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Parametric analysis and assessment of the photovoltaics' landscape integration: Technical and legal aspects

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ABSTRACT

The increasing spread of photovoltaic (PV) systems occurring nowadays does not always keep pace with respective legislative initiatives, especially those regarding a specific relation between PV systems, the natural environment and landscape. As a result of this differentiation, the existence of legislative gaps or omissions is noticed. Thus, while the development of Renewable Energy Sources (RES) is actively promoted by the government in general, from a legal point of view there are no equivalent preventive measures for the protection and preservation of physical environment and landscape aesthetics, at least in all types of RES, with the exception of wind farms. In fact, in the case of PV systems, there is no specific legal framework, which would regulate their integration in the environment, and in particular into landscape.

The work analyzes a method for assessment of aesthetic impact caused by PV plants. The method is developed in MATLAB and based on the use of a PV plant photo and the quantification of three parameters: visibility, color and fractality. Purpose of this work is to propose this method as an applicable integration rule of PV systems into landscape, aiming to reduce its aesthetic downgrading, contributing thereby to sustainability.

Additionally, in an interdisciplinary approach, the suggested method restores the issue of the explicit legislative provision of specific rules and criteria regarding the PV systems integration into landscape.

1. Introduction

The rapid increase of photovoltaic (PV) plants observed in Europe and especially in Greece in recent years raises considerable concerns. Those include aesthetic disturbance caused by PV modules installed in natural and anthropogenic environment, and consequently in landscape.

The aesthetic disturbance of renewables and especially wind turbines has started to be considered as a crucial topic from various researchers from the technical, legal and policy perspective. Tsoutsos et al. [10] addressed environmental intrusions, and apart from mentioning several mitigation measures for environmental impact in general, they actually proposed specific alleviation techniques for each type of technology. In case of PV the study considered a visual and aesthetic intrusion in the built environment. Another work that considers the landscape impacts of wind power development is the one of Nadai and Labussière [8]. Using the case of Aveyron in southern France is argued that the pace of wind power development can be understood only by looking in more detail the way in which landscape is dealt within local planning processes. Moreover Chiabrando et al. [3] acknowledged the considerable change in landscape due to PVs. Chiabrando et al. [4] modified a proposed procedure to evaluate the visual impact of a PV plant based on a quantitative indicator and discussed on how this procedure may be used and integrated into the administrative requirements of large and small scale PV plants developments. They concluded that such a procedure can be effectively used provided that a regulatory framework is set by the local authority that carries out the authorization procedures. The common denominator of these two works, concerning RES integration into landscape, is the local scale of planning and authorization.

Furthermore an examination of the relation between, Special Framework for the Spatial Planning & the Sustainable Development of RES (SFSPSD) and RES projects in Greece was conducted by Baltas and Dervos [1]. In this work a national regulatory framework was presented for the determination of the appropriate sites for the installation of renewable energy projects (wind farms, small

Abbreviations: PV, photovoltaic; RES, renewable energy sources; PEAE, preliminary environmental assessment and evaluation; RAE, regulatory authority for energy; SFSPSD, special framework for spatial planning and sustainable development.

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hydroelectric projects, photovoltaic parks). Moreover, the relative criteria for the installation exclusively of wind farms in the mainland and for their integration into the landscape in such a way that the visual effect has the least possible impact were described.

Torres-Sibille et al. [9], approached the issue of assessment impacts on the natural landscape of PV systems with the objectivity that mathematical models provide. The subject of their study was the introduction of an objective indicator for quantifying the aesthetic impact of PV using four criteria (visibility, color, fractality and concurrence). Finally, a comparison between the results of the objective (quantitative) and the subjective (qualitative) method of the impact assessment was conducted, showing the reliability of the index as the results coincide.

Based on the above and by taking into consideration the increased interest in Greece for the PV installations, the aim of the present paper is to examine the aesthetic considerations for PV plants from a technical and legislative as well as policy perspective. The paper is structured in two main parts. The purpose of the first part of the present paper is, on the one hand to present modern considerations of the legal definition and protection of landscape, through the lenses of the European Landscape Convention (ELC) and its ratification in Greece and, on the other hand to connect the above with the critical approach of national planning provisions and especially those of the SFSPSD of RES. Simultaneously, the current license framework for RES projects is analyzed and correlated. In the light of the aforementioned, the crucial issue is to be investigated whether the case of PV systems is regulated of specific requirements/rules for their integration into landscape. Moreover, any omissions or vacuums of the current national regulatory framework are detected. For the technical perspective, a deepening in the computing environment in which a method for quantitatively assess the aesthetic impact of the integration of the PV in the landscape, is developed followed the examples of the literature [4]. Finally a number of PV plants are examined as case studies.

