

SUSTAINABLE CITIES

REALISTIC TARGETS FOR AN UTOPIAN SUBJECT

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Abstract

The present paper aims to discuss subjects related mainly to the energy and environmental problems of cities. The increase of the urban population and the corresponding economic, environmental, cultural and social problems in cities are identified and analysed. General ideas related to the application of global sustainability principles, in the urban built environment, are presented and discussed in a critical way. Finally, specific proposals on the supply, use and management of energy in cities that aim to contribute towards a better environmental quality are presented and analysed.

Samenvatting

Deze paper wil voornamelijk de onderwerpen gerelateerd aan energie- en milieuproblemen in steden analyseren. De vergroting van de stedelijke populatie en de corresponderende economische, omgevings, culturele en sociale problemen in de steden worden geïdentificeerd en geanalyseerd. Algemene ideeën omtrent de toepassing van globale duurzaamheidsprincipes in de stedelijke gebouwde omgeving worden gepresenteerd en bediscussieerd op een kritische manier. Als besluit worden specifieke voorstellen omtrent levering, gebruik en beheer van energie in steden, die kunnen bijdragen tot een betere omgevingskwaliteit, voorgesteld en geanalyseerd.

1. Introduction

Cities or urban areas are defined as the physical environment that it is composed by 'a complex mix of natural elements including air, water, land, climate, flora and fauna, and the built environment that is constructed or modified for human habitation and activity, encompassing buildings, infrastructure and urban open spaces', (11).

The quality of urban agglomerations is mainly defined by the type and the strength of the anthropogenic activities, the existing infrastructures and the used resources, the generated wastes and emissions and the corresponding environmental impact, and by the efficiency and quality of the local institutions and governments.

The second half of the last century was a period of the more intensive urbanisation that our planet has never experienced. In fact, urban population has increased from 160 millions to about 3 billions in just 100 years, and it is expected to increase to about 5 billion by 2025. Transfer of people to cities has mainly happened and will continue to happen in the so called less developed countries as the result of increased opportunities offered in the urban environment and the degradation of the rural economies and societies.

Urban citizens, in the developed countries, have benefit from the huge technological developments offered by the industrial revolution. Major problems of the 19th century have been solved, while the economic development has permitted to improve the life standards both quantitatively and qualitatively. Social pressures and higher income associated with the urban lifestyle increased the capacity and the tendency of urban citizens to consume. It is characteristics that, the wealthiest 25 percent of the human population consumes almost 80 percent of the world's economic output (15). However, such an over-consumption has an important impact on the city's as well as on the global environment. Approximately 64 percent of the world's economic production/consumption and pollution is associated with cities in rich countries, while other environmental problems like heat island and indoor air quality have an important impact on the overall environmental quality of cities and health of city – dwellers, (17)

Urbanisation in less developed nations, where cities have received a population tidal wave, followed a completely different pattern. Tremendous increase of the population, lack of resources, and small or zero development has resulted in poverty and deep inequalities. The expectations of higher incomes and life quality in urban areas were seldom realized and a tremendous number of city-dwellers are actually living in absolutely unacceptable conditions. It has been estimated that almost 600 million of urban citizens in the less developed countries live in shelters and neighbourhoods 'where their lives and health were continually threatened because of the inadequate provision of safe, sufficient water supplies, sanitation, removal of solid and liquid wastes, and health care and emergency services' (16)

The widely agreed set of priorities to improve cities, define an agenda of actions, which usually is called the agenda of sustainable cities'. However, the term is quite misleading as there is no agreed and clear definition what the term 'sustainable cities' mean. In parallel, as cities are systems that just import energy and material from their immediate and host environment and then export back degraded energy, waste and pollution, can not be 'sustainable' by definition. Despite that, cities have to meet human needs in settlements without depleting environmental capital and poverty, inequalities and the very important depletion of the environmental capital, are emerging problems that ask for immediate actions.

Appropriate strategies aiming to reduce over consumption, increase the use of renewable resources and reduce the production of wastes and of the degraded energy up to a level not

exceeding the assimilative capacity of local ecosystems or the ecosphere seems to be the high priorities in cities of the developed world.

In parallel, sustainable strategies for cities in less developed regions focus mainly on the provision of basic human needs, such as appropriate dwellings, energy and water supply, sanitation systems, education, and health care services, (9).

Energy is one of the more important factor that define the quality of urban life and the global environmental quality of cities. The urbanisation process dramatically affects energy consumption. A recent analysis, (18), showed that a 1 percent increase in the per capita GNP leads to an almost equal (1.03), increase in energy consumption. However, as reported, an increase of the urban population by 1 %, increases the energy consumption by 2.2 %, i.e., the rate of change in energy use is twice the rate of change in urbanization. Increase of the energy efficiency, use or renewable resources to supply cities, improvement of the urban thermal microclimate and adoption of sustainable consumption policies, seems to be the main tools to reduce the energy consumption in cities of the developed world.

The present paper aims to discuss the main environmental problems of world cities, define the main priorities of the sustainable agenda and discuss extensively the energy problems of the cities in the developed world.

2. Urbanisation at the end of the 20th Century

2.1. Increase of the Urban Population

The planet's population is increasing rapidly. More than 80 million of people are added every year, and while the total world population was in 1987 close to 5 billion, it has pass six billion in 2000 and according to the United Nations will continue to grow until the middle of the next century, (1)

Most of the population growth is in cities. Urban population is growing much faster than the rural one; almost 80 per cent of the world's population growth between 1990-2010 will be in urban areas and most probably will be in Africa, Asia and Latin America, (2). This means simply, that there is a current addition of 60 million of urban citizens a year, and as mentioned in (3), 'is the equivalent of adding another Paris, Beijing or Cairo every other month'.

