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Energy Efficiency versus Heritage—Proposal for a Replicable Prototype to Maintain the Architectural Values of Buildings in Energy Improvement Interventions on Facades: The Case of the Expansion of San Sebastián

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Abstract: The implementation of energy efficiency improvements in facades, such as ventilated facades or External Thermal Insulation Composite Systems (ETICS), is leading to a widespread modification of these structures. The lack of appropriate regulations to curb the destruction of the built heritage, particularly in historical centers, has been identified. In response to this issue, a project has been developed to create a prototype for determining regulations for facade interventions. The Design Science Research Methodology (DSRM) has been employed in the development of the prototype, which has been tested in a case study of the ensemble formed by the Cortázar and Oriental expansion areas in San Sebastián. The initial prototype has been outlined, corrected, and improved in an iterative process, resulting in a final prototype that enables a faster, more rigorous, and efficient understanding, characterization, classification, study, and definition of intervention criteria, measuring the vulnerability of buildings to these interventions quantitatively. In this study, the vulnerability is defined as the risk that a facade will alter the characteristics of its architectural style and distort the reading of streetscapes that belong to a period with a clearly defined character. The case study results have been compiled into intervention criteria sheets for each of the studied buildings. This material has been presented to the relevant public authorities, with the hope that it may lead to a modification of current legislation, thereby helping to curb the loss of architectural heritage identity.

Keywords: urban design; colour plan; facade classification; architectural vulnerability; cataloguing system; facade rehabilitation; urban policy; built heritage; city identity

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1. Introduction

The loss of places' identities resulting from globalization in all its aspects has led to a need to reassert cultural differences; that is, to recover and preserve the cultural heritage of each place with the respective specificities [1]. Conservation of the built heritage requires that it be regularly maintained and occasional changes will thus occur as time goes by. If this heritage is not adequately recorded and protected, it runs the risk of being denatured. Conservation is a real necessity in daily practice and buildings' owners should possess tools to be able to properly maintain the heritage [2,3].

Those small changes over time underwent a turning point with the market entry of ventilated facades, ETICS (External Thermal Insulation System), new cladding materials and, finally, TBIs (Technical Building Inspections) [4] and facade renovation aid promoted by public administrations [5–8] to improve energy efficiency. This alteration of architecture by covering the enclosure, disregarding the building's architectural values, and disfiguring its identity, is taking place all over the world. However, the case is particularly alarming in the Basque Country, where its occurrence has increased at a staggering pace [9]. Groups of buildings built during a certain time period can be seen, in which each building is modified with different building systems, materials, colours, and compositions; entire neighbourhoods have undergone radical changes without the support of a plan with intervention criteria established beforehand, allowing each residents' association to decide on the characteristics of their facade. Also, systems like the brickwork patterns or the facade made with facing bricks are disappearing, and buildings enveloped by these are losing the sense of their construction and original design. This circumstance is contrary to the ICOMOS declaration, which states that the search for environmental sustainability should assure that the cultural significance of the 20th century's architectural heritage is maintained [10].

Although some research has addressed the topic of facade cladding and energy efficiency, they have done so from other perspectives. For example, Ashrafi et al. [11] evaluate the impact of urban developments around heritage elements protected by UNESCO. In other cases, the deterioration caused by pathological processes in the mortar cladding of historical building facades is analyzed [12]. Other studies address the issue of energy efficiency by avoiding interventions in the facade envelope through the incorporation of renewable energy systems. However, this research aims to focus on the distortion caused by interventions in facades of unprotected buildings in areas where there is a large number of buildings with heritage value, creating a unique characteristic urban landscape.

Of all the problems detected, the most pressing is that of the historic centres. That is why the first research work focused on the ensemble formed by Cortazar (1864) and Oriental (1882) *ensanches* (urban expansion districts) of San Sebastián, Spain. The respective area of San Sebastián is marked by diverse architectural styles. Most of the buildings with cultural value prior to 1945 have been protected, though not the later buildings, with some exceptions [13]. The value of these buildings does not only lie in their architectural uniqueness but also in the specific and recognizable urban image they generate. These are unprotected buildings in urban spaces with very high cultural value. A legal void has been discerned, which enables degrading facade interventions that distort both the architectural style and the urban image of the city [14–16].

In some cases, the facade has been maintained along with a change of colour. In such interventions the facade's material and composition are not changed, though the chromatic factor is, introducing ranges that did not previously exist in this urban space or in buildings pertaining to the same architectural tendency. In other cases, the entire facade has been modified, wrapping the existing one with a ventilated facade system, so that the original facade composition is hidden, simplifying the geometry and generating a flat facade (Figure 1).

(**a**) 2018 (**b**) 2022

Figure 1. (**a**) View of a post-war building's facade in 2018, with facade of continuous render and facing brick; (**b**) 2022 view of the same building, renovated—the frontage has been covered with a ventilated facade, causing an evident distortion of the whole.

There are also numerous examples in which homogeneous texture and surface synthetic materials have been used. These have nothing to do with the heterogeneous appearance of the traditional materials, thereby disfiguring the nature of the *ensanche* [17].

The problem described here has different origins. On the one hand, the lack of protection of buildings and the lack of specific ordinances for intervention in unprotected buildings is a problem [18]. On the other hand, the lack of a colour catalogue of existing buildings that makes it easier for owners to intervene with suitable criteria is an issue. There are also bad practices by some of those involved in construction, who advise residents' associations, urging them to newly enclose their buildings instead of fixing existing defects [19].

The aim of this article is to describe the project undertaken to determine a working methodology to establish and limit criteria for facade interventions in historic centres. In order to make this assessment as objective as possible, a quantitative measurement of the vulnerability of these buildings to facade envelope interventions is proposed. The methodology, an instrument called the *methodological prototype to determine criteria for intervention in the built heritage*, hereinafter the PROTOTYPE, has been tested in a case study of the Cortázar and Oriental *ensanches* of San Sebastián. This methodology can be replicated in other city districts and even in other cities. In Figure 2, the study area can be observed.

Figure 2. View of the Cortázar and Oriental *ensanches* (urban expansion districts) of San Sebastián, Spain.

2. Materials and Methods

The research method employed in this work is the design science research methodology (DSRM). This procedure proposes a cyclic development and assessment process in which the learning is specified in a technological rule. Authors such as Cash et al. [20] have asserted that this research method is usually motivated by theoretical or practical challenges and that it supplies contributions which, besides filling gaps in knowledge, also establish the bases for future research and findings.

According to Voordijk [21], DSRM is a prescriptive research procedure that generates knowledge to improve aspects of the built environment, as opposed to other methods that deploy descriptive research strategies that try to explain the phenomena occurring therein. Its prescriptive nature means the results are practically applicable in real environments.

Johannenson and Perjons [22] have noted that DSRM generates an artificial construction or 'artefact' which provides a solution to a problem, and that it can be a physical object, a set of guidelines or an ICT solution. Authors such as Van Aken [23] and Romme [24] point out that the application of DSRM can reduce the existing distance between theory and practice, due to its intrinsic ability to generate knowledge that serves to improve existing theories (Figure 3).

