Cities and energy: The sustainability (r)evolution

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Introduction

Cities are first and foremost places of social synergies, economic interactions and cultural efflorescence. Their success depends largely on the quality of life they offer to citizens and their capacity to generate and distribute wealth. Energy is the common denominator of all human activities, synonymous with life and vitality. At the dawn of the millennium, cities and the energy sector are on the verge of dramatic changes. Many strongly entrenched ideas start to vacillate and innovative approaches challenge the inertia of old infrastructures. New concepts and technological breakthroughs emerge, often as consequences of scientific progress, policy and market initiatives and citizens' expectations. The paradigm of sustainable development inaugurated a new civilization, enriched with concerns about the quality of development. The most inexhaustible energy resources are not only renewable sources, but also knowledge and innovation.

Cities are the places where most knowledge is created and most innovations take place. Even if their hegemony is often disputed by other dynamic territories, cities are not only the sum of their people, places and historic facts. They are made out of relationships and conflicts, convergences and divergences, with unique systemic results. The dynamic synergetic effects are more important than the merely accumulative ones. Sustainability means also "sustain ability to create and innovate." Cities have to provide their citizens with secure, reliable, competitive and clean energy and reflect socio-economic vigor and cultural energy. They have to promote technologies and consumption patterns that lead to a more sustainable future. More efficient and renewable energy systems, micro-power and co-generation can help them to improve their metabolisms.

Urban energy policy is normally developed and implemented at national, regional and local level. The European Community has a responsibility to act as a catalyst and promote technologies and approaches that raise the bar of excellence towards sustainable development. Energy is one of the pillars of the EU strategy on sustainable development. Special efforts are made to ensure that EU policies are "urban sensitive." The current EC Fifth Framework Programme for research and technological development is the first one to include a part dedicated to urban sustainability. The "Key action" on the "City of tomorrow and cultural heritage," especially designed to address strategic multi-disciplinary urban questions, promises to bring visible and tangible improvements to the life of European citizens.

This paper presents a series of innovations in cities linked to energy. It should be remembered that there are no "accreditation systems of best practices" at the European level and this *tour d'horizon* should be seen under the prism of relativity, intrinsically linked to the very notion of innovation, born to be surpassed. The paper is largely based on the author's previous work on urban issues, although it is impregnated by her present work with the European Commission on energy research policy. Any views and statements are personal and do not engage the European Commission.

Urban challenges and "built politics" in the era of sustainability

Cities are theaters of civilization, schools of abilities and temples of values. They have been defined as places in which the human genius is expressed, palettes of possibilities, yet to be realized (EC, 1997a). Criteria for their success can already be found in some master definitions. According to Aristotle, the city is "built politics." Vitruvius stated that cities should be solid, beautiful and useful. Jacobs (1969) defined cities as places that generate, in an ongoing way, their economic development from their own resources and from the "disordered order" of human interaction.

"Habitat II," the last UN summit of the 20th century, highlighted the role of cities for achieving global sustainability (HABITAT, 1996; UN, 1997). At the dawn of the third millennium (the *"urban" millennium*), the world, steadily urbanizing for centuries, stood at a very important crossroads. For the first time in the history of the planet Gaia, urban dwellers outnumbered

the rural ones. Since 1970, most urban growth has taken place in developing countries; it has been fuelled by both rural-urban migration and natural population increase (UN, 2000). Europe was the first continent to enter the *urban age,* half a century ago. Endowed with the most dense and mature urban network, it can provide models and lessons (BEATLEY, 2000; MEGA, 2000).

The concept of sustainable development derives originally from the scientific literature, where it implies the management of natural resources in ways consistent with the preservation of their reproductive capacities. Renewable resources should not be depleted to a degree higher than their reproductive capacity and non-renewable resources should be preserved, and technology race for substitutes. In the waning years of the 20th century, "sustainable development" became a most popular and emblematic, yet subversive and controversial, concept. It has been defined as a process and not as an end-point, as a journey rather than a destination. Like the journey to Ithaca, it may be construed as a struggle between the Scylla of exclusion and the Charybdis of over-consumption (EC, 1996, 1997a and 1999a; EFILWC, 1997; HALL and PFEIFFER, 2000; MOPTMA, 1995; OECD, 1994 and 1996; WHO-OECD, 1996).

The paradigm of urban sustainability projects cities onto the global scene of the future. It advocates a balance between the quality and quantity of development and asks for integration of socio-economic and environmental concerns. The Charter of European Cities and Towns Towards Sustainability, seen as the European version of Local Agenda 21 (CEMR, 1996), states that sustainable development helps cities and towns to base living standards on the carrying capacity of nature and progress towards social justice, prosperous economies and environmental improvements (ICLEI, 1995). Energy has deep and broad relationships with each of the three pillars of sustainable development and has a significant role to play in the journey towards an environmentally sound, socially integrated and economically flourishing future, promoted by active citizen participation (EC, 2001b; OECD, 2001a).

Energy is a precondition and a catalyst of development. During the 20th century, the number of people on earth increased fourfold, but energy use was multiplied by sixteen (McNEIL, 2000). The degree of electrification has served as an indicator of development and it is still a valuable yardstick for measuring welfare. Fundamental divides can be crystallized by the relationship of electric consumption per capita in the least developed and developed world: 80 kWh versus 8,000 kWh. Access to energy services is considered to be a sine qua non condition for well-being and quality of life. Two billion people on earth are still deprived of access to modern energy services. In the developed world, fuel shortages can paralyze cities and countries (OECD, 2001b).

Cities consume 75 percent of energy in the EU. In order to offer citizens the conditions for fulfilling life, the internal energy market holds new challenges. Member States and cities are interdependent as regards action against climate change, security of supply and the completion of the internal energy market. Cities have to meet the growing energy demand in a secure and sustainable way, diversify energy supply and enable a smooth transition from a fossil fuel-based energy economy to one based on renewable sources. The role of technology and innovation in advancing towards efficient energy systems, gradually integrating new and renewable energy sources, is fundamental.