In fact, at the beginning of the last century, just one tenth of the world population, 160 millions, were city dwellers, (4), while in 1950 it has just passed 200 million. In contrast, just after the change of the century, half of the world's population lives in cities, a 20-fold increase, (4). Statistics show that the real boom of urbanisation happened in the 90's. During the last decade of the century, urban population has grown from 2 to 3 billion, an increase rate of about 50 %, (5). Future scenarios for the next 15 years, predict a growth rate of about 2 % per year, (6), while UN projects, indicate that 61 % of the world's population or about 5.1 billion people will live in cities by 2025, i.e. an increase of 70 % in the first quarter of the century, (7,8,9). Table 1, reports on the urbanisation trends in the major areas of the planet, (2).

Region	1950	1965	1980	1995	2010
<i>Urban Population (million of inhabitants)</i>					
Africa	33	66	130	251	458
Asia	244	426	706	1192	1816
Latin America and the Caribbean	69	133	233	350	463
Rest of the World	404	559	685	781	849
<i>Percentage of population living in urban areas</i>					
Africa	14.6	20.7	27.3	34.9	43.6
Asia	17.4	22.4	26.7	34.7	43.6
Latin America and the Caribbean	41.4	53.4	64.9	73.4	78.6
Rest of the World	55.3	64.1	70.5	74.2	78.0

Table 1: Trends and projections in urban populations by regions 1950-2010, (2)

In Europe, the level of urbanisation is close to 75 %, while between 1980-1995 the urban population increased by 9 %. According to (28), in Europe, 2 per cent of agricultural land is lost to urbanisation every ten years. Hahn and Simonis, (29), report that during the last century, the surface of urban land per capita in Europe has increased ten times.. The expected annual growth for the next fifteen years, is close to 0.3 % and it is expected that our continent will stabilize at a level of urbanisation close to 82 %, (13)

In fact, urbanisation occurs mainly in Africa, Asia and Latin American countries as a result of the increased opportunities and services offered in cities, (Figure 1). Fifteen years ago urban growth rate in these areas of the planet was close to 3.8 %, almost four times higher than that of the developed countries, (0.8%), (10). Urbanisation rates of less developed nations are quite striking as between 1975 to 2000 1.2 billion people have move to cities while for the next 30 years it is expected that more than 2 billion people will become city dwellers. Intensification of agriculture that decreases job opportunities in the country, local conflicts, relative increase of the rural population, exhaustion of natural resources, land degradation, as well as increased opportunities for jobs, education and health care in cities, are the main driving forces of urbanisation in less developed countries.

As a result of the rapid urban growth, important environmental, social, political, economic, institutional, demographic and cultural problems have appeared Poverty, environmental degradation, lack of sanitary and other urban services, lack of access to land and adequate shelters are among the more serious ones.

2.2. The Size of the World's Cities

As a result of the rapid urbanisation, the size of the world's urban agglomerations has grown dramatically. As mentioned by the United Nations, (10), our planet host 19 cities with 10 million or more people, 22 cities with 5-10 million people, 370 cities with 1-5 million people and 433 cities with 0.5 to 1 million people.

To demonstrate the dramatic growth of the city's size it has to be mentioned that over the last 200 years, the average size of the 100 largest cities has been increased from 200000 inhabitants to about 5 millions, (11). Recent data and future predictions show that by 2015, there will be around 560 cities with more than 1 million people, (9), while the number of mega cities, cities with a population exceeding 8 million, has been increased from 2 in 1950, London and New York, to 21 in 1990, 16 of them in less developed countries, while in 2015 there are expected to be 33, 27 in the developing world, (12-14). In parallel, it is expected that by 2015 there will be 71 cities with more than 5 million people where it is expected to live almost the 17 % of the urban citizens, (8).

In fact, Table 2, most of the urban growth occurs and will continue to occur in less developed countries where it is projected to exist 114 cities of over 4 millions people by 2025, up from 35 cities in 1980. However, it has to be pointed out that most of the urban population, in less developed countries, live in cities with less than a million citizens, while almost 50 % of the urban population lives in cities with less than 100000 inhabitants, (11). As it concerns, Europe, it should be mentioned that half of the population lives in towns of 1000 to 50000 people, 25 % in medium towns of 50000 to 250000 citizens and the rest 25 % in cities with more than 250000 people.

Region	1800	1900	1950	1990
<i>Number of Million Cities</i>				
Africa	-----	-----	2	27
Asia	1	4	26	126
Latin America and the Caribbean	0	0	7	38
Rest of the World	1	13	45	102
<i>Number of the World 100 largest cities</i>				
Africa	4	2	3	6
Asia	64	22	32	44
Latin America and the Caribbean	3	5	8	16
Rest of the World	29	71	57	34
<i>Average Size of the World's 100 largest cities for different years</i>				
Number of Inhabitants	187000	724000	2.1 millions	5.3 millions

Table 2 : The Distribution of large cities by region, 1950-1990, (7)

3. Urban Environmental Problems and not only....

Environment is the one of the three pillars of sustainable development. Human activity has accumulated problems that has left increased pollutants in the atmosphere, vast areas of land resources degraded, depleted and degraded forests, biodiversity under threat, increasingly inadequate freshwater resources of deteriorating quality and seriously depleted marine resources.,(6),

Cities contribute highly to that. In parallel, the other two pillars of sustainable development, social and economic, face extremely important problems, especially in less developed cities. In a general way, the urban environmental problems may be summarized on three main aspects : the over-consumption of energy and resources that exceed their production by the nature, the production of degraded energy, wastes and pollution more than the assimilative capacity of the ecosphere, and the lack of the necessary infrastructures to ensure health and well being of all citizens in cities of less developed countries. .

Over-consumption of resources, mainly energy, associated with increased air pollution mainly from motor vehicles, increase of the ambient temperature because of the positive heat balance in cities, heat island, noise pollution, and solid waste management, seems to be the more important environmental problems in urban areas of developed countries. In parallel, poverty, increasing unemployment, environmental degradation, lack of urban services, overburdening of existing infrastructure and lack of access to land, finance and adequate shelter, are among the more important environmental, social and economic problems in cities of less developed countries.

