A comprehensive data framework for supporting public action regarding the energy renovation of Madrid's listed buildings stock

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Abstract
European cities often have a large stock of buildings legally protected for cultural reasons that keeps growing. Most of them are used in a conventional way by a variety of socio-demographic profiles (for instance some parts of Madrid's historic centre are poorer than others) so there is no reason to think that, on average, their users have different comfort needs – or are ready to pay more in their energy bills – to those living or working in standard homes or offices.

Therefore, owners and occupiers could be interested overtime in improving the energy efficiency of these heritage buildings, so conflicts with their conservation may arise. However, there are no data available to assess their impact on the EU energy and environmental goals for the residential and services sectors.

Meanwhile, the EU legal framework keeps delaying dealing with this problem. The Energy Performance of Buildings Directive allows Member States to exclude legally protected buildings from compliance with any energy efficiency requirements when there is a conflict with conservation. And the Energy Efficiency Directive also exempts them from a series of provisions for public authorities.

We studied a listed stock of +500 legally protected buildings with cultural value in the Recoletos Area in Madrid, using or own GIS model based on publicly available information and some data already owned by various public bodies. Most of them were residential, multi-apartment buildings, some of them with some offices in them, in a high-income area which represents a highly active real estate market.

This study allowed us to identify the energy renovation opportunities in each building's thermal envelope, showing that the aggregated area of not protected elements is larger than that of the protected ones for the buildings in the sample analysed.

The analysis performed is useful for two reasons: first, it shows that a general exemption of heritage buildings from energy efficiency requirements is not justified; it would make more sense to put in place flexibility mechanisms that allow diverting energy efficiency requirements from protected elements -where they are not feasible or very expensive to perform using our current technology- to other not protected elements or systems of the building, if energy unbalances can be avoided. Secondly, the method used to perform that analysis could be useful for public bodies to carry out low cost, initial assessments of the heritage buildings stock.

Introduction
The energy renovation of the existing building stock seems to offer, in general terms, many benefits of different nature which are additional or alternative to energy conservation and its related impacts[1]. On the other hand, a significant number of buildings are regarded as culturally valuable and protected, because it is believed that they offer some benefits to society or at least, to a given group of people[2]. If energy renovation of heritage/ culturally valuable buildings contributed to their conser-

1. IEA, 2014.
2. Throsby, 2001.

vation, and its benefits were also larger than its costs, it would make political sense to explore the optimal way to achieve this[3].

The European Union's legal framework focuses on avoiding clashes between conservation and energy renovation as we will explain later. At the same time, large research projects are being financed with EU'S funds to find new technologies that could allow overcoming these conflicts. Nevertheless, it seems that there is little data available on the extent of the problem or, put in a different way, the remaining potential for energy efficiency and power generation of a city's listed buildings.

Our research tries to get some data regarding a given area in Madrid using existing – or easy to produce – data, in order to develop a method that allows public bodies to perform an initial assessment of a group of listed buildings, without investing large amounts of resources in field.

OUTLINE OF THE PAPER

Firstly, the meaning of 'energy renovation', 'listed building stock', 'conservation' and other synonyms used through this document will be set. Later, we will present the theoretical framework in which our current work on this field is based: basically, why it should be tried to improve the energy performance of listed buildings.

The next sections will look at the specific case of the Recoletos area in Madrid, first briefly explaining why it was chosen for the study, and then listing the kind of information that we regard as useful for this kind of assessment and the most common sources where it can be found. We will continue discussing and presenting some results of a partial analysis focused on vertical elements of the thermal envelope. Finally, we will draw some conclusions and outline related future research needs.

DEFINITIONS

The expressions "heritage buildings" and "culturally valuable buildings" are used, interchangeably, in the following pages, to make reference to those buildings which are themselves or are part of, places of cultural significance[4]. Some nuances in this concept, which is complex, are important to our research for two main reasons:

- To determine what buildings are part of the stock to be surveyed. Not all heritage buildings are currently legally protected, and even some of those which are protected may hold not cultural value at all.
- To determine the kind of cultural value embodied in the building or in the *place* that encompasses a series of buildings. Otherwise, improvement works could change the tangible and/or intangible features that hold cultural value or at least, not improve their conservation.

We will use the word 'conservation' – of the cultural significance in heritage buildings – to refer to those works intended to keep the mentioned cultural value (See Australia ICOMOS, 2013). A heritage asset can be conserved by upgrading some of its functionalities in order to keep it in use, as we will shortly discuss later, under de "An opportunity for synergies" sub-section.

The expression "energy renovation" is used to mean: a) works that allow reductions in demand for energy services provided by technical building systems; b) improvements on the efficiency in which those energy services are provided inside or close to the building; and c) harnessing more primary energy renewable resources available in the building or its surroundings, to be used by the mentioned technical services.