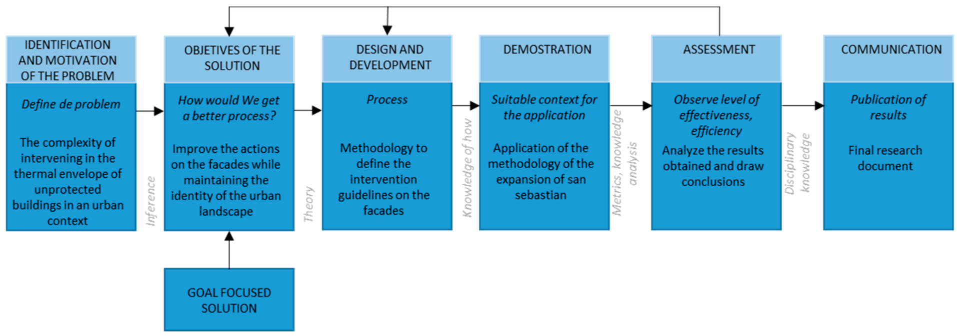


Figure 3. DSRM methodology. Simplified flow diagram.

Starting with the study of the problem and applying existing knowledge bases on the matter, a solution is developed which is evaluated and refined until the version is obtained which will be applied in the problem's environment. The prototype's design, besides meeting a specific demand, in turn helps improve the knowledge base.

When establishing the specific steps the DSRM should follow, the literature shows different sequences, depending on which ambit is applied. Manson [25] identifies 5 essential steps: 1 Awareness of the problem; 2 Proposal; 3 Development; 4 Evaluation; and 5 Conclusions. This methodology was adjusted to the specific characteristics of the research project. A diagram of the adjusted methodology is presented in Figure 4.

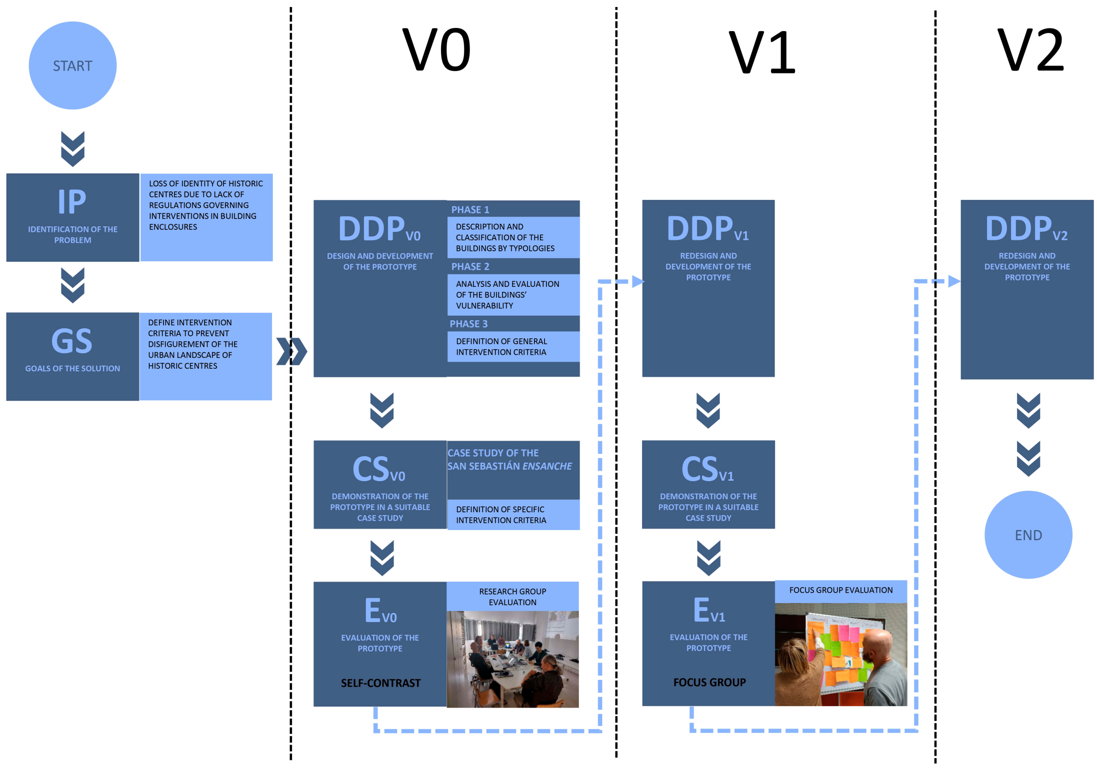


Figure 4. Diagram of the methodology adapted from the DSRM.

Figure 4 illustrates the methodology theoretically. The proposed methodology suggests several iterations of the different phases to reach the final prototype. During these revisions, the effectiveness criteria of the buildings are reviewed and contrasted among the research group members in various sessions. This contrast has led to several adjustments to the prototype, for example, in the assessment of the vulnerability of certain scenarios, thus generating successive versions of the proposed initial prototype. The final prototype is worked on in several workshop sessions with a focus group to ensure that the final prototype is endorsed by the panel of experts.

The process permits feedback based on the development and evaluation of the proposal, enhancing awareness of the problem, and improving the initial approach. The development of the research methodology used was achieved in the following manner.

2.1. IP—Identification of the Problem

The first step is the problem's identification and motivation. The problem the research considers is the distortion generated in the urban landscape of historic city centres due to energy efficiency interventions in facade enclosures using EIFS-type and ventilated facade building systems without any regulation.

2.2. GS—Goals of the Solution

In the second step, the objectives of the solution the presented methodology is meant to provide are defined. In this case, the main goal will be to determine general and specific criteria for intervention in these buildings, thereby enabling development of a regulation that prevents the distortion generated in historic city centres.

2.3. DDPV0—Design and Development of the Prototype V0

After identifying the problem and defining the objectives, a system has been structured to design a V0 prototype to establish the acceptable intervention criteria for each building. This prototype has been designed in three phases.

2.3.1. Phase 1: Characterisation and Classification of Buildings by Typology

In the first phase the buildings are described and classified in scenarios and sub-scenarios. This classification is done based on architectural, typological, and compositional characteristics of the buildings to study: material, texture, cladding arrangements, volumes, colour, railing typology, balconies, and dropped ceilings.

2.3.2. Phase 2: Analysis and Assessment of the Vulnerability of Buildings

In a second phase, the building's vulnerability to eventual facade enclosure renovation interventions using ETICS or ventilated facade systems is quantifiably analyzed and evaluated [26,27]. The characteristic features of each building are therefore determined with respect to geometry, existence of relief and decorative elements, texture, materials, and colour of the facade, including finishing work, railings, and false ceilings, etc. The risk of altering these characteristic features of each building will numerically determine their vulnerability. Two vulnerability levels are defined: medium/low vulnerability and high vulnerability.

2.3.3. Phase 3: Definition of General Intervention Criteria

In the third phase, based on this evaluation, the general intervention criteria are established.

2.4. CSV0—Demonstration of the Prototype in a Suitable Case Study

The next step will be the demonstration applying the designed procedure, in an appropriate case-study context, to subsequently evaluate the results obtained. Authors such us Hevner et al. [28] consider that the evaluation is crucial and urge researchers to demonstrate the usefulness, quality, and effectiveness of a design prototype, using rigorous evaluation methods. In this research, the Cortázar and Oriental *ensanche* districts of San Sebastián, Spain, were chosen. The choice is based on the fact that they comprise an urban area with high heritage value, emblematic of the city's image.

The respective area is manageable. Also, it was mostly built up between 1865 and 1940, passing through the period of eclecticisms, historicisms, and art nouveau, whose compositional, decorative, and stylistic kinship is very evident. Although a large number of the analyzed *ensanche* buildings have a certain degree of protection, there is a high number of buildings that have been excluded from that protective legislative framework and that is what inspired the approach taken by this study, because there are enough of them to denature the consistency of the long facade surfaces lining the streets.

