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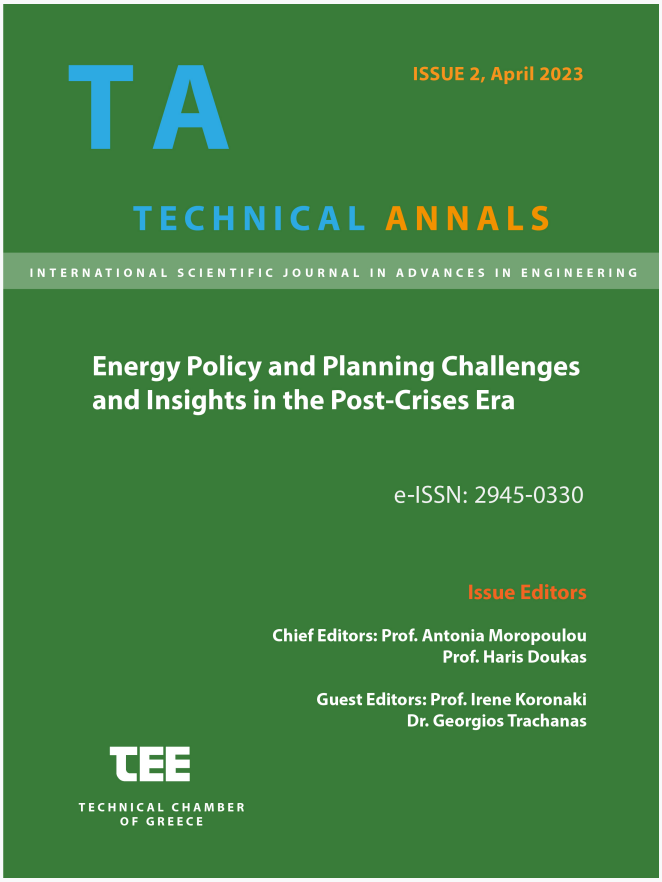

Historic building and green energy. Strategies to make supply from renewable sources compatible with conservation

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Historic building and green energy: Strategies to make supply from renewable sources compatible with conservation

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Abstract. The challenges of today are largely summarized in the United Nations 2030 Agenda. Buildings are also part of the 17 sustainability goals in several respects, one of them being the role of reducing greenhouse gas emissions, reducing waste, assessing the life cycle of materials, limiting heat loss and introducing renewable energy sources. In particular, the contribution deals with how to ensure the supply of energy from renewable sources for cultural assets and buildings that are part of historic centers. In these cases, it can be very difficult to achieve both the objective of protecting the monument or landscape as well as that of installing or connecting the building or urban or rural settlement to renewable energy sources. Through some European and Italian examples in particular, where about 8 million buildings were constructed before 1945, about 25% of the total, virtuous ways will be presented that make it possible to achieve both objectives simultaneously. The regulations that favor this dual objective will also be highlighted, such as the one of the Veneto Region on so-called energy communities and the national one that allows the deferral of energy production from one place of cultural interest to another that has none, without serious costs for the final beneficiary and safeguarding the cultural asset.

Keywords: Cultural Heritage, Climate Change, Green energy

List of abbreviations and acronyms

SDGs, *Sustainable Development Goals*
ICOMOS, *International Council on Monuments and Sites*
CE Delft, *Catalysis Engineering (Delft University of Technology)*
ENEA, *National Agency for New Technologies, Energy and Sustainable Economic Development*
PNRR, *National Recovery and Resilience Plan*
PNIEC, *National Integrated Energy and Climate Plan*
APE, *Energy Performance Certificates*
BIPV, *Building Integrated Photovoltaic systems*
BAPV, *Building Applied Photovoltaic*
D. Lgs., *Legislative decree*