Statutory protection in Madrid is often related to the external image of old building and the conservation of some of their original elements (in most cases main façades plus, sometimes, structure, and other parts of the thermal envelope). This is the kind of protection enjoyed by those buildings covered by this first case study of the Recoletos' area. Potential conflicts with energy renovation are, consequently, related to the external aspect of the asset (e.g. external insulation cannot be installed if it hides the external decoration of the façade) and/or to the authenticity of its elements (e.g. some wooden, or slim, iron-made windows cannot be replaced with thicker, PVC-made substitutes).

Nevertheless, other buildings can hold cultural significance in more complex manners: for example, the way that the building deals with energy using a traditional system or an early, experimental technical system, may deserve legal protection. These ways of holding cultural value are common in the academic literature but are only starting to be included in the legal framework of cultural protection, so they are underrepresented in protection catalogues like Madrid's.

As newer buildings with cultural value – either of a conventional or more specific kind – tend to be under-protected too, we concluded that taking just those buildings in the area with statutory protection (protected buildings) could leave some culturally valuable buildings out of our analysis (we mentioned before that "Not all heritage buildings are currently protected"). As a way to complete a proxy of the list of culturally valuable buildings in the area, we took the list of buildings with statutory protection (protected buildings) and added the list of buildings in the area highlighted by the Madrid's association of architects (COAM) in its architecture guide (which are supposed to be culturally valuable too)[5].

Initial problem and theoretical framework

In previous works (see Villarejo, Gámez, 2016), we started to set a theoretical framework whose key assumptions will be outlined in the current section. This is necessary as the study presented later here is based on that framework.

POSITIVE EXTERNALITIES AND THEIR VALUATION AS A LINK BETWEEN ENERGY EFFICIENCY AND CULTURAL POLICIES IN BUILDINGS

Energy policy in buildings, and in particular policies that support energy renovation of the existing stock aim mainly at reducing greenhouse gases emissions associated to energy

3. The mentioned cost-benefit analysis and its derived policy recommendations are the subject of study in a research that is being carried out at the Polytechnic University of Madrid. This paper presents some results derived from that line of research.

4. Australia ICOMOS, 2013. "Place means a greographically defined area. It may include elements, objects, spaces and views. Place may have tangible and intangible dimensions", "Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations" and "Cutural significance is embodied in the place itself, its fabric,, setting, use, associations, meanings, records, related places and related objetcts".

5. Fundación COAM (2003).

transformation as well as at increasing the energy security of the Union. They are also a means to develop a competitive new market that could create new jobs[6].

When people or companies install some kind of thermal insulation in their buildings they generate positive externalities: they are creating jobs, increasing energy security and mitigating climate change, but they cannot notice these effects nor are paid for their service to society.

Therefore, renovating a building generates benefits to third parties for which the agent that is paying for the works does not receive any compensation – we can't limit access to the environment, economic growth or security and then extract some kind of payment – In Economics terms, those benefits are labeled as 'positive externalities' and they constitute a market failure, because they will tend to be under-produced due to the lack of compensation mentioned before (they will not be counted as benefits when the profitability of the works at a private level is assessed).

We must admit that there are also a number of microeconomic benefits to energy renovations so, even without internalizing the societal returns, some operations are – or at least are perceived as – efficient in monetary terms: once a building has been upgraded, its occupiers can reach a given level of comfort paying for less energy carriers such as electricity or natural gas. At the same time, there is a growing body of literature that pays more attention to the fact that the growth in efficiency can be used to enhance the initial comfort conditions[7]. This additional comfort may improve the health and/or the performance of the occupiers. Energy renovations in buildings can also bring other benefits, such as an increase in the market value of the asset, or in the economies of scope when carrying out other improvements, such as those related to accessibility. Some of the benefits mentioned until this point can be translated into monetary terms, but others such as comfort or social inclusion can only be indirectly estimated, e.g. by comparing the alternative investment options that led to them.

In the same way, listed buildings are legally protected because they constitute a form of capital – cultural capital – collectively enjoyed by society. This capital generates flows of different natures to the present and future generations, including the most prosaic of them, such as more sales for some businesses and a higher value for other nearby real estate assets. (See Throsby, 2001).

When dealing with energy renovation, owners that carry out conservation and restoration works are not the only ones who receive some benefit derived from these investments. Once again, they will not receive any payment from the rest of beneficiaries, because heritage buildings are, at least to some extent, 'public goods' as the environment or the security provided by an army. For example: owners cannot restrict the sight of a beautiful façade and ask for money to see it, let alone making money out of the personal joy of knowing that our heritage is safe. Conservation and restoration works tend to produce 'positive externalities', and that is the reason why governments incentivize them – mainly through tax breaks and subsidies – in the name of the social group(s) that reaps part of their benefits.

