15th European Roundtable on Sustainable Consumption and Production
(15th ERSCP)
2012, May 2 – 4, Bregenz, Austria

Determination and Analysis of Factors Enabling the Development of an Eco-City

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Abstract

A sustainable city, or eco-city is a city designed with consideration of environmental impacts, inhabited by people and is dedicated to minimizing the requiring input energy, water and food waste, air pollution - CO_2, methane, and water pollution.
In recent years many cities around the world have invested hundreds of millions to develop new technologies that contribute to the overall transformation into eco-cities.
The creation of an eco-city requires strategy:
Diagnosis, adoption of specific objectives, intervention tools and rational methods. Assessing the effectiveness of the adopted strategy is an essential ingredient of the entire effort.
Ecoefficiency (economic and ecological) is a promising path for vision and commitment of cities willing to move towards sustainable development.
Ecoefficiency demands more and better with less impact on the environment. It is achieved by the delivery of competitively priced goods and services that satisfie quality of life, while progressively reducing resource intensity and ecological impact throught the life cycle. Energy intensity, material minimization, service intensity of goods, minimization of the toxic dispersion, enhancement of the life cycle and maximization of the use of renewable resources are key criteria for eco-efficiency.
This article introduces some significant environmental guidelines to the creation of an "eco-city" and examines their effectiveness. In the context of sustainable waste management, it is suggested sorting and recycling and their effectiveness is examined. These procedures are estimated to bring, except of economic benefits, significant benefits by reducing the environmental impacts resulting from the treatment and disposal and extend the value of raw materials, maximizing the value derived from their exploitation.
The use of photovoltaic systems utilizing solar energy is a viable strategy which contributes to the reduction of both private and municipal costs and minimizes the environmental impacts.
A case study in the Municipality of Nafpaktos illustrated the effectiveness of the above.

1. Introduction

An eco-city is a human settlement which is modeled on resistant structure and functioning of natural ecosystems. The city offers abundance to its inhabitants without consuming more resources than those produced ,without producing more waste than they can digest and without being toxic to the same or adjacent ecosystems (Register 2006)
These ecological habits of the inhabitants of this city show a way of life that supports the survival of the planet, while its social class reflects the fundamental principles of equality, justice and reasoning. The main purpose of this report is to examine within conceptual frameworks and methodologies available to integrate eco-efficiency and criteria in the design of infrastructure and development processes for the creation of such a city.
This is done in order to propose a theoretical framework and give indications which can be used for building eco-efficient and sustainable infrastructure. In this study, strategies for policy and planning methodology for the proper assessment of ecological efficiency of urban infrastructure are proposed in a comprehensive way, and the appropriate strategies and policies to achieve this aim are also presented. Several conceptual methodologies and pointers related to viable "green" residential development will be proposed and then there will be an economic assessment followed by an examination of frameworks and methodologies for an economically and ecologically efficient infrastructure. Finally, a series of main findings and recommendations will be included on the final piece of this study.

2. Strategies for Building a "Green City"

A range of different strategies have been developed for a sustainable approach to the design of a "green city". Selected strategies are included in the next piece of research and reflect useful and important sources of sufficient information that concern the process of planning a "green city".

2.1. The Model of Environmental Management

The planning units dealing with the city that in turn consist of smaller units such as building, roads or even parts of a larger system is composed of districts, cities, metropolitan areas, villages, regions and countries (Downtown 2009). Each level of this system can be programmed individually but also more aggregated with a sustainable design perspective. These aspects should always include specific links to the next level up and down, as none of these units can act as unified, independent entities. All these must work together as a part of a wider network in order to achieve an overall environmental management. Every element of the urban system requires the creation of input and output either of goods, services, information, water or even air and energy (Yeang 2009). These flows, the human movement which is caused by human needs and desires and also economic activity, almost always cross the boundaries between different ecosystems and spatial organizations. For example goods move from country to country or travel from city to city. The purpose of model environmental management is to mitigate these movements to a minimum. Specifically, three major points of the model environmental management are distinguished:

1. All the results of flow should not be negative. This depends mainly on the system and the process through which they move (Nelson 2008). For example, if a house uses

photovoltaic cells on its roof and some of the electricity produced, which is not required for its operation, goes back to the main network can be assumed as a positive development.

2. It is not possible for most of the systems to completely avoid inflows or outflows, particurarly due to the fact that the design also has to do with the structures and designs that already exist and are not starting from scratch (Register 2006). The guiding principle should be to find the sources and the control of such flows to the next level. For example, a building should not take more than one source of energy if it cannot be energetically independent and a city must take fruits and vegetables mainly from the surrounding area.

3. Not all the effects of these flows are negative or problematic and generally not all possible problems can be solved. The more troubled is the result of flow the more effort must be made to avoid it or get a limited amount (Register 2006). This decision must be taken individually and to always target to the best solution from the aspect of environmental and human health.

