Conflicts Between Environmental Protection and Energy Regeneration of the Historic Heritage in the Case of the City of Matera: Tools for Assessing and Dimensioning of Sustainable Energy Action Plans (SEAP)

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Abstract. The effort towards the reduction of energy consumption, reduction of emissions and the adoption of Renewable Energy production technologies produced significant spatial and urban transformations. In terms of environmental impact assessment, a structural contradiction between a system of governance that promotes renewable plants, an economic system ready to invest huge resources and high profitability, a weak system of territorial planning rules and instruments of landscape protection not yet adequate to govern such transformations.

This paper proposes a local case study (the city of Matera) where the ex-ante evaluation of investment programs for the energy regeneration of the public housing stock under the Covenant of Mayors has to be compared with the preservation objectives of an unique historical settlements ("*i sassi*"). In fact, the city, elected European Capital of Culture 2019, has characteristics of unique historical and architectural value of historical value. On it they act the signs of a PRG dated and the management rules of the UNESCO site most recently adopted (2014).

The Municipalities adopted the Sustainable Energy Action Plan (SEAP) - a new category of instrument of urban government which includes strategies and methods of urban transformation - but the intervention scenario not considered the integration of RES plants and technologies with historical settlements.

This paper, starting from remote sensing assessment of local radiation index, proposes a methodology to improve the integration between the issue of implementing RES at urban scale and to preserve traditional settlements in a sustainable perspective.

Keywords: Sustainable energy planning · RES · Urban renewal

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1 Introduction

This work proposes an in-depth analysis of the potential use of energy-saving technologies in urban areas based on the Global Horizontal Irradiance Index (GHI) an assessment [1] (it is a measure of solar radiation incident in a territorial scale through remote data) and consequent scenarios of Renewable Energy Sources (RES) technologies use within the European Union policy framework: the Covenant of Mayors [2, 3].

The adoption of RES technologies is a topical issue about several scenarios: development and adoption of innovative technologies, economic dynamics and RES resource development, local contributions to climate change adaptation, regeneration processes and sustainable urban development.

With reference to the paper's goals, the relationship between potential energy production related with the installation of photovoltaic and solar thermal technologies is compared with restrictions and criteria for the buildings changes and urban spaces transformability.

The case study of the Municipality of Matera highlights, on the one hand, the high attitude to reduce energy consumption and to regenerate public buildings, in the other hand, this situation is contrasted with a strict system of rules for the historic settlement protection. Then, it is necessary to balance these instances in order to define an intervention scenario well-matched with sustainability concept that includes environmental, social and local identity issues.

The 2008 marked a significant milestone in the climate change topic [4, 5] in the EU policies framework: the establishment by the European Commission of the Covenant of Mayors [2].

The first citizens together, voluntarily, with their communities join in to act concretely and locally to reduce energy consumption and emissions following the EU 202020 target [6]. This target means overcome 20% reduction of CO2 emissions [7]. When the agreement is signed, the PAES is formed: Action Plan for Sustainable Energy.

In January 2015, Matera adopted its own PAES, aiming to reduce CO2 emissions by 20.5% through a planned series of actions to reduce consumption and to improve the use of renewable resources, both in the public and in the private sector.

These actions are inside a wider program and management process related to the European Capital of Culture Matera's nomination [8, 9].

In this paper, according with Matera's PAES and its rules in terms of public investment policies for energy saving, has been applied a procedure to understand the scenario related to photovoltaic technologies. Starting from a punctual estimation of energy productivity on a set of public buildings selected (without architectural conservation constraints), an intervention scenario has been designed which allows an increase in emission targets of CO2 declared in the PAES [10]. The result is schematically shown in an update proposal intervention form about the PAES photovoltaic technology.