6. Artola et al (2016).

7. IEA, 2014.

Apart from receiving compensation or not, people and companies that invest in heritage buildings may get an emotional gain, enjoy social recognition, or just run a business with revenues that are partially or totally based on the cultural value of the building. But, as it happens to energy renovation, some private and societal benefits of cultural heritage conservation are difficult to translate into monetary terms.

Therefore, energy and cultural policies in buildings are or should be, basically, government interventions in the market to fix a failure related to externalities. In both cases it is very difficult to find out which kind of intervention is more efficient. The reason for it is that there are many kinds of costs and benefits involved, which cannot be directly compared. Conversely, the 'cost-optimal' methodology attached to the Energy Efficiency of Buildings Directive only takes into account the cost of works, capital, energy, and optionally, carbon credits, not including any other positive effect of energy renovation.

THE INTERACTION BETWEEN ENERGY IMPROVEMENT AND THE CONSERVATION OF CULTURAL SIGNIFICANCE IN BUILDINGS

If the points highlighted above are accepted, the next step is to work out how to deal with energy and heritage-related effects of energy renovation without having any tool to compare them.

Current regulatory framework

As mentioned above, the most common focus of current European policy until now is on how to avoid conflict between energy improvement and cultural conservation[8].

The reasoning under which the current Energy Performance of Buildings Directive (EPBD) has been written seems to be the following: the energy renovation of a building can put the conservation of its cultural significance at risk: as we are not equipped with the right tools to compare cultural damage with environmental benefits, it is better to opt for a cautious approach that avoids permanent damage of culturally valuable items. It will be better to make exemptions (heritage assets are unique), as there are still many buildings with less (or none) cultural value that can be upgraded (the same energy saving is undistinguishable from one building to the next one) before we must make a choice about listed ones.

The EPBD allows Member States to exempt heritage buildings from energy efficiency requirements, when applying them would put conservation at risk. Also, since upgrades derived from applying building regulations on energy must be 'economically efficient', it also implicitly allows excluding those cases when it is possible to upgrade the energy efficiency of the building in a compatible way with heritage conservation, if that compatibility effort involves a higher expenditure[9].

An opportunity for synergies

Nevertheless, we have hardly found any work regarding the synergies between energy efficiency and heritage conservation-related policies. An axiom of heritage conservation theory

8. European Union. Directive 2010/31/EU, article 4.2.a.

9. European Union. Directive 2010/31/EU, article 4, first paragraph: "Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements set in accordance with Article 4 *in so far as this is technically, functionally and economically feasible*" (cursive formatting has been introduced by the authors).

states that conservation involves, in most cases, keeping buildings in use. That is why many international documents stress the concept of 'adaptation' to a 'compatible use'.

In the future, keeping a certain level of comfort and/or limiting the operational costs involved, could become a key decision element when choosing a building to live or work. If that happens, improvements that help listed buildings to match the features of competing real-estate assets, will become not a source of risk for conservation, but an opportunity for enhancing that conservation.

FINDING THE AVAILABLE, COMPATIBLE WITH CONSERVATION, UPGRADING POTENTIAL

Is there a way to 'adapt' heritage buildings to these new, hypothetical comfort/operation costs requirements from users without losing their cultural value? In general terms, statutory-protected buildings are often regarded as 'hard to treat buildings' when it comes to energy efficiency upgrades. Nevertheless, in most cases, legal protection tends to be set regarding specific parts of features of the building, instead of protecting whole buildings[10]: the latter tends to be reserved to the most valuable constructions. In Spanish cities, culturally valuable buildings are often assigned a specific level of protection. Then, a series of restrictions regarding the works that can be carried out are set for each protection category (some specific remarks for each building can also be added). That 'catalogue' that sets the list of protected buildings by category, and the mentioned 'regulations' are usually incorporated into the planning regulations of cities.

As it was suggested at the end of the previous section, in most protected buildings, elements with cultural value and others without it co-exist. In either group, some elements may be impossible to upgrade using the currently available technology without conflicting with protection. Some others could be upgradable at higher costs than usual due to conservation issues. And finally, some others could be upgraded in the same conditions as if they were part of a not-listed building.

These different degrees of conditioning for cultural reasons must always be distinguished from those derived from the geometry (e.g. it is hard to insulate a floor in contact with the terrain) or the technical features (e.g. chemical compatibility issues) of the building, as they are described by Mellwig, Jochum and Pehnt for Germany (Mellwig et al, 2013). These limitations to energy renovation may appear mixed up with the cultural ones, but are not directly linked to the cultural character of a building[11].

