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CURRENT TECHNOLOGIES APPLIED TO URBAN SUSTAINABLE DEVELOPMENT

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Abstract

The present work organizes information in a systematized way, on environmental technologies applied to each of the tasks and activities that are performed in the cities, urban planning and development. These technologies are an updated part of all the technologies that can be applied, therefore, it is *the state-of-the-art* of new technologies applied to urban sustainable development which mostly are processes, instruments of measurement, simulators, equipment, materials, Software and Hardware that are of great help for urbanism designers and promoters of urbanism in the cities development. These technologies, which are described in the present article, have been selected on the basis of their up-to-dateness and application in the main sectors or fields of development and it is important to mention that only the most recent and influential on urban development and environmental technology have been chosen. The main objective is to provide an overview of the *state-of-the art* of these environmental technologies, and how we, designers, architects and promoters of urban development, can apply and use a number of technologies in urban planning with an environmental approach.
Keywords: sustainable urbanism, new technologies, development, tools.

1. Introduction

The existing diverse technologies nowadays are of great help for the development of any human activity, either it is industrial or not. In the construction industry and particularly in the development of cities and urban areas, technologies have been present as from the pre-industrial, industrial and contemporary-industrial ages in the processes of production from the generation of construction materials, new products to the construction and implementation of infrastructure and urban equipment. Currently, said processes of production, generation and development of cities are ever demanding, as they require more efficient technologies, both technically and environmentally. In developed countries initiatives have been generated in order to improve the quality of products and services (bridges, edifices, housing, infrastructure, equipment, etc), offered by developers, governments and construction companies and real estate agencies; one of these initiatives is the management of innovation and technological development (Delgado, 2008). In underdeveloped countries there is still a lot to be innovated in many areas of knowledge because of the new necessities the cities demand.

The axis of sustainable development contemplates environmental, economic and social efficiency of the processes of production (National Resources Institute [NRI], 1987). Technology is a tool to make the processes of production more efficient, therefore, the use and application of these technologies must create solutions to the different "threats" that might affect the diverse tasks and actions which propitiate the competitiveness of the cities, such as: use of soil, urban transport, management of the waste of the city, quality of the air, construction and building, cultural heritage of the cities, systems of urban information with electronic media, sustainable energy, agriculture, new construction materials applied to urban development and sustainable management of water. The solutions to these entries of urban competitiveness directly depend on urban sustainable planning and on the programs and projects that local and federal governments may implement and apply. Technologies are only tools that help successfully finish said programs and projects to make cities sustainable and eventually provide their inhabitants with a good quality of life. For instance in cities as large and as important as Los Angeles, California, U.S., the integration of technologies into the policies of urban planning have achieved improving many of the main problems of the city, working in an integral and systemic manner (Chen, 2009).

2. Sphere and application entries of technologies

The use of environmental technologies is an important factor to solve diverse problems and requirements of the society and the development of cities. We, the current generation of mankind, should propitiate technological development for the future generations, in diverse fields and particularly in the urban development of cities, in the following prioritized areas:

- Sustainable management of the place and use of soil
- Renewable and alternative energy
- Sustainable management of water
- Ecological materials
- Comfort in the constructed environment
- Other resources and processes

Technologies must be compatible with the production processes, underscoring their environmental character; separately, for these technologies to be implemented, the necessary conditions as for technological management, development of eco-projects and eco-products (Weaver et al., 2000), financial capability and sustainable planning must exist, in addition to sustainable urban-architectural

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regulations and public policies that support said developments; as well as social actors and cultural conditions, human resources specialized in commanding tools such as: Analysis and Evaluation per Cycle of Life, Systems of Geographic Information, processes of construction and integral development of projects by means of diverse Software and other resources considered further in this text. All of these resources must be integrated into the management of programs and projects of urban sustainable development in a systemic manner (Sánchez, 2002) in order to respond innovatively to the stated problems.

