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Energyscapes: Developing a Multiscalar Systemic Approach to Assess the Environmental, Social and Economic Impact of Renewable Energy Systems on Landscape

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ABSTRACT

The drive for sustainable energy production is leading to an increased deployment of land based renewable systems which have acquired a widespread and relevant role in the transformation of landscape, sensibly affecting its perception by people and therefore eventually finding resistance at a local level. Within this context it is important to define landscape as “an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”, according to the European Landscape Convention (Florence, 20.X.2000) and to envisage renewable energy systems as encompassing devices for production transportation and stocking of energy.

Hence the impact of energy devices on landscape is multifaceted: including visible and invisible factors, large and small scale consequences, environmental, social, political and economic issues, involving stakeholders at different levels and, moreover, resulting in short and long term effects and thus requiring time to be considered as a fundamental variable. The complexity of the topic is though too often overlooked by unilateral perspectives traditionally adopted in the contexts of both policies and research.

The aim of this work is therefore to develop a multidisciplinary, multi-scalar, systemic methodology which embraces the mainstream sectional approaches in an integrated multi-criteria analysis of the impact of the energy devices on landscape. Two case studies are disclosed to present the relevance of the methodology applied on different typologies and contexts. Innovative aspects comprise the drafting of criteria and guidelines to evaluate and select best practices.

KEYWORDS: landscape – renewable energy systems – eco-compatibility – eco-efficiency – systemic approach

1 INTRODUCTION

Managing landscape for conservation, improvement and reconstruction is of utmost importance for the development of natural, human, cultural and social potentials of territories on a local and regional scale. Energy crisis, the quest for energy efficiency and the drive for sustainable energy production have led to a fast moving technological innovation in the sector of renewable energy systems which have acquired a widespread and relevant function in the transformation of landscape and will continue playing a crucial role in the future society of the 21st century. Renewable resources in contrast to fossil fuels are characterized by their temporal and spatial variability (Blaschke et al., 2012); therefore a comprehensive understanding of the impact of energy systems on landscape should include not only energy production but also transportation and consumption as a complex network of nodes and carriers (Howard et al., 2012). Moreover, in order to analyse and manage the relationship between energy systems and landscape it is important to overcome an exclusively aesthetical idea of landscape which considers energy systems as a disturbance and to adopt the definition according to the European Landscape Convention (Florence, 20.X.2000) as “an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”.

This concept encompasses subjective and objective dimensions which unfold in a historical perspective, hence the introduction of energy devices in landscape entails visible and invisible consequences on large and small scale, resulting in short and long term effects and affecting environmental, social, political and economic issues, involving stakeholders at different levels from society and institutions. It is a complex topic where conflicts and disagreements arise due to the unilateral policies and sectorial perspectives generally adopted to rule or investigate the possible integration.

Reporting the intermediate results of an ongoing (2013-2015) research financed by the Italian Ministry of University and Scientific Research (MIUR), which has the aim of overcoming the ostensible conflict between energy systems and landscape and defining methodologies and guidelines to make this relationship possible, this article focuses on the outlining of strategies and models for an eco-efficient and eco-compatible integration of energy systems in urban landscapes.

2 METHODOLOGY

With the general aim of the sustainable development, to be declined in its environmental, social and economic spheres and because of the complexity of the impact of energy systems on landscape, a multi scalar, systemic multidisciplinary approach of evaluation (Morin, 1977) is necessary.

Within this broad mode of ecological thinking, the four basic concepts of eco-efficiency, eco-compatibility, multi-functionality and whole life costing, have been pinpointed as both leading rationale and target of the research work. These keywords have been defined respectively: eco-efficiency as “the efficiency with which ecological resources are used to meet human needs” (OECD, 1998); eco-compatibility as the “compatibility between the built and the physical environments, including different categories of impact and the different phases of the building life cycle” (UNI 11277, 2008), multi-functionality as the performance of a product, object or process to respond to many requirements more than the primary requirement it has been conceived for; whole life costing as “all significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements” (ISO 15686-5, 2008)

As a starting analytical step of the work, the different models and approaches commonly encountered in scientific literature or practice, have been pinpointed and examined as possible interpretations of the relationship between energy systems and landscape (Venturi Ferriolo, 2002) to be applied and compared in order to enlarge the analysis to a systemic view.

Concurrently, a wide and diverse selection of case studies illustrating the relationship between energy systems and landscape have been collected and classified according to specific categories to stress the modes of the integration. The following categories have in fact been adopted to highlight the different typologies of energy systems: the source of renewable energy, the function (production, transportation and storage of energy), the production system (distributed or centralised) and use, whether it is an off grid or an on grid production. Location (urban, rural or peri urban environments) and scale (territorial, urban and building) are included to place emphasis on the impact on landscape.

Though a comprehensive analytical evaluation of selected examples is currently carried on, in order to provide a quantifiable evaluation and define the framework of the final methodology, as a first qualitative result of the analytical step, some case studies have been selected, because of their outstanding significance in some key contexts, to illustrate possible model strategies for a compatible integration between landscape and energy systems.