CoP, United Nations - Climate Change - *Conference of the Parties*
COM, *referred to European Commission*
EU, *European Union*
MW, *Megawatt*
TWh, *Terawatt-hours*
GWh, *Gigawatt hours*
RES, *Renewable energy source*
IPPC, *Intergovernmental Panel on Climate Change*
MtCO2eq, *Million Tonnes of carbon dioxide equivalent*
Mtoe, *Million tonnes of oil equivalent*
EURAC, *private research center based in Bolzano*
SUPSI, *University School of Italian Switzerland*

1. Introduction

After the Millennium Summit in 2000, the first sustainable development goals (Millennium Development Goals) were introduced. These were the basis for the adoption of global policies and measures, while also the first commitments of states to achieve sustainable development goals were defined. Since then, the green transition has not only served to improve the quality of the environment, but has also become «a new paradigm aimed at reducing the risks associated with global threats such as climate change, loss of biodiversity, desertification, and depletion of natural resources, while at the same time enhancing social and economic well-being» [1,2].
2015 was the year of the *Sustainable Development Goals* document, better known as *Agenda 2030* and shared by 193 countries of the *United Nations*, containing universal goals, to be achieved by 2030, consisting of 17 SDGs and their 169 targets, the result of integrating the elements of environment, economy and society. Many of these objectives are relevant to the principles of heritage conservation, with the aim of limiting the use and waste of resources and land. As far as energy is concerned, in the logic of the ecological transition, the supply of energy efficient renewable energy sources plays a decisive role, an area in which buildings are important, requiring attention with respect to plant evolution and with respect to the technologies offered by the market in the field of renewable energy.
In the face of such significant and global goals, a certain capacity to ground measures and policies is needed because «localizing the SDGs means much more than 'landing' internationally agreed goals at the local level. It means making the aspirations of the SDGs a reality for communities, families and individuals, particularly those at risk of being left behind. Local governments are crucial in the process of transforming the *2030 Agenda* from a global vision to a local reality. And local communities, stakeholders who know best about individual and collective needs and capacities, are key partners in the implementation and delivery of the global agreement» [3]. 2015 is also the year of the *Paris Climate Agreement*, which calls for the countries involved to respect the temperature increase by 2100 to a maximum of 1.5-2 C°. First among all continents, the European Union is devoting many measures and resources to the theme of improving the quality of architecture, initiating processes of redevelopment and efficiency of

the building stock, reducing pollution and land consumption, priority objectives that can be traced back to the *New European Bauhaus* and *Green Deal*.

2. Energy and European Historic Buildings: Present Situation and Perspectives

2.1 The 2030 Agenda and the Europa Nostra and ICOMOS cultural role

In Europe, about 30% of buildings can be considered historic. Of these, between 2% and 5% in the different states [4] are buildings with specific levels of protection of cultural origin. The global goals signed in the *Paris Agreement* - in the different global COPs and those contained in the *2030 Agenda*, as well as the related European goals set out in the *Green New Deal* aiming at decarbonization and reduction of global warming gas emissions and the goal of zero land consumption in 2050 - require each country to move in a coordinated way with the others and with a certain urgency to implement appropriate measures. It is noted that the role of Cultural Heritage is considered not only part of the problem but also of particular significance.
The Green Paper on European Cultural Heritage (2021, Europa Nostra, ICOMOS, ClimateHeritageNetwork) «argues convincingly that our cultural and natural heritage is fundamental to realizing the ambitions of the European Green Deal [...]. The rich and diverse landscape of our continent is also deeply intertwined with cultural heritage, being tangible or intangible, urban or rural, inland or coastal. Climate change, consequently, affects both people and their living and working environments. [...] But cultural heritage is also part of the solution» [5].
The 2019 ICOMOS document entitled *The Future of your Pasts: Engaging Cultural Heritage* also addresses the issue of climate change in relation to cultural heritage and the new associated risks. According to ICOMOS, climate change exacerbates risks and threats, and therefore determines the urgency of improving good conservation practices. Cultural heritage can play a decisive role for the challenges of this era as «cultural factors determine the enabling conditions for adaptation and mitigation, including whether and how people respond to calls for climate action. Recognition at the highest political levels of the role of cultural heritage, together with the urgency of the challenges of climate change, creates a profound opportunity and a challenging responsibility for all those connected with heritage» [6].
In Europe, on average, buildings account for 40% of energy consumption and 36% of the emission of greenhouse gases. With the *Fit for 55* package [7], the European Union aims to reduce harmful emissions by 55% by 2030 compared to 1990 levels. A building in the lowest energy class consumes 10 times as much energy as a zero-emission building: the aim is to encourage member states to make buildings more comfortable, more efficient, reducing the use of fossil fuels, combating energy poverty and polluted air, both at building and city scale.

