 million in 2008) of the People's Republic of China (PRC), is developing the Sino-Singapore Tanjin eco-city (SSTEC) in collaboration with Singapore. The SSTEC will be constructed on non-arable salt land located in the Tianjin binhai New Area, which already has one of the fastest economic and demographic growth rates in the PRC by 2020, the 34.2 square kilometer SSTEC area will be home to 350,000 people. The project's mixed land-use plan will accommodate not only housing but also service-oriented, high-technology, environment related industries, which will create 190,000 jobs. This includes a large-scale National Animation Center to be built during phase 1 of the SSTEC's development that will create jobs for 12,000 people. The total investment cost for public infrastructure and facilities for the entire SSTEC area will be CNY25.5 billion ($3.8 billion) according to preliminary estimates. Construction began in September 2008, with completion of phase 1 comprising 7.8 square kilometers scheduled for 2015.

The SSTEC is intended to be an energy- and resource-efficient model eco-city that will release relatively few greenhouse gases, while maintaining economic viability and social harmony. Several features of the SSTEC are noteworthy. First, it was selected from a pool of four candidate cities, with political support from the Prime Minister. Second, it will convert non-arable salt land into urban land with a high economic value. Third, by partnering with Singapore, the SSTEC will avail of global experience and scientific knowledge. Fourth, its transport oriented development plan, which integrates transport with land use, includes a higher floor area ratio allocation in the areas near metro stations, thus allowing population densities approximately equal to those of the Tianjin city center. Fifth, the SSTEC's mixed land-use plan will reduce the need for workers to commute from outside the SSTEC area. Sixth, its building standards require greater energy efficiency than do corresponding national standards, thereby promoting renewable energy use. Seventh, its planned per-capita water consumption is capped at 120 liters per day, thus allowing more than 50% of water use

to be derived from nonconventional sources. Eighth, social harmony will be maintained, since affordable public rental houses will comprise at least 20% of the SSTEC's total housing stock. It is planned that 90% of all trips will be made either in clean, energy-efficient public transport on foot or by bicycle [25].

Kitakyushu, Japan - model eco-town: Japan's Kitakyushu eco-town (Figure 2) has developed the most extensive range of recycling and environmental industries in the country in that these recycle a wide range of materials and products. Current recycling includes PET bottles, office equipment, vehicles, fluorescent tubes, medical equipment, construction waste, solvents, paper, food residues, styrofoam packaging, cans, and metals. The total collective investment for these activities was ¥ 430 million ($ 390 million, at ¥ 110 per US dollar), of which ¥ 82 million came from national source and ¥56 million from local public source. The following aspects are relevant to the Kitakyushu systems approach:

a) Supply: Recycling depends on obtaining sufficient raw material of acceptable quality. This in turn depends greatly on citizens' cooperation in separating waste. At the time of the eco-town's creation, preexisting collection systems were not capable of delivering the required quantity and quality, and the city of Kitakyushu thus worked with neighboring local authorities to establish a sufficiently large catchment area to supply eco-town recycling businesses.

b) Markets: Although much of the recovered products are of low value (e.g., fuel), where higher added-value markets have potential, the city acts as a green purchaser (e.g., of clothes using PET-derived fiber, and recycled fluorescent lights).

c) Local agglomeration: The eco-town demonstrates the importance of localization. The local cement and steel industries allow low-grade recycled plastics and other combustibles to be used for fuel, thus avoiding significant transport costs. A local vehicle-recycling cluster has developed spontaneously at the Hibiki site, where a group of car disposal companies have formed a cooperative that provides common services to all of the local vehicle recycling businesses.

d) Regulatory interaction: Technology development has interacted with national regulatory standards in a synergistic manner in the eco-town's operations. For example, a shredder-less recycling process was developed for vehicles that avoid the air pollution problems of standard recycling processes. This allowed the Ministry of Economy, Trade and Industry to incorporate this technology into a revision in the Auto Recycle Law then being drafted for the purpose of setting more stringent standards for vehicle recycling.

e) Process innovation: Process development (learning by doing) in office equipment disassembly has increased the recycle rate to 96% and

Figure 2: An aerial view of Japan's Kitakyushu eco-town.

halved the time needed to recycle each machine. High-quality recycled plastics are returned to the manufacturer to make new equipment, while low-quality plastics are recycled into fuel. Experience in disassembly allows feedback into materials selection and design, thus allowing the subsequent generation of equipment to be designed in a way that optimizes resource efficiency over the entire life cycle of the product concerned.

