TeMA

Journal of
Land Use, Mobility and Environment

This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled “Smart City: planning for energy, transportation and sustainability of urban systems”, held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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Special issue, June 2014

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SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

Special Issue, June 2014

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This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

TeMA
Journal of
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LOCAL SCIENTIFIC COMMITTEE

LOCAL ADMINISTRATIVE TEAM

TeMA Journal of Land Use, Mobility and Environment

EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time’s shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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Naples, 4-6 June 2014

ENTROPY AND THE CITY.

GHG EMISSIONS INVENTORY: A COMMON BASELINE FOR THE DESIGN OF URBAN AND INDUSTRIAL ECOLOGIES.

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ABSTRACT

From a thermodynamic point of view, the attribution of the adjective *sustainable* to an open system like the city is, at least, very problematic. The biosphere is a closed system, kept far from the thermodynamic equilibrium by the flow of energy coming from the sun. The biosphere maintains and increases its internal order dispersing entropy, generated by all the internal processes, as thermal infrared radiation. But then, the elegant picture of sustainability given by thermodynamics can not be applied to open systems, and notably to the city, without raising both theoretical and practical problems.

The city is almost by definition a place of consumption and of degradation of potentials, kept in local equilibrium by external flows of matter and energy, but at the same time plays a key role in shaping and maintaining the global flows of matter, energy, and information, and this role must be taken into account when interpreting thermodynamic-based descriptions.

The urban capital probably represents the greatest investment made by mankind. Materials have been harvested from the earth crust and from the natural systems, and have been concentrated and ordered in the city. But the "city" is not the infrastructure: it's concept of a different logical type. The city is a further level of organization that produces services of higher level. The urban infrastructure is necessary, but not sufficient to produce the city services.

The city is the most important social and health "device". A proper accounting must consider the city-performance of the urban infrastructure, beyond the mere, local energy and carbon efficiency.

In this context, local GHG accounting is proposed as a rather simple and useful basis to ground process-wise studies and projects, including the creation of effective local industrial ecologies, in a continuous city-making effort toward higher sustainability.

KEYWORDS

City, People wellbeing, urban capital, GHG accounting, carbon footprint, industrial ecology.

1 ENTROPY: WHY DO THINGS GET IN A MUDDLE?[1]

The most general, generic, and at the same time the most implacable sight that human knowledge can project over complex systems is given by the second law of thermodynamics. The general tendency toward disorder can be found in disparate classes of phenomena, always tracing the ultimate limit between what is possible, and what is not.

The very problem of sustainability rises from the existence of limits that are thermodynamic in their nature: if there is no potential for work, no exergy (i.e. available energy), natural or artificial systems cannot work (Wall and Gong 2001). From a thermodynamic point of view the entire, astonishing complexity of the biosphere, including the artificial systems, can be described as a closed system that maintains its internal order due to the flow of high quality energy coming form the surface of the sun (and due to the heat coming from the nucleus of the earth). The dynamic internal order of the biosphere, the homeostasis of its ecosystems, is maintained without violating the second law of thermodynamics because a continuous flow of disorder, of greater magnitude, is expelled as heat to the cold sink of outer space.

The history of the biosphere is indeed the evolutionary path of a closed system that, thanks to this perennial flows of exergy, have actually increased its internal order and complexity, from the establishment of global material cycles to the rise of biodiversity in an incredible variety of organisms, organized and mutually connected in ecosystems.

1.1 EXERGY, EMERGY AND OTHER "PROXY" DESCRIPTIONS

The most direct attempt of modeling and describing the thermodynamic behavior of ecosystems, including artificial ones like the city, has been conducted analyzing exergy2 flows.

Ecological modelers have tried to quantitatively describe the flows of energy and materials within ecosystems since decades. H.T. Odum, in particular, has pioneered the modeling of energy flows, extending progressively the sight from aquatic ecosystems to larger complexes and to the entire biosphere, including men's activities, urban systems and cities.

H.T. Odum haven't tackled entropy measures directly, but conscious of the intrinsic limits of an energy-based modeling, i.e. the necessity of including "quality" parameters beside energy quantities, has introduced the concept of Emergy. Emergy (or energy-memory) represents the amount of solar energy necessary to sustain a unit of a certain product, or flow. The solar input is the base value that is "concentrated" by natural systems in flows of higher value. Each material in a natural ecosystem has hence a different intensity or transformity, because higher quantities of solar input are necessary to produce it. For example: 1 joule of energy embedded in the acacia biomass is equivalent to 5540 sej (solar energy joules).

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[1] "Why do things get in a muddle?" is the title of a Gregory Bateson's *metalogue*, one of the most successful attempts to describe entropy in intuitive terms.

