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There are a number of different future-city visions being developed around the world at the moment: one of them is Smart Cities: ICT and big data availability may contribute to better understand and plan the city, improving efficiency, equity and quality of life. But these visions of utopia need an urgent reality check: this is one of the future challenges that Smart Cities have to face.

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SMART CITIES CHALLENGES

SMART ENVIRONMENT FOR SUSTAINABLE RESOURCE MANAGEMENT

Vol.7 n.1 April 2014

print ISSN 1970-9889 e-ISSN 1970-9870
University of Naples Federico II

TeMA Journal of
Land Use, Mobility and Environment

SMART CITIES CHALLENGES:

SMART ENVIRONMENT

FOR SUSTAINABLE RESOURCE MANAGEMENT

1 (2014)

Published by
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"

TeMA is realised by CAB - Center for Libraries at “Federico II” University of Naples using Open Journal System

Editor-in-chief: Rocco Papa
print ISSN 1970-9889 | on line ISSN 1970-9870
Lycence: Cancelleria del Tribunale di Napoli, n° 6 of 29/01/2008

Editorial correspondence
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TeMA Journal of Land Use, Mobility and Environment

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Journal of
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TeMA 1 (2014) 29-42
print ISSN 1970-9889, e- ISSN 1970-9870
DOI: 10.6092/1970-9870/2267

review paper received 22 gennaio 2014, accepted 17 marzo 2014

www.tema.unina.it

NEW TECHNOLOGIES FOR SUSTAINABLE ENERGY

IN THE SMART CITY: THE WET THEORY

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ABSTRACT

The paper tries to develop a new approach to the sustainable planning for the smart city based on the assumption that the relationship between new technologies and urban system could be developed in a new way considering the WET theory. The WET theory starts from the main components for the establishment and the survival of the human settlements: Water, Energy and Technologies (WET). By considering this approach, technology could be envisaged as a switch element for the bifurcation that could be generated inside the process of management of the modern urban systems. On the one hand, technology can improve the use of renewable energies and it can promote a different way of using energy inside the city. On the other hand, technology can produce a huge structural work that can drive the urban system towards a worst dimension, by causing permanent change inside the territory as a whole, particularly at large scale. Starting from these considerations, the paper proposes a focus on the two mentioned possibilities, by considering the best dimension, represented by the DESERTEC project and the worst one prefigured by the South to North Water Diversion Project (SNWDP) that is going to start in China.

KEYWORDS:
Smart City, Urban Entropy, New Technologies, WET Theory.

TeMA
有关土地使用、交通和环境的杂志

TeMA 1 (2014) 29-42
print ISSN 1970-9889, e- ISSN 1970-9870
DOI: 10.6092/1970-9870/2267

review paper received 22 January 2014, accepted 17 March 2014

www.tema.unina.it

智能城市（SMART CITY）中的可持续能源新技术

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摘要

本文旨在为智能城市的可持续发展规划开发一种新方法，其基础是设想通过 WET 理论以一种新的方式在新技术和城市体系之间建立关系。

WET 理论源于人类居住区的建立和生存所必需的主要因素：水、能源和技术（WET）。通过考虑采用此方法，将技术视为能够打通现代城市体系管理进程中关键节点的转换因素。而且，技术还可以提高对可再生能源的利用，并在城市能源利用领域中开拓出一条与众不同的道路。但在另一方面，技术可带来大量的建筑施工，这会使城市体系朝向不利的一面发展，总之会在区域内造成大规模的永久性改变。

从这些考虑因素入手，本文将就上述两种可能进行着重阐述，以 DESERTEC 项目代表有利的一面，以在中国即将开始的南水北调工程（SNWDP）代表不利的一面。

关键词

智能城市；城市熵；新技术； WET 理论

1 TECHNOLOGY AND CITY

Technology represents a basic element in the process of building up the urban artefact. When man has felt the need to adapt the natural environment in order to establish human activities, he has used technology to do it. From sharp stone or primitive axe towards digital excavators or remote controlled crane.

The term technology is connected with the term technique. Nevertheless, with technological revolution we have been driven to consider technology, which identified the process and the study to transform materials into goods, with the product itself. Today the term "technology" is used to refer to ICT tools available. In a certain way it's so possible to identify technology with technique. Furthermore, it is possible to say that the term technique means all the actions, choices and behaviors that transform an object into a tool.

"Without technique the man would not exist and would not existed ever" (Ortega y Gasset 1933). It is important to preserve anyway the meaning of process, also mental, which is inside the word: "mechanic", definitely confirmed with word: "machine". The term: "mechanè" is already present inside the Omero's writings with the meaning of: gear, mechanism, but not only in a physical way, it can mean: reasoning cunning, trick as well. "The machine has been designed to get a certain result, born in order to get this goal and represents the materialization of a strategy useful to get a specific purpose" (Boncinelli 2006).

Starting from those assumptions it is very interesting to consider the city as a human artifact created just thanks to the technique/technology. If we consider the evolution of the technique related to the process of progressive transformation of the natural environment, made by man in order to survive to different natural threats, we will observe a curve growing from the proto-techniques toward the mature phase of technology (figure 1).