The first section of this work introduces a general overview of the EU measures taken to counter climate change, from the early 1990s to the latest ones. Starting from the EU general framework, we have gone through an analysis of the state of implementation

of the European policies of the Covenant of Mayors in Basilicata, highlighting the level of accession to the COM and the elaboration of the PAES of the Lucan municipalities. It is a feature characterizing the presence in the Basilicata Region of a public entity: Società Energetica Lucana S.P.A. (SEL), which provides technical support in the drafting of the PAES. In the second part, the PAES of the Municipality of Matera has been analyzed, with particular attention to: electrical energy consumption of public and municipal buildings (municipal and provincial), the expected consumption reduction targets for 2020, the actions taken during 2009–2012 (which we call "A") and those scheduled during the period 2013–2020 (which we call "B") and the verification of what has been done without the official monitoring report. The third part of this work describes the used data and the related analysis and evaluation processes. In addition to the remarkable reproducibility of the procedures adopted in this research, the conclusions show that the proposal developed in this paper contributes to raising the target of energy efficiency and environmental sustainability set for 2020 by the Municipality of Matera: a further "topic" for the role Of European Capital of Culture 2019.

2 From European Policy on Climate Change to Sustainable Energy Action Plans

The European Union in the early 1990s has acted globally to counteract climate change on the Earth considering that climate in the early 1980s was defined, according to ONU, "shared resource of mankind".

European climate policy could be expressed with following dates: in 1992 European Union with all of its members joined the United Nations Framework Convention on Climate Change (UNFCCC) [11], the main international treaty on climate change. Successively in 1997 there was the Kyoto Protocol subscription [12]: the first step on reducing greenhouse gas emissions. In 1998 there were set the reduction targets of emissions for 15 European States of that period, choosing as common target the reduction of 8% according to the 1990s levels. The period 2003–2013 was characterized by the accession of several regulatory instruments to encourage an improvement of Kyoto goals. In period 2013–2020 European Union joined Climate Change Package (Integrated Energy and Climate Change Package, IECCP) [6]. IECCP reserves Member States of EU to be achieved by 2020 following goals:

- Energy production from renewable sources equal to 20% of energy consumption and use of biofuels equal to 10% in transports;
- Reduction of greenhouse gas emissions equal to 20% according to 1990;
- Reduction of energy consumption equal to 20% according to baseline scenario improving energy efficiency.

In December 2015, it was joined Paris agreement [13], adopted by all parts of UNFCCC: it is the first-ever universal, legally binding global climate deal enter into force by 2020.

European Union established key objectives every ten years to 2020 [6]: reducing equal to 20% greenhouse gas emissions according to 1990, improving equal to 20% the percentage of renewable energies and improving at least 27% energy efficiency. Instead

for 2030 the European Union established following objectives: reducing at least 40% greenhouse gas emissions according to 1990, improving at least 27% the percentage of renewable energies and improving at least 27% energy efficiency [2]. No later than 2050, European Union aims to reduce its emissions substantially about 80–95% according to 1990s levels in the endeavor required from advanced countries [2].

2.1 Covenant of Mayors

The Covenant of Mayors is a singular movement "bottom up" that is successful with wide margin of success mobilizing a lot of local and regional authority, encouraging to develop action plans and directing their efforts to climate change mitigation. In 2008, after the adoption of the Integrated Energy and Climate Change Package EU 2020, European Commission promoted Covenant of Mayors to endorse and supporting efforts made by local authorities in implementation of policies in the area of renewable energy.

The new Covenant of Mayors for Climate and Energy was launched on 15 October 2015. In that occasion, fundamental pillars reinforced were shown: climate change mitigation, adaptation and access to secure, sustainable and affordable energy for all. Signatories have a shared vision to 2050: accelerating the decarburization of our territories, strengthening our capacities to adapt to unavoidable climate change impacts, thus making our territories more resilient, increasing energy efficiency and the use of renewable energy sources on our territories, thus ensuring universal access to secure, sustainable and affordable energy services for all.

By 2030, signatories commit to reducing carbon emissions across their territory by at least 40%, to increasing their resilience to the impacts of climate change. Following the successful of Covenant of Mayors, in 2014 started Mayors Adapt [14], that is based on the same model of governance, encouraging policy commitments and adopting prevention actions preparing cities to unavoidable climate change. At the end of 2015 the initiatives merged into the Covenant of Mayors for Climate and Energy, that adopted EU 2030 objectives and an integrated approach to mitigation and adaptation to climate change. Adaptation to climate change is necessary to contrast their negative effects and save resources. Turn own political commitments into real activities, the signatories of the Covenant of Mayors have to edit Baseline Emission Inventory and a Risk and Vulnerability Assessment. The signatories, within two years from their accession, undertake to edit a SECAP that outlines the main action that authorities have to plan to do.