[2] In thermodynamics, Exergy is the energy that is available to be used. Exergy accounts for the irreversibility of a process due to increase in entropy and is always destroyed when a process involves a temperature change. This destruction is proportional to the entropy increase of the system together with its surroundings. Exergy analysis is performed in the industrial field to use energy more efficiently. In ecological modeling exergy is generally is represented as a sum of potentials, i.e. the existing distance from a reference state.

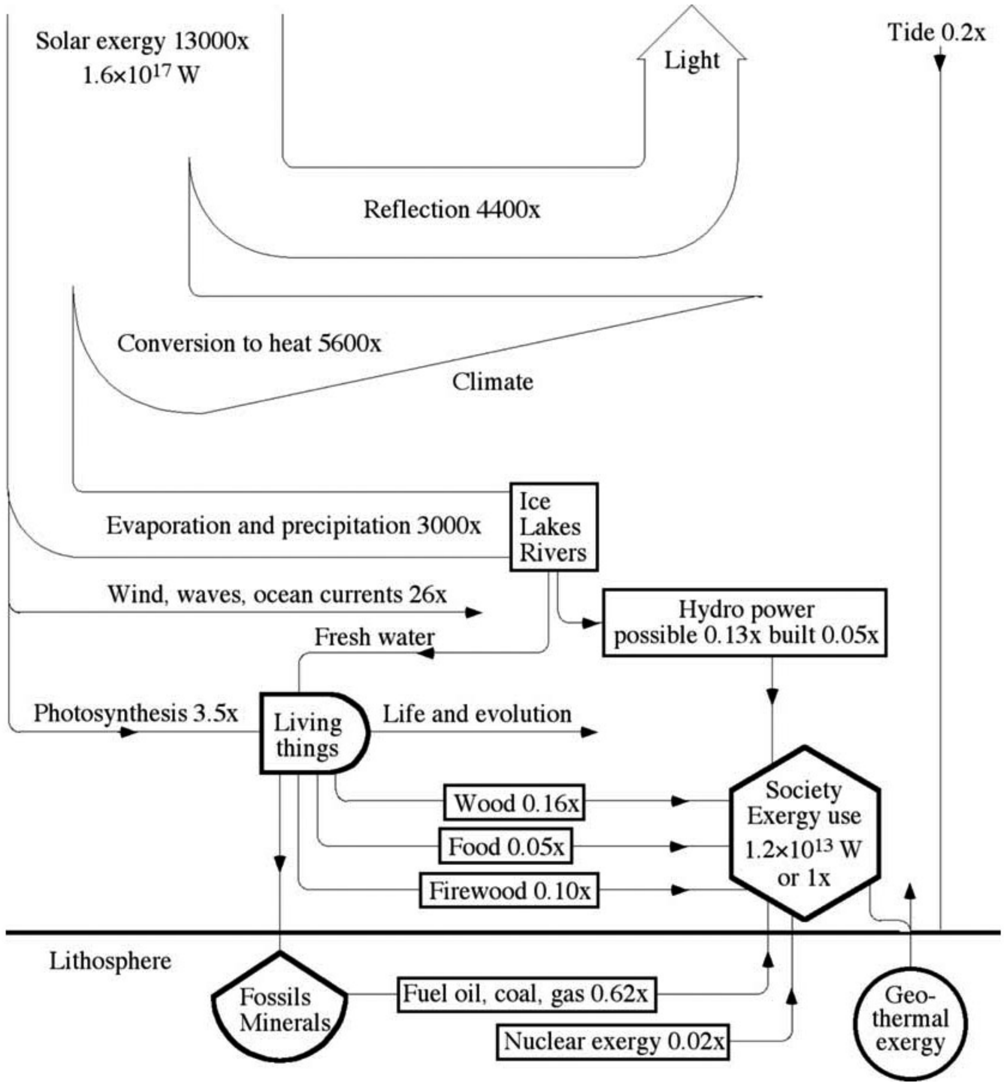

Fig. 1 Exergy flows on the earth, indicated with relation to the exergy flow input to the society -12 Terawatts - that is indicated 1 x. (Wall, Gong, 2001)

Emergy is a great concept for analyzing and understanding natural ecosystems, and has been applied also to the urban systems, specifically to quantify the Urban Capital, a concept of central importance for the topic here at stake. But for his foundational idea, i.e. that everything depends on solar input, the presence of relevant flows of materials from the geosphere, i.e. of substances structurally independent from sunlight, its accuracy and significance is severely limited in artificial systems.

The global quantitative scenario has been described in explicit terms of exergy only later (Wall and Gong 2001). A reference environment have been established to quantify the chemical potential of material flows in the biosphere (Szargut et al., 2005) and exergy has been applied for the ecological modeling introducing the genetic information potential, producing exergy conversion factors to be applied to living biomass (Jørgensen, 1992, 2004). Exergy modeling is very used worldwide in the field of ecological modeling for natural systems (cfr. Silow and Mokry, 2010) and a thoroughly comparison between the behavior and the meaning of exergy in technological and ecological systems has been proposed by the modeling school of Siena (Susani, 2006).