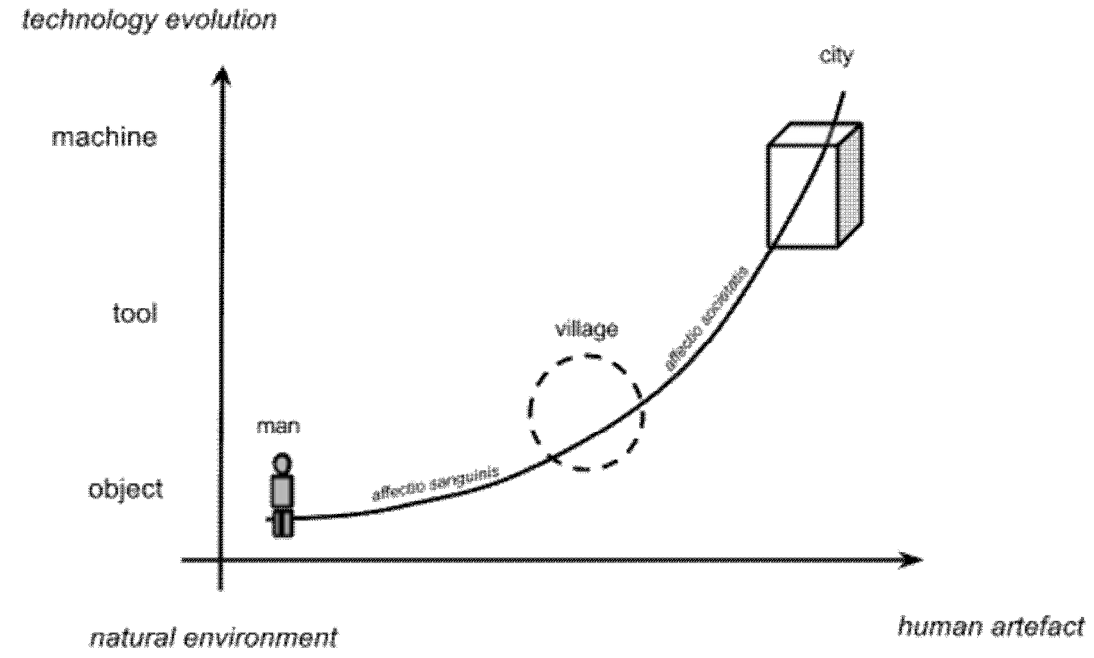

Fig. 1 The curve of the adapted space related to the evolution of technology and the development of the human settlement

City and technology have very close relationship since the first human action made to resist to natural events or produce a human settlement because of the changes and the evolution between the *affectio sanguinis* and the *affectio societatis*. Technology has to be considered like a fundamental factor inside the evolution process of the human beings. Thanks to technology, man can extend its senses in order to have a best perception of the environment. Thanks to technology, man can develop his capabilities to understand natural events, to carry on sciences development and to build a common space for more people.

Technology has to be intended as a basic factor of the human evolution. Today, technology has a new acceleration, which can separate it from the human evolution process. In the industrial revolution the machine was employed to support men in the production activities. In that period there was a total change in human settlements but technology was still inside the process. With the digital revolution, technology has gone beyond the human capability of using it, by producing a huge transformation in the human capabilities of relationship. If men don't understand that technology has to be adopted and not added up in the evolution process, there will be a wrong use of innovation and a distorted dimension of mankind.
The smart city has to consider the adoption of the ICT inside its process of development and not the addition of the technological equipment (like sensors) to the physical system of the city.
According to this approach, technology is one of the fundamental factor for the smart city as the WET theory tries to describe.

2 URBAN ENTROPY INSIDE THE SMART CITY

Considering the system approach to the interpretation of the city (Regulsky 1983) it is possible to say that the evolution of the urban system is closely connected with the evolution of its subsystems and mainly with the socio-anthropic ones (Gibson 1993). One of the problem that can cause a wrong development of the system is entropy. The urban entropy is intended like a negative condition of the system, which tends to move out itself from the management process, following distorted trends of development. The urban entropy is related to several factors: urban pollution, energy waste, the excessive production of waste, the increment of the conditions of vulnerability of sub-systems, the high social conflict, a high crime rate, etc.. These conditions may produce adverse effects and different kinds of discrepancies within the urban system, related to the improper use of available resources.
It is possible to say that a city is much more sustainable when the physical system and the functional one evolve with a compatible speed. In other words, the system has a dimension of urban sustainability when it saves the permanence of the functions in the historic sites of the city. The more the urban functions are moved away from the traditional sites of location, the less the urban sustainability improves.
The functional system represents the subsystem of great importance, but this should be considered in relation to the other subsystems: the physical (spaces and areas where the functions take place), the economic (represented by the processes that support the functioning of the city) and the social (composed by the individuals who populate the city and their interactions) (Papa 1992).
Considering this approach, it is possible to define policies for the governance of urban and territorial transformations by starting from the need to make the evolution of the system be compatible and sustainable. However, it should be immediately noted that, interpreting the city as a system within larger metasystems (including the Earth), and being the planet a closed system, the amount of entropy inevitably generated by the processes of transformation of energy (considering the second law of thermodynamics) is steadily increasing (Pulselli e Tiezzi 2008).
The cities, being energy-consuming systems (Fistola 2010), are the places where policies to reduce entropy should be implemented through appropriate actions of urban planning. Delving into the matter, it is possible to say that the first actions of a new territorial government are due to the entropic mitigation. The more we can control the urban entropy (which the system generates for its survival and evolution), the greater we can contain urban development into the expected range of trajectories within which the potentially positive states (i.e. sustainable and compatible with the available resources) are located. Reconsidering the graph showing the trend of urban evolution (figure 2), it is possible to identify the entropic areas, represented by the portions of space outside the expected range of the paths. When the system crosses into these areas, it means that the levels of entropy are dramatically high and an over-use of resources to bring back the system within the range of the expected trends is needed.

