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Planning for Energy Efficiency in a Historic City. The Case of Santiago de Compostela, Spain

Ana María FERNÁNDEZ-MALDONADO[1], Patricia LIÑARES MÉNDEZ[2], Esteban VIEITES MONTES[3]

[1] *Delft University of Technology, Faculty of Architecture and the Built Environment, Department of Urbanism, Delft, THE NETHERLANDS*

[2] *University of Vigo, Department of Natural Resources and Environment, Vigo, SPAIN*

[3] *University of Santiago de Compostela, Technological Research Institute, Santiago de Compostela, SPAIN*

*E-mail:*a.m.fernandezmaldonado@tudelft.nl, plinhares@uvigo.es , esteban.vieites@gmail.com

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A B S T R A C T

Santiago de Compostelais well-known for its historic core of exceptional quality, as a World Heritage Site. Due to its mild climate, its large amount of green areas, and its compact urban pattern with mixed functions, it has a low level of residential energy consumption, but not in its historic core, in which monumental buildings of different age combine with dwellings in a pedestrianised urban environment. The European 20-20-20 targets present big challenges for historic areas such as Santiago. The present study assesses Santiago's strengths and weaknesses in terms of urban planning and energy efficiency, and explores what local planning can do for the adaptation of the historic centre to energy-efficiency considerations. The findings show that local plans have paid attention to environmental issues differently in the past decades, according to each period's priorities. Only recently, local planning has address ed energy efficiency issue, mainly in the case of public infrastructure. They also suggest a limited capacity of the local authorities to pursue energy efficiency goals at a residential level, and serious lack of knowledge about the actual energy situation. A proactive role of the local government towards energy efficiency requires the commitment of all stakeholders. The presence of institutions specialized in urban regeneration, such as the 'Consorcio', gathering the most important local stakeholders, suggests positive outcomes if long-term coordination is achieved.

1. INTRODUCTION

Santiago de Compostela is the capital city of the Autonomous Community of Galicia, well-known as the end destination of the Way of Saint James, a popular European pilgrimage. In terms of energy-efficiency, Santiago enjoys several qualities of a low residential energy consumer. It is blessed with a mild climate and abundant green areas, while its local urban planning has stimulated an urban pattern which has maintained the compactness and mixed functions of the traditional Spanish urbanism. There is, however, an important aspect that needs to be tackled by the city to be on the right track towards energy efficiency: the adaptation of the historic centre's buildings to bioclimatic considerations in the context of strict levels of protection of the built environment. Due to Santiago's exceptional historic core, local planning regulations have changed priorities during different periods, but have always shared the objective of conserving, regenerating and maintaining the spatial quality of its built environment.

The *Plan Especial de Protección e Rehabilitación da Cidade Histórica (PE-1),* successfully addressed the regeneration process, stating/setting strict levels of protection and minimum conditions for liveability, thus becoming a model process for similar Special Plans in Spain. The review of PE-1is expected to include aspects of environmental, social and economic sustainability, which were not considered in the original plan, promoting energy-efficiency for the (new) buildings. The objective of the present study is to assess Santiago's present situation in terms of urban planning and energy efficiency, by identifying their strengths and weaknesses, and exploring possible avenues for local planning to promote and orient the adaptation of the historic centre to the energy-efficiency considerations required to confront climate change. The paper begins with a theoretical part, referred to aspects of energy efficiency in the case of historic buildings. The empirical part addresses three different aspects of Santiago: the evolution of its urban environment, the successive urban planning regulations and the energy context.

The conclusions summarize the findings and discussion, recommending measures to improve the energy efficiency situation of the city of Santiago.

2. THEORY AND METHODOLOGY

2.1. Energy – efficiency and historic buildings

It is estimated that 80% reductions of CO_2 will be necessary to tackle climate change at a meaningful level in the long term. The EU implemented the so-called '20-20-20' strategy, whose targets for 2020 are: 20% reduction in GHG emissions (from 1990 levels); 20% increase the production of renewable energy; and 20% improvement of energy efficiency. "In the context of historic sites, these targets present very significant challenges, due to the considerable restrictions on what is and is not permitted on buildings and in their surroundings for such sites – these restrictions too often sit at odds with climate change and other targets" [1, p. 3].

The strategy includes several directives and related measures (see Table 1). However, they do not clearly mention the historic buildings. Art. 4 of the Energy Performance of Buildings Directive (EPBD) states that member states may decide not to apply the energy requirements in the case of *"buildings and monuments officially protected… where compliance with the requirements would unacceptably alter their character or appearance"* [2, p. 26].

Table 1. Main measures of the EU directives for tackling climate change *(adapted from [3])*.

EPBD (Energy Performance of Buildings Directive)	RED (Renewable Energy Directive)	EED (Energy Efficiency Directive)
Application of minimum requirements on the energy performance of new buildings and large existing buildings subject to major renovation	To set up sector-specific targets for renewable heating and cooling.	To establish a long-term strategy for investment in renovation of the stock of residential and commercial buildings, both public and private.
Energy performance certification of buildings	Adopt support policies for RES-H at least for new buildings and existing buildings subject to a major renovation.	Member states must ensure a refurbishment rate of 3% per year of the total floor area of all heated and/or cooled buildings (> 500 m2) owned and occupied by their central governments
Regular inspection of boilers and air-conditioning systems in buildings; assessment of heating installation if boilers are older than 15 years	Defines technology specific restrictions for heat pumps and bio-liquids.	Establish energy efficiency obligation schemes (White Certificate Schemes) for energy savings of 1.5% per year
All new buildings must be nZEB (nearly zero-energy building) in Dec. 2020 and all new public buildings in 2018.	Public buildings subject to major renovation must fulfil an exemplary role in the context of the use of RES-H.	Member states must promote the availability of independent high quality energy audits to all final customers.