2.2. The three-step strategy

Keeping in mind the three points listed in the previous paragraph, the following three-step strategy helps to give priority to the measures to be taken according to their effectiveness to achieve viability of the whole project. More specifically strategies that can be useful for all types of flows can be used such as energy, water or building materials that move through an ecosystem, speaking either for a building, an apartment or even a city. According to Yeang (2009) they can also be used in transport planning and land use.
Step one: Avoiding unnecessary use and waste prevention. If we can not do this, we go to the next step.
Step two: Use of resources and sustainable reuse of waste. If we can not do this, we go to the next step.
Step three: We use limited resources wisely and we make deal with waste. By applying this strategy we can see for example that it is better to insulate a building well (step1) than installing high efficiency heating (step 3) in insulated building. Also it is better to use again rubble from a demolished building, for example in the construction of a road (step 2) instead of crushing and replacing or burying them somewhere else (step 3). In order to achieve a sustainable vision for each sector, the measures related to the three steps are necessary and should be integrated into an optimized system.
Summarizing, we can say that the complexity process of planning an “eco-city” requires a full approach in order to be successful. The first step of this planning process is the agreement on the solutions to be achieved in order to realise this vision and transform the urban development into an “eco-city”. Main issues to be considered for the design of the urban model are its individual points, as suggested by Nelson (2008):

1. Location and incorporation of a polycentric urban system of public transport.

2. The form of settlements: design of a compact community made with the central axis of pedestrians, being oriented for mixed use and specific density which will include attractively designed public spaces built with green.

3. Infrastructure of transport: design from the bottom up, firstly for non-motorized transport, then for public transportation and finally for private motorized transport.

4. Energy systerms: solar orientation of buildings with minimal energy losses with priority in renewable energy sources for energy supply.

Having examined the existing strategies and theories surrounding the design of a "green city", an analysis of economic and ecological effectiveness of a "green city" as well as the factors affecting it, follows.

3. The Economic and Environmental Effectiveness

The concept of economic and ecological effectiveness includes decoupling of economic growth from environmental pressures and that is important in order to achieve a strategy shift towards more sustainable forms of infrastructure and projects. This is particularly important in this situation, when many cities need development and expansion of infrastructure in order to meet their rapid urbanization. The estimation of current eco-efficiency of this city 's infrastructures is the first step of analysis. As mentioned by Liedtke (2004), whether and how a city 's resources related with the desired value to society and their adverse effects are used, determines the course to take. The indicators of achievement are expressed as the proportion between the value of a service of goods and the environment which they affect (DeSimone and Popoff 2000). A measure of the value that they provide to the city could be purely monetary. For example when talking about transport, it could be the miles per passenger. In this case, the carbon intensity will be measured using CO2 per Euro as an impact in town, CO2 per passenger per mile for transport and CO2 per square meter for building units.
Analyzing the example above, significant conclusions which indicate where we should focus and why, can be made. If we see that because of many kilometres per passenger, a big amount of CO2 waste exists, such actions could promote for example the use of public transport. The main problem however is that environmental costs can be considered as social costs and external effects which means that they will not be taken into account at every transaction that occurs in the market (Liedtke 2004). This distortion of the market creates an ecological deficit which in turn has a connection of cause and effect to the natural balance of systems and often results into disasters. These effects may lead to a further distortion of the market because of increased and unplanned costs for responding to such natural disasters. Even worse, they lead to a manifold increase in compensation payments for losses and cause further disturbance to the functioning of market forces. This vicious cycle could be overturned mainly by adopting eco-efficiency. This strategy does not require additional cost and financing as far as investments get offset by improvements in efficiency (DeSimone and Popoff 2000). For example the option of eco-efficient means of transport has the potential to improve significantly the cost of traffic congestion which currently consumes in some large cities a significant percentage of GDP. As soon as these changes are complete, private sector will have more incentives to develop cleaner methods of production as well as more efficient methods of production resources, full life cycle of production strategies and so forth.

Eco-efficiency has both ecological and economical dimensions, regarding the product or service and its impact on environment. Progress in eco-efficiency can be achieved either by more value per unit of the effect of the item on the environment or by resource consumption

unit (DeSimone and Ppoff 2000). There are many ways in order to estimate eco-efficiency with one basic equation. The product or service, their value and environment ‘s impact, include many different indicators that can not be merged into a single number. Eco-efficiency indicators that best serve the processes of communication and decision making, should be selected. Specific calculations depend on the needs of the individual decision maker. For a city construction, the counting officer may wish to focus on the number of those products shipped per kilojoule of energy consumed during this construction. A financial analyst can focus on the economic value of the cost of building material used for each kilojoule. The value and influence of the environment can also be measured for different entities such as production lines, processing sites, as well as individual products, market segments or entire economies. In the same way eco-efficiency can be calculated and used for many of these entities and the same index may not be suitable for each occasion. For example an eco-efficiency indicator for road ‘s construction could be one kilometer produced per kilojoule of energy consumed during construction. Alternatively, the administrator of this construction could calculate an indicator based on economic value (eg kilometres per construction cost) per kilojoule of construction or of energy consumed to create this.