Therefore, we consider that a 'binary' approach to the energy renovation of heritage buildings, regarding them as 'upgradable' or not, is not useful. Rather, we believe that it makes more sense to carry out an individualized analysis assessing the energy efficiency potential whose harnessing does not conflict with protection, and the potential that does imply either a conflict or an over cost to avoid any conflict; and support at least the realization of the first, foreseeing the realization of the other two as technology advances, drawing a roadmap that might become part of information instruments such as 'building passports'.

It was previously argued that promoting the less conflictive renovation of culturally valuable buildings could make political sense. Moreover, it has just been explained that identifying the elements of the thermal envelope most suited for these improvements requires some degree of analysis. Therefore, we propose that public bodies could contribute to the assessment of energy improvement potentials in protected building stock. We also encourage the development of tools to incentivize these improvements, including some financial help for assuring compatibility with protection. We have developed a method to collect and analyze existing data in order to support public administrations on this task.

PRECEDENTS

Although our research is not based in the EFESSUS project (Erikson et al, 2014), it has become an interesting reference in this field. A Decision Support System (DSS) for the energy renovation of 'Historic Districts' was developed during the project. Among other factors, the impact of the renovation options available in the heritage value of the building is taken into account. To achieve this, their software compares, for different scales and kinds of value, the impact of each available technical solution and the cultural value of each element to be improved, offering an ordered list of feasible works starting from the most convenient of them.

This promises to be an excellent tool to identify the most appropriate interventions to be carried out in a whole historic district. Although it has been designed to work with different degrees of available information, its full potential is harnessed with very complete GIS-BIM models. Our method is focused on a previous stage, when policies to support renovation are being designed. The works supported by these policies may well be analyzed in detail later using the EFFESSUS system.

OPERATIVE ASSUMPTIONS

Fixing a market failure must not take more costs than keeping that failure unfixed. A European capital such as Madrid protects more than 20,000 buildings: an individual survey of each of them and developing tailored solutions would be prohibitive and even with available resources it might not make economic sense at all. This stock is also too large for decision makers to set a protection regime as well as to assess energy renovation potential and its support instruments on a case-by-case basis.

Our aim is to find a way in which public institutions could carry out this initial study of potentials in a fast and not resource-intensive way, using the information already possessed by different government levels, plus that from some public accessible services (such as aerial and street photography), minimizing 'ad hoc' surveys and discarding any field work inside the buildings. The mentioned EFFESUS also worked on identifying public sources of existing data related to historic districts (HAY et al, 2014).

Meanwhile, owners, architects and other agents involved need some form of guidance, and probably support, based on the specific features of the building they are in charge of.

As it is not possible to work with as many individual solutions as there are buildings, and a single solution would not

10. In Madrid, the lowest levels of protection are focused on either the volumetry of the building, or on its façades facing the street.

11. It must be acknowledged that a building that cannot be upgraded for geometrical or technological reasons could face, as a consequence demolition. If it were protected because of its cultural protection that demolition could not take place.

work for all them, it is proposed to look with similar features, at least from the following approaches:

- From a technical point of view, it is necessary to find out the remaining upgrading opportunities that each building offers, taking into account what cannot be done because of protection. Then, similar cases may be detected, which could be grouped together in order to design a specific 'intervention menu' for each of them as many previous projects propose[12].
- In addition, those intended works will probably face some barriers for different reasons, from split incentives to lack of financing. Governments have a range of tools at their disposal to support energy renovation such as grants, soft loans or feed-in tariffs[13] and are also better suited to tackle other legal, mainly property rights-related, problems.
- Synergies and economies of scale for carrying out non-energy-related improvements when performing energy upgrades such as accessibility issues should be taken into account. This would lower the cost of the energy efficiency – related intervention, as part of these costs would be shared with other improvements that could be performed at the same time.
- Finally, as a second layer of analysis, assessing potential interactions among buildings in the same block/area should be developed.

By adopting this approach, it will be easier to design a limited number of comprehensive strategies/packages to support energy improvement, which will be more suited to their respective target buildings than the general energy renovation policies currently in force.

It must be underlined that this initial survey and grouping is not intended to define the specific intervention which should be performed on an individual building. A further, in-depth analysis will always be necessary for the latter, at the project design phase[14].

In the following pages, we present initial results related to the first and second steps, as part of a project still in process.