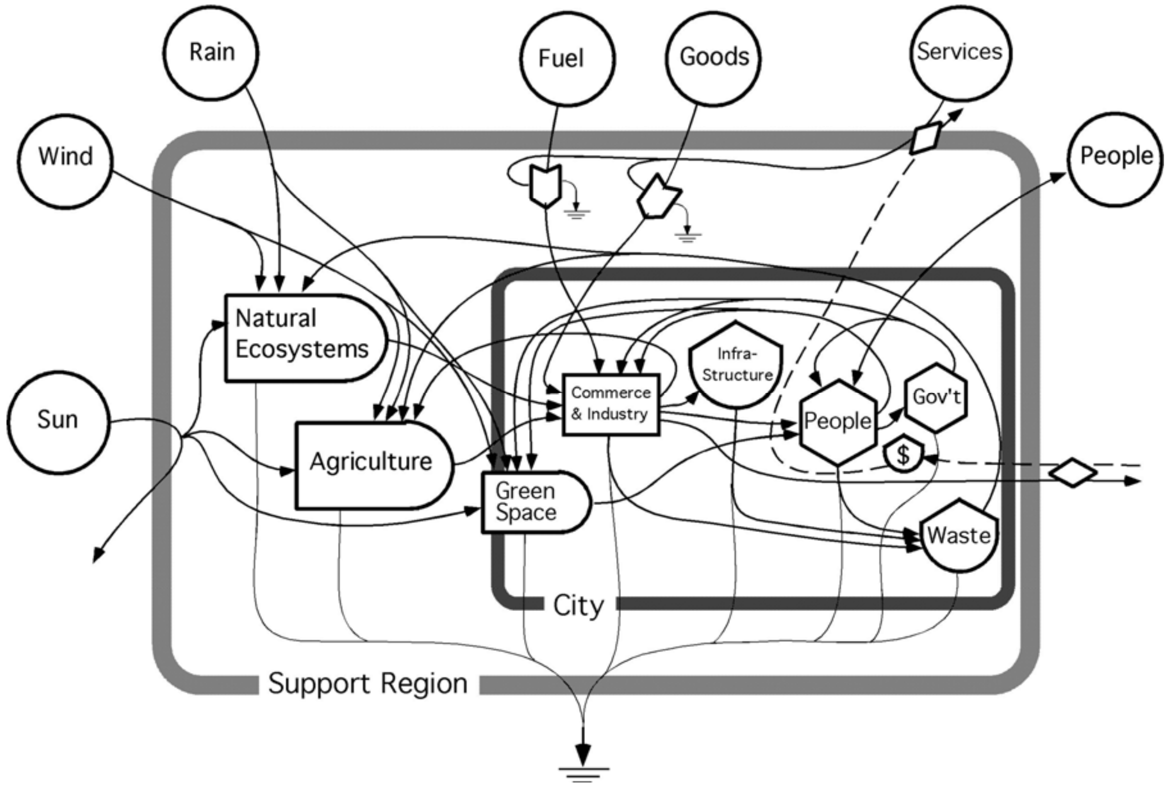

Fig. 2 A simplified, qualitative diagram of energy flows in the city and in the surrounding support region. The diagram uses the H.T Odum symbols to distinguish between sources, production, consumption, transformation and sinks. Money (dotted lines) typically flows in the opposite direction with respect to energy and materials flows. (Image created by Mark T. Brown, from Odum, 1996)

From the point of view of ecological disciplines exergy-based modeling of anthropic systems is of great interest, but it should be underlined that when applied to specific systems such as cities or metropolis also involves severe technical and practical issues, and that the resulting values must be always be considered with care and properly interpreted.

In measuring urbanized areas (i.e. cities, metropolis, megalopolis, etc.), besides exergy, other values and indicators seem to have a sufficient degree of generality to better figure – and therefore to be used as significant - useful proxies of the global thermodynamic picture of sustainability, e.g. emergy modeling (with the limits described above), but also other approaches like the ecological footprint and, more interestingly, the carbon footprint and greenhouse gases (GHG) inventories.

The relative relationships between exergy, emergy and CO2(e) accounting have been inquired and debated, and each indicator or approach has manifested both theoretical and practical limits, providing specific insights, while producing typical biases and errors, but it is interesting to observe that all these approaches share a common nature.

1.2 GREENHOUSE GASES, NATURAL CAPITAL AND URBAN CAPITAL

In the very general, thermodynamic picture of the biosphere sustainability, greenhouse gases (GHG) play a special role.

Sequestering carbon dioxide from the original atmosphere into the ground, the biosphere has dramatically incremented its thermodynamic efficiency. On the reverse path, putting back methane and carbon dioxide in the atmosphere, manmade emissions are making the earth more adiabatic, reducing the capability of the planet of expelling entropy, hence reducing the global carrying capacity.