2.5. EV0—Evaluation of the Prototype by the Research Group

A preliminary prototype V0 is used to assess the degree of integration of the building within the facade canvas in which it is inserted. For this purpose, a protected reference building located on the same facade canvas, understood as the facade front of a block, is selected and compared in percentage terms by measuring composition, material, and colour. Through the contrast carried out by the research group, it has been observed that this system introduces distortions in modern buildings in the expansion area. Consequently, it has been corrected, resulting in version V1 of the prototype.

2.6. DDPV1—Design and Development of the Prototype V1

It has been found that the prototype initially proposed does not meet all the established objectives in all the buildings studied. In some cases, the proposed prototype allows for undesired interventions, so starting from version V0, it has been redesigned, creating a V1 version, incorporating the necessary adjustments to achieve the proposed objectives.

This V1 version has been re-implemented in the case study, including tools that allow for objectively measuring the risks and drawbacks that interventions in the facade envelope may entail. To achieve this, tables for the identification and classification of buildings into scenarios are designed, as well as a table that quantitatively measures the vulnerability assessment of each of the buildings studied.

2.7. CSV1—Demonstration of the Prototype in a Suitable Case Study

The redesigned V1 version has been applied in the selected scenarios, firstly classifying the buildings into sub-scenarios based on the characteristic features of the building under study. Secondly, the vulnerability of each of the buildings has been quantitatively assessed. The combination of both aspects has allowed for the definition of specific criteria for each building.

2.8. EV1—Evaluation of the Prototype by the Focus Group

The results have been conveyed to a focus group comprised of a panel of experts. The focus group has been composed of specialists such as architects specializing in urban planning and building typology, architects with expertise in construction systems and rehabilitation, and historians.

The focus, or discussion, groups are qualitative research tools that gather a group of experts to opine about a question, process, or product that is of interest for the participants [29].

This technique gathers a small number of experts in the same space and requires a moderator to lead the session. The latter begins by presenting the question to deal with and asks questions so that the participants can interact.

The focus group compiles what the participants opine and do regarding a question and, after exploring the nature of their responses, enables a reduction of the uncertainty associated to the research topic [30]. This procedure is extensively used to design and develop products, although it was initially conceived so it could be applied in the area of sociology [31]. This process has served to gather the participants' perception of the proposed methodology, conduct an assessment, and suggest improvements to the proposed methodology. In this case, the focus group selects a series of buildings and applies the proposed prototype to analyze its correct operation and determine if the general and specific criteria defined based on the applied prototype are coherent and serve to achieve the initially proposed objectives. The final evaluation has enhanced the prototype, resulting in the generation of the ultimate prototype, V2.

2.9. DDPV2—Design and Development of the Prototype V2

The results obtained from the application of prototype V1 have been conveyed to a focus group. This focus group, comprised of a panel of experts from various specialties, has compared these results, suggesting some adjustments, which have enabled a version that fully meets the predetermined objectives. As a result of the application of this final prototype, specific sheets have been generated for each building, defining the level of flexibility of interventions and the actions allowed for each defined parameter.

3. Results

The Cortázar and Oriental expansion of San Sebastián has been chosen as the case study. This urban layout was constructed following the demolition of defensive walls in the second half of the 19th century [32]. Following the trend set by Cerdá for Barcelona (1859) and Castro for Madrid (1860) [33], Antonio Cortázar created an orthogonal grid of streets and blocks occupying an area of 45.7 hectares. It runs along a flat terrain bounded by the sea, the river, and the surrounding hills. It is articulated by using 11 orthogonal streets that are catalogued as 1st, 2nd, and 3rd order streets due to their widths, which range from 12 m to 34 m in the most important avenue. Two types of blocks are arranged in this plot according to their size: those between the old case and the main avenue are 12 rectangular blocks of 86 m $\times$ 62 m; those that go from the main avenue to the south are square and vary between 50 and 60 m on each side.

These blocks are divided into plots of about 20 m $\times$ 20 m. In the first section, the rectangular blocks, there are between 12 and 15 plots between party walls in each block. The maximum surface areas are about 400 m^2. In the southern part, the size of the plots decreases to a minimum of 160 m^2 [34].

The initial heights are ground floor plus three floors and an attic. Later ordinances allowed the heights to be raised, but this was done in a homogeneous way, so there are no major jumps in the skyline of the city and there is a very clear sensation of compactness and order [35].

Its use is predominantly residential, with a high proportion of seasonal holiday lettings. The Ensanche was built almost entirely between 1864 and 1920. As a result, there is a high degree of stylistic homogeneity. The first section, from the historic quarter to the Plaza de Gipuzkoa, is in neoclassical style, becoming more ornate as time goes on. From the Plaza de Gipuzkoa towards the Avenida de la Libertad, eclecticism and historicist revivals began to appear, and so there was a proliferation of ornaments attached to the facade. From Liberty Avenue to the south, eclecticism becomes more abundant, as do the historicist revivals, and art nouveau appears towards the southern end. At the end of this southern end, the 1920s saw the arrival of regionalism.

The ensemble is very coherent in the facades of the streets. The neoclassical, eclectic, and historicist styles are dominant, and by sharing the compositional premises, the materials and the sense of ornamentation make a continuum with a defined and very recognisable character. The geometry of the facades, the colours, the balconies and miradors, the heights, etc., all the elements that create the image of the city, have been very well associated, without creating major discordances.

Most of the original buildings have been protected, either due to their unique values or their environmental character. This environmental character refers to the facade fronts of its immediate surroundings. However, those buildings that have undergone degrading renovations, substantial replacements, or are post-1945 remain unprotected. Specifically, 105 unprotected buildings have been identified, where current regulations allow for the installation of any type of external cladding, such as External Thermal Insulation Systems (ETICS) or ventilated facades, without limitations on materials or colours. In many cases, these modifications degrade the facades of the buildings and, in any case, distort the character of the expansion area and its identity. Therefore, it is considered an ideal case study to test the prototype.

3.1. Phase 1: Description and Classification of the Buildings

In this initial phase, a study of the intervention area, an inventory of the buildings to be analyzed, and the applicable urban regulations must be conducted. A preliminary classification of the buildings will be carried out based on the architectural style to which they belong, and the building classification table will be adjusted to accommodate any new styles found in the area. The characterization of the buildings is done using indicators defined in Table 1.

Table 1. Indicators defined for the characterization of buildings.

Facade	**Indicators**
Cladding or facade material	Stone facing or veneer Tiles Continuous render Masonry Ashlar Brick Curtain wall
Facade material texture	Medium roughness High roughness Smooth matte Smooth shiny
Facade material arrangement	Vertical Horizontal Grid
Facade volume	Facade plane + balcony recess plane Singular volumetrics Flat
Facade cladding colour	Sand Pale Red (brick) Striking (dark grey, yellow, pink, etc.)
Finishing work colour	White Grey Black Brown Natural wood Striking colour (blue, green, etc.)
Colour of blinds or shutters	White Grey Black Brown Natural wood Striking colour (blue, green, etc.)
Balconies and railings	
Balcony type	Cantilever Recessed Continuous No balcony
Railing type	Only parapet Metal with vertical bars Parapet + railing Glass

Table 1. *Cont.*

Facade	Indicators
Railing colour	White Grey Black Brown Natural wood Striking colour (blue, green, etc.)
Colour of the dropped ceiling	White Grey Black Brown Natural wood Striking colour (blue, green, etc.)