The European Commission funds several programmes and projects for energy efficiency purposes in historic urban environments. An example of this is EFFESUS (Energy Efficiency in Historic Centres), whose purpose is to investigate the energy efficiency of the European historic urban areas, developing innovative technologies and systems (Santiago is a case study in EFFESUS). On the other hand, UNESCO has launched the RENFORUS Initiative (Renewable Energy Futures for UNESCO Sites) in 2012, to document the empirical evidence of the sustainable energy projects of UNESCO sites, committed to energy efficiency and renewable energy sources. Several European countries have developed national guidelines and recommendations for the renovation of heritage buildings for purposes of energy efficiency, although this topic has not yet received great attention in Spain [4]. The UK has been at the forefront of national recommendations, stating that achieving a proper balance between energy efficiency and conservation, a proper understanding of the technical aspects is required, on the one hand, and constructive aspects, on the other. *"... regard should be given to ensuring that the building is well understood, to avoid damage; minimizing disturbance to existing fabric; reversing the changes easily without damaging the existing fabric (especially changes to services); and appreciating that some buildings or parts of buildings are of such quality, importance or completeness that they should not be altered at all save in the most exceptional circumstances"* [5, p. 24].

In the impossibility to make all historic buildings nZEB (nearly zero-energy building), retrofitting interventions should then try to achieve the lowest possible energy demand without compromising the building's physical characteristics, while ensuring the financial feasibility of the process [6]. In Italy, recent legislation (Legislative Decree n°63/13) (2013) prescribes energy efficiency requirements for historic buildings, which were previously outside the scope of the energy saving legislation. Consequently, they have to draw up a certificate of energy performance (EPC), and go through inspections of the operation and maintenance of technical installations [7]. Based on this legislation, the university of Ferrara has used GIS to map the buildings' EPC in the city and its historic centre, resulting in an "energy map", useful to compare energy performance of different districts and not exclusively of single buildings [8]. Prestigious European centres for research on this topic are the Historic Scotland and the Architettura>Energia Centre of the University of Ferrara [4]. Scotland's environmental objectives are very ambitious: 42% CO_2 reduction for 2020 and 80% for 2050. To reach these goals, Historic Scotland has devised an Action Plan for 2012-2017 [9], whose strategy of energy reduction focuses on improving knowledge and skills in the construction sector. The main actions are:

- research into energy efficiency of traditional buildings, using pilot schemes in a range of building types;
- research with external partners in thermal comfort, air quality, embodied carbon and energy modelling;
- dissemination of these results to stakeholders including professionals, community groups and homeowners;
- coordination with the education and industry sectors to improve knowledge and skills in the construction sector training.

The Architettura>Energia Centre deals with energy and environmental upgrading of (new and) existing buildings, and has expertise in designing guidelines to increase the energy efficiency and environmental quality of the existing (historic) buildings. The centre also provides financial assessments for investments in energy efficiency, such as calculation of the amortization for energy saving measures, and calculation of the current value of energy efficiency investments [10].

Several studies propose methodologies for energy retrofitting of historic buildings. Vieveen (2013) has proposed a six-step methodology including: an inventory of heritage qualities; inventory of the technical conditions; explanation of current energy consumption; understanding the current user complaints; inventory of future user demands; and exploration of the potential energy interventions [11]. Filippi (2015) considers: improvement of energy performances of the building envelope; updating components of the air conditioning and lighting systems; management of natural ventilation; passive cooling; monitoring of the indoor environmental quality and energy efficiency by building automation systems; updating existing energy systems, exploitation of renewable energy sources; use of eco-compatible, recycled or recyclable materials [12]. De Santoli (2015) proposes guidelines with differentiated parts for the two professions interacting in the retrofitting interventions: the designer (for the constructive and use aspects), and the technicians (for the energy measures) [7].

Most of these studies focus on the building's technical and constructive aspects. However, sustainable interventions require to take into account three aspects linked to the sustainability pillars: heritage preservation (societal aspects); energy use (environmental aspects); and affordability (economic aspects). Few studies focus on aspects linked to the implementation and affordability of the works. Research shows that supportive financing schemes are crucial for the implementation of energy efficiency works in heritage buildings, thus legislation including such schemes can have a major impact. Herrera and Bennadji (2013) do include affordability issues in their proposed methodology for retrofitting interventions in historic buildings in Scotland [6], with nine criteria (see Table 2).

Table 2. Criteria to assess sustainability level of the retrofit interventions [5].

Environmental assessment	**Societal assessment**	**Economic assessment**
Energy use	Indoor quality	Affordability
Emissions	Thermal comfort	Maintenance
Material resources	Heritage preservation	Cost-effectiveness

Two relevant South-European experiences can be found in the Italian municipality of Genoa and the Spanish municipality of Tres Cantos. In Genoa, a *"Sustainable Energy Action Plan"* (SEAP) was successfully completed in 2010, following a three-phase programme (preparation, implementation, and monitoring) involving public institutions, private stakeholders and ordinary citizens, as a result of the municipality affiliation with the Covenant of Mayors (CoM). The Action Plan used the results of the *"Baseline Emission Inventory"* (BEI), which quantifies the energy consumption of a territory in a selected reference year [13].

The main goal was the achievement of 20% GHG reduction by 2020 in two main sectors: *"Buildings, equipment/facilities, and industry"* and *"Transport"*. The first one, accounting for 77% of the global consumption in 2005, is divided into municipal buildings (consuming 386,956 MWh in 2005), tertiary buildings (2,143,868 MWh), residential buildings (3,653,783 MWh), and municipal public lighting (37,800 MWh).

Several causes explain the low energy efficiency in Genoa's buildings, such as: age (about 95% of buildings in Genoa were built before 1971); limited use of insulating materials for outer walls, and often over-sized and inefficient one-family heating facilities. The SEAP became a key urban energy policy document, identifying major areas for improvement, in both public and private sectors.

In the case of Tres Cantos, a *"satellite city"* 22 km north of Madrid, a *"bioclimatic ordinance"* was issued and successfully applied to tackle the environmental situation [14]. The ordinance describes: (1) the object and scope of the ordinance; (2) urban design issues: the design of roads and parking, of open spaces and green areas; (3) construction issues (for new or rehabilitated buildings): incorporating active and passive techniques; and (4) monitoring, control and discipline aspects of the ordinance implementation. The ordinance followed a three-step methodology, which included the following:

a). Recognition of the environmental conditions, such as relief, landscape, drainage or surface water, vegetation, etc.

b). Identification of factors affecting climate and microclimate, especially wind and sun, to formulate the main strategies to achieve the objectives pursued.

c). Inclusion of strategies in the urban plan, integrating them in general urban systems (road network, facilities, green areas and open spaces) and drafting the necessary ordinances.