3 The Actualization of Covenant of Mayors in Basilicata (IT): The SEAP of Matera

Regionally, reduction of energy consumption is one of main goal of PIEAR – Energy Regional Environmental Plan [15]. The Basilicata Region wants to achieve, targets set by UE and Italian government, an increase of energy efficiency that allows in 2020 a reduction of energy demand in the amount of 20% according to the same expected from

this period[1]. The PIEAR provides that increase of electricity production from RES, expected to 2020, will be achieved with following planning:

- Wind farm for 981 MWe;
- PV systems for 359 MWe;
- Biomass installations for 50 MWe;
- Hydroelectric installations for 40 MWe.

Starting from January 2017, 63[2] Municipalities joined the Covenant of Mayors (at 2016), where 33 are in province of Potenza and 33 in province of Matera.

In the following feature we have overall view of Municipalities joined to Covenant of Mayors (Fig. 1).

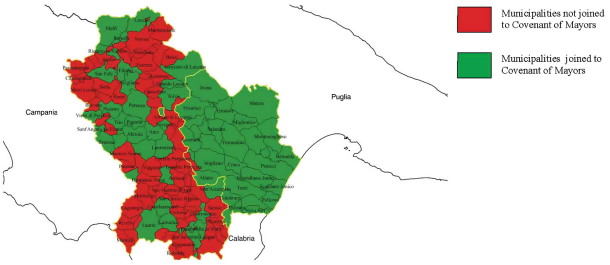

Fig. 1. Basilicata municipalities and signature to Covenant of Mayors.

3.1 The 'Società Energetica Lucana' (SEL) and the Support for Editing SEAP to Local Authorities

Regional Council in Basilicata with regional law (see [16]), n. 13 of 31-07-2006 promoted the foundation of SEL, a completely public company, that manages and improves the energy demand encouraging RES installation. SEL provides support to local authorities for editing SEAP from signature to Covenant of Mayors to following steps as monitoring and evaluation of achieved goals. Municipalities turned to SEL are exclusively from province of Potenza.

The province of Potenza, on 25 September 2012, was identified as support structure to Covenant of Mayors. Main goal of the Province is encouraging municipalities to join Covenant of Mayors, helping them to processing SEAP.

The Province of Potenza reinforced an important international promotion of its energy policy and adaptation to climate change considering local resilience [17, 18].

Since 2016, it is leader of an international cooperation project: LOCARBO (Novel roles of regional and LOcal authorities in supporting energy consumers' behaviour change towards a low CARBOn economy" - Program INTERREG EUROPE

[1] The energy demand expected is given by ENEA Trisaia, September 2011.

[2] Information collected from website http://www.tuttitalia.it/associazioni/patto-dei-sindaci/basilicata/ (Accessed on January 2017).

2014−2020) [17]. The project aim is improving instrument of policy-making to increase energy efficiency joined to build environment through participation of stakeholder and users.

4 From GHI to Pre-sizing of the Solar Power Production Scenario

In this work, we have considered some inclined and non-flat photovoltaic (PV) systems, so it was necessary to search for an inclination of the PV systems that was optimal to obtain the best efficiency in terms of solar radiation, considering that the optimal angle of inclination β of PV systems depends on the latitude φ and solar declination δ with the formula $\beta_{ott} = \varphi - \delta$ (see [19]). In this way, we have chosen to adopt an optimal inclination angle of the PV system function of the latitude according to the Joint Research Center (JRT) – Institute of energy and Transport (IET) of EU Commission (see [20, 21]) that achieved a solar radiation database from climatologic data homogenized for Europe and available in the European Solar Radiation Atlas, using the r.sun model and the interpolation techniques s.vol.rst and s.surf.rst. The database consists of raster maps representing twelve monthly averages and one annual average of daily sums of global irradiation for horizontal surfaces, as well as those inclined at angles of 15°, 25°, and 40°.