The entropic areas can be further subdivided according to the increasing entropy. The areas can be distinguished in two different kinds. The first one refers to reversible entropy areas, for which it is possible to recover the system tracing it back to the range of urban sustainability (by using a considerable amount of social, environmental and economic resources). The second one refers to unrecoverable entropy areas where the system goes to the "heat death" and the city suffers the structural collapse and the disintegration of the relationship among elements (Fistola 2012).

In order to give some examples of the above said assumptions, it can be supposed that inside the recoverable entropy area it is possible to place those cities in which entropy has been mainly produced by a "dominant" cause such as urban pollution, strong social conflicts, widespread urban hazard for natural causes, hydrogeological instability, and so on. The extra resources to be used for the "reconversion" of the system within the range of sustainability can be of energy, social financial nature and so on.

In a very marginal position and borderline in respect to the unrecoverable entropy area there are the urban contexts where, in the different subsystems, some entropic generations/productions take place, which act in synergy and entail the use of exceptional resources for reconversion through specific interventions. It is the case of the promulgation of special laws for those cities affected by a heavy structural crisis. Finally it will be said that the cities affected by the "heat death" are those exposed to a constant and very high entropic pressure or those hit by disasters that require evacuation. Indeed the case of Chernobyl is a striking example.

Starting from this idea, it is possible to say that the reversible entropic areas characterize the processes of "growth", while the range of sustainability includes the processes of "evolution" of the city. As for the concept of sustainable development, it must be recognized the impossibility of defining a condition of perfect sustainability (because any development process produces entropy), also within the range of expected trends the city produces entropy since it use resources (energy) for its evolution.

3 THE WET THEORY: A NEW GENERATIVE ENVIRONMENT FOR THE CITY

Thus entropy, considered as urban energy dissipation (derived from the available resources), is the element to mitigate in the will of orienting the urban system towards sustainability. As above-assumed, technology can play a vital role in this regard.

To consider the relationship between technology and energy within the city it is possible to refer to the "WET Theory". The WET theory can provide a useful scientific reference for managing territorial transformations since it reconsiders the essential resources for the urban evolution which, as for the primordial wet environments of our planet, allow the growth of vital systems. Water and energy represent the necessary conditions for the survival of the socio-anthropogenic and functional subsystems respectively and therefore able to ensure the subsistence of the urban system.

Technology ensures the progress and the advancement of the urban system by representing the key factor in the evolution. It is known from the theory of entropy applied to social systems (Rifkin 1992) and from other studies on the environmental impacts (produced by the anthropic presence) that technology acts as a transformer of energy and therefore as an entropy generator.

In particular, the equation "IPAT", (Chertow 2001) describes how the Impact can be correlated to factors such as Population Affluence and Technology.

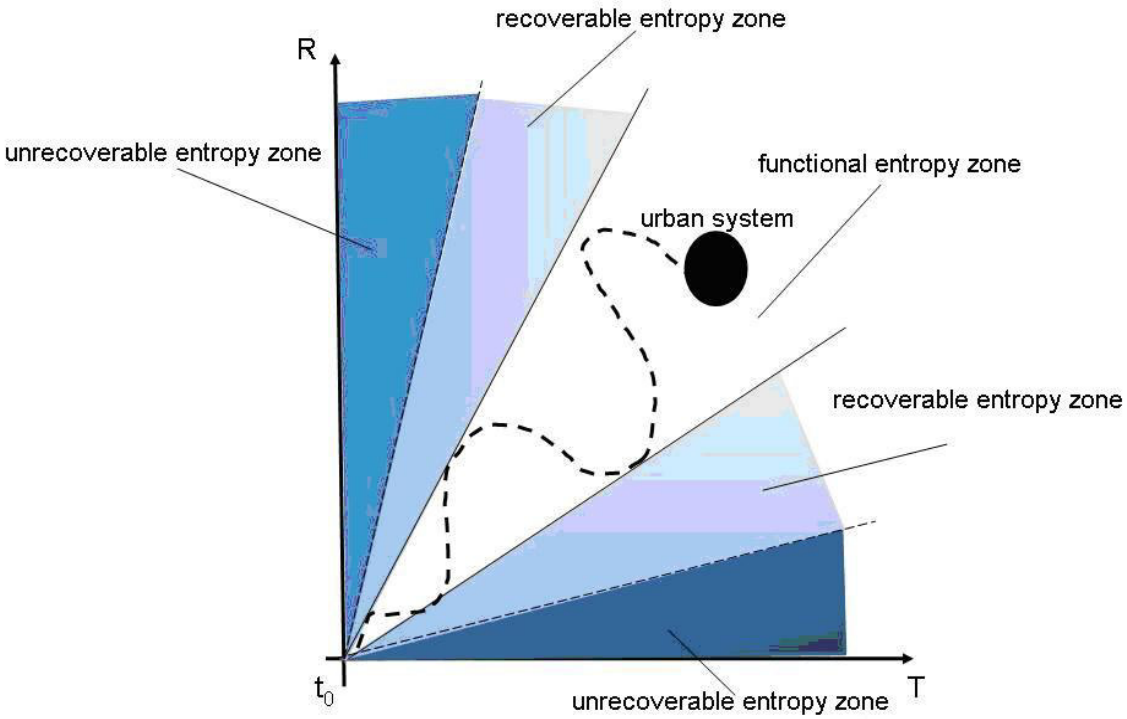

Fig. 2 The evolution trend of the urban system and the different entropy zones

Even from this equation, it can be assumed that the environmental impacts, which here can be considered like the systemic expression of entropy, are directly associated with the development of the elements of the urban subsystem (Commoner 1972).