2.2. Methodology

Due to the important heritage aspects of the built environment of Santiago de Compostela, to address the relationship between planning and energy efficiency, this study has reviewed the literature on issues related to planning and energy efficiency of historic buildings, with a special emphasis on successful experiences in Europe. On the other hand, based on analyses of academic journal papers, local policy documents and plans, data sources at different levels, and interviews with relevant stakeholders done within the EU-FP7 project PLEEC (see [23] for details), the study presents a brief description of the historic evolution of the built environment of Santiago city, and explains the current situation and efforts of the local planning to tackle climate change aspects in the historic core of Santiago. A special attention is given to the 'Special Plan of Protection of the Historic City' (PE-1), its interventions and related programmes, due to the significance it has had to indirectly contribute to the favourable features of Santiago in terms of energy efficiency.

To understand the energy conditions in Santiago, our initial idea was to analyse data about energy consumption at municipal level, city level and district level. But several efforts to get detailed and updated figures on energy consumption from different sources remained unsuccessful, which gave us a first idea of the (limited) relevance of energy issues at local level. We worked with data of energy consumption in Galicia and the A Coruña province, but also made own calculations about energy consumption in the historic centre with the updated records (2008) of the Special Plan. Based on these analyses, we finally suggested measures to be taken into account to improve the energy efficiency conditions in Santiago.

3. RESULTS AND DISCUSSION

3.1. Historic evolution of Santiago de Compostela

In the ninth century, Santiago de Compostela became an important European city, as the destination of the Way of Saint James, which gave the city its name. However, the popularity of the Way was almost extinct outside Spain in the 14th century due to the effects of the plague, and later to the rise of Protestantism. During centuries, Santiago has remained a relatively unimportant European city, growing at a slow pace. In 1775, the first urban regulations were launched under the hygienist considerations of the time, the *Ordenanzas de policía* (Police Ordinances) [15], providing very specific norms for the local built environment. At the beginning of the twentieth century Santiago recorded an increase in the number of population, which led to a densification of its built environment. In 1908, its urban fabric almost coincided with what is today its historic core (see Figure 1).

Demographic changes leading to urban growth occurred in Santiago considerably later than in other

Spanish and Galician cities. This urban expansion delay produced the intensification of the use of the space in the historic core.

Due to its significant religious and cultural role, Santiago focused on the renovation and adaptation of the built environment of the historic core, to support its condition of historic and monumental town. The interventions involved the increase of building height, building galleries in the upper levels. In 1930, more than one third of the buildings had three floors and less than one sixth had only one floor [17], [18].

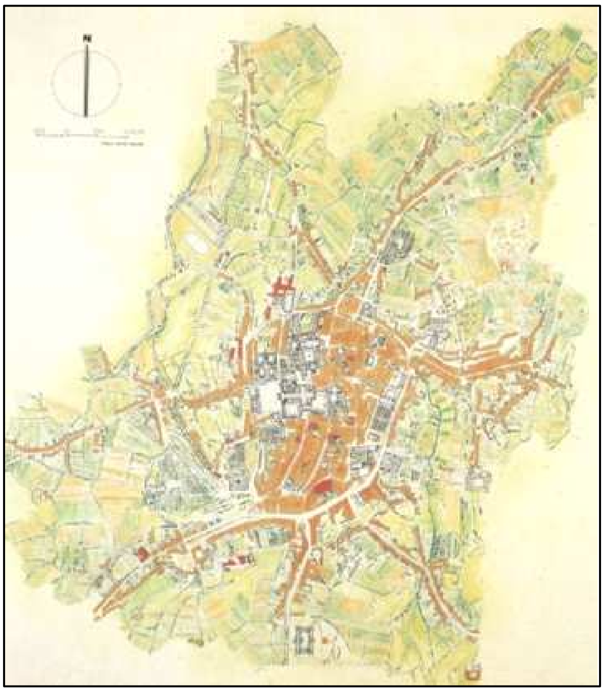


Fig. 1. Map of Santiago in 1908 [16].

The remarkable densification process and its consequences on the sustainability of the historic buildings were analysed by Liñares (2012). Figure 2 shows the evolution of a typical section of an urban block in the inner-city, from two-storey single family buildings with a large backyard during medieval times, to several-storey buildings during modern ages, and again to building structures with increased height and depth occupied by several families, with very little open space in-between. The latter process has severely damaged the bioclimatic qualities of the involved buildings and surrounding urban space, producing a negative impact on the energy efficiency of the urban fabric of the historic centre and the extensions that followed its development, as, for instance, El Ensanche [19].

At the end of the 20th century, two events improved Santiago's fortune. With the 1978 constitution and the establishment of Autonomous Communities in Spain, Santiago was appointed as the capital of Galicia and the seat of its government, attracting many new jobs and residents. In 1985, Santiago's historic centre was designated an UNESCO World Heritage Site. Not long after, the Xacobeo regional strategy was launched with the purpose to recover, diversify and internationalize the historic centre and the Way of Saint James [21]. Part of the strategy was the creation of El Consorcio (the Consortium) in 1992, a coordination body with members of the Spanish government, Galicia's regional government and Santiago's municipal government, the Catholic Church and the University, whose main objectives were to preserve and revitalize Santiago's cultural heritage and the development of cultural tourism related to the pilgrimage route. The whole strategy succeeded in improving the urban quality of the historic centre, developing tourism in the city and improving quality of life in the whole city [22]. The historic centre covers an area of 108 ha, with a buffer zone of 217 ha and has a remarkable state of conservation of civil and religious monuments. Middle Ages, Renaissance, and 17th and 18th century buildings are integrated into a high-quality urban fabric.