Eco-town projects: are among the most successful policy programmes for the promotion of eco-industrial development in Japan. The central government provides both technical and financial support to local governments to establish an area (eco-towns) where zero-waste is promoted regionally through various recycling and industrial symbiosis efforts. Once a development plan is approved by the ministry of international trade and industry, local governments are eligible for financing to promote and encourage ecologically sound industrial activity.

Zero emission research initiative: The United Nations University's zero emissions research initiative (ZERI) is an example of non-governmental participation in efforts to research and foster eco-industrial development initiatives in Japan [26]. ZERI serves as a public think-tank providing technical and scientific information for the advancement of these projects [27]. This initiative began in 1994 in Japan, where united nations university (UNU) and ZERI headquarters are located. The first zero emission world conference was held in Tokyo in 1995 and many from both public and private sectors participated in the meeting and introduced the idea to their communities. Since then, "zero emissions " has become a buzz word in Japan. Although there are currently only 2 projects with which UNU is directly involved, the zero emissions concept is widely accepted in both public and private sectors. At least 15 private companies have achieved or are planning to achieve zero waste production [27]. Both local and central government programs, such as eco-town projects, hold up a zero emissions society as their goal. However, "zero emissions" has focused primarily on "zero solid waste" and tends to neglect the other types of emissions. So public and private organizations who adopt the motto of zero emissions promote recycling and waste reduction efforts but do not seek to really achieve the overall goal this implies.

Eco-town projects in Japan: Focus on economy and competitiveness: The ministry of economy, trade and industry and the ministry of environment, Japan are presently promoting an eco-town project, aiming for the construction of a resources-recycling economic society through the development of industrial industries by utilizing local industrial accumulations, the prevention, and the promotion of recycling of wastes based on the uniqueness of local districts. The eco-town projects are operated by local authorities to support advanced environment-conscious town building through cooperation with local residents and industries (eco-town projects/environmental industries in progress, ministry of international trade and industry (MITI) in 1997: Environment-Conscious Type of Town-Building models of eco-town municipalities/business firms: Case Introduction: The details of the Schematic plans of eco-town project are given below in Figure 3.

In Japan, Eco-town projects can be promoted and funded by a government program started by the MITI in 1997. The main objective of the programme is to encourage community development throughout the environmental industry and development of environmentally sound community systems involving industrial and public sectors. The programme was initiated as the result of a waste management crisis.
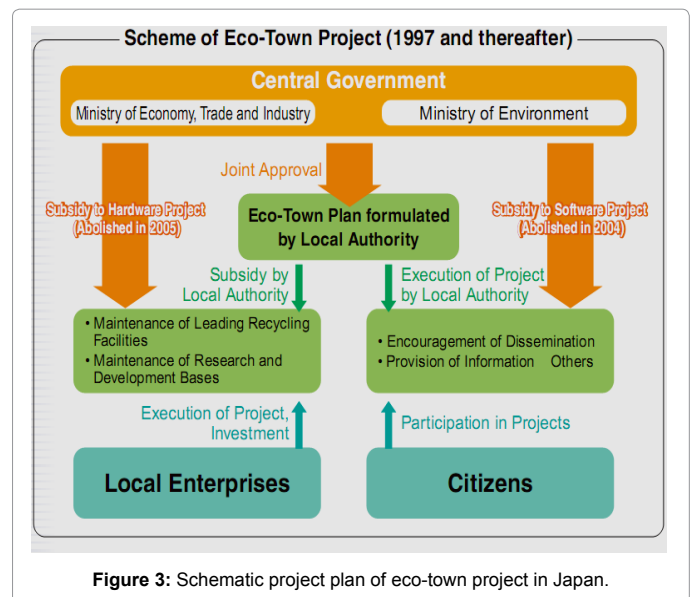

Figure 3: Schematic project plan of eco-town project in Japan.