According to these available data, above described, we have chosen to adopt the ENEA guide "Progettare e installare un impianto fotovoltaico" (2008) (see [22]). The produced energy of the PV system is given by the expression:

$$Ep = H \times S \times Eff.pv \times Eff.inv = H \times Pnom \times (1-Ppv) \times (1 - Pinv)$$

Where:

- Ppv are the losses (thermal, optical, resistive, falling on diodes, mismatch) of PV system, measured to a first approximation about 15%;
- Pinv are the losses (resistive, switching, magnetic, power control circuits) of the inverter that are provisionally assumed of about 10%;
- Pnom is the power rating of the PV system necessary to produce the energy Ep;
- H is solar irradiation on the surfaces (S).

5 An Application of a Case Study: The City of Matera

The short description showed below about the local SEAP of Matera (see [23]), is the reference where we have taken into consideration the data about the energy local production.

There is an analysis of the urban local planning useful to identify the historical heritage. It is important to remember that Matera is a UNESCO site with a management planning, that is an instrument to preserve the historical buildings. For this reason, we want to build PV systems in accordance with safeguard of the historical town. So we

have considered only the public buildings that had electric and thermic consumptions, ruling out those on which there have just been carried out operations or it was possible to make a prediction of them. The final part deals with the sizing and an estimate of costs of the operations even in relation with criteria adopted in accordance with best condition of PV systems.

5.1 The SEAP Prediction and the Proposal for Intervention

From 2009 to 2012 the energy local production refereed to local PV systems under 100 kWp, is increased by 429,45%, passing from 1.495,40 MWh/year in 2009 to 7.917,34 MWh/year in 2012 (Table 1).

Table 1. PV local energy production in period A

Local PV energy production - period A		
Production MWh	Reduction CO2 t/a	Percentage contribution to the CO2% reduction
6.421,94	2.039,80	0,85%

In period A it is expected an increase of the local electric energy production using PV systems with promotion and the their promotion. The aim of this action is to promote the installation of PV systems on public buildings (Table 2).

Table 2. PV local energy production in period B

Local PV Energy production - period B		
Risparmio MWh/a	Reduction CO2 t/a	Percentage contribution to the CO2% reduction
1.495,40	474,98	0,16%

As a critical feature of Matera SEAP, no many efforts are promoted to increase users' capacity to 'self energy management' practices [24].

As regards the proposal of operations, using RSDI Geoportal of the Basilicata Region (see [25]) it was possible to derive with the conceptual map of the DBGT Geotopographic Database in shape file format, especially the classes "edifici" and "unità volumetriche." In the following figures are represented the logical criteria of the buildings selection and the proposal of operations are shown (Figs. 2 and 3).

5.2 Proposal of Operation and Estimate of Costs

To each building previously selected it was associated GHI value [1], that will be adopted for the sizing of the PV system necessary to copy entirely the energy needs have shown in the table of consumption inside the SEAP.

According to the SEAP predictions, there will be a RES production by 100% in 2020 compared to the last consumptions of 2012. Therefore, we started to the last