Improving energy efficiency across all sectors and throughout activities is a key factor for advancing towards sustainable cities. The Action Plan to improve Energy Efficiency in the European Community indicates that there is an estimated potential for energy efficiency improvement of more than 18 percent of present energy consumption. The Action Plan includes policies and instruments for overcoming obstacles and enhancing opportunities, such as the integration of energy efficiency into regional and urban development, taxation and tariff policy (EC, 2000d).

Sustainability may symbolize a continuous invention of new opportunities, and a permanent aspiration for a better world. Pure evolutionary change and adaptive responses to new technologies, within the established rules and procedures, are not sufficient for progressing towards sustainable energy pathways. Sustainability demands adroitness in maximizing resources, skills and chances. Any innovation creates the conditions for its own demise. The more established a system, the more difficult it is to change. Vested interests resist change, and resistance increases when innovations touch the core interests or boundaries of institutions. This is particularly relevant for energy, because infrastructures, investments and practices are long-lived and well established. Innovation is "creative destruction" (SCHUMPETER, 1976), the key to progress (OECD, 1996). It implies a radical shift to the creation of new ideas, products and processes, at the expense of conventional ones. Innovation theory distinguishes innovation from invention, at the one end, and transformation, at the other. Invention is often identified with the research and technological development of a concept, while innovation includes all the politics of its implementation. It is a process involving a dramatic and thorough change that opens up the range of opportunities and an organizational restructuring that allows the new product, concept or idea to bring about the desired transformation. The most challenging innovations address the long-established, capital-intensive infrastructures and practices and the urban energy field includes many of them (M.I.T., 1997).

Cities are huge, untapped reservoirs of ideas, enthusiasm, commitment and labor. They are places where creativity concentrates, since its only sources are human brains and hearts. From a new idea to its grafting into a mainstream policy, the birth, growth and death of an innovation depend on a city's creative assets and their mobilization towards meeting urban challenges. As nobody holds the monopoly on innovation, the recognition of the creativity of every individual actor and willingness to accept shared responsibility are essential. All approaches require vision, strategy and planning, concerted action and effective coalitions to build on radical change and incremental progress. Change is inevitable, the challenge is how best not simply to keep abreast of the change, but to drive it (BURA, 1997). Cities must harness the power of new technologies and social innovation to explore their "truly endless frontiers" (SAPOLSKY, 1995) and optimize their concentration of knowledge and information.

The knowledge-based, service-oriented economy may lead to digital cities experiencing a radical modification of the relationships between people and space. Many more cities and regions may be given the opportunity to become world players, but a global conglomeration can have strong central quarters and weak peripheral ones. Globalization may trigger a process of change which cannot be influenced by peripheral local communities but which can reshape them against their will. An increasing body of research suggests that the strengthening of the urban core may be the best way of rising to the challenges brought about by globalization, sustainability and social cohesion. It may provide a human face to global achievements. Cities are the political institutions most able to create new democratic spaces between the world economic macro-regulations and the micro-regulations of the local communities (MEGA, 1998).

An Odyssey in search of innovative energy projects for the improvement of the multifunctional and multicultural urban spaces and functions may be a journey to the cities of tomor-

row. The most successful projects are often the results of well-integrated approaches, combining environmental achievements with economic benefit and favoring social integration and local democracy (*Polyvation*s versus *Monovations*). Polyvation may lead to multiple dividends and can have lasting broad effects if invested in a true strategy. The incorporation of cleaner, renewable energies will only be achieved if an appropriate global planning is developed for urban areas. This will, in return, require a new local socio-economic environment in order to facilitate the penetration of new technologies in the market place.

Energy as a criterion of the resourceful city

Planetary and local ecological problems call for new policy formulae in cities, the principal perpetrators and main victims of global damage. Cities are dynamic ecosystems that underpin socio-economic and cultural activity. They have enormous ecological footprints, estimated after the evaluation and aggregation of the biophysical capacity of land surfaces needed to produce the necessary resources and to absorb the waste. London's ecological footprint is estimated to occupy an area 125 times larger than administrative London, even if assessment is limited to the consumption of food and forest products and the capacity to generate emissions of carbon dioxide. Its life has to be supported by an area equivalent to 94 percent of Britain's productive land (EEA, 1998).

Agenda 21 provided an international benchmark for urban performance. The preparation of Local Agendas for the 21st century created a global momentum for the analysis and the enhancement of the urban environment. European cities were among the first to adopt local plans 21 and energy is a fundamental field for action. All 288 Swedish local authorities had prepared local plans 21 by the time horizon set in Rio. In Finland, the Lahti Environmental Forum brought together all societal actors in order to boost sustainable development in the region. Commitment of each and everyone is a key concept. In France the Charter of Mulhouse is a model for improving the environment and public health.

An ecological city strives to become more competitive and offer a better quality of life, while incorporating environmental considerations into public and private decision making (OECD 1996). Urban ecology offers new visions to cities (RUEDA, 1995), which convert themselves into laboratories of ecological innovation, with high experimental value. Schwabach, Germany, offers an example of the efforts to implement an urban ecology planning strategy. The adopted driving principles highlighted that nothing is impossible and everybody has to participate. Energy actions are an important part of the 1993-2003 Model Urban Development Strategy, towards Schwabach Ecological City (SCHMIDT-EICHSTAEDT, 1993; WHO-OECD 1996).

Leicester was the first city to be awarded the status of Environment City in the UK. It is assisted by the "Business Sector Network" to bring together ideas from the city's commercial sector and provide assistance to businesses, while "Environ," a non-profit-making company, helps local organizations with environmental audits and advice (EFILWC, 1997). The "energy efficiency centre" promotes action for improving the efficiency standards for buildings and schools, introduces an energy education package for teachers and invites students to contribute to the energy monitoring of their schools. The "energy efficiency bus," equipped with solar panels and connected to the Internet, visits schools and enterprises to promote consciousness about renewable energy. "Energy passes" to optimize the energy conditions of houses is a common measure in the German *Länder* (*Energie-Cités*, 2001).