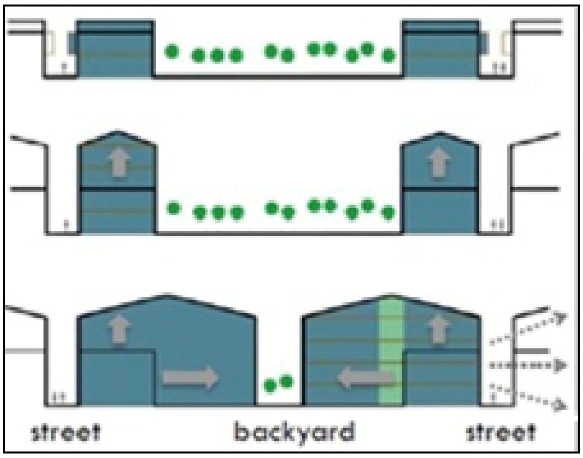
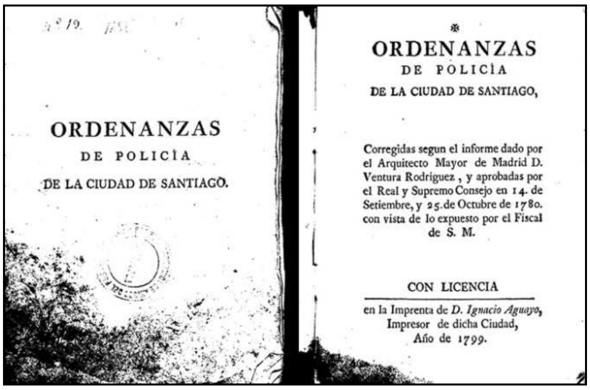


Fig. 2. Increase of building height and depth in historic houses in Santiago along past centuries [19].

In 1989, the city formulated a new General Plan of Urban Development (PXOM), which considered the depopulation of the historic centre as one of its most significant problems [23]. The plan promoted a compact urban growth, a continuous urban fabric, and a strict regulation for new developments. It was complemented by the *Plan Especial de protección e rehabilitación da cidade histórica* (Special Plan of protection and retrofitting of the historic city) (PE-1) (see section 3.3). They had as common objectives: (1) to promote the residential use of the historic centre; (2) to improve the pedestrian infrastructure, meeting places, and links between different parts of the city, eliminating vehicular traffic; and (3) to create green corridors in the historical city linking parks with rural landscape [22]. They have strongly contributed to the maintenance of Santiago's compact urban fabric resisting the sprawling trends of the construction boom that affected most Spanish cities from the 1990s until 2007 [23]. This compact urban fabric and its green urban structure are both favourable features for low energy consumption.

3.2. Successive planning and conservation regulations in Santiago

The first regulations, the *Ordenanzas de Policía* were approved in 1780 [15] seeking for the citizens' health and comfort, but for especially sanitary conditions (see Figure 3).



ORDENANZAS
DE POLICÍA
DE LA CIUDAD DE SANTIAGO.

ORDENANZAS
DE POLICÍA
DE LA CIUDAD DE SANTIAGO,

Corregidas segun el informe dado por el Arquitecto Mayor de Madrid D. Ventura Rodriguez, y aprobadas por el Real y Supremo Consejo en 14. de Setiembre, y 25. de Octubre de 1780. con vista de lo expuesto por el Fiscal de S. M.

CON LICENCIA
en la Imprenta de D. *Ignacio Aguayo*, Impresor de dicha Ciudad, Año de 1799.

Fig. 3. Front pages of *Ordenanzas de policía* [15].

They regulated building height, size and alignment, fire safety, waste management and water drainage. The façade's openings, position and size were standardized, in order to achieve certain homogeneity. Overhangs were demolished, ruined houses and arcades were removed, streets were paved and subterranean plumbing was installed. Local government's officials inspected the works and new constructions and architect Miguel Ferro Caveiro was appointed for the supervision of the works. The ordinances also addressed economic aspects: in case owners could not afford the intervention, public bodies would fund the works; if public funds were not available, private investors could assume the costs; and, in both cases, the investment would be later recuperated by renting the property.

During the 20th century, the conservation of historic buildings in (European) cities was tackled in different ways, according the priorities of the city authorities, since each city presents its own particularities. Gradually, the concept of rehabilitation – "*the minimum necessary intervention to improve, adapt and make liveable and able to host any function*" [24] – was widely recognized and adopted during the 1980s. This new concept replaced the first type of interventions, mainly based on the demolition of the building's interior to be rebuilt again, but keeping the façades in order to preserve the original appearance. Many cities start developing new plans according to this new concept, which resulted in specific regulations. Many Spanish cities elaborated Special Plans for their historic centres. Table 3 shows the most relevant Specials Plans of Spanish heritage cities, including Santiago's PE-1, which has been frequently cited for its innovative and comprehensive character.

Table 3. Main features on buildings and historic landscapes of Special Plans in historic cities of Spain [24].

Santiago de Compostela	Focused on basic health and sanitary conditions (running water, electric systems…) and conservation of the urban environment (aesthetic and archaeological aspects). Preserved orchards in the middle of the city would be cultivated and maintained by owners.
Oviedo	Initially, façades were preserved and interiors rebuilt. Only public buildings were subjected to massive rehabilitation.
Barcelona	Elimination of irrecoverable elements to create more open areas. Everything else is rehabilitated.
Bilbao	Included the historic city's business premises in the heritage catalogue.
Madrid, Valencia	Carried out first initiatives taking into account the energy efficiency aspects.
Segovia	The successful "Plan Verde de Segovia" *(Segovia Green Plan)* recovered the riverside area around the city, reforesting 68 ha.
Toledo, Pamplona, Logroño	Followed Segovia's example, promoting the riverside as leisure areas.
Gijon, Caceres, Teruel	Included relevant landscapes beside their historic cities, such as hills, old promenades and traditional areas, reforesting and gardening to transform them into leisure areas.
Sevilla, Malaga, Granada	Included special measures to maintain the refreshing features that the interior gardens of the Andalusian cities provide inside the city.