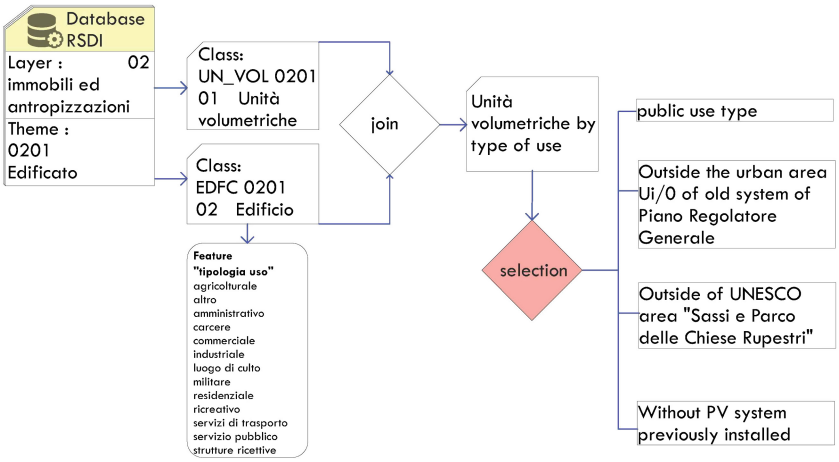

Fig. 2. Logic scheme of the selection of the proposal operations

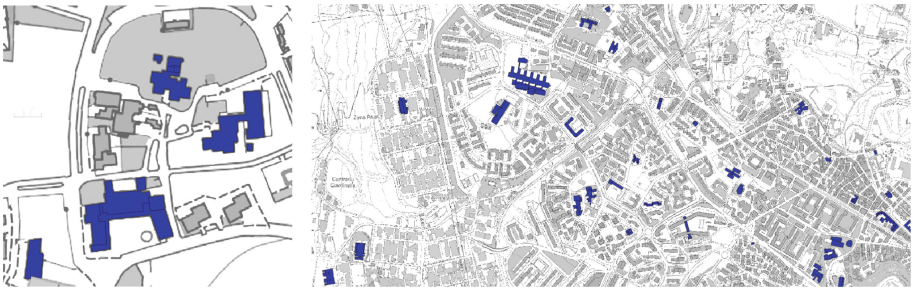

Fig. 3. Some representations of the urban areas where the public buildings have been selected for the PV system energetic estimate

available data of electric energy consumption and we carried out a general sizing of the PV system using the ENEA guide (cfr. [22]). In Table 3 data and results for each building are shown.

The hypothesis suggested in this work and shown in Table 4, consists of the integration of the action N27-PE.1B provided by SEAP of Matera town and referred to the buildings that are potentially changeable, that is those of public use selected according to qualifying criteria for installation of PV systems with aim of the energetic need of each building using the GHI application estimated according to the remote sensing.

After the pre-sizing it was possible to develop a general economic estimate of the operations necessary to the implementation of these systems. According to the SEAP of Matera town the investment cost planned for middle market is 3500 €/kWp.

Table 3. Total covered surface of the chosen public buildings (source SEAP MATERA [23])

Building	Energetic consumption SEAP 2012 kWh/year	PV system surface m^2	% of covered surface
I.T.C.G Stella via E. Mattei	88504	168,95	4,63
I.T.I.S. via Virgilio	163698	312,49	2,4
Istituto Alberghiero via Castello	60411	113,5	9,18
Istituto Professionale maschile-Da Rondinelle	29117	55,43	0,87
Istituto Ragioneria	75579	143,82	6,43
Istituto Tecnico Agrario	98637	187,78	3,72
Liceo Artistico via Cappuccini	33958	63,73	4,24
Liceo Classico via Nazioni Unite	39532	75,22	3,2
Liceo Scientifico viale Europa	79242	150,79	5,1
Patrimonio - via Aldo Moro, snc	550643	1047,81	58,38
Patrimonio Piazza Monte Grappa 11	86	0,16	0,01
Patrimonio piazza S. Agnese 7	16752	31,44	3,4
Patrimonio via G. Saragat 44A	11508	21,9	2,63
Polizia Locale - via Trabaci	64027	121,73	11,33
Scula Materna viale Quercia 3	7555	14,38	2,15
Scuola - via Frangione 4	2924	5,49	0,93
Scuola Elementare via Bramante 8	16854	32,07	1,59
Scuola Elementare via Guglielmo Marconi2	38867	73,96	4,89
Scuola Elementare via Lucrezio snc	9610	18,34	1,36
Scuola Elementare via Nitti	25326	48,19	2,95
Scuola Elementare via S. Pardo	24376	46,38	12,05
Scuola Materna via Cererie snc	5510	10,48	1,17
Scuola Materna via Emilia snc	7390	14,06	1,08
Scuola Materna via Meucci 2	4319	8,22	3,27
Scuola Materna via Morelli Marcello snc	3832	7,2	0,66
Scuola Materna via S.Giovanni Mate 3	2821	5,37	1,16
Scuola Materna via Vulture snc	6261	11,79	2,07
Scuola Media ed Elementare (Francesco T.)	35652	67,84	3,98
Scuola Media Francesco Torrata	40914	77,85	3,3
Scuola Media Giavanni Pascoli viale Parini snc	64079	121,93	17,57
Scuola Media Nicola Festa via Lanera, 59	34732	66,09	3,58
Scuola Media via Fermi 8	12006	0,86	0,03
Scuola Superiore Professionale Femminile Isabella Morra	69535	132,32	5,33
Uffici Giudiziari via Aldo Moro snc	676466	1287,24	29,93