The different level of organization between the original, primordial earth in its early stages, with its insulating atmosphere and radical simplicity, and the actual biosphere, represents the Natural Capital.
The generation of Natural Capital can be seen as the creation of order, of potentials that can be well described as exergy or emergy stocks, but the creation of higher complexity during the biological evolution is also reflected in the concentrations of GHG in the atmosphere.
GHG emissions inventories have become more and more central in the scientific community with the increasing evidence of manmade global warming and of climate change threats. The most important, massive effort in ecological modeling is today represented by the series of world-scale models presented in the IPCC assessment reports (FAR, 1990; SAR 1995; TAR 2001; AR4, 2007 and AR5, 2013). National GHG inventories have been established as well as standardized procedures for quantification and monitoring (e.g. the UNI-14064 standard). Each day new data are collected worldwide, and the pipelines for the harvest and management of GHG data are continuously enforced, with an increasing influence on the monetary economy through the establishment of carbon markets.
This global, enormous effort in establishing a control mechanism for the global thermodynamic balance, i.e. a feedback from GHG emissions into the economy, represents a very important opportunity also for urban planners, if (and only if) adequately understood and interpreted in the context of the city.
What is important to bear in mind is that GHG inventories represent a particular vision of a general, thermodynamic problem: the radiative forcing determined by GHG emissions represent a reduction of the capacity of the atmosphere to expel entropy, *hence influencing the efficiency of all the underlying processes*.

2 SUSTAINABILITY OF OPEN SYSTEMS: THE URBAN CAPITAL AND THE ROLE OF THE CITY

A tendency in using the GHG or carbon dioxide emissions as a “proxy” for measuring sustainability is already emerging. In a recent paper (Rybski et al, 2014) that made the headlines in some popular media, researchers from the Potsdam Institute for Climate Impact Research have analyzed emission inventories of 256 cities from 33 countries, looking for power-law correlations between emissions and size of the cities. The results apparently show that larger cities perform better than smaller in developing countries, in terms of emissions per-capita, while the opposite happens in developed countries. The results are quite interesting, but the approach and the same title of the study: “cities as nuclei of sustainability”, suggest the immediate opportunity of a very important, general caveat.
While the earth can be considered a closed system, exchanging only energy with the external sinks, cities are open systems, exchanging with the outer world flows of matter, energy, information, and this is more and more relevant in the contemporary, hyper-connected economy.
Thermodynamic-based approaches (i.e the GHG accounting and the entire family of proxy indicators described above) do represent a necessary, but radically not sufficient instrument to assess the sustainability of open systems. It is hence clear that the adjective “sustainable” can not and must not be applied to the city without adopting very special care: by definition the city is an open system, relying on energy flows coming from outside and not capable of dispersing the entropy generated by its internal processes without affecting the external ecosystems and the biosphere.