The energy balance of cities depends on the city and energy planning and policy, the urban infrastructures, transport patterns and citizen lifestyles. City structures and policies can contribute immensely towards minimizing the material and energy intensity of goods and services, reducing toxic dispersion, enhancing material re-use and maximizing the use of renewable resources. Sustainable urban policies should be carried out with respect to the carrying capacity and the equilibrium of the urban and sub-urban ecosystems and with regard to the availability and the distribution of resources. Energy flow analyses and impact monitoring are crucial instruments. Urban eco-auditing, with energy and environment balance sheets, provides assessments and forecasts. The balance sheet of Sundsvall, including the accounts of stocks and flows of environmental resources and the environmental auditing in Kirklees, offers a horizon of models and lessons at the forefront of current practice (EFILWC, 1997).

Sustainability appraisals, reporting and indicators may serve as compasses in the journey of urban sustainability. Urban indicators include series of environmental, social and economic indicators (EFILWC, 1998a; OECD, 2000) and their significance extends beyond what is directly obtained from observations. Energy consumption can serve as a yardstick for measuring the progress of cities towards sustainable development. Energy indicators are increasingly promoted to improve city management. They should be policy-significant, clear, simple, scientifically sound, verifiable and reproducible. Aggregate indexes, like the genuine savings indicator, may inform if a city becomes more or less sustainable. However, no indicator can inform if a city integrates socio-economic and environmental objectives in its overall development strategy (OECD, 1996).

Air pollution indicators developed for 45 European cities, with a total population of 80 million, show that 35 percent of the inhabitants are exposed to concentration levels that exceed the short-term air quality guidelines for SO_2 and/or winter smog conditions. An even higher percentage are exposed to ozone-related summer smog conditions. The primary source of pollution is the combustion of fossil fuel in energy generation, industrial processes and transport (EEA, 1997). During the last ten years, there has been significant success in reducing certain pollutants, through source control measures and abatement strategies. Lead concentrations dropped sharply. Sulphur dioxide and nitrogen dioxide have decreased; however, WHO guideline thresholds for sulphur dioxide, carbon monoxide, nitrogen oxides and particular matter are exceeded in a great number of European cities (EEA, 1998).

The dominant sources of atmospheric pollution in cities are shifting from the combustion of high sulphur fuels and industrial processes to motorized traffic and the combustion of gaseous fuels. In terms of EU NO_x emissions, the reduction accomplishments of the power generators have been counteracted by the increasing emissions from the growing transport sector. Nitrogen oxides, particularly nitrogen dioxide, are known to cause specific damage to lung tissues. Air pollution from traffic is expected to mark one of the most significant exceedances of the recommended threshold concentrations (EC, 1999c; EEA, 1997). Studies indicate that life expectancy in polluted urban areas in Poland and the Czech Republic is significantly lower than the average for these countries as a whole. In addition to its effects on human health, air pollution may also damage ecosystems, buildings and monuments (EEA, 1998).

Urban energy consumption has a critical contribution to global warming, which is partially the end product of millions of individual decisions made by citizens and businesses within their immediate environments (EC, 2000c). Emission patterns are influenced by long-lived investments in energy supply, transport infrastructure, housing and industrial installations. A

network of global-minded cities, the Alliance of European Cities for the Climate, brings together hundreds of cities dedicated to achieving a 50 percent reduction in CO_2 emissions by 2010 as compared to 1987. The Tokyo Metropolitan Government is committed to cutting carbon dioxide by 6 percent off 1990 levels by the target year 2010, substantially higher than the Kyoto targets for Japan. The Tokyo action plan to promote the creation of an "eco-society" includes comprehensive actions on resource management, water recycling, energy, transportation demand management and environmental education for citizens (UN-TOKYO METROPOLITAN GOVERNMENT, 1998).

Power supply is the single most important contributor to GHG emissions and it is expected to be so over the near future (EC, 2001a). Electricity consumption per capita in the EU increased by an average of 2 percent per annum between 1995 and 1998, in line with GDP, while total energy consumption increased at an average annual rate of 1.1 percent (EEA, 2001b). In 2000, electricity in the EU was generated from nuclear (35 percent), solid fuels (27 percent), oil (8 percent), natural gas (16 percent), hydro and other renewables (15 percent). Electricity production is predominantly centralized. An important change in energy supply could be the transition towards networks of smaller decentralized power plants nearer to the consumers. Micro-power is expected to develop gradually alongside the grids and increasingly use renewables or natural gas, reducing greenhouse gas emissions (DUNN, 2000).

Heating, and increasingly cooling, of buildings accounts for about one third of total consumption. Unlike electricity, heat production is predominantly decentralized, whether it takes the form of individual heating systems, or of dedicated heat stations with their associated networks. Combined heat and power (CHP) enhances "waste" energy from electricity production, while allowing for the environmental impacts from additional heat generation to be avoided. The generated heat can by used locally for district heating and industrial use. CHP and decentralized district heating are not a novelty for European cities. Saarbrücken installed its first district heating system in 1964. It now uses co-generation plants for almost all its electricity production. CHP systems accounted for 11 percent of electricity generation in the EU in 1998, 7 percent short of the indicative target of 18 percent by 2010 (EEA, 2001b, OECD, 2001b).

Promoting renewables and energy efficiency in buildings and urban spaces

The fast-growing use of renewable energies in cities is a positive signal and authorities are investigating ways to reduce their still prohibitive cost and open the path to their wider exploitation. The share of renewable energy in total consumption in the EU is 6 percent, despite a consistent annual growth of 30 percent, particularly for hydropower and biomass, and spectacular growth of more than 2,000 percent in the wind energy sector over the last ten years. The target is to double the share of renewables from 6 percent to 12 percent in 2010, with 22.1 percent of electricity produced from renewable sources in 2010 (EC, 1997c).