There are 10 projects currently approved as Eco-Town Projects in Japan as given below:

- Sapporo City (Recycling industrial park)

- Hokkaido Prefecture (Recycling industry and by-product exchange promotion)

- Chiba Prefecture (Eco-cement plant, environmental engineering complex)

- Iida City (RDF energy center, zero emission industrial park)

- Gifu Prefecture (Recycling industry complex, environmental research and education facility)

- Omuta City (RDF power plant and RDF collection network, recycling industrial park)

- Akita Prefecture (Electronic recycling facility and promotion of sustainable energy)

- Uguiszawa City (Recycling mining park, environmental information and education center)

- Kitakyushu City (eco-industrial complex, recycling park, research centre)

- Kawasaki City (eco-industrial complex, recycling park, research centre)

Source: Ministry of International Trade and Industry (MITI), Japan, 1997

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- Kitakyushu City (eco-industrial complex, recycling park, research centre)

- Kawasaki City (eco-industrial complex, recycling park, research centre)

As shown above, each project takes a different form in carrying out eco-town plans. Some involve eco-industrial parks or regional by-product exchange, while others focus on recycling technologies. The flexibility of the eco-town projects allows local government to develop their plan in accordance with their specific characteristics and situations [28-30].

Aerotropolis (A Transport-cum-business hub for the 21st century)

What is an Aerotropolis?

An aerotropolis is a region that develops and grows within an airport and related activities as central economic growth drivers and the hub of economic activity. The region as a whole may gain a competitive advantage over other business centres by utilizing the mutual synergies between various business types, proximity to transportation infrastructure and with each other. At a micro scale, a typical aerotropolis may include separate zones for office business parks, hotels, logistics parks, industrial parks, e-commerce centres, retail centres, distribution centres, information technology complexes and wholesale merchandise marts that may benefit by locating themselves around an airport and along the transportation corridors surrounding them. Additional regional amenities such as convention centres, and entertainment complexes can add value to any typical aerotropolis development. The business core may be surrounded by mixed-use residential areas. A multi-modal transportation hub provides transit connectivity for regional population to key areas of the aerotropolis (Figure 4).

Source: This diagram and the above explanation is based on aerotropolis concepts explained on

Regional context of aerotropolis

As aviation-related businesses cluster around airports with good access to ground transportation, a new business concept is emerging globally: the Aerotropolis. Designed to attract economic investment and workforce talent, an Aerotropolis is an urban planning area in which the infrastructure and economy center on an airport. In 2011, Time Magazine featured the Aerotropolis concept as one of " ideas that will change the world." The east county economic development council (ECEDC) has begun studying the best ways to create an Aerotropolis surrounding county-operated Gillespie Field, a public airport in El Cajon. The ECEDC and the south county economic development council (SCEDC) jointly have received a $40,000 grant from the U.S. Economic Development Administration to develop Aerotropolis plans surrounding both Gillespie Field and San Diego's Brown Field Municipal
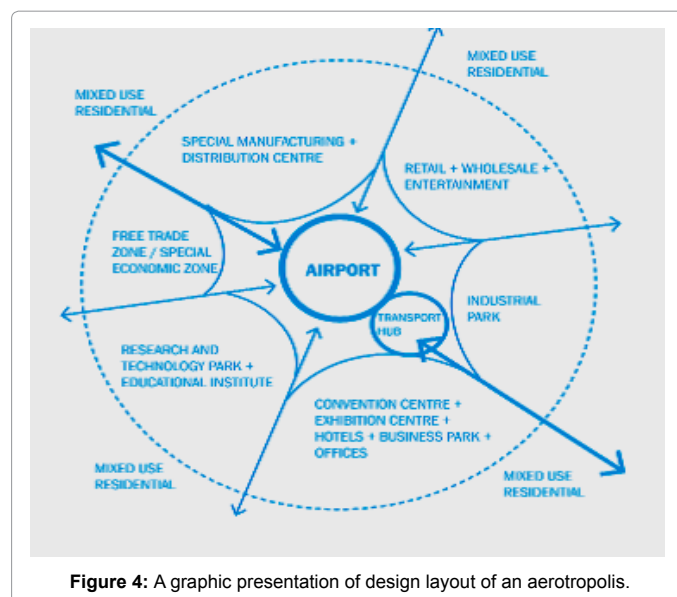