The efficiency of cells for photovoltaic systems is measured by the percentage of energy production to the theoretical amount of energy provided by the sun falling on the cell (Yeang 2009). So, if 100 Watt hit the specific cell (under normal test conditions which means laboratory conditions) and this generate 13.5 Watts, then the cell efficiency is 13.5%. Photovoltaic systems may be considered as expensive to purchase or install but their life duration is about 40 years which means that they are efficient. These systems avoid the release of carbon dioxide in the atmosphere taking into account that a typical 1 kW system prevents the release of 1,3 tones of carbon dioxide emissions per year. This amount may seem small in comparison to other polluters; however these data should be added to our equation for the ecological efficiency. So, sunlight that subsequently is converted into steam, should be evaluated in financial sense (eg cost per month) and at the same time to assess the cost to the environment, namely carbon dioxide per month so that we can have an accurate measurement of the ecological and economic efficiency.
In the waste management method of source separation and recycling there are many different ways that someone can measure the environmental and economic efficiency. Naturally, all measurements must follow particular and generally accepted indicators such as total energy consumption, materials being used, measurements of harmful gases and other economic and ecological indicators considered necessary to this project. In the field tested, the environmental impact caused by collection, disposal and recycling is mainly guided by the amount of material and its management. All the material moved or tons of recycled material could be useful business and ecological indicators which are related to the environment and affect indicators for monitoring the performance of the project

4. Case study

Taking into account the theories of design and development of a "green city" the study of utilization of solar energy is chosen as an important factor in achieving the conversion of a city to an eco-city and the effectiveness of this method is examined.
The Case Study was conducted in the Municipality of Nafpaktos. The study involves the construction of photovoltaic panels on the roofs of the municipal buildings. It includes the measurement of the suitable surface for this construction, the estimation of the total power consumption of the buildings and the assessment of the economic and environmental benefits of the specific construction.

INPUTS
Total area of terraces and roofs of municipal buildings: 18888 sq. m.
Selected area: 18 888 * 60% = 11330 sq. m.
Annual electricity consumption of buildings: 3.960.000 KWh
1 solar panel requires 1.6 sq. m surface and produces 250 W
The hours of produced energy in the Municipality of Nafpaktos corresponds to 1550 h per year according to the source pvgis.com
Selling Price KWh of solar panels:0.4 €/ KWh
Construction cost of solar panel: 1600 € /KW
Construction of P / V panel through bank loan by 10% rate and a repayment period of 10 years
In environmental terms it is estimated that 1 KW photovoltaic prevents the release of 1.3 tones of Co2 annually

OUTPUTS
Cost of annual consumption in PPC: 514,800 €
On the selected area 7081 panels can be placed
7081 panels produce 1.770 KW
The Municipality of Nafpaktos can produce 2743500 KWh
Annual benefit from the sale produced KWh: 1.097.400 €
Cost of manufacturing solar panels to the selected area: 2.832.000 €
Total cost of construction including studies and bureaucratic procedures: 3.000.000 €
Total liabilities of the Municipality of Nafpaktos to the Bank and the PPC:992,940 €
Total benefit to the municipality by the investment for the first 10 years:1,044,600 €
Total benefit for 15 years after the repayment of the loan:8,751,000 €
Final benefit for 25 years of manufacturing photovoltaic panels:9,795,600 €
The project prevents the release of 2301 tones Co2 annually

The case study was conducted in order to evaluate and measure the economic and environmental effectiveness of an investment in the Municipality of Nafpaktos. More specifically the study indicates that an investment of 3,000,000 € for the construction of photovoltaic roofs of municipal buildings, financed by a bank, can generate a net benefit to the Municipality of almost 10,000,000 € for 25 years, as long as there is a contract for the sale of solar energy between the Municipality and PPC.
Apart from the economic benefit, it is proven that this investment brings also significant environmental benefits, as it prevents annually huge amounts of C02 being spread in the atmosphere.

5. Conclusion

In this project, strategies, theories and ways were presented, according to which an economically and ecologically self-sufficient "green city" can be built. Ecology, renewable sources of energy and harmony with the natural environment can be enhanced with rules and methods that are efficient for the economy and society in general. Although this study is small in size, it can prove even in a basic level that ultimately the environmental costs outweigh their costs and offer the greatest, not only financially, but also by improving the quality of life.

6. References

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