3. Innovative practice of sustainable practices in the sphere of urban development

Two decades ago the technological factor was not as weighty as it is now in the sustainability of products and process of urban infrastructure development. Nowadays, the challenges are harder and technology is required not only to solve the technical issues of supplying of energy, water, materials, construction, planning and design, but also to do it under sustainability premises (Commissie Lange Termijn Milieu-Beleid [CLTM], 1990). When using strategies of sustainable development in urban and architectural projects, new technologies, compatible with said strategies, must be incorporated in order to generate products of ecologic design (Urban Environmental Institute [UEI], 2002). There will be some cases where the costs of said technologies are not feasible for their implementation in the projects yet, namely, the case of photovoltaic systems in many parts of the world, of hydrogen cells or systems of chemical and mechanic treatment of residual waters; thereby, the use of other technologies must substitute or cover said economic necessities so that there is a better human development (UEI, 2002). Likewise, there must be financial support to afford and support the cases of economic insufficiency in the implementation of new technologies. Currently there are plenty of technological resources to be explored. Further we show the *state of the art* of the main technologies feasible to be applied for the solution of diverse problems in the urban-environmental sphere, which propitiates the improvement of the cities, diminution of the environmental impact and helps to sustainably apply natural, financial, and human resources in the development of the cities.

This part of the document shows a state *of the art of the main technologies* which may be used to help plan and design urban sustainable development, by area or sphere of application.

A. Use of urban soil; the main technologies in relation to the use of urban soil that might help urban sustainable development are:

A1. Geographic Information Systems (GIS); they are systems of spatial location making use of geographic and statistical databases, where the characteristics and trends of a model of geographic development can be visualized (Tomlin, 1990). GIS consist mainly of hardware and peripheral devices

to control and apply them (Figure 1). SIG are capable of recognizing a series of patterns to model the use or urban soil in the cities; they produce scenarios for the change of soil use and evaluate proposals of development including the sustainable management of natural, human and financial resources (Radut et al., 2009).

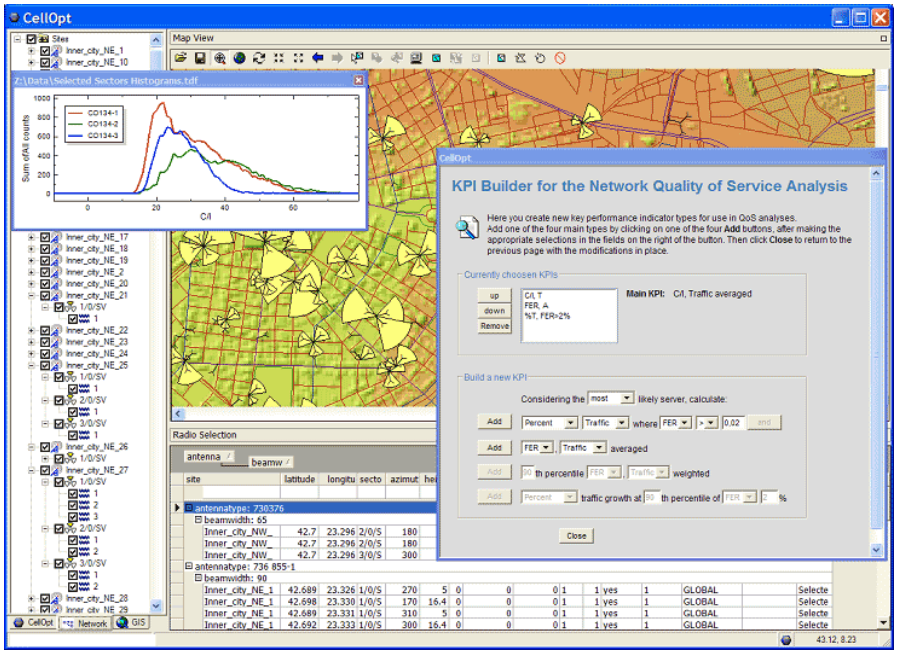

FIGURE 1. SOFTWARE OF GEOGRAPHIC INFORMATION SYSTEMS FOR DEVELOPMENT AND URBAN SUSTAINABLE PLANNING (SOURCE: WWW.GIS.COM)

Geographic information technologies which work on line on the Internet have also a great potential to provide an excellent support for public systems of geographic and urban information, and at the time they can be integrated into other similar technologies such as multimedia, virtual reality, virtual visualization, et cetera, for the same ends (Yigitcanlar, 2009).