The EU now possesses over two thirds of the global wind-generated power capacity (12.8 GW of cumulative installed capacity in 2000, compared to 17.6 GW for the World). The annual wind energy installed capacity is 3,507 MW (3,763 for the World). Wind energy technologies develop very quickly. The average weight of wind turbines has halved in five years, the annual energy output per turbine has increased fourfold, and costs have decreased by a factor of ten in ten years. The average wind turbine size installed is now 900 kW, compared to 440 kW five years ago. Wind turbines of 3 MW and above are being developed. The price of wind-generated electricity continues to drop steadily. For several countries, where the market stimuli make wind power attractive, the main barrier is the difficulty of obtaining land use planning consent. Efficient urban frameworks are essential (IEA, 2001a).

Clean and environmentally friendly solar energy can be harnessed by using photovoltaics (PV), which generate electricity directly, and solar thermal collectors which convert sunlight into heat. Photovoltaics made of silicon, the most common element of the earth's crust and the basis of the global electronics industry, can convert radiation directly to electricity, through the intrinsic photo-effect, realized in layers of semiconductors. Cities become increasingly equipped with solar panels powering houses, streetlights, traffic lights, parking meters, billboards and advertising panels.

Freiburg is a pioneer city in the use of renewable energies. Bio-climatic architecture, enhancing physical parameters to the maximum, enabled the city to optimize its energy performance. Political and public support created favorable conditions for the city to be the center of two international renewable energy research institutes, the Oko-Institute and the Fraunhofer Institute. Solar water heating and photovoltaic systems were introduced long ago. The city has the oldest active solar demonstration house in Germany, built in 1978. The Freiburg utilities adopted a new tariff structure encouraging demand-side management and offering more favorable buy-back rates for photovoltaic energy. The latest developments include the first self-efficient energy house in Germany that uses only the sun as a source of energy and combines the most advanced solar and energy storage technologies. The virtuous circle of technical demonstration, awareness-raising and participation has been established, thanks to the commitment of the city and its citizens (MEGA, 1998).

The Kronsberg development in Hanover uses some of the latest energy technologies, while the city of Malmö invests in energy innovation. Barcelona provides a prime example in energy management. Energy efficiency in buildings has been the focus of integrated efforts. The Municipal Action Plan included the replacement of incandescent lighting by low-energy lighting, improvement of air-conditioning devices, installation of solar heat collectors in educational, office buildings and sport complexes and of photovoltaic panels in university and office buildings. A range of improvements was introduced to save energy in city buildings. These activities have brought savings of 1,700,000 kWh per year, translating into 243,500 Euros per year.

In terms of energy options, Barcelona has given priority to the promotion of thermal solar energy. The BARNAMIL project, conceived by the Barcelona City Council, has involved many local organizations and groups, together with the local energy agency BARNAGEL and the Catalan business association APERCA. The adoption of the Thermal Solar Municipal Ordinance, which encourages the installation of solar heat collectors in buildings, marked an important step forward. The ordinance defined the rules and conditions for the installation of solar collectors and addresses all new and renovated public and private buildings.

The city of Mataro, to the north of Barcelona, took advantage of the construction of a new library to experiment with photovoltaics and to create a prototype building to demonstrate that the use of solar energy is not only feasible but also profitable. A computerized monitoring system enables the photovoltaic installation to operate at 62 percent efficiency. The project has been well received by citizens and the city supports it through the dissemination of leaflets and brochures explaining the advantages of solar energy (*Energie-Cités*, 2001).

The "Aachen Model" for supporting renewable energy has gradually been implemented since 1994. Two feasibility studies had shown that overall wind energy potential was sufficient to cover 10-12 percent of the urban needs, while efficient solar panels on all the south-facing roofs could supply 55 percent of it. Owners of wind or photovoltaic equipment receive a guaranteed payment per kWh for 15-20 years. The overall cost is included in the cost calculations of the municipal power utility and it is passed on to all consumers. This resulted in only one increase in tariffs amounting to 0.005/kWh. The trans-border Aachen-Heerlen industrial park Avantis is an innovative CO_2-neutral experiment. Bioclimatic architecture principles were already taken into account at the design and construction phase of the buildings. A local piped-heating system is being set up to heat the buildings and a biogas plant is to be incorporated into the heat supply system. A photovoltaic facility is expected to be installed on the roof of the biogas plant and a wind farm, composed of nine large wind turbines of a capacity of 1.5MW each, is planned next to the industrial park (*Energie-Cités*, 2001).

Bio-energy sources, including organic, agricultural and forest residues, have the advantage of being versatile and used to generate electricity, heat, or transport fuel. In addition, the use of biomass as a fuel source could reduce the problem of waste storage and disposal. Urban waste is increasing in line with GDP and absorbs a large fraction of the municipal budgets. Bio-energy can transform a liability into an asset.

Buildings constitute the largest overall energy end-user, mainly for heating, lighting, appliances and equipment. They account for 45 percent of the total energy consumption in the EU. Increasing floor space per capita and higher levels of heating and cooling comfort for homes and offices constitute the main reasons for growing consumption. The urban built environment has a large potential for cost-effective energy savings. Energy efficiency measures include the retrofitting of older housing with double-glazing, insulated cladding or low-energy light bulbs and the introduction of an "energy pass" to optimize the energy conditions.