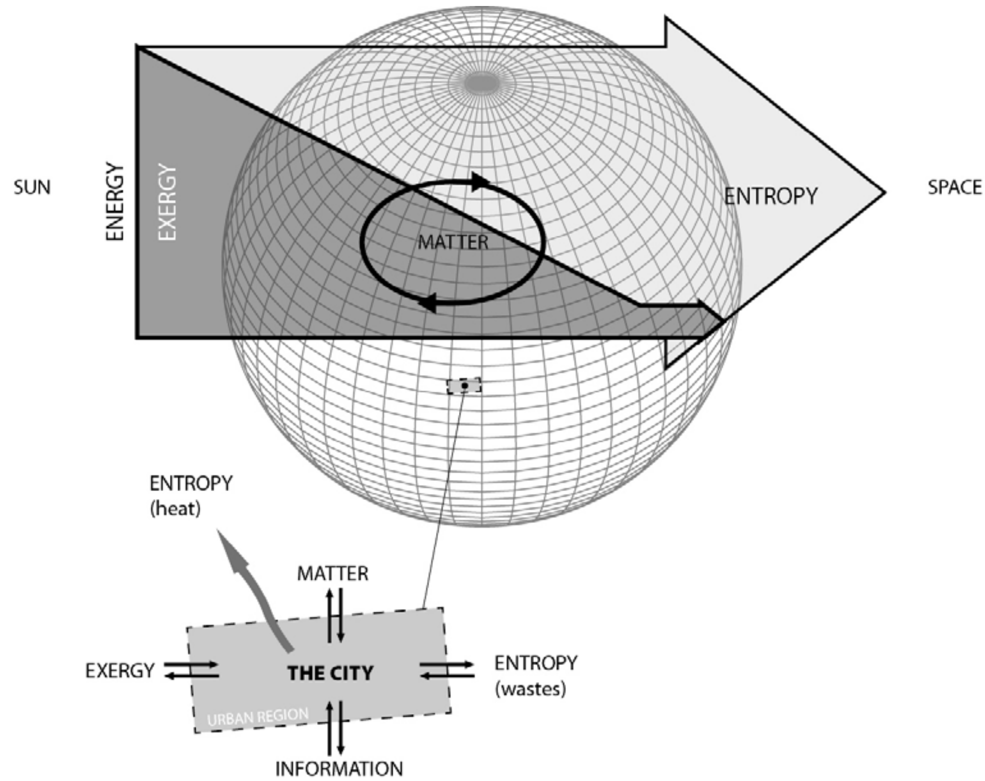

Fig. 3. The global energy balance and the local systems: energy is used to sustain the material cycles within the biosphere in a quasi/steady-state condition, but the sustainability of open systems cannot be univocally assessed. (Concept adapted from Wall, Gong, 2001)

This is a pretty simple observation, but we must consider that urban planners often use adjectives in a specific fashion, in their attempt to define, qualify, bound the object of their attention and their research. Using adjectives the city can be effectively characterized, in synthetic and meaningful expressions: the modern city, the medieval city, the ancient city and so on, immediately representing precise forms, complex morphologic characteristics or recurrent solutions. The deriving image can be considered stable and univocally defined in the literature. But it's not always so: adjectives of disparate nature have been used by urban planners and architects to characterize the city, the ideas becoming more and more vague and faint. The city has been defined as 'liquid', 'adopted'… and at the same time technical terms, with a well-defined pregnancy, suffer of a kind of abuse that makes them weak, if not quickly useless.

Talking about energy, ecology and climate change, the most abused adjectives are probably 'sustainable' and 'resilient', but many more have to be considered at risk.

It is of utmost importance, for the sake of the research and to permit real advancement in urban studies, to preserve the pregnancy of this words and concepts, avoiding misuse and misunderstandings.

In order to use and interpret GHG accounting results to produce real benefits in terms of knowledge and sustainability it is important to be aware of their nature. Hence, as first, it must be clear that GHG accounting, or energy efficiency measures of the kind, must not be 'sold' and marketed as measures of sustainability with an independent value. A zero emission profile is positive signal in general, but not sufficient per-se to assess sustainability.

A local system can have a local zero emissions profile simply importing goods from outside and exporting outside its wastes. Or, going in the even more subtle world of controls and informative feedbacks, a speculation capable to destroy an entire ecosystem, or economic sector, can be launched from a clean looking, green-washed, zero emissions company.

This doesn't mean that local emissions balances are irrelevant, and that it's impossible to talk about, or improve the sustainability of the city. On the contrary, it is possible and extremely important, especially in a more and more urbanized world, but ingenuities can produce dangerous diversions.

We suggest here some preliminary consideration, to be taken in account when dealing with cities' sustainability, with regard to energy, entropy and global sustainability.

- From materials accounting studies we know that the urban infrastructure represents the greatest investment made by mankind. Hence, a proper attention on the subject is of paramount importance. We must never forget the giant expenses we have already done to build the urban infrastructure and the city, namely: the urban capital we own.
- The "city" is not the infrastructure: it's a concept of different logical type. The city is a further level of organization that produces services of higher level. The urban infrastructure is necessary, but not sufficient to produce the city services.
- The city is the most important social and health "device". A proper accounting must consider the city-performance of the urban infrastructure, beyond the mere, local energy efficiency.
- In the rush of mankind to urbanization, in the fast growing giants like China, India, Brazil, as well as in the developing countries, an enormous quantity of entropy (in simpler terms, of carbon emissions) is being spent on building the urban infrastructure. But the city-effect is often poor.
- Looking at the European cities that are entering in a (more or less) steady state from a material flows perspective, we must properly consider the investment made in concentrating materials. The distribution of materials in the city is far more ordered than in the baseline of the earth crust (This means, for example, that urban-mining practices could be a fundamental path in the inner evolution of the city toward sustainability).

Indeed, the city effect achieved by the investments, i.e. the organizational quality of the urban infrastructure, the capacity of proper nurturing its citizens in all their human and social needs, appears a concept of paramount importance in the perspective of sustainability, also in the specific perspective of energy efficiency. Considering for example that has been calculated (Chung and Meltzer, 2007) that the health care accounts for 8% of US carbon footprint, it is clear that a city capable to suppress the demand, i.e. to reduce the need of hospitalization giving a healthier and stimulating environment, can make a huge difference in global emissions, that will never be apparent dealing with GHG inventories unless a specific reasoning, interpretation and project is put on the table.

On the other side, looking at the relationships of the city with the external region and the rest of the world, the role played by the city must always be considered. This means that it is always necessary to dig into the meaning of the quantities and the flows we are measuring, in order to understand if and how the expenses, i.e. the emissions intensity of a city, are justified by the role played by the city in the regional and general context.