Among the terms of the equation, technology seems to offer possibility to make an immediate and effective action to reduce impacts (Sachs 2008). It is clear that, the technology component seems to be the regulatory element on which it is possible to act immediately.

A first example can be provided by the processes of virtualization (Fistola and La Rocca 2001) which can be activated through the new technologies that effectively reduce the intensity of use of urban functions and also its land consumption.

This reflection could possibly lead to reconsider the "anti-technological" approaches in the field of urban science that for a long time have led to move away from the possibility of understanding and interpreting the processes of urban change, and have produced the consequent impossibility of defining new policies, in order to manage the evolution of the urban system.

Cities are the places of human survival, spaces for a new society and factories of knowledge, technology now pervades every relational, productive and economic process.

The smart city seems to be the closest urban scenario to which it is necessary to define the methods, the procedures and the policies for the government of the evolution of the urban system (Fistola 2013).

The use of the system logic in the paradigmatic definition of smart city allows to extend the idea of “smartness” by including also the metropolitan area and the landscape components.

In other words, maybe it is possible to consider also the “smart landscape”, which can refer to the setting up of the identity components of the extra-urban dimension capable of stopping territorial entropy and to drive the governance of transformations towards harmonic and balanced contexts, whose development could be always checked and compatible with the available resources of the system evolution.

The task of the new urban planning consists in proposing and implementing these processes by considering new approaches and new theories oriented to increase the social capital in the city and inspired by the sustainability and compatibility of the urban evolution.

The use of new technologies for building a complex territorial knowledge have to support the decision-makers in their choices.
Accordingly, for example, the GIS become the innovating environments of territorial knowledge development (Fistola 2009) and, combined with the remote sensing techniques, can help in building information complex scenarios for an effective support to transformation.
However, it should be considered that the use of technology could have a dual development in relation to the entropy production.
When technology is adopted to drive evolutionary urban processes (and it is used by considering the general principles of sustainability), it produces positive effects and it greatly reduces urban entropy. On the other hand, when technology is mainly used in relation to the need to foster and promote the process of economic growth of a specific region, it may trigger a significant number of negative externalities that can spread on contiguous territories and ecosystems. This possibility can be seen as a bifurcation that is generated on the curve that describes the evolution of sustainable urban system and it can usefully represent the proper, or improper, use of the technology (Figures 3).

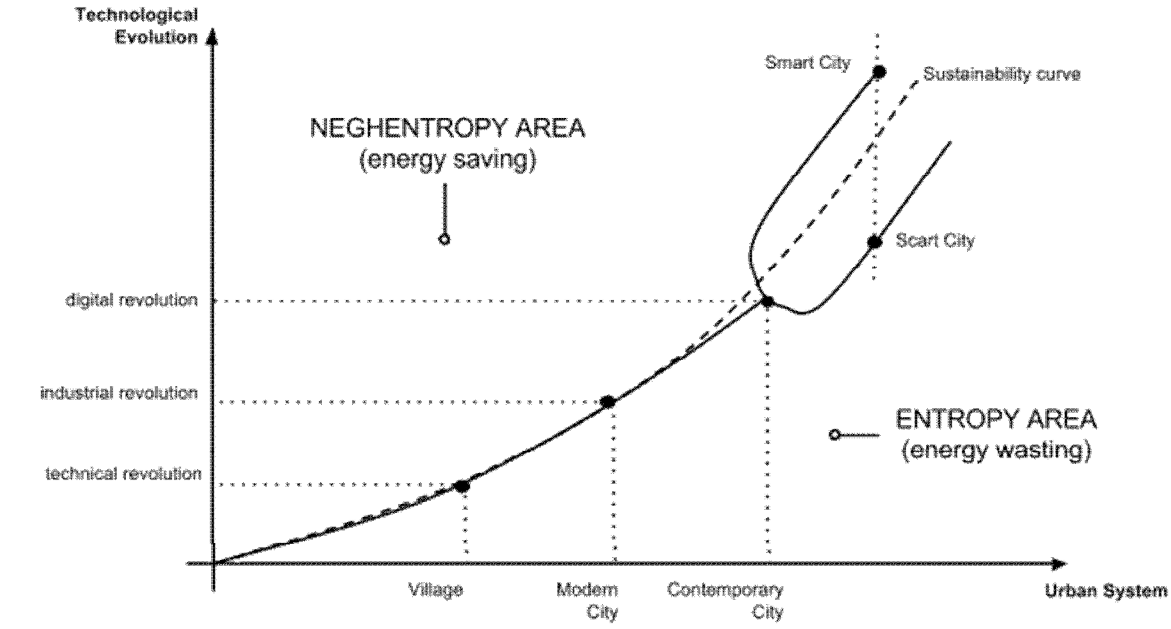

Fig. 3 The curve of sustainable evolution of the urban system and the bifurcation in the possible use of technology inside the city.