Measures to improve the energy performance of buildings are integrated in a common framework by a directive proposed recently by the European Commission. Buildings in Europe have a lifetime of 50 to more than 100 years. Given this low turnover, the largest potential for improving energy performance in the short term is in existing buildings. The directive suggests that harmonized measures throughout the EU are necessary for the development of integrated energy performance standards, which should be applied to new and existing buildings when renovated. Energy performance standards should lead to certification schemes presented to the public. Especially for public buildings, standards would recommend the optimal climatic conditions to be set for energy efficiency. Last but not least, the importance of the inspection of boilers and other heating and cooling systems is essential for energy efficiency. A global energy saving of 22 percent could be achieved by 2010 with these measures.

The certification schemes founded on the above methodology would be applied to buildings and dwellings when they are built, sold or rented. The specific inclusion with the rental of buildings could counteract any negative aspects of the different interests of the building owner and tenant. As owners are not responsible for the energy bills, they are often less motivated to improve the energy efficiency of the buildings, and are unlikely to invest in energy-saving features such as insulation. However, if tenants are authorized and exhorted to view the energy efficiency standards when choosing a property to rent, there are incentives for owners to invest in improvements.

Public buildings and privately owned buildings that are used by the public can act as pioneers and contribute to awareness-raising. Symbols are important, such as the buildings hosting the Danish and Dutch ministries of Environment. Effects can be enhanced by display of energy performance certificates and recommended optimal climatic conditions, e.g. the most favorable indoor temperatures in relation to the external conditions.

Towards a less unsustainable mobility

Urban transport is a major voracious energy field of attention and action (EC, 2001d). Mobility has long been regarded as a cardinal social value, a supreme symbol of freedom. However, fragmented decisions, in the presence of multiple externalities, created serious traffic problems that concentrate in place and time. Mobility patterns depend on both infrastructure supply and, increasingly complex and unsystematic, transport demand. Many metropolitan areas suffer from a vicious circle of road construction and further suburbanization. Commuting times show an extraordinary stability through time and experts suggest that there is an anthropologic constant in the form of a fixed time budget (EC, 1992a).

Energy consumption in the transport sector, depending almost entirely upon oil (98 percent of transport consumption, representing 67 percent of final oil demand), has increased steeply. The sector is the fastest-growing energy consumer in the European Union. Energy use increased by 47 percent since 1985 compared with 4 percent for the rest of the sectors. This is mainly due to the continuing growth of road transport, passenger and freight, while air transport is also increasing rapidly, due to the rise of leisure trips. The shares of rail and inland waterways transport are declining and modal split is deteriorating. Current price structures continue to favor private over public transport (EEA, 2001b).

Increased transport demand has largely outstripped gains from fuel efficiency and technological improvement. Even if fuel efficiency improvements in cars account for the deepest cuts in carbon emissions, growth in demand for transport seems to be a long-term obstacle to emission reduction. The automobile industry, under its voluntary agreement with the European Commission, has multiplied its efforts to reduce CO_2 emissions from passenger cars. Even if a reduction of 6 percent in emissions from new cars were achieved between 1995 and 1999, all three manufacturing associations (Europe, Japan and Korea) have to intensify their efforts in order to meet their longer term objectives.

Urban transport conditions vary widely among cities, both in terms of the demand and the degree of the response. The extraordinary rapid growth in the number of private cars, income-elastic goods, is the main factor of congestion in most cities. A "Car-Free City" could be composed of self-sufficient microcosms, fully accessible on foot from one end to the other, separated by green spaces and united by high-speed public transport. The car-free city seems to be not only ecologically efficient, but also even economically efficient, as it appears to be two to five times less costly, depending on population density (EC, 1992a). Decreasing dependence on private cars requires high quality public transport. Cities, aspiring to excellence, invest in highly performing underground systems, upgraded surface systems, silent tramways, intermodal transport linkages, car pooling and car-sharing schemes.

The human leg is the only truly sustainable transport means. A pedestrian-friendly city is more human. Copenhagen has been a pioneer city in recognizing the social value of pedestrian streets. Strøget, the first pedestrian scheme in the heart of a European capital, has successfully reached almost 40 years of age. The creation of new pedestrian paths was in tune with the downtown parking policy targeting the elimination

of 2-3 percent of parking spaces per year. With the improvement of the public system and enlargement of the bicycle network, more and more space has been taken away from traffic and given to people, who duly started returning to the center (RAUTSI, 1993). Amsterdam is the European city with the most elaborate bicycle network, complementing the road and canal routes. In Naples, places like Piazza de Plebiscito have rediscovered their former splendor after the removal of private cars. Although Venice remains the archetype of car-free cities, Basle and Zurich rate first in the world in terms of the number of trips per passenger by public transport per year. Bologna was the first European city to organize a referendum (1985) on the restriction of private cars in the city center.

Rapid, reliable, affordable, comfortable, flexible, easily accessible, noiseless and well-designed public transport is a precondition for persuading citizens to use fewer private cars (EF, 1995c). Examples at the leading edge include experiences from Swiss and German cities. Zurich is considered to have one of the best urban transport systems in Europe and the world. Electric and hybrid buses and filobuses are appearing on the urban landscape. Tramways are returning in European cities. Nantes, Grenoble and Strasbourg introduced from 1985 onwards three technological generations of tramway. In Germany, the concept of "short distances" is gaining ground. Heidelberg, Freiburg and Basle have been pioneers in introducing low-noise vehicles in noise protection districts and eco-tickets for public transport. Intelligent and effective inter-modal linkages are progressing. In La Rochelle, the multi-optional concept Autoplus has been introduced through a partnership between municipalities, the semi-public owners company for public transport, taxi owners, two private bus companies, one ship owner, one hotel and one bank (CFCC, 1994; MUNICIPALITY OF AMSTERDAM, 1994).