3 CASE STUDIES

The following case studies of energy systems in specific exemplar landscapes disclose and outline possible pathways towards a sustainable integration.

3.1 Evacuated Tube Solar Collector “Wirebridge Armadillo” in the Monza historic centre, Italy

The Wirebridge Armadillo (Web-1), is an evacuated tube solar collector to convert energy from the sun into usable heat which can be used for hot water heating. This innovative product, recently launched on the Italian building industry market, is specially designed to be easily adaptable to any roof. Not only the manifold can be customized according to the roof covering colour but also the distance between the evacuated tubes, thanks to the flexibility of the header-pipe assembly (with dry connect sockets that the heat pipes plug into), so as to follow the geometry and dimension of the tiles. The dry assembly of each part of the system (with no welded elements) allows for a quick and easy installation and dismantling, enabling the separate disposal and the possible recycle of the different materials. The tubes are high quality certified components with a high efficiency heat generation.

Figure 1: “Wirebridge Armadillo” installed on a clay tiles covered pitched roof

The installation analysed, on an ancient residential building in the historic centre of Monza, a mid-sized city north east of Milan, demonstrates the specific innovation of the product when integrated on historic buildings and highlights the more general question of energy upgrading of the cultural heritage.

Figure 2: The case study building in the historical centre of Monza

This conflict between heritage and energy conservation is long standing since the EPBD (Energy Performance of Buildings Directive) 2002/91/EC, which, towards climate change targets, agreed in the Kyoto Protocol, lays down among the other requirements, "the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation". It leaves, though, to the Member States the decision of the application of these standards to "buildings and monuments officially protected as part of a designated environment or because of their special architectural or historic merit, where compliance with the requirements would unacceptably alter their character or appearance". Even the re-cast of the EPBD (Directive 2010/31/EU) still excludes historic buildings and monuments from the obligatory framework of sustainable interventions.

The case study building in Monza, is located in the centre of the city, a listed area, because of its historical significance, therefore the installation of the solar collectors, which provide the necessary hot water for domestic uses of a 80 sqm flat, is subject to the evaluation of the local office of the 'Soprintendenza ai Beni Ambientali e Architettonici' (the government department responsible for the environment and historical buildings). Albeit the presence of solar panels are usually judged by Italian conservationists as an unacceptable alteration to the original characteristics of historic buildings' roofs, spoiling the historic landscape, the installation of the Armadillo product has been approved of because of its camouflage in the clay tiles roof covering.

Table 1 Concise qualitative evaluation of the "Wirebridge Armadillo" in Monza

Eco-efficiency	Eco-compatibility	Multifunctionality	Whole Life Costing
– **high energy efficiency** – **reduced co^2 emissions** – **SPF and Solar Keymark certificates**	– adaptable (perception) to any roof covering – compliant to landscape conservation regulations – recyclable materials – reduced use of materials (copper) – lower grey energy (20%) of the header pipe compared to competitors – reduced dimensions of components – no emissions when operating – reduced packaging materials usage	– adaptable (installation) on site to any roof covering – customized manifold colour and tubes span – self load bearing system – producing water for domestic use and heating	– self load bearing system (no need for extra sub-structure) – easy maintenance thank to the simple installation and fixing – pricing aligned with competitors – high durability (no water flowing in tubes) – direct and indirect (fiscal) incentives

Hence, the case study shows a possible strategy to provide an answer to the conservation issues of the cultural heritage, without compromising the environmental aims of the energy upgrading of buildings. It is through product design innovation, in terms of efficiency, eco-compatibility and visible integration into the existing historical landscape, that technological advancements can be achieved.

3.2 Electric generation with "Lybra" Power Bump in Rescaldina shopping centre, Italy

Speed bumps are widely used on roads and car parks to oblige drivers to reduce their speed, mainly for safety reasons. The "Lybra" Power Bump is a new kind of speed bump, an experimental patented modular device, which can capture part of the energy the cars produce by passing over it, turning it into a magnetic field and then into electric energy. No energy is actually "stolen" from the passing cars, while some kinetic energy is recovered, that would otherwise just be lost.

The Italian patent dates back to 2010 and boasts reduced maintenance operations, thanks to a modular component technology, reduced maintenance costs, thanks to the lack of mechanical transmission, and high efficiency.

This project is now tested in the parking area of a big size popular shopping centre in the outskirts of Rescaldina, a city north west of Milan. The hypermarket belongs to a well-known international retail group and multinational corporation, one of the world's principal distribution groups with a presence in 12 countries. It has been estimated that with an average traffic of 8,500 cars per day, it would be possible to generate up to 100 MWh every year, the same energy that would be produced by a 80 kW photovoltaic plant. If the project proves successful, more Power Bumps will be installed in other sites allowing for a mass production of the devices that would lower costs and make the recovered energy cheaper, helping, at the same time, to compensate part of the carbon dioxide emissions connected to road transport.