Figure 4: A graphic presentation of design layout of an aerotropolis.

Airport in Otay Mesa (Figure 5). One of the goals is to determine which industry clusters can best enhance economic development, increase investment, and create higher paying jobs. Although it is collaborating with the SCEDC, the East County group's main focus will be on Gillespie Field, said Santee City Councilman John Minto, chairman of the ECEDC. In addition to the $40,000 grant, the ECEDC has "received another $50,000 from the San Diego Foundation and we are matching with some internal money as well," said Jo Marie Diamond, president and CEO of the council. If successful, an Aerotropolis could become a catalyst for economic growth that benefits the entire East County community, she explained. "The underlying premise is an Aerotropolis is an economic accelerator [31-35]."

The Wall Street Journal reports that in countries like Dubai, China, India, and Africa, cities are being built from scratch around air travel."The ECEDC's goal is to create a business hub where travelers and locals can conduct business, shop, and dine. This would benefit manufacturing and distribution facilities; hotels; retail stores; commercial offices; conference centers; and entertainment venues.

Aerotropolis: Powerhouse of Tremendous Economic Potential

Gillespie field San Diego county Aerotropolis

"What does that do for the community?" Craver asked. "It increases the tax base. It increases the economic viability of the area. It will create jobs, which is something we desperately need." The ECEDC has determined that the airport and its business parks now contribute over $400 million per year to the local economy and provide nearly 3,200 jobs. In terms of the number of operations, Gillespie Field ranks No. 1 among San Diego County airports. It also generates enough revenue to cover operations at all of San Diego's regional airports. This revenue comes from airport operations and property taxes on the surrounding industrial area. There are 55 acres in aviation use and 37 acres of industrial use land available for development. Diamond explained that the aerotropolis concept is about developing businesses outside the airport gates. The planning area could extend for miles beyond Gillespie Field, but there are no plans to participate in development of the airport itself [36-40].
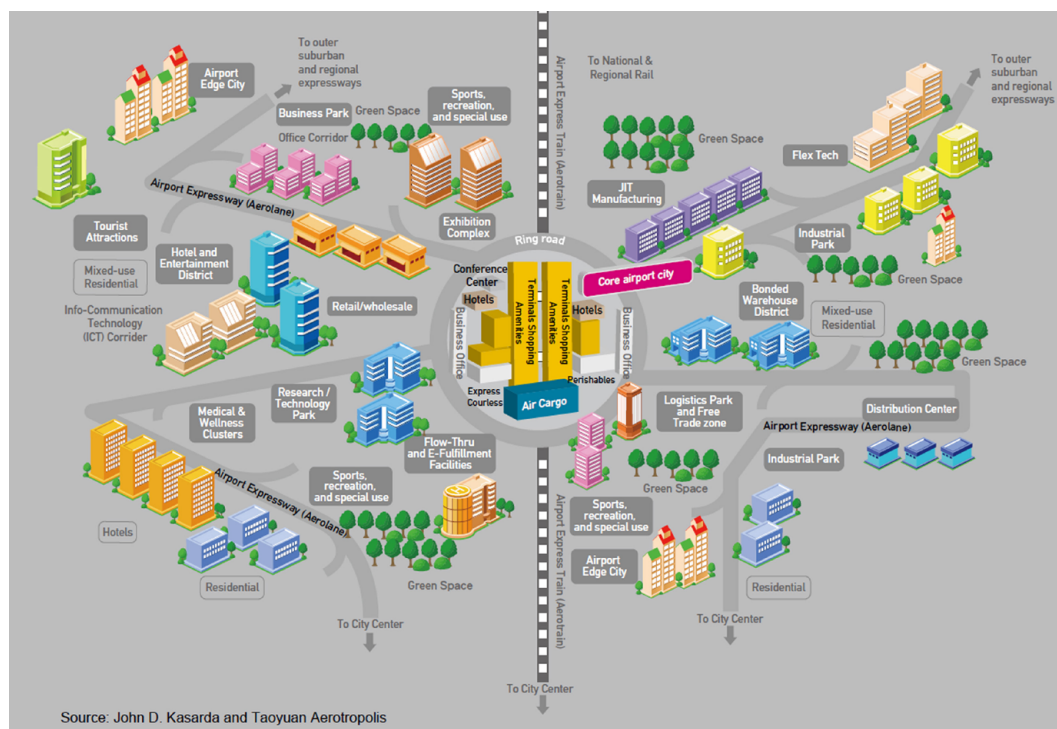
Figure 5: An aerial view of aerotropolis with full landscape designs.