3.3. Special plan for the protection of Santiago (PE-1)

PE-1 was developed within the frame of the *Ley del Patrimonio Histórico Español* (1985), with the purpose to defend the local heritage against mere economic-driven developments [25]. PE-1 has been considered as a exemplary Special Plan, which included the classification of buildings according its heritage level; the strict regulation of (exterior and interior) interventions in buildings; and the careful documentation of heritage buildings. PE-1 distinguishes five areas in the historic centre according to heritage relevance, linking them to a particular set of allowed interventions. It also establishes four levels of building protection through a catalogue of the patrimony according to their historic or environmental values, while the non-catalogued buildings are under a generic protection. PE-1 also prepared 'building spreadsheets' with individual specifications (see Figure 4), which include the building's description, level of protection, area of intervention, main elements under protection and particular interventions. The fieldwork was carried out in 1988 and processed between 1992 and 1993, although the approval of the plan was delayed until 1997.

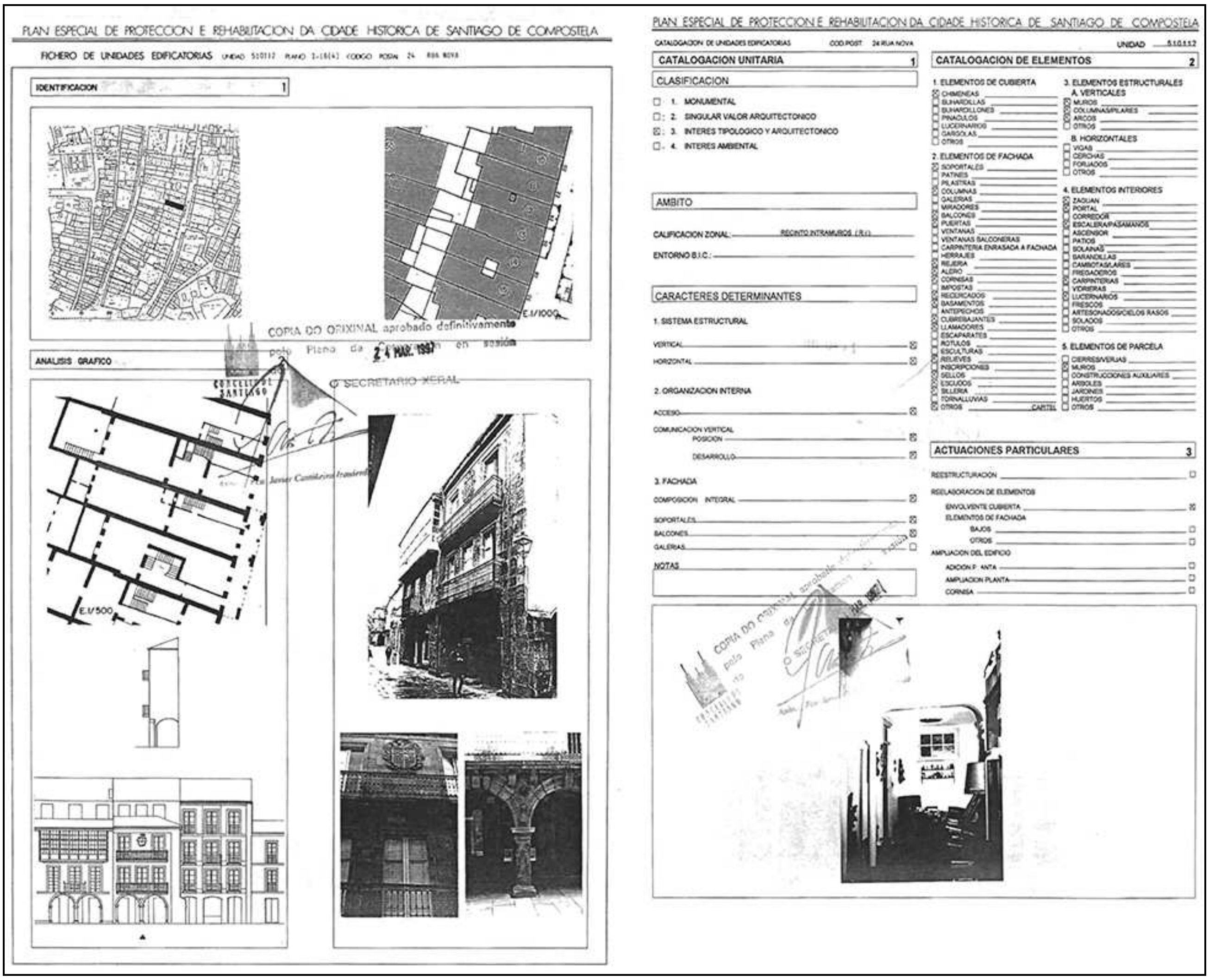


Fig. 4. Building records in the Plan Especial [25].

PE-1 focuses on the conservation and restoration of the buildings' visible elements, such as facades, walls, roofs or gardens that are visible from the street, describing different types of general interventions (conservation, restoration, rehabilitation, restructuration and extension) and particular interventions (facades and external elements, ground floor facades and external elements, partial interventions in dwellings and retail, and consolidation).

An important priority was to reach standard sanitary conditions in indoor spaces, because many buildings still lacked sanitary services. Article 30 states that buildings should have at least well-functioning electric, water supply and sanitation systems, as well as adequate sanitary conditions inside the building and free spaces. Owners must carry out works to assure aesthetic, security and sanitary aspects, but if the works would exceed 50% of the building's current value, the municipality would assume the extra-costs.

PE-1 has promoted the conservation of Santiago's historic urban environment, but it did not directly consider sustainability or energy efficiency aspects. Indirectly, however, it has greatly contributed to keep Santiago as a compact city, favouring energy efficiency. Regarding building volume, which determines the dwellings potential for day lighting, solar radiation and natural ventilation, PE-1stated that the constructions located in the inner core must respect the conservation of their volume and occupation rate, so both the main and back facades must be unalterable. Constructions behind the internal line established in the plans are not allowed and the rest of the plot must be maintained as free space. Current plot layout must be respected, and additions and subdivisions are forbidden. Further, location and dimensions of street facades, plot surfaces, occupation of surfaces, building heights and roofs are unalterable, unless differently specified. Some alterations of building depth are allowed under certain circumstances.

3.3.1. Interventions under PE-1 and related programmes

Interesting examples of retrofitting interventions have been carried out in important historic buildings by private institutions or households. The retrofitting activities have been supported by the national and regional government measures.

The *Consorcio has* had an important role through the programme *Recuperación Urbana* that began in 1992.