Table 2 Concise qualitative evaluation of the “Lybra” Power Bump in Rescaldina

Eco-efficiency	Eco-compatibility	Multifunctionality	Whole Life Costing
– electricity production from an otherwise wasted source – intensive usage	– recyclable materials – simple and reduced number of components – no emissions when operating	– production of energy + safety purpose	– low energy production cost (<0,1 €/MWh) when operating – high durability – reduced maintenance costs (no mechanical transmission) – high efficiency (no gas, no cables, no rotating bodies) – easy maintenance (separated modules to allow easy replacement)

The remarkableness of the case study relies first of all in the possible markets, for example other retail groups, logistics companies or highway authorities and, especially, in the model policy it suggests. As in the Rescaldina shopping centre, the installation of the power generator can be encompassed in a more general marketing programme, to promote the retail brand through the communication of its investments in green policies. Therefore the power bump is somehow multifunctional: it is exploited for advertisement purposes, which easily stimulate private investments, but at the same time it produces energy in an eco-efficient and sustainable way.

Secondly, if the testing will result in a widespread affordable industrial production of the component, the potential fields of application propose an interesting model strategy for supplying energy to public spaces through generators integrated in urban furniture. The power bump, providing energy and allowing for a safer traffic can be installed to supply energy for public lighting with the same impact on urban landscape as a speed bump, being, in fact, a multifunctional device.

3.3 Photovoltaic array “Solar Strand” in Buffalo State University, Buffalo, New York, USA

The Solar Strand is a ground-mounted photovoltaic solar array of 3,200-panels with a size of 747.3 kW (Web-3) opened in 2012 built at the entrance of the University of Buffalo North Campus. It’s been built and financed with an investment of $ 7,5 million by the New York Power Authority (NYPA), a state agency which was interested in the exploitation of the campus premises, all sealed in chain link fence.

The new power plant was conceived as an exemplary project within the governmental NY-Sun Initiative for bringing together and expanding multiple solar power incentive programs for spurring the growth of the state's solar economy and quadrupling annual development of solar power in New York State by 2013, to make New York State a leader in the clean energy economy.

As a result of the institution commitment towards sustainability, the project, which stretches across 15 acres, is included in a more extensive regeneration of the site in order to re-establish a more functional and beautiful ecology.

Figure 3: Aerial view of the Solar Strand in Buffalo University Campus during construction

The international competition, held by the University for the final design of the infrastructure, was won by the renown American landscape architect Walter Hood. The project is an infrastructural landscape which dialogues with the natural surroundings, is open to public accessibility and has been conceived as a land art installation. The organization of the panels array follows the metaphor of DNA representation in gel packs to create a modular component consistent with most formal solar installations. The lowest level bracket is set at the height of a human being so that the plant can be inspected and visited from every direction in space. When walking inside the plant visitors can experience the rhythm of the double and triple stacks whilst from a distance the staggered heights, scaling up and down in connection with the surroundings, offering different changing perspectives, can be observed. The two largest panel sets rise to 8.5 m, forming a monumental public plaza space where visitors can rest and listen to classes, which introduce people and school children to the topics of sustainability and renewable sources of energy (Scognamiglio, 2012).

Any technical element was designed to be human friendly: the steel pipes that run the length of the strand to enclose a vast network of wiring can also be used as seats or foot rests and, in some spots, they are set back so visitors can get up close and touch the panels.

Figure 4: People gathering in the public plaza of the Solar Strand to listen to classes

The project also involved extensive recycling and repurposing of campus materials, including 1,000 tons of bricks and concrete from campus renovation projects that now form the strand's cobbled brick and flagstone paving. Also new trees were planted in and around the strand to reinforce the geometry of the site.

Table 3 Concise qualitative evaluation of the Solar Strand in Buffalo

Eco-efficiency	Eco-compatibility	Multifunctionality	Whole Life Costing
– nearly 400 tons of greenhouse gases emissions avoided every year – high efficiency pv panels – sun shading activities below panels	– no emissions when operating – trees and shrubs planting – reduced soil consumption	– urban park + energy generation + land art installation – energy infrastructure + urban furniture – educational purpose (engaging the community towards sustainability issues) – triggering local renewables market	– 7 million dollar project cost – saving more than $60,000 in annual electricity costs – economy of scale due to infrastructure dimension

The construction of the photovoltaic array has become a multifunctional project conceived as an artistic product (Web- 4), thus responding to the initial oppositions of the community moved by a "Nimby" attitude, as a public space accessible to all and as an educational project to call to people with a sense of belonging and participation. Therefore, albeit the 1,1 megawatts of the initially proposed conventional power plant where reduced to the 750 kilowatts of the customized Solar Strand, to comply with economic restraints, the advantages in terms of landscape integration, social, cultural and environmental sustainability indicate that the project can be envisaged as a possible model behaviour to integrate renewable energy systems in public spaces.

4 CONCLUSIONS

In the context of energy systems and landscape, showing either a standardized approach which materializes in the simple application of market products or in an anarchic background left to free private initiative, with the absence of a sound structural institutional framework, the illustrated case studies, though still to be quantitatively evaluated, developed and enriched in number through the ongoing research, offer possible model strategies to conceive a compatible integration. Whether ecologically and economically compatible at large and local scale, energy devices can be turned into beneficial positive multifunctional elements to add shared meaning and fruition to the landscape in order to overcome community obstructions and to meet, instead, the society requirement needs.

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