Strategic location

Dana Quittner, an education consultant who chairs the ECEDC's Gillespie Field Committee, said one of the things that makes the airport a good aerotropolis candidate is its strategic location near several freeways: State Route 52 on the north, Interstate 8 to the south, State Route 67 on the east, and State Route 125 on the west.

Smart growth perspective

An aerotropolis should incorporate "smart-growth" concepts. That means compatible development near residential communities, schools, and existing transit would reduce the need for people to make long driving commutes. This strategy supports the economy and protects the environment. A recent Caltrans Airport Forecasting Study found that education and employment trends have created a demand for office and commercial growth that is compatible with development near Gillespie Field.

Aerotropolis (City of Leduc, Alberta, Canada)

Although an aerotropolis concept applies to a broader area on all sides surrounding the airport, approximately 640 acres of undeveloped land is currently available for future development and is located immediately south of the Edmonton International Airport and west of Queen Elizabeth II Highway. The site can also be accessed via local road networks from existing low density residential neighbourhoods such as Bridgepoint and Deer Valley. It is located within the existing city boundary and is privately owned. The aerotropolis project in the city of Leduc began in 2009. The unique approach utilized by the city included modeling air, traffic and ground noise around the airport and developing a policy plan called 'Aerotropolis Integrated Land-use [41-45].

Site context

Compatibility plan (AILUCP). This is a 50-year document designed to protect the current and future development on lands abutting the Edmonton International Airport, as well as protecting the airport's present and future operational needs. This plan highlights the potential of the undeveloped area immediately south of the Edmonton International Airport to become one of North America's premier warehousing, distribution, and multi-modal hubs. The report also stresses that in addition to offering long-term economic growth, the future development should also provide for local community needs by supplying sufficient land for commercial, recreational and office space

City of Leduc municipal development plan

City of Leduc's municipal development plan (MDP) designates the subject site as predominantly 'Aerotropolis Business Industrial' development with transitional residential and business mixed uses along the southern portion of the site adjacent to existing low density residential neighbourhoods as shown in the following diagram. In addition, a variety of commercial development policies support development of industrial and business parks on subject sites with focus on a wide range of uses such as industrial, logistics, warehouse, distribution, eco-industrial, agri/food-business and high-quality office park. The MDP policies provide a strong framework for future development of this site as one of North America's leading Aerotropolis projects.

Leduc county inter- municipal development plan

The city of Leduc and Leduc county inter-municipal development plan (IMDP) is consistent with the city of Leduc MDP and designates a predominant portion of the subject site as E1-Port Alberta business

industrial policy area. This policy area provides a framework for future business industrial developments consistent with the future vision for Port Alberta. The southern portion of the site is designated for transitional residential uses.