Bearing in mind the various existing architectural typologies, several architectural and compositional indicators were established to describe the buildings and classify the scenarios and sub-scenarios (specific features shared by a group of buildings, belonging to a period or a style). Those indicators have been grouped in two sections. One section corresponds to the facade, identifying the cladding materials, their texture, arrangement, and colour, as well as the volume and the colour of the finishing work, such as blinds and/or shutters. For their part, the balconies and their railings were described according to balcony and railing type as well as railing chromatic factor. The definition of these indicators evolved as comparisons were made in the workshops with the panel of experts. The definitive indicators accepted by the focus group are defined in Table 1.

The description of the buildings helped determine different scenarios and sub-scenarios [36]. Each one groups buildings with similar architectural, typological, and stylistic features.

In this case study ten scenarios were identified; in some of them sub-scenarios were in turn defined. The classification of scenarios and sub-scenarios was reviewed in various sessions with the panel of experts until the final classification was decided on. The result is set out in Table 2.

Table 2. Classification of scenarios and sub-scenarios.

Scenario	Description	Sub-Scenario
Scenario 1	Buildings with singular volumetrics	Sandstone Pale stone
Scenario 2	Light buildings	Sandstone Pale stone Other
Scenario 3	Heavy buildings	Sandstone Pale stone Other
Scenario 4	Buildings—first half of the 20th century	Neoclassical Eclectic Modern Post-war
Scenario 5	Historicist buildings	Eclectic Neoclassical
Scenario 6	Buildings with continuous balcony	

Table 2. *Cont.*

Scenario	Description	Sub-Scenario
Scenario 7	Renovated buildings	Sculptural in origin Heavy in origin Continuous balcony in origin Light in origin
Scenario 8	Office buildings	
Scenario 9	Buildings with curtain wall	
Scenario 10	Free design buildings	

In Figure 5, the unprotected buildings of the studied *ensanche* are presented, classified into scenarios and sub-scenarios.

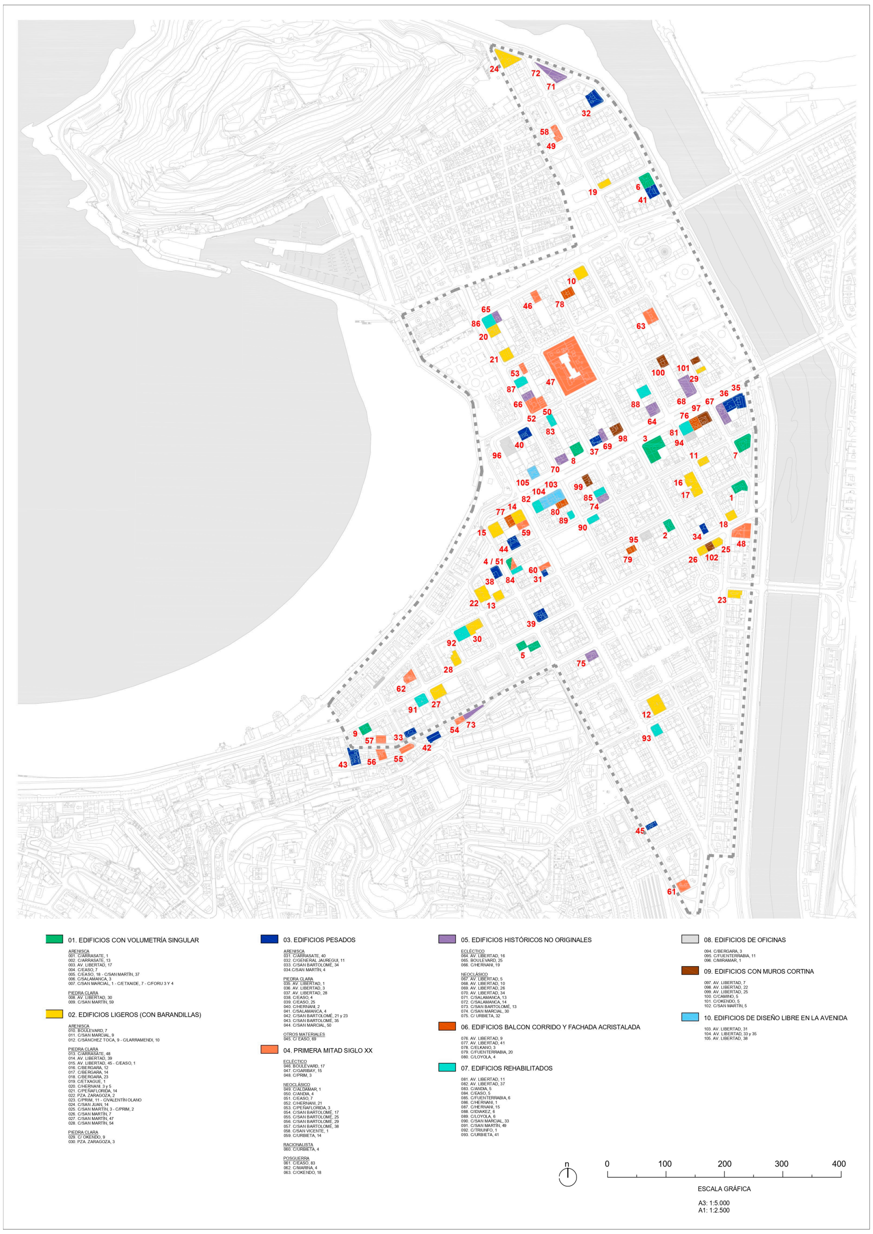


Figure 5. Map of the Cortázar *ensanche* and Eastern *ensanche*. Classification of unprotected buildings into scenarios and sub-scenarios.

Although the prototype was applied to all the scenarios in the research project, this article presents its application in scenario 4, concerning buildings—first half of the 20th century, because it was considered one of the most vulnerable scenarios and the one that presented the greatest variety of typologies.

3.1.1. Scenario: First Half of the 20th Century Buildings

The scenario of buildings made in the first half of the 20th century begins in the first construction decade of the Cortázar *ensanche* (urban expansion district), 1860–1870, and ends in the 1950s. It groups the neoclassical, eclectic, historicist, or regionalist buildings included in the academic composition family of the *ensanche*. They all have a rigorous geometric base, a fundamental legacy of the old city's neoclassical reconstruction by Pedro Manuel de Ugartemendía after its total destruction in 1813. The imprint of Ugartemendía would remain until the first third of the 20th century, but as time passed would be covered with more complex facade planes, textures, and decorative elements.

3.1.2. Sub-Scenario Neoclassical Buildings

The first sub-scenario is designated 'neoclassical'; it is the oldest, though its permanence in the *ensanche* lasts well into the 20th century. Its basic features are a smooth facade plane with a minimally cantilevered balcony, rigorous alignment of facade openings along vertical and horizontal axes (the size of all openings situated above the ground floor is identical), and a base floor with sandstone ashlar facing or a veneer of the same material. The surface of the central body of floors is usually finished with render or sandstone veneer. The render's colour can encompass all tones between natural and ochre sandstone. In Figure 6, unprotected neoclassical buildings with degrading elements are presented.

Figure 6. Unprotected neoclassical buildings with degrading elements.