A2. Virtual Reality Technologies (VR); it is a technological tool in the field of simulation that represents reality through artificial means. Its contribution to urban development is the modeling of urban environments in 3-D, using computers with advanced visualization techniques, allowing visualizing urban areas in different perspectives and approaches in a 3-D graphic environment; it also allows the prior evaluation of environmental impacts caused to a determined place and helps make decisions in urban regional planning. These solutions and techniques increase the effectiveness and flexibility of results while also decrease the time and effort required to undertake the task (Rosindo, 2006).

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A3. "Airborne" type laser measurement systems; it is a system that automatically allows the collection of 3-D geographic information data, at an affective price and in high resolution, which includes technology of terrain modeling and its interaction with the infrastructure of the place. It allows the virtual construction of urban areas for their virtual planning, control and monitoring of the use of soil in the cities.

A4. "Remote Sensing" systems (RS); they are technologies that enable gathering information from a place or plot, without physical contact. Some sorts of these systems include aerial photographs and satellite images. In urban development they allow detecting the changes in the use of soil identify the growth of the urban sprawl and natural resources, and mainly help monitor and control the disproportionate growth the cities.

B. Urban transport; the main technologies that might help us plan and manage urban transport are:

B1. Use of alternative fuels and advanced technology for transport vehicles

- LPG, a mixture of butane and propane, obtained from a sub-product of oil refining, which produces less pollution than most common gasoline.

FIGURE 2. STATION OF NATURAL GAS FOR URBAN SUSTAINABLE TRANSPORT (SOURCE: HTTP://EN.CNGV.GOV.CN/UPLOADFILES/20064493095O7.JPG).

- Natural gas; a mixture of hydrocarbons, mainly methane (CH4), which is obtained during the process of extraction of crude oil. The gas may be used in automotive vehicles (Figure 2) and produces even fewer pollutants and lower emissions than LPG and common gasoline. It is a

good alternative to reduce global warming in more than 80% than only using common gasoline. In the market one finds the Honda Civic GX vehicle that works on natural gas.

- Biofuels; they are alcohols and other chemical products with cell biomass, such as agriculture waste (crops, residues and stub), rice straw, waste of forest industry, wastes of food processing, residues of pruning and cultivations, municipal organic residues. Soft wood plantations, paper pulp mud, wood residues; instances of biofuels are: biodiesel, and ethanol which notably reduce CO2 emissions to the atmosphere, thereby contribute to prevent global warming (Lutsey et al., 2009).
- Electric automobiles; vehicles that work with electricity by means of rechargeable batteries; these batteries must be charged using clean or renewable energy. An electric vehicle is from 400% to 600% more effective than an internal combustion one; the use of these vehicles would mean a great step in favor of the total reduction of greenhouse effect gases in the transport of the cities.
- Hydrogen fuel cell; this cell produces electricity directly from a reaction between Hydrogen and Oxygen of the atmosphere. The only waste of this reaction is the water and heat it emits. This technology is still expensive and is not applicable to commercial vehicles, yet the benefit would be the non-dependence on oil-based fuels, as well as a great reduction of environmental pollution (NRC, 2004).
- Hybrid vehicles; they are a combination of electric vehicles and the use of some other alternative fuel, such as diesel, natural gas or LPG, ethanol, biodiesel and even common gasoline. It also significantly reduces air pollution. In the market there are already some hybrid vehicles: Toyota PRIUS, Ford ESCAPE HYBRID, Lexus HYBRID and Honda Civic HYBRID.