3.1 Cities in the Developed World

3.1.1 Over Consumption of Resources

Over-consumption of resources in cities of the developed world is well shown when the ecological footprint of cities is calculated and compared between cities. The ecological footprint of a population group 'is the area of land and water required to produce the resources consumed, and to assimilate the wastes generated by the population on a continuous basis, wherever on Earth that land is located', (5). Calculations have shown that there are only 1.5 ha of ecologically productive land and about 0.5 ha or truly productive ocean for every person on Earth, (19). However, the eco-footprints of average residents of high income countries range as high as five and six hectares per capita, (20, 21), Other analyses calculate the eco-footprint of wealthy countries up to 10 hectares per capita while people in the less developed countries have footprints of less than one hectare, (22,23).

A recent British study has estimated that the ecological footprint of London for CO₂ assimilation, food and forest products. is close to 120 times larger than the city's area or about nine-tenths the area of the entire country, (24). Ecological footprint estimations for Canada, have shown that in the Toronto, Canada, region, (25) the per capita ecological footprint is close to 7.6 ha./person. Given that Toronto hosts 2,385,000 residents, the aggregate eco footprint is 18,126,000 ha, an area 288 times larger than the city's political area (63,000 ha). In a similar way, it is calculated that Vancouver, Canada, (23), the eco-footprint of the city is 3634000 ha, or 319 times its nominal area. In an other study using region-specific data of the 29 largest cities of Baltic Europe, (26), it is calculated that an area of forest, agricultural, marine, and wetland ecosystems 565 to 1,130 times larger than the area of the cities themselves is required. Concluding the analysis on eco-footprint it must be pointed out that as shown in (21), the resources of the equivalent of three planet earths, are required, if the world's current population continues to live at the OECD average of today, (16). In parallel, as stated in (19), 'to raise the present world population to Canadian material standards using prevailing technologies would require nearly four Earth-like planets'.

3.1.2 Thermal Degradation of Cities

Increasing urbanization has deteriorated the urban environment. Deficiencies in development control have important consequences on the urban climate and the environmental efficiency of buildings. The size of housing plots has been reduced increasing thus densities.. Increasing number of buildings has crowded out vegetation and

trees. As reported, New York has lost 175000 trees, or 20 % of its urban forest in the last ten years, (27).

As a consequence of heat balance, air temperatures in densely built urban are higher than the temperatures of the surrounding rural country. The phenomenon known as 'heat island', is due to many factors the more important of which are summarized in (30), and deal with : a) the canyon radiative geometry that contributes to decrease the long wave radiation loss from within street canyon due to the complex exchange between buildings and the screening of the skyline, b) the thermal properties of materials that increase storage of sensible heat in the fabric of the city, c) the anthropogenic heat released from combustion of fuels and animal metabolism, d) the urban greenhouse, that contributes to increase the incoming long wave radiation from the polluted and warmer urban atmosphere, e) the canyon radiative geometry decreasing the effective albedo of the system because of the multiple reflection of short wave radiation between the canyon surfaces, f) the reduction of evaporating surfaces in the city putting more energy into sensible and less into latent heat, and g) the reduced turbulent transfer of heat from within streets.

Urban heat island studies refer usually to the 'urban heat island intensity', which is the maximum temperature difference between the city and the surrounding area. Data compiled by various sources, (17), shows that heat island intensity can be as high as 15 C. Extensive studies on the heat island intensity in Athens involving more than 30 urban stations show that urban stations present higher temperatures compared to reference suburban stations between 5 to 15 C.

Heat Island data in some North American cities are reported in (27). The importance of temperature increase becomes more apparent when the cooling degree-days corresponding to urban and rural stations are compared. In, (31), the increase of the cooling and heating degree-days due to urbanization and heat island effects for selected North American locations, is given Tables 3-4. As shown, the difference of the cooling degree-days can be as high as 92 percent, while the minimum difference is close to 10 per cent. Regarding the heating degree-days the maximum difference is close to 32 percent while the minimum one is close to 6 percent. Increase of the cooling degree-days has a tremendous impact on the energy consumption of buildings for cooling.

Location	Urban	Airport	Difference (%)
Los Angeles	368	191	92
Washington DC	440	361	21
St. Louis	510	459	11
New York	333	268	24
Baltimore	464	344	35
Seattle	111	72	54
Detroit	416	366	14
Chicago	463	372	24
Denver	416	350	19

Table 3 : Increase of the cooling degree days due to urbanization and heat island effects. Averages for selected locations for the period 1941-1970. Source :(31).

Location	Urban	Airport	Difference (%)
Los Angeles	384	562	-32
Washington DC	1300	1370	-6
St. Louis	1384	1466	-6
New York	1496	1600	-7
Baltimore	1266	1459	-14
Seattle	2493	2881	-13
Detroit	3460	3556	-3
Chicago	3371	3609	-7
Denver	3058	3342	-8

Table 4 : Increase of the heating degree-days due to urbanization and heat island effects. Averages for selected locations for the period 1941-1970. Source (31).

Higher urban temperatures have a serious impact on the electricity demand for air conditioning of buildings; increase smog production, while contributing to increased emission of pollutants from power plants, including sulphur dioxide, carbon monoxide, nitrous oxides and suspended particulates. Heat island effect in warm to hot climates exacerbates cooling energy use in summer. As reported, (27), for US cities with population larger than 100000 the peak electricity load will increase 1.5 to 2 percent for every 1 F increase in temperature. Taking into account that urban temperatures during summer afternoons in US have increased by 2 to 4 F during the last forty years, it can be assumed that 3 to 8 percent of the current urban electricity demand is used to compensate for the heat island effect alone.