3.1.3. Sub-Scenario Eclectic Buildings

The second sub-scenario is 'eclectic'; its main feature is more decoration attached to the facade wall, which is thicker and also filled with different textures and materials. Although its compositional base is rigorously geometric, as the neoclassical was, there is a clear intention for each construction to be distinguished from the others and to be unique. The eclectic style most used in San Sebastián, whose main reference during that period was Parisian architecture, is the 'Beaux-Arts' eclecticism characterized by the use of forms and decoration from different French classical styles. Details from the Italian and French repertoires would also be added. The facades would be filled with balustrades, corbels, veneers of different kinds of stone, bossed bases, mansards, and opening surrounds, etc. Toward the end of the 20th century, decorative elements such as isolated columns, large cantilevered corbels, bay windows, or balustrades increased in number and variety and would be detached from the face. The appearance of moulded cement mortar decorative elements, much cheaper than carved stone and marketed in catalogues since the late 19th century, contributed greatly to making the eclectic styles increasingly ornate. They would continue to be significant in the 20th century until the war of 1936. In Figure 7, unprotected eclectic buildings are presented.

Figure 7. Unprotected eclectic buildings.

3.1.4. Sub-Scenario Modern Buildings

The third sub-scenario has been called ‘modern’ because it arises from some of the premises of the European modernist movement in the 1930s. After this new architectural trend arrived in San Sebastián, the initial pureness of approaches in its most vanguard and radical version was diluted in other ways more appropriate for the taste of the general public. On the one hand, the deco option, the most successful in the 1930s, appeared. On the other, especially in the 1940s, a formula which arrived at modernity from the classicist synthesis matured. With Spanish precedents such as Teodoro Anasagasti and the influence of fascist architecture in Italy, its continuity was maintained without problems, as the regime’s new director-general for architecture, Pedro Muguruza, was one of its most relevant followers. This formula is based on very rigorous geometric order, which differs from Ugartemendía, in that the openings are more square (there are no balconies and if there are they tend to have a blind parapet instead of a balustrade). A base level is usually differentiated, which includes the commercial ground floors and a first floor that can be for either offices or dwellings. This is read as a different unit from the body of floors immediately above, as the chosen material is changed: stone veneer for the base and render or brick for the body of floors. In Figure 8, unprotected modern buildings are presented.

Figure 8. Unprotected modern building.

3.1.5. Sub-Scenario Post-War Buildings

The fourth sub-scenario is labelled 'post-war', gathering the new compositional models that appeared after the war of 1936 and constituting the urban language of the Franco regime. Over a rigorously geometric base, proceeding from Escorial and early Castilian baroque, are superimposed various classical lines, from those marked by Luis Gutiérrez Soto at the Air Ministry to the forms and dispositions of late-baroque Madrid palaces. As for materials, brick is included (usually brick veneer), alternating with artificial stone veneer, which runs from white to light ochre, from limestone to sandstone. It can include large vertically arranged bay windows and balconies set back from the facade surface. Vertical rhythms are often found in the composition, with brick surface strips, bay windows, and balconies, etc., and always assuring geometric regularity and symmetry. Another sign of identity of this compositional pattern is the two-colour tendency. The type ranges between two models: one more ornate, with bay windows and cement mortar decorative elements attached to the façade, without ever reaching the excesses of the *ensanche*'s eclecticism, and another more synthetic and modern where there are only balconies, windows, and facing of brick, reducing decoration until it almost disappears. In Figure 9, unprotected post-war buildings are presented.

Figure 9. Unprotected post-war building.

3.2. Phase 2: Analysis and Evaluation of the Buildings' Vulnerability

As explained in the introduction, there are many studies on the vulnerability analysis of buildings concerning different external agents that may undermine or attack their heritage value integrity. Some of these studies focus on analyzing vulnerability due to the use and maintenance of these heritage buildings [37].

Others base their research on the impact of singular atmospheric events, disasters such as earthquakes, or due to the action of coastal phenomena, flood-prone areas, etc. [38–40].

However, in no case have studies been conducted on the objective and quantitative quantification of the vulnerability of unprotected buildings located in predominantly heritage-protected urban areas, which, to improve their energy efficiency, are transformed and modified entirely through techniques and various constructive processes of overlaid exterior coatings, such as ventilated facades, ETICS, or any other material alien to their original configuration and composition.

The present research addresses methodically, uniquely, and originally the problem or question of evaluating these buildings and their original constructive vulnerability and configuration concerning these invasive exterior energy rehabilitation techniques, creating a replicable prototype extending to the urban core in which they are inserted. Through this methodology and its results, it is possible to propose and specify the most suitable intervention techniques or systems for their energy rehabilitation, safeguarding the heritage value of the urban fabric as a whole of which they are part.

The description of the buildings identified the need to assess each building's vulnerability, understood as being the risk of undergoing a change that disfigures their original nature. The various materials used in the facade cladding of each building, their texture and colour, the geometric complexity (with a profusion of planes in some cases and flat facades in others, with decorative elements and relief in some cases and austere facades in others) means that the buildings have a different degree of distortion when renovated with exterior facade insulation systems such as ETICS or ventilated facade. Questions of the yes/no response type were considered. In the first versions, the value of negative responses for all criteria was set at 0 and affirmative responses at 1. Each version was applied in all of the buildings studied, a total of 105. Comparisons of the values for these criteria with the expert panel concluded that some criteria generate more vulnerability than others, whereby the value for some of those criteria was modified. In the case in which the facade has ashlar and/or masonry enclosures, whether on the ground floor or upper floors, those criteria are valued at 3, due to the risk of being covered with other less noble materials, causing evident distortion. Table 3 sets out the definitive criteria determined to evaluate and quantify the vulnerability of each building.

Table 3. Criteria and quantification for the analysis and evaluation of building vulnerability.

Criteria	Yes/No	Value
Does it have two or more plane alignments?	Yes No	1 0
Does it have three or more plane alignments	Yes No	1 0
Does it have upward and/or downward sloping planes?	Yes No	1 0
Does it have diagonal protruded and recessed planes?	Yes No	1 0
Does it have curved elements?	Yes No	1 0
Does it have vertical strips?	Yes No	1 0
Does it have horizontal moulding?	Yes No	1 0
Does it have occasional decorative elements?	Yes No	1 0
Does it have flower boxes?	Yes No	1 0
Does the balcony parapet have different protruded and recessed planes (+4)?	Yes No	1 0
Does it have opening surrounds in relief?	Yes No	1 0
Does it have horizontal striped texture?	Yes No	1 0

Table 3. *Cont.*

Criteria	Yes/No	Value
Does it have vertical striped texture?	Yes No	1 0
Does it have floor (not ground floor) facade with exposed masonry?	Yes No	3 0
Does it have upper floor (not ground floor) facade with exposed ashlars?	Yes No	3 0
Does it have ground floor facade with exposed masonry?	Yes No	3 0
Does it have ground floor facade with exposed ashlars?	Yes No	3 0

Based on the vulnerability assessment, ranges are determined that dictate the possibility of intervening in the building from the exterior.

If the building is less vulnerable, it means that it lacks complex geometries, ornamental elements, or plane changes that could disappear with facade intervention, so the intervention criteria are more flexible. In cases where vulnerability is high, however, it implies that the compositional and material architectural attributes are at risk of disappearing with this type of intervention, so the intervention criteria are more restrictive, even to the extent of defining that no action can be taken on the facade from the exterior. Figure 10 illustrates the ranges defined based on the quantitative evaluation of vulnerability and intervention flexibility.