An OECD/ECMT research, building upon 18 national policy reviews, concluded that car dependency in cities could only be reduced by integrated approaches, combining measures reinforcing each other. Reducing energy consumption and traffic congestion and advancing towards better environments require a mix of pricing constraints and effective land-use planning. Integrated policies should aim at reducing the demand for travel, increasing accessibility, internalizing the cost of travel to reflect the burden on space and the impact on the environment and promoting attitudes and lifestyles consistent with environmental sustainability (OECD-ECMT, 1994). The introduction of road tolls is linked to the pricing of the use of infrastructures, according to the marginal cost for supplying the service. It is intended to bring equilibrium between transport supply and demand. From Seoul to Oslo experiences highlight the benefits in dealing with traffic congestion and raising funds for new transport infrastructure.

Promoting sustainable urban mobility requires a balanced portfolio of integrated measures. They include the promotion of lower-consumption vehicles and new propulsion technologies, improved collective and non-motorized modes, demand-management schemes, such as parking controls and access restrictions, information systems for better traffic management, integrated intermodal freight and passenger systems, fair and efficient pricing regimes and land-use and urban planning to minimize the need for transport. European initiatives include ELTIS (the European Local Transport Information Service) jointly funded by the EC and the International Union of Public Transport (UITP), the citizens' network benchmarking initiative and the European platform on mobility management. The EC-supported CIVITAS initiative launched in 2000 aims at introducing a radical strategy for Clean Urban Transport. Fourteen EU cities and 5 in the candidate countries have been selected to integrate their efforts in developing attractive alternatives in the use of private cars.

Biogas fuels give new opportunities to cities that strive to lower vehicle emissions. The inhabitants of Stockholm make four million daily trips, while $10x10^6$ tonnes of freight cross the city every year. Even if the modal split reveals that 55 percent of trips are made by public transport, 70 percent to 80 percent of air pollution is the result of motorized traffic. The municipality developed – in collaboration with other European cities – the project ZEUS (zero and low emission vehicles in urban society), partially funded by the EC Thermie programme. One of the ZEUS sub-projects is the introduction of vehicles fuelled by biogas, originated from recycled liquid organic waste. A pilot station for biogas production has been constructed and hybrid vehicles, fuelled by petrol and/or biogas, were gradually introduced. A fleet of 200 vehicles (lorries and private cars) has been the result of the cooperation among the municipal enterprise for waste water management, fuel companies and city infrastructure services. The transport of biogas to the filling station is ensured by a biogas-fuelled lorry (*Energie-Cités,* 2001).

Demonstrating Innovative Urban Transport measures to improve the environment and reduce energy consumption has been the objective of the JUPITER initiative and other targeted transport projects supported by the EC since 1993. Investments in advanced vehicle technology and clean fuels and the introduction of measures favoring environment-friendly forms of transport were the main elements of this initiative, the fruit of collaboration between the European Commission and a network of European cities. The JUPITER II project achieved a reduction in energy consumption of 20 percent and emissions of harmful air pollutants of between 16 percent and 25 percent. Modal shift has been particularly significant in most cities with a 12 percent increase in public transport and this could double through a more extensive implementation. A substantial reduction of over 4 percent in CO_2 and 20 percent in particulate emissions demonstrated the potential of the commercial mainstream of innovative energy-saving and the environment.

The car, oil and electricity industries around the world are all working to develop new low emission propulsion and generation technologies. Fuel cells, electrochemical devices that produce energy from hydrogen (or other fuels first transformed into hydrogen) and oxygen, much more environmentally friendly and efficiently than conventional combustion engines, are expected to mark the beginning of a new transport era. The modularity and cleanliness of fuel cells make them very attractive, even if they present a high cost of energy generation compared to conventional modes. The main breakthrough of the last years has been the radical reduction of the size of the fuel cells to run a car. It seems that costs in transport applications can be reduced by a factor of 50 and this brings a challenge for accelerated research and demonstration.

Particularly in buses, tests are being run in Munich and Erlangen in Germany, and this is expected to increase by a further ten European cities by 2002 (HART, 2001). Car manufacturers Ford, General Motors, DaimlerChrysler, Honda, Toyota expect to have a significant number of fuel-cell cars on the market by 2004. Developments such as the Californian zero-emission laws, which require 2 percent of vehicles sold to be electric battery of hydrogen fuel cell powered, may hasten the movement. The HyperCar or the hyper-green power car of the near future can bring a true revolution if linked to smart electronics and energy Internet (OECD, 2001b).

New districts as energy laboratories of the future

City planning can greatly influence energy and environmental performance. The New Charter of Athens, issued by the European Council of Town Planners, indicates a clear shift in

prevailing planning principles (ECTP, 1998). The 1933 Charter of Athens had introduced functionalistic principles in planning, demanding the separation of spaces for work, living, leisure and communication. Emphasis is now being placed in achieving sustainable human settlements for all, based on true involvement. The preference for the compact versus the diffuse city is constantly gaining ground. Most cities opt for renewal rather for expansion, for consolidation of the urban fabric and improvement of the suburbs. Concepts such as the "urban villages" suggest that settlements should grow by multiplication and not over-expansion of their vital cells, in order to promote interactions and yield diversity and dynamism. Functional coexistence and mixed land uses already govern many urban regeneration plans.

Sustainable regeneration and urban renaissance schemes are reinforcing the economic diversification, social heterogeneity and cultural diversity throughout a city. This may lead to huge energy savings, since urban sprawl represents disproportionately high levels of energy consumption, compared to the core parts of a city. Compact settlements imply a clear definition of the urban/rural boundary to discourage sprawling processes, regeneration of open and derelict spaces, functional diversification of land uses at the neighborhood level and the environmental improvement of the external sub-centers, well served by public transport and services. The Danish model of "decentralized concentration" highlights the importance of all these components, while the Dutch compact city policy is based on the principle of spatial multi-functionality, reflecting a need for "a little of a city throughout the city" (MEGA, 1997 and 1998). *Building Entopia* has become a sustainable planning aim (DOXIADIS, 1975).