2.2 The European directives on buildings energy efficiency

Since 2010, a series of directives concerning the energy efficiency of buildings have been disseminated. In 2021, with communication COM (2021) 802 - final [15], a significant proposal was presented to improve the EU 31:2010 Energy Efficiency Directive [16], already amended by Directive 844:2018 [17] and Directive 786:2019 [18]. The final draft, after a lengthy discussion and a considerable number of amendments, is awaiting consideration by the European Parliament and European Council for final approval. The proposal for new directives on the energy efficiency of the built heritage is intended to align the rules for the energy performance of buildings with the Green Deal and give the necessary impetus to complete the process of decarbonizing the building stock by 2050. What had emerged from previous evaluations [4] about the possibility that listed historic buildings would no longer be exempted, in the form of a derogation, due to their characteristics and represented value, seems to be definitively overcome.

However, the reliability of energy performance certifications and the consideration of interventions for their overall environmental impact are still issues under discussion, even though the energy performance certifications of buildings will have to report the relevant life cycle emissions and a green license will be introduced. The December 2022 proposal exempted from the obligation of energy efficiency policies historic buildings - to be identified by each state - places of worship, temporary buildings with a time of use of less than two years, industrial sites, workshops, and non-residential agricultural buildings with low energy demand; residential buildings that are used or intended to be used less than four months a year or with energy consumption of less than 25% of the estimated annual consumption - so-called holiday homes - and finally detached buildings with a total covered useful floor area of less than 50 square meters. With regard to the target, the new proposal is more restrictive than that of December 2021, which envisaged the transition from energy class G to at least F, by 2027 for non-residential buildings and by 2030 for residential buildings, but allowing a longer period for the transition. The first step concerns new buildings, which must be zero emissions ones by 2030, a target to be brought forward by two years for public buildings. In general, new buildings must reduce energy requirements and at the same time be powered as much as possible by renewable energy sources.

New minimum energy performance standards are proposed, starting with a share of each Member State's building stock with the worst energy performance, which will have to rise progressively by one or more classes, starting in 2027 and 2030, in order to reach zero emissions by 2050, fulfilling the requirement to alleviate energy poverty and achieve targets for drastic reductions in greenhouse gas emissions. It is noted the introduction of minimum energy performance standards, based on the behavior of each state with respect to energy efficiency and decarbonization targets, also defined as a national target of progressive decrease of the average primary energy consumption of the entire building stock in the period 2025-2050, aimed at achieving the important goal of zero emissions by 2050. For existing buildings, the directive aims to introduce minimum energy performance standards corresponding to the maximum amount of primary energy that buildings may use per m² per year [9].

Two very significant conclusions derive from this set of efficiency standards:

- the first is that all national ecological transition plans will have to be fully integrated into energy and climate plans, because these two issues are interconnected;
- the second is that to achieve certain ambitious decarbonization targets by 2050, the European Community and the member states will have to develop a powerful policy of economic subsidies: according to estimates, the transition from the lowest class to class F will affect about 30 million out of more than 210 million buildings in Europe, and up to 150 billion Euro will be allocated for the implementation of minimum energy performance measures until 2030 to facilitate the transition.