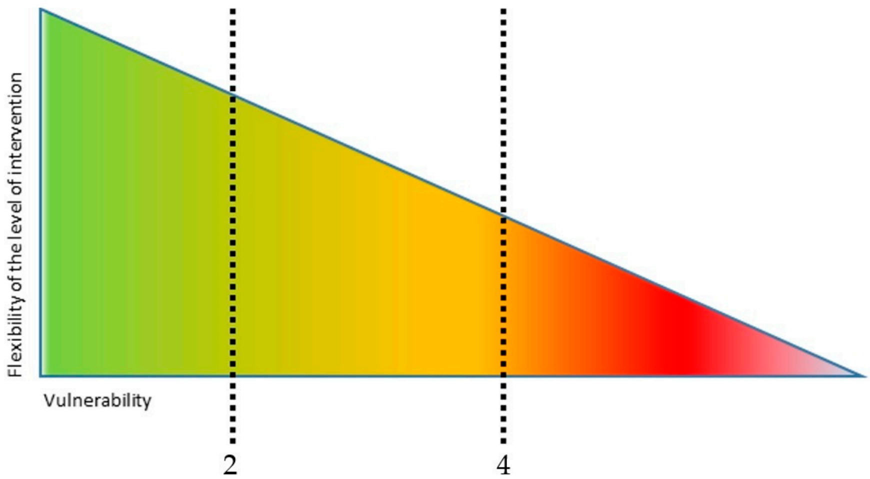


Figure 10. Vulnerability/Flexibility of the level of intervention diagram.

In the case study, the degree of vulnerability of each building has been obtained. The overall results show a significant similarity in the vulnerability degree of the sub-scenarios, where both eclectic buildings, modern buildings, and post-war buildings are highly sensitive to the risk of undergoing a modification that distorts their character. The group of neoclassical buildings is more heterogeneous, encompassing buildings with greater variety in terms of compositional richness and ornamentation. These results are shown in Table 4.

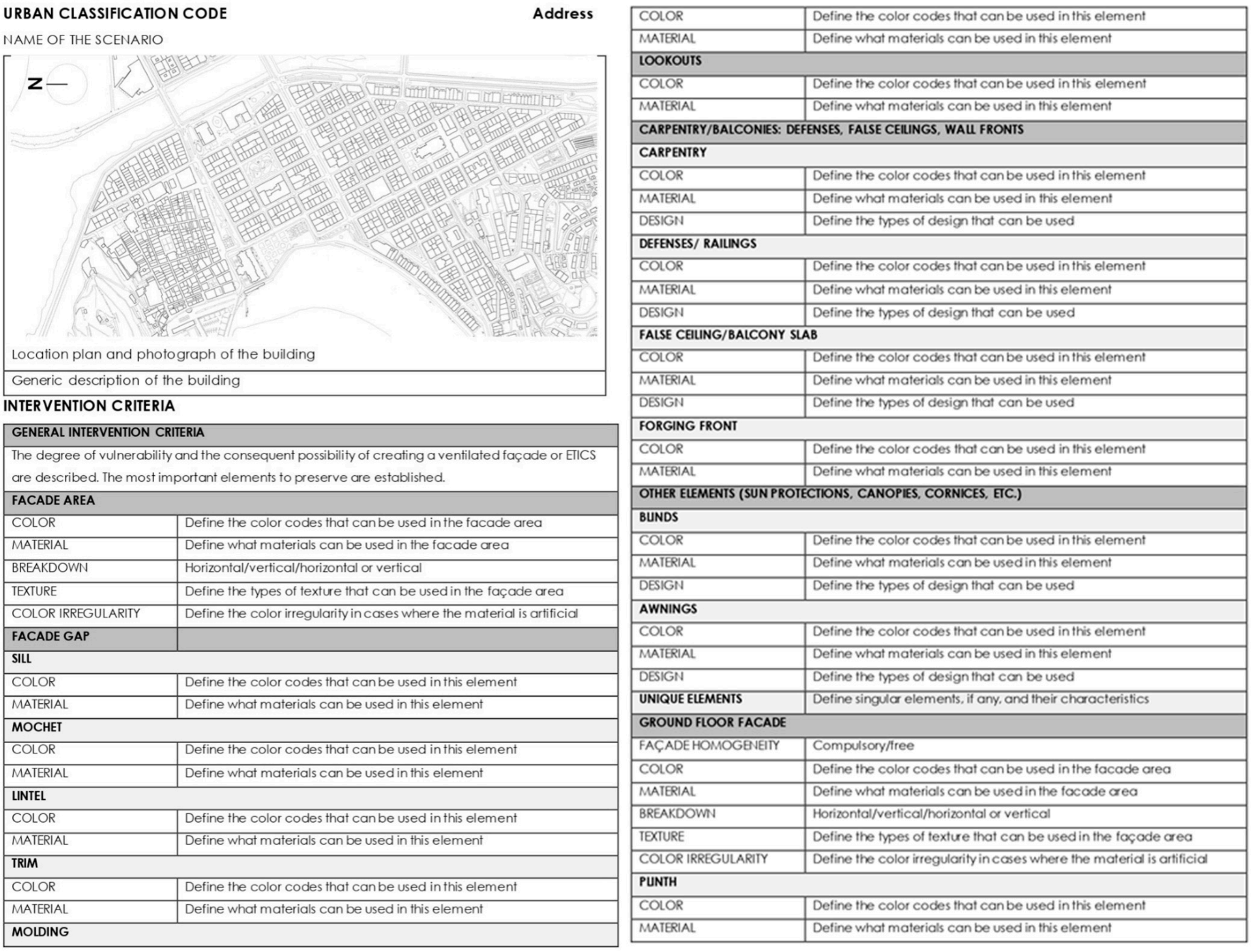
Table 4. Degree of the vulnerability of the facades. Scenario 4, buildings—first half of the 20th century.

Sub-Scenario	Low	Middle	High
	≤2	**>2–≤4**	**>4**
Neoclassical buildings	62.5%	25%	12.50%
Eclectic buildings			100%
Modernist buildings			100%
Post-war buildings			100%

3.3. Intervention Criteria in Each Building

The fulfillment of the project objectives requires the creation of a record in which the morphological, material, and chromatic characteristics of building facades, as well as intervention criteria, are clearly defined. In this regard, the development of an indicator record has been deemed essential and should be as explicit as possible, with parameters that must be defined independently of the building's heritage significance.

The intervention criteria table establishes the parameters to be considered when regulating facade rehabilitations or renovations. These parameters have been defined, applied to the selected buildings, and adjusted based on the results obtained. The definitive parameters are presented in Figure 11.


URBAN CLASSIFICATION CODE **Address**

NAME OF THE SCENARIO

Location plan and photograph of the building

Generic description of the building

INTERVENTION CRITERIA

GENERAL INTERVENTION CRITERIA	
The degree of vulnerability and the consequent possibility of creating a ventilated façade or ETICS are described. The most important elements to preserve are established.	
FACADE AREA	
COLOR	Define the color codes that can be used in the facade area
MATERIAL	Define what materials can be used in the facade area
BREAKDOWN	Horizontal/vertical/horizontal or vertical
TEXTURE	Define the types of texture that can be used in the façade area
COLOR IRREGULARITY	Define the color irregularity in cases where the material is artificial
FACADE GAP	
SILL	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
MOCHET	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
LINTEL	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
TRIM	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
MOLDING	

COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
LOOKOUTS	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
CARPENTRY/BALCONIES: DEFENSES, FALSE CEILINGS, WALL FRONTS	
CARPENTRY	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
DESIGN	Define the types of design that can be used
DEFENSES/ RAILINGS	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
DESIGN	Define the types of design that can be used
FALSE CEILING/BALCONY SLAB	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
DESIGN	Define the types of design that can be used
FORGING FRONT	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
OTHER ELEMENTS (SUN PROTECTIONS, CANOPIES, CORNICES, ETC.)	
BLINDS	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
DESIGN	Define the types of design that can be used
AWNINGS	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element
DESIGN	Define the types of design that can be used
UNIQUE ELEMENTS	Define singular elements, if any, and their characteristics
GROUND FLOOR FACADE	
FAÇADE HOMOGENEITY	Compulsory/free
COLOR	Define the color codes that can be used in the facade area
MATERIAL	Define what materials can be used in the facade area
BREAKDOWN	Horizontal/vertical/horizontal or vertical
TEXTURE	Define the types of texture that can be used in the façade area
COLOR IRREGULARITY	Define the color irregularity in cases where the material is artificial
PLINTH	
COLOR	Define the color codes that can be used in this element
MATERIAL	Define what materials can be used in this element

Figure 11. Model of the intervention criteria sheet.