Like for the entire class of thermodynamically based indicators, the main interest of the GHG emissions inventory lies in its generality, in the capability of being relatively independent from a great number of underlying processes. For this reason it represents an extremely useful sight that is necessary, even if never sufficient for assessing sustainability.

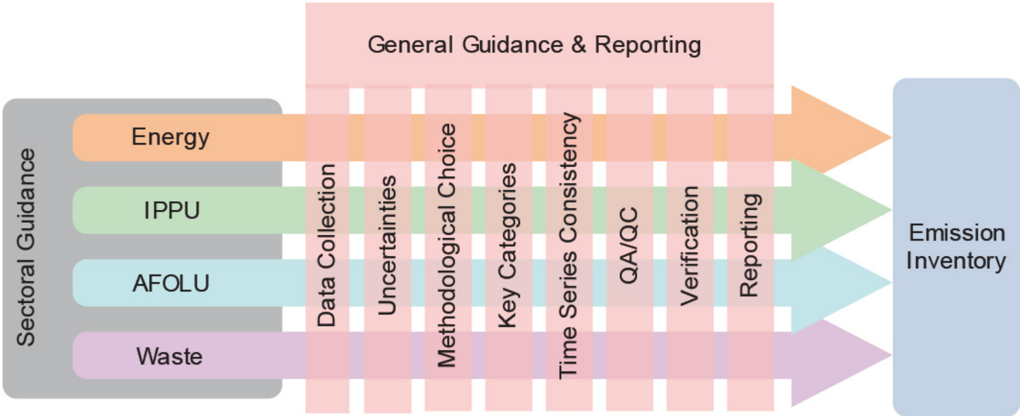

Fig. 4: a general diagram of the IPCC guidelines for GHG inventories. Four main sectors are considered: Energy, Industrial Process and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and waste. The acronym QA/QC is used for quality assurance, quality control and verification. (IPCC, 2006)

3 DEALING WITH THE CITY: GHG ACCOUNTING IN SUPPORT OF URBAN PLANNING AND POLICIES

The International Panel for Climate Change (IPCC) has defined the methodology and the guidelines for the creation of GHG inventories (IPCC, 2006), while the ISO 14064 standards provide governments, businesses, regions and other organizations with an integrated set of tools for programs aimed at measuring, quantifying and reducing greenhouse gas emissions.

Greenhouse Gas Inventories are conceived as complete estimates of the anthropogenic *annual* emissions and removals of greenhouse gases from a specific territory, developed source-by-source and sink-by-sink. Special care is devoted to the creation of consistent time series, in order to produce comparable results, and it is worth noting that the IPCC guidelines (including the emission factor database and the IPCC inventory software) have been originally prepared in support to the creation of national-level inventories.

At such a large scale, with strong external boundaries, the geographic principle (or production principle, i.e. the accounting of all the emissions related to the activities within the boundary) can be adopted as the main criterion, but the smaller the area under study, the more the intensity of the exchanges with the external area increase. For this reason the responsibility principle (or consumption principle, i.e the accounting of emissions generated outside the system, but related to the internal activities) can be considered.

One of the most recent experiences of the application of the methodology on sub-regional level, the REGES project of the Province of Siena (Ecodynamics Group, 2014), has for example adopted a mixed approach, creating two different scenarios for the attribution of the emissions generated by the forest products, while adopting a geographic approach for the attribution of emissions related to power consumption (considering at first the total use of local power production, and then the national mix).

The technical and methodological implications of the creation of GHG inventories at the urban scale have still to be examined in depth, and with regard to the different contexts: cities of different scale and with a different structure, with different densities etc. Particular attention should be given in defining the object of the study: as a matter of fact, from the planner perspective cities are often bigger than their administrative boundaries. In some cases they can be figured as megalopolis or metropolis (Gottman, 1970 OECD, 1997, OECD Territorial reviews, 2006) and others - such as Randstad-Holland, Öresund Regionen, United States Northeast Megaregion, Padanian LiMeS) - are Linear Metropolitan Systems (Soria y Mata's, 1970, Busi, 2007).