The agenda *'Ter é manter'* supports owner's initiative in improving the building envelope and common services. The financial support addressed to the improvement of the windows has contributed to raise the thermal resistance and the air tightness of the dwellings and to improve the aesthetics of the facades. Between 2006 and 2009, 170 dwellings received financial aids for windows improvement, (see Table 4).

The *Edificios Tutelados* (PET) programme promotes the renovation of empty buildings, financing the works with the rent of the property during 12 years, after which it is returned to the owners.

The success of PE-1 and related programmes have been evident. While in 1989, only 50.83% of all buildings in the city centre were in good condition, in 2008 the percentage went up to 83.35% (Figure 5, left). Regarding homes, in 1989 only a share of 62.3% was in good condition, which increased to 83.7% in 2008 (Figure 5, right).

Table 4. Interventions carried out under the program of window retrofitting, 2006 - 2009 [26].

	2006	2008	2009
Total	57	85	28
Cancellations	6	7	2
Refusals	0	3	0
Major interventions	0	7	6
Technical reports	39	69	20

PE-1's implementation had such an important role in improving the urban quality of the historic centre, that the European Commission and the European Council of Town Planners awarded the Special Plan the 1997-98 European Town Planning Prize in the category of Local Planning and a Best Practice Award from UN-Habitat in 2002 [22].

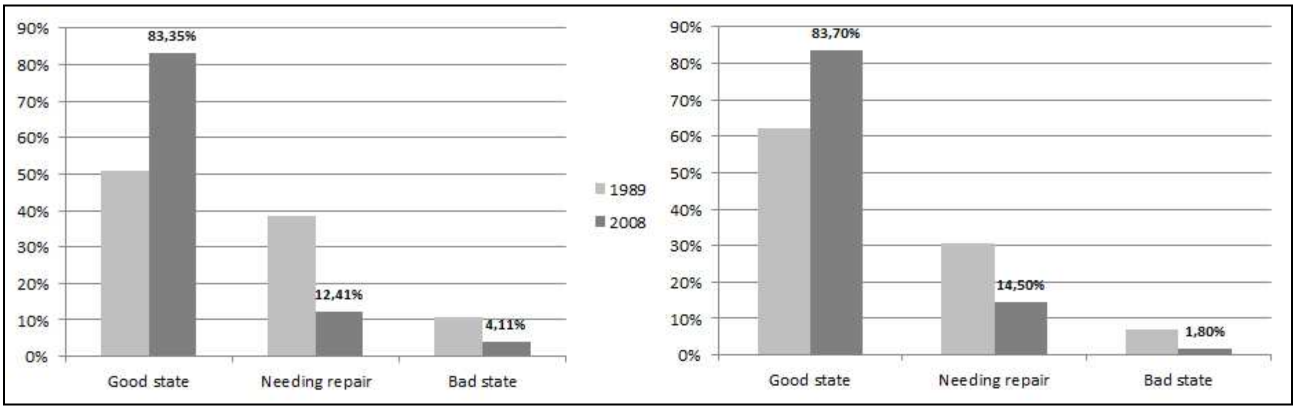


Fig. 5. Improvements of historic buildings (left) and homes (right) in the historic centre of Santiago, 1989-2008 [26].

To improve knowledge about the historic city the *Consorcio* created the Observatory of the Historic City, which uses an online GIS application, the Heritage Information System.

This contains abundant archaeological, architectural and urbanistic information of the historic city buildings, as well as related plans and historic maps. The *'building spreadsheets'* have been revised and extended for the review of PE-1, compiling more recent information regarding the residential and non-residential units and creating a digital database.

3.3.2. Revision of the special plan

In September 2013, the council of Santiago initiated a process to contract the revision of PE-1, which was adjudicated in November 2014 to the firm Thuban Estudio, S.L. The revision should include a Management Plan, a list of urban regeneration projects, and the preparation of ordinances and guidelines for the urbanisation and re-urbanisation of the historic core [27].

A main difference from the previous plan is the point of departure, which will change from a mere urban regeneration into a sustainable development perspective. PE-1 was addressed to improve the basic sanitary conditions, refurbishment and retrofitting the old buildings with minimum services (electricity, running water etc.), to make them more liveable preserving its heritage characteristics. The revision should go beyond those objectives, to tackle the conditions of the historic city from a holistic point of view, focusing on sustainability according to its three main pillars: social, economic and environmental aspects [28].

The new PE-1 will be elaborated according to the current technologies required by the local regulations and city needs, focusing in the following:

- integrating different tools of analysis to get a diagnosis of the territory considering sustainability aspects;

- proposing ways to design a spatial model to orient spatial development towards sustainability, taking into account the rational use of the natural resources, improving resiliency and the welfare of present and future generations;

- elaborating the *"Plan de Ordenamiento Territorial Sustentable para la Ciudad Histórica de Santiago de Compostela"* (Sustainable Territorial Ordering Plan for the Historic City of Santiago de Compostela). This plan will be systematically monitored by means of indicators, to allow for constant feedback.

The plan will include specific targets, prioritizing and fostering the residential function of the historic city. To recover the historic city for its permanent residents will require innovative renovation techniques, for which the flexibility of the new PE-1 will play a key role for the refurbishment of buildings. The refurbishment of heritage and non-catalogued buildings must reach a morphological integration, without neglecting the archaeological aspects. In such way, the revision should approach the refurbishment and retrofitting interventions giving special attention to the heritage, accessibility, technology and environmental aspects, not merely to build technically-fit dwellings but to use it as an integration resource [28].

Similarly, the revision will promote a more socially compact, cohesive and efficient city, by recovering local economy strategies, diversifying functions and users. Such *"forced"* relationship between different uses and sectors will develop the city's organizational complexity, to increase socialization and liveability levels.

Specific issues as mobility are also considered in the revision. Although the historic city is mostly car free, the accessibility and connectivity with the rest of the city must be ensured. Frequent communication through public transport, the continuous activity of charge and discharge to supply the commercial business as well as spaces, where parking is allowed will be under new specific regulations.