Comparisons of high ambient temperatures to utility loads for the Los Angeles area have shown that an important correlation exists. It is found that the net rate of increase of the electricity demand is almost 300 MW per F. Taking into account that there is a 5 F increase of the peak temperature in Los Angeles since 1940, this is translated into an added electricity demand of 1.5 GW due to the heat island effect. Similar correlation between temperatures and electricity demand has been established for selected utility districts in USA. Based on the above rates of increase, it has been calculated that for USA the electricity costs for summer heat island alone could be as much as \$ 1 million per hour, or over \$ 1 billion per year, (27). Computer studies have shown for the whole country the possible increase of the peak cooling electricity load due to the heat island effect could range from 0.5 to 3 percent for each 1 F rise in temperature.

Studies on the Tokyo area reported in (32), conclude that during the period between 1965 to 1975, the cooling load of existing buildings has increased by 10 - 20 % on average because of the heat island phenomenon. It is concluded, that if it continued to increase at the same rate, it had to make more than a 50 % increment in 2000.

Calculations of the spatial cooling load distribution in the major Athens area, based on experimental data from twenty stations has been reported in (33), Figure 2. It is found that the cooling load of reference buildings is about the double at the centre of the city than in the surrounding Athens area. It is also reported that high ambient temperatures increase peak electricity loads and put a serious strength on the local utilities. Almost a double peak-cooling load has been calculated for the central Athens area than in the surroundings of the city. Finally, a very important decrease of the efficiency of conventional air conditioners, because of the temperature increase, is reported. It is found that the minimum COP values

are lower to about 25 % in the central Athens obliging designers to increase the size of the installed A/C systems and thus intensify peak electricity problems and energy consumption for cooling, (34,35).

3.1.3 Air Pollution and Noise

In addition to increased energy demand for cooling, increased urban temperatures affect the concentration and distribution of urban pollution because heat accelerates the chemical reactions in the atmosphere that leads to high ozone concentrations. Other sources like transports, industry, combustion processes, etc. contribute to increased pollution levels in the urban areas. In Europe it is estimated that in 70 to 80 percent of European cities with more than 500000 inhabitants, the levels of air pollution, regarding one or more pollutants exceeds the WHO standards at least once in a typical year, (28)

Urban pollution is linked to climatic change, acidification and photochemical smog. Comparison of daily peak temperatures in Los Angeles and 13 cities in Texas with ozone concentrations show that as temperature rise ozone concentrations reach dangerous levels, (29). Also, polluted days may increase by 10 percent for each 5 F increase, (27). Urban geometry plays an important role in the transport and removal of pollutants. The roughness of urban buildings and landscapes increases air turbulence enhancing thus the dispersion of pollutants. Also, if pollutants land in sheltered areas like street canyons may reside longer than they would in a windy rural environment.

The roughness of buildings and the urban structures affect wind within the city and slow down wind speeds increasing thus pollutants concentration. Increased industrialisation and urbanisation have created important pollution problems in urban areas. Sulphur dioxide, particulate matter, nitrogen oxides, carbon monoxide, etc., affect in a direct way the human health while affect historic monuments and buildings. It is calculated that the cost for damage only by sulphur dioxide to buildings and construction materials might be in the order of 10 billion ECU per year for the whole Europe, (37).

Damage from increased pollutants is evident. Analysis of the relationship between hospital admissions and sulphur oxide levels in Athens, (38), found that a " three fold increase in air pollutants doubles hospital admissions for the respiratory and cardiovascular disorders" and that " acute respiratory illness shows the highest correlation for the SO₂ variable".

Levels of nitrogen oxide are particularly high in urban environments. NO₂ levels in San Francisco and New York exceeds 200 µg per cubic meter while in Athens the corresponding concentration is close to 160 µg per cubic meter, (39).

Health problems associated with the urban environment are mainly associated to the increased use of cars. This has been acknowledged recently by the British Medical Association, (40). Pollution from gasoline and petrol has been proved to be partly responsible for heart diseases. Poloniecki, (41) have shown that in London, 1 in 50 heart attacks treated in hospitals were strongly linked with carbon monoxide which is mainly derived from motor vehicle exhausts.

The role and the impact of outdoor conditions to the indoor climate as well as the relation between the outdoor and indoor pollution are obvious notions of building physics and should not be repeated here. However, intensive urbanisation and deterioration of the outdoor air observed during the last years creates a new situation with serious consequences to the indoor environmental quality. In fact outdoor pollution is one of the sources of the so-called "sick building syndrome", the other is related with indoor sources. Numerous studies reported during the last years, show the serious impact of the outdoor environment to the indoor air quality, (42).

Outdoors pollution and inadequate ventilation are may be the primary causes of poor indoor air quality in buildings. Monitoring of 356 public access buildings has shown that in approximately 50 % of the buildings non-proper ventilation rates was the primary cause of illness complaints and poor air quality, (43). Increased outdoor concentrations affect seriously indoor concentration of pollutants. Measurements of nitrogen oxide concentrations in a hospital in Athens, (44), show high concentrations for indoor standards, which rises between 33 to 67 μg per cubic meter.

Noise in the urban environment is a serious problem. As in (28), unacceptable noise levels of more than 65 dB(A), affect between 10 to 20 percent of urban inhabitants in most European cities. It is also reported that in cities included in the Dobris Assessment, unacceptable levels of noise affect between 10 to 50 percent of urban residences. OECD, (45), has calculated that 130 millions of people in OECD countries are exposed to noise levels that are unacceptable. The same study reports that in the Netherlands during the decade 1977-1987, the population proportion claiming moderate noise disturbance has increased from 48 to 60 percent, while in France, between 1975-1985, the urban population exposed to noise levels between 55 and 65 dB(A) increases from 13 to 14 millions. UBA, (46), reports that in the western part of Germany and in towns with up to 5000 inhabitants, 14-16 % of the population are strongly annoyed by street noise. In towns with between 5000 to 20000 inhabitants this percentage increases to 17-19 percent, while in cities between 20000 to 100000 inhabitants is 19-25 %, and finally in cities of more than 100000 inhabitants this percentage rises between 22 to 33 percent.