2.3 Are we moving towards new ways of using energy?

Besides the topic of energy efficiency, the technological evolution of renewables is also a central issue with respect to the environmental sustainability goals. According to an Italian study [8], today the independence of citizens is assuming an increasingly significant role in the context of the current energy supply dynamics, which the crisis of fossil fuels on the one hand, and the increase in prices due to the geopolitical context on the other, has made an important issue. European governance seems to favor these dynamics, allowing more control over energy choices, which is likely to lead to a truly revolutionary reform of the energy market within a few years. The study states that «according to a report published in 2017 by the Transnational Institute and the European Federation of Public Service Unions entitled *Return to public management of basic services: Municipalities and citizens close the privatization chapter* in recent years there have been at least 835 cases worldwide of a return to municipalized service of public utilities involving more than 1,600 cities in 45 countries» [8]. Among the most significant cases is that of Hamburg, Germany, where «a new public company (*Hamburg Enèrgie*) was established with the aim of building plants powered by renewable sources and marketing the energy produced. The initiative [...] resulted in the installation of more than 13,00 MW of wind power and 10,00 MW of photovoltaic power, involving local citizens and businesses as co-investors. In less than 10 years, *Hamburg Enérgie*'s customers have grown to over 100,000» [8].
Similar cases to Hamburg have also occurred in Spain, in particular in Barcelona, where thanks to the municipal company *Barcelona Energia*, the supply of renewable energy for 3,900 public consumers in 2018 was increased to 20,000 private consumers in 2019 at market prices throughout the metropolitan area [8]. The same study reports on the initiative of Nicola Sturgeon, Scotland's first minister, who in 2017 proposed the creation of a public company to provide 100% renewable electricity especially to low-income households.
The forms of citizen involvement in these open processes of the energy market are also different from those of municipalization processes, thanks to the impetus of market liberalization: «With the activation of the liberalization process and thus the opening up of energy production and sales activities to competition, other companies were allowed to enter the electricity system. And it is precisely the characteristics of renewable energies, which are extremely widespread throughout the territory, that suggest an alternative model for organizing the energy system and in particular the electricity system. A widespread system, where the consumer can also be a producer» [8]. The form that is most likely to favor these processes of diffusion of renewable energy users is undoubtedly the cooperative form, in which users join together in aggregated associations.

This has already happened in many European countries and represents a phenomenon of definite interest for the near future in Europe: «Denmark was in many ways a pioneer, hosting almost 1000 cooperatives in 2000. *Ecopower* is active in Flanders: established with 30 members in 1990, it now has more than 50,000 members who have invested more than 50 million EUR and provides electricity to more than 1% of Flemish households.
Som Energia was founded in Girona in 2010 and has 57,000 members and almost 100,000 contracts throughout Spain.
In Germany, cooperatives active in the energy market increased from 86 in 2006 to 1024 in 2016, including almost 200,000 members in total. Taken together, German energy cooperatives sell more than 80 TWh per year (or 15% of the German electricity market).
In a recent study by CE Delft (*The potential of energy citizens in the European Union*) it is estimated that by 2050 more than 250 million European citizens could contribute to producing the electricity they consume [...] and cooperatives could reach 16% of European electricity supply.
In Italy there are currently more than 30 cooperatives serving almost 50,000 consumers through 1,000 km of grid for a total of about 200 GWh per year» [8].