The proper use, described by the high branch of the bifurcation, allows a significant advancement of the city towards the sustainability dimension, increases the urban smartness (Fistola, 2013) and generates a reduction of entropy. The lower branch, instead, which is located below the curve of urban sustainability, leads the city towards a condition of entropic spread and continuous wasting of energy resources.
Then the two branches of the bifurcation can describe two potential conditions that the urban system can take according to the correct or incorrect use of technology: the smart city or the scart city.
The two mega-projects, described in the following, can represent this bifurcation, showing how the use of technology can drive an urban (territorial) system towards two opposite conditions.

4 THE ENTROPIC WAY: THE SOUTH TO NORTH WATER DIVERSION PROJECT IN CHINA

In China, since about a quarter of century, researchers and scientists, people and politicians have been discussing about the South to North Water Diversion Project (SNWDP), which is considered the greatest work of engineering infrastructure in the world, if it will be completed.

There are different opinions between those who believe that the project is essential to solve the water requirements of the northern countries and those who believe that the environmental and economic impacts will be higher than the benefits.

The project bases on the idea of diverging four principal rivers from south to north to supply the need for water in the northern developed regions. The northern part of China is historically characterized by water scarcity compared to the southern regions, also because it has been a center of population growth, industrial development and intensive agriculture for a long time. The idea was conceived by the former Chinese leader Mao Zedong in 1952. After fifty years of discussions and conflicts, it was approved by the Country's Cabinet, in December 2002.

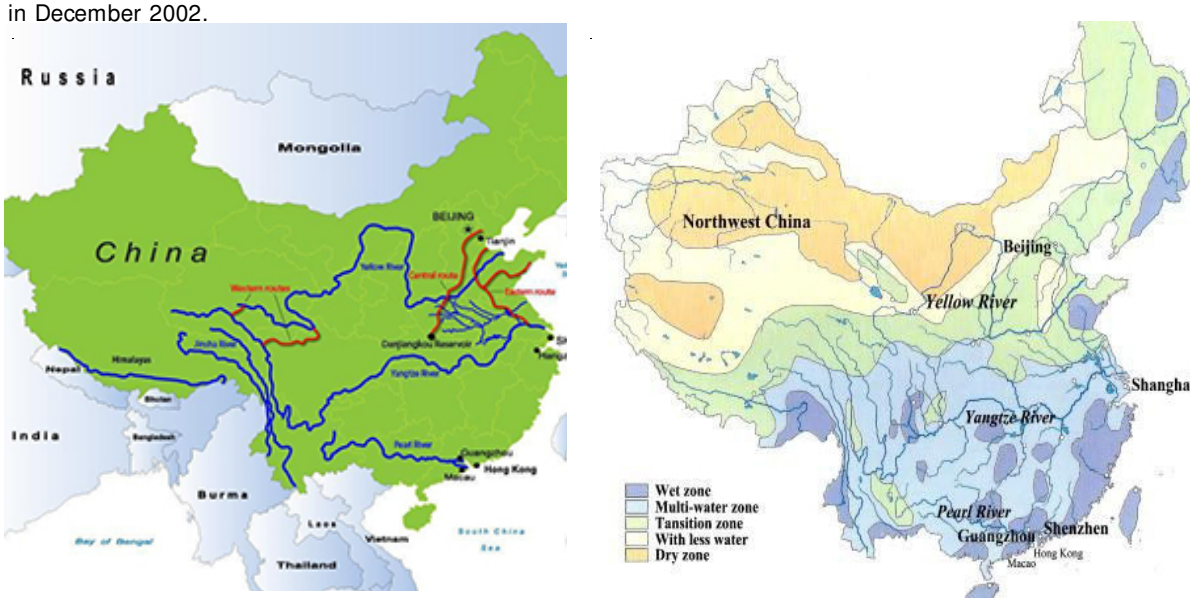

Fig. 4 Map of the South to North Water Diversion Project (left) and distribution of wet and dry zones in China (right))

The mega project has an estimate total cost of 62 billion of US dollars. In the government's opinion, the project is essential to guarantee the economic developing of the northern and western regions in the fastest way even though this vision is very controversial.

The project consists of three water-transferring routes -the Eastern Route, the Central Route and the West Route-, which will connect four rivers basins: the Yangtze River in the central China to the Hai, the Yellow and Huai Rivers in the north area. The eastern and central routes will be channeled under the Yellow River, while the western route entails pumping water over a part of the Himalayan mountain range.

The Eastern Route has started to be built since December 2002 and is expected to be finished in 2030. This route diverts water from the Yangtze River and is an upgrade of the ancient course of the Beijig-Hangzhou Grand Canal that was built to transport grain and other commodities to Beijing through the Jangsu, Anhui and Shandong provinces.

This part of the project is in an advanced state and through a tunnel under the Yellow River the water will reach Tianjin. The finished diversion will involve a complex system of pumping stations (23 total stations with a power capacity of 454 megawatts) to take about 1 billion m^3/year.

The Middle Route started in 2003 and was expected to be finished in 2010 but still now it is under construction. The northern stretch was finished in 2008 and its cost was about two billions of US dollars.

It doesn't takes water from rivers but from reservoirs in Hebei province, where farms and industries had to cut their consumes to let the water be diverted to Beijing and Tianjin.