3.2 Cities in the Less Developed World

As already stated previously, poverty, increasing unemployment, environmental degradation, lack of urban services, overburdening of existing infrastructure and lack of access to land, finance and adequate shelter, are among the more important environmental, social and economic problems in cities of less developed countries.

3.2.1 Urban Poverty

The growth of large cities in the less developed countries, has been accompanied by an increase in urban poverty mainly because of the increasing gap between incomes and land prices, and the failure of markets to provide housing for low-income groups. As reported by the United Nations, (6), 'in cities of the less developed world, one out of every four households lives in poverty; 40 per cent of African urban households and 25 per cent of Latin American urban households are living below locally defined poverty lines'.

Poverty is mainly concentrated in specific social groups and in particular locations as the economic reality in these countries, forces low - income groups to settle in deteriorated and marginal lands in or around cities without access to basic infrastructures and services.

Poverty is among the major reasons of environmental degradation and unfortunately urban poverty is on the increase. In fact, as reported by the World Health Organization (WHO) poverty and inequality are two of the most important contributory factors to poor environmental conditions and poor health. It is characteristic that in 1970, the richest 20 percent of the planet had almost 30 times more income than the poorest 20 percent. In our days, this figure has doubled. The net income of the 358 richest people of the world is larger than the combined annual income of the poorest 45 percent of the world's population., (9)

3.2.2. Housing

Perhaps the major of the basic needs in poorer areas of cities in less developed countries include, the use of 'affordable and decent housing which contributes to ensure, health, security, development, empowerment, well-being, and urban functional efficiency.

As estimated by the United Nations, (10), more than one billion of urban citizens, live in non appropriate houses mostly in squatter and slum settlements, while in most of cities in less developed countries between one and two thirds of the population live in poor quality and overcrowded housing, (11), with insufficient water supply inadequate or no sanitation, non appropriate rubbish collection, no electricity and energy networks and under the risk of flooding and other environmental phenomena, (47).

3.3.3. Energy and Air Quality

Electricity provision, use of non appropriate fuels for heating , cooking and lighting, and indoor air quality are major problems in cities of less developed world. In low-income cities, less than 750 US \$/ person, only 70 % of the population is connected to grid, which provide electricity just for some hours per day.

The income of the households defines the type of fuel used for thermal processes. Low-income households choose cheap fuels like wood, kerosene or paraffin, while the higher the income the more use of cleaner fuels, natural gas, or electricity is done, (53-54). As pointed out, this is a kind of an 'energy ladder', (53-54).

The use of open fires and of non appropriate fuels, in overcrowding houses, are important sources of indoor air quality that contributes to acute respiratory infections that that kill 4 million people a year, mostly children under the age of five years, (14) . Existing studies suggests indoor concentrations of total suspended particulates 10 to 100 higher than the existing standards, (55). As reported in (56), in South Asia countries, indoor air pollution from solid fuels burned in open fireplaces probably contribute for a larger total exposure than outdoor pollution sources (56).

As it concerns outdoor air quality, there are more than 1.5 billion of urban dwellers that are exposed to levels of outdoor air pollution that are above the accepted maximum concentrations, while it is estimated that 400000 additional deaths are attributed every year to outdoor air pollution.

3.3.4 Lack of Infrastructures.

Most cities in the less developed countries do not offer the necessary infrastructure in order to provide citizens with safe potable water, sanitation and waste collection and treatment.

Officially, it is estimated, that as many as 25 percent of urban dwellers in the developing world did not have access to safe potable water supplies (5), however, the real number may be much higher..

Even, those living in areas with pipes supplies, reliability of the water network is a serious problem. Water supply has declined from 124 litres a day in 1967 to 64 litres a day in 1997. In 1967, almost all housings connected to the water network received 24 hours service, while by 1997 the percentage has declined to only the 56 % , with almost 20 % of the households received water only 1-5 hours per day, (11, 48,49).

Those, not connected to the network, they have either to buy water from private vendors or to queue for hours each day in public standpipes and then carry for kilometres more than 120 kg of water. As there is a great shortage of taps, there are more than 500 citizens per tap waiting for more than 90 minutes. In some cases, there are more than 1500, while

there are cases with more than 2500 inhabitants per standpipe, (11, 48,49,50). However, as estimated in (51), more than 20-30 per cent of the population in less developed world they have to buy water from private vendors spending 5-30 per cent of their total income to buy water, (47,52)

As it concerns sanitation facilities, it is estimated that almost two thirds of the population of cities of less developed countries, have no hygienic facilities of disposing of exceta and perhaps a higher percentage lack the necessary means to dispose of wastewaters, (57). As is mentioned in (11), cities with more than a million of inhabitants have no sewer systems, while Fewer than 35 per cent of cities in the developing world have their wastewater treated, (6).

In parallel, between one-third and one-half of the solid wastes generated within most cities in less developed countries are not collected. As estimated by the World Bank, more than 200 billion US dollars have to be invested each year in basic infrastructure in less developed countries and in the period 2005, while given the population growth and the additional demand of material "...it would be reasonable to expect the total volume of investment to reach six trillion [U.S.] dollars by that time" (59).

4. Is Urban Sustainability an Oxymoron or a Realistic Perspective

Cities are systems that import energy and resources and produce degraded energy and matter that has to be assimilated by the surrounded area. Thus, when based on the ecological and systemic definitions, is hard to consider cities as sustainable systems.