B2. Technology for the control of automated traffic; there are two systems:

- Technology of Personalized Transit (TPT); it is a way of transport that is personal and public. It works by means of a mechanical system of booths which travel in the same route and direction, safely and fast. This system would allow a better and faster traffic in the city, directly transporting the passengers, reducing the emissions of energy at a low cost.
- Advanced system of driving assistance; it refers to a system of automated vehicles guided by computerized control systems, they would allow the reduction of accidents, reduction of commuting time, reduction of fuel consumption, reduction of environmental pollution, control of

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traffic and traffic jams at low costs of implementation and maintenance of the transport infrastructure.

The technology described in B2 can also be integrated into other technologies such as databases, where all the information on the infrastructure of cities becomes integrated, as a useful tool to speed up the processes of urban design in the cities (Rodzi, 2009).

B3. Systems of transit control; in two manners:

- Global navigation satellite system; making use of radio signals emitted by satellites capable of exactly locating elements of transport and control systems. In combination with GPS a total control of the elements of a system of transport might be achieved.
- "Electronic Road Pricing"; electronic system of payment to be used in highways and roads, which would allow better flexibility in the use of the systems and infrastructure of transport; this would reduce heavy traffic and allow a greater control of traffic in rush hours.

C. Management and disposal of the city's solid waste

C1. Systems of waste classification; Facilities where by means of several techniques the separation of municipal waste, for either its recycling or other disposition, is carried out; these systems would allow the reduction of common landfills, fostering the reuse and recycling of materials, reducing the volumes of materials to be incinerated and fomenting biological and compost systems in rural and urban areas.

C2. Aerobic processing of waste; it is a biological procedure to eliminate and process municipal and domestic waste (figure 3), using aerobic and anaerobic techniques. The aerobic treatment is the natural biological degradation of residues, allowing processes of complete purification.

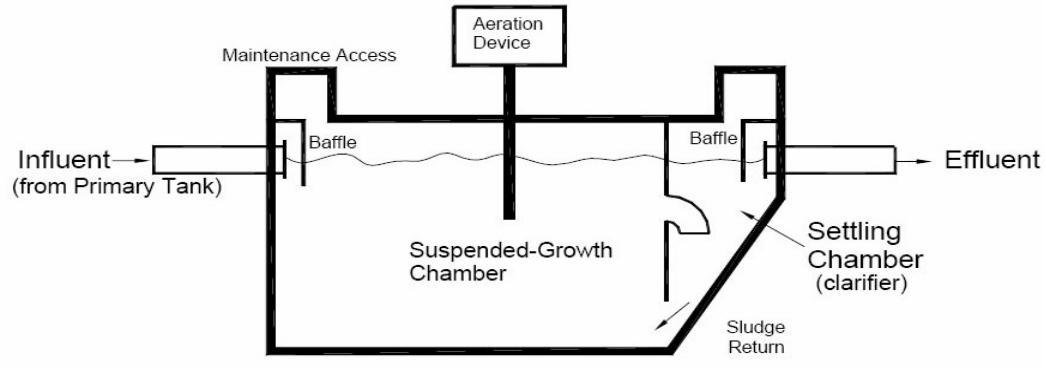

FIGURE 3. AEROBIC SYSTEM OF FINAL TREATMENT OF RESIDUES (SOURCE: WWW.INSPECT-NY.COM)

C3. System of information of management of waste (SIMW); they are databases that allow modeling and simulating to select, evaluate and optimize the management and control of waste, propitiating solutions for the large volumes of municipal waste, even before it is generated.

C4. Stabilization of waste; it is a technique to stabilize waste, mainly hazardous, for instance: stabilization of waste destined to landfills, avoiding the pollution of soil, water or air; through compost or inert-material techniques, adding some chemical products that help decrease the toxicity of the residues; additionally, these processes may help produce alternative energy in the municipalities (Tchobanoglous et al., 2008).