Case study

CHOOSING THE RIGHT PLACE TO CARRY OUT THE STUDY

We chose the Recoletos area to carry out our study. It is delimited as an administrative sub-division of the District of Salamanca, in Madrid. The choice of Recoletos was based on the following criteria:

- Listed buildings in this area are not very old. They were built during the XIXth and XXth centuries so we avoid mixing these barriers related to the cultural significance of buildings with other barriers linked to the building systems featured by each asset.
- The urban form, based on a north-south, east-west grid is common to many Spanish and European cities, making it possible to compare them in future research works. In addition, it is especially promising when taking into account our research's assumptions[15], as it features a large, internal courtyard in every block, often occupied by garages or other low rise structures, with lower-quality and undecorated façades facing it. Therefore the chances of finding large, not protected parts of the thermal envelopes that are easy to upgrade are higher.
- The average income of Recoleto's inhabitants is high, making it less necessary to incorporate poverty indicators that make the assessment more complex. Nevertheless, that population is relatively old, so barriers related to lack of liquidity and divergence of investment priorities are kept.
- The prestige of the area makes it very attractive for small, wealthy companies such as law and investment firms. The lack of office spaces makes it common to find apartments, offices and shops sharing buildings that are nominally apartments blocks. That offers an opportunity for energy renovation because of the differences in thermal loads and operation times.

Recoletos is just taken as an example. What we find relevant to be presented here is the method that we have started to develop; and the relative scale of the groups of elements/buildings that we compared in the successive tables for our case study. That comparison seems promising in terms of potential for conventional renovation.

Results and discussion

We analyzed 569 culturally valuable (currently or potentially protected) buildings over a total figure of around 790 existing buildings (protected + not protected) in Recoletos.

The protection levels, as well as the specific protection of some elements of thermal envelopes, were obtained from Madrid's urban information tool[16], which includes the cartography of the city's Urban Plan. For the additional, potentially protected buildings we used the guide from Madrid's association of architects (COAM) as a proxy.

An 87.3 % of valuable buildings (81.7 % in terms of their aggregate area) enjoy medium or low protection levels, or have not been protected yet. These figures –low average protection-suggest a potential for the energy renovation of not protected parts of the valuable buildings. In this paper, we will focus on the vertical elements of their thermal envelope[17].

12. There have been some efforts to classify the building stock for energy renovation purposes. One of the best known of them is the TABULA project, supported by the Intelligent Energy Europe program until 2012. See http://episcope.eu/iee-project/tabula/ and Ballarini (2014).

13. Economic support can be especially helpful in cases where the most cost-effective solution cannot be used because of conflicts with cultural protection, and more investment than usual is needed for the same results.

14. What's more, it is even possible for some surveyed building's elements to prove incompatible with any upgrading option. Surveying incompatible elements can be later useful to compare its upgrading cost in absence of protection with those of offsetting them somewhere else in the building. Depending on policy choices, and these figures can be used to justify exemptions, or for ordering alternative measures and compensating owners for incurred over costs.

15. That there is a large potential of the refurbishment of not protected parts of many heritage buildings' thermal envelope.

16. http://www-2.munimadrid.es/urbanismo_inter/visualizador/index_inter.jsp.

17. As it was said before this is an initial assessment: asymmetry in the level of insulation from one façade to another should be subjected to a more detailed analysis.

Table 1. Square meters of thermal envelope for an average height of 3.5 meters/(lineal meters × number of floors).

Sq.m/(linear meters × N of floors)	Protected elements			Not protected elements			
	External Façades	**Internal façades**	**Side boundary wall**	**Internal courtyards**	**Internal façades**	**Side boundary wall**	**Internal courtyards**
1 main, protected façade	116,422.50 (33,263.57)	40,454.58 (11,558.45)	11,022.55 (3,149.30)	68,138.70 (19,468.20)	108,885.53 (31,110.15)	66,804.33 (19,086.95)	137,167.59 (39,190.74)
2 main, protected façades (usually buildings in corners)	150,600.80 (43,028.80)	12,770.45 3,648.70	5,172.83 (1,477.95)	31,163.65 (8,903.90)	32,165.35 (9,190.10)	19,518.63 (5,576.75)	67,708.90 (19,345.40)
Others	4,105.50 (1,173.00)	0.00	0.00	0.00	0.00	0.00	0.00
Whole bloc (4 façades or more)	3,894.45 (1,112.70)	0.00	0.00	210.00 (60.00)	0.00	0.00	1,295.70 (370.20)

We needed to find the approximate area of the vertical parts of each building's thermal envelope. Firstly, we measured the length of each main façade using the GIS cartography from the Spanish cadaster (which is, at the same time, based on aerial photos). Then, we multiplied it by the number of floors excluding ground floors and penthouses[18], and then by an average height of 3.5 meters.

We did the same without the exclusions, for side walls and internal façades facing block courtyards, as well as for ventilation courtyards inside the building (ventilation courtyards shared between two buildings have not been taken into account yet). We classified each part of the building using the cadaster's GIS cartography along with 3D, aerial views from the "Apple Maps for IOS" service.