Design chareette: Charrett format

The design Charrette, held on October 19, 2012 with over 30 attendees, was established to strategize how best to utilize land and integrate economic activities south of the Edmonton International Airport. Groups represented included: Alberta Transportation, Edmonton International Airport, Edmonton Regional Airports Authority, Port Alberta, Melcor developments etc. The presence of diverse stakeholders ensured a comprehensive dialogue and a creative exercise for establishing future vision for the site. The format of the day began with a keynote presentation from airport transportation planning expert Prof. Douglas Baker from Queensland University of Technology, Brisbane, Australia. The participants were divided into 5 separate groups. The charrette exercise was divided into two parts. In the first part, each table discussed ongoing initiatives within the area and their values for potential development. This exercise was helpful in establishing trust and breaking down communication barriers. It also established a strong foundation for the design exercise. In the second part, all groups were tasked in visually describing, sketching and mapping future land uses, infrastructure, economic activities and housing. After more than an hour of designing, the groups presented their concepts to the others with time for questions and discussion. There was visible unity in the designs, programmes, and needs as well as a sense of development cohesion among the group; participants agreed upon the majority of requirements that were needed to make this area a successful future Aerotropolis.

GMR (Hyderabad) aerospace and industrial park: An aerospace and industrial cluster

Strategic location: With more aerospace and industrial players looking to India for setting up their operations, there is a need for specialized infrastructure providers to support aerospace and industrial growth. Leveraging GMR Group's experience in highways, energy and airport projects, the group presents 'GMR aerospace and industrial park' an aerospace and industrial cluster as part of GMR Hyderabad international airport. The site location of GMR aerospace and industrial park has been strategically chosen with emphasis on connectivity. The Park is well connected by air, road and rail, including robust connectivity to ports. This strategic location offers businesses an easy access to suppliers, enabling efficient supply chain management. These linkages present the benefits of faster turn-around time and maximization of productivity.

Why GMR aerospace and industrial park?: GMR aerospace and industrial park provides 'ready-to-use' industrial infrastructure allowing companies to focus on their core business (Figure 6). GMR aerospace and industrial park offers the flexibility of choosing land within special economic zone (SEZ) for businesses looking to serve foreign markets, and land in domestic tariff area for businesses looking to serve Indian market. By virtue of the park being housed within RGIA, the aerospace and industrial park enjoys greater security (Figure 6). Supply of utilities like power and water are highly reliable. The park also enjoys the complete airport ecosystem like availability of hotel, reliable and affordable transport, emergency services, security, etc.

The following advantages present a strong case for GMR aerospace and industrial park's vision of creating an aerospace and industrial cluster in the region.

- Runway access

- Ready-to-use infrastructure

- Benefits of special economic zone (SEZ) and free trade zone (FTZ)

- Significant presence of aerospace companies and SMEs in Hyderabad

- Benefits of being part of a cluster

- Attractive lifestyle at low cost

- Excellent location and connectivity

- Robust talent pipeline

Figure 6: A model replica of GMR aerospace andindustrial park in Hyderabad, India.

EU prototype model of smart eco-polis: EU Prototype Model of SMART ECO-POLIS adopted the Smart eco polis strategy and implementation plan where eco-town and local communities are envisioned as smart and green, livable and creative, vibrant and attractive, climate-resilient places of the future and unique destination of excellence. The polis region is run by a distributed intelligent management platform for future-proof infrastructure, smart mobility and transportation, efficient utilities, clean energy networks, smart power and communication grids, public facilities, intelligent street lighting, intelligent building systems, etc.