However, cities present important advantages and should not be considered as places that only generate environmental cost. It may provide high quality living conditions with lower levels of energy use, waste, pollution and in general low environmental impact, than the wealthy rural or suburban areas, (13, 60). In parallel, health services in cities are much better developed than in rural areas and this is well proven by international epidemiological and demographic studies that suggests much higher survival rates in cities (13). Economy of scale in cities decreases considerably land pressure and the cost of new infrastructure and services like water treatment plants, energy and other networks, educational and health services, etc. Finally, benefits provided by cities, to people outside their boundaries should not be neglected as the city economical activities provide incomes by purchasing goods. Thus, cities may hold promise for sustainable development mainly when are able to support a large number of people and limit their per capita impact on the natural environment.

According to (19), there are two basic criteria for ecological sustainability of cities:

- To consumption renewable and replenishable energy and resources that should not exceed their production in nature, and;
- The production of degraded energy and matter by the cities must not exceed the assimilative capacity of local ecosystems or the ecosphere.

To comply with the defined frame, cities have to satisfy five broad categories of environmental goals, (11)

- a) To provide the environmental conditions that can ensure health of urban citizens and reduces vulnerability of the population. This includes basic infrastructures and services like adequate provision of water, sanitation, garbage collection and drainage for all the urban area and citizens.
- b) To reduce the risk of chemical and physical hazards in the every day life of the city.

- c) To provide citizens with a high quality urban environment that protect the natural and cultural heritage, provide outdoor comfort and the necessary urban spaces for the well being of city dwellers, (urban parks, public spaces, sport facilities, children's playground, etc).
- d) To reduce as much as possible the shift of the environmental load and cost generated by the cities to the inhabitants and ecosystems surrounding the urban area, and
- e) To ensure that the consumption of resources and goods and the corresponding generation of matter and degraded energy are compatible with the limits of the natural capital and do not transfer environmental load and cost to future generations or to other human groups.

To relative performance of urban systems on the above goals define the degree that cities fulfil the needs of the people and protect the global environmental capital. It is evident that to satisfy such a complex set of goals, a very efficient institutional, political, social, economic and cultural regulatory framework is requested.

5. We do not have 'Solutions' but we have Ideas

Working towards more sustainable cities one has to define specific actions that may contribute to solve local environmental problems. It is clear that every city has its own characteristics and problems, and there are not universal solutions that may be applied everywhere.

Thus, the aim of the present chapter is not to describe a comprehensible set of ideas to achieve urban sustainability. Such a goal is extremely ambitious and for sure out of the objectives of the present paper. What the present contribution aims to offer is a discussion on the ideas and possibly solutions we have to foreseen in order to decrease the energy consumption of buildings, in cities of developed world, reduce the environmental cost because of the energy use and improve environmental comfort in and around buildings. Such a goal may appear to be reduced, however as buildings are the main consumers of energy in cities, it contributes tremendously to achieve a more sustainable urban environment in our continent that may not transfer the environmental cost to the future generations and to other human groups in the planet, (62-64).

For sure, there is a big list of ideas on how to decrease the energy consumption of buildings in our cities. However, and according to the author view and opinion, the main concerns and technological ideas that may be well thought-out in priority are :

- a) Improve the Urban Microclimate, fight heat island and reduce the energy needs for cooling.
- b) Use of sustainable energy supply systems for buildings based on the use of renewable sources like solar and biomass district heating and cooling.
- c) Use of demand side management techniques to control and regulate the energy consumption of big consumers.
- d) Integration of passive and active solar systems in the envelope of new and existing buildings, and use of high energy performance supply and management equipment
- e) Application of appropriate city planning techniques when new settlements are designed. The idea of compact city, reducing the needs for transport as well as the energy consumption of buildings is gaining an increasing acceptance. Ideas like these developed by the New Urbanism movement, (68-69), based on mixed land uses, greater dependence on public transports, cycling and walking, decentralization

of employment location, etc, may be further developed and applied to create a more sustainable urban environment.

In parallel, a series of institutional, economic and regulatory actions are foreseen as important. The more important of them may be :

- f) The development of a new more efficient legislative frame on the energy performance of buildings. The development of the new European Directive on the Energy Performance of Buildings is a very good base to further improve the efficiency of urban buildings.
- g) Integration of the environmental cost in the price of goods and services
- h) Adoption of 'green consumption' principle by the urban citizens
- i) Adoption of the principle of 'fair trade' by the citizens and their institution in order to reduce exploitation of people mainly in less developed countries.
- j) Application of new ecological principles on the production and management of energy related systems and components, like the principle of natural capitalism.
- k) Strength the involvement of local authorities on the production, maintenance and management of the energy systems on the city level.

In the following some of the above ideas are further developed.

5.1 Improve the Urban Microclimate

Improvement of the ambient microclimate in the urban environment involving the use of more appropriate materials, increased use of green areas, use of cool sinks for heat dissipation, appropriate layout of urban canopies, etc., to counterbalance the effects of temperature increase, is among the more efficient measures.

Increase of the energy consumption in the urban areas, because of the heat island effect, put a high stress to utilities that have to supply the necessary additional load. Construction of new generating plants may solve the problem but it is an unsustainable solution while it is expensive and takes a long time to construct. Adoption of measures to decrease the energy demand in the urban areas, like the use of more appropriate materials, increased plantation, use of sinks, etc, seems to be a much more reasonable option. Such a strategy, adopted by the Sacramento Municipal Utility District, (SMUD), has proved to be very effective and economically profitable, (64). It has been calculated that a megawatt of capacity is actually eight times more expensive to produce than to save it. This because energy saving measures has low capital and no running cost, while construction of new power plants involves high capital and running costs.

The optical characteristics of materials used in urban environments and especially the albedo to solar radiation and emissivity to long wave radiation have a very important impact to the urban energy balance. Yap, (65), has reported that systematic urban -rural differences of surface emissivity hold the potential to cause a portion of the heat island.