PE-1 will keep the preservation of the traditional orchards in the middle of the historic city, and other green areas in the outskirts, under obligation to be cultivated. The municipality grants the land rights to people who want to cultivate a little/small orchard. In such way, Santiago's historic district maintains 50% of surface of green areas [29], a singular feature that contributes to its sustainability.

3.4. Energy context in Santiago de Compostela

3.4.1. Energy planning

Santiago is a case study of three European projects: EFFESUS (Energy Efficiency in Historic Centres), FASUDIR (Friendly and Affordable Sustainable Urban Districts Retrofitting) and PLEEC (Planning for Energy Efficiency Cities). It is also present in several European initiatives for climate change and energy efficiency such as the 2020 Plan, the Spanish Network of Cities for Climate (Red Española de Ciudades por el Clima) and the Covenant of Mayors (CoM). Santiago's signatory status on the CoM, however, is currently on hold because it did not fulfil the obligation to submit its Sustainable Energy Action Plan (SEAP). Furthermore, a simple analysis of the local policies shows that local planning has not had any consideration on energy consumption or the promotion energy efficiency. The 2008 General Plan is very weak in terms of environmental sustainability, and it does not mention concepts of climate change, renewable energy or energy efficiency. In 2012, the Council began a process to contract the preparation of a Master Plan for Energy Efficiency and Sustainability, whose draft dates from February 2015. This draft plan has also been submitted by the city as one of the deliverables of the PLEEC project, an Energy Efficiency Local Action Plan, which was not supposed to be contracted in advance to the project, but to be the fruit of the many workshops and activities of the PLEEC project. The mentioned draft is quite disappointing, because from the four energy-consuming sectors: residential, business/ industry, municipal and transport, the plan only addresses the last two. Asked about this particularity, the local governments' officials mentioned the little normative power that the Spanish planning system offers to local authorities to influence energy efficiency for these sectors, claiming that they have no more power than issuing recommendations to residents and firms [23].

The lack of local knowledge about the whole energy situation is further complicated by the lack of statistics about energy at local level. The several attempts to get detailed and updated figures on Santiago's energy supply and consumption at municipal and/or district level from Santiago city council or the incumbent energy provider were unsuccessful.

To get an approximate idea of the energy context we first describe it at regional level: Galicia shows a high level of energy consumption (the total final energy consumption period increased by 38.2% in the 1997-2009); a high degree of energy dependency; and high levels of GHG emissions. Galicia transforms 9% of the primary energy of Spain, and imports 86% of the primary energy resources used. The level of self-sufficiency in Galicia was of 39.5%, decreasing to 23.6%

if oil products are considered [30]. Oil products constituted more than half of the total final energy consumption in Galicia, in 2009 (see Table 5).

Table 5. Sources of final energy consumption in Galicia, in 2009 [31].

Type of energy	Consumption (Ktep)	(%) of consumption
Oil products	3431	53.60
Electricity	1768	27.60
Renewable energy	724	11.30
Natural gas	475	7.40

Most of the energy consumption in Galicia comes from the industrial sector. In 2009, it was 47.4% of its total final energy consumption, whereas the residential and public services together only consumed 19.5%. The same indicators for Spain were of 33.3% and 28% [31].

Table 6 provides some important energy-related indicators that may help drawing a sketch of the energy conditions of Santiago, collected for the examination of 25 sustainable Spanish cities commanded by Siemens [32], but none of this figures was collected at municipal or city level. Santiago appeared as second best of the 25 examined cities in terms of residential energy consumption, according to figures at provincial level.

Table 6. Energy-related indicators of Santiago de Compostela [32].

Indicator	Value	Year	Level
Per capita CO_2 emissions	11.50 Mt	2007	Data at regional level
CO_2 intensity	365.5 Mt	2007	Data at regional level
Per capita energy consumption	24.71 GJ	2011	Data at provincial level
Energy consumption per GDP unit	0.78 GJ	2011	Data at provincial level
Renewable energy consumption	High	2010	Data at regional level

3.4.2. Energy consumption in the historic centre

The updated records (2008) of the Special Plan provide data on the type and uses of energy in the historic centre. They have recorded 10,071 units within the historic city, in which the residential use was predominant (77%) over commercial (10%), storage (5%), hotels (5%) and offices (3%) uses (see Figure 6, left). The sources of energy were mainly electricity (45%) and butane gas (27%), whilst the rest of 28% was shared between propane gas, natural gas, oil and wood, as it can be seen in figure 3 (See Figure 6, right).

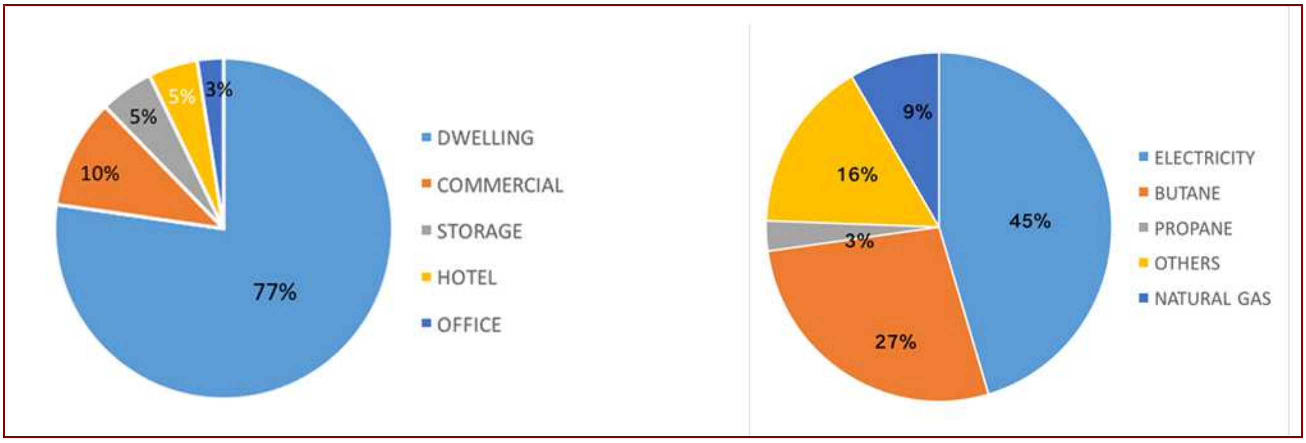


Fig. 6. Main uses (left) and types of energy supply (right) in the historic centre of Santiago in 2008 [25].