Now the legendary Aphrodite's place in Europe, POLIS CHRISOCHOUS, extending from the national park of Akamas to Pafos forest of Tylliria, along the Med coastlines of marine Natura 2000 sites, is first to meet the major concern of global urbanization: there are no examples to date of cities or regions or states launching fully integrated, strategically designed Smart and Sustainable development programs, strategies and plans". The Smart Eco POLIS Programme aims to transform the whole region of POILS as an intelligent green region: environmentally sustainable, inter-connected, instrumented, innovative, and integrated, regionally and globally attractive for businesses, citizens, visitors and investors. LIFE Integrated Projects Environment and Nature and Horizon 2020 Lighthouse Smart Communities Projects are among the key EU 2014-2020 Funding Tools.

Smart and Sustainable Polis is run by its nature-wise urban brains, an intelligent city environmental governance platform, managing its resources, assets, processes and systems: Urban Land and Environment, Roads and Transportation, Energy networks and Utilities, ICT networks and fiber telecom infrastructure, Public and residential buildings, Natural Resources, Water and Waste management, Social infrastructure, Health and safety, Education and culture, Public administration and services, Communities and Businesses. Launched under the Smart Cities Global Initiative, the Smart Polis Programme presented for the "World Smart Cities Award", "looking for the most ambitious Smart City strategies, the most advanced projects and the most innovative solutions around the world which foster the evolution of the Smart City concept" [45-48].

Smart Eco-Polis: A miniaturized global initiative

Committed to the EU Smart Cities and Communities Initiative to improve the quality of life and communal well-being, the Council of POLIS is determined to transform the POLIS Region as a European (Mediterranean) model of regional sustainability, as an innovative corridor of seaside smart town resort and eco communities; carbon neutral or zero-carbon and zero-waste region with integrated "green" and "blue" economies. The Smart Eco-Polis Global Initiatives taken by the Organisers of the EU Smart Cities and Communities undertook the following strategic decisions, as per their mission objectives:

The SMART ECO POLIS Strategy and Implementation Plan where the Eco-town and local communities are envisioned as smart and green, livable and creative, vibrant and attractive, climate-resilient places of the future and unique destination of excellence.

The Polis Region is to be run by a distributed intelligent management platform for future-proof infrastructure, smart mobility and transportation, efficient utilities, clean energy networks, smart power and communication grids, public facilities, intelligent street lighting, intelligent building systems, etc.

In order for the urban wealth and communal benefits to be pursued, the Urban Areas and Rural Communities shall have ecologically healthy living, safety and well-being, integrated sustainable town and communal planning and land use, connected residential areas, green living, clean environment, eco-friendly roads, car-free zones, smart streets, clean transportation, energy and advanced utilities, urban agriculture, home ecology, green buildings, renewable energy networks, rainwater catchment systems, solar desalination plants, biomass refineries, solar gardens, environmental quality, low utility bills, lease or sales premiums, increased property values, high property developments, coastal and maritime eco-tourism, quality jobs, solar eco communities and smart eco town, global branding and highly competitive marketability.

The SMART ECO POLIS Initiative shell be performed by the Public-Private-Civil Society Partnership, led by the Advisory Council, chaired by Mayor and assisted by the city councilors and local community presidents, and run by the program management, leading strategists and members of the European Innovation Partnership on Smart Cities and Communities.

The SMART ECO POLIS Advisory Council invites future-looking businesses and national ministries, utilities and NGOs, banking institutions and investment funds, developers and investors, academia and research organizations, citizens and civic associations, to adjoin the exciting journey of building intelligent eco communities and cities, as the keys to a sustainable recovery and smart growth of Cyprus and Europe.

Stimulated by the EU 2014-2020 schemes (Figure 7) for smart, sustainable and inclusive growth, the creation of smart cities and sustainable communities is a future-building process where all sides shall continually learn from each other, discover new opportunities, develop relationships, proactively responding to evolving challenges, threats, opportunities and priorities.