Sustainable regeneration tries to inject new life into petrified spaces and transform idle city assets into sustainable resources and revenue generators . In Barcelona, the rehabilitation of the Ciutat Vella, comprising four quarters in the historic center, has been an unprecedented and unique event, in terms of dimension, time and civic commitment. Following the opening of the city towards the sea and the creation of the Villa Olimpica, the urban fabric is being progressively remodelled, with the injection of key improvements, through selective renovation, rehabilitation, construction, pedestrian paths and green spaces. Citizen centers have been created and have provided cultural references (EFILWC, 1997).

Unique events hold special chances. The Lisbon 1998 World Exhibition with the theme "The Oceans, an heritage for the future," offers a model. The city grasped this irreplaceable opportunity for redeveloping a significant stretch of the waterfront chosen as the location for the EXPO. A derelict urban area, which had played a role in the past life of the city but went into decline as its activities became obsolete and marginal, has been transformed into a site for innovation. The project was not confined to the exhibition precinct of 50 ha but aimed at creating a whole new resourceful city of 330 ha, to be completed by 2010. Prevailing winds and climatic conditions were exploited to the maximum. Advanced energy management concepts have been implemented from the initial stage. An eco-efficient distribution system for thermal energy, heat and cold, was set up, together with a system for observing and monitoring the results. The "terms of reference" increased the requirements for efficiency beyond the Portuguese thermal regulations (EC, 1998).

Industrial, technological and business parks have been created throughout Europe and many of them provided models, both of design and of public-private partnerships for turning deprived areas into healthy spaces of environmental and economic profit. Stockley Park, a former derelict area, within the green belt to the west of London, offers an inspiring example. A partnership between the developer, the local authority and the university created an international business park and public leisure land including recreational facilities. In exchange for the right to construct the business park over 36 ha, the developer guaranteed the reclamation of the whole site (140 ha), removal of groundwater pollution, environmental enhancement and landscaping. Local residents were involved in the process through extensive community consultation.

In Germany, the IBA Emscher Park has been an important pole for urban development and ecological renewal within the northern Ruhr district. It constitutes a unique "Best Practice" on a regional level for the ecological and economic renewal of a former industrial region, with the modernization of coal mining settlements, the creation of new housing, the development of fallow land and the promotion of attractive locations for industry and services. The preservation and re-use of industrial sites, the landscaping of the Emscher area into a park, the ecological restructuring of the river and the protection of the water environment are creating a healthy and productive space (IBA, 1999).

The conversion of waterfront areas, seaside and riversides for activities of the future is a major feature of several European cities, whose city-center ports have disappeared, leaving behind the husk of an infrastructure in search of a new face and function. The Salford Quays development on the Manchester Ship Canal came about through the will to turn a derelict space into an ultimate leisure area, respecting the environment and promoting culture. Disused dock buildings are being turned into exhibition halls, shops, craft workshops and cultural centers. The conversion of the former harbor area in Gothenburg transformed an abandoned area into a multifunctional city through a multiple partnership between the city, the architects, the former shipbuilding companies and the public. In Turku, the new cultural complex has been the result of the award-winning "Despina" project, which remodelled the waterfront after the closing-down of the shipyards.

Sound housing environments, the living cells, constitute the second most important factor of social integration, next only to fulfilling employment. Social and subsidized housing has often been remote, uniform, collective, reactive, anonymous, devoid of management and created tensions. In many cities, housing is now beginning to be intelligent and environment-friendly, self-regulated, personal, individualized, proactive, with corporate neighborhood space and responsive local management. Vibrant local communities are replacing void neighborhoods, after a radical rethinking of space and its social significance. Housing may provide a field of innovation and excellence for energy. The "solar village," created in the north of Athens, for low-income households, offers an example of an urban structure that intends to maximize the overall energy efficiency. Many cities introduce residential low-energy developments and sometimes entire environment-friendly neighborhoods. In Bremen and Zurich, some new residential quarters can accept only residents who accept to live without a private car. In Denmark, co-housing communities, each comprising 20-50 households, consist of individual houses, designed by their owners, and communal houses, workshops, playgrounds, organic gardens and wind turbines for the production of electricity (MEGA, 1998 and 1999b).

Enhancing socio-economic vitality and cultural energy of cities

Even in the most prosperous cities, there are spatial islands where economic deprivation, environmental degradation and social exclusion concentrate and reinforce each other. Rundown city centers and chaotic suburban zones are most often places of functional impoverishment, with insufficient equipment and facilities, lack of private investment, high unemploy-

ment, poor housing, low mobility, delinquency and crime, little access to information, education and entrepreneurship. The fragmentations of the urban fabric and the cumulative spiral leading to poverty and distress become an obstacle to the creation and distribution of urban wealth. Unequal sharing has draining effects on the vitality of urban activities and it is a source of both unsustainable lifestyles and obstacles to cultural change. Inequality must not be seen as the ransom to pay for success, but as an obstacle to sustainable prosperity. Solidarity is the cement of society and social justice is a precondition for advancing towards a good society, offering opportunities for a fulfilling life to all (GALBRAITH, 1996).

Fulfilling employment is considered to be the very first factor of social integration in cities. Energy may offer new opportunities for sound employment in cities and bring double dividends for the environment and the labor market. In the Netherlands, long-term unemployed were trained as energy-saving advisers (OECD, 1994). In Denmark, a program aimed at reducing energy consumption in heating by 30 percent would create thousands of permanent jobs. In Berlin, in Kreutzberg, unemployed young people, former squatters, were given the opportunity to own a residential block, if trained to become high level technicians in sustainable regeneration.

Many environmental charters and actions create needs for new skills and generate employment, especially in the field of eco-counselling and energy and waste management. The preparation of agendas 21 in the UK created many new jobs in local authorities. Renewal works are highly labor-intensive and provide opportunities for a wide variety of professional skills. A study on urban regeneration programs in Portugal shows that, for the same budgetary expenditure, twice as many people were on average employed for rehabilitation works as for new buildings. Residential energy improvements have proved to generate employment. A EU study highlights that 900,000 new jobs could be created by the renewable energy industry by 2001.