3. Some suggestions and good practices from Italy

3.1 Two measures: *façade bonus* and *ecobonus*

The Italian government has introduced forms of incentives for the realisation of interventions to improve the efficiency of the building stock, historical and protected buildings. There are essentially two measures: the so-called *façade bonus* and the *ecobonu*s.
The *façade bonus* is a tax relief consisting of a tax deduction of 90% of the expenses incurred in 2020 and 2021, and 60% of the expenses incurred in 2022, for interventions aimed at recovering or restoring the external façade of existing buildings, of any cadastral category, including instrumental properties. The buildings must be located in historic centres. Only interventions on the opaque structures of the façade, on balconies or on ornaments and friezes are eligible for the benefit, including those only for external cleaning or painting. On the other hand, the bonus does not apply to work carried out on the building's internal facades if they are not visible from the street or from ground for public use. The measure aims to combine objectives of decorum with those of efficiency, except in the case of building envelopes that are not suitable for this dual purpose.
The *Ecobonus* - also known as *superbonus* - is the tax relief introduced in 2020 that consists of a 110% deduction of the expenses incurred from 1 July 2020 for the implementation of specific interventions aimed at energy efficiency and static consolidation or reduction of the seismic risk of buildings. Facilitated interventions also include the installation of photovoltaic systems and infrastructure for recharging electric vehicles in buildings. The main objective is to achieve energy efficiency in buildings, without neglecting other objectives. To obtain the tax benefit, the interventions must lead to a jump of two energy classes.

To date, the measures have cost the Italian state over 68.7 billion EUR for a total of over 359,000 buildings [19], just over 2% of the Italian building stock. It will be necessary to take more analysis in the future, but it already seems clear that the number of buildings that have benefited from the *ecobonus* measure, now
relaunched with a lower tax benefit quota, is very small compared to the total and, on non-listed historical buildings in many cases, in the absence of specific sector regulations, it is common to carry out interventions that seriously alter their historical and documentary qualities.

3.2 The perspective of the National Recovery and Resilience Plan and other energy transition plans

The goal of the national PNRR (*National Recovery and Resilience Plan*) for the ecological transition involves a total investment of almost 70 billion EUR with the aim of reaching 30% renewable energy by 2030, increasing this to 70% by 2050. In addition to these operational measures, which have shaken up the market and put Italy in the position of having drawn up and applied a regulation that goes in the right direction, in the author's opinion, it is in line with the declared objective of the *European Green Deal* to «start a wave of renovations» of public and private buildings, a *National Integrated Energy and Climate Plan* (PNIEC) [10] that was drawn up and approved. Basically, the plan follows two points of European policy to drastically reduce pollutant emissions by 2030 and to achieve full decarbonization by 2050. Looking in detail at the individual sectors, the most significant contribution to CO2 emissions is made by transport and civil sectors (residential and tertiary), which account for 100 and 72 MtCO2eq respectively by 2020 out of a total of 278. The Plan interfaces with other actions and envisages a strategy characterized by multiple measures to achieve certain targets. On the one hand, limiting our considerations to the civil built heritage sector, «the reduction in emissions to 2030 compared to 2005, in the PNIEC scenario is around 35 MtCO2eq and reflects the expected acceleration in the rate of energy efficiency of existing buildings, reinforced by a greater diffusion of deep redevelopment interventions and the application of particularly high-performance technologies» [10]. Also, at national level, the binding European target of at least 32% of energy from renewable sources in 2030 will have to be pursued in order to facilitate the implementation of the energy mix that will progressively move away from fossil fuels according to the following contributions: «55% share of renewables in the electricity sector; 33.9% share of renewables in the heat sector (heating and cooling uses); 22% incorporation of renewables in transport» [10]. With reference to the electricity sector, in addition to other sources for which limited growth is expected, such as geothermal and hydropower, in order to direct the deployment of the significant incremental capacity of photovoltaics envisaged for 2030, the «Plan envisages promoting their installation primarily on buildings, canopies, car parks, service areas, etc.'. However, it remains important for the achievement of the 2030 targets that large ground-mounted photovoltaic systems also be deployed, but giving priority to unproductive areas, not intended for other uses, such as areas that cannot be used for agricultural purposes. In this perspective, realizations in already artificial areas [...], contaminated sites, landfills and areas along the infrastructure system should be favored» [10]. With reference to the heating sector, the intention is also to encourage the spread of heat pumps, which, «given their high efficiency, will have an increasing weight in the renewable thermal mix, further supported