D. Air quality in the cities

- Efficient use of alternative, clean and biodegradable fuels.
- Transport improvement programs in the cities.
- Programs to alleviate and reduce greenhouse effect gases in the cities.
- Programs to reduce industrial pollutants.

E. Construction and building; it is the entry with the heaviest impact on the cities; therefore the following technologies that may help us control the impact of these activities are proposed.

FIGURE 4. AUTOMATED SYSTEMS IN BUILDINGS, ENVIRONMENTAL TECHNOLOGIES TO CONSTRUCT EDIFICES (SOURCE: WWW.AUTOMATEDBUILDINGS.COM/FRAME_PRODUCTS)

E1. Automation systems in buildings (ASB); they are systems that help optimize air conditioning and central heating systems, alarms and security systems, artificial lighting systems, energy saving, control of equipment and electromechanical, electrical and electronic installations by means of "intelligent" control devices; this helps, besides reducing the environmental impact caused by the building, increase comfort inside of it. By and large, this system helps other subsystems and installations (figure 4) to

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function in an adequate manner. The automation in buildings is a design tool that, by and large, is always researched and developed by engineers, so it is considered that architects should also have direct involvement in the design and implementation of these technologies (Hoang, 2005).

E2. Regulators and controllers of earthquakes; they are electromechanical devices that control the friction between connections in buildings which function when there is an earthquake. This system permits reducing costs in designing and constructing the structures of the buildings, allows a better operation and structural behavior. In the fabrication of these mechanisms recycled steel is used, so it is more sustainable still.

E3. In the design, construction and maintenance of the buildings and other constructions the aforementioned GIS, GPS and VR systems are also utilized, which allows creating scenarios of visualization to plan the activities, as well as control and monitor the constructions.

E4. Evaluation methods and analysis per Lifecycle in Building; they are models, systems and methods to determine the cycles of useful life in buildings, and help estimate the economic feasibility of construction from construction elements to complete buildings of any kind. To carry out these activities there is a number of software programs that simulate and calculate said elements. It is important that technologists foresee that the technologies the buildings are equipped with have a service life accordant with the needs of the users and that these technologies might help people learn how to modify the ambiance or interior of the buildings to satisfy their own needs (Intille, 2002).

F. Cultural, architectural and artistic heritage in the cities; in order to take care of this heritage of the cities there are several very useful tools that might help us in the tasks of conservation, preservation and restoration, namely:

F1. Digital photogrammetry; it helps take measures to feed the urban information systems in a city.

FIGURE 5. PORTABLE LASER CLEANER TO BE USED IN THE PRESERVATION AND REHABILITATION OF MONUMENTS AND WORKS OF ART (SOURCE: WWW.LAMBDASCIENTIFICA.COM)

F2. Technologies of laser cleaning; they are technologies and methods to remove grime and noxious layers adhered to the surfaces of buildings (figure 5). These technologies provide very efficient cleaning and control levels, since they are not contact methods and are very affordable. The advantages over traditional techniques lie in the fact that laser technologies do not have contact with the building, nor do they use corrosive chemical products; there is a better control in the removal, they can be used in any sort of material, do not harm the surface and have a precise control.

TABLE 1- TECHNICAL FEATURES. LASER SOURCE

Technical features:		
Laser source	**Nd:YAG**	
Wave length	1064 nm	532 nm
Energy	10mJ ÷ 300mJ	
Frequency	1 ÷ 5Hz	
Pulse duration	20 ns	
Spot diameter	3 mm	
Dimensions	41x23x28 (LxPxA) cm	
Weight	12 kg ca.	

F3. Bio-remediation; it is the use of biological mechanism to transform or immobilize pollutants that harm the environment. It enables preserving and rehabbing degraded monuments, without the use of highly noxious or corrosive chemical products (example of recommendable products: Biorush®, Bio-renfor-CE®, Coalition®).