The creation of new enterprises is a central element in enhancing urban capabilities and small and medium-sized energy businesses may be important for producing local wealth. Many renewable energy generators are small enterprises with uncomplicated industrial relations, capable of a high degree of specialization. Clusters of highly performing and networking SMEs, able to compete in "niches" and specialized markets, may have an important potential for revitalizing territories. As well as providing competitive products and services while offering a variety of employment opportunities, the presence of SMEs also fosters the development of a diversified economic fabric, resistant to fluctuations. SMEs can spark the creation both of new energy services and produce positive ripple effects, by stimulating the development of subcontractors and auxiliary services.

Last but not least, cities, "objects of nature and subjects of culture" (Levi-Strauss), are high places of cultural energy. They have unique aesthetics and identity. The notions "Euroaesthetics" and "Euroculture" do not exist. Creating quintessentially urbane cities demands science and art and can only produce prototypes. Urban design and planning involve responsibility for the well-being of cities and citizens. It needs strong leaders, thoughtful citizens and enlightened private developers to deal with land management, the built environment and the historic identity.

Public spaces are "radioactive places," islands of social life in the archipelago of the city. Koolhaas called them fortresses of freedom, reconciling nature with culture and fostering democracy. Public spaces should be given priority and shaped as civic places, freeing, and not blocking urban energy. The unification of the archaeological spaces in Athens and their functional and aesthetic links to green spaces is expected to enrich the cultural capital of the city. The Manual of Public Spaces in Brussels offers a fine example in setting up qualitative recommendations for the functional, environmental, cultural and aesthetic character of the spaces, roads and pavements, roadside plantations and public lighting, forging cultural identity.

Cities are made from men able to grasp opportunities

> But cities are not made from their roofs, stone walls, bridges and canals, but from men able to grasp opportunities ...
>
> (Alcaeus, 7th century BC)

Governance is the art and science of co-governing societies with the participation of societal actors. An invigorating debate between governments and the constituencies they represent is everywhere in the making. Policy options cannot be based on artificial system management, but on the evolving dynamics and preferences of society. New civic contracts are being sought with civil society to increase public transparency and accountability, reduce the risk of inconsistent and ineffective policies and enhance capacity for reflection, decision and co-action. In the era of globalization, sustainability and cohesion, interactive communication can facilitate considerably the accessibility and credibility of public authorities and chart the way forward on closer citizen participation and co-operation. Energy is one of the domains where citizen participation is crucial.

Citizenship means participation. Citizens are the political stakeholders. They should be transformed from mere consumers into true actors (METROPOLIS, 1996). Residents, users of public infrastructure and energy services, may contribute decisively in creating a collective momentum of development (EF, 1998c; HEALEY, 1997). Partnerships may make the community more knowledgeable, help people to shape and control their localities and promote citizenship. Demonstration projects and media publicity should target the participation of the under-represented social groups and open the decision-making process. Projects ranging from the improvement of exceptional vernacular architecture to the tracing of new metro lines have been crowned with success thanks to the active participation of residents (EFILWC, 1997 and 1998c).

The move from government to governance is fundamental for social actors wishing to envision and build, individually and collectively, a better energy future, offering more opportunities for security, sustainability and equity. Developments in market liberalization, co-generation, new and renewable energy sources and decentralized distribution require the sharing of responsibilities, together with an adequate transfer of powers and resources.

The channels of representation and participation have to get enriched with new communication instruments and methods. Scenario workshops, bringing together different local groups, traditionally opposed, on "neutral grounds" and on "equal terms" can be precious for achieving consensus on future actions (IIUE, 1995). Action Planning weekends involve the organization of carefully structured collaborative events that bring together all local stakeholders on issues of great sensitivity. They can disagree intelligently among themselves and in a constructive civilized manner, but they may also find some points of anchorage. Other projects offer new opportunities to volunteers, not simply for exercising charity, but for investing in the common future. The charrette method inspires and teaches. It constitutes a highly transferable community-based design process that allows professional designers and community participants to present alternatives and influence projects (OECD, 1996).

The democratization of scientific expertise is judged essential in progressing towards good governance. Objective and incontestable expertise is increasingly required for a wide range of policy issues and different levels of governance in the European Union. It has to be robust and credible across a variety of scientific and policy cultures (EC, 2001e). Stimulating genuine citizen involvement and promoting informed and fruitful public debate need, however, much more action. An EC study on "democratizing expertise" suggests that the key issues are access to sound information and knowledge and transparency, accountability, effectiveness, early warning and foresight, independence and integrity, plurality and, last but not least, scientific excellence (EC, 2001c).

Knowledge has not only to be "scientifically robust," but also "socially acceptable." It has to be trans-disciplinary, multi-sectoral and pluri-cultural and get cross-fertilized through the active input of scientists, social experts and civil society. Greater integration in the governance of processes involving risks is fundamental in order to have wider and deeper interaction of expertise during the full cycle, including risk identification, assessment, evaluation, management and communication. This will enhance early warning, encompass plurality and promote an effective interface between risk assessment and management. Trust, transparency and accountability are key words. The "mutual trust," versus the "top-down and bottom-up" paradigms is gaining ground (EC, 2000e).

New governance models should pay particular attention to the citizens of the future. The "fifty-fifty" project in Hamburg involves all 423 schools of the city, committed to reducing energy and water consumption by 59 percent. In Finland, the "Children as Urban Planners" project in Kitee aims at educating active citizens in environmental awareness and responsibility for their built and natural environment. Eco-stations and science museums organize education programs targeting the younger populations. Hundreds of municipalities are creating "municipal councils of children" to promote civic awareness. New visions emerge, towards a human face for the cities of the future (WORLD BANK, 1995a).

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