2. The current institutional and legislative framework

2.1. The modern view over landscape

Nowadays landscape appears as a synthesis of natural and anthropogenic components of environment that interrelate and interact with each other, abandoning the strict inclusion in one category. The word landscape has complex and multiple meaning that change depending on the context within it is used. The involvement of various scientific disciplines (geography, ecology, economics, sociology, etc.) with landscape leads to multiple interpretation and wording of its definition; each science studies and approaches landscape from a different perspective.

For instance, in geography applies that “natural element holds the background position on which human element dominates by declaring its identity”. On the other, in ecology and biology sciences “landscape is the spatial and spiritual unity of interrelated subsystems of geosphere, biosphere and noosphere”. Alongside, the science of landscape architecture approaches landscape via aesthetics and perception, two notions with strong theoretical background and subjective content. The aesthetics of landscape is an experience gained through human perception. In fact, the perception people have about landscapes vary from person to person depending on their intellectual level, mentality or psychosynthesis [7].

Intense activity and questioning on international level led to the adoption of a modern prospect widening the scope of the notion of landscape, as it no longer revolves around the concepts of “particular beauty” or “special value”. On the contrary, a more social approach is sought, that would grant landscape the importance of common heritage and living environment as an aspect of everyday life that impacts on the quality of people’s surroundings. To that end the aforementioned European Landscape Convention, which entered into force in March 2004 and ratified in Greece via Law 3827/2010 (Government Gazette A 30/2010), establishes a novel approach as regards the content of landscape and stipulates its legal wording, as follows: “Landscape” means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (article 1a). This wording enlarges the implementation field of landscape protection, management and planning including all its types everywhere. It concerns landscapes that might be considered outstanding as well as every-day or degraded landscapes (article 2 of the ELC) [5].

2.2. The regulatory provisions of special framework for spatial planning and sustainable development for RES

According to the Greek Constitution 1975/1986/2001/2008, article 24 paragraph 1 “The protection of the natural and cultural environment constitutes a duty of the State and a right of every person. The State is bound to adopt special preventive or repressive measures for the preservation of the environment in the context of the principle of sustainable development”. In addition, paragraph 2 of the same article stipulates that “The master plan of the country, and the arrangement, development, urbanization and expansion of towns and residential areas in general, shall be under the regulatory authority and the control of the State, in the aim of serving the functionality and the development of settlements and of securing the best possible living conditions”.

In late 2008, the Special Framework for Spatial Planning and Sustainable Development for RES was approved by the Greek Government, via its decision 49828/2008 (Government Gazette B 2464) which aimed to formulate siting policies of RES power generation projects. The main purpose of this legal instrument is to establish standards and criteria which would make such projects viable and contribute to harmonious integration in the environment. The Special Framework was considered to be a very important structural intervention for the development of RES in Greece and was part of a broad reform to institutionalize integrated spatial planning, absent until then.

2.3. Siting criteria

Article 17 in Fourth Chapter of the Special Framework regards on siting criteria for facilities exploiting solar energy in general, including PV systems. The article mentions indicatively some characteristics according to which the reception area of the installation could be considered as one of priority: a) be infertile or of low productivity, b) be hidden from frequented places, c) be capable of connecting to the electricity network. This same article includes a paragraph which lists areas excluded from siting such facilities.

In contrast to the field of photovoltaics, for which only some indicative of the characteristics are listed, siting matters for wind farms are approached with apparent diligence in the Second Chapter of the Special Framework. More specifically, a key element of the siting rules for wind farms is the distinction of Greek territory primarily in categories based on geographic and demographic criteria and then to areas of wind priority or suitability based on wind potential.

2.4. Integration rules in to landscape: the provisions and the omissions

The establishment of integration rules for wind farms in the landscape is deemed to be particularly important. In Appendix IV of the Special Framework entitled “criteria of wind farms integration