by technological progress in the sector»[10]. Furthermore, again according to the PNIEC, «an increase in the share of thermal RES will also be achieved through widespread redevelopment of the existing building stock leading to a significant reduction in consumption» [10]. As also shown by the trend reported in the latest IPCC report, with reference to the year 2017 - the first useful year in which the PNIEC was drawn up-, energy consumption marks the strong incidence of the civil use sector, 45% of total final consumption, up by 7.4% compared to 2016. Of this 45%, 29% of the total is absorbed by the residential sector, while 16% is absorbed by the service sector, which is the one with the highest growth. As is well known, in order to achieve the binding national target of decarbonization and the introduction of adequate RES quotas for both the electrical and thermal sectors, the main instruments in the field to promote the use of thermal renewables are often integrated with those for energy efficiency and are already operational, and a considerable share of these resources are allocated to the measure of tax deductions for energy efficiency measures and the building renovation of existing building stock. According to the PNIEC it is estimated that «as a result of the measures in force today by 2030 it will be possible to achieve annual energy savings from building redevelopment of 5.7 Mtoe, of which 3.3 Mtoe from the residential sector and 2.4 Mtoe from the tertiary sector (public and private)» far greater than that expected from the industry sector (1.3 Mtoe) and the transport sector (2.6 Mtoe), which confirms the significant role in achieving the de-carbonization and energy efficiency objectives represented by the building stock. Although the potential for energy savings in the civil sector is very large and can often be attributed to energy efficiency measures with sustainable payback periods, a great deal of effort is required to overcome congenital difficulties in the processes and in the various fields of application.
It is interesting to note that the PNIEC identifies - in addition to the need to strengthen minimum standards and regulations and the related checks and controls - the introduction of measures to improve the quality of Energy Performance Certificates (APE) and ways to encourage the purchase of high energy class homes, strategic objectives such as «improving the compatibility between energy efficiency objectives and the use of renewable energy sources in buildings, the possibility of introducing energy efficiency obligations during renovations, justified in terms of cost-benefit ratio, and the promotion of synergies with renewables in self-consumption» [10].

3.3 Can the “energy community” and the “on-site exchange elsewhere” radically change the ways of energy supply?

As well explained by the Veneto Region architect Franco Alberti in a conference promoted by the University IUAV of Venice, «the energy community is based on the decentralization of energy production» [11], favoring the sharing «in energy communities of citizens, associations and business entities, which share a set of principles and rules and procedures concerning the management and governance of the community, towards self-management and sharing of resources. End customers, consumers of electricity, can join together to produce locally, through renewable sources, the electricity necessary for their own needs» [11]. A 2022 law of the Veneto Region promotes energy communities and sets a series of goals in line with some European best practices and the guidelines of the national PNIEC, responding to the current energy crisis by setting the following series of goals:

- promotion of local development in terms of competitiveness, environmental sustainability and circular economy;
- contribution to the achievement of energy autonomy and sustainable energy transition as well as to the fight against energy poverty;
- innovative energy supply, distribution and consumption model to facilitate the production and exchange of renewable energy, energy efficiency and reduction of energy consumption [12].

«After about a year of experimentation», Alberti continues, «now this decree introduces important new features in the field: plants will be able to reach a higher maximum output and communities will be able to relate to much larger territorial portions, encouraging greater investment and benefits for users. We are therefore moving towards a greater dimension of energy communities, given their role both in the ecological transition and in achieving the climate and energy objectives of the coming decades: consider that ENEA predicts that in 2050 there will be 264 million prosumers, who will produce up to 45% of the EU's renewable electricity» [11].
Another measure that may be very important in the future to encourage a widespread diffusion of energy from renewable sources, without necessarily equipping historic buildings with such installations while safeguarding their characteristics, is the so-called on-site exchange elsewhere, whereby users can feed excess photovoltaic energy produced into the electricity grid and then withdraw it at a later date, without the need for the feed-in and withdrawal points to coincide.