The application of this table to each building allows for the establishment of composition, colour scheme, and materiality parameters specific to each sub-scenario. The degree of vulnerability of each building will be considered to determine the type of intervention that can be carried out on each building. Data analysis within each sub-scenario will enable the establishment of general intervention criteria.

The established indicators, as previously mentioned, originate from the inherent characteristics—due to their belonging—of the expansion area, the setting in which they are located, and the evident vulnerability to which they are exposed.

The architectural diversity of the studied buildings has necessitated the systematization of the record, formalizing the interventions. Thus, the established indicators clearly and concisely determine the intervention to be carried out.

Following the methodological order set out in the previous paragraphs, below is presented an example of the file specifically produced for each of the buildings included in the research.

The file defines both the scenario and the sub-scenario in which the building was classified. It also specifies the respective location in the map of the *ensanche* and the postal address, additionally providing a photo of the building's facade and indicating the designer of the original plan, as well as the respective date, which are data gathered from either the Municipal Archive of San Sebastián or the Cadastre of Gipuzkoa.

Before addressing the intervention criteria, each file presents, as an introduction, a generic description of the sub-scenario it pertains to, from which were extracted the values that, due to its specific nature, enable us to establish the general intervention criteria, as well as a summarized description of the building itself. The latter includes the most relevant respective information, such as the number of floors, the facade composition and materials, singular elements that determine its nature, and, ultimately, all relevant information that can be irrevocably altered when intervening on the facade.

The intervention criteria are determined in a table below, generically from the beginning, to subsequently go on defining the possible actions on each of the elements that comprise the facade. The buildings pertaining to a scenario (or sub-scenario) enables the generation of several action guidelines common to the whole family, so that they do not lose the generic values inherent to the scenario in which they are situated. Most of the permitted intervention is therefore clearly defined in this section; it will subsequently be defined and detailed by means of the items indicated in the table.

The table continues to determine and define the characteristics of the series of elements comprising the facade, indicating for each of them the criteria to follow. The *Blind facade wall* is defined, complemented with *Colour/material/arrangement/texture/colour irregularities*; both items present the guidelines to follow, refining and singularizing what is indicated in the general intervention criteria. This section referring to the facade wall is vitally important, without detracting from any of the others, as it bears a large part of the responsibility for endowing the building with a specific uniqueness impossible to achieve by altering its characteristics. Local materials, with their characteristic colours, texture, and arrangement, maintain what is defended in Law 6/2019 in section III of its statement of reasons [35] 3: *"A new all-encompassing definition of the concept of surroundings is also established, reflecting its instrumental nature with the aim of maintaining the landscape, urban and architectural context in which the property is integrated. Also, in line with new trends and current sensitivities, visual and acoustic pollution is regulated."*

The following group of elements, *Openings (windowsill, recess, lintel, surround moulding)*, *Bay windows*, and *Finishing work/balconies (defences—railings and parapets, dropped ceilings, slab fronts*, describe and limit possible interventions involving the openings, their accessories and materials, and their relationship with the facade wall. This section was subject to constant modifications, that helped precisely determine the need to conserve construction elements that in principle do not seem relevant (surely due to their current industrial fabrication) but which add irreplaceable value to the facade. We could speak of certain types of finishing work, wooden protections, dropped ceilings, etc., made by artisans (carpenters, etc.) which due to their form (though executed in other material) are inherent to the building's specific nature.

Finally, there is an item for *Other elements (solar protections, awnings, cornices, etc.)*, whose existence also defines the singular nature of the building (even situating it chronologically), before ending with *Composition of the ground floor facade wall*, an aspect hard to approach due to the various factors it involves.

3.4. Phase 3: General Intervention Criteria

Once the characterization is completed, the vulnerability degree study is conducted, and the intervention criteria are defined for each building, general intervention criteria are established for the sub-scenario. The purpose of this final step is to correct the sheets of each building, unifying the criteria used. It is a way to ensure the impartiality and accuracy of the work done.

Based on the description done for each group of buildings in the sub-scenarios, the vulnerability evaluation carried out, and the intervention criteria of each building, the general intervention criteria were established [41,42]. To that end, the first work consisted of determining the parameters affecting the architectural quality of the buildings when an intervention is undertaken. Although it seems that these parameters should be in existing regulations to protect buildings with heritage value, many of the studied parameters are not indicated in the regulations applicable to the *ensanche* districts. According to the municipal regulations of San Sebastián, exterior insulation to improve energy efficiency cannot be used in protected buildings finished in stone, ceramics, render, or a repertoire of decorative details attached to the facade. This guarantees preservation of the original facade material and original decorative elements. In cases where the facade finishings are not original or valuable, the thermal insulation systems should guarantee that the intervention over the original facing material and original decorative elements, as well as the essential composition lines, can be reversed [43]. In most cases, the respective morphological, material, or colour characteristics are not specified. These new parameters were therefore tested and applied in all the files, and they were corrected and the DSRM methodology was followed, seeking universal indicators, and attempting to systemize the procedure as far as the unique nature of each building allowed.

Below are presented the criteria established in the final prototype for buildings pertaining to the following sub-scenarios: neoclassical, eclectic, modern, and post-war styles.

3.4.1. Neoclassical Buildings

Buildings in neoclassical style present a classicist typology with a large presence in the historic centre and in the *ensanche*, whose nature has two bases: geometry and smooth veneer (corresponding to the original type done in ashlar) or render (according to a more affordable reading of the model) wall. This group of buildings has horizontal moulding, occasional decorative elements, opening surrounds in relief and masonry, or ashlars in some cases.

The intervention criterion is therefore to maintain the aspect of these buildings without denaturing their composition, materials, texture, or colour. If it is render, the general criterion should be to maintain a render surface. If it is stone, the general criterion should be to maintain a stone surface.

The original location of the windows should be respected, whether intervening inside or outside the facade. It is important to respect the mouldings of the surrounds and decorative elements. The horizontal impost lines should maintain the surface resulting from the intervention and the same degree of relief as in the original.

It is advisable to prohibit the replacement of metal railings by continuous panes of glass or other plastic or similar materials.

3.4.2. Eclectic Buildings

The eclectic buildings are generally extremely vulnerable to the risk of undergoing a change that disfigures their original nature.

Given the compositional richness, volumetrics, and material of these facades, interventions in them run a great risk of losing their value. All of them have three or more plane alignments, with veneers of different materials and various amounts of relief, which creates a characteristic sensation of texture in this style. They can have horizontal mouldings, occasional decoration, opening surrounds in relief, striped textures, exposed masonry, and ashlars. The finishing work is usually very rich, especially in cases with bay windows. The buildings' materials are high quality.