Table 1[19, 20] shows the relevance of that group of not protected elements compared to the extent of the protected ones. The figures are presented both in approximate square meters (measured length × number of floors × 3.5 meters) and in linear meters (in parenthesis, length × number of floors).

It must be taken into account that, for highest protection categories, the whole thermal envelope is protected, even if it holds not cultural value. Nevertheless, it was decided to keep all those elements in the 'protected' columns instead of adding them to the not protected/not valuable fields, because they are actually protected so getting planning permission to improve them is actually harder than for the unprotected ones, and a distinction should be made. For not currently protected buildings (these taken from COAM's architecture guide), their main façades were labeled as 'protected' and the rest of the envelope as 'unprotected'.[21]

18. This was done because ground floor levels facing streets are in most cases occupied by shops, and because penthouses tend to be set back from the façade. We will look into them in further stages of the research.

19. External Façades: These figures reflect the length and approximate area of the main segment of the building's façade, excluding its ground floor and penthouses on its top, if they exist.

20. Internal façades: Contrary to what it was described for external façades, the internal façades are measured taking into account ground and penthouse levels.

21. The size of this part of the stock is very small so it has almost no effect in the final figures.

Table 1 shows that there is a large potential for conventional improvements when compared with the area of elements that will be harder to improve for cultural reasons: for example, buildings with one protected fade add about 168 k sq.m of protected external, internal and boundary façades/walls compared to around 176 k sq.m of not protected ones. The latter figure, compared to the former, is far from anecdotic.

Also, as a first step in the analysis it evidences that, in this specific area of Madrid, the geometry of the blocks with inner courtyards constitutes an advantage for those buildings outside the corners of each block (usually those with two main façades). They often enjoy and unprotected or, at least, less decorated inner façade nearly as large as the main, often protected façade. This is just an example of how 'low hanging' opportunities for 'conventional' energy renovation of heritage buildings can be easily found by performing a geometrical analysis that takes the protection of each element into account.

OWNERSHIP REGIME, USE OF EACH FAÇADE, MAIN USE(S) AND RECENT RENOVATIONS

Studies dealing with the energy renovation of the building stock in a given place tend to focus on these building's geometrical and technical features in order to assess their technical and 'repayable' (by energy savings) potential for energy efficiency.

Although these studies are useful at an even more initial point of policy design, it must be noticed that they don't take into account the actual feasibility of the works that they assess – e.g. legal, financial constrains[22] – nor the fact that the energy efficiency improvement of a thermal envelope is often carried out along with additional works – e.g. maintenance, cleaning, accessibility. The latter – synergies and economies of scope – is one of the many cost an benefits that are often left out of energy efficiency potential assessments, a fact that, at the same time, makes it difficult to prioritize the use of public resources among the set of buildings that is being studied.

22. An upgrade work may produce enough energy savings to pay for itself but there are many factors which could reverse that result, including energy poverty, investment priorities or recent works whose residual value should be taken into account.

Table 1 combined a fairly conventional geometrical analysis, with the heritage-related legal constrains in place. In this section, we add some other not- technical/geometrical features of the buildings analysed that we find relevant for the design of public instruments to support the energy renovation of the heritage buildings stock, and for which there are existing sources of data that cover Madrid:

1. First, the level of statutory protection of each building may be used to prioritize access to resources or to set the amount of public resources – at least, technical support – granted. Therefore, it is sensible to distinguish buildings among protection levels. Four of the protection levels in force in Madrid have been taken into account. Buildings awarded with a 'Singular' protection category are totally or partly relevant to Spain's or Madrid's history and/or are an essential element of Madrid's urban fabric. An 'Integral' level of protection means a high quality building that holds relevant architectonic or/and environmental values. A building with a 'structural' protection is valuable enough to deserve the conservation of its shape and of its main architectonic elements. Finally, a 'partial protection' mandates the conservation of the building's main characteristic elements, which serve as a reference to understand the period when it was built, as well as its style and function[23].
2. The date of the last deep renovation of a building is always relevant, as the next renovation cycle might have not started yet, so owners will tend to avoid making large investments for some years[24]. Also a recent renovation means that valuable elements will have been probably either restored or removed. Therefore, there are two reasons for not prioritizing the energy improvement of these buildings using public resources. Conversely, those buildings that have not been overhauled yet should be prioritized in order to avoid an unnecessary waste of resources, loss of cultural value and, above all, avoiding inefficient interventions that could lead to lock-in. By using the Spanish cadaster, it is possible to figure out the year when a deep renovation or a partial demolition of the building (often removing all not protected elements) has taken place. Sometimes that information is not as clear as needed and has to be compared to aerial photographs in order to check if the building was partially demolished or not.
3. Ownership regime. In Spain, most houses and apartments, and many offices, are owned by their occupiers, so the proportion of wholly-owned apartment buildings is small. When ownership is 'horizontally – divided' the thermal envelope and the building systems are owned by an 'owners' association' and any work on them must be approved by a majority set in law depending on the intended upgrade's specific features. Owners associations tend to experience difficulties when trying to agree on this kind of expenditures. Meanwhile, a unique owner who doesn't occupy the building faces a 'split incentives' problem, as he will not benefit directly from the improvements (although he can later raise the rent or sell the building for a higher price). Among unique owners, a public body (which has often to comply with annual renovation targets) or the Church will often have different priorities than for-profit organizations or individuals.
4. Following the Spanish law, the improvement of a part of the thermal envelope such a façade will often depend on all owners -not only on the ones whose apartments/offices are in contact with that specific element-. If for example a protected façade is not improved but the back façade is insulated, some owners may end up without making any gain from the works but paying for them (e.g. those whose windows are part of the protected façade). This could prove unpalatable for them, a situation that must be foreseen when designing the set of incentives to be employed. Therefore, it will be useful to know how many units of apartments or offices are linked to each façade compared to the total figure.
5. Use. The use of buildings conditions the technical parameters of their feasible energy efficiency improvements, investment priorities and amortization time. Moreover, it opens the door to more sophisticated technical systems that take advantage of multiple operation parameters, such recovering heat for dwellings from office's HVAC. Mixed uses are very common in Madrid, so data on the number, aggregated area and position of secondary uses should be included in our model.
6. The position of the elements to be improved related to the plot. If a wall or façade is place on the boundary with a neighboring plot, any external insulation added will fall in a different domain.

Table 2 adds a second set of filters to the results in Table 1. We took those buildings with only one façade[25] and classified them by their main use(s) (excluding shops in the lower levels, that is too common in this part of Madrid to be taken as a distinguishing feature), by level of protection, and by recent, deep renovation or partial demolition and reconstruction[26]. Each cell shows the aggregated figure (number of buildings) that complies with the conditions set, plus, between parenthesis, the figure broken down by level of protections, ordered from the highest to the lowest one (singular, integral, structural, partial, not protected but included in COAM's architecture guide) described before. See Table 2[27, 28].

A further selection in Table 3 shows a hypothetical 'priority list' of the most valuable assets ('integral' and 'singular' protection levels), which have not been renovated for the last 30 years and that may experience more problems to agree on necessary improvement works due to the 'horizontal division' of their ownership.

23. Madrid's planning regulations, article 4.3.4.

24. Other renovation dates would be useful but the information available in databases is scarce for Madrid's case; also, considering partial interventions would add too many variables to an analysis like the one that is being described here.

25. The optimal approach is to choose those with a similar proportion of protected – non-protected/protected but not valuable façades, but the one façade criteria is a proxy for that in this case.

26. It was set at 30 years. This is a reasonable figure for residential but not for offices buildings.

27. Reconst. >1986: Data on reconstructions are preliminary.

28. Apartments: Offices in residential units are difficult to detect as they are not properly registered and show on the cadaster's registry. This makes it preferable to assess apartments and mixed apartments-and-offices buildings together.

Table 2. Number of buildings with only one façade. Main use, protection level, ownership regime and deep renovations in the last 30 years.

	Protection level	1 Owner/few/ public body	Horizontally divided	Reconst. >1986	Refurbished after 1986	Not R/R
Apartments	223 (0,8,97,127,1)	47 (0,1,17,29,0)	186 (0,7,80,98,1)	13 (0,0,6,7,0)	6 (0,1,2,3,0)	214 (0,7,89,117,1)
Houses	2 (0,2,0,0,0)	2 (0,2,0,0,0)	0	0	0	2 (0,2,0,0,0)
Offices	24 (2,3,6,9,4)	17 (2,2,4,8,1)	7 (0,1,2,1,3)	1 (0,0,0,1,0)	4 (0,1,2,1,0)	19 (2,2,4,7,4)
Mixed apartments + offices	89 (0,10,31,46,2)	15 (0,1,8,6,0)	74 (0,9,23,40,2)	16 (0,0,3,13,0)	4 (0,1,2,1,0)	69 (0,8,27,32,2)
Hotels	9 (0,1,5,2,1)	8 (0,1,5,1,1)	1 (0,0,0,1,0)	3 (0,0,2,1,0)	3 (0,1,2,0,0)	3 (0,0,1,1,1)
Mixed apartments + hotel	1 (0,0,0,1,0)	0	1 (0,0,0,1,0)	0	0	1 (0,0,0,1,0)
Other	12 (2,1,1,7,1)					

Table 3. Buildings with one external façade and "integral" protection whose ownership is divided and that have not been renovated in the last 30 years, with residential or residential and offices use.