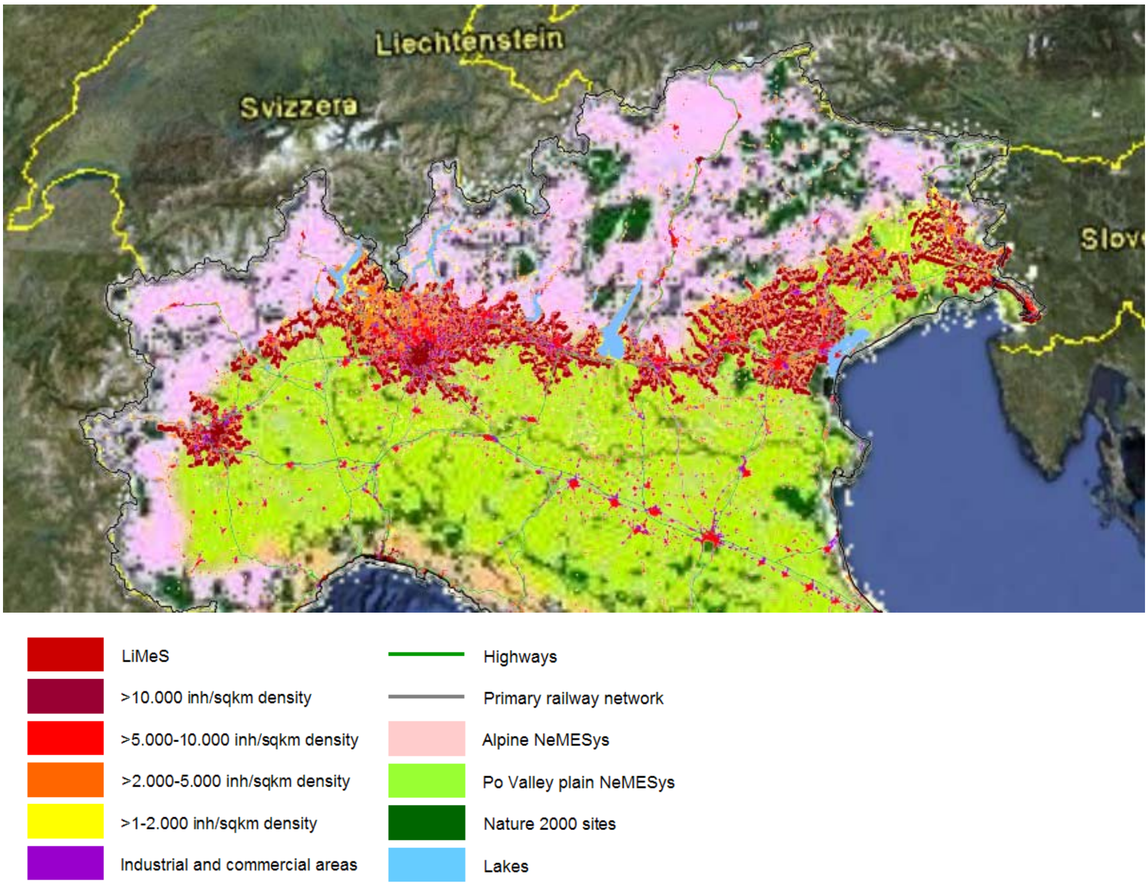

Fig. 5 : Po Valley LiMeS (i.e. Padanian LiMeS) has an approximately extension of 500km and a population of 16 million people: polycentric areas, which are characterised by the aggregation of a series of centres with partial non-specific dominance (Pezzagno, Docchio, 2010).

The perspectives, considering the results achievable at the *proper level* (mega-regional, regional or sub-regional) appear very promising.

GHG inventories permit a deep sight in the “metabolism” of the “local” system, maintaining a basis that is soundly consistent with global, national and regional inventories. Hence, not only local results are comparable, but just like the global balance is composed by national values, national inventories can be significantly mapped through the regional and local level, adding detail and resolving the granularity of smaller elements in the picture.

With the extensive adoption of the methodology, we can easily imagine each city, with its metabolism and its role, being consistently described in the general scenario, participating to the single, world-scale equation of GHG emissions[3].

In the case of linear metropolitan systems must be underlined that these polycentric conurbations are usually distinguished by a clear-cut morphological identity regarding the spatial distribution of activities (city-network) accompanied by flows of socio-economic integration of the main growth factors (employment, services, knowledge and social capital). In other words, they are urban centres and areas with intense demographic and productive activity, aligned along a specific axis, with a metropolitan system of relations.

This urban area constitutes the limit (*limes* means limit in Latin language) between two macro-areas characterized by specific environmental systems. These systems called NeMESys (Neighbouring Mega Ecological Systems) generally result to be deeply different from the LiMeS areas from a morphological,

[3] Because – let us pay tribute to the Naples famous De Curtis prince – «it’s the sum that makes the total».

environmental and landscape point of view and are different one from each other. In the Po Valley reality for example the first one is constituted by “the alpine and prealpine system”; the second one is constituted by “the Po Valley irrigated plain system”. As environmental areas, very low-anthropogenic-pressure levels characterize the lands that constitute NeMESys territories. In these territories we can find the majority of the minor deprived urban communities of Northern Italy. These communities are essentially rural and suffer from the lack of investments, infrastructures and facilities that are allocated/located in the high-anthropogenic-pressure areas which enormous and constant growth functions as a catalyst for the financial resources of administrative regions and provinces. The lack of resources especially occurs whenever one rural community does not have, within its territory, any specificity (i.e. special protected area or natural reservoir, etc.) that requires financing from national or regional administrations. In this case rural municipalities does not have the chance to plan their territories towards a sustainable growth and tend to loose population for the lack of features and resources and work that they offer. On the counterpart, if properly addressed, the push towards the sustainable development of these minor communities could be an opportunity for the preservation and the valorisation of a huge ecological system that could maintain the entire system balanced (LiMeS and NeMESys). This can be faced only with an appropriate knowledge level of the dynamics underlying the complexity of the system. At the same time the creation of consistent time series of GHG emissions annual inventories permits to define a sound baseline to monitor both the evolution of the city (LiMeS) under business-as-usual conditions and with respect to the introduction of specific policies or planning decisions (useful also for the NeMESys). A baseline that can be used both for the assessment of policies and actions in the “local” context and for the establishment of best practices to be adopted at the “global” (LiMeS and NeMESys) level.