If they underwent interventions that were not very respectful after their construction, it is recommendable to restore the original values. Any intervention should seek to recover the cited values.

That is why it is advisable to prohibit undertaking an intervention that modifies the facade on the outside. Any intervention meant to insulate the building should therefore be done from inside it. The specific characteristics of the facade should be maintained in any respective intervention.

3.4.3. Modern Buildings

In the case of modern buildings, the original window alignments should be respected, whether intervening outside or inside the facade.

It is important to respect the mouldings of the surrounds and the decorative elements. Horizontal impost lines should maintain the same degree of relief as in the original.

In all cases where there is stone veneer, the most advisable intervention is done from inside the facade. In the case of an intervention on the outside, the solution could be ventilated facade, ETICS, or a combination of both, as long as the original reading is guaranteed; the facade's specific characteristics should be maintained, respecting both the texture and the colour. It is advisable to forbid the replacement of metal railings by continuous panes of glass or other plastic or similar materials.

3.4.4. Post-War Buildings

Post-war buildings have high or very high vulnerability in facade interventions, which can entail the risk of undergoing a modification that disfigures their original nature. The different facade planes, as well as the use of various materials when implementing different construction solutions, determine the essential features of these buildings. They are therefore the elements to care for and maintain. Specific elements to maintain would be the surrounds, mouldings, railings/balustrades, and decorative elements.

The most advisable would be an intervention done from inside the facade. In some cases, if the intervention is done on the outside, it could be a ventilated facade solution, EIFS, or a combination of both, though always guaranteeing the original reading; the specific characteristics of the existing facade should be maintained, with all the aforementioned specificity regarding the respective manufacture and other elements, both in texture and in colour. It is advisable to forbid the replacement of metal railings by continuous panes of glass or other materials.

4. Conclusions

Regulation of the built heritage has usually been managed with expert panels. Although the systemized definition of a building's heritage value is not considered viable, the need to establish a methodology or prototype which approaches that systemization as much as possible has been discerned. The use of a tool with such characteristics has major advantages regarding both effectiveness when drawing up the regulation, and as help for impartial decision-making and even in the creation of a more precise regulatory text in which all aspects of the building are studied in detail. The created prototype's use will enable a quicker, fairer, and more effective understanding, description, classification, study, and definition of intervention criteria.

The design science research methodology (DSRM) was ideal for carrying out the work. The original prototype was continually corrected and improved, starting in the V0 version and until the V2 version, through several cycles of review and evaluation, with consequent application of the DSRM method. The prototype was tested in all unprotected buildings in the *ensanche*, in its different versions, from the original to the definitive, whereby the results obtained have been compared.

The resolution of doubts arising in the definition of intervention criteria has been addressed through 3D simulations. Visualizing the consequences that a particular regulation may have on facade rehabilitation allows for informed decisions with a solid foundation.

The prototype is designed at two different scales. A first scale encompasses the whole procedure and is replicable in other urban environments without any need for adjustment or modification. There is also a closer scale devoted to defining the specific intervention criteria in each of the elements of each building, such as windows, blinds, or railings. In all the cases, an effort was made to systemize the required intervention type. However, the definition of parameters such as material, colour, or form in some of the elements of each building is sufficiently different, making it impossible to determine generic application criteria. In such cases singular solutions were achieved, endorsed by the panel of experts from the focus group.

The definitive prototype is supported by the expert panel and applicable to the Cortázar and Oriental *ensanches* of San Sebastián. The prototype's use is feasible elsewhere in the world, although its proper application requires study of the place's architectures such as styles, colours, materials, etc. In the future, the project's replication in other urban spaces is intended, starting with other *ensanche* districts in San Sebastián. Areas with major architectural heritage value have been identified, which are rapidly being modified and require urgent regulation to halt loss of identity and to promote their regeneration and re-signification. These new projects will enable testing of the created prototype, besides enriching it with contributions from architectural styles not studied (Figure 12).

(**a**) (**b**)

Figure 12. 3D simulations. (**a**) Three-dimensional simulation of the building without intervention; (**b**) Simulation of a possible intervention on the facade envelope that completely distorts the facade of this street.

Also, the realization of this work identified the need to produce a colour catalogue of San Sebastián's protected buildings. This lack makes a specific respective regulation unviable, because not only do unprotected buildings in the *ensanche* continue to be modified, but the colour of protected buildings also changes. The working team has therefore begun to research this new matter. It must be borne in mind that the colour of the city, in this case, the sandy colour of the sandstone from the Igeldo quarries, configures part of its *genius loci*. The predominant colour can be the basis, not just for establishing a colour plan for protected buildings, but also for unprotected buildings and new developments in the city.

Improving the energy efficiency of buildings involves the study of technical, urban planning, and architectural parameters. However, the acceleration of the refurbishment process, due to the existence of subsidies, has led to the standardization of the use of SATE or ventilated facade, almost automatically, without a general study of the conditions of the building and its surroundings. Its use in non-protected buildings in historic centers is leading to a distortion of the architectural heritage, especially from the 20th century, and a general loss of the urban image and identity of the cities. This is where this project comes in, which serves as a tool for designers and public administrations, as a preliminary step to the study of systems for improving energy efficiency, by establishing guidelines for the protection of architectural heritage in interventions on the exterior of facades.

It is for this reason that an objective and quantifiable methodology is proposed, endorsed by a panel of experts from various disciplines, to limit or regulate how to intervene in each case. The results obtained have been compiled in a series of sheets (Figure 11). The application of the tested and replicable methodology demonstrates that the quantitative assessment of the degree of vulnerability of each building allows a level of flexibility in the interventions on the facade envelope. In the case of a building with a remarkably high vulnerability, it may be impossible to act from the outside with an ETICS system or a ventilated facade. On the other hand, an extremely low vulnerability allows for flexibility in such interventions.

In the case study, Table 4 shows the degrees of vulnerability of the architectural typologies studied, concluding that, except in the case of the sub-scenario of neoclassical buildings, the rest present a vulnerability of 100%, making it advisable to prohibit intervention from the outside, with the usual standardized solutions of ETICS and ventilated facade. This does not imply that the building cannot have an energy improvement with other strategies such as the placement of thermal insulation on the inside of the envelope and other solutions.

Although the systematization of the generation of regulations for the safeguarding of architectural heritage seems unfeasible, the implementation of the prototype in the case study has made it possible to verify its suitability as a better and more effective way of creating regulations. An objective and quantifiable methodology, endorsed by a panel of experts from various disciplines, has been designed to regulate how to intervene in each case. In this way, the legislator has at his disposal a tool with which to systematically analyze and define a regulation for each type of building. The tool accelerates, systematizes, and facilitates the process.

The conclusions obtained have proven to be a tool, not only for the protection of heritage in the face of the rise of exterior building cladding, but also for any type of intervention on the exterior of the facade, understanding facade intervention as a fact that influences the identity of the built heritage independently of its individual heritage value.

The conclusions of the case study have been presented to the corresponding administrations and they have requested the application of the prototype in a new area, through a contract. Therefore, it can be concluded that the work has been a great success due to the innovation provided and the methodology can be applied and improved in a new case study, in an area with somewhat different characteristics to the one studied, with a greater number of buildings and a variety of architectural styles.

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Sagarna), A.A., M.R., F.M. and J.P.O.; writing—review and editing, F.M. and J.P.O.; visualization, M.R.; supervision, A.A.; project administration, M.S. (Maialen Sagarna); funding acquisition, M.S. (Maialen Sagarna). All authors have read and agreed to the published version of the manuscript.

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