Being in line with the EU Strategy 2020, the Eco-Polis Investment Programme is to utilize the EIB's Framework Loan under the EU Multiannual Financial Framework 2014-2020 - 7-Years planning, strategies, policies and regulations, funds, programmes and projects, all innovative funding opportunities, schemes, and initiatives, as well as local government incentives for smart urban growth and sustainable redevelopment. Financing could follow the public-private-citizen partnership business models, and be shared by the private firms, investors and municipal government.

The smart polis cloud platform

The urban internet of everything is the cloud-networked connection of people, processes, data, and things. The i-Region Environmental Operation Center is connected with thousands of sensors and cameras spread throughout the cities, as the city brain of the Urban IoE, in which M2M technologies are vital to present intelligent data analytics for city processes.

"SMART POLIS "Intelligent Platform is to integrate a technology-centric (smart) level, an intelligent (people-centric) level, and eco-sustainable level improving the urban economy, community integration, quality of life, and overall sustainability.

$14.4 trillion of potential value at stake for the private sector, IoE is a $19 trillion opportunity for businesses and governments globally 2013-2022.
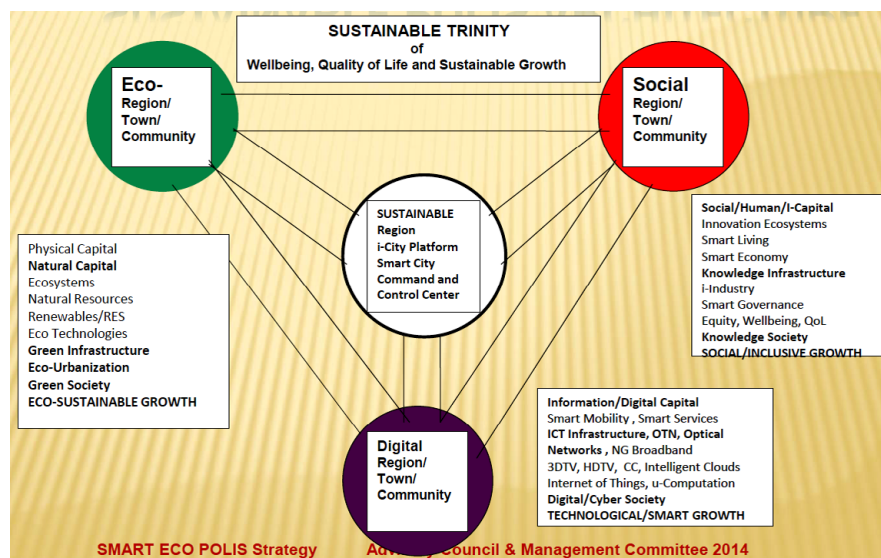
Figure 7: Sustainable Aerotropolis structure.

Eco-SMART POLIS: Life IP environment projects in the EU

Polis and the surrounding area, because of its unique beauty, idyllic natural environment and excellent climate, is among the first choices for environmental sustainability and eco regional development policies, fitting the LIFE + projects for environment and climate action (Integrated project for Environment implementing on a large territorial scale (regional) environmental/climate plans or strategies required by specific Union environmental or climate legislation, developed pursuant to other Union acts or developed by Member States' authorities, primarily in the areas of nature (including Natura 2000 network management), water, waste, air and climate change mitigation and adaptation).

Committed to the EU Strategy 2020 for smart, sustainable and inclusive growth and the Smart Cities and Communities Initiative to improve the quality of life and communal well-being, the Council of POLIS is determined to transform the POLIS Region as a European (Mediterranean) model of regional sustainability, as an innovative corridor of seaside smart town resort and eco communities; carbon neutral or zero-carbon and zero-waste region with integrated "green" and "blue" economies.

The City Council adopted the SMART ECO POLIS Strategy and implementation plan where the core town and local communities are envisioned as smart and green, livable and creative, vibrant and attractive, climate-resilient places of the future and unique destination of environmental excellence.

Considering the scale, scope and high ambition of our integrated eco region strategy/plan, it is expected that the LIFE programme could contribute its average amount, EUR 10 million, with the total project budget to be around EUR 17 million, mobilized from other EU Funds.

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