One of the main problem occurred in the construction of this route has been the displacement of people living near the Danjiangkou Reservoir and along the canal. This created a lot of social conflicts and discontent both in people and scientists wondering about the real utility of the project, especially considering

the state of water pollution. It is very likely that the project will have no benefit at all, because it will not diverge any potable water.

The third route, called the Big Western Line, started in 2010. It has been scheduled to bring water from the major tributaries of the Yangtze (Tongtian, Yalong and Dadu rivers) to the northwest Chinese region.

For the water transfer project it is expected to build some pumping stations for lifting water, while some long tunnels will drive the water course through Bayankala Mountain. The whole project is expected to be completed in 2050 and it is clear by now that the initial cost has been underestimated.

Fig.5 Tunnel under the Yellow River

At present, this project raises many concerns. First of all the high levels of pollution in China affect also the quality of water and the opportunity to bring potable water through these three routes is very improbable. At that time it would have had to take 426 sewage treatment plants to bring water to Beijing.

The second issue regards the incapacity of the Chinese government to make appropriate decisions to solve the problem concerning the policy for coping for supplying water as well as for encouraging conservation and rationalized use of the resource. In this sense, the SNWDP seems to be the mean for Chinese government to rely on technologies to avoid making decisions.

5 THE SUSTAINABLE WAY: THE DESERTEC PROJECT, A NETWORK OF RENEWABLE ENERGY

DESERTEC seems to be the largest project to use renewable energies, even though it is quite far from getting large approval and consensus. Nevertheless, it can represent a positive example of using technologies potentiality in order to reduce impacts on the inevitable territorial transformation.

The project is based on the idea of taking renewable energies from countries where they are more available and abundant. This could be possible by means of a super smart grid using the high voltage direct current (HVDC) as method of transmission.

The DESERTEC concept considers to use all kinds of renewable sources of energy (wind, sun, water) leaving a central role to energy produced by sun in the desert regions of the world.

The Desertec Foundation official web site shows the principles for the individuation of the main sources inside the smart grid on which the project is based:

- Solar-Thermal Power (CSP) in desert regions;
- Wind power in coastal areas;
- Hydro power in mountainous regions;
- Photovoltaics in sunny areas;
- Biomass and Geothermal power where geographic conditions are favorable.

The Trans–Mediterranean Renewable Energy Cooperation (TREC), an international network of politicians, academics and economists that gave rise to the Desertec Foundation (DF), developed this concept in 2003. The Foundation's target regards the implementation of the project in the EUMENA (Europe, Middle East and North Africa) region.

In 2008, the first version of the Mediterranean Solar Plan of the Union for the Mediterranean (UfM), aimed at developing the renewable energy projects, was presented. The Foundation's studies, in fact, demonstrated that it could be possible to satisfy both the whole energy demand by the MENA (Middle East and North Africa) region and a part of the European demand by using a little part of the desert sun. The energy produced would be enough to feed the desalination plant for the potable water in the MENA region too.

The research developed during the recent years states that the MENA region could satisfy its own energy requirement and it could export the surplus considerably reducing CO_2 emissions by 80%. It has been also calculated that the savings for Europe would amount at about € 30 megawatts/h (Desert Power 2050).

But the real challenge of DESERTEC consists in realizing a global network of renewable energy connecting those countries where this energy is more easily produced. This means, first of all, to work on political convergence of all the involved countries because the net will overshoot borders.

It is a very hard target to get, if we consider the economic interests at stake. Probably related to these uncertainties, in 2009, the no profit Desertec Foundation started an industrial initiative -called Dii GmbH- aimed at implementing the project by assuring technological, political and economic conditions to its realization. The Desertec Principles, Criteria and Indicators (PCIs) were worked out in 2012. They are based on the idea of cooperation between regions and nation-states and affirm the necessity of a transition from fuel energy to green energy.

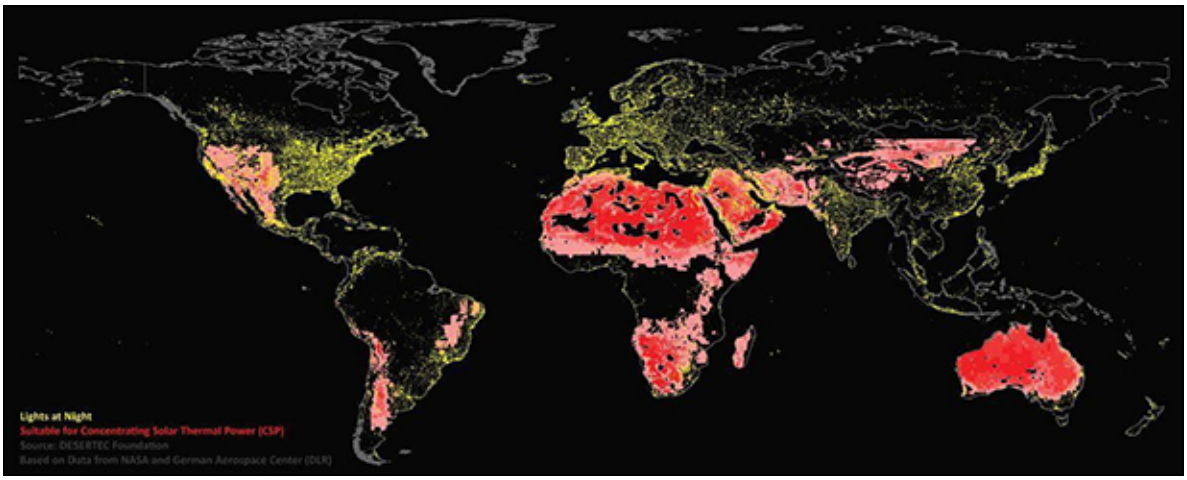

Fig. 6 Localization of deserted areas (red) and energy demand concentration (yellow)