3.4 Integrated photovoltaics as an innovative technology for energy efficiency in cultural heritage

A recent document called *Guidelines for the Integration of Photovoltaics in settings of historic and scenic value* [13] aims to provide suggestions for the design and installation of integrated photovoltaic systems in contexts protected by Italian standard of protection of cultural property (D. Lgs 22/01/2004, n. 42) in the Lombardy Region. The paper was produced within the framework of the *Interreg 2019-2022 research project IT-CH - BIPV MEETS HISTORY - Creation of a new value chain for architecturally integrated photovoltaics in the energy rehabilitation of the historical built heritage*. The project was carried out by EURAC Research, the University School of Italian Switzerland - SUPSI and the Lombardy Region.
The approach and methodology used led to particularly innovative outcomes with respect to the issue of the provision of energy supply systems from renewable sources in areas of historical buildings and landscapes endowed with artistic and historical values, in a cross-border territory located between Italy and Switzerland.
In particular, the study highlighted the significant prospects for the use of BIPV (Building Integrated Photovoltaic) systems, building-integrated photovoltaic technology, which go beyond the logic of traditional BAPV (Building Applied Photovoltaic) systems, which are in fact plant systems that are installed or placed on existing elements, but are components of the building envelope such as roofs, appendages such as canopies and canopies, shading systems, parapets, curtain walls, etc.
Given today's standards and technologies, BIPV is the «technology that is most easily applied in historical and landscape restoration projects» [13]. Among the elements to be paid attention to, is in particular the need to carry out an integrated design and to define a balance between aesthetic, technological and energy aspects: «photovoltaic

systems must be given an architectural value so that their insertion, especially on the historical-architectural heritage, is designed in an integrated way, also from a compositional point of view» [13]. In addition, «a site-specific assessment for each intervention remains essential, which takes into account and organizes the constructional, material, chromatic and compositional characteristics of the building, the broader landscape context in which it is inserted and the technological and plant engineering aspects of photovoltaics» [13].
It is also considered to highlight the Italian Decree Law 17/2022: the rule was drafted to respond to the challenge of energy transition and decarbonization, as well as the increase in electricity and gas prices. It provides for the introduction of measures to simplify and incentivize the installation of renewable energy systems, with specific reference to solar energy, both thermal and photovoltaic.
The law made some changes to the regulation to allow its application also in historical centers, with the exception of areas subject to landscape constraints, where prior authorization is still required, being understood that even for buildings located in constrained historical centers, installation is free if it is done with «panels integrated in roofs that are not visible from external public spaces and panoramic viewpoints, except for roofs whose coverings are made of traditional local materials».

4. Conclusions

The international scenario calls for stringent measures to reduce greenhouse gas emissions from the building sector, which alone accounts for about 40% of the total emissions. In Europe, a large part of the building stock is represented by historic buildings, some of which are also listed, in very small percentages.
If these buildings can be excluded from the application of the relevant efficiency directives, about 20-25% of the total buildings on the continent, to what extent will they be affected by the ecological transition? The green energy supply component is substantial, firstly because it is necessary along with insulation to increase energy efficiency and also because it serves to reduce the carbon emissions that are produced by traditional domestic systems. All European states, including Italy, are trying to work out measures to make this transition, which will possibly require substantial resources. The ability to build streamlined regulatory measures will be useful, resorting to energy supply systems different from the traditional ones, which favor communities and the dislocation of the place of production from that of consumption. Likewise, the results of technological innovation will be very important.
In conclusion to this short series of reasoned information, we share what has appeared in an Italian newspaper in 2021 [14]: one of Italy's leading cultural heritage experts, Salvatore Settis, warns that we must soon move from an abstract opinion on renewable energies to the concrete exercise of substantive choices, also pointing out that wind and photovoltaic plants can also have a negative impact on the historical landscape. The expert rightly points out that the issue can lead to a choice between two mutually relevant instances such as landscape protection and ecological transition, and that a balance is needed so that one does not override the other [14].

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