Table 4. Action N27-PE.1B for the estimated buildings

ACTION CODE **N27-PE.1B**	SECTOR	LOCAL ENERGY PRODUCTION	
	AREA OF INTEREST	Renewable energies	
	KEYWORDS	**Promotion and encouragement to installation of PV systems on public and private buildings and other renewable energies systems (RES)**	
	CONNECTED	N31-AL.4B; N11-EP.1B	
Description	The action considers installation of PV systems on the covered surface of each municipal/province public building, to satisfay the energy needs according to the last consuption inside the SEAP. PV system installed will be with following characteristics: losses of PV system measured to a first approximation about 15%; losses of the inverter that are provvisionally assumed of about 10% and an optimally-inclined surface of 35°. This action will agree with: decrising consuption of elecrticity, decrising emissions of $CO_2$and reducing the cost of the electricity consuption. Planned use of covered surfaces, will make it possible to exploit only the covered surface necessary to achieve totally energy needs of each building, so the leftover covered surface will be available to other RES.		
Area of Interest	Production from renewable energies		
Policy instruments	National and Regional Incentives		
Responsible for implementation	Municipatility of Matera, Province of Matera		
Activation period and	2013-2020		
Costs	€ 5.333.517,891		
Percentage of CO_2 provided (t/year)	**846,01 tCO_2**/year		
Renewable energy production provided (MWh)	**100% of the building energy production**		
Monitoring	Marker	Power rating of PV installed	
	Frequency of monitoring	Annual	
	Instruments and systems for monitoring	Analisys of Atlasole web data	
	Supervaisor of monitoring activity	Energy Manager/ Energy Bureau	

If we wanted to know and update the costs analysis, we have to consider the information inside contained in "Prezzario Regionale delle OOPP della Basilicata"[3] 2015 edition. It is considered appropriate to compare the estimate the SEAP prices of Matera town and "Prezzario Regionale delle OOPP of Basilicata", according to the national scale indicated in the article of Sole 24 Ore on 30 September 2016 written by Dario Aquaro. In the following scheme the estimate costs of operations are shown (Table 5).

[3] Price list of public buildings of Basilicata edition 2015 where in R section: "Sistemi per lo sfruttamento delle energie rinnovabili e l'uso razionale delle fonti energetiche", are described single items wich are part of RES technologies.

Table 5. Estimate investments costs

Estimate of collective investments			
kW installed	Annual MWh produced	Total emission reduction of tCO 2/year	Estimate cost €
1.828,00	2.400,00	846,01	5.333.517,891

6 Conclusions

Our proposal discussed in this work, refers to the GHI application, that was obtained through remote sensing data PVGIS-CMSAF[4] in order to define a pre-sizing procedure of PV systems inside the operation strategy provided by the SEAP.

The case study of Matera town, allowed to consider the necessity to compare the issues to contribute and promote energy renewal of existing buildings with the preservation issues connected to the historical and architectonical values of traditional built patrimony.

The town of Matera is a UNESCO site [26] is a relevant case study as it is characterized by a wide presence of public buildings inside the historical urban area. A work hypothesis is that of the target achievement of the energetic needs of the public heritage. Thanks to this work, it was possible to verify the possibility of this target even in presence of a wide preservation concerning the urban area in Matera town.

Through this methodological procedure it is possible build RES technologies according to the preservation of the historical heritage. This problem can be overcame if we take in consideration a dimension and an energetic balance on a larger scale. In fact, we suggest inside the SEAP, to achieve the objective of energetic efficiency and CO2 reduction with operations that are concentrated only on a portion of local public patrimony, respecting the preservation and the landscape values non-negotiable landscape value. It will be useful to compare such procedural schema with methods and models for real estate estimation (as recent concrete applications [27–29]) considering that energy renewal increase the market values of building contributing to generate urban renewal as additional value to take into account in such planning activities (cfr. [30]).

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