The document points out five main principles for achieving the final goal of sustainability (environmental, economic, social):

1. Electricity from renewable resources,
2. Reliability of electricity supply,
3. Water use,
4. Socio-economic impact / Local benefits,
5. Environmental responsibility and conservation of natural resources and biodiversity.

Each principle is articulated into criteria and indicators to achieve sustainable levels.

The Desertec criteria are a work in progress that will be developed and transformed also according to the contribution of the actors involved. The Desertec-Dialogue, in fact, is the project promoted by the German Ministry of Foreign Affairs and is based on the definition of the criteria that are to be shared and accepted by local and external stakeholders involved in the realization of the energy plants.

The main objective consists in combining the legitimate interests of investors and companies with the important demand for a reasonable regional development. Following the vision of the Foundation, which is based on the collaboration between Europe and MENA regions, this dialogue project is also aimed to satisfy the demand for employment by creating new opportunities of working. It started in Morocco and Tunisia in autumn 2013.

The objective to create consensus both at local and at large scale is pursued by a network of regional skilled coordinators who are placed in each state. Their role consists in individuating the adequate conditions to spread out the DESERTEC vision also by involving local actors (no profit organizations, academics, private societies, etc.).

The implementation of the DESERTEC project is based also on scientific cooperation: in 2010, in fact, a University Network as a cultural platform to develop studies and research in energetic field was founded.

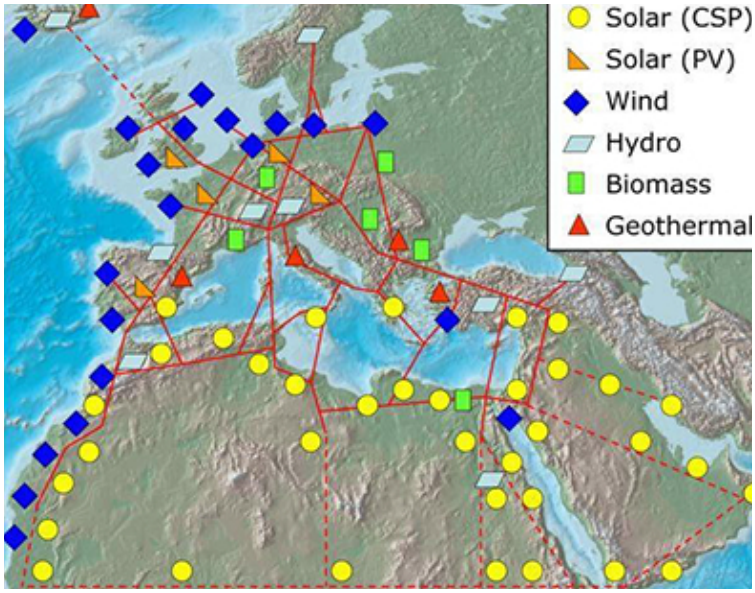

Fig. 7 The DESERTEC mega grid

The network consists of 18 universities from North Africa, the Middle East and from Europe engaged in promoting the knowledge transfer. Among its targets, the Universities Network also contributes to the education of skilled experts able to improve the production and the installation of alternative and renewable energy systems.

Some experimental projects have been started to test the DESERTEC theory on sustainability and clean energies. The first project has been the TuNur project. Begun in 2011, it was aimed at developing the first utility-scale solar export project between Tunisia and Europe. The project is worked out by a South-North partnership between a group of Tunisian investors (50%) and UK-based Nur Energie (50%). It is expected to induce about 20.000 new jobs and it will use dry-cooling systems to reduce water by 90%. And that will bring energy to Italy by 2016.

In Algeria, an ambitious national program was launched to promote energy efficiency. The program is targeted to install 12,000 MW of power and to generate capacity from renewables until 2030 to supply 40% of the domestic electricity demand and to allocate an additional 10,000 MW for export (Dii-Eumena, 2011).

In Morocco, an agreement has been signed between Dii and the Moroccan Agency for Solar Energy (MASEN)

to investigate the possibility to integrate African and European market in producing sustainable energies. The energy that will be produced will feed both the Moroccan and the Spanish network by 2016.
In 2011, the Desertec signed a Memorandum of Understanding (MoU) with Medgrid, the other meta-project launched in 2009 by the French government under the Mediterranean Solar Plan (MSP). This agreement showed an integrate vision, which is to connect the two projects by five interconnection and to create a single market of renewable energies. At present, the Desertec project has stopped and its possibility of realization are in discussion. As in the case of the SNWDP, it raises some concerns especially about its costs and its capacities of integrating different political interests.