Use of high albedo materials reduces the amount of solar radiation absorbed through building envelopes and urban structures and keeps their surfaces cooler. Materials with high emissivities are good emitters of long wave energy and readily release the energy that has been absorbed as short wave radiation. Lower surface temperatures contribute to decrease the temperature of the ambient air as heat convection intensity from a cooler surface is lower. Such temperature reductions can have significant impacts on cooling energy consumption in urban areas, a fact of particular importance in hot climate cities.

Trees and green spaces contribute significantly to cool our cities and save energy. Trees can provide solar protection to individual houses during the summer period while evapotranspiration from trees can reduce urban temperatures. Trees also help mitigate the greenhouse effect, filter pollutants, mask noise, prevent erosion and calm their human observers. As pointed out in (27), 'the effectiveness of vegetation depends on its intensity, shape, dimensions and placement. But in general, any tree, even one bereft of leaves, can have a noticeable impact on energy use'.

5.2 Use of Sustainable Energy Supply Systems

Sustainable energy supply systems and mainly the use of district heating and cooling systems based on the use of renewable energies like solar and biomass or the use of waste heat, is the major tool to introduce clean energy in cities. Produced energy may supply the residential sector, industry, urban agriculture, and any other sector requiring hot or cold water. District heating and cooling brings heat or cool into the buildings (by way of chilled water), and avoids a number of distributed air conditioners with poor performance and high cost. It pays itself on economies of scale but brings large energy and environmental advantages. It provides opportunities to significantly reduce electrical consumption, and thus pollutant emissions.

District heating and cooling installations using renewable energies are constantly increasing in Europe. In many European countries the potential for district heating systems is very high, while the number of settlements supplied by district heating networks is continuously increasing.

District cooling systems has mainly developed in the United States and present a number of very important advantages. The more important advantage has to do with the dramatic decrease of peak electricity load. A good example is given in Figure 3, where the reduction of the peak electricity load in Cleveland is shown prior and after the integration of a district cooling system in the city, (66)

District energy systems are very efficient as operate at high efficiencies, can increase effective building space, decrease operational , maintenance and capital cost of the user, and can improve indoor air quality as do not generate any chemical or biological pollution in the building. In parallel, district heating and cooling techniques when operated by Municipalities and Community authorities may be the source of important of revenues for the local society.

5.3 Use of Demand Side Management Techniques

Demand side management techniques may be the more appropriate tools to reduce the peak and total energy demand, in cities. During the recent years, some forms of demand side management techniques have been extensively used by the European utilities.

Apart of the use of sustainable district heating and cooling systems, five types of demand side management actions can be identified :

DSM1. Use of more energy efficient air conditioners and heating devices that implies better performance and better design and integration to the building.

DSM2. Application of advanced control systems like inverters, fuzzy logic in order to take into account the operational profiles of urban buildings, like the highly intermittent occupation of residential and commercial buildings in urban areas.

DSM3. Direct load control like remote cycling, by the utilities on the cooling usage as on other usage. This techniques is widely applied during peak periods on a few millions of appliances room air conditioners in the US. By limiting the available duty cycle during peak

periods, utilities can reduce significantly the peak demand. Attention has to be given on consumer's comfort.

DSM4. Improvements on the building design to decrease their heating and cooling load. This may involve actions on heat and solar protection, heat modulation and dissipation of excess heat in a lower temperature environmental sink.

DSM5. Use of cogeneration techniques. This type of distributed generation of electricity + possibly cold/hot water or steam can reduce peak transportation costs and use of fuel.

5.4 Use of Passive and Active Solar Systems in Urban Buildings

The adaptation of urban buildings to the specific environmental conditions of cities in order to efficiently incorporate solar and energy saving measures and counterbalance the radical changes and transformations of the radiative, thermal, moisture and aerodynamic characteristics of the urban environment is a major priority. This incorporates appropriate sizing and placing of the building openings, to promote solar energy utilization, enhance air flow and natural ventilation and improve daylight availability, integration of photovoltaics as well as use of passive cooling techniques to decrease cooling energy consumption and improve thermal comfort.

Passive solar heating, cooling and lighting techniques have reached a high degree of technical maturity. Large scale applications, especially in new settlements, have shown that very high energy gains can be achieved while the thermal and visual comfort as well as indoor air quality are very satisfactory, (67). Further penetration and use of solar technologies is associated with their adaptation to the new conditions almost imposed by the specific social, economic and technical trends dominating the overall sector of the built environment.

6. Conclusions

The energy consumption of the building's sector is considerably high and is expected to further increase because of the improving standards of life and increase of the world population. Satisfying the increased energy needs, particularly in less developed countries, without to compromise the atmospheric environment, clean and low cost systems and techniques have to be employed. Passive and active solar techniques combined with advanced conservation technologies seem to be the more appropriate and efficient solution to this problem.

Appropriate future planning in cities should consider that the built environment is not just a collection of buildings, but it is in fact the physical result of various economic, social and environmental processes strongly related to the society standards and needs. Economic pressures related to property and labour market, investment and equity, household income and the production and distribution of goods, in combination with social aspects related to culture, security, identity, accessibility and basic needs, and finally, in association with environmental influences related to the use of land, energy and materials, define and determine the built environment we live in, () , and will determine the future of solar technologies as well.