Figure 7 gives an idea of the number of residential units and their different energy sources in four main energy consuming activities: (room) heating, hot water heating, cooking and cooling. Electricity is by far the most used energy source in all of them. Butane gas follows in heating and hot water. Oil and wood, and natural gas are second and third for cooking. Despite the mildness of the local climate, the spreadsheets recorded 179 residential units making use of electric cooling appliances in the historic centre.

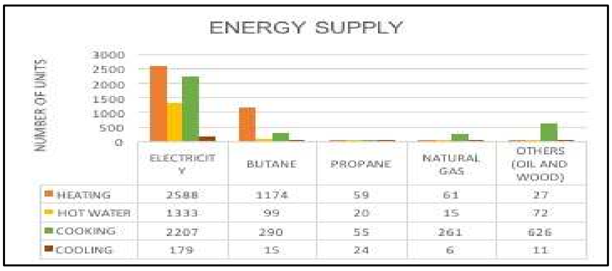


Fig. 7. Types and uses of energy at residential level in the historic centre of Santiago [25].

5. CONCLUSIONS

The previous sections have described the urban regeneration, urban planning and energy efficiency features of the city of Santiago de Compostela, as well as the continuous efforts of the city council and all stakeholders to maintain the spatial quality of the urban environment of its historic centre. An important consequence of these planning efforts to regenerate and maintain a lively and attractive historic core has been the consolidation of an urban pattern with the compactness and mixed functions of traditional Spanish urbanism and the preservation of green areas in and around the historic centre. The combination of such urban pattern and green areas with Santiago's mild climate has led to a small ecological footprint and allow residential energy consumption (which unluckily could not be verified by statistical information). This way, yet without specifically mentioning energy efficiency or environmental sustainability in policy documents, the local urban policies have indirectly contributed to them.

Despite the low residential energy consumption at provincial level, our own analysis of the energy situation of the historic buildings in the centre of Santiago has been useful to show that they have a low level of energy efficiency. On the other hand, the publicly financed interventions that have been carried out on the buildings' envelopes through PE-1 related programmes, mainly focused on conservation and retrofitting, have progressed slowly in relation to needed improvements in energy consumption.

The adaptation of the historic centre buildings to bioclimatic considerations is, therefore, the next important task to undertake by the city of Santiago de Compostela, and this constitutes no smaller task than the urban regeneration challenge, successfully tackled in the past decades by the city under the frame of PE-1. Analyses of local policy documents show that if previously sustainability concerns were completely absent in their texts, they seem to have become more important in the city plans. Such concerns are expressed in the revision of the *Plan Especial* PE-1 as general sustainability intentions, but not yet as specific measures to be implemented in terms of energy efficiency.

Another evident issue of our study of energy planning in Santiago is the little awareness of the local society about the climate change challenges, as well as the limited commitment of the local government to sustainable energy issues, something put forward by the city's conduct in the CoM and PLEEC project. These issues are complicated by the lack of precise knowledge about the local energy situation. Our successive efforts dedicated to obtain detailed information about the energy situation and consumption have been unsuccessful. None of the municipal or regional entities consulted were able to offer figures about energy consumption at municipal and district level. This study has also shown that the local government is only giving attention to energy efficiency demands in case of its own buildings and municipal services and the transport sector, without considering residential and industrial sectors.

To be able to face the climate change challenge, the local government needs to take a more proactive role, promoting environmental sustainability and energy efficiency for the whole city and not only of the sectors it can directly control. Part of this should be efforts to find the ways to use the planning system as tool instead as a constraint. According to the Spanish planning system, local governments may use Zoning Regulatory Ordinances as tools to regulate different issues in residential and industrial areas. As in the case of Tres Cantos, in Madrid, bioclimatic or environmental ordinances may be prepared to determine qualities of the built environment to adapt the city to energy efficiency requirements. The elaboration of tailor-made bio-climatic ordinances for the natural, climatic and built environment conditions of Santiago's historic centre would be an important step forward in the desired direction.

The most important problem in terms of energy planning is the insufficient knowledge about the existing energy situation, a great constraint to local action and to the necessary local discussion about the relevant measures to apply. The local government should begin with commanding a precise diagnosis of the whole energy situation at local level as essential step to prepare an action plan to respond to that situation. The "Sustainable Energy Action Plan" of Genoa and its methodology can serve as a useful reference for this. As Genoa, Santiago may use the many resources of Covenant of Mayors (CoM) to commit to local sustainable energy.

Such proactive role for local energy planning evidently requires the commitment of the city of Santiago to energy efficiency goals, something that cannot be achieved without the contribution of all stakeholders. Thanks to the exceptional character of its historic core, Santiago counts with a great advantage in terms of stakeholders. Its historic centre has been object of successive successful regeneration interventions in different moments in the past, resulting in the evident improvement of its spatial quality, both in its constructive and sanitary conditions, becoming a model regeneration for other Spanish cities. One of Santiago's major assets is the presence of the Consorcio, gathering the most important stakeholders, who work together for the common goals of preserving and maintaining the historic centre of Santiago. Thanks to the activities developed during the last decades, Santiago seems in a good position to undertake the adaptation of its historic centre to the new bioclimatic considerations. For the environmental demands related to energy use, as well as the societal demands related to indoor comfort and the conservation of the historic heritage, the Consorcio fulfils an important role in developing pilot projects and developing local knowledge and training for the retrofitting of Santiago's historic buildings. Regarding the supportive financing schemes considered crucial for works in heritage buildings, the Consorcio also has an accumulated experience on funding and subsidising them, although due to the Spanish economic crisis, additional funds and subsidies will be probably more difficult to get than before.

The review of the Special Plan for the Historic City of Santiago will constitute an excellent opportunity for the city council to develop such a proactive role towards a sustainable type of urban regeneration, with a special orientation to energy efficiency considerations in the case of residential buildings.

Everything considered, Santiago has more advantages than constraints to adapt itself, one more time, to the sustainability requirements of the 21st century.

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