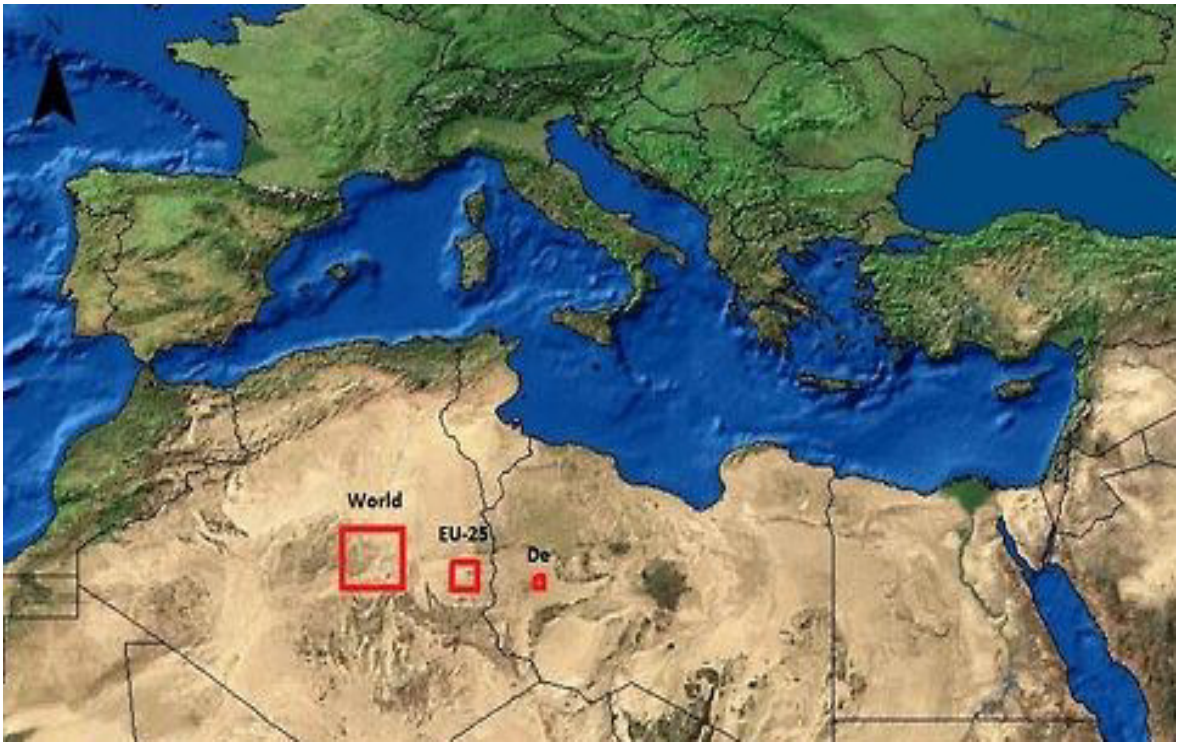

Fig. 8 The DESERTEC concept is based on the realization that a little part of the Sahara desert area could feed energy for Europe and the rest of the world

The project has also been considered as a new colonialism for being too much concentrate on the export of energy from the producing countries. It is surely a top-down process of change that probably will need a long time to be realized, but it well represents the case of adopting technology to drive evolutionary urban processes towards sustainability consumption of resources.
Although its limits, also due to the presence of important exponents of the world finance, the DESERTEC could represent an attempt to drive the inevitable change that we have to impose on our current lifestyle in terms of consumption of resources (La Rocca 2011). On the contrary, the SNWDP project represents an example of using technologies to realize mega-projects that could create deep differences of development within the same country. The negative effects that can affect the natural ecosystems and the contiguous regions will generate entropy and energy wasting. In this sense, it is possible to state that urban smartness, at the urban scale as well as at large scale, strongly depends on the use of technology.

6 CONCLUSION

The focus on the urban smartness (Fistola 2013) and the study about the relationship between urban smartness and the proper use of energy inside the city have mainly to deal with the concept of urban entropy. This new way to analyze the trend of the city seems to allow an alternative way to envisage the right or the wrong way to use technology for the evolution of the urban system.

Surely, technology speeds up the development process and permit the realization of mega-projects, but its use (proper or improper) can strongly affect the urban and territorial development in terms of livability and subsistence. As the paper tries to state, it is important to underline that in a condition of poor resources it is no possible to take the wrong way (of the bifurcation), because this way produces a very high increase in entropy and drives towards the heat death of the urban system.

The two examples considered show how everything seems to be achived by using technologies. The case of the Chinese project seems to lack a global vision regarding the effects that the mega-project could have on the economic and social development of the southern regions. The project target is so much concentrated on the necessity of assuring water to the capital region that it does not take in any account the negative effects this change could generate.

On the other hand, the DESERTEC shows how it is possible to optimize the use of the resources to get energy and how technology can be used also to soothe political conflicts among different countries involved. This could have a positive effect on the production of entropy inside the evolution process of territory.

The WET theory, which is at the first stage of its development, could be useful to point out, from a different point of view, the relationships between water, energy, technology and the urban system considering the technology as a key factor for the sustainable evolution of the city.

NOTES

Although the paper grounds on a common research work, paragraphs 1, 2, 3 has been written by R. Fistola and paragraphs 4, 5 by R.A. La Rocca. Conclusions are the result of joint reflection.

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Image on first page: "Urban Entropy" by James Enos http://www.wearethefrontier.com; Fig. 1-2-3 are from the authors; fig. 4-5 are from http://www.internationalrivers.org; fig. 6-7 are from http://www.desertec.org.

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