F4. Isotopic technologies; these technologies reproduce ancient and original materials to incorporate them into the conservation and rehabilitation processes of historical monuments. The authenticity of the monuments and edifices might be preserved as much as possible making use of these technologies.

F5. Technologies and material to protect and secure the structure of buildings; shape memory alloys (SMA), which are metals with two important properties: they have pseudo-elasticity, combined with high flexibility, moreover they have the "ability" to return to their original shape under determinate physical and chemical conditions (example: Nickel-Titanium alloy). They can be used in structural connection of buildings to regulate loads and deformations; they can also be used in façade elements to regulate comfort conditions, in air and light entrances to the building creating a better hygro-thermal comfort.

F6. Barriers to prevent floods; diverse material and shape barriers, mobile and inflatable with air or water, very useful to deviate currents and control floods, even to control and manage erosion in affected lands.

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G. Systems of urban information in electronic media; they are systems with sufficient information in public-access databases where data and stats on the management of the main urban sustainable indexes are registered, which might work as a support for planners and urban designers of the cities. These systems might be:

- e-government (for public use through the government)
- e-learning (for public and private use through universities)

H. Agriculture

- Agricultural production using renewable energy, new machinery, biodegradable fuels and irrigation systems with little water.
- Organic agriculture, making use of natural fertilizers and supplies.
- Process of phyto-remediation, which makes plants absorb pollutants from water and soil without harmful causes or effects; this help revert the effect of environmental pollution.
- Food production with a high index of nutriments.
- Diminution of waste from agriculture.

I. Sustainable energy; as for energy management in cities and buildings recommendations have already been made in the section related to fuels to improve transport in the cities, in this section we add the following:

- The use of alternative energy to operate and efficient use of the building is recommended by means of new-generation photovoltaic panels (figure 6), systems of passive heating of water, Aeolian-electric energy, geothermal energy, mini-hydraulic energy and even nuclear energy.
- Saving and balance in the use of electric energy at the households, places of work, offices and any building.

As for the use and heating of water in the buildings, there are several systems, such as vacuum tube heaters, which are rather costly technologies; nonetheless, there are also very efficient and inexpensive systems, which are good technologies and lessen these expenses, an instance of this is a plain solar collector, built with galvanized steel optimized for the conditions of weather in Mexico (Marroquín et al., 2009), yielding excellent results and decreasing costs.

FIGURE 6. ARRANGEMENT OF PHOTOVOLTAIC PANELS FOR ALTERNATIVE ENERGY GENERATION IN BUILDINGS (SOURCE: WWW.WAGNER-SOLAR.COM)

J. New construction materials applied to sustainable development; the new materials either ceramic, metallic, polymeric, natural or compound (combination of the previous) are of great help in the application of new environmental technologies in the development of the cities. The new construction materials preferably must be: recyclable, reusable, biodegradable, re-producible and long-lasting. An instance of materials of great usefulness for the environment and improvement of conditions of the cities and urban spaces is pervious or porous concrete, which is not new, however has recently experienced a great boom in use in order to allow the reload of the aquifers, decreasing the effects of the urban heat islands, and indeed provide the cities with greater volumes of water. This material is basically a cement compound with coarse aggregates and without fine aggregates, adding to the mixture a superplasticizer to increase the mechanical resistance of the material (Wang, 1997) and that additionally preserves its capacity of permeability of water to the subsoil.

J1. Ceramic materials or compounds of ceramic matrix are the least polluting, as their origin and production is carried out in the most natural way, avoiding the excessive use of energy, water and other supplies.

J2. Metallic materials are recommendable in the construction industry because of their characteristics of high mechanic resistance and recyclability.

J3. Polymeric materials such as PVC, polystyrene, polyurethane and other similar are not recommendable from the environmental point of view, since for their production large amounts of energy, water and raw materials are required; besides the process of production releases very toxic substances into the atmosphere.