Of course, not every action can produce a signal strong or clear enough to be read in GHG inventories, but this represents an interesting effect in the priority-setting, shifting the attention to the global context even when dealing with local choices.

In this perspective establishing an effective basis for a local *industrial ecology*, like in the decennial experience of Kalundborg Symbiosis and of many other recent experiences worldwide, will appear more appealing and visible. Creating the premises for a more efficient exchange of by-products and wastes between local enterprises can contribute at hugely reducing the emissions per GDP unit.

Using GHG emissions inventories at local level appears extremely promising in order to evaluate and monitor the effectiveness of instruments like the LEED certification, both at building scale and for neighborhood development policies, or to confront the results measured in the CASABEE-City experiences as BEE (Built Environment Efficiency) values[4].

Large capacity-building projects in the field of sustainable energy solution like the SPECIAL-EU could monitor the effectiveness of the adoption of policies by town planners on the basis of GHG inventories, but indeed, each significant intervention on the city: a new traffic line, a new logistic platform, a new class of transport vehicles, etc. could be read and properly *understood in its order of magnitude* with respect to the local context in terms of effects on the GHG inventory.

[4] CASBEE-City is developed by JSBC (Japan Sustainable Building Consortium) with the cooperation of the PCLCC (Promotion Council of Low Carbon Cities) as a comprehensive assessment tool on built environmental efficiency for city-wide scale that allows users to identify the performance of their city. As with other tools in the CASBEE family, CASBEE-City is also measured by BEE (Built Environment Efficiency) value. The performance of a city is calculated as BEE value.

4 CONCLUSION

The urban infrastructure represents the greatest investment made by mankind so far. Materials have been harvested from the earth crust and from the natural systems, and have been concentrated and ordered in the city. This creation of order has come at a cost: the generation of a flow of entropy, in part dispersed as thermal irradiation, in part absorbed by the biosphere itself, often at the cost of a dangerous degradation of local ecosystems, and depleting the fundamental chemical potential represented by the GHG gases sequestered from the atmosphere into the crust during billions of years.

Several thermodynamic-based approaches have been proposed to assess the weight of the urban infrastructure in the biosphere: exergy and emergy flows have been quantified, while materials accounting studies have produced significant pictures of the behavior and weight of material flows in the urban systems. Today, in the class of general, “thermodynamic” descriptions, the most affordable, concrete opportunity to define a significant baseline to represent and monitor the general performance of an urban system is probably represented by the mapping and inventory of GHG emissions.

Dealing with a complex, open system like the city, GHG mapping represent a necessary, but not sufficient instrument to assess sustainability.

At the same time, thermodynamic-based approaches and proxy indicators are extremely important for the study and the management of the city toward higher levels of sustainability. Just for their generality, their capability of producing values that are independent by the underlying processes, this kind of studies (and, specifically, the GHG accounting) represent the common ground necessary for an effective interdisciplinary discussion.

GHG accounting approaches do produce values that are not sufficient to determine the local system sustainability, and should never be interpreted as self-significant. This means also that a better performance of a local system in terms of reduction of carbon impact is generally desirable and while must never be considered as a strict goal function, can orient and give a common horizon to a vast class of policies and approaches in town planning and management practices.

Urban studies have to arise from the general picture defined by thermodynamic values and GHG accounting, and must then interpret the values in in a process-specific and evolutionary perspective.

Dealing with a necessarily trans-disciplinary sight, urban planners must in particular be aware of the “second level” services produced by the city, that can rise from the urban infrastructure only if the quality of the urban system is sufficient. This kind of services do span from social inclusion, to health, to the capability of producing a vibrant cultural environment (Consonni, 2008): they are indeed of key importance and a specific effort must be spent in order to quantify their role in the global equation of sustainability.

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IMAGES SOURCES

Fig. 1: Wall and Gong, 2001

Fig. 2: Image created by Mark T. Brown, from Odum, 1996. Distributed in Wikimedia.

Fig. 3: original picture, concept adapted by Wall, Gong 2001

Fig. 4: IPCC, 2006

Fig. 5: Docchio, Pezzagno, 2011

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