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Figures

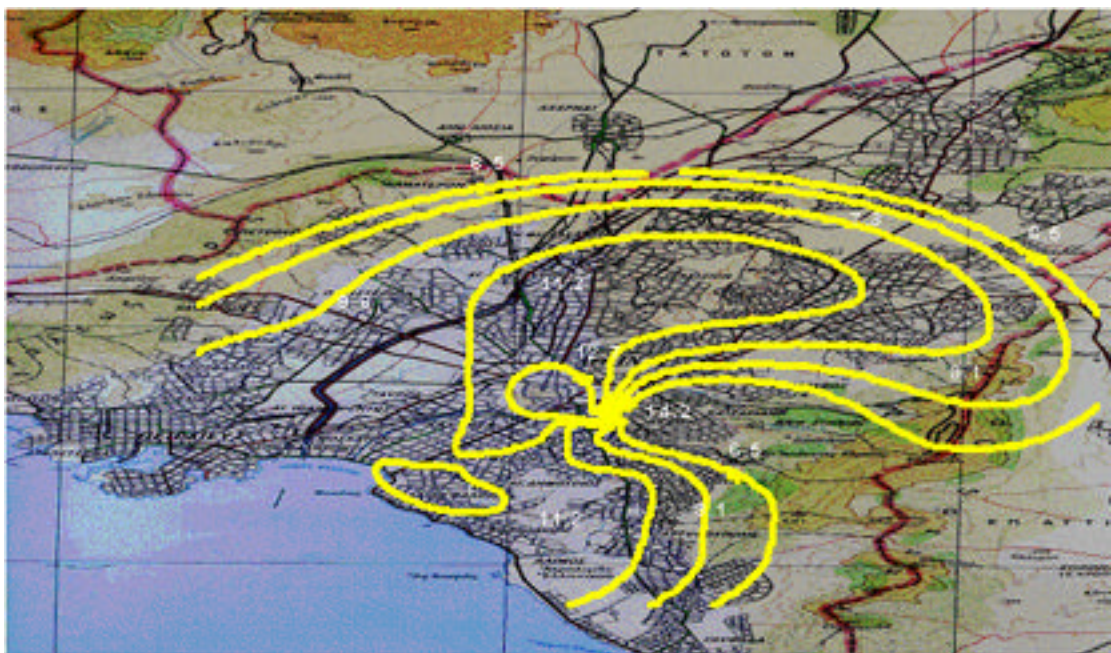
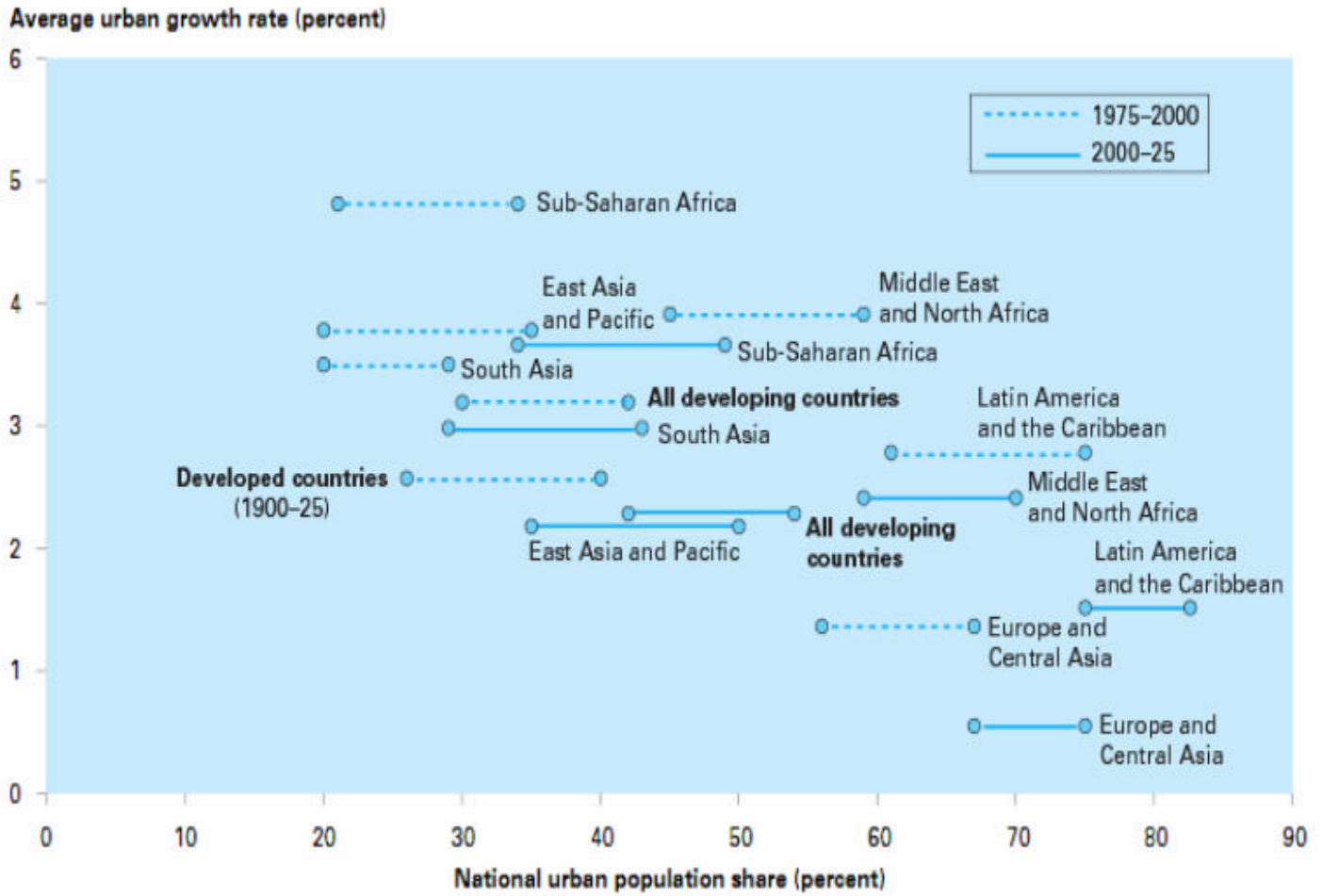


Figure 2. Iso - Cooling load lines for the reference building in Athens for August 1996 and for 26 C set point temperature.

Figure 3 . Decrease of the peak electricity load . in Cleveland because of the introduction of district cooling techniques.