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J4. Natural and regional materials are the most recommendable materials to construct and build, for they prevent a high environmental impact as they require minimal transformations to be used.

J5. New nano-structured materials; they are new long-lasting and resistant compounds, they have a number of mechanical, thermal, acoustic properties; these materials use nano-metric dimensions to be processed and designed, and they are still under research and development.

J6. Sustainable eco-products and eco-processes of design; they are products and processes completely ecologic, for there is a strict control of quality in their production of low environmental impact. Some examples in architecture and urbanism are:

- Panels with excellent thermal behavior.
- Materials derived from plastic waste.
- Cermets (compounds of ceramic and metallic materials).
- Materials from industrial waste and recycling.

It is important to mention that the election of building materials within the development of architecture and urbanism might help decrease environmental impacts, likewise, the use of adequate constructive systems for the better disposition of the structures and surrounding of the buildings, such as the processes of *deconstruction*, which is a process where pieces of buildings and even entire buildings can be dismantled and moved to rescue the construction materials, as an alternative to demolition (Riordan et al., 2008).

K. Management and quality of water

- Water treatment systems using silver plates
- Water purification systems with particles based on glass compounds. It consists in using small glass beads with low carbon content that has the property to remove and decontaminate water without the use of energy or costly chemical products.
- Organic filters to clean residues from grey waters.

It is estimated that in order to improve the supply of water in the cities, the private sector must invest more economic resources in order to be able to reverse as well several current problems, mainly environmental impact and scarcity of water (Rode, 2009).

All of these environmental technologies produced for a better urban development must be accompanied by other sorts of tools such as: Computer Aided Design, and other sort of software to analyze and

measure data as well as evaluate a determinate situation, not only environmental but also sustainable as a whole.

4. Conclusions

The new environmental technologies applicable to urban sustainable development depend on the degree of the development of the country, its infrastructure, specialized human resources and management of the plans and programs of urban development; in addition to other tools such as methodologies and procedures that help their application. On the other side, regulation, lineaments and rules alike play an important role in the use and advantageous exploitation of these new technologies, as well as the way to apply public policies in the region does. It is worth mentioning that these technologies, which have been presented in this work, only correspond to the most up-to-date and innovative, as there are some other technologies which are not mentioned for the objective of the article was to show *the state-of-the-art* of said environmental technologies applied to sustainable urbanism

Technologies are tools which make labor and tasks of human activities easier and more efficient; said activities in relation to urban development are: diagnosis, design, analysis, evaluation, development, planning and execution in the following entries of urban sustainable development:

- Use of soil
- Urban Transport
- Management of city waste
- Air quality
- Construction and building of cities
- Cities' cultural heritage
- Urban information systems in electronic media
- Agriculture
- Sustainable energy
- New construction materials applicable to urban development and
- Sustainable management of water in the city

These variety of technologies presented following the entries of the previous list can be utilized as guidance for the methodological design of several applications in relation to urban planning and design,

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being tools that help us in different activities of technical and environmental nature, which in a certain moment we might make us of to shed light on solving technical environmental problems. Based on the entries or fields of application of environmental technologies, it is concluded that those of greater technological development are those of development of construction, urban transport, urban information systems, sustainable energy, and new materials, since currently this sort of industries have been developed and researched much more than during the last decade, putting forward surprising and innovative technological results to solve problems related to urbanism, from the environmental and sustainable point of view. It is also concluded that new technologies are only tools that help us perform the tasks of urban planning, but the most important in urbanism corresponds not only to *technologies* but to the ways and methods of design and management, this is to say, the way of using such technologies, which without good use and application would not be of any usefulness and so many technological advances would be laid to waste.

Finally, we state that technologies are ever changing and require to be continually updated, mainly if we use processes, sophisticated systems and methods to evaluate and analyzed some activity implicated in urban sustainable development and planning.

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