No	Address	Position of the inner façade	Apartments to main façade	Units with access to both façades	Total Apartments	Office	Main façade sq mts	Privat. used area sq.m	Apartments/ floor
1	Ayala 3	A2	10	50 %	18	4	140.00	6,394	1–6
2	Serrano 22	A1	10	91 %	14	0	138.00	6,524	2
3	Velázquez 27	A1	17	53 %	38	1	60.00	8,046	4–7
4	Gurtbay 5	A2	8	100 %	10	0	132.50	2,931	2
5	Hermosilla 31	–	10	31 %	39	3	74.20	7,514	4–13
6	Núñez de Balboa 24	A1	8	100 %	8	0	76.00	2,685	2
7	O'Donell 5	A1	5	100 %	6	0	104.00	2,983	1
8	Velázquez 16	A1	10	100 %	10	2	140.20	5,458	2
9	Alcalá 119	A1	14	100 %	1	2	140.00	3,841	2
10	Alcalá 117	A1	15	100 %	16	2	144.70	3,950	2
11	Alcalá 115	A1	14	100 %	13	2	104.00	3,804	2
12	Velázquez 14	A1	13	100 %	15	0	124.00	5,409	2
13	Velázquez 28	A1	10	100 %	12	0	140.00	4,235	2

- From a technical point of view, all these buildings are similar: side walls and internal façades are protected but they don't seem to hold any value, so they could be easily improved. Nevertheless, in two cases the internal façade is placed on the plot's boundaries while the rest of them could use their own plot to insulate these back façades.
- Also, the distribution of the apartments in relation to the vertical elements of the thermal envelope shows some exemptions. Buildings 1, 3, 5 and, to some extent number 2, hold some dwellings without access to the main, protected façade.

As it can be seen, it is possible to select buildings by different combinations of variables, depending on the aim of the 'filtering' operation performed. Here, we first looked for a list of buildings to prioritize. But once they have been assessed, it is noticeable that they don't need the same kind of support, and that they have more in common with other buildings already discarded than with the group to prioritize. Therefore, it is possible and necessary to use multiple classifications; the combination of tools for public action that each asset requires will probably derive from these multiple layers of analysis.

Conclusions and future research needs

This paper has shown that there is a large scope for the energy renovation of culturally valuable buildings in the area of Recoletos, in Madrid. This conclusion is based on the proportion between protected/potentially protected and not protected/not valuable vertical elements of their thermal envelopes. Also, it was shown that an assessment only based on geometrical and technical features along with protection level is too limited for policy design.

This analysis was carried out used existing information on Madrid, owned by public bodies plus data generated by examining 2D and 3D aerial photos as well as ground level photos, freely available on the internet. Therefore, public bodies have, at least for Madrid's case, enough information to carry out the inexpensive assessment on the energy efficiency potential of the listed stock, following the method that we proposed. Sadly, there are other valuable data missing or difficult to find for Madrid, mainly related to the building's technical systems, the rental of units inside buildings and related to non-registered, alternative uses for apartments.

The assessment performed could have also included not culturally-valuable buildings. This is good news, as there is no reason to think that the energy renovation of culturally valuable buildings should be performed under an independent support scheme. It would be even less resource-consuming to employ, for the whole building stock, the same analysis model and the same set of support tools to combine. Cultural value should be included as a feature to take into account when assessing, prioritizing and setting the amount of public support deserved by each building.

Regarding the tools that should be used by public bodies to support the energy renovation of listed buildings, our results implicitly show that at least three of them could be enhanced by using this method:

- An information tool available for owners, regulators and technicians which showed the opportunities for energy efficiency improvements of each building – e.g. 'building passports' – could be especially useful when dealing with culturally valuable assets.
- It doesn't seem necessary to exempt heritage buildings from energy efficiency regulations nor to waste the opportunity of mandating energy efficiency improvements when a building regulation is activated. Rather, if the energy efficiency improvement of a given element is difficult or expensive to perform, public bodies could allow owners to postpone its upgrading in exchange for saving the same amount of energy by performing alternative improvements in other elements or systems of the building.
- Free technical support mechanism related to heritage protection and economic support for small adjustments due to protection as part of broad schemes of building renovation.

The next steps of this research will be the enhancement of the described method with the inclusion of accessibility-related and occupiers' age data, in order to explore both economies of scope in energy renovations and financial priorities of occupiers. Also, we will look for alternative sources of information in order to take into account the thermal systems in place, future interactions with electric cars, and complementary uses in the same block. This will make it possible to use the method not only for assessing support for improvements of the building's thermal envelope but also regarding its technical systems.

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